Performance Analysis of Queuing Mechanism in Voice Applications

Sajjad Hussain Shah, Wajid Ali, Israr Ahmad, Sohail Jabbar, Abid Ali Minhas

ABSTRACT- Data reliability, network performance and quality of service are the core issues discussed and work out in the recent few decades. Both reliability and network performance have been affected by different network resources and mechanisms used to forward data from senders to receivers. For instance, when data from a sender *S1* is aimed to pass through Network *N* to receiver *R1* the network devices in between them queue this data by some specific mechanism known as queuing mechanism. Now depending on the queuing mechanism the data wait for further processing and transmission to reach its destination. In this paper, we have examined and analyzed different network queuing mechanisms in Voice application out of our obtained results. Different queuing mechanisms in different nature of data (text and voice) have been simulated using OPNET IT Guru Academic edition. Empirical results show the impact of a particular queuing mechanism on the network performance, data reliability and many other QoS parameters such as delay, jitter and packet loss.

KEYWORDS: Quality of Service, Queuing Mechanism, First in First Out, Weighted Fair Queue, Priority Queue, Jitter, End-to-End Delay

I- MOTIVATION

Computer network is considered as resource sharing center, where users from different departments can access shared resources like printer, scanner or even files. Beside this computer networks also enable us to share as well as transfer information and data between different computers which would have not been possible without networking. Companies and businesses strongly rely on computer networks for the last many decades. They used to transfer data normally textual data, over the network. But according to Epiphaniou G, *et al* [1] when the need for a best effort network service, like in internet was felt to converge both voice and data into a single network then this requires more concentration and work than ever before for textual data communication. This need gives birth to two critical and sensitive issues namely data reliability and network performance. According to Marshall D [2] Local Area Network (LAN) provides us very high speed but on the other hand it has got one major technical limitation i.e., communication is only limited to a small geographic area, So the bottom line is that LAN satisfies the condition of network speed or network performance and hence we are not considering LAN for our research work. Contrary to LAN, the Wide Area Network (WAN) has solved the problem of communication over a limited geographic area but with an issue of limited speed.

Manuscript Received May 19, 2012; Revised Tuesday, May 26, 2012.
Corresponding authors:
Sajjad Hussain Shah, Member, Bahria University Wireless Research Center (Email: sajjadmcse@gmail.com)
Wajid Ali, Member, Bahria University Wireless Research Center (Email: Wajid_6@yahoo.com)
Israr Ahmad, Sheffield Hellam University, South Yorkshire, UK. (Email: Israr_h13@yahoo.com)
Sohail Jabbar, PhD Scholar, Bahria University Wireless Research Center (Email: sjabbar.research@gmail.com)
Abid Ali Minhas, Head, Bahria University Wireless Research Center. (Email: abid.research@gmail.com)

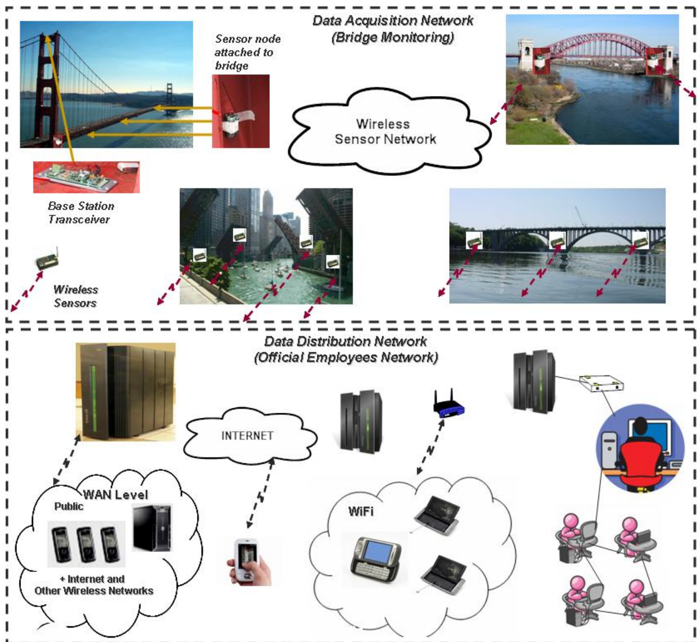

Figure 1: Synergistic Mating of Wireless Network (for Data Acquisition) and Wired Network (Data Distribution)

In WAN, the computer or group of different LANs are connected to each other and can communicate with each other through a medium with the help of some network devices such as gateways, switches and routers that make this large system more complex and difficult to manage. So, to provide assurance on the ability of a network to deliver expected results, we have a large collection of networking technologies and techniques referred to as Quality of Service [3]. Fundamental of network performance within the capacity of QoS often include availability (uptime), bandwidth (throughput), latency (delay), and error rate. The main benefits of a QoS enabled network includes the ability to prioritize data flow, to allow critical flows to be served, this is before flows with less priority, and greater reliability in a network. The network reliability is achieved by controlling the amount of bandwidth; an application may use it and thus controlling the bandwidth competition between these applications. The bandwidth-intensive applications extend network capabilities and resources, but also complement, add value, and enhance every business process. Networks must provide secure, conventional, measurable, and sometimes guaranteed services as required. To accomplish the required Quality of Service by handling delay, delay variation (jitter), bandwidth, and packet loss parameters on a network becomes the secret to a successful end-to-end business solution. Thus, QoS is the combination of techniques to manage network resources. On packets arrival at some node, if a suitable queuing discipline to manage those arrived packets is selected, then a favorable impact can be realized in the quality performance of any network, whether wired or wireless. The network devices perform different queuing mechanisms to forward data towards its final destination. The idea of queuing mechanism came into existence in order to minimize or control the network congestion that further arise the issue to more packet drop ratio, increased end to end delay and poor network overall performance.

Queuing theory has been observed in our day-to-day life and then implemented in different research and scientific work. According to Tadj L [4] queuing theory in a broad sense is the study of waiting in line phenomena; he describes it as a branch of applied mathematics which uses and works on the concepts of stochastic processes. Queuing theory was first perceived and worked out by Danish engineer, A. K. Erlang, with his publication work in 1909 on automatic telephone exchanges. Markowitz E gives a very precise and short overview of queuing theory in this article [5], its history, significance, function and considerations with its impact on the internet and computer networking. Internet was as a result of work done by different academics group in the late 1960s by the US defense department. This great achievement would not have been possible without queuing theory because it helped them in identifying the actual number of servers and size of data packets required for the system to be used by the people. So the bottom line is that queuing theory is an old phenomenon but it is used in many modern applications and systems. According to Hicks M [6] the simplest and sole job of network devices is to forward data packets towards its destination as quickly as possible. DiNicolo D [7] states that every network device has limited memory and available bandwidth; therefore there is always a disparate need of some queuing mechanisms to utilize the available limited resources like memory and bandwidth in an efficient and effective manner.

Cisco [8] states that communication networks are playing a backbone role in the development of many organizations. These networks carry multiple types of data from source to destination including audio, video and normal textual data. To achieve targets, these networks need to provide predictable, measureable and guaranteed services. High level of quality of service (QoS) can be achieved by proper managing the parameters like Delay (The total delay that a data packet takes while travelling from source to destination), Jitter (The variation occurs in delay), Packet loss ratio (Packet dropping due to over flow of buffer), Throughput (The effective number of data units that are transported in per unit time). Hence in a nutshell one can say that quality of service (QoS) is a set of network techniques to manage properly its available resources. Hicks M [6] further states that there are different queuing mechanisms for specific network environment to ensure QoS for network traffic and its effect on the overall network performance. According to Sheldon T [9] the most commonly used mechanisms amongst them are the following.

First-in, first-out (FIFO) queuing – The packet that arrives first is given the first priority to be serviced which means that first come first serve.

Priority queuing (PQ) – Packets are tagged according to their importance and are processed according to their priority level.

Weighted fair queuing (WFQ) – The weight is used to control the percentage of link bandwidth which is assigned to each Queue.

Fair queuing (FQ) – Any type of traffic queue gets fair chance of processing and hence the problem of high and low priority has been solved by fair queuing

Class-based queuing (CBQ) – A network router queuing method that allows traffic to share bandwidth equally, after being grouped by classes. These classes can be based upon a variety of parameters, such as priority, interface, or originating program.

Class-based weighted fair queuing (CBWFQ) – you define traffic classes based on match criteria including protocols, access control lists (ACLs), and input interfaces. The Packets which satisfies the match criteria for a class constitute the traffic for that class.

A queue is reserved for each class, and traffic belonging to a class is directed to the queue for that class [8]. These queuing mechanisms have their varied effects on various types of applications. Multimedia applications are emerging as constantly using network applications which demand proper bandwidth. Contrary to this it can have great impact on the overall network performance.

Saddik A [10] describes in his article that in last decade there is an immense development in the field of multimedia applications and hence there is a great need for a good quality of service (QoS) for multimedia applications. There are different types of networks like wired or wireless, which co-exist with each other but the quality of service (QoS) and characteristics are different for each network type that can be measured through parameters like bandwidth, jitter and delay etc. Different elements of multimedia applications are Text, Graphics, Audio, and Video.

In this research article we have simulated and discussed the three most common and popular queuing mechanisms which are FIFO, PQ and WFQ. We have also examined the impact of specific queuing technique on specific data and video traffic.

II- SIMULATION AND EXPERIMENTAL ANALYSIS

OPNET framework allows users to debug, test, and analyze algorithms in a controlled and repeatable environment. As OPNET runs on a Personal Computer, users can examine their OPNET code using debuggers and other development tools.

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Its primary goal is to provide a high fidelity simulation of OPNET applications.

This Scenario has been tested for various queuing mechanism for the purpose of resource allocation because every router must implement some queuing mechanism on the basis of which router transmits the data. The following are Queuing mechanisms which are tested in this Scenario; first-In-First-Out (FIFO) Queuing, Priority Queuing (PQ), and Weighted-Fair Queuing (WFQ). In this Scenario, we have setup the simulation for a network to see the performance and utilization of the network resources, which have three applications i.e. FTP, VoIP and Video as shown in Figure 2.

A. Performance Matrices

Following matrices are considered to evaluate the performance of data and voice applications:

- Packet Loss Ratio
- Voice Traffic Received
- Voice Jitter
- Voice End-to-End Delay

B. Discussion

A comprehensive discussion is carried out on the performance evaluation of said stuff using the aforementioned performance matrices. The initial results obtained in the form of graphs are shown in Figure 3, Figure 4, Figure 5 and Figure 6.

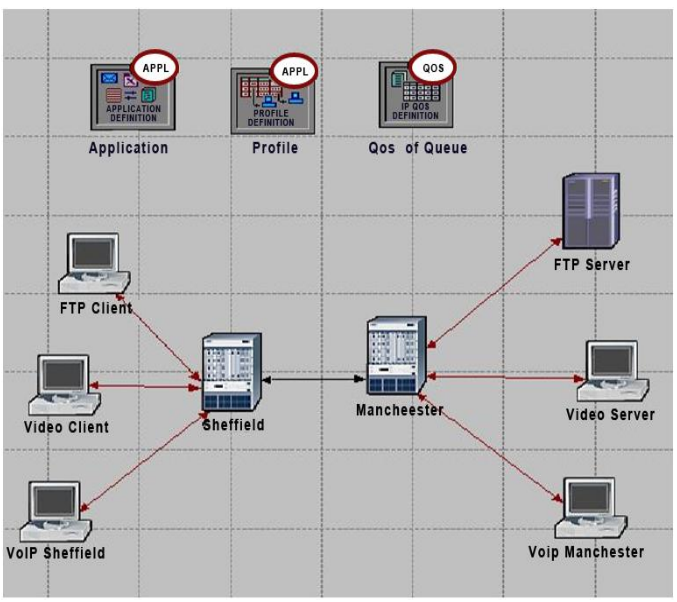

Figure 2: Scenario created for checking effect of Queuing Mechanism

a. Analysis of Packet Loss Ratio

Ganguly S and Bhatnagar S [11] describe that we have situations where network devices like router has not enough memory in its buffer to store or hold more data packets and hence incoming packets have to be dropped. In packet-switched networks if a packet is lost a notification should be send to the transmitting device to retransmit the loss packet. Some special protocols like TCP are used for the purpose of reliability in packet-switched networks. There is no packet loss element in circuit-switched networks because when the connection is established between sender and receiver in circuit-switched network the connection is only dedicated to both these parties and no one can interfere unless it is terminated by one of the party.

In Figure 3, the X axis shows the total simulation time which is 5 minutes and the Y axis shows the number of packets dropped per second during transmission. If we look into the graph, it clearly shows that during the first minute, the time interval of all the three implemented queuing mechanisms were performing exactly the same but after one minute time only WFQ was performing the same while there is different percentage of packet loss ratio in FIFO and PQ. If we do the comparison of the Weighted Fair Queuing and Priority Queuing in this scenario, it is clear from the graph that after 2 minutes and 10 seconds the number of packet drop increases in the Weighted Fair Queuing while the Priority Queuing maintains a constant and less packet drop ratio than the rest of the two queuing mechanisms. According to my own opinion the bottom line is that if we have priority queuing on routers in the above scenario, we would have better network performance as a result of less number of packet loss ratio. Beside packet loss sensitive network applications, packet loss ratio will have better results if network devices have priority queuing instead of FIFO or WFQ mechanisms.

Similarly if we have FIFO queuing mechanism it will have a bad or poor effect on network performance as packets will be retransmitted as a result of high rate packet loss ratio.

Figure 3: Analysis of packet loss ratio

b. Analysis of voice traffic received

The most interesting thing in this simulation is that we have voice as network traffic. The Figure.4 graph shows time on X axis and Y axis shows number of voice packet bytes received per second. From the graph of this simulation it is clear that the voice traffic received is the same during the first minute for all the three queuing mechanisms used. After the total simulation time of five minutes the PQ scheme and WFQ scheme is approximately the same, while the result of the

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

FIFO is the poor as a result of receiving the voice traffic in bytes per second.

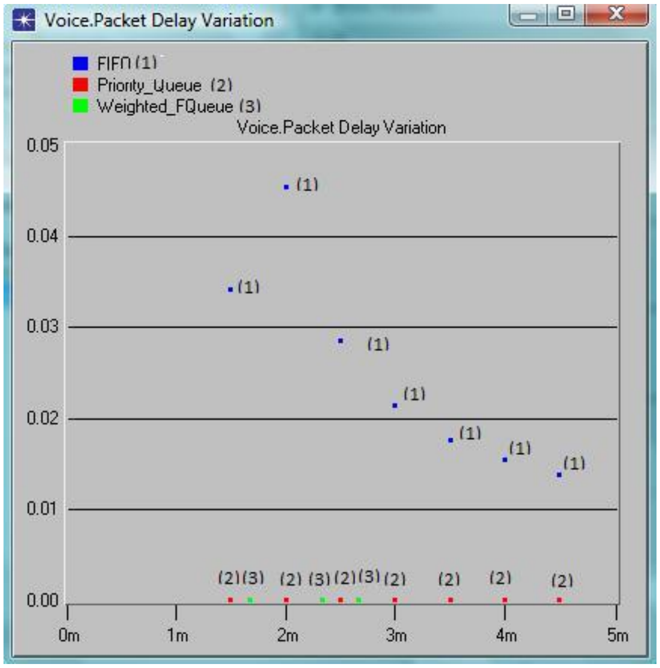

Figure 4: Analysis of Traffic Received for Voice as Network Traffic

c. Analysis of voice jitter

In Figure.5 graph shows that voice packet delay variation or simply jitter is the same for almost first one and half minute.

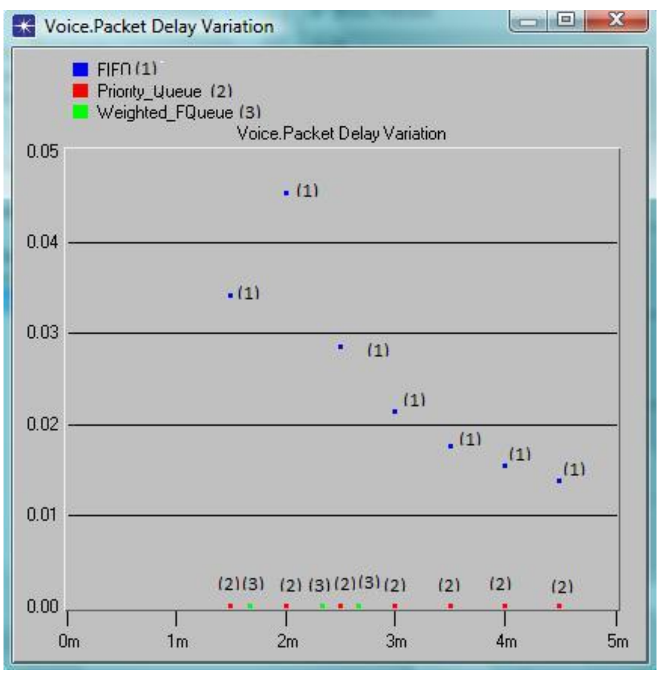

Figure 5: Analysis of jitter for voice as network traffic

Suddenly a high rate of jitter for FIFO mechanism can be seen, when voice packets are transmitting over the network. On the other hand the graph also shows that jitter for the other two queuing mechanisms i.e. PQ and WFQ is minimum compared to FIFO queuing scheme. According to our opinion based on the results obtained from this simulation if network devices like routers are configured with PQ and WFQ schemes and voice packets are aimed to transmit through the network, in such situation we can achieve better network performance instead of having FIFO as a queuing mechanism. Because FIFO gives poor network performance as it is more exposed to jitter for voice data packets.

d. Analysis of voice End-to-End delay

The Figure.6 graph shows high end-to-end delay for FIFO scheme when voice data is transmitted as network traffic. Contrary it is less for the other two queuing mechanisms i-e, PQ and WFQ schemes. There was no end-to-end delay for the first one and half minute for all the three queuing mechanisms used in simulations while after one and half minute there is dramatic delay for FIFO queuing scheme. It maintains this delay at constant rate till the full simulation time (5 minutes). So according to our opinion based on the results obtained from the above simulation we can have better network performance if network device like routers are configured with PQ or WFQ scheme. In the simulation result we can see voice as network traffic. Contrary to this the network performance will be a poor one if the network devices have FIFO as a queuing mechanism.

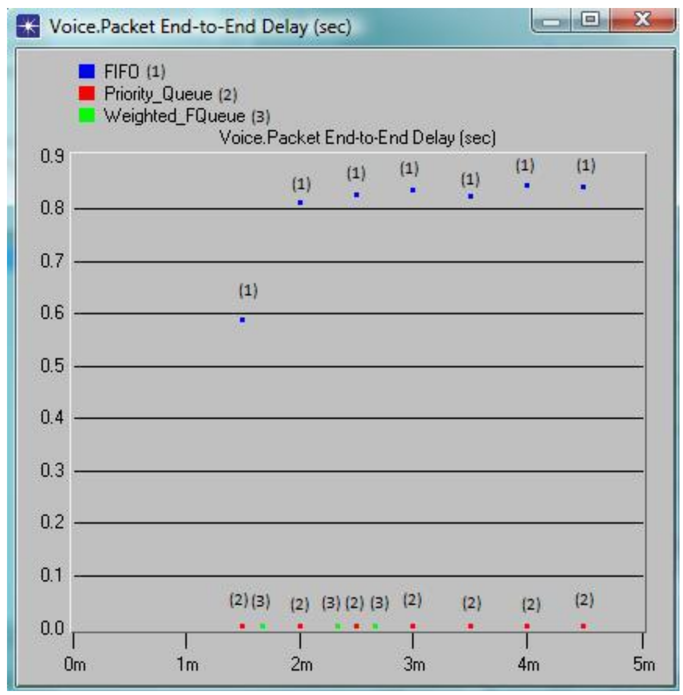

Figure 6: Analysis of End-to-End delay for voice as network traffic

III- CONCLUSION & FUTURE WORK

Based on the three queuing mechanisms used in simulations, it is suggested that data reliability and network performance can be improved to a certain extent when network devices like routers and switches have appropriate queuing mechanism configured on it. On the other hand the process is much more complex and not that much easy as number of factors has to be considered to achieve this objective. In order to achieve better network performance we have QoS parameters like delay, jitter and packet loss ratio etc, which have different impacts on overall network performance for different queuing techniques. The bottom line is that different network applications have different QoS requirements under some queuing mechanism used as queuing technique on network devices.

Beside this Network performance varies as change in queuing mechanism occurs for specific network traffic. The idea is discussed and simulated for limited scenarios and can be further discuss and apply over few more different dimensions. For instance this idea would be more interesting and knowledgeable for wireless network environment. Similarly other simulation tools like NS2 must be tested for simulation purposes in future to obtained final and further results. Moreover, in this article only three queuing mechanisms have been used in the simulations phase. So, in future other available and mostly implemented queuing mechanisms / techniques can be considered to simulate in order to explore more depth in this area of research.

REFERENCES

[1] Epiphanies G, et al (2010), Affects of Queuing Mechanisms on RTP Traffic Comparative Analysis of Jitter, End-to-End Delay and Packet Loss. [Online]

[2] Marshall D, (2001), Networks -- How the Internet Works [Online] Last accessed 10 September 2010 at: http://www.cs.cf.ac.uk/Dave/ /node38.html

[3] Mitchell B, (2010), QoS- Quality of service in computer networking. [Online] Last accessed 03 November 2010 at: http://compnetworking.about.com/od/networkdesign/g/bldef_qos.htm

[4] Tadj L, (1995), Waiting in line Intro to queuing theory, [Online] Last accessed 01 October 2010 at: http://ieeexplore.ieee.org

[5] Markowitz E, (2009), Queueing Theory & Computer Networking [Online] Last accessed 12 October 2010 at: http://www.ehow.com/about_5448389_queueing-theory-computer-networking.html

[6] Hicks M, (2004), Optimizing Applications on Cisco Networks, [Online] Last accessed 20 October 2010 at: http://fengnet.com/book/Optimizing-Applications/toc.html

[7] DiNicolo D, (2007), Cisco CCNA Study Guide. [Online] Last accessed 25 October 2010

[8] Cisco (2010), Quality of Service (QoS), [Online] Last accessed 04 November 2010 at: http://www.cisco.com/ en/US/products/ps6558/products_ios_technology_home.html

[9] Sheldon T, (2001), *Queuing*, [Online] as on 25 October 2010 at: http://www.linktionary.com/q/queuing.html

[10] Saddik A, (2010), Quality of Service in Multimedia Networks - QoS Elements, Realization of QoS, Network Scalability and Application Layer Multicasting, [Online] Last accessed 01 November 2010 at: http://encyclopedia.jrank.org/articles/pages/6874/Quality-of-Service-in-Multimedia-Networks.html.

[11] Ganguly S, Bhatnagar S (2008), *VOIP: wireless, P2P and new enterprise voice over IP.*

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)