# A Fair Queuing Technique for Efficient Content Delivery Over 3G and 4 G Networks in Varying Load Condition

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## ABSTRACT
The challenges of new communication architecture are to offer better quality of service (QoS) in internet Network. A large diversity of services based on packet switching in 3G network and beyond 3G leads dramatic changes in the characteristics and parameter of data traffic. Deployment of application server and resource server has been proposed to support both high data rates and quality of service (QoS) for Next Generation Network (NGN).One important generalization of the Next Generation Network is, it's a queue of network. It is expected that traffic in NGN will undergo both quantitative and qualitative changes. Such networks can model problems of contention that arise when a set of resources is shared. With the rapid transformation of the Internet into a commercial infrastructure, demands for service quality have rapidly developed. In this paper, few components of NGN reference architecture have been taken and system is evaluated in terms of queuing network. This paper gives a comparative analysis of three queuing systems FIFO, PQ and WFQ. Packet end to end delay and packet delay variation is evaluated through simulation. Results have been evaluated for a light load and heavy load condition. Result shows WFQ has better quality comparing with other techniques in a voice based services where as PQ a technique is better in Video based services. Simulation is done using OPNET.

## Categories and Subject Descriptors
B.4.4 [**Performance Analysis and Design Aids]**: Data communication –Simulation.

## General Terms
Performance, Design, Evaluation.

## Keywords
QoS-Quality of service, NGN-Next generation network, FIFO, PQ, WFQ

## 1. INTRODUCTION
It is essential to understand and take a deep look in to the future, for a view of what a network may look like and explore how a service or group of services may fit together to form a useful example of where next generation network will take us. To offer better quality of service in a network a lot of parameter should be considered such as bandwidth, latency, delay, jitter and packet loss etc. NGN's architecture is basedon decoupling transport layer and service layer. Basically, that means that whenever a provider wants to enable a new service they can do it straight upon defining it at the service layer without considering it the transport layer. Fig.-1 shows reference architecture of NGN model. Required components of NGN have been extensively discussed in past [10] [12].

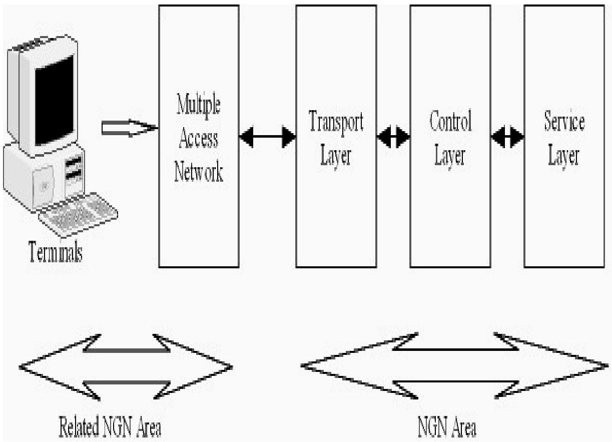


Fig-1(Reference Architecture Diagram of NGN Model)

## 2. METHODOLOGY AND REQUIREMENTS
In next generation proposed architecture, these are following set of requirements.

- Drivers and basic requirements.
- NGN QOS standardization.
- Resource and Admission control Functions.

In order to meet some of the requirements listed for Next generation Network, some proposal has been discussed in past [16]. In the generic model a node or a service center represent each resource. Thus in a model for computer system performance analysis we may have service center for the servers, a service center for each I/O channel [2].

A service center may have one or more server associated with it. If a job requesting service finds all the server at a service center busy, it will join the queue associated with the center and a later point in time when a server becomes idle a job from the queue will be selected for service according to some scheduling discipline. After completion of service at one service center the job may move to another service center for further service, reenter the same service center or leave the system [4].

There are two types of networks.

- Open Queuing network: It is characterized by one or more sources of job arrivals and correspondingly one or more sinks that absorb jobs departing from the network.
- Close Queuing network: In this type of network job neither enters nor depart from the network. The probability of transition between service centers and the distribution of job service time characterized the behavior of jobs within the network. For each center the no. of servers the scheduling discipline and the size of the queue must be specified. We assume that the scheduling is FCFS and that each server has a queue of unlimited capacity.

# 3. THE ANALYTICAL DECOMPOSITION OF NGN REFERENCE MODEL WITH OPEN QUEUING NETWORK

Consider a two stage tandem network. The system consists of application server and resource server with respective service rate $\mu_0$ & $\mu_1$. Observe that application server has a Poisson arrival source of rate $\lambda$ and exponentially distributed.

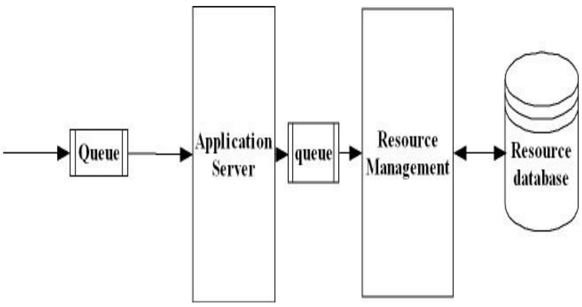


Fig 2. A two stage open queuing network of NGN

This system can be modeled as a stochastic process whose states are specified by pairs ( $k_0, k_1$ ).

$$k_0 \geq 0$$
$$k_1 \geq 0$$

Where $k_i$ (i=0, 1) is the no. of jobs completion of the service at one of the two server. The changes of the two servers occur on a completion of service at one of the two servers or an external arrival. Since all interevent times are exponentially distributed, it follows that the stochastic process is a homogeneous continuous time Markov chain [14].

Let p ( $k_0, k_1$ ) is the joint probability of $k_0$ jobs at application server and $k_1$ Jobs at resource server in the steady state. Equating the rates of flow into and out of the state, we obtain the following balance equations [7].

$$(\mu_0 + \mu_1 + \lambda)\, p(k_0, k_1) = \mu_0\, p(k_0 + 1, k_1 - 1) +$$
$$\mu_1\, p(k_0, k_1 + 1) + \lambda\, p(k_0 - 1, k_1) - -(1)$$

For the boundary state we have

$$(\mu_0 + \lambda)\, p(k_0, 0) = \mu_1\, p(k_0, 1) + \lambda\, p(k_0 - 1)$$

Where $k_0 > 0$

$$(\mu_1 + \lambda)\, p(0, k_1) = \mu_0\, p(1 - k_1 - 1) + \mu_1\, p(0, k_1 + 1)$$

Where k1>0

$$\lambda . p(0,0) = \mu_1 . p(0,1) - - - -(2)$$

The normalization is provided by

$$\sum_{k0 \geq 0} \sum_{k1 \geq 0} p(k_0 . k_1) = 1$$

The Solution of the preceding balance equation is

Where $\rho_0 = \lambda / \mu_0$ and $\rho_1 = \lambda / \mu_1$

The equation shows a stability condition of the network as condition for stability of the system is that both $\rho_0$ & $\rho_1$ are less than unity. Equation (3) is a product form solution to M/M/1 queue. Many efficient algorithms for calculating performance measure for closed queuing network have been developed and discussed in past [13] [6].

# 4. VARIOUS QUEUING TECHNIQUES

We treat a number of elementary queuing models. Attention is paid to methods for the analysis of these models, and also to applications of queuing models on 3G and 4G network.

Various queuing disciplines can be used to control which packets get transmitted and which packets which packets get dropped. The queuing disciplines are:

1. First-in-first-out (FIFO) queuing.
2. Priority queuing (PQ)
3. Weighted-Fair queuing. (WFQ)

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 [10]. Although a single FIFO queue seems to provide no QoS features at all, it actually does affect drop, delay, and jitter. Because there is only one queue, the router need not classify traffic to place it into different queues and router need not worry about how to decide from which queue it should take the next packet—there is only one choice. Due to this single queue uses FIFO logic, the router need not reorder the packets inside the queue. With a longer queue, however, the average delay increases, because packets may be enqueued behind a larger number of other packets. In most cases when the average delay increases, the average jitter increases as well.

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 has four preconfigured queues, high medium, normal and low priority queue. Queues are serviced in strict order of queue priority, so the high queue always is serviced first, then the next-lower priority and so on. If a lower-priority queue is being serviced and a packet enters a higher queue, that queue is serviced immediately. This mechanism is good for important traffic, but can lead to queue starvation. 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 queues 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 when a packet is to be sent. The maximum length of a queue is defined by the length limit. When a queue is longer the limit packets are dropped [15].

The idea of the fair queuing (FQ) discipline is to maintain a separate queue for each flow currently being handled by the router. The router then services these queues in a round robin manner. WFQ allows a weight to be assigned to each flow (queue). This weight effectively controls the percentage of the link's bandwidth each flow will get. WFQ is a generalization of fair queuing (FQ) [11]. Both in WFQ and FQ, each data flow has a separate FIFO queue.

## 5.NETWORK DESIGN AND CONFIGURATION

The following network design has been taken into consideration to evaluate network performance on various queuing network. At the first step single traffic is used for each of the functions such as Ftp, Video Conferencing and VOIP which is shown in Fig. 3. Fig. 4 shows a heavy traffic load condition and it uses four routers. For 3G and 4G requirement the basic architecture can be modified with reference of Bandwidth. The architecture has been modified and a bandwidth of 50 Mbps to 100 Mbps has been considered for 3G network and tested multimedia content delivery over this network. For 4G networks the architecture has been modified and considered bandwidth up to 1Gbps and tested for multimedia content delivery over this network. In both case packet end to end delay has been measured for different queuing discipline. Performance based on queuing network has been discussed in past using various queuing policy but failed to achieve wide acceptance due to various complexity [7] [8] [9].

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

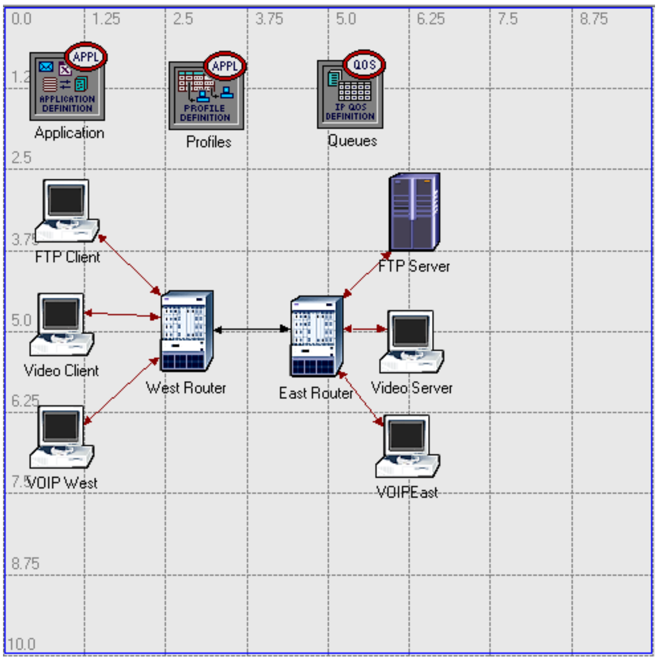


Fig 3. Network architecture for FIFO, PQ and WFQ

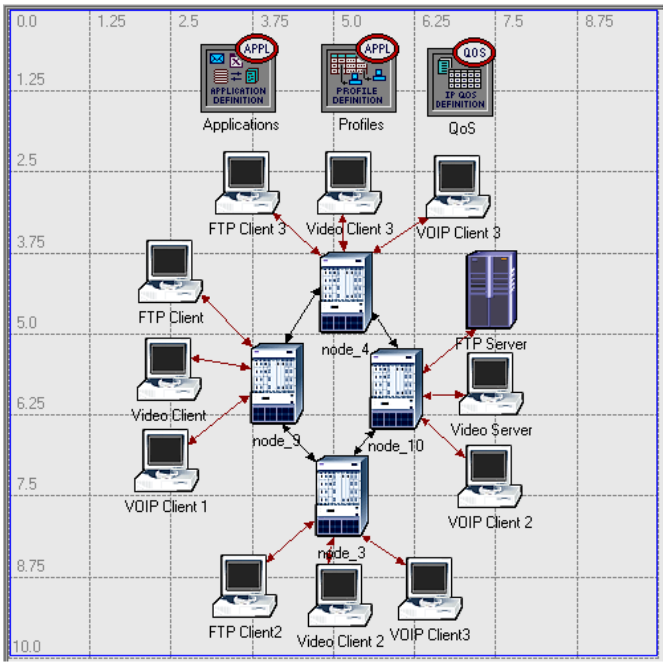


Fig 4. Network architecture for FIFO, PQ and WFQ for heavy load

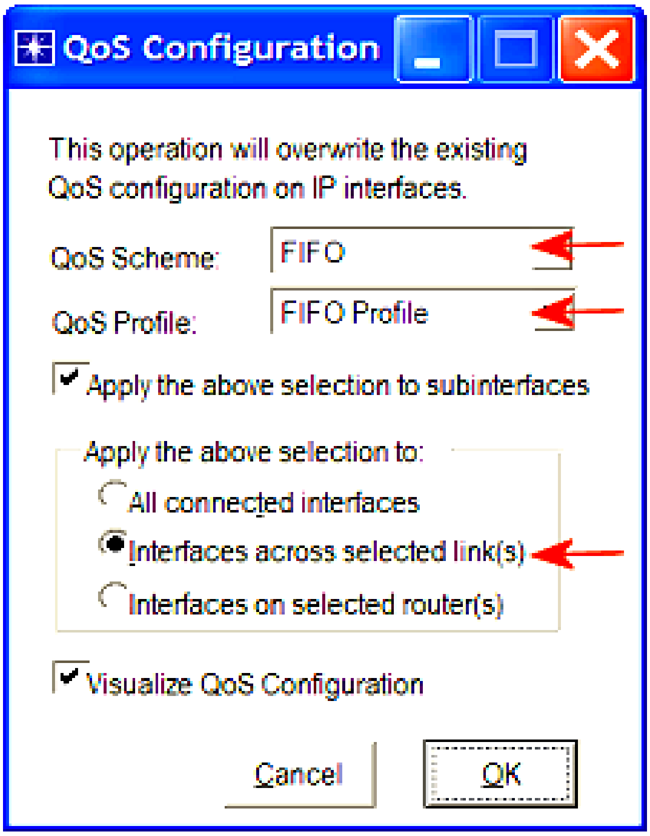


Fig 5.Router Configuration

Different queuing discipline in the routers can affect the performance of the applications and the utilization of the network resources. Routers need to be configured for those three Queuing disciplines. The configurations are given Fig. 5

## 5. SIMULATIONS RESULTS AND ANALYSIS

Simulation has been done using OPNET software for every queuing scheme and packet end to end delay and traffic dropped is measured for variable bandwidth. It is tested for voice traffic and video conferencing.

Fig 6, 7 shows packet end to end delay in case of voice transmission. Packet end to end time delay is nearly zero for both PQ and WFQ scheme. As the time increases PQ and WFQ groups packet shows same characteristic. Packet end to end delay is always higher in case of FIFO scheme.

Fig 8, 9 shows packet end to end delay for video transmission. Here packet end to end time delay is higher for WFQ scheme where as it is lower for PQ scheme. Packet end to end delay is always higher in case of FIFO scheme.

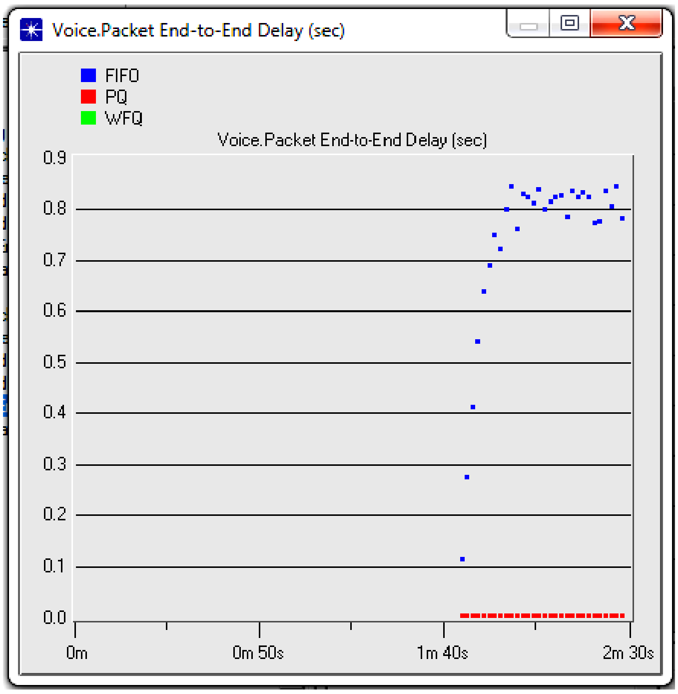


Fig. 6 Packet end to end delay for FIFO, PQ & WFQ

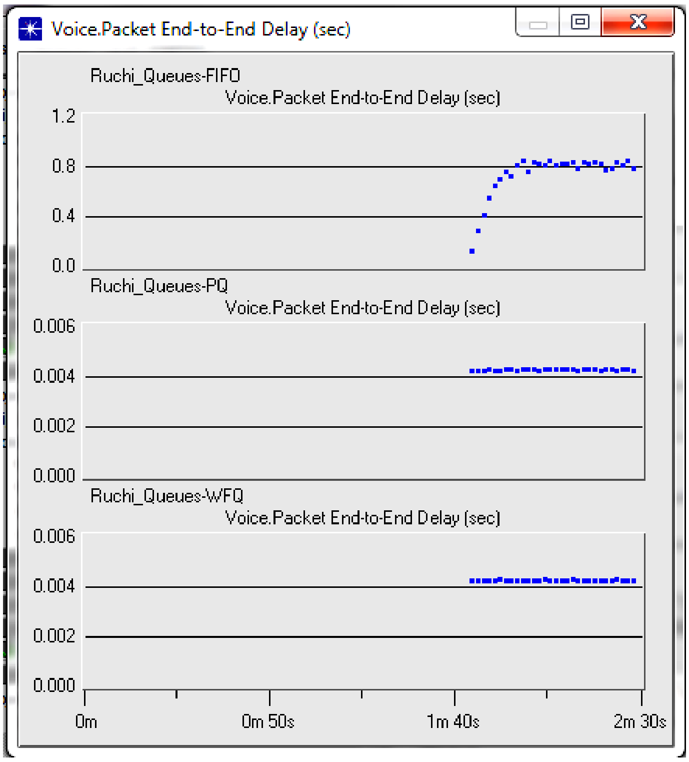


Fig. 7 Individual delay variation for FIFO, PQ & WFQ

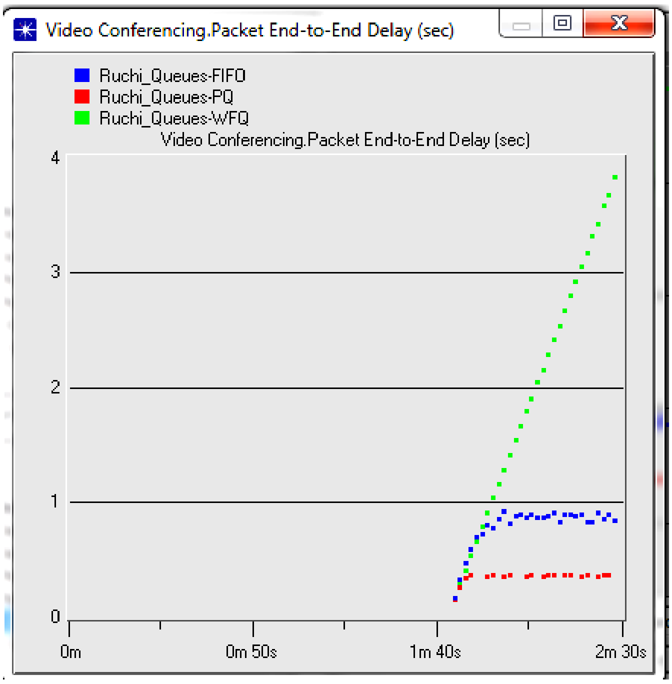


Fig. 8 Packet end-to-end delay for FIFO, PQ & WFQ

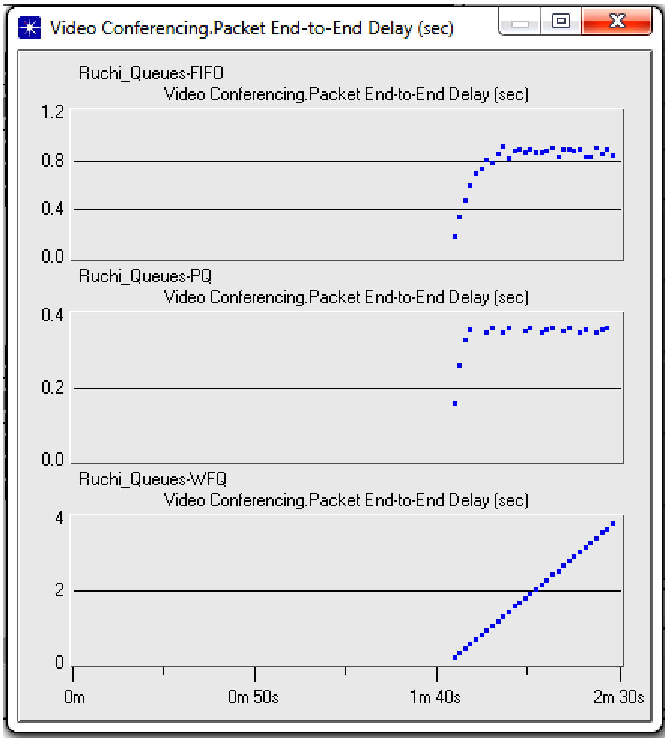


Fig. 9 Individual Packet end-to-end delay for FIFO, PQ & WFQ

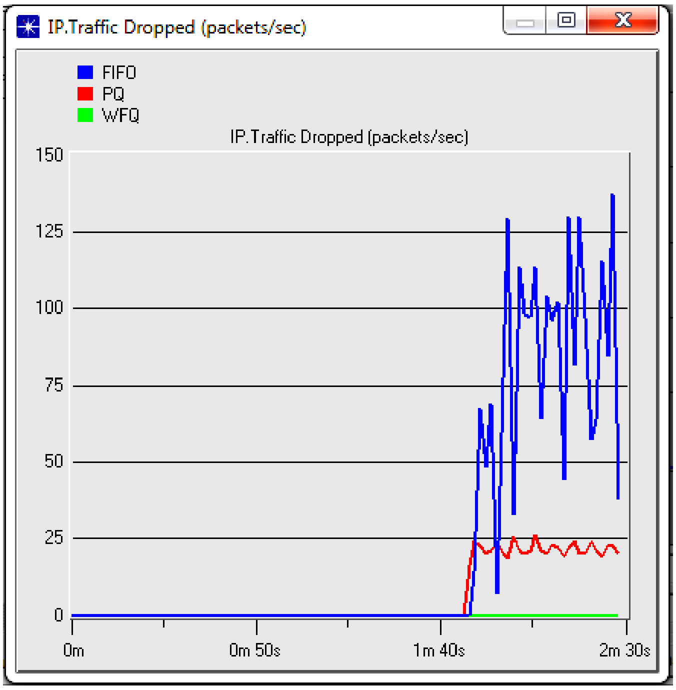


Fig. 10. Traffic drop for FIFO, PQ and WFQ

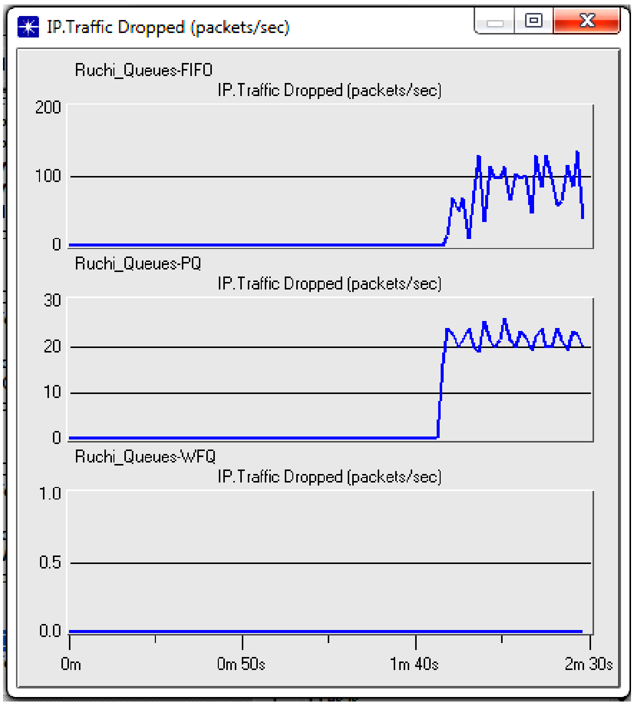


Fig. 11. Individual Traffic drop for FIFO, PQ and WFQ

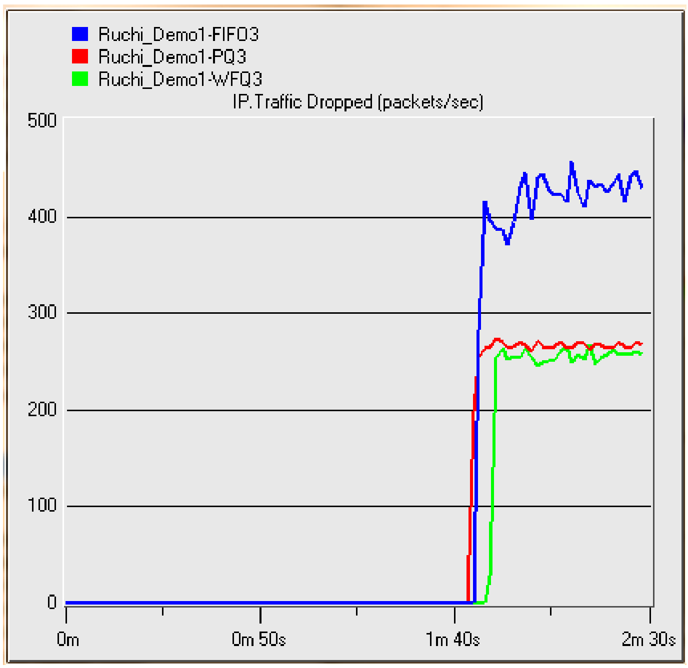


Fig. 12. Individual Traffic drop for FIFO, PQ and WFQ for heavy load condition.

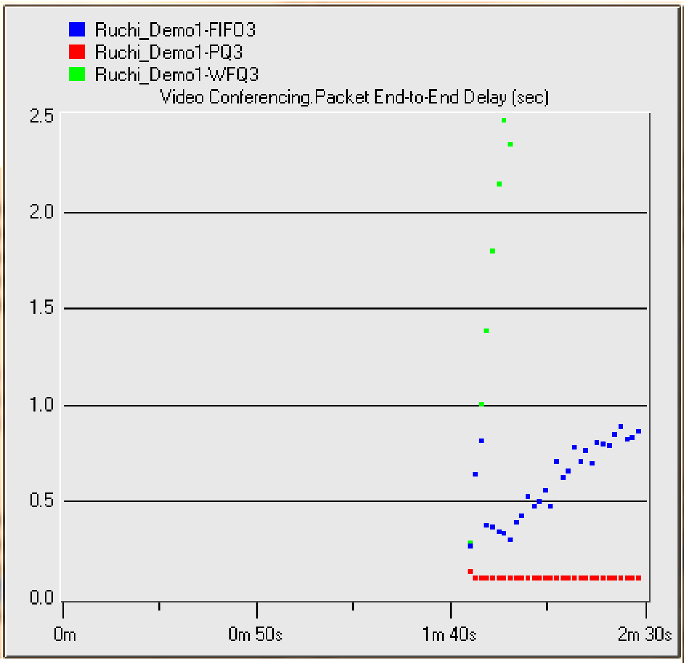


Fig. 13 Packet end-to-end delay for FIFO, PQ & WFQ for video traffic in heavy load condition.

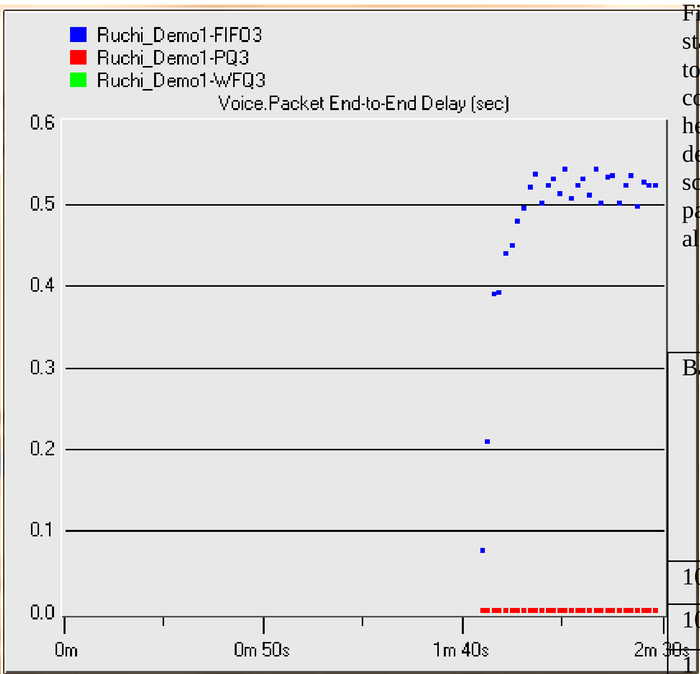


Fig. 14 Packet end to end delay for FIFO, PQ & WFQ for voice based traffic in heavy load condition.

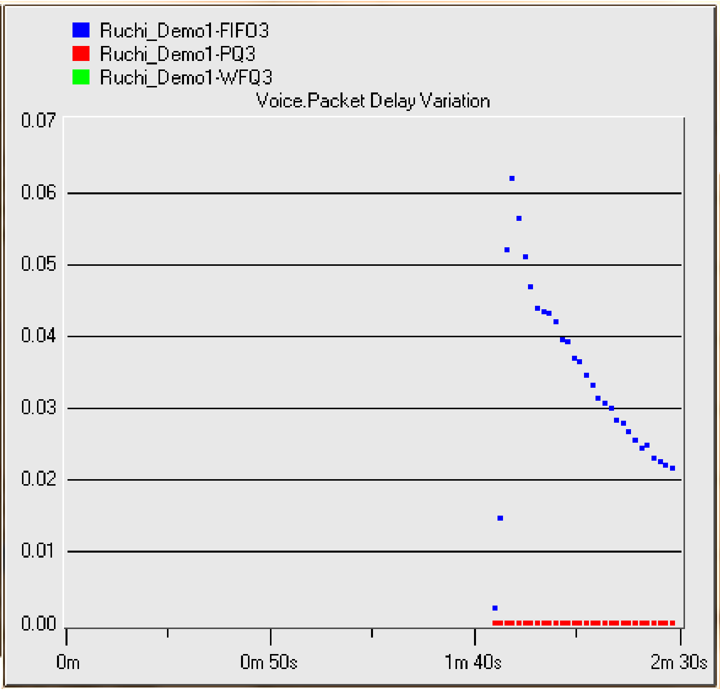


Fig. 15 Packet Delay Variation for FIFO, PQ & WFQ in heavy load condition.

Fig 10, 11 shows traffic drop statistic. Fig 12 shows traffic drop statistic for heavy load condition. Fig 13, 14 shows packet end to end delay for voice and video traffic drop for heavy load condition. Fig 15 shows packet delay variation statistic for heavy load condition. Table I, II, III shows packet end to end delay and packet delay variation for FIFO, PQ and WFQ scheme for audio and video. Some attempt has been taken in past to do performance evaluation using various queuing algorithm [1].

TABLE I
STATISTICS OF FIFO SCHEME OVER VARIABLE BANDWIDTH

| Bandwidth | FIFO (Voice) | | FIFO (Video) | |
|---|---|---|---|---|
| | Packet End To End Delay (Sec) | Packet Delay Variation (Sec) | Packet End To End Delay (Sec) | Packet Delay Variation (Sec) |
| 10 Mbps | 0.9208 | 0.0684 | 0.845 | 0.056 |
| 100 Mbps | 0.915479 | 0.0693365 | 0.864995 | 0.057727 |
| 1 Gbps | 0.794608 | 0.057637 | 0.748554 | 0.0432041 |

**TABLE II**

**STATISTICS OF PQ SCHEME OVER VARIABLE BANDWIDTH**

| Bandwidth | PQ (Voice) | | PQ (Video) | |
|---|---|---|---|---|
| | Packet End To End Delay (Sec) | Packet Delay Variation (Sec) | Packet End To End Delay (Sec) | Packet Delay Variation (Sec) |
| 10 Mbps | 0.364336 | 0.00728955 | 0.00428886 | 0.0000050662 |
| 100 Mbps | 0.338956 | 0.00623114 | 0.00414799 | 0.000005106 |
| 1 Gbps | 0.32047 | 0.00529942 | 0.00412595 | 0.0000050861 |

**TABLE III**

**STATISTICS OF PQ SCHEME OVER VARIABLE BANDWIDTH**

| Bandwidth | WFQ (Voice) | | WFQ (Video) | |
|---|---|---|---|---|
| | Packet End To End Delay (Sec) | Packet Delay Variation (Sec) | Packet End To End Delay (Sec) | Packet Delay Variation (Sec) |
| 10 Mbps | 0.0042 | 0.0000050265 | 3.83405 | 1.50679 |
| 100 Mbps | 0.00416661 | 0.0000050066 | 3.97437 | 1.50678 |
| 1 Gbps | 0.00413858 | 0.0000050265 | 2.08074 | 0.524183 |

It has been observed that as the traffic drop is higher in FIFO scheme for both the traffic condition. For WFQ scheme it is minimum in light load as well as heavy load condition.

CONCLUSION

It has been observed after comparing the detail statistics of the result that packet end to end delay is always higher in case of FIFO scheme for both voice and video based content deliver over network. PQ scheme gives better result in some cases as packet end to end delay in case of video based content delivery over the network. However WFQ gives best result among them. Result shows that traffic drop is almost zero in case of WFQ scheme. As per the presented result here in case of WFQ scheme packet end to end delay are proper for audio based content but for video it is bit higher. Results are useful for performance modeling for 3G and 4G network.

## 8. ACKNOWLEDGEMENT

Our sincere thanks to Thakur educational trust and management to provide all the facilities and infrastructure to carried out the research work.

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