# Scheduling Mechanism for Real-Time IP Traffic in DiffServ Networks

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## 1 Introduction

The current Internet architecture provides only best effort service. Such service is adequate for traditional Internet applications like e-mail, web browsing or file transfers. However, the new emerging real-time applications, such as voice over IP (VoIP), and multimedia conferencing, require high bandwidth capacity and are sensitive to delay and delay variation. Consequently, the need to equip the Internet infrastructure with mechanisms to enable Quality of Service (QoS) is natural.

The research efforts by the Internet Engineering Task Force (IETF) to enable end-to-end QoS over IP networks have led to the design of the Differentiated Services (DiffServ) architecture [1]. The architecture defines a framework for providing QoS in the Internet. It also defines the externally visible per-hop behaviors (PHBs) capable of supporting different traffic classes for the provision of QoS on the Internet. In DiffServ approach, a key desirable property is the ability to provide service differentiation among traffic classes in a scalable way. [2] describes a DiffServ PHB called expedited forwarding (EF) intended for use in building a scalable, low loss, low latency, low jitter, assured bandwidth, end-to-end service that appears to the endpoints like an unshared, point-to-point connection. To achieve such behavior, service isolation is needed among different traffic classes. The packet scheduler is one of the key components of DiffServ networks, which play important roles in service isolation because it actually gives different services to different traffic classes.

Thus, we adopt a simple and yet an effective scheduling algorithm for DiffServ based Internet. The mechanism is capable to adapt to distinct conditions of multiple service classes within Diffserv QoS classification dimensions. It incorporates the best characteristics of some existing approaches, notably the well known weighted fair queueing (WFQ) scheme, and its variant, worst-case fair weighted fair (WF2Q) queueing [3]. We call this algorithm "Enhanced" WFQ, as it depicts the capacity to adapt efficiently to Differentiated services environment conditions.

The most important aspect of EWFQ, in the context of supporting real-time applications, is that, unlike priority queueing, traffic with a lower priority service classes still gets their bandwidth shares. This allows more equitable sharing of link bandwidth, which otherwise being considered difficult to satisfy the QoS requirements of other classes, too. For instance, in the case of priority queueing, absolute priority is given to real-time traffic when higher priority is designated to them. However, in order to prevent the real-time traffic from monopolizing the whole bandwidth, it is also necessary or desirable to place an upper limit on the bandwidth consumption.

## 2 Proposed Scheduler: EWFQ

In this section, we propose a scheduling algorithm called EWFQ for DiffServ Networks. The basic operation of EWFQ is similar to the popular WFQ. However, the scheme considers the existence of service classes rather than dealing with flows. Therefore, EWFQ is an enhancement to the popular WFQ scheduling mechanism in such a way that not only tight delay bounds are maintained but also simplification of implementation complexity are offered in the context of Diffserv environment. The calculation of virtual times are weighted according to given weight ratios such that resulting in better performance for the classes with higher weight parameters.

First, this offers better controllability to users as only the weight parameters have to be set. Moreover, such a scheme is useful if there is a direct relationship between the delay bounds specified in the scheduler and the playback delays in real-time applications, such as VoIP. In this case packets exceeding their rates have to be delayed or discarded in the node devices. So the proposed scheduler offers the ability to separately influence the delay and bandwidth components, which both degrade the quality of real-time applications as perceived by end users.

## 3 Performance Evaluation

We validate this scheme using simulation with Network Simulator, ns-2. The key aspect of the experiment is to evaluate the guaranteed bounds on delay and jitter to high priority class by EWFQ scheme, while equally observing its fair allocation of link bandwidth to other low priority service classes. These performance characteristics enable to determine whether the suggested scheme can support VoIP applications in Diffserv networks to achieve an acceptable speech or sound quality.

### 3.1 Description of Simulation Model

To evaluate the effectiveness the scheduler through simulations, we use the simple network model as depicted in Figure 1 below. In this model, we consider a network connection between six computers over a single-domain route in which the network connection passes through three routers.

In order to perform more realistic simulations with a variety of traffic behaviors, we also consider three types of traffic mixes as follows: voice traffic, constant-bit-rate (CBR)

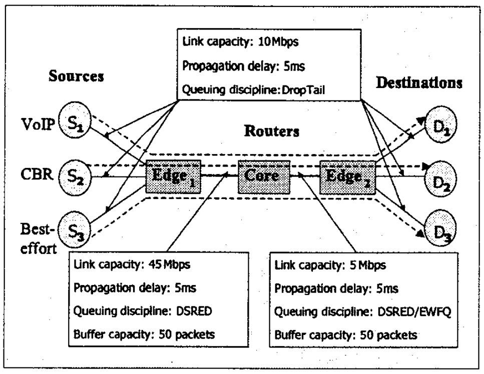


Figure 1: DiffServ Network Model for Simulations

data over UDP, and FTP data over TCP. The voice traffic is an exponential on-off traffic, and consists of 100 flows; each characterized by packet size of 84 bytes, burst time 350ms, idle time 650ms, and rate of 64kbps during on period. Our aim is to emulate voice traffic over differentiated IP networks so that we can use this as VoIP model traffic to be treated with Diffserv EF PHB. On the other hand, the second class of traffic consists of 3 CBR sessions to be treated with assured forwarding (AF) PHB, and the third class, which represents best effort (BE) background traffic, consists of a set of 5 FTP flows.

Furthermore, the packets from these classes of traffic are scheduled using EWFQ policy with relative weights of $\phi_1 = 6(60\%)$, $\phi_2 = 3(30\%)$, and $\phi_3 = 1(10\%)$, to represent DiffServ PHBs of EF, AF, and BE, respectively. The scheduler was setup at the hot-spot point between Core and Edge 2 routers, according to Figure 1. That means, the three service classes share the same bottleneck link of 5 Mbps bandwidth. To isolate the three types of classes, each router has three physical queues of size 100 packets scheduled using EWFQ policy.

### 3.2 Simulation Results

We briefly discuss simulations results showing the benefits of the proposed scheduler in DiffServ network environments. Figure 2 and Figure 3 present the end-to-end packet delay and jitter of each class, respectively.

From these simulations results, we observe that voice traffic, which is classified with the highest priority, receives much tight delay bound, while its jitter is almost insignificantly small. Though it is not shown here, the request for bandwidth is also completely satisfied compared with lower priority traffic classes. This was true even when the rates of the background best effort traffic were increased. If the weight $\phi_1$ is set to be large, and at the same time the voice traffic class has many more sessions to establish, then the performance of other classes is degraded significantly due to the delay in the their respective queues, as the scheduler visits much often the higher priority queue.

Figure 2 shows clearly how all voice packets are served with the highest assurance of delay bounds regardless to the rates of other lower priority classes. For other classes, the delay variations are correlated with the increment of their

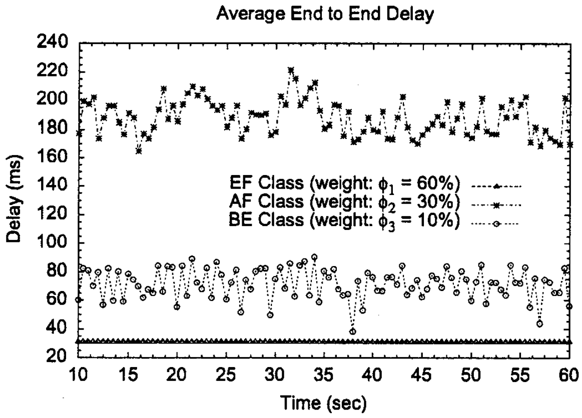


Figure 2: End-to-end delay guaranteed by EWFQ

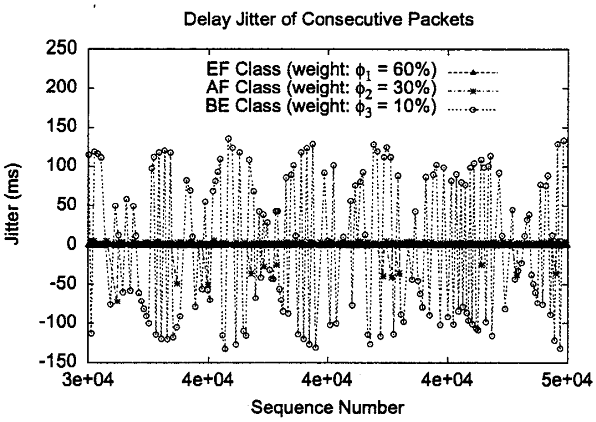


Figure 3: Inter-packet jitter

average queue size. This is again due to 60% of the service time of the scheduler is spent for voice class. As a result, the more the queue is in congestion, the more the delay for packets to reach the destination is increased.

## 4 Conclusion

With the emerging real-time applications, such VoIP, the Internet must be ready to handle different types of traffic classes. In this study, we examine whether it is feasible to achieve service differentiation across multiple traffic classes. To this end, a proper scheduling mechanism is proposed for DiffServ-based networks. The results show that the proposed EWFQ is effective in providing better service to voice over data while providing the additional benefits of fair bandwidth sharing among other traffic classes. The new method is able to maintain delay bounds, and distribute bandwidth according to the predetermined weights for service classes, under various traffic and network conditions.

### References

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