International Journal of Real-Time Application and Computing Systems (IJORTACS)

Volume 1, Issue VI, June 2022, **pp. 28-42**

Submitted 06/5/2022

Final peer reviewed 11/5/2022

Online Publication 16/6/2022

Available Online at http://www.ijortacs.com

IMPROVING CONGESTION CONTROL IN A PACKET SWITCHED NETWORK USING FAIR QUEUING TECHNIQUE

[1]Uzochukwu M., [2]Prof. Onoh G.N.

[1]uzochukwumuonaka@gmail.com

[12]Department of Electrical Electronics Engineering, Enugu State University of Science and Technology

Abstract

This work presents improving congestion control in a packet switched network using fair queuing technique. The aim is to reduced delay experienced in the characterized WLAN used for the study. This was achieved using the necessary physical and structural models to design the wireless network under study and then improve the router performance using fair queue technique. The fair queue algorithm was developed using structural method, pseudopodia and implemented with Matlab. The result shows that the new system was able to effectively manage congestion when simulated and achieved throughput percentage of 89% and latency performance of 76ms.

Keywords: Packet Switched, Congestion, Wireless Network, Throughput, Latency, Matlab

I. INTRODUCTION

Communication systems of any kind, either analogue or digital have a limit to the amount of data traffic that it can transmit at a given time. In situations whereby the network demand is more than the required capacity, it results to congestion of the network, which means that the latency in data communication of the system is impaired, or challenged (Bryan and Patrick, 2011). Therefore, there is a great need to prevent this in public and private data network entities to facilitate the operation of trade, industries, transport, network, provision and planning within the despoliation of the global enterprise (Davarian, 2014).

Researchers has given network congestion avoidance, monitoring and control focus over the past decade, especially in the field of information and communication technology. When the congestion in a network is not properly managed, there is a threat to the efficiency of the network utilization which can lead to collapse of the network. Therefore, the management of congestion in both wired and wireless network is a means of enhancing the network performance for adapting to the traffic load without adversely affecting the user's usability (Francis, 2007).

This paper is focused on the improving the avoidance of network congestion in a packet switched network, most especially the situation whereby many users are interconnected on the same network and transmitting various packets at the same time. To solve this problem fair queuing technique has been proposed to improve the congestion avoidance and management in a network. This technique is preferred to other technique because it usually identifies various packets according to their sizes and then allows the smaller bits to be transmitted first before higher bits. This way latency is reduced and congestion is controlled.

Table 1: LITERATURE REVIEW

AUTHOR	TITLE	WORK DONE	RESEARCH GAP
Luigi et al., (2017)	Large-Scale Network Utility Maximization (NUM): Countering Exponential Growth with	The work develops scalable algorithmic tools that are capable of providing efficient solutions in time which is dimension-free,	The author leverage suite of modified gradient methods known as "mirror descent", and derive a scalable and efficient algorithm for the NUM problem based on gradient exponentiation
Ioannis et al., (2008)	Intelligent routing and bandwidth allocation in wireless networks	They rely on the interaction of autonomous agents who communicate with each other through the environment (a phenomenon known as stigmergy)	propose a new class of routing algorithms based on principles of biological swarms, which have the potential to address these problems in an autonomous and intelligent fashion
Haris (2017)	Wireless Networks with Artificial Intelligence: Design, Challenges and	The work discusses the rise of network intelligence and then, we introduce a brief overview of AI with machine learning	The work provides readers with motivation and general methodology

	Opportunities. Belgium.	(ML) and their relationship to self-organization designs	for adoption of AI in the context of next-generation networks
Yongmin et al (2017)	Distributed control and optimization of wireless networks	The work investigates various bibliographies relating to wireless network control	The work presents the ant colony and guffman coding techniques for the optimization of wireless network
Zia et al. (2015)	Multi-cell admission control for UMTS	The work studied and addresses improving mobility management through multiplexing intra and inter mobility to minimize the signal traffic	The work addresses mobility management using inter and intra technique to reduce signal traffic

II. METHODOLOGY

The methodology adopted in this paper is the process model which consists of self-defining equations and computer aided software engineering method. The materials used for data collection and implementation of the method in this paper includes; routers, laptop, network switch and User Equipment (UE).

a. Characterization

Giganet packet switch network at digital dreams Nigeria Ltd was characterized in this paper. This characterization involves studying the throughput performance and effect of congestion between the nodes during data transmission of various packet data over the network. The characterization involves the collection of real-time data in three network nodes of the network, a network simulator and monitoring device were used as shown in figure 1.

Figure 1: The Network Setup

b. Data Collection

This paper considered the testbed in figure 1 for data collection. It used three nodes for transmitting various packet types in the network; however, the one transmitting FTP signal was monitored closely and used for the characterization. Table 2 shows the data collected from the monitoring device for the FTP transmitter node;

TABLE2: CHARACTERIZED RESULT FOR FTP DATA

Packet sent (kb)	Throughput (kb)	Latency (ms)	Packet Loss (kb)	Result for network performance
25	23	20.0	2	Throughput and latency ok
50	46	65.0	4	Throughput and latency ok
75	70	72.0	5	Throughput and latency ok
100	93	81.0	7	Throughput and latency ok
125	118	113.0	7	Throughput ok, latency ok
150	127	141.0	23	Throughput ok, latency ok
175	132	145.0	43	Throughput ok, latency ok
200	150	145.0	50	Throughput ok, latency ok
225	170	146.0	55	Throughput ok, latency ok
250	190	148.0	60	Throughput fair, latency ok
275	167	222.0	108	Throughput poor, latency poor
300	147	230.0	157	Throughput poor, latency poor
325	159	265.0	166	Throughput poor, latency poor
350	177	272.0	173	Throughput poor, latency poor
375	189	281.0	186	Throughput poor, latency

				poor
400	265	313.0	195	Throughput poor, latency poor

c. System Proposal

The wireless network proposed in this system uses the IEEE 802.11 methodology for the communication of wireless network structures with the necessary network components like the network nodes, switches, routers, servers with the international telecommunication union standard specification. The structure of this network is presented in figure 2

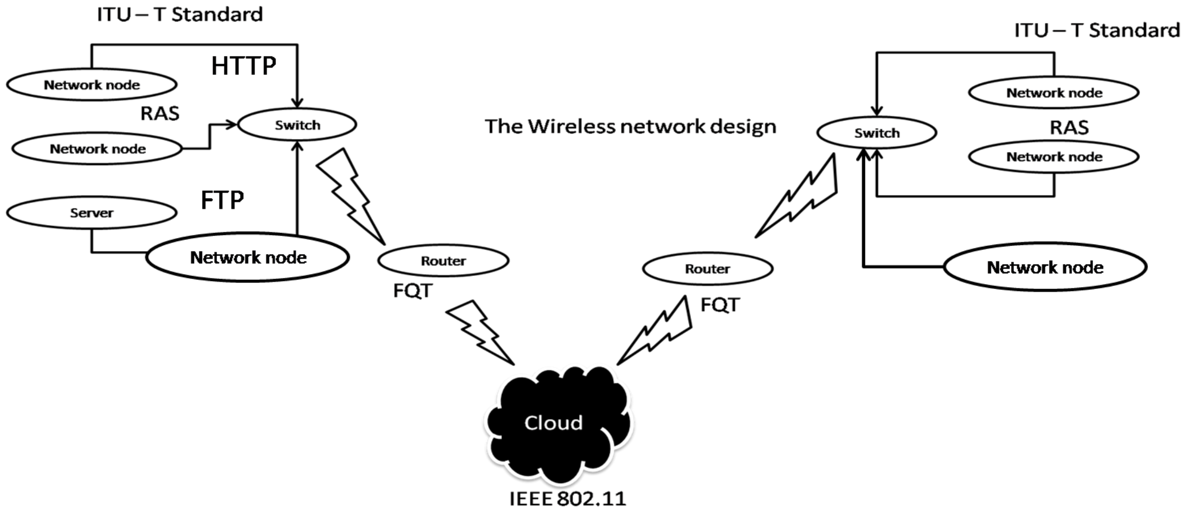

Figure 2: the proposed communication network design

III. SYSTEM MODELLING

This section presents the technique, algorithm, flowchart and models adopted in the actualization of improving the congestion avoidance system. The fair queuing technique has been adopted in this work for highly optimized and effective system in congestion avoidance.

a. Development of the Fair Queuing Technique (FQT)

The FQT is a scheduling algorithm which is used in a network scheduler for congestion management. The algorithm is designed to achieve fairness when limited resources bandwidth is shared. It presents a fair resultant bandwidth allocation according to the required weights assigned for the packet. The FQT scheme is demonstrated in figure 3

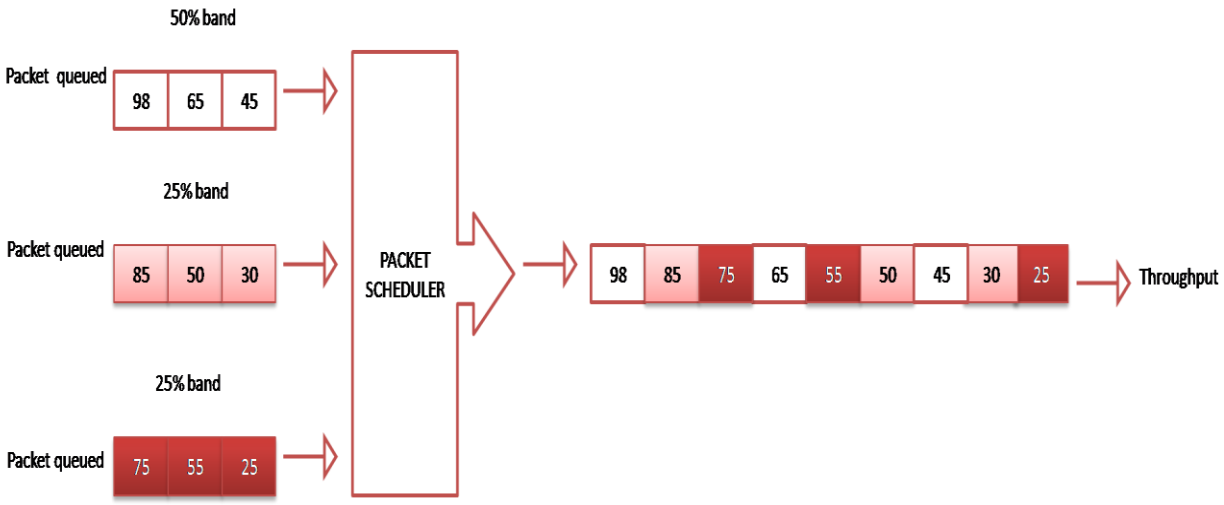

Figure 3: FQT scheme

b. Pseudocode and Flowchart of the Algorithm

1. Start
2. Identify incoming packet
3. Identify packet size
4. Classify packet according to sizes
5. Schedule throughput from the least size
6. Allow delay of 45ms for other packets
7. Stop

The flowchart of the Fair queuing technique is shown in figure 4

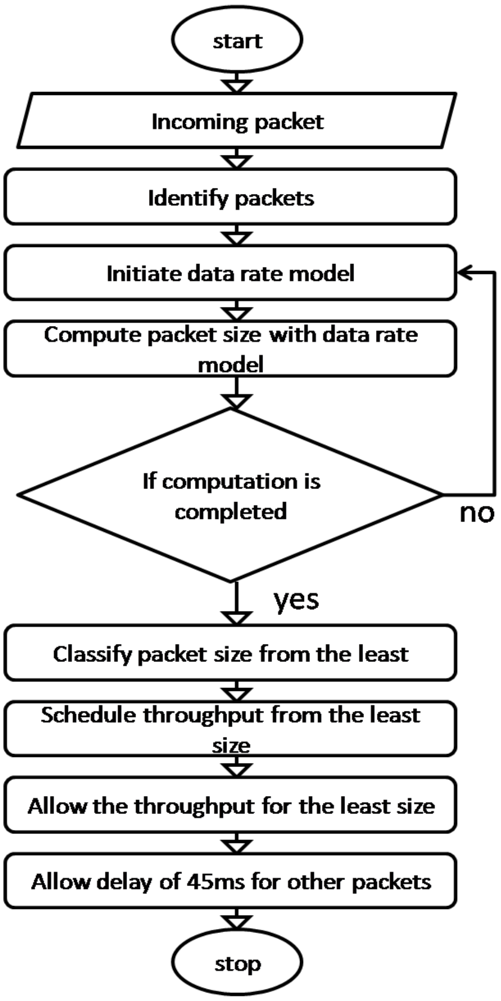

Figure 4: Fair Queuing Flowchart

c. Data Rate Model

The data rate model was developed considering the signal to noise ratio; the bandwidth size and the time slot for dividing the packets. The model is presented as;

$$R_{u,t} = \alpha W \log 2(1+SNR_{u,t}) \quad (1)$$

Where W is the bandwidth, α is the fraction of bandwidth employed for the packet data transmission, SNR is signal to noise ratio at user u and time slot of t.

d. Throughput Model

The throughout is presented using the range between the total packet sent per given time and the rate delivered or rejected as shown in the model below (Wang, 2009).

$$\text{Throughput} = \frac{VS_q}{T_{tx,q} - T_{rx,q}} \quad (2)$$

Where VS_q is the amount of packet to be transmitted by user qth, $T_{rx,q}$ is the time for service request and $T_{tx,q}$ is the time taken to transmit each packet.

e. Network Congestion Model

Network congestion is produced when the users transmit in the same frequency channel. The model of the network under congestion is designed considering the number of nodes transmitting packet at a given time, the signal to noise ration identified as (SNR), and the propagation path loss (pl), presented using the equation below;

$$q = 3[SNR]^\wedge \frac{1}{pl} \quad (3)$$

f. Latency

This latency is always due to propagation delay, source delay, network delay and destination delay. During this process, some of the energy associated with the transmitted packet is lost in the form of noise. Packet end-to-end delay can be measured as the difference between packet arrival and packet start time

$$\text{Packet delay} = \frac{\sum i\,(\text{packet arrivali} - \text{packet starti})}{n} \quad (4)$$

Where packet arrivali is the time when packet "i" reaches the destination and packet starti is the time when packet "i" leaves the source. "n" is the total number of packets.

IV. IMPLEMENTATION

The technique was implemented as a written script in MATLAB development environment. The script was guided with mathematical models developed and the pseudocode of the fair queue algorithm also developed using signal processing toolbox, communication toolbox, ITU-T client standard and IEEE 802.11 methodology for system implementation of a packet switch network. Equation (2) was used to implement three network nodes. The nodes transmit FTP and HTTP data over network while the other node was used at the other end of the communication process to complete the end-to-end communication protocol. From the nodes, packet signals were transmitted based on the packet flow model in equation (1) while the traffic formed due to the communication process within the network is presented with the model in equation (4) and controlled using the proposed fair queuing algorithm. The network performance was evaluated considering throughput presented with equation (3) and latency equation in equation (4) and will be discussed in the next section.

V. RESULT AND DISCUSSION

This section presents the outcome of the simulation performed with the packet switch network using fair queuing technique in MATLAB simulation tool. A comparative review of the technique with the characterized network was also presented later in this section.

TABLE 3: SIMULATION PARAMETERS COLLECTED FROM THE TESTBED

Parameters	Values
Number of nodes	3
Maximum packet size	400kb
Monitoring system IP	172.22.3.99/25
Simulation time interval	0.002ms
Average noise level	-164 dBm/Hz
Modulation type	16QAM
The Resolution bandwidth	10 kHz
Middle frequency (f1)	203.25 MHz
Middle frequency (f2)	583.25 MHz
Frequency	224.25 MHz
Power	1.5 W
Cable Type	RJ45
Impedance	20 ohms
Gateway	172.22.3.1
LAN IP	192.168.10.0/24
Duplexing scheme	Time division multiplexing

Table 3 presents the parameters used to perform the simulation in MATLAB.

TABLE 4: RESULTS OF NETWORK WITH FQT

Packet sent (kb)	Throughput (kb)	Latency (ms)	Packet Loss (kb)
25	23	70	2
50	46	75	4
75	70	72	5
100	93	71	7
125	118	73	7
150	127	71	23

175	132	75	43
200	150	75	50
225	175	76	55
250	190	78	60
275	209	72	66
300	233	80	67
325	248	85	77
350	271	82	79
375	290	81	85
400	311	83	89

The result in Table 4 shows the performance of the packet switched network when the fair queuing technique has been deployed on it.

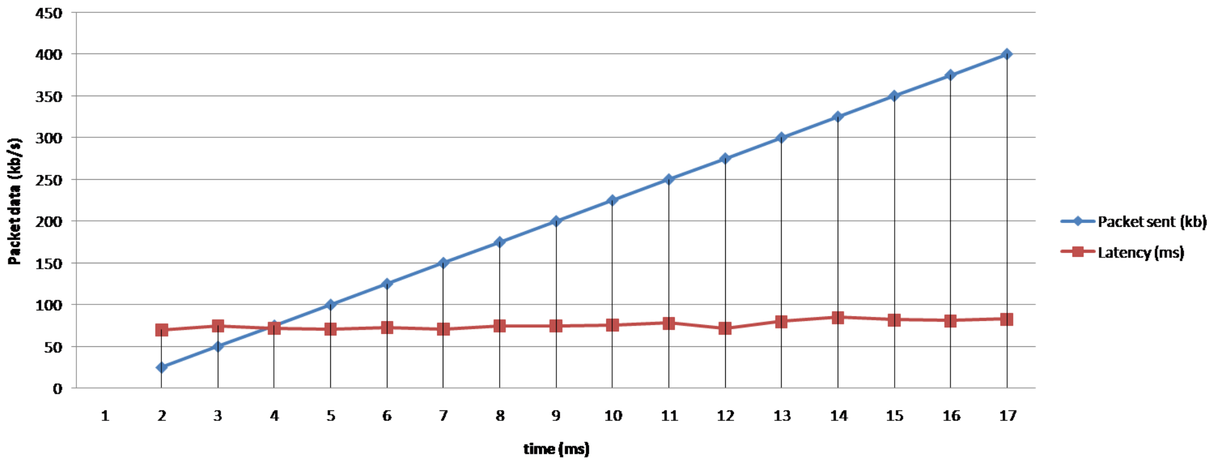

Figure 5: latency performance with FQT

The figure 5 presented the latency performance of network as shown above, from the result it was observed that the average latency performance is 75ms. The overall quality of throughput performance on the network is presented below

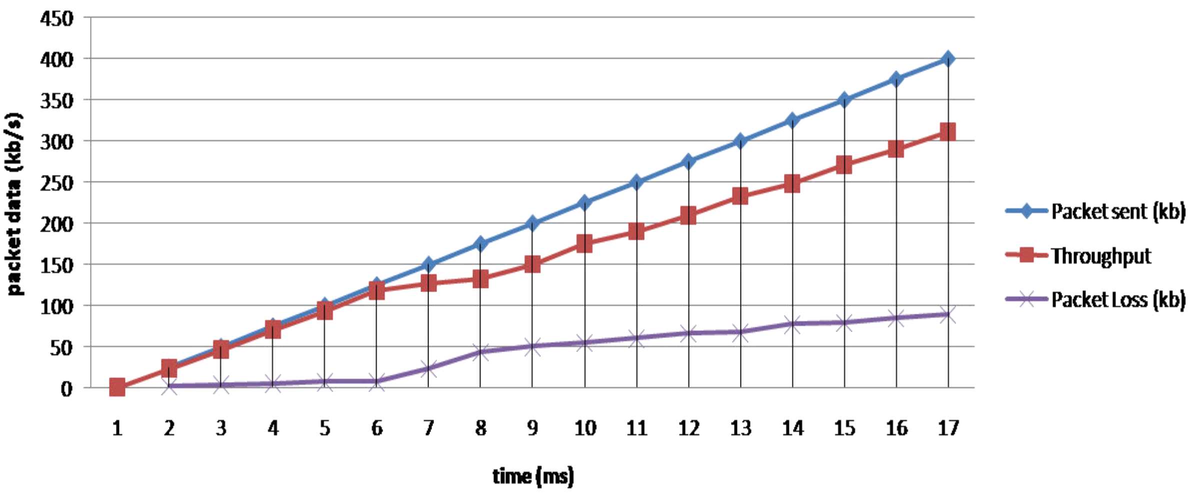

Figure 6: quality of service

The figure 6 presented the quality of throughput performance on the network, from the result it was observed that the packet set experienced negligible loss rate with an average throughput percentage of 89%.

TABLE 5: COMPARATIVE ANALYSIS

Packet sent (kb/s)	New Throughput (kb)	New Latency (ms)	Characterized Throughput (kb)	Characterized Latency (ms)
25.0	23	70	23	20.0
50.0	46	75	46	65.0
75.0	70	72	70	72.0
100.0	93	71	93	81.0
125.0	118	73	118	113.0
150.0	127	71	127	141.0
175.0	132	75	132	145.0
200.0	150	75	150	145.0
225.0	175	76	170	146.0
250.0	190	78	190	148.0
275.0	209	72	167	222.0
300.0	233	80	147	230.0
325.0	248	85	159	265.0
350.0	271	82	177	272.0
375.0	290	81	189	281.0
400.0	311	83	165	313.0

The result in Table 5 presented the comparative performance of the network when tested with the proposed technique and without the technique. These results were analyzed as shown below;

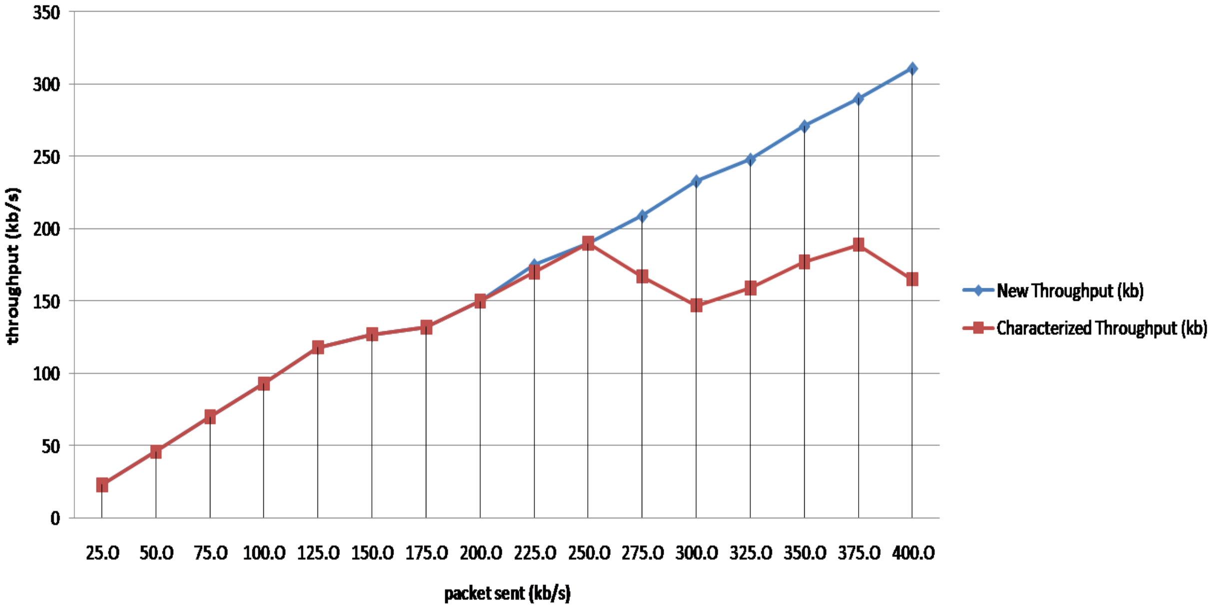

Figure 7: comparative throughput performance

The figure 7 presented a comparative analysis of the throughput performance of the new packet switched network and the characterize network. From the result the percentage increase in throughput performance is 20.9%. The next result presented the comparative throughput performance as shown below;

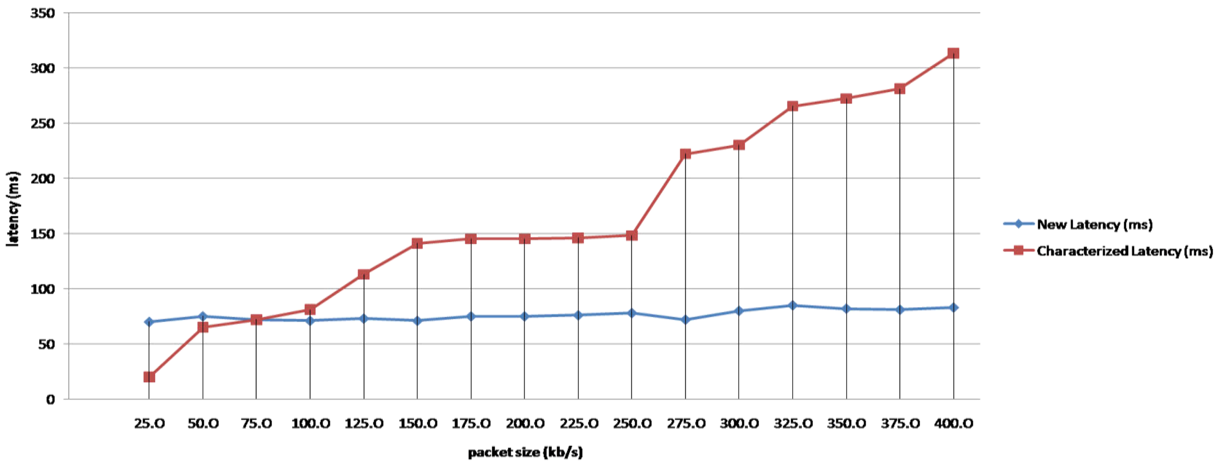

Figure 8: comparative latency performance

From the result the percentage increase in latency performance is 54% which is the increased in the speed of transmission in the packet switched network when improved with FQT.

VI. CONCLUSION

This work presents a congestion control management algorithm for packet switched network. This was developed using fair queuing techniques and deployed at the digital dream packet switched network. The result showed that the latency and throughput performance of the network was improved to the effectiveness of the algorithm. Throughput percentage improvement achieved was 20% as against 65% of the characterized network.

CONTRIBUTION TO KNOWLEDGE

- Fair Que algorithm was developed for congestion control in packet switched network

REFERENCES

Bryan, T., and Patrick.F., (2011) "A Practical Approach to the Reduction of Pseudorange Multipath Errors in a L1 GPS Receiver" IJRIAS; Vol 3; Issue 3; pp. 411-412; available at: ".http://tech.info/documents/ paper1_IB2_mrf-jun34.

Davarian, F. (2014).Earth-satellite propagation research. Communications Magazine, IEEE, 32(4), 74-79. From:http://ieeexplore.ieee.org.

Francis, C. (2007).Uses of the New Types of Wireless Technologies for istribution and Substation Automation. Xanthus Publishing; pp. 511-592

Haris G (2017), Wireless Networks with Artificial Intelligence: Design, Challenges and Opportunities. Belgium. Pp. 211- 301

Ioannis N. Arindam K, Mohammed E. and Robert J (2008); Intelligent routing and bandwidth allocation in wireless networks" [J] IJRIAS; 3[2]; pp. 733-752

Luigi Vigneri, Georgios Paschos, and Panayotis Mertikopoulos (2017); Large-Scale Network Utility Maximization: Countering Exponential Growth with Exponentiated Gradients; pp. 811-892

Wang C., Li B., Sohraby K., Daneshmand M. & Hu Y. (2006) Priority-based Congestion Control in Wireless Sensor Networks. In: IEEE international conference on sensor networks, s. pp.22 – 31.

Yongmin Zhang; Wenchao Meng, Heng Zhang, Preetha Thulasiraman and H. Luan (2017) Distributed control and optimization of wireless networks; pp. 901-955

Zia Yongmin ;Wenchao Meng, Heng Zhang, Preetha Thulasiraman and H. Luan (2015) Multi-cell admission control for UMTS.IEEE standard 802.11 Wireless LAN Medium Access Control (MAC) and Physical layer (PHY) specifications; pp. 309-328