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First In First Out (FIFO) And Priority Packet Scheduling Based On Type Of Service (TOS)

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Abstract

Mobile Ad Hoc Networks (MANETs) require prudent resource allocations especially in scheduling mechanisms that manage buffering of packets during waiting time. Various scheduling algorithms may be implemented to govern packet transmission and control packet loss hence managing the Quality of Service (QoS). Such mechanisms include first-in-first-out (FIFO), priority queuing (PQ), and weighted-fair queuing (WFQ). In this research paper, a comparison is made between FIFO and PQ mechanisms in a mixed traffic scenario (HTTP, FTP and VoIP applications). PQ is implemented on the basis of packet Type of Service (ToS), with VoIP data packets being given the upper hand. OPNET simulator is utilized in this paper. The study has been carried out on some issues like: Traffic dropped Traffic Received and packet end to end delay and the simulation results shows that WFQ technique has a better-quality than the other techniques.

Keywords: MANETS, QoS, PQ, FIFO, Queuing, ToS, OPNET

1. INTRODUCTION

A queue is used to store traffic until it can be processed or serialized. Both switch and router interfaces of MANETs have ingress (inbound) queues and egress (outbound) queues. An ingress queue stores packets until the switch or router CPU can forward the data to the appropriate interface. An egress queue stores packets until the switch or router can serialize the data onto the physical wire. Switch (and router) queues are susceptible to congestion. Congestion occurs when the rate of ingress traffic is greater than can be successfully processed and serialized on an egress interface. Common causes for congestion include: The speed of an ingress interface is higher than the egress interface, the combined traffic of multiple ingress interfaces exceeds the capacity of a single egress interface and the MANET node is unable to handle the size of the forwarding table.
MANETs have many benefits, such as self-reconfiguration, ease of deployment, and so on. However, this flexibility and convenience come at a price. Ad hoc wireless networks inherit the traditional problems of wireless communications, such as bandwidth optimization, power control, and transmission quality enhancement [HYPERLINK \l "Ste04" 1], while, in addition, their mobility, multi-hop nature, and the lack of fixed infrastructure create a number of complexities and design constraints that are new to mobile ad hoc networks. The challenges include: being infrastructureless hence lots of design issues and hard network management issues, topologies dynamically keep changing, radio interface at each node uses broadcasting for transmitting traffic and usually a limited range leading to issues such as hidden terminal problems, limited link bandwidth, poor quality of links, variation of link and node capabilities, energy issues 2] robustness and unreliability, poor network security, scalability issues [HYPERLINK \l "Cha02" 2] and quality of service.

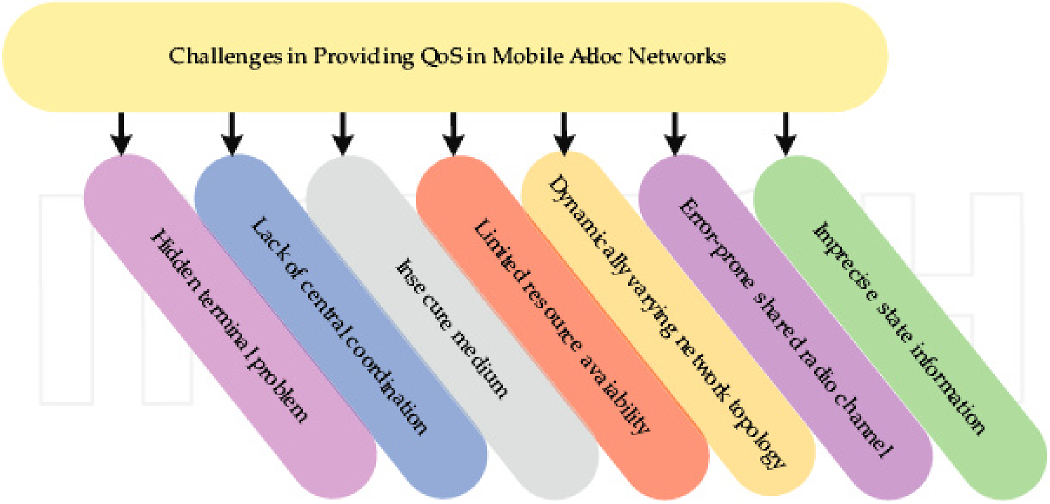

Figure 1: Challenges of MANETs in QoS provisioning3]

A quality of service (QoS) guarantee is essential for successful delivery of multimedia network traffic. QoS requirements typically refer to a wide set of metrics including throughput, packet loss, delay, jitter and error rate [HYPERLINK \l "VES00" 3] Wireless and mobile ad hoc specific network characteristics and constraints described above pose extra difficulty in achieving the required QoS guarantee in a mobile ad hoc network.1]

2. PACKET HANDLING TECHNIQUES

I. FIFO

FIFO is an acronym for First In First Out. This expression describes the principle of a queue or first-come first serve behavior: what comes in first is handled first, what comes in next waits until the first is finished etc. Thus it is analogous to the behavior of persons "standing in a line" or "Queue" where the persons leave the queue in the order they arrive. First In First Out (FIFO) is the most basic queuing discipline. In FIFO queuing, all packets are treated equally by placing them into a single queue, then servicing them in the same order they were placed in the queue. FIFO queuing is also referred to as First Come First Serve (FCFS) queuing [HYPERLINK \l "Ste04" 1].

Figure 2: FIFO queue.4,4]

II. WEIGHTED FAIR QUEUING

Weighted fair queuing (WFQ) is a data packet scheduling technique allowing different scheduling priorities to statistically multiplexed data flows.

WFQ is a generalization of fair queuing (FQ). Both in WFQ and FQ, each data flow has a separate FIFO queue. In FQ, with a link data rate of R, at any given time the N active data flows (the ones with non-empty queues) are serviced simultaneously, each at an average data rate of R/N. Since each data flow has its own queue, an ill-behaved flow (who has sent larger packets or more packets per second than the others since it became active) will only punish itself and not other sessions [HYPERLINK \l "And02" 4].

As opposed to FQ, WFQ allows different sessions to have different service shares. If N data flows currently are active, with weights $w_1, w_2 ... w_N$;data flow number i will achieve an average data rate of;

$$\frac{Rw_i}{(w_1 + w_2 + ... + w_N)} \qquad (1)$$

It can be proven that when using a network with WFQ switches and a data flow that is leaky bucket constrained, an end-to-end delay bound can be guaranteed.[1] By regulating the WFQ weights dynamically, WFQ can be utilized for controlling the quality of service, for example to achieve guaranteed data rate.

Weighted fair queuing (WFQ) is a method of automatically smoothing out the flow of data in packet-switched communication networks by sorting packets to minimize the average latency and prevent exaggerated discrepancies between the transmission efficiency afforded to narrowband versus broadband signals. In WFQ, the priority given to network traffic is inversely proportional to the signal bandwidth. Thus, narrowband signals are passed along first, and broadband signals are buffered.

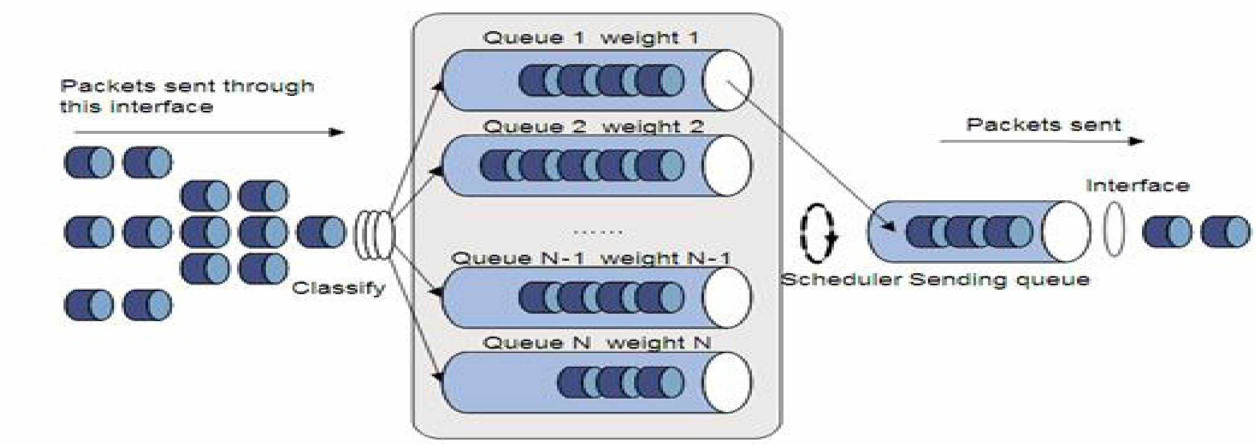

Figure 3: Illustration of Weighted Fair Queuing [5]

WFQ has little or no effect on the speed at which narrowband signals are transmitted, but tends to slow down the transmission of broadband signals, especially during times of peak network traffic. Broadband signals share the resources that remain after low-bandwidth signals have been transmitted. The resource sharing is done according to assigned weights. In flow-based WFQ, also called standard WFQ, packets are classified into flows according to one of four criteria: the source Internet Protocol address (IP address), the destination IP address, the source Transmission Control Protocol (TCP) or User Datagram Protocol (UDP) port, or the destination TCP or UDP port. Each flow receives an equal allocation of network bandwidth; hence the term fair.WFQ can prevent high-bandwidth traffic from overwhelming the resources of a network, a phenomenon which can cause partial or complete failure of low-bandwidth communications during periods of high traffic in poorly managed networks.

III. PRIORITY QUEUING

Priority Queuing assigns multiple queues to a network interface with each queue being given a priority level. A queue with higher priority is processed earlier than a queue with lower priority. Priority Queuing can have four preconfigured queues: high, medium, normal and low priority queue.

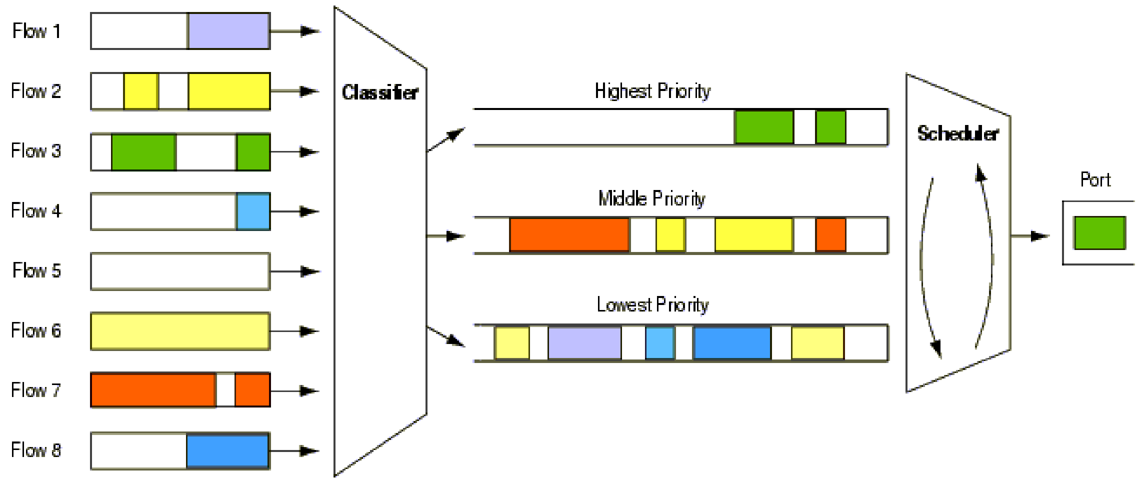

Figure 4: Illustration of Priority Queuing [5]

If packets arrive in the high queue then priority queuing drops everything its doing in order to transmit those packets, and the packets in other queue is again empty. When a packet is sent out an interface, the priority queues on that interface are scanned for packets in descending order for priority. The high priority queue is scanned first, then the medium priority queue and then so on. The packet at the head of the highest queue is chosen for transmission. This procedure is repeated every time a packet is to be sent. The maximum length of a queue is defined by the length limit. When the queue is longer, the limit packets are dropped [5]

3. OPNET

Optimized Network Engineering Tool (OPNET) is a top discrete event network simulator used both by research and commercial communities [7]. It provides a wide-ranging framework for modeling wired and wireless network scenarios. Simulation models are organized in a hierarchy consisting of three main levels: the simulation network, node models and process models. The top level refers to the simulation scenario or simulation network. It defines the network layout, the nodes and the configuration of attributes of the nodes comprising the scenario. The node models are at the second level in the hierarchy and consist of an organized set of modules describing the various functions of the node. The modules in the nodes are implemented using process models, the lowest level in the hierarchy.[5]

4. OVERALL SIMULATION SETUP

Simulations carried out are aimed at establishing the advantage of priority packet scheduling over FIFO packet scheduling in a variety of applications and load conditions. The applications are:

- Voice over internet protocol (VoIP)
- Video
- File transfer protocol (FTP)

The load conditions involved are; low load condition and high load condition.

A MANET set up of four nodes is configured. The figure below depicts. Each two nodes will be communicating one of the applications set out here. Nodes 1 and 2 were configured for VoIP. Nodes 3 and 4 were configured for video conferencing. Nodes 5 and 6 were configured for file transfer

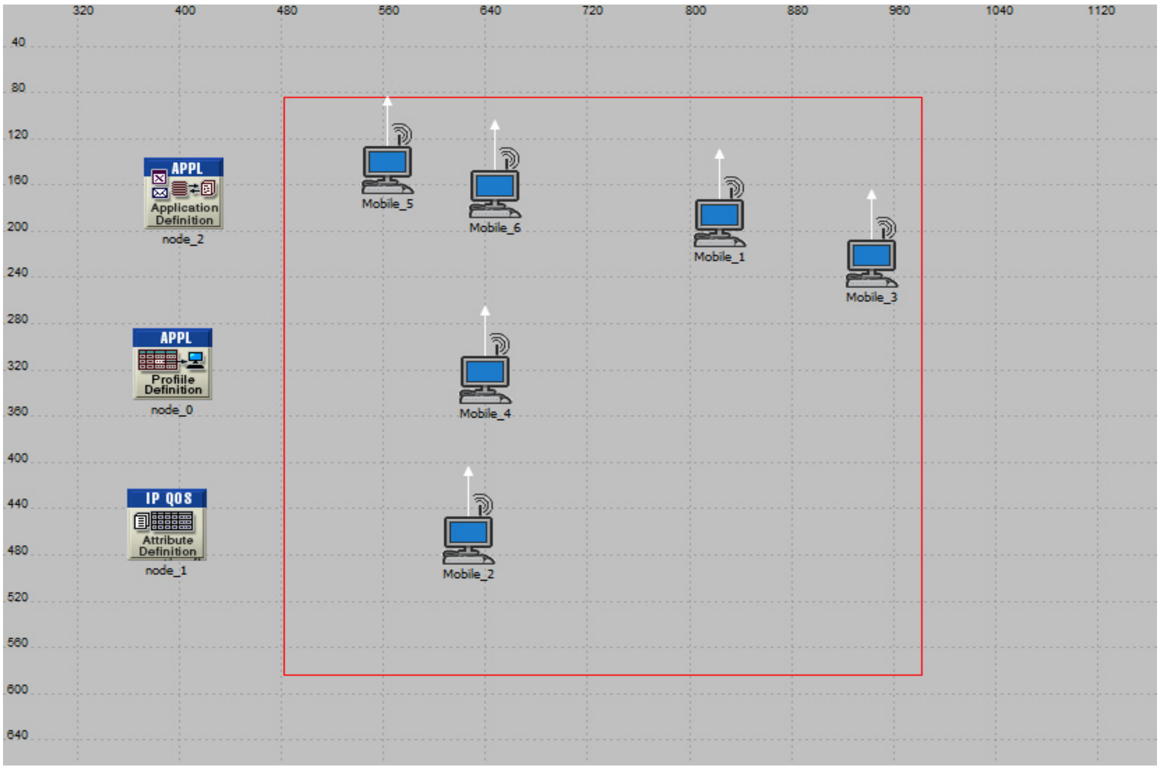

Figure 5: The MANETs set up in OPNET.

4.1 Deployed applications

4.1.1 Voice over Internet Protocol application

A VoIP application is deployed between MANET nodes 1 and 2. The nature of the VoIP application is as depicted in table below.

Table 1: VoIP attributes configured.

Attribute	Value	Value
Silence Length (seconds)	Incoming Silence Length (seconds)	exponential (0.65)
	Outgoing Silence Length (seconds)	exponential (0.65)
Talk Spurt Length (seconds)	Incoming Talk Spurt Length (seconds)	exponential (0.352)
	Outgoing Talk Spurt Length (seconds)	exponential (0.352)
Symbolic Destination Name	Voice Destination	
Encoder Scheme	G.711 (silence)	
Voice Frames per Packet	1	
Type of Service	Interactive Voice (6)	
RSVP Parameters	None	
Traffic Mix (%)	All Discrete	
Signaling	None	
Compression Delay (seconds)	0.02	
Decompression Delay (seconds)	0.02	

4.1.2 Video conferencing application

A video conferencing application is deployed between MANET nodes 3 and 4. The nature of the video conferencing application is as depicted in table below.

Table 2: Video conferencing attributes configured

Attribute	Value
Frame Inter-arrival Time Information	15 frames/sec
Frame Size Information (bytes)	128X240 pixels
Symbolic Destination Name	Video Destination
Type of Service	Excellent Effort (3)
RSVP Parameters	None
Traffic Mix (%)	All Discrete

4.1.3 File transfer application

A file transfer application is deployed between MANET nodes 1 and 2. The nature of the file transfer application is as depicted in table below.

Table 3: File Transfer attributes configured.

Attribute	Value
Command Mix (Get/Total)	50%
Inter-Request Time (seconds)	exponential (360)
File Size (bytes)	constant (50000)
Symbolic Server Name	FTP Server
Type of Service	Best Effort (0)
RSVP Parameters	None
Back-End Custom Application	Not Used

5. RESULTS

5.1 RESULTS PRESENTATION

The simulations were done for low load condition and high load condition. The measurements under consideration were Mean Opinion Score (MOS), Jitter and Packet end to end delay for VoIP, Packet delay variation and Packet end to end delay for Video Transfer and Download response time and upload response time for File transfer. The results were tabulated for about 1800 seconds (half an hour) for each simulation measurement under consideration. The process was repeated severally to ensure that the results obtained were optimum. The graphical presentation of the results was done for both low load condition and high load condition. These are shown in figures 6a to 11b next

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5.2 LOW LOAD CONDITION

5.2.1 VOIP APPLICATION

a) Mean Opinion Score (MOS)

Figure 6a: Graphical presentation of the VoIP MOS values

b) Jitter

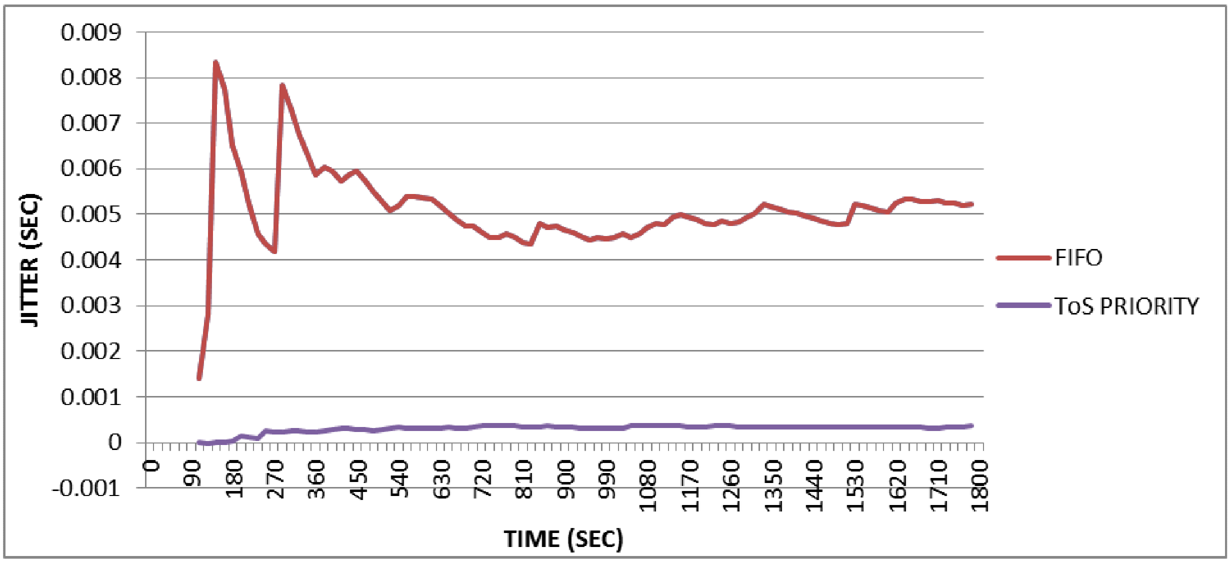

Figure 7a: Graphical representation of VoIP Jitter results.

c) Packet End To End Delay

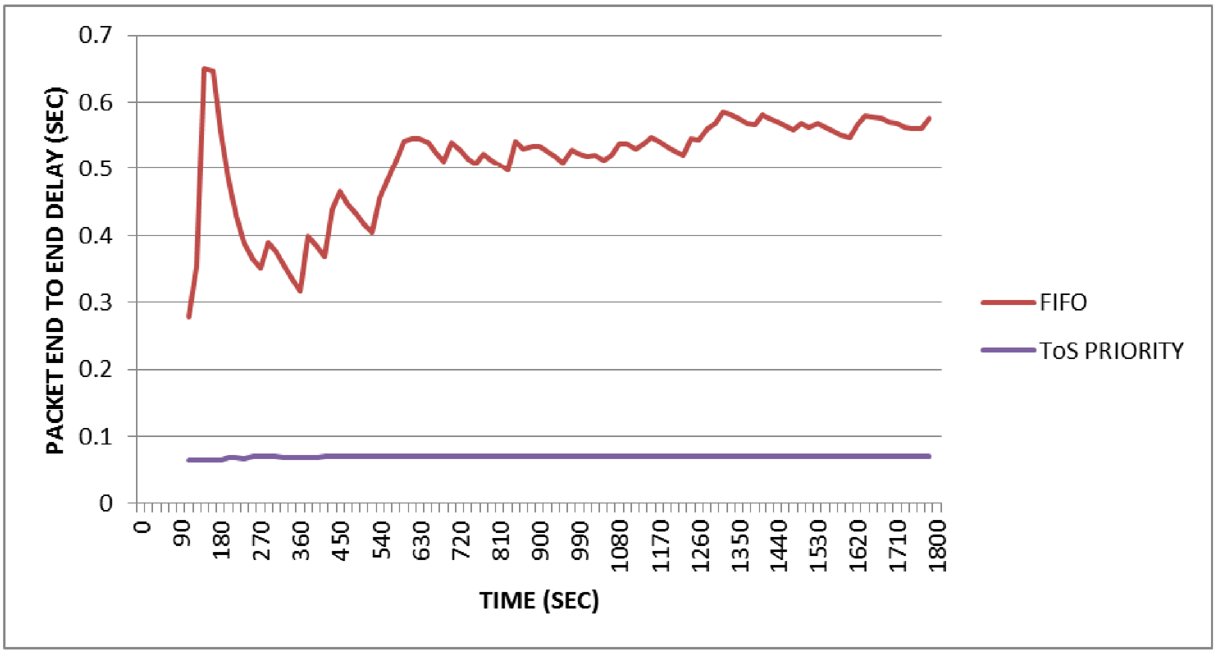

Figure 8a: Graphical representation of VoIP packet end to end delay results.

5.2.2 VIDEO TRANSFER APPLICATION

a) Packet Delay Variation

b)

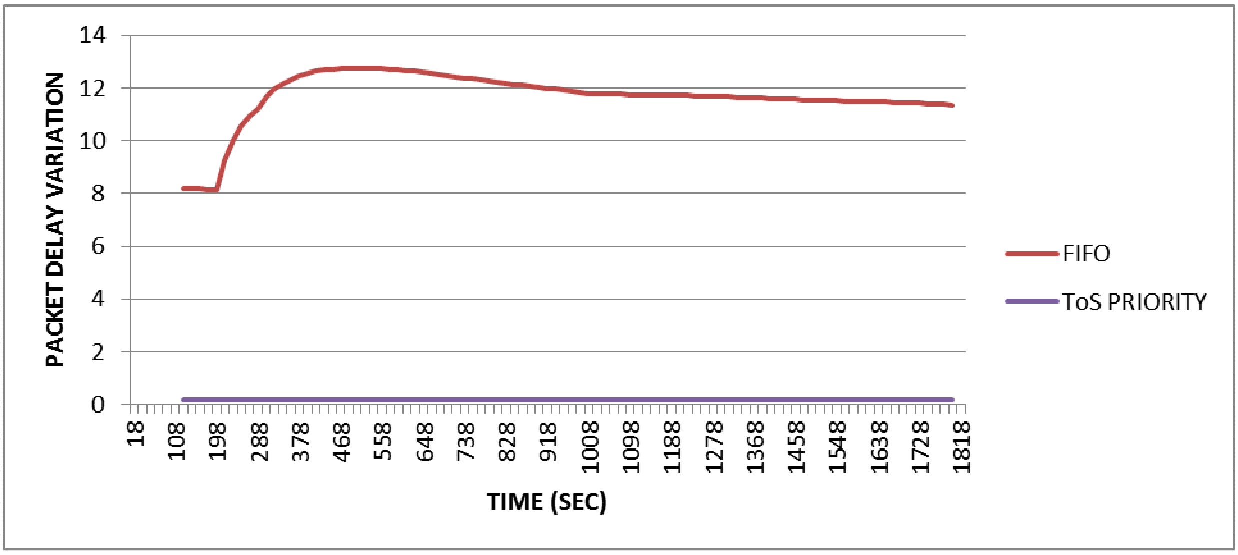

Figure 9a: Graphical representation of packet delay variation results for video transfer.

c) Packet End To End Delay

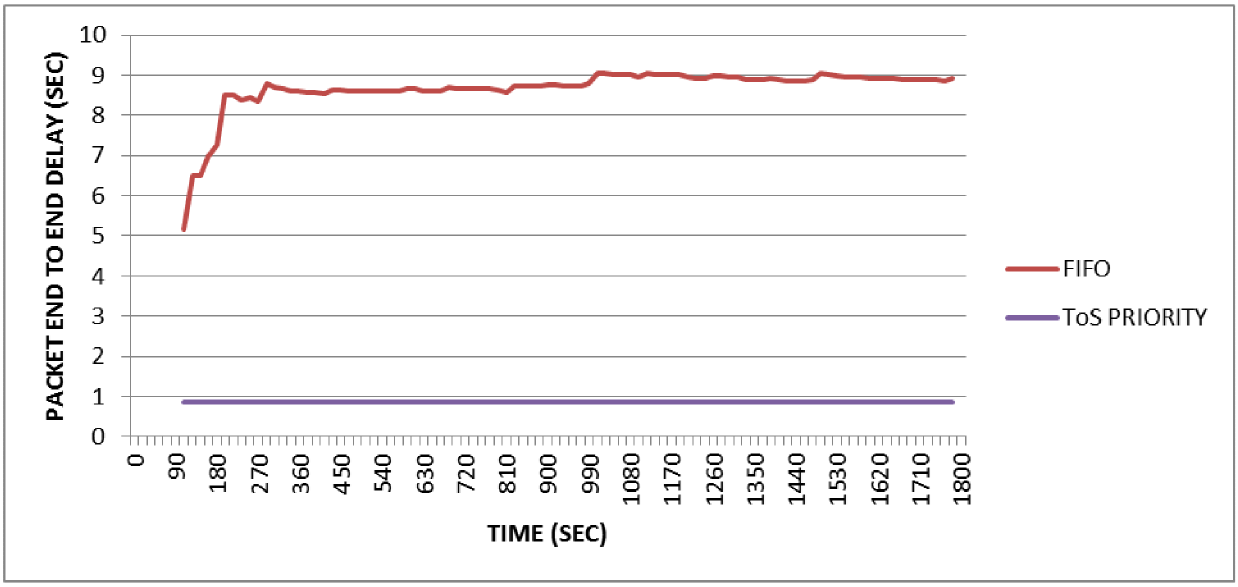

Figure10a: Graphical representation of packet end to end delay results for video transfer.

5.2.3 FILE TRANSFER APPLICATION

a) Download Response Time

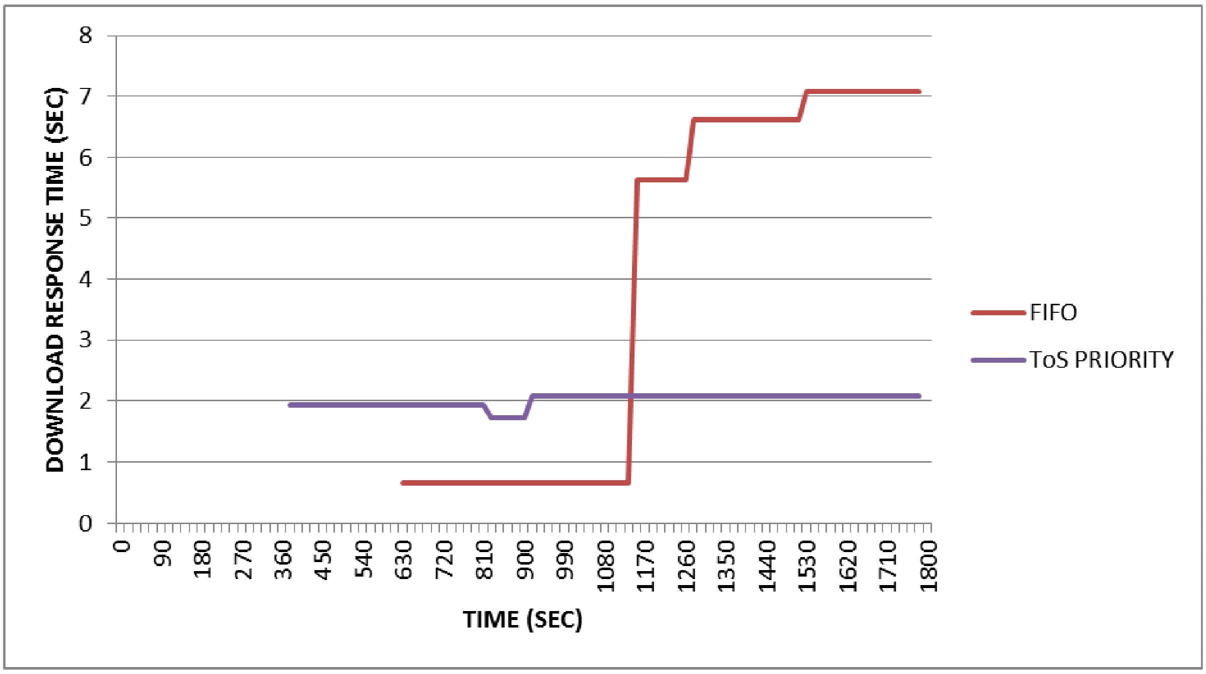

Figure 11a: Graphical representation of download response time results for file transfer.

b) Upload Response Time

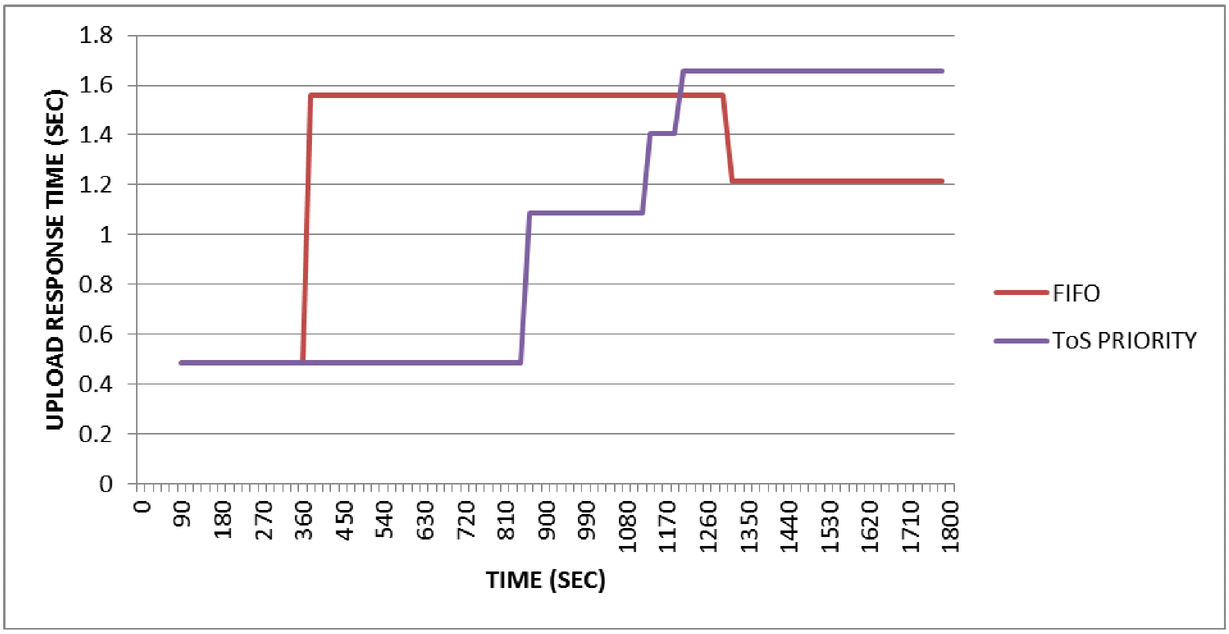

Figure 12a: Graphical representation of upload response time results for file transfer.

5.3 HIGH LOAD CONDITION

5.3.1 VOIP APPLICATION

a) MOS

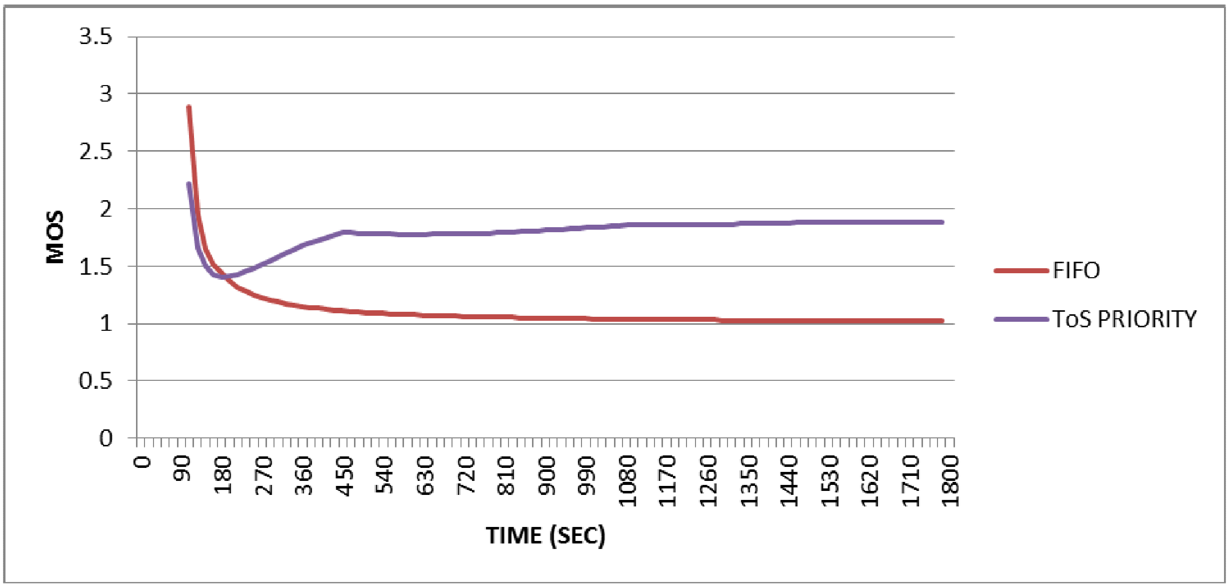

Figure 6b: Graphical representation of MOS value results for VOiP under high load.

b) Jitter

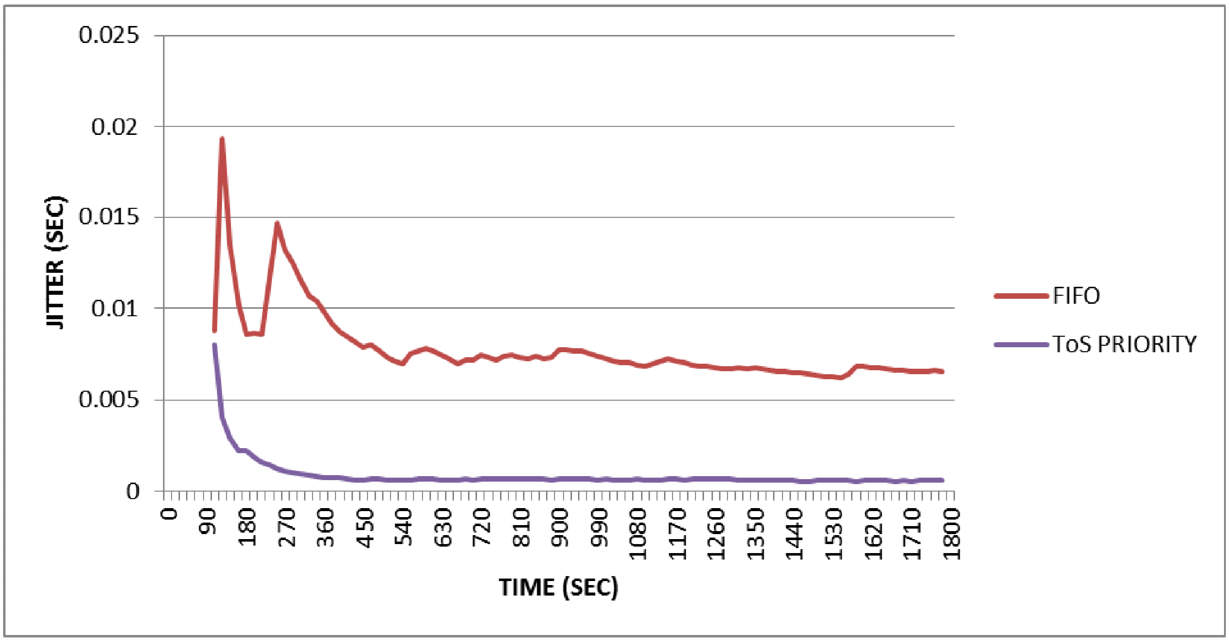

Figure 7 b: Graphical representation of jitter results for VOiP application under high load

c) Packet End To End Delay

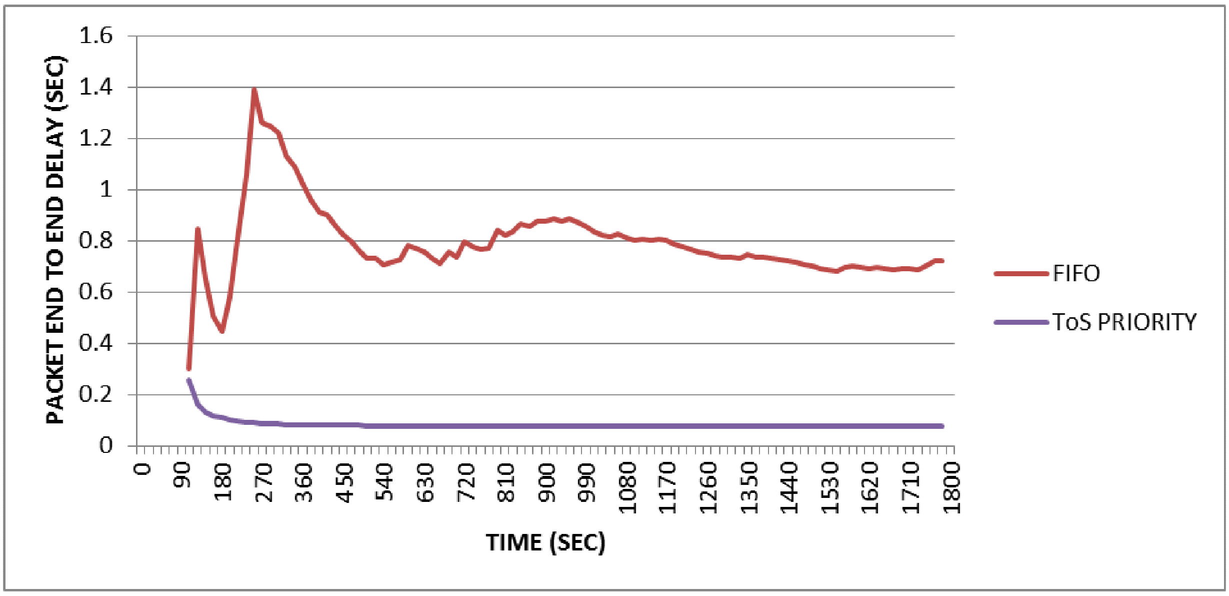

Figure 8b: Graphical representation of packet end to end delay variation VOiP under high load

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5.3.2 VIDEO TRANSFER APPLICATION

a) Packet Delay Variation

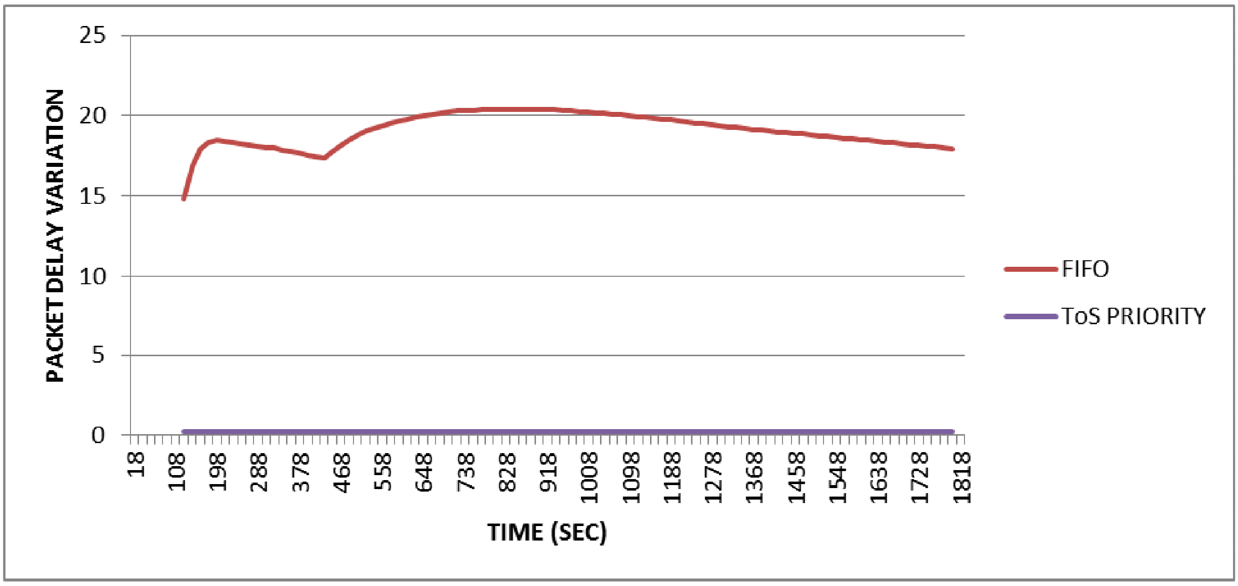

Figure 9b: Graphical representation of packet delay variation results for video transfer.

b) Packet End To End Delay

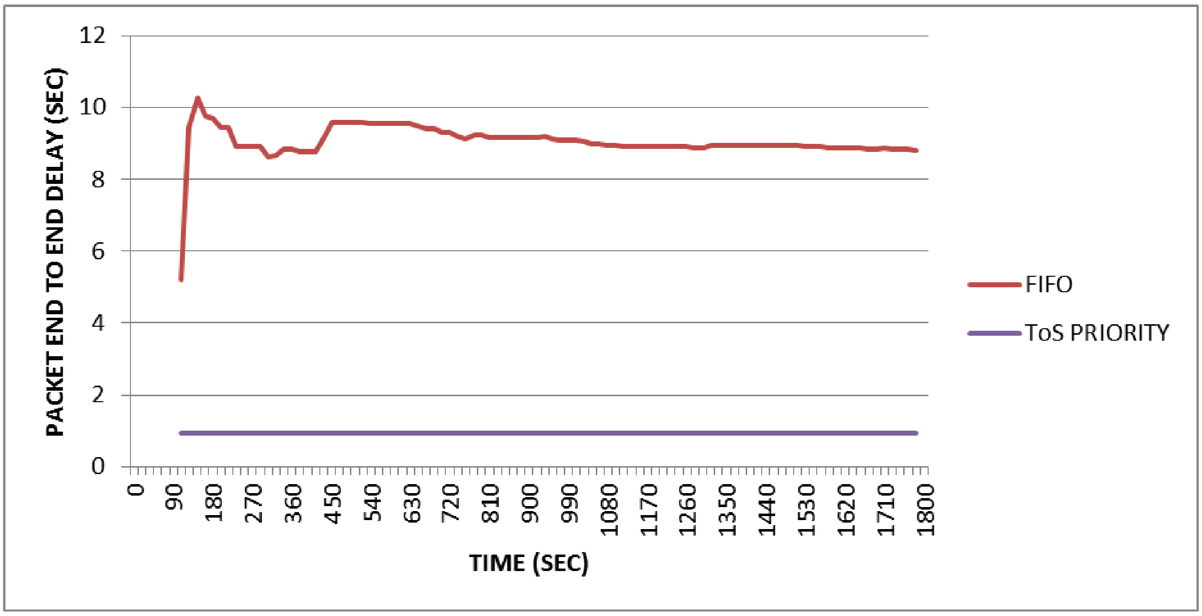

Figure 10b: Graphical representation of packet end to end delay variation for video transfer.

5.3.3 FILE TRANSFER APPLICATION

a) Download Response Time

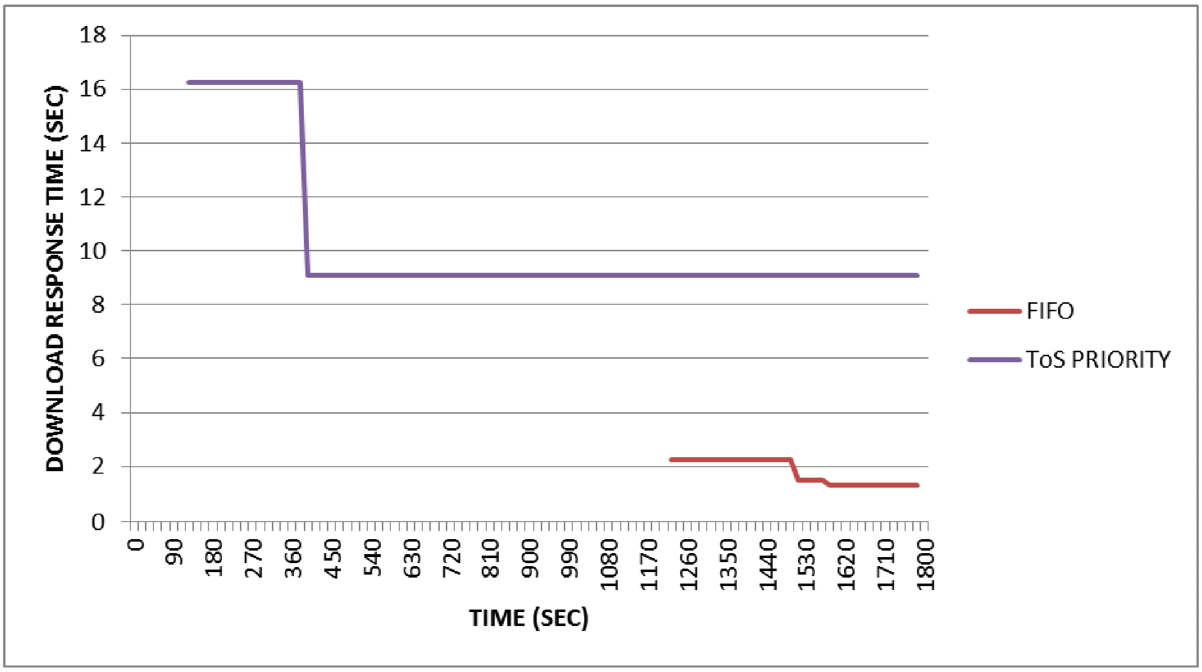

Figure 11b: Graphical representation of download response time results for file transfer

b) Upload Response Time

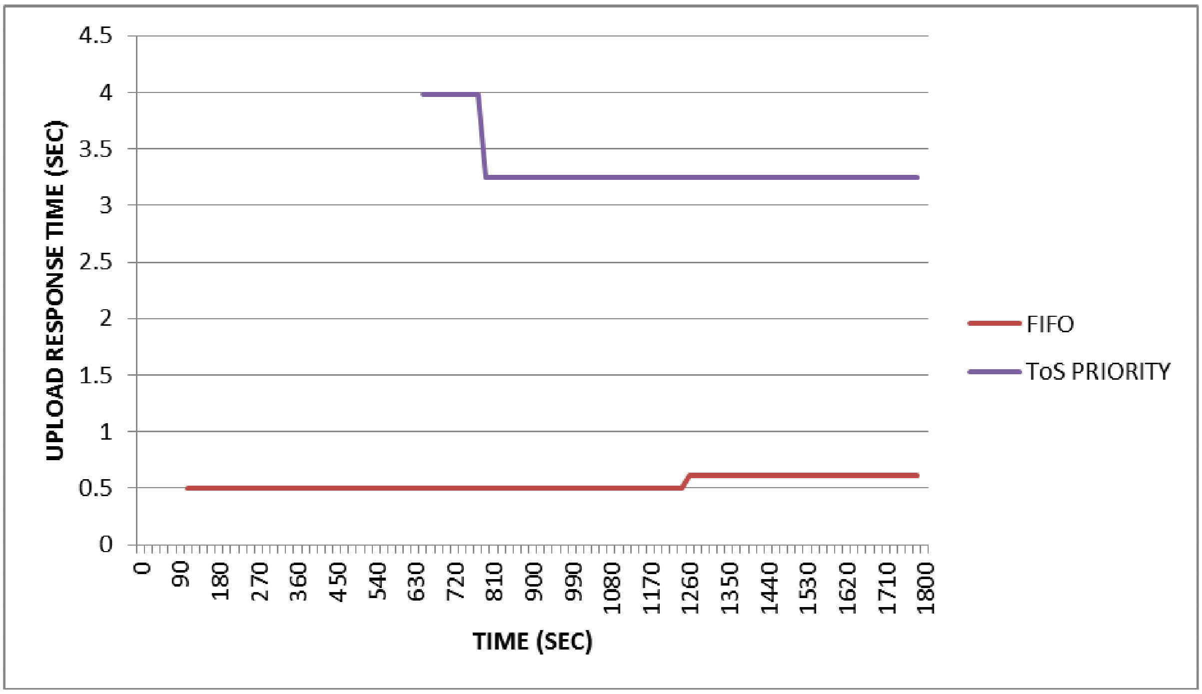

Figure 12b: Graphical representation of upload response time results for file transfer

5.2 EXPLATION OF RESULTS

5.2.1 VOIP

Figure 11a and 11b shows a graphical plot of MOS values obtained in the VoIP application. MOS gives a numerical indication of the perceived quality of the voice received after being transmitted and eventually compressed using codecs. MOS is expressed in one number, from 1 to 5, 1 being the worst and 5 the best. MOS is quite subjective, as it is based figures that result from what is perceived by people during tests. However, OPNET software can measure MOS on networks as in the case here. Taken in whole numbers, the numbers are quite easy to grade.

- **5** - Perfect. Like face-to-face conversation or radio reception.
- **4** - Fair. Imperfections can be perceived, but sound still clear. This is (supposedly) the range for cell phones.
- **3** - Annoying.
- **2** - Nearly impossible to communicate.
- **1** - Impossible to communicate

It can be observed that the MOS values for TOS priority are far much better that those of FIFO. The TOS priority values range between 2 and 3.4 while those of FIFO are very slightly above 1 under low load conditions. They are around 2 for TOS priority and slightly above 1 for FIFO under high load conditions.

Jitter for FIFO is high and does not subside in both low and high load conditions. For TOS priority, jitter is minimal nearest to zero in both the low and high load condition.

Packet end to end delay for TOS priority is almost constant at 0.08 seconds while that of FIFO varies between 0.5 and 0.6 seconds under low load condition. It remains the same for both cases under high load condition.

5.2.2 VIDEO TRANSFER APPLICATION

Figures 9a, 9b, 10a and 10b show the graphical representations of the results from the video transfer application. TOS priority gives almost nil packet delay variation while FIFO has got substantive packet delay variation in low load condition. However, under high load condition, the packet delay variation for TOS priority is around 0.08 seconds while that of FIFO is around 0.8 seconds. Packet end to end delay variation gives similar results with TOS showing less delay as compared to FIFO.

5.2.3 FILE TRANSFER APPLICATION

The download response time is constant at around 2 seconds for TOS Priority while that of FIFO varies between 6 and 7 seconds in low load condition. It is also noted that FIFO takes a longer time for results of the simulation to begin streaming. The same trend is depicted under the high load condition. However, upload response time at some time gets worse for TOS priority as compared to FIFO although from the start it has a better response.

6. CONCLUSION

MANETs face many challenges and therefore sensitivity is needed in the decision of the type of packet scheduling to be used. In this simulation analysis, it is shown that TOS priority gives superior results for VoIP, video transfer and file transfer. Its recommended that such a priority scheduling is enhanced and used here.

From the simulations, it can also be established that load conditions affects jitter and delay variation. Higher load leads to high jitter and delay variation. However, end to end delay is not affected by the load conditions in MANETs.

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