VoIP Performance Over different service Classes Under Various Scheduling Techniques

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Abstract: IP Telephony application or Voice over Internet Protocol (VoIP) is one of the most promising services that can be implemented over the Internet. VoIP is gaining popularity day by day, because of its low bandwidth requirements, lower cost for long distance communication, minimized access charges, and efficient backbones and convincing new services. Real-time applications such as VoIP has many requirements to achieve reliability and enforce quality of service (QoS) capability of IP networks, therefore lack of QoS standards in VoIP network could deter the deployment of this technology in an enterprise. In this paper we investigate the behavior of two VoIP service classes, one is excellent effort and the other is interactive voice, using various scheduling disciplines including First in First out (FIFO), Priority Queue (PQ), Custom Queue (CQ) and Modified Weighted Round Robin (MWRR). The parameters considered for evaluation are packet end-to-end delay (sec) and packet delay variation. This is a simulation study using OPNET IT Guru Academic Edition that is a well known simulator for network performance analysis.

Key words: VoIP, FIFO, CQ, MWRR, PQ, ToS.

INTRODUCTION

Now a day, communication technologies are facing vide variety of problems ranging from local area network to wide area networks that can degrade the performance of a network. Some of them are jitter, delay and packet loss ratio, as they need some special care to avoid.

QoS plays and important role for communication systems to be reliable, so by considering QoS parameters, the above mentioned problems can be reduced or even avoided. QoS can only provide reliable and guaranteed communication between end systems and between different service classes. These different classes have different requirements on communication network or media. For example, in data application the packets can be delayed without noticing, while in VoIP service packets should not be delayed for even a single microsecond.

Scheduling techniques work in combination with queuing techniques (S. Keshav 1991; L. Kleinrock 1975). Scheduling disciplines or queuing plays an important role for network congestion management. It is the only way to fairly share the available network resources. They are also deployed in an environment to prioritize traffic into different service classes and to provide guaranteed communication to delay sensitive applications such as telephony and interactive games.

To deliver QoS, different scheduling techniques require differentiating among different types of packets in the queue and should know the service class for each packet.

VoIP (Voice over Internet Protocol 2007) traffic is very sensitive to packet delay variation and packet end-to-end delay in IP networks. IP Traffic is known as "best-effort", because it delivers packets at the same time as it receives. There are many factors contributing to the total delay in IP traffic, some of them are large packet size, variable bit rate, different types of services (ToS) and large files transfers etc. (Cisco Systems Inc).

In this paper we analyze the performance of two VoIP service classes, one is excellent effort (low load) and the other is interactive voice(high load), through different scheduling disciplines including, First in First out (FIFO), Priority Queue (PQ), Custom Queue (CQ) and Modified Weighted Round Robin (MWRR). The parameters considered for evaluation are packet end-to-end delay (sec) and packet delay variation. This is a simulation study using OPNET IT Guru Academic Edition 9.1 that is a most widely used simulator for network performance analysis.

The remainder of this article is organized as follows: Section II presents brief introduction of queuing disciplines used in this paper. Section III presents the related work. Section IV provides simulation framework, results collected from different scenarios and detailed discussion on these results, and we conclude the paper in Section V.

Overview of Scheduling Disciplines:
A. First-In First-Out (FIFO): A basic and simple queuing discipline implemented on most of the type of routing machines is FIFO. FIFO technique is widely used because of its simple configuration logic. As its name implies First-in First-out, the
logic of FIFO is very simple. Packet arriving from different service classes pick up in the FIFO queue and process in the same order in which queue receive packets. First packet getting into the queue would be the first one of getting out from the queue. Packets already in FIFO queue are dispatched in the same order as they entered into the queue.

Despite of its simple configuration, it has some limitations. Packets belonging to different service classes can’t be distinguished as high, low or medium priority packets. It can’t prioritize delay sensitive traffic. Fig. 1 shows simple configuration of FIFO.

**Fig. 1:** FIFO Queuing.

### B. Custom Queuing (CQ):

Custom queuing is also known as bandwidth allocation discipline, that services each non-empty queue sequentially in round robin format, and allocate a configurable percentage for each traffic flow on each queue. CQ guarantees mission critical data to be assigned certain percentage of the whole bandwidth, while assuring other traffic getting predictable throughput (R. Fantacci 2001). CBWFQ is an example of custom queuing.

Custom queues as shown in fig 2 are classified into 16 queues. Distant from the 16 queues, queue 0 is a special queue called system queue, which is used to handle keepalive and control packets that are considered as high-priority packets. Queues 1 to 15 are used to carry user defined traffic whereas user traffic cannot pass through queue 0. The classification of IP packets in custom queuing is based on input interface, access control lists, application types and packet size.

**Fig. 2:** Custom Queuing.

### C. Priority Queuing (PQ):

Priority queue shown in fig. 3 is classified as four output subqueues, high, medium, normal and low, in descending priority order. Packets are transmitted in decreasing order of priority, means highest priority queue is emptied first and then data on next highest priority queue is transmitted and so on. Packets in medium priority queue can be services until the packets in highest priority queue are transmitted. Packets within a normal priority queue are serviced as FIFO order. Normal priority queue contains unclassified data traffic.

Priority queuing technique is best suitable for situation where mission critical traffic needs to be categorized as high priority traffic (K. Sadafale, S. Barahate and Prashant Jawade 2010). Some time during network congestion, mission critical traffic can utilize 100 percent bandwidth of a link. The classification of IP packets in priority queuing is based on input interface, access control lists, application types and packet size.
D. Modified Weighted Round Robin (MWRR):

MWRR (Subash T and S. Indiragandhi 2006) is used in Cisco Catalyst switches. A weight is assigned to each queue in MWRR queuing. This technique uses variable-sized packets to be serviced. For this purpose it uses a deficit counter variable to initialize to each queue’s weight. Before a queue is serviced, its deficit counter is initialized to the queue’s weight. A packet is scheduled if the deficit counter is greater than zero. Assume, 5-cell packets are being serviced and at the same time the counter would be decremented by 5. As long as the value of counter is greater than zero the packets in queue are scheduled, if not skips to the next queue. Again for the next round the queue’s deficit counter is incremented by the queue’s weight.

For each non-empty connection (H.M. Chaskar and U. Madhow 2003) MWRR serviced a number of packets where:

\[
\text{Number normalized} = \frac{\text{Weight}}{\text{mean packet size}}
\]

Related Work:

Simulation study (Subash T and S. Indiragandhi 2006) analyzed optical networks using some queuing techniques, and concluded that PQ, DWRR, MWRR and WFQ has nearly similar packet drop ratio. A sharp fall is observed when traffic is received using PQ and CQ, where WFQ doesn’t receive any voice traffic through all simulation time, due to its bursty nature.

Studies (Klepec, B. Kos, A. 2001; Velmurugan, T., H. Chandra and S. Balaji 2009) compared the performance of VoIP traffic at different network loads when using DiffServ architecture. FIFO and PQ queuing techniques were used to compare packet delay for VoIP traffic.

(K. Salah and A. Alkhoraidly. 2006) Focused on different technical and design issues related to VoIP deployment in an enterprise. The following issues were included: QoS requirement for VoIP traffic, Call distribution and flow of traffic, future growth capacity planning and impact of background traffic on VoIP traffic.

We have used the following parameters for analysis: packet end-to-end delay and packet delay variation for the analysis of VoIP traffic. To the best of our knowledge, a detailed study intended to the comparison of VoIP for different service classes has never been commenced in earlier research work.

Simulation Study Analysis:

This portion presents our simulation study to compare performance of different VoIP classes using FIFO, PQ, CQ and MWRR queuing discipline.

Experimental Tool: OPNET:

OPNET’s IT Guru Academic Edition (OPNET) provides an environment where different network architectures can be model to test and validate different protocols, devices and applications before actual deployment of network architecture.

OPNET is a most widely used network simulator for modeling real world scenarios and is used by researchers, planners, system administrators and students. It also provide testing facility for various Internet protocol implementations ranging from local area network (LAN) to wide area networks (WAN) using many built-in architectural models.
Simulation Framework:

The simulation framework that we have used is shown in Fig. 1. It contains the followings:

- Two ethernet gateways (ethernet4_slip8_gtwy) directly connected to each other with PPP_DS3 link.
- Two ppp_wkstn on left side initiates requests for both Excellent Effort Voice and Interactive Voice applications respectively.
- Two ppp_wkstn on right side responds to each service request for Excellent Effort Voice and Interactive Voice applications respectively.
- Two PPP_DS1 links to connect each application client to router1.
- Two PPP_DS1 links, which connect router 2 to each application server.

RESULTS AND DISCUSSIONS

![Simulation Framework](image)

Fig. 4: Simulation Framework.

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![Figure 5](image)

Fig. 5: HI Priority DestVoice Called Party-Packet end-to-end delay (sec).

![Figure 6](image)

Fig. 6: HI Priority Dest Voice Called Party-Packet Delay variation.

For the voice packet end-to-end delay (sec) of high priority destination, Fig. 5 shows that the PQ scheduling technique attains the lowest average of 0.003249 seconds. In contrast, the protocols FIFO, CQ, MWRR attain respectively the average queuing delay variation of 0.01535, 0.01216 and 0.01591.

The PQ scheduling technique is therefore 78%, 73% and 79% better than FIFO, CQ and MWRR respectively for VoIP with high priority (interactive voice) application.

For the packet delay variation (jitter) of high priority destination, the results in Fig. 6 show that the PQ technique attains the lowest average of 5.36882E-07. In contrast, the queuing techniques FIFO, CQ and MWRR respectively.
achieve respectively the average queuing delay of 0.00062, 0.00038 and 0.00107. The PQ technique is therefore better than FIFO, CQ and MWRR respectively for high load (interactive voice) applications.

![Figure 7: Low Priority Dest Voice Called Party–Packet End-to-End Delay (sec).](image1)

For the voice packet end-to-end delay (sec) of low priority destination, Fig. 7 shows that the CQ scheduling technique attains the lowest average of 0.01252 seconds. In contrast, the protocols FIFO, MWRR and PQ attain respectively the average queuing delay variation of 0.01677, 0.01582 and 0.013225.

The CQ scheduling technique is therefore 25%, 20% and 61% better than FIFO, MWRR and PQ respectively for VoIP with low priority (excellent effort voice) applications.

For the packet delay variation (jitter) of low priority destination, the results in Fig. 8 show that the CQ technique attains the lowest average of 0.00039. In contrast, the queuing techniques FIFO, MWRR and PQ achieve respectively the average queuing delay of 0.00064, 0.00092 and 0.00305. The PQ technique is therefore 39%, 57% and 87% better than FIFO, MWRR and PQ respectively for low load (excellent effort voice) application.

![Figure 8: Low Priority Dest Voice Called Party–Voice. Packet Delay Variation.](image2)

![Figure 9: HI Priority Src Voice Calling Party–Voice. Packet End-to-End Delay (sec).](image3)
For the voice calling party, packet end-to-end delay (sec) of high priority source, Fig. 9 shows that the PQ scheduling technique attains the lowest average of 0.00324 seconds. In contrast, the protocols FIFO, CQ, MWRR attain respectively the average queuing delay variation of 0.01500, 0.01185 and 0.01567.

The PQ scheduling technique is therefore 78%, 72% and 79% better than FIFO, CQ and MWRR respectively for VoIP with high priority (interactive voice) application.

For the packet delay variation (jitter) of high priority source, the results in Fig. 10 show that the PQ technique attains the lowest average of 5.38852E-07. In contrast, the queuing techniques FIFO, CQ and MWRR achieve respectively the average queuing delay of 0.00058, 0.00040 and 0.00085. The PQ technique is therefore better than FIFO, CQ and MWRR respectively for high load (interactive voice) application.

For the voice packet end-to-end delay (sec) of low priority calling party (source), Fig. 11 show that the CQ scheduling technique attains the lowest average of 0.01194 seconds. In contrast, the protocols FIFO, MWRR and PQ attain respectively the average queuing delay variation of 0.01522, 0.01575 and 0.02622.

The CQ scheduling technique is therefore 21%, 24% and 54% better than FIFO, MWRR and PQ respectively for VoIP with low priority (excellent effort voice) applications from source perspective.

For the packet delay variation (jitter) of low priority calling party (source), the results in Fig. 12 show that the CQ technique attains the lowest average of 0.00038. In contrast, the queuing techniques FIFO, MWRR and PQ achieve respectively the average queuing delay of 0.00056, 0.00085 and 0.00223. The PQ technique is
therefore 30%, 54% and 82% better than FIFO, MWRR and PQ respectively for low load (excellent effort voice) application from source perspective.

**Conclusion and Future Work:**

This paper evaluates the performance of VoIP with two service classes; excellent effort voice (low load) and interactive voice (high load) using FIFO, CQ, MWRR and PQ scheduling techniques. We simulate and compare four scenarios each using FIFO, CQ, MWRR and PQ queuing technique respectively, focused on the following parameters for analysis; voice packet end-to-end delay (sec) and voice packet delay variation.

For high load source and destination, priority queue (PQ) imparts the least packet end-to-end delay and packet delay variation than FIFO, CQ, MWRR on VoIP traffic. For low load VoIP applications, custom queue (CQ) marginally better, as it produced lowest packet end-to-end delay, and packet delay variation.

As for our future work, we intend to compare more service classes in VoIP and multimedia networks taking special care of QoS.

**REFERENCES**


