QUALITY OF SERVICE-BASED MODELING USING ICT INFRASTRUCTURE FOR DATA OPTIMIZATION

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Abstract

The incapability of Worldwide Interoperability for Microwave Access (WiMAX) to deliver high bandwidth when serving multiple customers causes a signal reduction or attenuation, provides unreliable services, and further reduces the effective capacity of the technology. The need to investigate the behaviour of this state-of-the-art technology for the establishment of multi-hop networks has become indispensable. To address and analyse the challenges of low bandwidth when a large number of clients are using this technology, a simulator tool that eases the cost and energy was deployed. An ICT infrastructure was used to model WiMAX for performance evaluation by considering a different number of nodes for operational data optimization of some highly dependable Quality of Services (QoS) such as jitter, delay, and throughput for the realization of the study. Three (3) network models consisting of 10, 15, and 20 network nodes were considered and an appreciable result that presents a better performance was achieved.

***Keywords**: Attenuation, Bandwidth, Data Optimization, jitter, OPNET, QoS.*

Introduction

WiMAX (also known as wireless broadband) is a communication technology that is based on the technology of the Wireless MAN standard that belongs to the 802.16 families. The two possible WiMAX scenarios are the Fixed WiMAX using the standard equivalent to IEEE 802.16-2004 while the other, i.e., mobile WiMAX uses IEEE 802.16-2005 or 802.16e. These approaches enable broadband through a direct link to the Internet Service Provider at any point in time. It allows wireless data communication by routing as many nodes as possible, and some of the networks and their architectural modes include point-to-point to the entire cell access. This technology is a hopeful substitute for 3G and wireless networks for delivering connections across broad coverage areas at a low cost, as well as high data speeds. It offers data rates of up to 70Mbps across distances of up to 50 kilometres, as well as mobility at automotive speeds. WiMAX is the only wireless technology that can provide good Quality of service (QOS) at high data rates for IP networks and the Voice over Internet Protocol (VoIP) service to allow bidirectional voice interaction is one of the most popular uses for the 802.16 standards (Adhicandra, 2013). The subscriber station and the base station are the two most important components of a WiMAX system. A base station can be connected to one or more nodes, which are subscriber units. These base stations and subscriber stations can be combined to form a point-to-multipoint (P2MP) cell. Several BS may be used to create a cellular wireless network (Base Stations). A fixed antenna is often used in WiMAX-based systems and is positioned at a height at the subscriber station location. A base station's antenna can be either directed or omnidirectional. A fixed subscriber unit uses a directional antenna, whereas a mobile or portable subscriber unit uses an Omni-directional antenna. The 802.16 standards may also be used in a point-to-point topology with a pair of directional antennas. (Vats & Sachdeva, 2012). The network simulator, the Optimized Network Tool (OPNET) modeller is object-oriented that uses a hierarchical method to model communication networks. The usefulness of the OPNET may be broken down into four key phases: modelling, picking and choosing statistics, creating a network simulation, analyze and viewing the findings. Various quality services are available and these include delay, throughput, jitter, End-to-End delay etc.

The remaining part of the work is divided into the following sections: section 1 presents the introductory part of the work, section 2 represents related work, the methodology is presented in section 3, the results and discussion are presented in section 4, and the conclusion part of the work is presented in section 5.

Related Work

The realism of some authors can be commended by the efforts they put together to uncover mysteries behind WiMAX technology. In this regard, it is pertinent to appreciate and present their work in good faith as shown in this section.

Mewara and Manghnani (2015), studied the effects and performance of three queuing techniques: First-In-First-Out Queuing (FIFO), Priority Queuing (PQ), and Weighted Fair Queuing (WFQ) based on VOIP applications such as HTTP, FTP, and Email. The parameters considered in the OPNET simulator for analysis were packet end-to-end delay, jitter, packet delay variation, and mean opinion score. After proper investigation, PQ was selected to provide the best service among the queuing schemes and also concluded that the performance of these queuing schemes changes with an increase in the number of nodes.

A comprehensive study was carried out to compare and evaluate the performance of both mobile and fixed WiMAX networks in different scenarios. Load and throughput quality of service based on different applications using OPNET simulator was carried out. Real-time and non-real-time applications such as FTP, Email, HTTP, Videoconferencing, and Voice were selected for both fixed and mobile WiMAX. The results obtained proved that fixed WiMAX outperformed mobile WiMAX in terms of both the load and the throughput (Mohammed & Mustafa, 2018).
Ali et al. (2018), conducted a performance comparison analysis between WiMAX and Wi-Fi networks by selecting voice and video applications. This was based on throughput and voice packet end-to-end delay quality of service in the OPNET simulation environment. They concluded that WiMAX offers better performance than Wi-Fi in terms of faster data rate and longer distance coverage.

In the same year, Abdulrazzaq et al., (2018), further considered the restrictions and performance of WiMAX networks in an OPNET environment. QoS parameters such as throughput and voice packet end-to-end delay based on two applications video (heavy) and video (light) were simulated for 5 minutes in various scenarios. It was concluded that video (heavy) experienced lesser delay than video (light) and video (heavy) experienced larger throughput than video (light).

Also, further research was done by Dubi and Muniyandi (2019), to analyze the performance of VoIP over WiMAX mobile networks where mobility, number of nodes, WiMAX service classes, and VOIP codec were major considerations. The implementation was carried out in an OPNET environment. The simulated results obtained proved that the service layer Unsolicited Grand Service (UGS) is more suitable for VOIP service as a result of superlative performance and standard. The least delay and greater worth of customer satisfaction rate of services were established by the G.723.1 best coding and the lowest utilization of capacity was also sustained. Ishgeem et al. (2021), the performance of UMTS (Universal Mobile Telecommunications System) and WiMAX networks were explored for VoIP (Voice over Internet Protocol) services based on different applications such as email, video conferencing, HTTP, and FTP. The analysis and evaluation of the effects of these traffic flows were conducted on jitter, end-to-end delay, and packet loss selected as the quality of service in the OPNET environment. When VoIP was loaded with low and medium HTTP traffic, the UMTS network performed significantly well in terms of end-to-end delay, packet loss, and jitter, but poorly with heavy HTTP traffic.

To appreciate the usefulness of WiMAX technology, Mokeresete and Esiefarienrhe (2022), Embraced OPNET modeller to examine if WiMAX IEEE 802.16e as an access technology could be used as Botswana's national broadband project. They however used an experimental approach where the simulated valuation of the WiMAX IEEE 802.16e/m was implemented over three of Botswana's subscriber locations. Based on their findings, they discovered that WiMAX IEEE 802.16e can be deployed to address most of their issues and access at the last-mile level. They also discovered that this technology is more appropriate for high-density areas, can tackle infrastructure development encounters in rural areas, and further offer essential high-speed connectivity access.

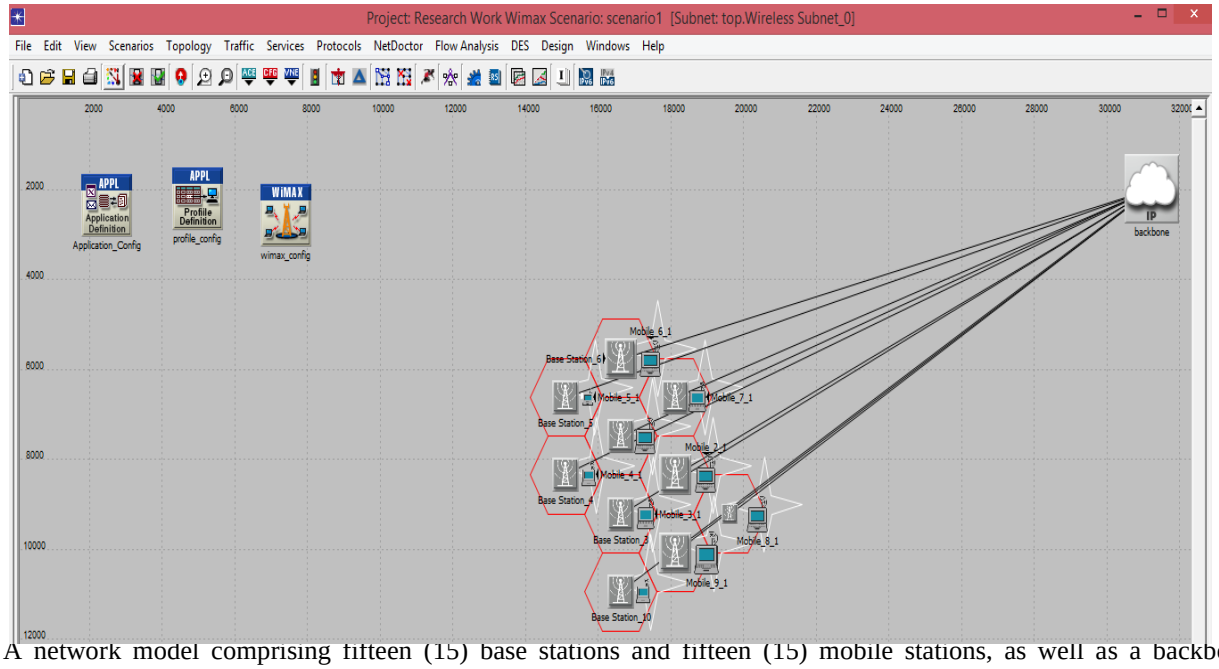
In this research work, An ICT infrastructure was used to model WiMAX for performance evaluation by considering a different number of nodes for operational data optimization of some highly dependable QoS such as jitter, delay, and throughput for the realization of the study. To further explore the efficacy and practicality of this technology, three (3) network models consisting of 10, 15, and 20 network nodes were considered and modelled.

Methodology

In terms of time and cost, simulation and modelling are important methodologies in the creation and study of systems. This research was implemented using a simulation tool known as OPNET v14.5 to investigate the performance of WiMAX technology. The behaviour of three (3) network models was examined in different scenarios with 10, 15, and 20 network nodes and the results obtained were compared to appreciate the effects on the performance of the technology. For each of the scenarios, ICT infrastructures were put together to model the technology. A base station, Mobile station, Backbone, Application configuration, Profile configuration, and WiMAX configuration were all deployed in this case. On the wireless deployment wizard-technology for WiMAX

configuration, 0.50W was selected for both Subscriber Node Transmission Power and Base Station Transmission Power. Vehicular was considered for Path loss and Multipath Model and hexagons of different sizes provide WiMAX network layout. The application configuration was designed with voice encoder schemes (All Schemes), profile configuration with voice application, mobile station formed with PHY (Value). The PHY profile type (wireless OFDMA 20), BS MAC Address (Distance Based), Multipath channel model (ITU pedestrian A), Handover parameter, MS Handover Regression timer (MS) (30), and maximum handover request retransmission (6) was considered. Also, WiMAX was configured with Service Class Name (GOLD), scheduling type (UGS), maximum sustained traffic rate (384kbps), Maximum Reserved traffic rate (384kbps), and maximum latency (30.0).

Figure 1 below presents a network model consisting of ten (10) base stations with ten mobile stations, backbone, application configuration, profile configuration, and WiMAX configuration.



A network model comprising fifteen (15) base stations and fifteen (15) mobile stations, as well as a backbone, application configuration, profile configuration, and WiMAX configuration, is shown in Figure 2 below.

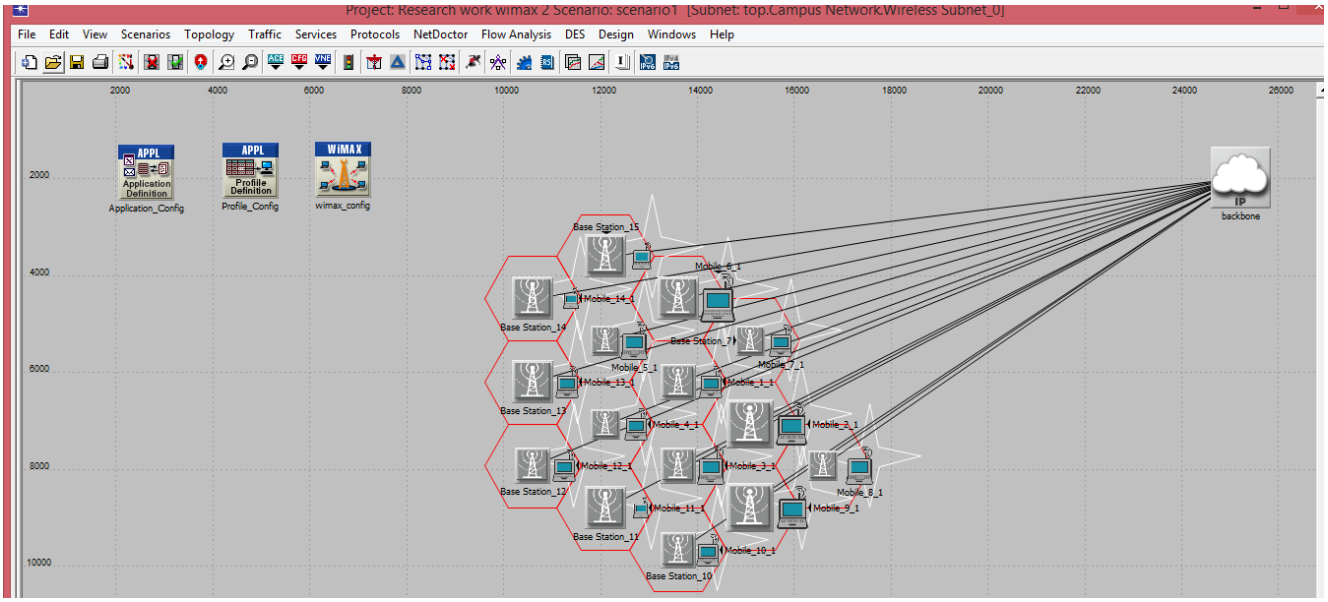
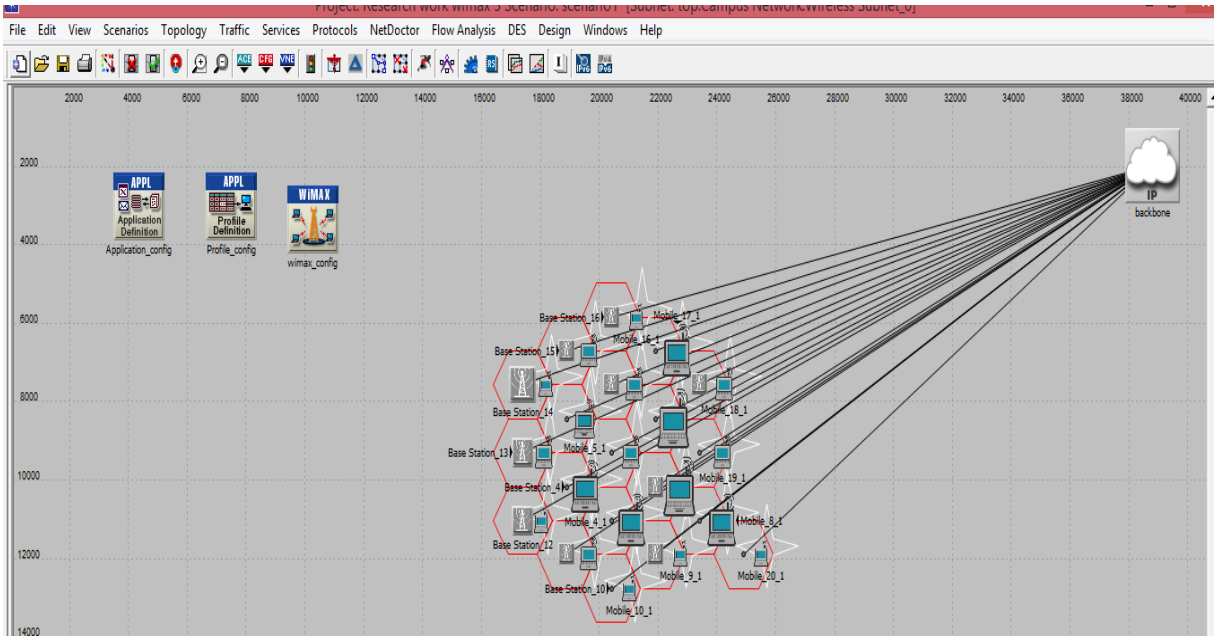


Fig.2: **Fifteen Base Stations and Work Stations Network Model**

The network model shown in Figure 3 below includes a backbone, twenty (20) base stations, twenty (20) mobile stations, application configuration, profile configuration, and WiMAX setup.



The simulation's outcomes indicate how the scenario performed under various assumptions depending on the simulation design. As a result, simulation aims to identify the precise model and forecast how the system will react in real-world situations. Jitter (sec), Load (sec), and Throughput (bits/sec) were chosen as the QoS for statistical analysis for each of the scenarios after the modelling and investigation processes were complete.

Table 1 below presented10 nodes network modelthatdemonstrated jitter (sec), load (sec), and throughput (bits/sec) simulated for 1 hour. The graph for this table is presented in figure 4 using a statistical tool to show the behaviours of these parameters as regards the network model.

Table 1: Ten Nodes Network Model

Time (sec)	Jitter (sec)	Delay (sec)	Throughput (bits/sec)
0	0.00005816	0.0026	1,408.00
10	0.00000704	0.3423	973,013.63
20	0.00000427	0.2242	1,393,549.87
30	0.00000277	0.1885	1,460,502.15
40	0.00000205	0.1719	1,490,354.59
50	0.00000171	0.1617	1,512,335.43
60	0.00000137	0.155	1,525,883.25

Figure 4 represents the graph obtained when the quality of services was investigated for the ten-nodes network model for WiMAX technology. As we can see from Table 1, there was a little decrease in variations in time delay from when the signal was sent and when the signal was received over the network connection of simulated time for jitter (negligible). A delay was also experienced over the simulated time as some bits of data were unable to travel across the network from source to destination and thus decreases with an increase in time. Also, from the table, the rate at which data travels from one location to another increases with time for throughput. The graphical representation using a statistical tool is shown in the Figure below.

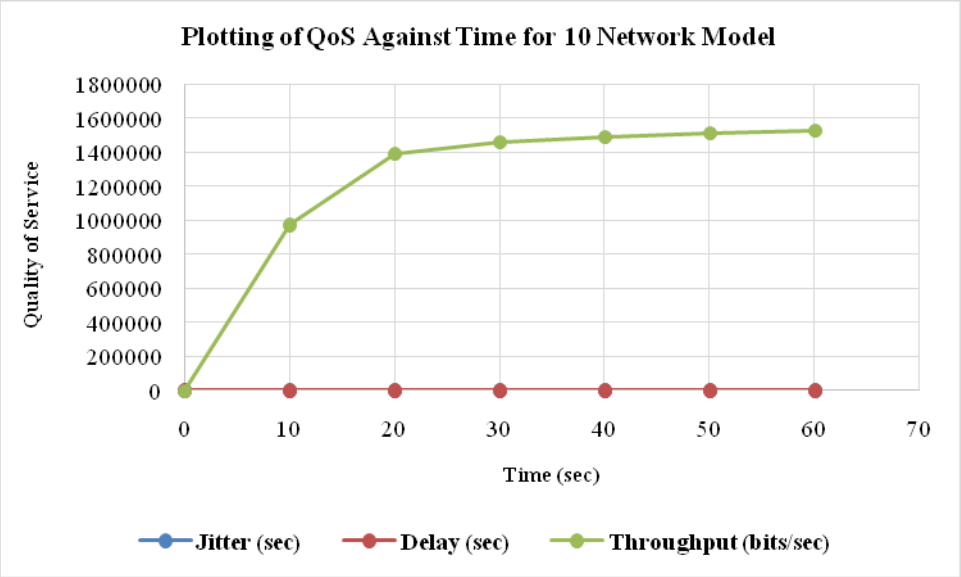


Fig.4: Graph for 10 Nodes Model

Table 2 depicts15 nodes network modelthatdemonstrated jitter (sec), load (sec), and throughput (bits/sec) simulated for 1 hour. The graph for this table is shown in Figure 5 using a statistical tool to display the behaviours of these parameters as regards the network model.

Table 2: Fifteen Nodes Network Model

Time(sec)	Jitter (sec)	Delay(sec)	Throughput (bits/sec)
0	0.00001376	0.00375	1,943.00
10	0.00000372	0.01732	687,989.80
20	0.00000662	0.01804	1,391,942.65
30	0.00000028	0.01791	1,599,096.85
40	0.00000019	0.01791	1,713,247.34
50	0.00000016	0.01789	1,782,373.24
60	0.00000016	0.01787	1,824,702.32

Figure 5 depicts the graph of quality of services for the fifteen-node network model. From table 2 above, a decrease of variations in time delay from source to destination was observed over the network connection of simulated time for jitter (negligible). A delay was also experienced over the simulated time as some bits of data were unable to travel across the network from source to destination and thus varied with time. For the throughput, the rate at which data travels from one location to another increases with time. Using a statistical tool, the graphical depiction is shown in Figure 5 below.

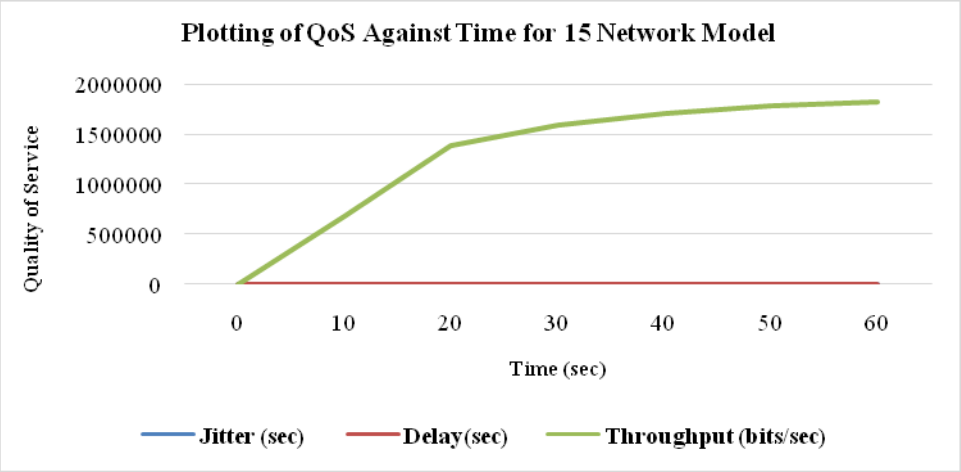


Fig.5: Graph for 15 Nodes Model

Table 3 represents 20 nodes network modelthatdemonstrated jitter (sec), load (sec), and throughput (bits/sec) simulated for 1 hour. The graph for this table is shown in Figure 6 using a statistical tool to display the behaviours of these parameters as regards the network model.

Table 3: Twenty Nodes Network Model

Time (sec)	Jitter(sec)	Delay (sec)	Throughput (bits/sec)
0	0.0006557	0.0036	2279.00
10	0.0000071	0.2336	1347,876.39
20	0.0000064	0.2331	2318,655.57
30	0.0000042	0.2693	2542,655.35
40	0.0000031	0.2693	2653,598.41
50	0.0000024	0.2772	2725,870.41
60	0.0000002	0.2817	2768,320.25

Figure 6 signifies the graph for quality of services when examining twenty nodes network model for WiMAX technology. Decrease of variations in time delay from source to a destination over the network connection of simulated time experienced in jitter (negligible). A delay was experienced over simulated time as some bits of data were unable to travel across the network from source to destination and thus varied with time. Also for throughput, the rate at which data travel from one location to another increase with time. The graphical illustration using a statistical tool is shown in Figure 6 below.

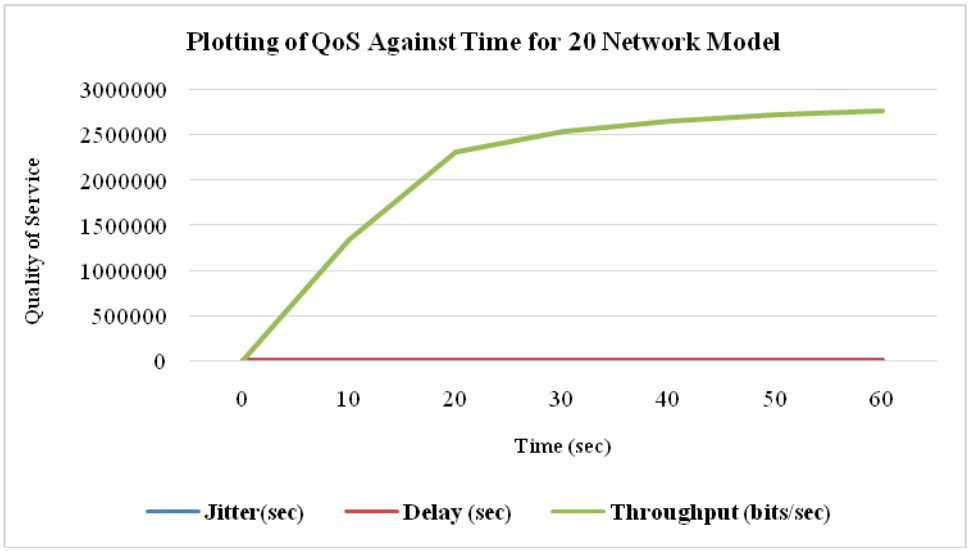


Fig.6: Graph for 20 Nodes Model

To view and understand the difference in the performance of these three models using the same quality of services, a comparison analysis was however conducted on these scenarios to show behavioural display and present its effects on an increase in nodes of WiMAX technology.

Table 4: Comparison of Jitter (sec) in All Scenarios

Time (sec)	Jitter (sec) in 10 Nodes Model	Jitter (sec) in 15 Nodes Model	Jitter(sec) in 20 Nodes Model
0	0.00005816	0.00001376	0.0006557
10	0.00000704	0.00000372	0.0000071
20	0.00000427	0.00000662	0.0000064
30	0.00000277	0.00000028	0.0000042
40	0.00000205	0.00000019	0.0000031
50	0.00000171	0.00000016	0.0000024
60	0.00000137	0.00000016	0.0000002

For clarity, a consideration comparison analysis was presented for a single quality of service; jitter (sec) for all three network models. Initially, variation in time delay was higher with the 20-node model, but with an increase in time, the jitter became negligible for all three scenarios. The graphical illustration of table 4.0 is shown in Figure 7 below.

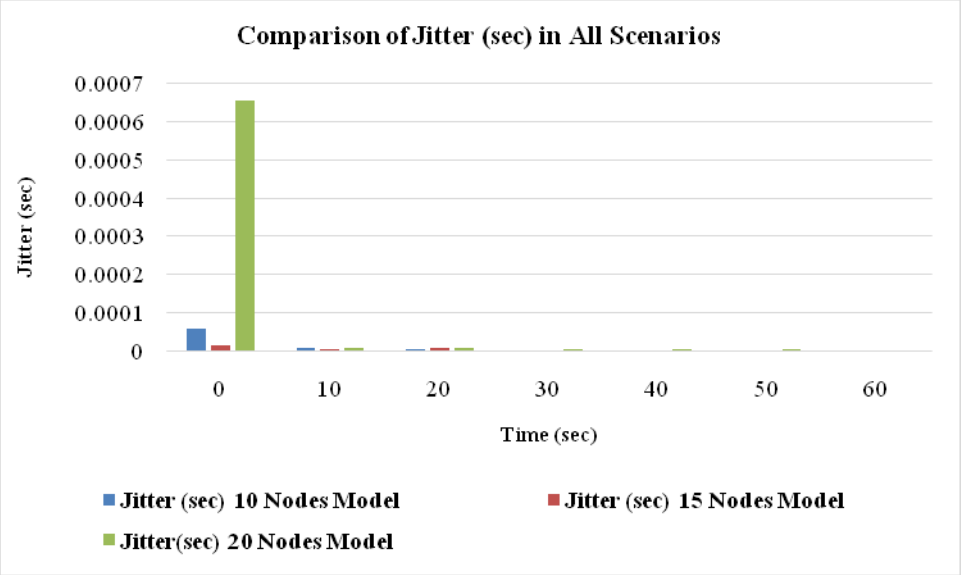


Fig. 7: Graph of Jitter (sec) for all the Scenarios

Table 5.0: Comparison of Delay (sec) in All Scenarios

Time (sec)	Delay (sec) 10 Nodes Model	Delay(sec) 15 Nodes Model	Delay (sec) 20 Nodes Model
0	0.0026	0.00375	0.0036
10	0.21423	0.01732	0.2336
20	0.2242	0.01804	0.2331
30	0.1885	0.01791	0.2693
40	0.1719	0.01791	0.2693
50	0.1617	0.01789	0.2772
60	0.155	0.01787	0.2817

A comparison analysis was presented for a delay (sec) for all three network models. Initially, a delay was insignificant for all three scenarios, high in the model with 10 nodes, but decrease with time. A little variation in delay for the 15 nodes model was noticed (almost negligible) and an impulsive difference in delay was observed as the number of nodes increased to 20. The graphical image of Table 5 is shown in Figure 8 below.

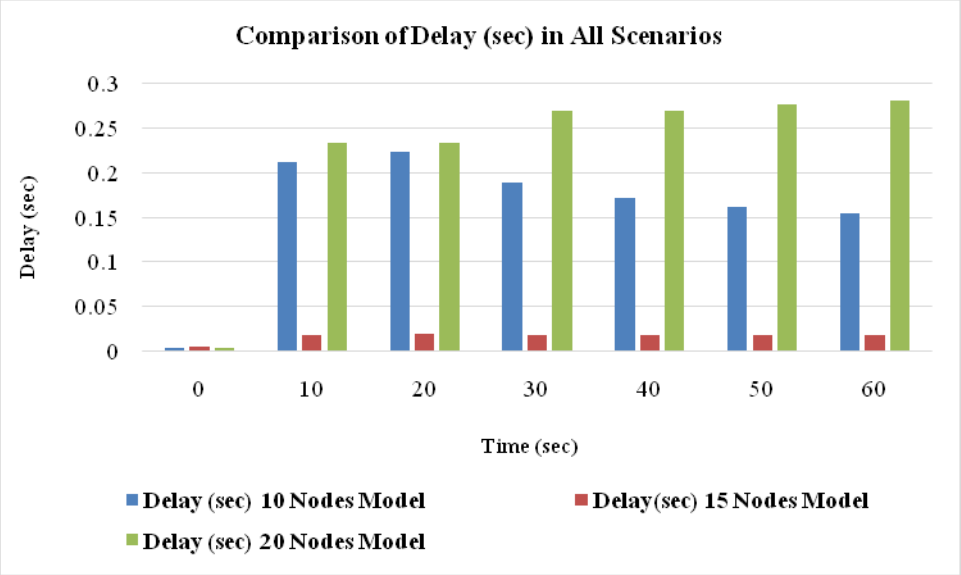


Fig. 8: Graph of Delay (sec) for all the Scenarios

Table 6: Comparison of Throughput (bits/sec) in All Scenarios

Time (sec)	Throughput (bits/sec) 10 Nodes Model	Throughput (bits/sec) 15 Nodes Model	Throughput (bits/sec) 20 Nodes Model
0	1,408	1,943	2279
10	973,013.63	687,989.80	1347,876.39
20	1,393,549.87	1,391,942.65	2318,655.57
30	1,460,502.15	1,599,096.85	2542,655.35
40	1,490,354.59	1,713,247.34	2653,598.41
50	1,512,335.43	1,782,373.24	2725,870.41
60	1,525,883.25	1,824,702.32	2768,320.25

Lastly, a comparative analysis of throughput (bits/sec) was presented for all three network models. Initially, the throughput for all the scenarios was small, but with an increase in time, the throughput increased and this was more visible in the 20 nodes model. Here, we can conclude that the higher the nodes, the higher the throughput but with little variation. The graphical demonstration of Table 6 is shown in figure 9 below.

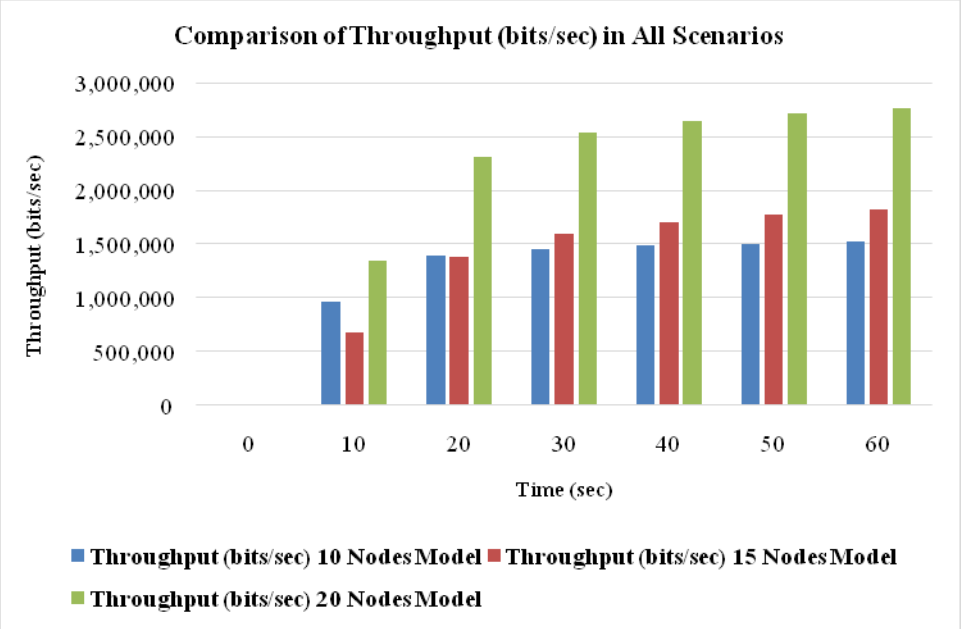


Fig. 9: Graph of Throughput (bits/sec) for all the Scenarios

5.0 Conclusion and Recommendations

In this research work, jitter, delay, and throughput were investigated for three different network models. Based on the results obtained from the comparison analysis, higher delay, higher jitter, and higher throughput were experienced in the 20-nodes model. However, to arrive at the optimal quality of service for data optimization in WiMAX technology, the number of nodes in each model can be considered to be a major factor. Further avenues such as other quality of services, and increasing the number of nodes in the network models can be explored.

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