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A COMPARATIVE STUDY OF QOS OVER IPV4/IPV6 USING OPNET MODELER

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Abstract:

The increasing number of internet users around the world and their demand for multimedia applications like VoIP and video conference force the network providers to think about Quality of Services. Since these new applications are sensitive to network performance, the demand for larger bandwidth is increased especially when network parameters like Jitter, End to End (E2E) delay and Packet loss play a very important role to guarantee such application in terms of quality. In such environment, Quality of Service (QoS) is considered to be the most important network performance parameter which has a significant effect on multimedia applications like Voice Over Internet Protocol (VoIP) and others. internet protocol IPv6 was designed to improve QoS supported by internet protocol IPv4 and to enhance the reliability of packet based network to handle such services. This paper considered three queuing systems which are First In First Out (FIFO), Priority Queuing (PQ) and Weighted Fair Queuing (WFQ) as a comparative study to investigate their effects on real-time applications in IPv4 and IPv6 networks support. The proposed simulation environment was executed by Optimized Network Engineering Tools (OPNET) Modeler 14.5 where the simulation results are collected and analyzed. The results show that IPv6 with PQ provides better performance for real-time applications, despite that IPv6 with WFQ is more efficient with low priority traffic.

Keywords: IPv4, IPv6, FIFO, WFQ, PQ, delay, jitter, OPNET.

INTRODUCTION:

There is no doubt that the internet has become a vital communication factor that everyone depends on in their life. Last decades, Internet applications such as File Transfer Protocol (FTP) and Electronic mail (E-mail) were used primarily and all network traffic in this period was treated in the same manner with equal priority basis without differentiation (Saha and Javed, 2014). Network parameters like E2E delay, Jitter, packet loss and others had not that level of guarantees especially with the IP's best effort services.

However, introducing the new real-time applications such as video conferences, VoIP application create the necessity to enhance the network parameters such as delay, Jitter, Packet loss and Bandwidth to provide a reliable service where these factors play a significant role to establish such services. Since the internet have a lot of multimedia and interactive applications which, in turn, have a specific requirement in terms of delay and bandwidth to be established that make a challenge for the essential design manner of internet protocols in general. Hence, QoS has become very important for employing a high performance of critical multimedia application and this make it an active area of many researchers. The QoS Management guarantees bandwidth for key applications and users therefore; the transmission data rates and error probability can be measured and improved and in certain cases also guaranteed to some extent (Balasundaram, Velmurugan and Suresh, 2014). The ability to differentiate and prioritize traffic such as voice and video streaming on other types like FTP and E-mail is regarded as the main advantage of QoS which allow critical application flows to be serviced first before the other application flow with lesser priority. Hence, achieving network reliability could be done by controlling the of bandwidth that utilized by the applications. As a result, QoS management addresses issues regarding to the high application demands (Bhanu, 2000) (Hayder, 2015).

QUALITY OF SERVICE (QOS):

Quality of Service (QoS) is defined as a set of services that enable the network to provide better services for the user to divide the bandwidth according to the needs of different applications used. In addition, QoS refers to the capacity of a network to support appropriate behavior for the traffic passing through, by controlling certain network parameters such as latency, Jitter and Packet loss. It also can be defined as a set of requirements that included in a contract between internet service provider and their customers which called Service Level Agreement (SLA). The importance of QoS is derived from the huge growth of real-time application over the internet so the network designer should take into consideration appropriate solutions to provide an appropriate QoS level to the user especially for multimedia application use (Parra, Angela and Gustavo, 2011) (Domzal, 2013).

QUALITY OF SERVICE SUPPORTED ON IPv4 AND IPv6:

The invitation of Internet Protocol (IP) was done in the early 1980’s where its idea is to be responsible for sending and routing packets on the network and makes the best effort to distribute packages. The current trends towards converging IP networks is based on applications development that authorize the information exchange like voice, data or video on the same network infrastructure since the IP networks deal with packets separately and consider each packet as irrelevant. At the first attempt, it was not considered whether its design could support real-time applications or not. Recently, the increasing demands of using real-time and time-critical applications that send their data packets over networks make an urgent demand of QoS. Such applications’ transmitted data is very sensitive to time and cannot tolerate delay, jitter and packet loss. The first copy of IP was IPv4 which is a connectionless protocol and it does not support the concept of guarantees for delivery of packets because it cannot deal with the concept of 'flow' correctly where in IPv4, the QoS provided by Type of Service (ToS) (Hayder, 2015). However, IPv6 is the modern version of Internet Protocol (IP) where it considered as the successor to IPv4. This protocol has been designed to allow a smooth transition from IPv4 since it considered to be an evolutionary step from IPv4. It has two field that can used as a tool for implementing QoS flow label and traffic classification. Hence, we could say that the significant difference between IPv4 and IPv6 QoS lies in the fact that IPv4 does not have the mechanism to differentiate between time tolerant and time sensitive data like file transfer and voice and video applications. Thus, the instructions of QoS are inserted into the IPv6 packet header so that packets are processed more efficiently reducing queuing delays at the routers.

TECHNIQUES TO IMPROVE QOS:

There are different techniques that utilized by the router to process the arrival packet data and execute the queue scheduling algorithms that manage the priority of each packet depending on its time tolerance. Since the queuing scheduling algorithm can affect directly on data flow, the data should be classified in a proper manner according to its priority. Router uses scheduling mechanisms to provide an appropriate share of resources such as link bandwidth and CPU process for various connections and to ensure that capacity is divided in a fair manner. In addition, packet flows could be enforced by the scheduler to be suitable with the definition of a traffic profile by using shaping technique (Bhanu, 2000) (Hayder, 2015). There are several scheduling algorithms to manage router behaviors and queue outputs, and important ones are summarized below:

First-in First-out (FIFO):

The FIFO is regarded as the simplest queuing technique that depends on the concept of the first packet arrived at the router buffer is the first one that transmitted where all arrival packets waited in the buffer until they are processed by the router. The probability of dropping data is increased when the average incoming rate exceeded the processing rate so that leads the buffer to be filled up and then the new incoming packet is discarded. The FIFO queuing process is shown in Figure 1

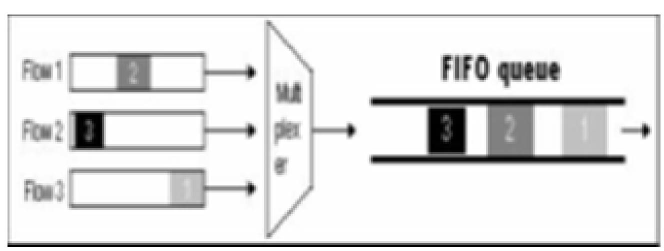

Fig.1. FIFO Queue (Saha, 2014).

Priority Queuing (PQ):

It is very clear from the name Priority Queuing that this strategy deals with packets depending on its classes, therefore; the packets are allocated to be in separate priority classes and each having its own queue. PQ consists of a set of queues ranked from the Highest to lowest according to priority. This means that the first packet that being processed should be within the highest priority queue then followed by the lowest priority. Hence, each package assigned to one of these queues is served in strict order of priority. It is noteworthy that in case of network congestion, package with lower priority will be dropped first. The PQ technique is illustrated in Figure 2 below:

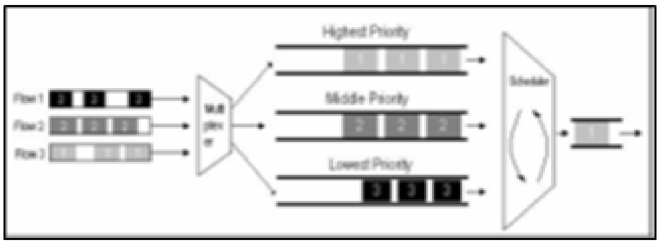

Fig.2. Priority Queue Scheduling (Saha, 2014).

Since there are three levels of queuing (High, Medium and low), packet's priority classification will depend on marks founded in packet header of both IPv4 and IPv6 like TOS and Traffic Class respectively (Miaji, Yaser and Suuhaidi, 2010). Priority scan process is done by the router when it is ready to transfer a packet from the highest level of priority to the lowest then, packet with highest level is ready for forward. Forwarding of highest priority packages is continuous unless the specified queue is empty while the packets in the low priority queue are discarded, a notification is sent to the sender.

Weighted Fair Queuing (WFQ):

It is the method that deals with packets by allocating them in different classes and then put each packet in different queues according to their priority. WFQ tries to provide an automated fair bandwidth allocation for all traffic on the network and then forward these traffic flow by utilizing a combination of source and destination addresses and port number (James and Keith, 2012).

A queue for each flow is assigned and the amount of bandwidth required by these flows is determined by WFQ, so this process can prevent the effect of other traffic on the same network. The main advantage of using WFQ is that it ensures the availability of bandwidth for other application with low priority like HTTP. In addition to other applications with high priority level such as multimedia applications with high throughput. Hence, the router can determine flow priority by considering their bandwidth requirement (Golam 2010). Figure 3 shows the classified packets in the WFQ method.

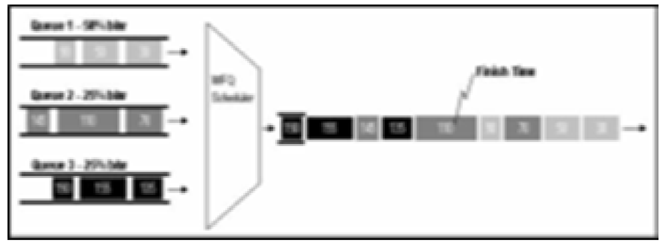

Fig.3. WFQ Scheduling (Saha, 2014).

NETWORK TOPOLOGY:

To compare the performance of both Internet Protocols IPv4 and IPv6 with different scheduling methods, the OPNET was used to test a simple network topology, (Adarshpal and Vasil, 2013) shown in Figure 4. The topology consists of three pairs of computers (FTP and server, VoIP pair and video conferencing pair), two routers and two switches. The duration time was set to be 30 minutes while the traffic flows were selected to three different applications which are FTP, video conference and VoIP.

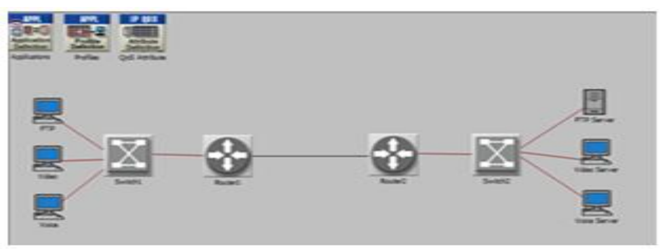

Fig.4. Network topology

Configuration:

The bellow configurations applied in the OPNET Modeler and simulated to get results.

- Firstly, PPP_DS1link was used to connect the routers in our proposed topology and 10Base_T links were used to connect the Work stations and the servers with routers.

- Regarding the applications, High Load "FTP application" has been selected, Constant (10) to Inter-Request Time and Constant (1000000) to File Size are assigned.
- For video application, a high-resolution video was assigned to initialize a video conference call and Streaming Multimedia (4) to ToS is assigned.
- In terms of VoIP application, it has been assigned a PCM Quality speech to Voice and Interactive Voice (6) to ToS.

Since the queuing algorithm that used within the routers could have an effect on the performances of different applications over the network and resource utilization, routers should be configured to support a three queuing disciplines used in our simulations as shown in Figure5.

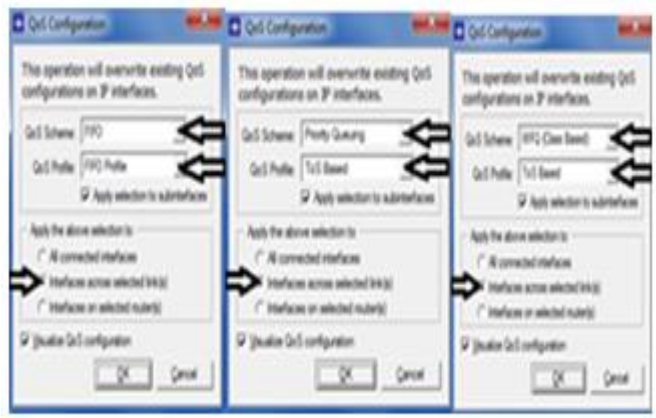

Fig.5. Router configuration

FTP Application:

According to Figures 6 and 7, it is obvious that there is a variation between the average traffic sent and received in FTP. It could be said that the received traffic amounts are lower than the sent traffic for all scenarios due to the packet loss on the same network in general. The highest traffic amount was recorded to be for WFQ queuing algorithm in both IPv4 and IPv6 scenarios while PQ algorithm appears to have the worst traffic amount among the others for both network IPs. The reason behind is belonging to the priority algorithm used in this queuing process where the highest priority is given to the multimedia application over the FTP application. Hence, the best recorded result regarding to FTP application is belonging to WFQ with IPv6 scenarios because in WFQ technique in the bandwidth is divided according to the different queues and different priority depending on the flow traffic type. As a result, WFQ is best mechanism to transfer FTP application among others (PQ and FIFO). It is clear that FIFO recorded results between PQ and WFQ due to its technique where all arrival packets are put in a single queue and forward them according to the bandwidth availability.

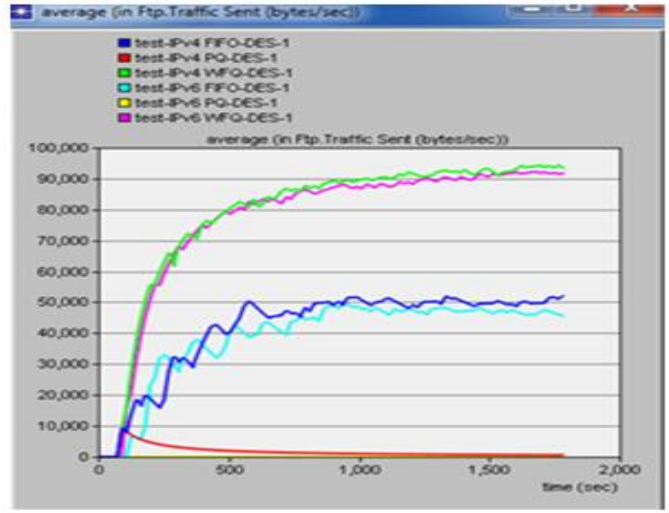

Fig.6. Traffic sent for FTP

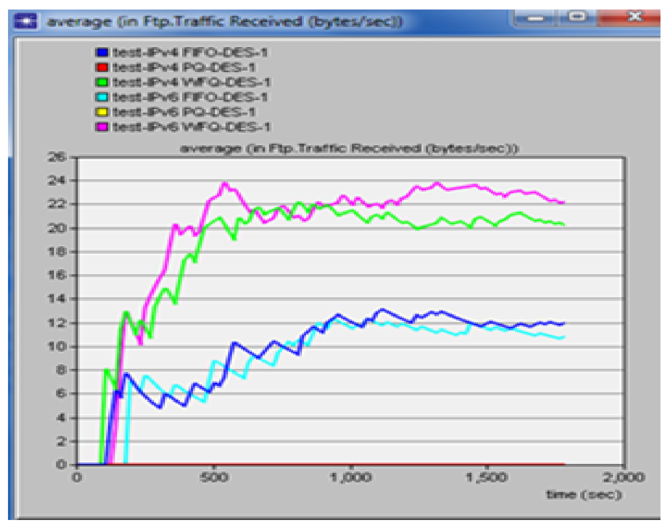

Fig.7. Traffic received for FTP

Video Conference Application:

Regarding video application traffic, it is clear that all scenarios have the same amount of sending traffic as shown in Figure 8. In contrast, there is a variation between all queuing algorithm regarding the received traffic as shown in Figure 9 where the WFQ with IPv4 has the best amount while the worst record is belonging to PQ with the same IP. FIFO algorithm has middle records between WFQ and PQ with IPv4 as it performed with video application. Each queuing algorithm has recoded packets loss because the higher total demand for bandwidth compared with the low link capacity allocated between routers. As a result, the network suffers from high resolution load which leads to increase the amount of dropped packets and, in its turn, increasing the ratio of packet loss because the buffer is full of new arrival packets which cannot be forwarded yet.

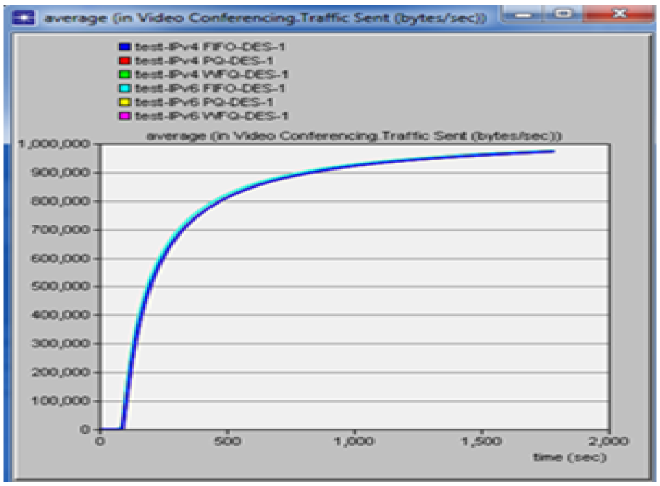

Fig.8. Traffic sent for video

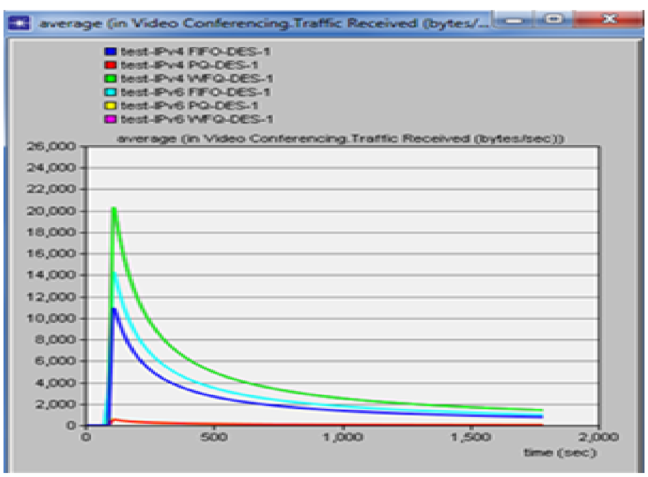

Fig.9. Traffic received for video

According to Figure 10 shown below, the higher E2E delay is belonging to WFQ in the video conferencing application while PQ creates less delay compared with others. FIFO appears between WFQ and PQ for both IPv6 and IPv4.

In terms of comparing between IPv4 and IPv6, it is obvious that WFQ and FIFO gives less E2E delay with IPv6 network. But it could say that PQ has the lowest delay if the three queuing algorithms are considered.

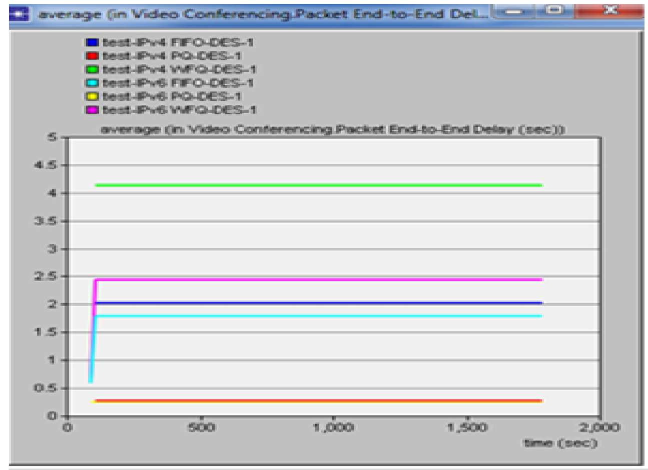

Fig.10. Average video packed end-to-end delay

The Packet delay variation (PDV) of video conferencing is shown in Figure 11. PDV which is defined as the difference in the end-to-end delay for receiving packets in a single flow without caring about packet lost. Itis clearly observed that whenever the traffic load increased for WFQ and FIFO increased accordingly; whilst PQ is always recorded zero values for all traffic applied. PQ has better results than FIFO and WFQ in both IP networks.

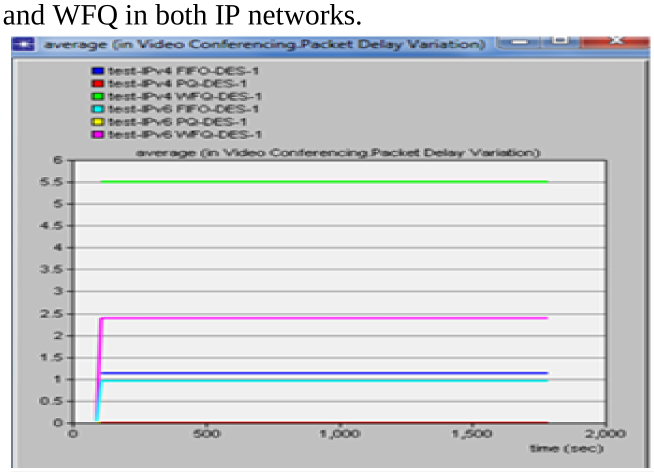

Fig. 11. Video delay variation

Voice Application:

The average traffic sends and received by the voice application shows in Figure 12 and 13. Like what happened in video traffic, the amount of voice traffic is the same for all scenarios. The highest received traffics is recorded for PQ algorithm while FIFO has the lowest in both IPv4 and IPv6. Since the scheduling algorithm and type of IP used affect the amount of received traffic, the results come in this manner where PQ gives the voice flow the highest priority. WFQ for both IPv4 and IPv6 results vary between PQ and FIFO in terms of received traffic. In addition, when comparing between IPv4 and IPv6 in terms of performance, it could say that IPv6 has lower received traffic compared to IPv4 for WFQ and FIFO queuing algorithm.

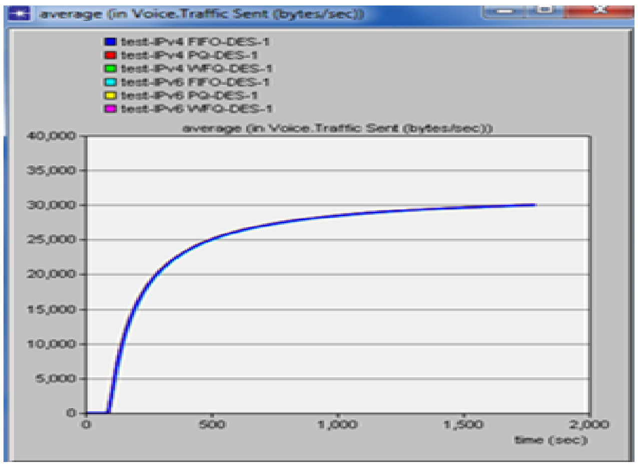

Fig.12. Traffic sent for voice

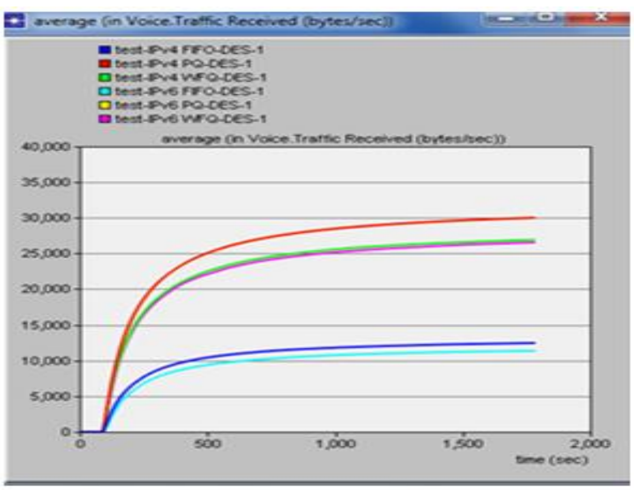

Fig.13. Traffic received for voice

According to Figure 14 that shows the average end-to-end delay in the voice application. The highest delay value was recorded with FIFO compared to the other queuing algorithm. On the other hand, E2E delay records were approximately equal and small on both IPv4 and IPv6 with WFQ and PQ algorithm. The reason behind FIFO having the highest delay is due to its queuing technique where the packets at the sender side will be in one queue and forwarded according to their entrance position. Therefore, it has more delay, especially over IPv6, because IPv6 has larger packet headers which cause more delay on the network.

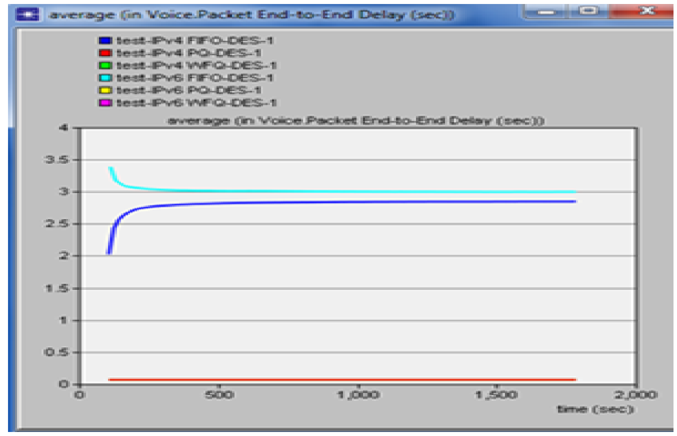

Fig.14. Average voice packed end-to-end delay

Figure 15 illustrates the Packet Delay Variation (PDV). WFQ and PQ has better results than FIFO in both IPv4 and IPv6 networks. WFQ and PQ have values closer to zero while FIFO has more delay variation than the others. Although FIFO has higher delay variations, it has more importance and should not be ignored. Because it provides equal weight to each application, which prevents effect of one to another.

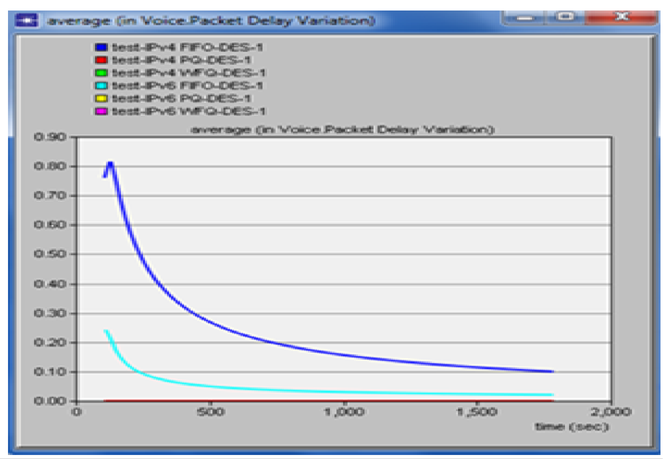

Fig.15. Voice delay variation

shows in Figure16. Since the average variation E2E delay was the highest with FIFO queuing algorithm then it recorded the highest Jitter as well where it has a higher value in positive side and higher value in negative side for IPv4 and IPv6 respectively.

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The best queuing techniques with VoIP in term of lower Jitter value are WFQ and PQ since these algorithms distinguish voice packets and behave them such a way to minimize jitter.

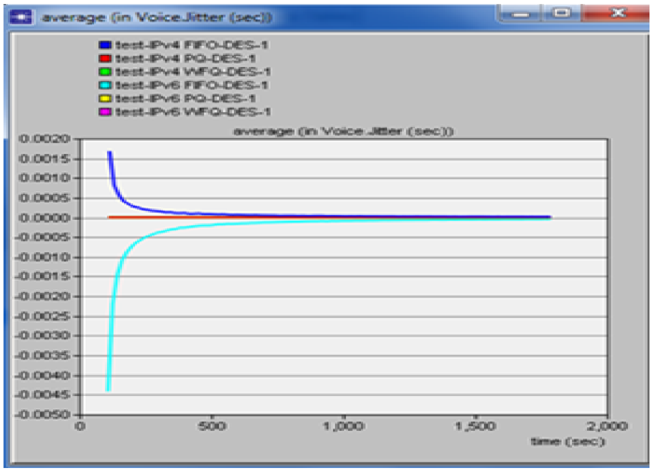

Fig.16. Average voice Jitter

AVERAGES OF THROUGHPT LINKS:

Referring to Figure 17, the highest average throughput is recorded to PQ algorithm while the lowest throughput is belonging to FIFO in both IPs. WFQ recorded throughput values to be in between other algorithms for IPv4 and IPv6. It is noteworthy that IPv6 has lower throughput values than IPv4 for all types of queuing algorithms scenarios.

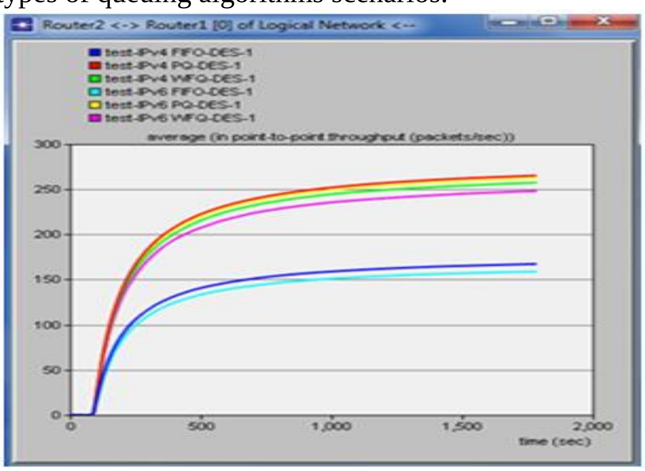

Fig.17. Point to Point through put

IP TRAFFIC DROPPED:

The packet loss (dropped packet) shows in Figure 18. FIFO is higher compared to WFQ and PQ. FIFO sends packets through one queue in the buffer and it passes the packets according to their entrance position into the queue. Therefore, it has more delay, especially over IPv6, because IPv6 has larger packet headers which cause more delay on the network.

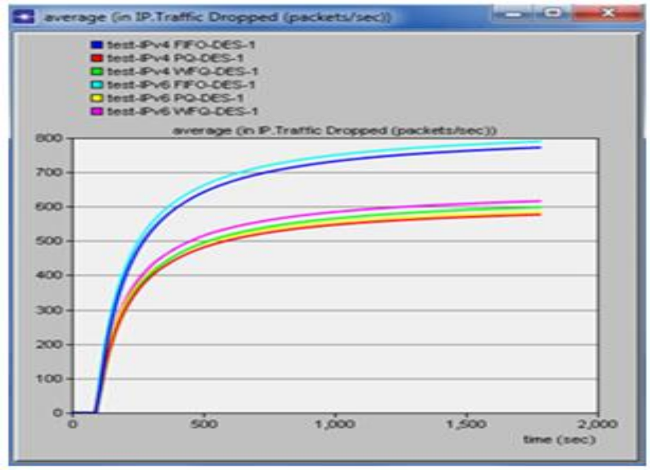

Fig.18. Average IP fraffic dropped

RESULT:

The average E2E delay that obtained for both voice and video applications is shown in Table 1 where the behavior of queuing algorithm on IPv4 and IPv6 can be easily compared. The results showed that PQ and WFQ had provided the same delay regarding the voice application while it recorded a very high delay for FIFO algorithm. In contrast, regarding to video application, the results illustrate that PQ algorithm has the lowest delay among the other while FIFO recorded the highest delay even that WFQ was configured to have the highest delay in some configurations and traffic conditions. This finding has proved and could be in line with results given in (Mohammed, Adnan and Hawraa, 2013) and (Rashed, Mohammed and Mamun 2010).

TABLE I. Delays for Voice and Video

Parameter	FIFO		PQ		WFQ	
	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6
E2E Delay Video (sec)	2.02	1.77	0.26	0.25	4.13	2.42
E2E Delay Voice(sec)	2.81	3.01	0.06	0.06	0.06	0.06
Delay Variation Packet Video	1.13	0.95	0.0	0.0	0.50	2.39
Delay Variation Packet Voice	0.10	0.02	0.0	0.0	0.0	0.0

In this paper, a comparative study has been done to investigate the performance of three different applications which are FTP, VoIP and video conference over the two existing Internet Protocols versions (IPv4 and IPv6). In addition, this study focus on studying the effects of a different queuing algorithm on the performance of such applications using OPNET simulator. The best performance among the queuing algorithms is belonging to the WFQ queuing since it provides the best results over both IPv4 and IPv6 in terms of sending real-time traffic simultaneously with other traffics on the same networks. The results also showed that PQ algorithm is the best among the other in terms of recording lower delay especially for voice and video traffics although that the amount of received traffic of video conference is the lowest over both IPs. Furthermore, it is a drawback for the FTP application. It could say that the worst performance regarding the end-to-end delay, Jitter and packet loss goes to FIFO algorithm with voice and video traffics even it provides the best with FTP application among the other two algorithms. The reason behind is due to the differences between these three algorithms in terms of queuing technique that used in each which affects the traffics queuing and forwarding.

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