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A Comparative Study of Different Queuing Scheduling Disciplines

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Abstract
This paper presents a comparative analysis of different queuing scheduling disciplines for networking services using Optimized Network Engineering Tool (OPNET). Mainly, we focus on various queuing scheduling disciplines including Modified Weighted Round Robin (MWRR), First in-First out (FIFO), Priority Queuing (PQ), and Weighted Fair Queuing (WFQ). This modeling and simulation are based on the effects of these queuing scheduling disciplines on packet delivery for three next generation Internet streaming applications: File Transfer Protocol (FTP), Video-conferencing, and Voice over Internet Protocol (VoIP).
Keywords— *MWRR; FIFO; PQ; WFQ; VoIP; FTP; video-conferencing, OPNET*

I. INTRODUCTION

Nowadays, people around the world depend on various computer networks services such as Video-conferencing, FTP, and VoIP as a next generation Internet applications. Queuing is becoming an important role in traffic management for these services due to the fact that each router in the packet network must implement different queuing scheduling disciplines that govern how packets are buffered while waiting to be transmitted. Various queuing scheduling disciplines can be used to control which packets get transmitted or dropped. Also, Quality of Service (QoS) plays an essential role for computer communication systems to be reliable. Indeed, to deliver QoS, different scheduling techniques require differentiating among different type of packets in the queue and should know the service class for each packet in the network. The modeling in this network which carries applications (FTP, Video-conferencing, and VoIP) is investigated by understanding the queuing scheduling discipline in the network which can affect the performance of these applications.

The major issues in a network are related to the allocation of network resources, as buffers and link bandwidth to different users. The performance of traffic flow over Local Area Networks (LAN) utilizing buffers to avoid any irrelevant traffic that clusters the network using sniffer pro has been demonstrated in [1]. The different types of queuing mechanisms that determine configuration in network have been compared in [2-7]. However, the comparison between single queues with a combination of two queues technique has been investigated for the same network in [8]. The received traffic and dropped traffic between two users or nodes for different services like FTP, Video, and VoIP are analyzed in [9]. In fact, the traffic dropped and received in three different networks by considering one Type of Service (ToS) is analyzed in [10].

This is a simulation study using OPNET for the network performance analysis. OPNET software provides a comprehensive environment for the specifications, simulation, and performance analysis of computer communication networks. We investigate how the choice of the queuing scheduling discipline in the routers of the network can affect the performance of the stream applications and the utilization of the network resources. The parameters we consider for evaluation are packet end-to-end delay (sec), packet delay variation, traffic dropped (packets/sec), and traffic received (bytes/sec).

II. QUEUING SCHEDULING DISCIPLINES

Without doubt queue scheduling disciplines play an important role in the networks performance due to the fact that they are the solution to the fair share of the available resources of the network. In this section we give a basic overview of the queue scheduling disciplines used in this research to support QoS for next generation IP networks.

A. *First in-First out (FIFO)*

FIFO queuing discipline places all packets it receives in one queue and transmits them as bandwidth becomes available. All packets arriving from different flows are treated accordingly to their arriving order and all are being placed in the same queue. This means first packet that arrives at the router is the first packet to be transmitted. Although, the amount of buffer space (queue) at each router is finite, if the packet arrives and the queue is full, then the router drops that packet. This is can be done without regard to which flow the packet belongs to or how essential the packet is. Figure 1 shows example of the M/M/1 queue for FIFO.

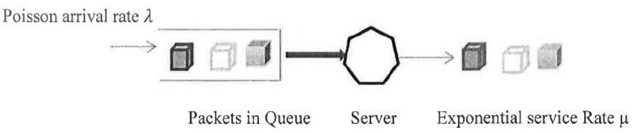

Fig. 1. M/M/1 queue for FIFO

B. Priority Queuing (PQ)

PQ discipline classifies all packets by the system and then places the packets into different priority queue. Packets are supported by multiple queues usually from high to low. Queues are processed in strict order of queue priority. Thus a high priority queue is processed earlier than the lower priority queue. Packets in the high priority queue is processed until the queue is empty, then packets in the low priority queue are transmitted. PQ has four traffic priorities: high, normal, medium, and low. Figure 2 shows example of the PQ.

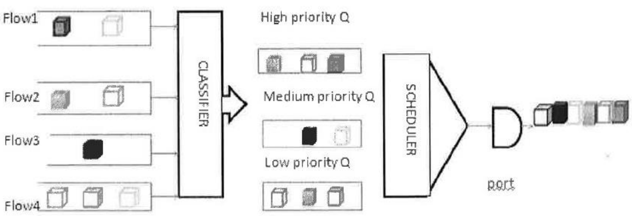

Fig. 2. Priority queuing

C. Weighted Fair Queuing (WFQ)

WFQ discipline classifies packets by queue. WFQ uses multiple queues to separate flows and gives the flows equal amounts of bandwidth. This prevents the FTP from consuming all available bandwidth. WFQ allows a weight to be assigned to each queue. The weight controls the percentage of the link's bandwidth each queue will get. WFQ discipline sorts packets in weighted order of arrival of the last bit, to determine the transmission order. (ToS) bits could be used in the IP header to identify that weight. WFQ is aware of packet sizes and can support variable sized packets, so that flows with large packets are not allocated more bandwidth than the queues with smaller packets. Figure 3 shows example of the WFQ for service according to package finish time.

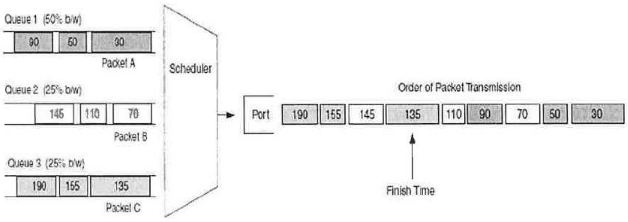

Fig. 3. Weighted fair queue for service according to package finish time

D. Modified Weighted Round Robin (MWRR)

MWRR queuing discipline allows a weight to be assigned to each queue. The queue with higher weight takes the priority to get process first. It uses variable-sized packets and a deficient counter variable to initialize each flow's weight. A packet is scheduled if the deficient counter is greater than zero. The processed number of packets in MWRR is equal to the normalized weight over the mean packet size. MWRR queuing discipline serves packets at the head of every non-empty queue whose modified counter is greater than the size of the packet at the head of the queue. Figures 4 and 5 show an example for Weighted Round Robin (WRR) scheduling algorithm for service round of 25 packets and for Modified Weighted Round Robin (WRR) scheduling algorithm for service round of 250 packets, respectively [11].

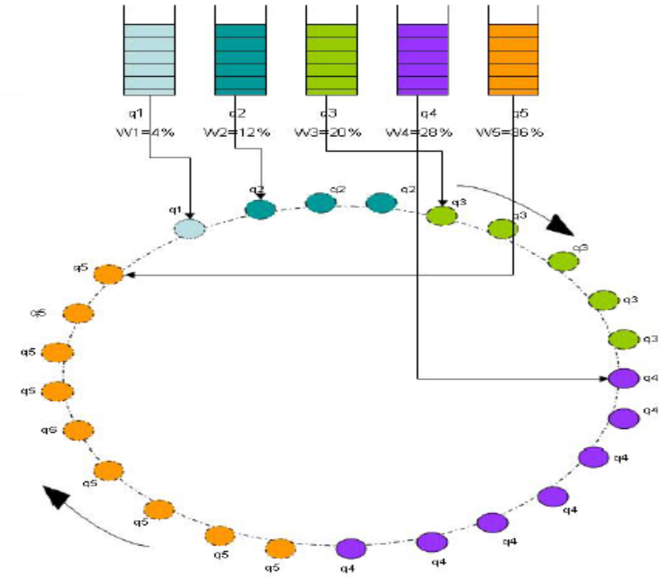

Fig. 4. Weighted round robin scheduling algorithm [11]

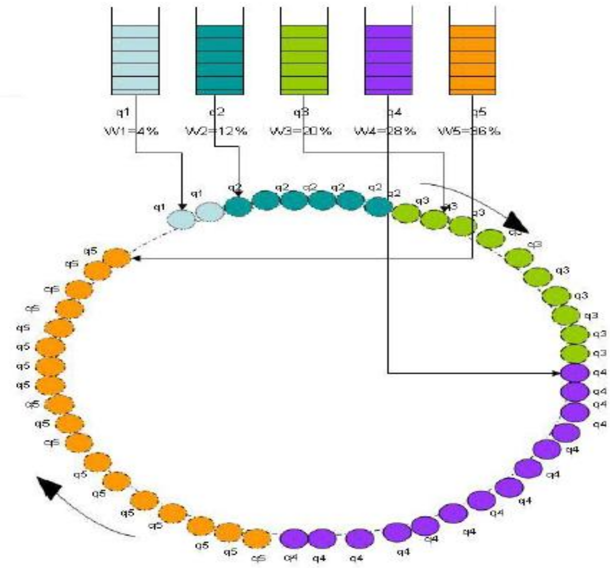

Fig. 5. Modified weighted round robin scheduling algorithm [11]

III. RESULTS AND DISCUSSION

In this simulation model, we have used OPNET software to build a small IP network and then to exam the effect of different queuing scheduling disciplines with different kind streaming applications: FTP, Video, and VoIP, on packet delivery and delay on the network. The network topology of the model is designed from two LANs, one consisting of different streaming clients and the other consisting of the corresponding servers as shown in Fig. 6. The bottleneck has been created in the link between the two routers. The simulation network model is used to collect statistics to do the performance analysis based on IP protocol (traffic dropped in packets/sec), Video conferencing (traffic received in packets/sec), and Voice (traffic received in bytes/sec).

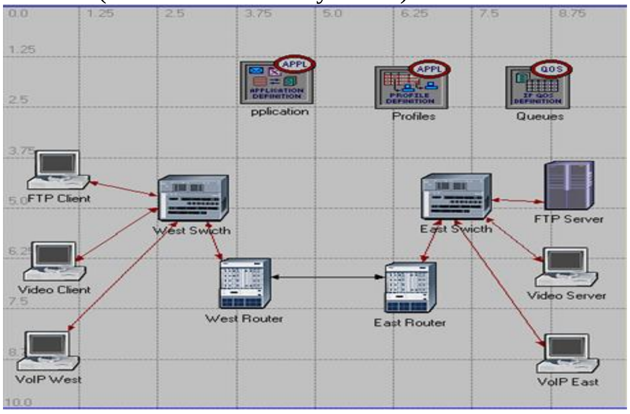

Fig. 6. The network topology of the model

Different queuing scheduling disciplines in the routers for the IP network can affect the performance of different Types of Services (ToS) like VoIP and video streaming, and the utilization of the network resources. Figure 7 shows the routers configurations of the four queuing scheduling disciplines.

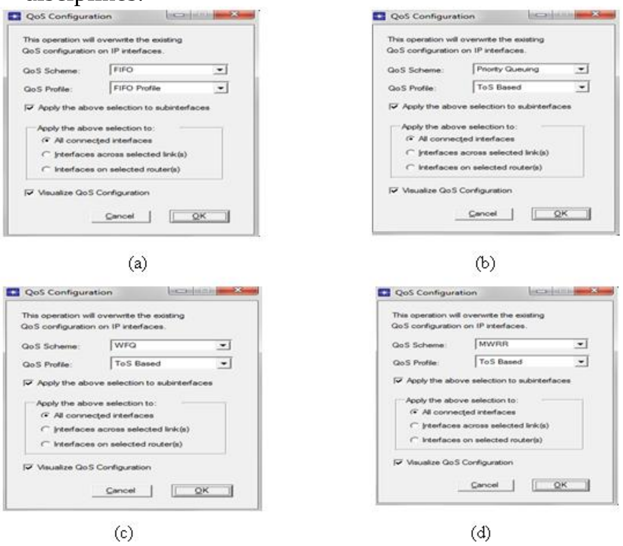

Fig. 7. Router configuration for (a) FIFO (b) PQ (c) WFQ (d) MWRR

Figure 8 shows the dropped IP data packets for the four queuing scheduling disciplines as a function of time in seconds. The figure shows that the highest rate of dropped packets occurs with the FIFO queuing scheduling discipline. PQ is lower and then followed by MWRR. The lowest rate is provided by the WFQ queuing scheduling discipline where there is no packet drop.

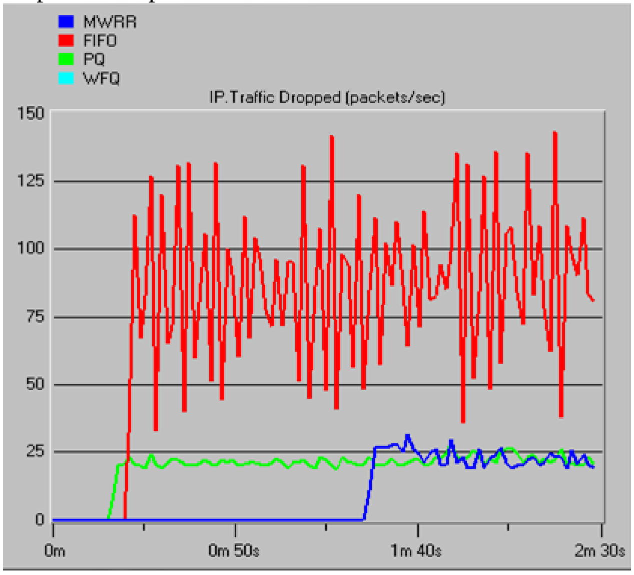

Fig. 8. IP traffic packet drops (packets/sec)

Figure 9 shows the traffic received statistics for Video conferencing, where it can be observed that in cases of MWRR, FIFO, PQ, and WFQ video receiving rate graph is not observed, where PQ starts high, then continues very low, but MWRR begins at a higher rate than FIFO, then becomes low with passing time, and FIFO stays high.

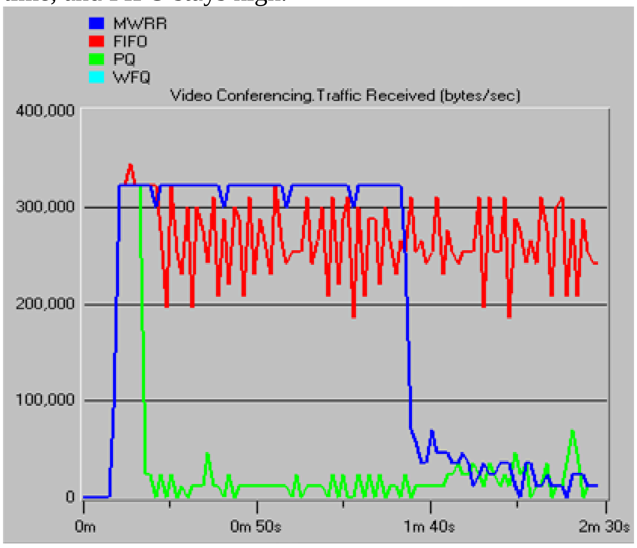

Fig. 9. Video-conferencing traffic received (bytes/sec)

Figure 10 shows traffic received statics for VoIP, where it is observed that as the traffic increases the performance graph increases in all the queuing scheduling disciplines. However, the performance graph of FIFO is lower than those of MWRR, PQ, and WFQ.

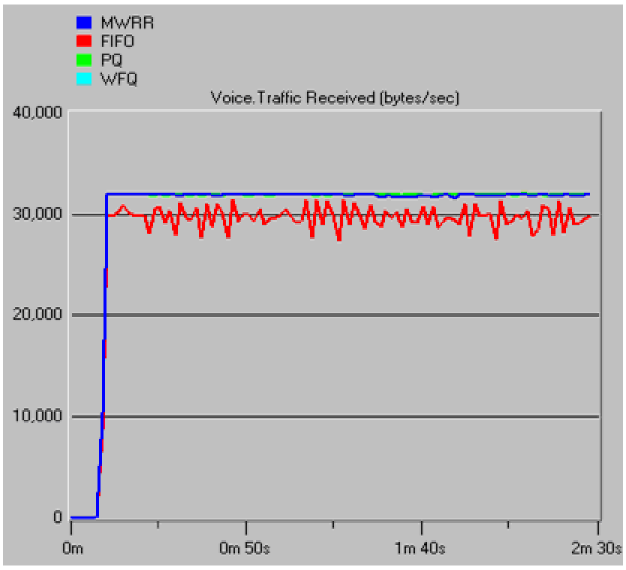

Fig. 10. Voice traffic received (bytes/sec)

Figure 11 shows the packet end-to-end delay time for VoIP. The highest delay is experienced by the FIFO queuing scheduling discipline. MWRR has very low delay near zero. The best delay is provided by the WFQ and PQ where no delay is observed.

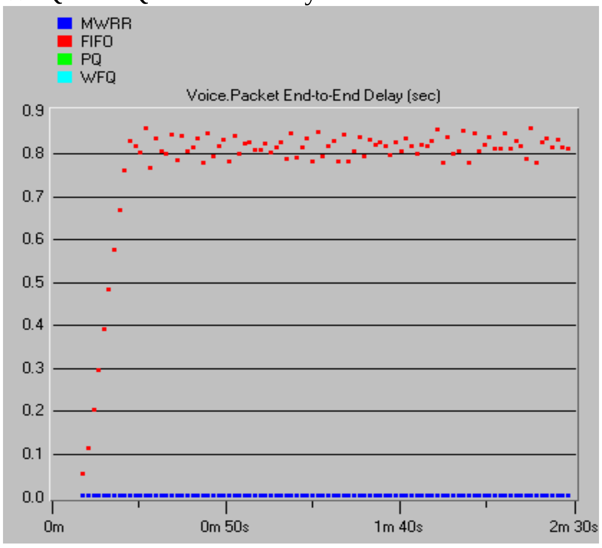

Fig. 11. Voice packet end-to-end (sec)

Figure 12 shows packet delay variation time for VoIP. As the time or traffic increases the highest packet delay variation time is experienced by the FIFO queuing scheduling discipline. MWRR has very low delay variation near zero. The best delay variation is provided by the WFQ and PQ where no delay is observed.

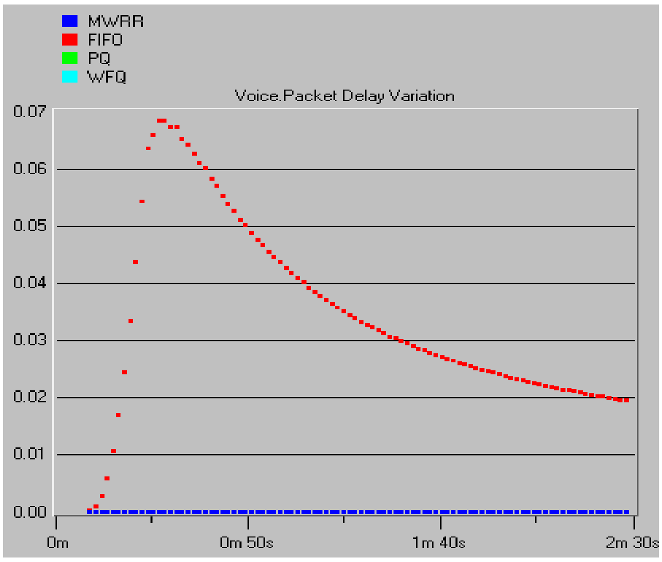

Fig. 12. Voice packet delay variation (sec)

IV. CONCLUSION

In this paper, we evaluated the QoS that can be obtained by end applications when Integrated Services (IntServ) subnetworks are connected together using Differentiated Services (DiffServ) network. The comparative network performance was analyzed for MWRR, FIFO, PQ, and WFQ with different kind streaming applications: FTP, Video conferencing, and VoIP using OPNET simulation tools to achieve the QoS. Indeed, we studied various parameters to improve queue technique in more acceptable and optimized networks.

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