NETWORK ANALYSIS USING CUSTOM QUEUEING AND WFQ

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Abstract: **System administrators are in an increasing degree involved with the troubleshooting of solving network problems concerning the quality of service for the different applications. Adding more bandwidth is not always the option to solve network bottlenecks. This is where QoS – Quality of Service aware network plays an important part. If your network has real time traffic like voice, video etc, configuring and maintaining the right QoS parameters becomes all the more important. QoS obviously means Quality of Service. On Analysis it was evaluated that the traffic is queued in "router A" because of the bottleneck. The Custom Queuing mechanism differentiated traffic between queues based on the type of service (TOS). Traffic is sent from each queue in a round-robin fashion. Queues send traffic proportionally to their byte count. In this network queues with high index have higher byte count. As a result of this classification traffic with higher TOS gets better delay. In case study 2, the traffic is queued in router A because of the bottleneck. In this, the WFQ mechanism differentiates traffic between queues based on the type of service (TOS). Queues send traffic proportionally to their weight. Queues with high index have higher weight. As a result of this classification traffic with higher TOS gets better delay.**

Keywords: QoS, ToS, WFQ, Custom Queuing

1. Introduction

Today's computer networks have gone from typically being a small local area network, to wide area networks, where users and servers are interconnected with each other from all over the world. This development has gradually expanded as bandwidth has become higher and cheaper. But when dealing with the network traffic, bandwidth is only one of the important properties. Delay, jitter and reliability are also important properties for the quality of network connection. This is because different applications has different needs, and therefore require different properties from the network. System administrators are in an increasing degree involved with the troubleshooting of solving network problems concerning the quality of service for the different applications. Adding more bandwidth is not always the option to solve network bottlenecks. There are other factors you need to consider like latency, jitter, packet loss, congestion, buffer overflow, etc that might also affect the network performance. This is where QoS – Quality of Service aware network plays an important part. If your network has real time traffic like voice, video etc, configuring and maintaining the right QoS parameters becomes all the more important. QoS obviously means Quality of Service. It is a way to ensure that mission critical and delay sensitive applications get priority over normal data traffic and harmful scavenger traffic while being processed in network devices like network switches and routers in a Local Area Network. QoS enables a network administrator to guarantee a minimum bandwidth for certain classes of traffic & limit the maximum bandwidth for other classes of traffic. QoS enables real time applications like video/ voice to maintain low latency, jitter levels which are absolutely critical for good user experience and they minimize the effects of packet loss and buffer overflow in congested networks. QoS can also play a role in mitigating DoS attacks. QoS parameters can be configured in manageable network switches and routers. All the packets/ network traffic entering into each switch/ router are classified into various Class of Service (CoS) categories. So, network protocol and management traffic might be one CoS category, voice and video traffic might be another CoS category, etc. But before that, all the network traffic should be appropriately classified and marked as close to the source (end point) as possible. Once classified, they need to be Queued using appropriate hardware queues (based on their CoS category) at all levels in the network. Network traffic (individual packets) can be classified and grouped using one of the following methods:

- Explicit 802.1p or DSCP marking
- VLAN / Switched port based grouping
- MAC address based grouping

It is important to ensure that a single QoS scheme is consistently implemented throughout the network. QoS requirements in traditional data networks mainly result from the rising popularity of end-to-end bandwidth-hungry multimedia applications. Different multimedia applications have different QoS requirements expressed in terms of endto-end QoS parameters. The network is thereby required to provide better services than original best effort service, such as guaranteed services (hard QoS) and differentiated services (soft QoS), for end-to-end users/applications. The researchers in the literature have pursued end-to-end QoS support using a large number of mechanisms and algorithms in different protocol layers while maximizing bandwidth utilization. At the same time, different types of networks may impose specific constraints on the QoS support due to their particular characteristics. For example, the bandwidth constraint and dynamic topology of mobile ad hoc networks make the QoS support in such networks much more challenging than in others. Supporting QoS in wired networks can generally be obtained via the over-provisioning of resources and/or traffic engineering. With the method of over-provisioning, we add abundant resources in the network so that it can provide satisfactory services to bandwidth-hungry multimedia applications. This method is easy to realize but all the users are served at the same service class. Therefore, the service may become unpredictable during peak traffic. In the method based on traffic engineering, we classify our users/applications in service classes and assign each class a different priority. QoS is achieved via some strategies such as admission control, policy managers, traffic classes, and queuing mechanisms.

2. Literature Survey

Queuing schemes provide predictable network service by providing dedicated bandwidth, controlled jitter and latency, and improved packet loss characteristics. The basic idea is to pre-allocate resources (e.g., processor and buffer space) for sensitive data. Each of the following schemes require customized configuration of output interface queues. Queuing schemes:

- First In First Out (FIFO),
- Priority Queuing (PQ),
- Custom Queuing (CQ), and
- Weighted Fair Queuing (WFQ).

The stream of packet between two nodes in a network is called a flow. This flow will in a connection-oriented network follow the same route, but in a connectionless network, the packet may take different routes [1] [14][15]. The problem with a connectionless network is that the routes may have different properties. The four main properties for a network connections are [1][15] are Bandwidth, Delay, Jitter and Reliability. The QoS for the routes may not matter for some applications, but it may be crucial for others. *Chengyu Zhu* et.al (Jun 2002) compared the active queue management algorithms using the OPNET Modeler.A number of active queue management algorithms for TCP/IP networks such as random early detection (RED), stabilized RED (SRED), BLUE, and dynamic RED (DRED) have been proposed in the past few years. This study presented a comparative study of these algorithms using simulations. The evaluation was done using the OPNET Modeler, which provided a convenient and easy-to-use platform for simulating large-scale networks. The performance metrics used in the study were queue size, packet drop probability, and packet loss rate. The study showed that, among the four algorithms, SIZED and DRED were more effective at stabilizing the queue size and controlling the packet loss rate while maintaining high link utilization. The benefits of stabilized queues in a network were high resource utilization, bounded delays, more certain buffer provisioning, and, traffic-load-independent network performance in terms of traffic intensity and number of TCP connections. *K. Salah and A. Alkhoraidly* (May 2006) discussed an OPNET-based simulation approach for deploying VoIP. VoIP deployment was a challenging task for network researchers and engineers. This paper presented a detailed simulation approach for deploying VoIP successfully. The simulation used the OPNET network simulator.Recently OPNET has gained a considerable popularity in both academia and industry, but there was no formal or known approach or methodology as to how OPNET can be used to assess the support and readiness of an existing network in deploying VoIP.The approach and work presented in this paper predict, prior to the purchase and deployment of VoIP equipment, the number of VoIP calls that can be sustained by an existing network while satisfying QoS requirements of all network services and leaving adequate capacity for future growth. This paper presented a detailed description of simulation models for network topology and elements using OPNET and also described modeling and representation of background and VoIP traffic, as well as various simulation configurations. Xinjie Chang (2002)worked on Network simulations with OPNET.In it, several computer network simulators were compared. One of the most powerful simulation software packages - OPNET (OPtimized Network Engineering Tool) was introduced in detail. The implementation details of the network models in OPNET are given. *Huijie Li and Xiaokang Lin;Yang* (2006) surveyed An OPNET-based 3-tier network simulation architecture. This paper presented an approach to create a distributed and Web-based 3-tier simulation architecture based on the external model access (EMA) library of OPNET. This architecture can partition modeling and simulation tasks efficiently, and synchronously access the system functions regardless of the location. And at the same time it can share the extremely expensive simulation resources, including the OPNET platform and the hardware devices, among a potentially large number of users. The extensible markup language (XML) was also adopted to describe network simulation scenarios that can be automatically translated into simulation scripts. This technology was especially predominant when focusing on large-scale network simulations. The discussion about the quality of service (QoS) in providing internet protocol (IP) based service in wireless and wired networks have been carried by

Jukka Manner et.al (2002). The study focused on the shortcomings of real time transport protocol (RTTP), insiginia and itsumo protocols. The study focused on the methodologies like strict flow shaping at the network edge, coupling of micro-mobility and quality of service (QoS) protocols, advanced reservations, pre handover negotiations and context transfer methodologies were adopted for improvement in quality of service (QoS).

3. Problem Formulation

Queuing schemes provide predictable network service by providing dedicated bandwidth, controlled jitter and latency, and improved packet loss characteristics. The basic idea is to pre-allocate resources (e.g., processor and buffer space) for sensitive data. Following schemes require customized configuration of output interface queues.

Priority Queuing (PQ) assures that during congestion the highest priority data does not get delayed by lower priority traffic. However, lower priority traffic can experience significant delays. PQ is designed for environments that focus on mission critical data, excluding or delaying less critical traffic during periods of congestion.

Custom Queuing (CQ) assigns a certain percentage of the bandwidth to each queue to assure predictable throughput for other queues. It is designed for environments that need to guarantee a minimal level of service to all traffic.

Weighted Fair Queuing (WFQ) allocates a percentage of the output bandwidth equal to the relative weight of each traffic class during periods of congestion.

Following terminology describes the various objects used to configure the network scenario's:

- **QoS Attribute Configuration Object**
  The QoS Attribute Configuration object defines profiles for the following technologies:
  - FIFO
  - WFQ
  - Custom Queuing
  - Priority Queuing

Each queuing-based profile (e.g., FIFO, WFQ, PQ, and CQ) contains a table in which each row represents one queue. Each queue has many parameters such as queue size, classification scheme, RED parameters etc. Some examples of setting queue priorities are:

- Weight for WFQ profile. Higher priority is assigned to the queue with a higher weight.
- Byte count for Custom Queuing profile. More traffic is served from the queue with a higher byte count.
- Priority label for Priority Queuing. Higher priority is assigned to the queue with a higher priority label.

Router Configuration

QoS specification parameters are available on a per interface basis on every router. The sub-attribute called "QoS info" in the "IP Address Information" attribute is used to specify this information. An incoming and outgoing CAR profile can be assigned to this interface as well as a queuing mechanism (FIFO, WFQ, PQ, and CQ) with its queuing profile. "Queuing Profiles" are special schemes defining different queue configuration options. These are defined on the "QoS Attribute Configuration" object. By default, all QoS parameters are disabled.

Traffic Specification (in server and client nodes)

Clients and servers are in charge of defining the traffic prioritization by setting the IP precedence in the TOS (Type of Service) field of IP datagram. Traffic is prioritized on session basis. In clients the attribute "Application Configuration" defines for each application (Email, Ftp, Http, video conferencing etc.) and the type of service. In servers the attribute "Supported Services" defines for each application and the type of service as well. The type of service is not the only criterion to prioritize traffic in routers. Traffic can be also prioritized based on IP addresses, protocol, and application ports.

This project includes two scenarios. The role of each of the scenario is as follows:

1.Custom Queuing:This scenario illustrates custom queuing at the IP layer.
2. WFQ: This scenario illustrates WFQ at the IP layer.

Different Queuing schemes available are:

1. None: This scenario is a reference scenario. No queuing is defined at the IP layer.

2. FIFO: This scenario illustrates FIFO queuing at the IP layer.

3. Priority Queuing: This scenario illustrates Priority Queuing at the IP layer.

4. Custom Queuing: This scenario illustrates Custom Queuing at the IP layer.

5. WFQ: This scenario illustrates the impact WFQ at IP layer

Custom Queuing Profile: Defines a custom queuing profile for an interface. The following attributes apply to each interface as a whole:

- Name: Name of the queuing management profile.

- Queuing Classification. This attribute is shown as a table. Each row represents a queue. The following attributes apply to each queue:

- Byte count for Custom Queuing

- Maximum Queue Size: A queue which has more packets than its maximum queue size will drop incoming packets.

- RED/WRED parameters: Packets are placed in a queue according to the following criteria, which can be left undefined.

- ToS: Specifies the type of service.

- Protocol: TCP. UDP, OSPF, IGRP, EIGRP, ICMP only.

- IP Source Address

- IP destination Address.

- TCP/UDP Source Port: The choices shown are aliased to the standard port numbers for applications (Http is aliased to 80 for example)

- TCP/UDP Destination Port: Same as TCP/UDP Source Port.

If an incoming packet doesn't comply with any of the user-defined criteria, it is put in the queue

Configured as the "Default Queue". Custom queuing can be enabled on each interface in "advanced" routers. Queuing profile and queuing processing mechanism are set in attribute "QoS info" in "IP Address Information" compound attribute. Queuing profile defines the number of queues and the classification scheme. Queuing profiles are defined in the QoS configuration object. This object is found in "utilities" palette.

Table 1 Application Configuration

S.N	Attribute
1	Video Conferencing (Background)
2	Video Conferencing (Standard)

Table 2 Profile Configuration

S.No	Profile Name	Applications
1	Background Traffic	Video Conferenci (Background)
	Standard Traffic	Video Conferenci (Standard)

Table 3 QoS Configuration

S.N	ToS	Byte Cour	Queue Catego
1	Best Effort (0	2000 byte	Default Queue
2	Background (1)	4000 byte	Low Latency Queue

Table 4 Router Configuration

Attribute	Value
Buffer Size	1 MB
Processing Rate	Link Speed
Queuing Scheme	Custom Queuing
Queuing Profile	ToS Based

Table 5 Client Configuration

Attribute	Value
Application: Destination Preferences	Video Destination (S1)
Selection Weig	100
Application Supported Profile	Background Traffic

CASE STUDY I

Network configuration for Case Study 1:

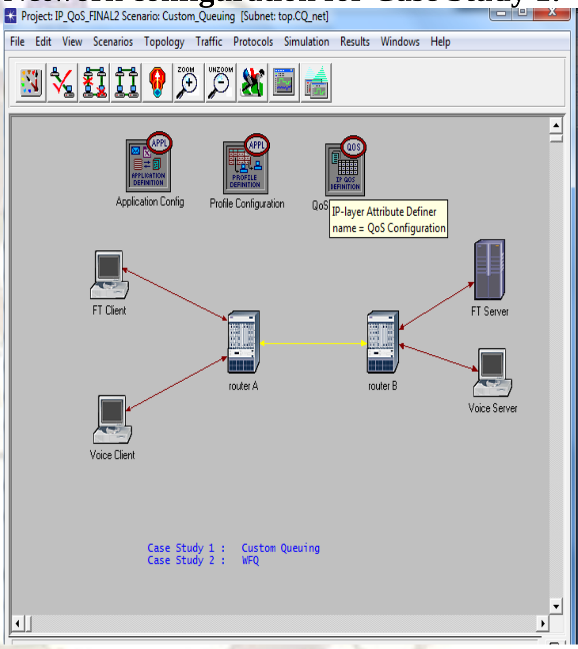

Figure 1 Network scenario for case study 1

The network is composed of two video clients. Each pair uses a distinct TOS (Type Of Service) for data transfer. The link between the two routers is a "potential" bottleneck. Routers support multiple queues for each type of service. Queue 2 receives TOS 2 traffic, queue 1 receives TOS 1 traffic. Queues are serviced using "Custom Queuing" mechanism. On Analysis it was evaluated that the traffic is queued in "router A" because of the bottleneck. The Custom Queuing mechanism differentiated traffic between queues based on the type of service (TOS). Traffic is sent from each queue in a round-robin fashion. Queues send traffic proportionally to their byte count. In this network queues with high index have higher byte count. As a result of this classification traffic with higher TOS gets better delay.

CASE STUDY II

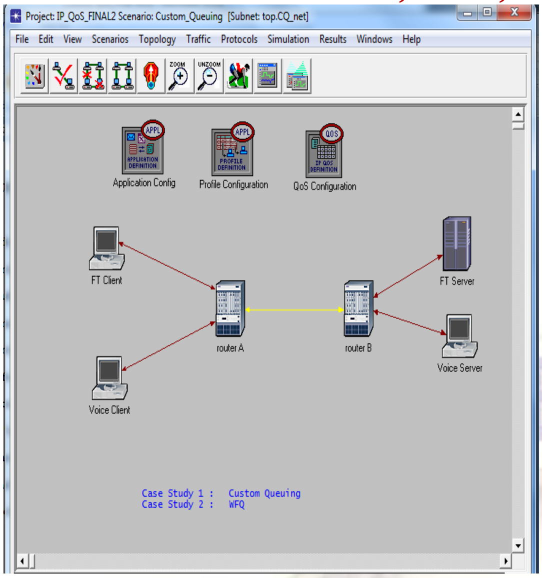

Figure 2 Network scenarios for case study 2

The network is composed of four pairs of FTP and video clients. Each pair uses a distinct TOS (Type Of Service) for data transfer. The link between the two routers is a "potential" bottleneck. Routers support multiple queues for each type of service. Queues are serviced using "Weighted Fair Queuing" mechanism. WFQ queuing can be enabled on each interface in "advanced" routers. Queuing profiles and queuing processing mechanism are set in attribute "QoS info" in "IP Address Information" compound attribute. Queuing profiles define the number of queues and the classification scheme. Queuing profiles are defined in the QoS configuration object. This object is found in "utilities" palette. Traffic is queued in "router A" because of the bottleneck. In this, the WFQ mechanism differentiates traffic between queues based on the type of service (TOS). Queues send traffic proportionally to their weight. Queues with high index have higher weight. As a result of this classification traffic with higher TOS gets better delay.

5. Results

Traditionally the server had processed both the client environment and the production environment. But with the arrival of the pc, user environment processing could be removed from the servers, and done on the clients own processor. This meant a more efficient usage of the processing servers. In situations where the data could be stored on the pc itself, the processing of the production data could be executed on the local processor. But this moved the bottleneck away from the production server processors, and to the network bandwidth. Some advantages with the thick client approach are:

- Lower server requirements, as a thick client does most of the application processing itself.
- Lower user environment network bandwidth usage, because there is no keyboard or screen data that has to be sent to and from the server.
- Higher system reliability, as the thick clients can operate even when the processing servers are unavailable.
- Better multimedia processing: because multimedia processing require high bandwidth and high performance processors.

On Analysis it was evaluated that the traffic is queued in "router A" because of the bottleneck. The Custom Queuing mechanism differentiated traffic between queues based on the type of service (TOS). Traffic is sent from each queue in a round-robin fashion. Queues send traffic proportionally to their byte count. In this network queues with high index have higher byte count. As a result of this classification traffic with higher TOS gets better delay. In case study 2, on Analysis it was evaluated that the Traffic is queued in "router A" because of the bottleneck. In this, the WFQ mechanism differentiates traffic between queues based on the type of service (TOS). Queues send traffic proportionally to their weight. Queues with high index have higher weight. As a result of this classification traffic with higher TOS gets better delay. . The results have been graphically analyzed in the graphs shown in the following figures:

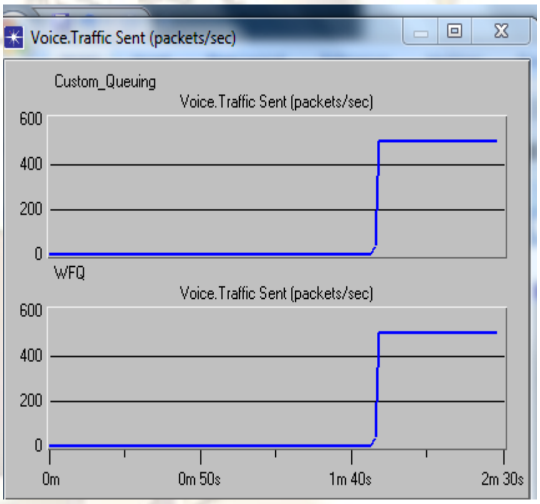

Fig. 3Traffic Sent (Packets/ Sec)

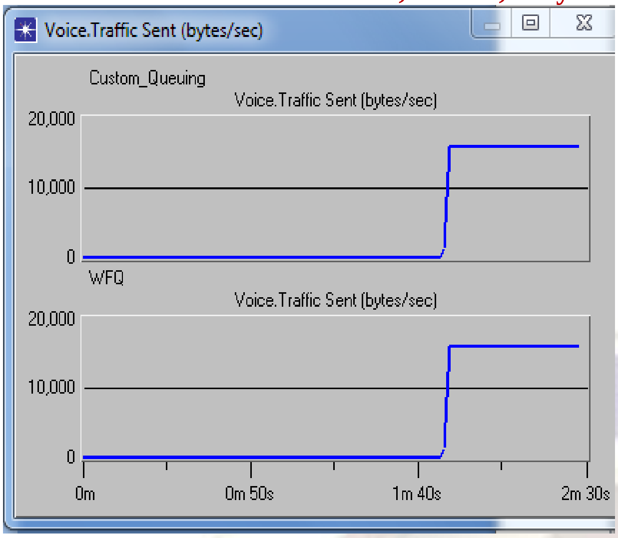

Fig. 4Traffic Sent (Bytes/ Sec)

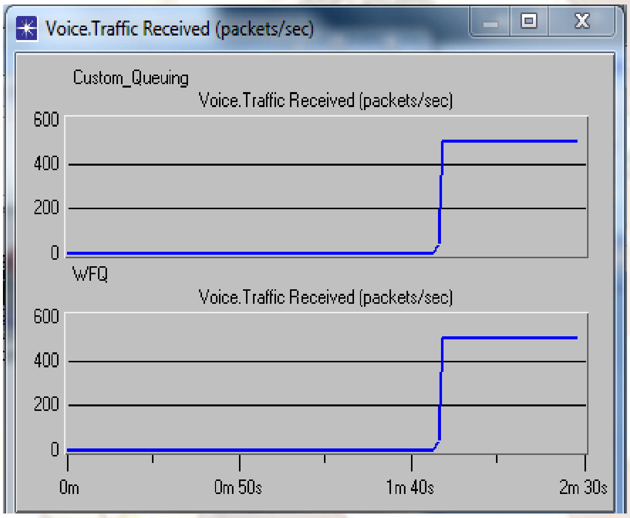

Fig. 5 Traffic received (Packets/Sec)

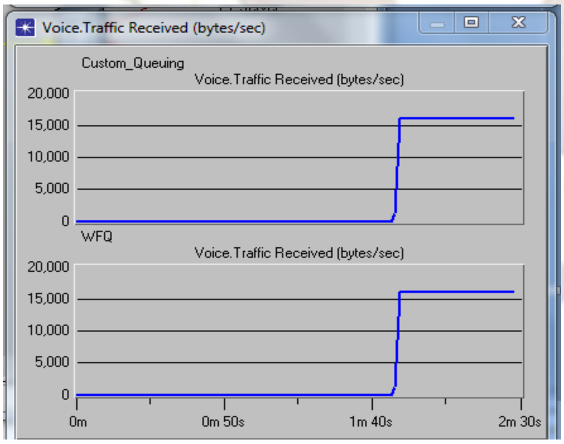

Fig. 6 Traffic received (bytes/Sec)

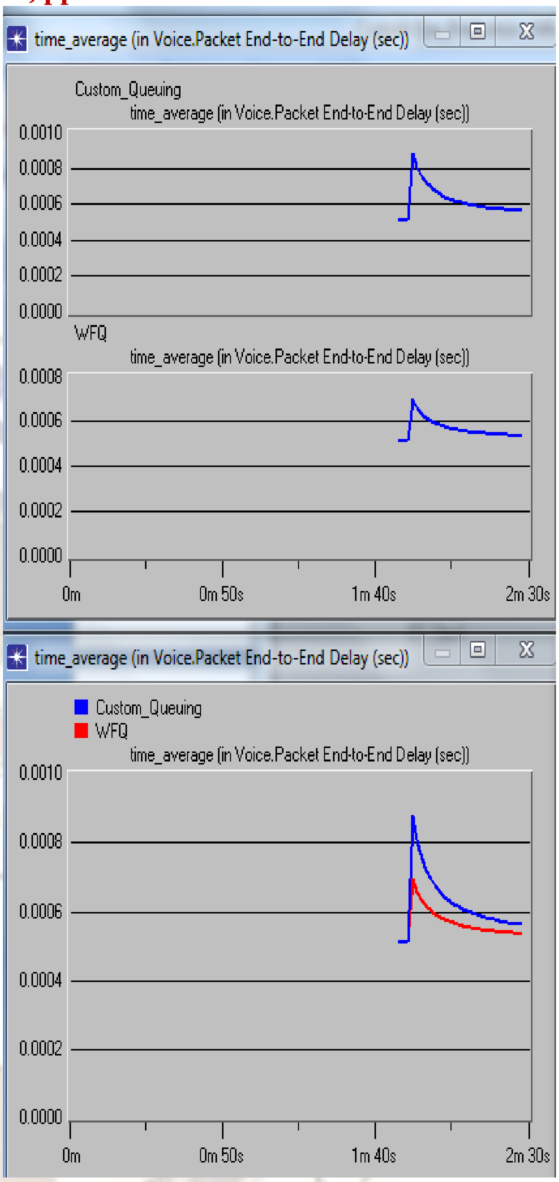

Fig. 4.5 Packet End-to-End Delay (Sec)

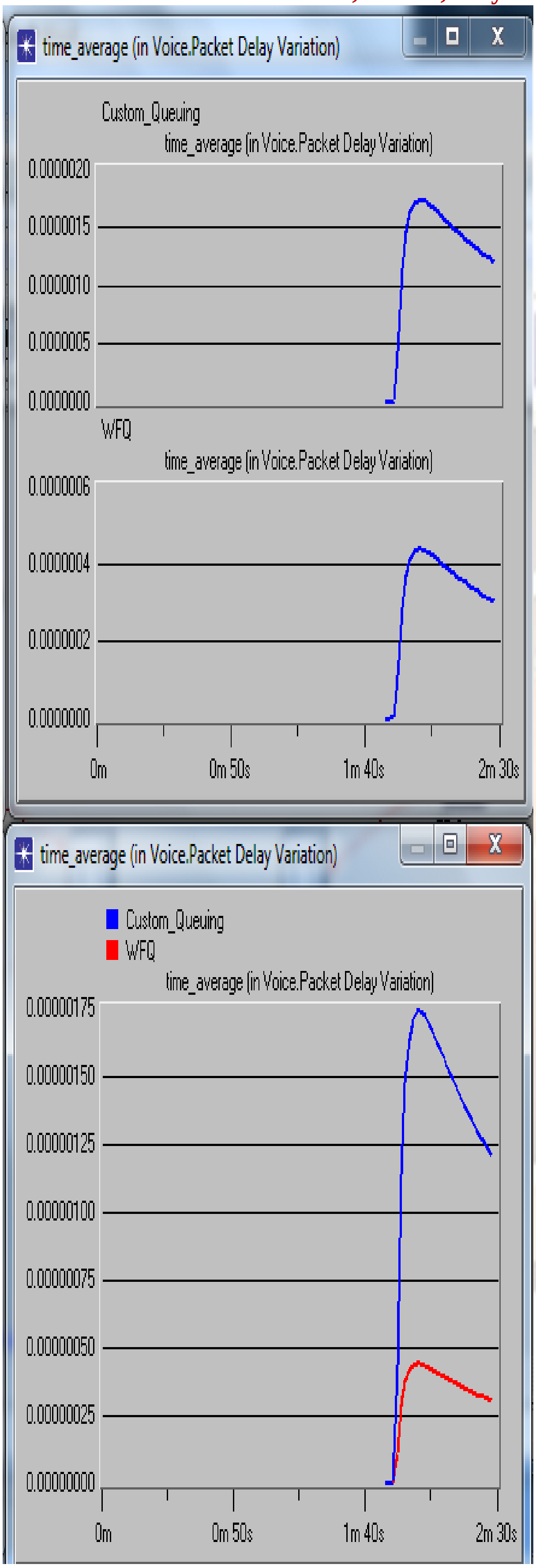

Fig. 4.6 Packet Delay variation

It is important to ensure that a single QoS scheme is consistently implemented throughout the network. QoS requirements in traditional data networks mainly result from the rising popularity of end-to-end bandwidth-hungry multimedia applications. Different multimedia applications have different QoS requirements expressed in terms of end-to-end QoS parameters. The network is thereby required to provide better services than original best effort service, such as guaranteed services (hard QoS) and differentiated services (soft QoS), for end-to-end users/applications. The researchers in the literature have pursued end-to-end QoS support using a large number of mechanisms and algorithms in different protocol layers while maximizing bandwidth utilization.

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