Novel Adaptive Scheduling Scheme for Multimedia Networks with Differentiated Services

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Abstract – **In this paper we present a new scheduling discipline, which is a designed to be used with diffserv enabled multimedia networks. The main approach is to use Weighted Round Robin that dynamically adapts to the traffic behavior. The goal is to avoid use of weights that are statically assigned. Dynamic weights adjustment is crucial in multimedia networks which provide multimedia services including real-time services such as video streaming and Voice over IP, with implemented admission control. Also, the correlation of the scheduling scheme and the admission control is investigated in the paper.**

Keywords – **Admission Control, DiffServ, Packet Scheduling, Weighted Round Robin.**

I. Introduction

Today we are facing an explosion of Internet traffic, mostly real-time traffic such as VoIP and video conferencing, which puts a lot of demand on the current network topologies. It complicates the process of planning and dimensioning of such networks in terms of Quality of Service (QoS) support [1]. Network designers need to develop mechanisms to support such growth of services and improve network performance.

There are many technologies, like DiffServ (Differentiated Services), IntServ (Integrated Services), Admission Control and different scheduling schemas etc, which support to real-time services in multimedia networks [2]. DiffServ means Differentiated Services and provides a way to classify traffic for different treatment by the network [3]. This lets us to give different treatment to different types of traffic. The standard proposes three classes of traffic: Expedited forwarding or the premium service, Assured forwarding and best-effort. In addition assured forwarding is divided in four classes and each having three subclasses.

Scheduling schemas along with DiffServ can further improve network performance. Admission Control lets us determine how much traffic we let in the network. If there are available resources in the network a connection is allowed, otherwise is denied.

For DiffServ network on needs a scheduling discipline in each router in the DiffServ domain [4]. Most used scheduling disciplines are priority queuing, Weighted Fair Queuing and Weighted Round Robin. When priority queuing is used the priority class packets are serviced prior to other classes. This may result in poor performance of the other classes, because bandwidth is monopolized by higher priority class.

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When a discipline is based on usage of weight coefficients, then each class receives bandwidth that is proportional to the given weight. In this approach the main problem is how to set the weights. Additionally, admission control is needed for real-time flows such as conversational services [5] (e.g. Voice over IP – VoIP). With admission control and frequent traffic load changes, the static weights approach doesn't give best performance of the network and desired service quality.

In this paper we propose a novel discipline with adaptive weights. Weights are adapted dynamically so that each class receives bandwidth proportional to the assigned weight. Such scheduling schemes are Weighted Round Robin (WRR) and Weighted Fair Queuing (WFQ). We perform analysis of the performance of the proposed scheduling scheme in scenarios with implemented admission control.

In our simulation analysis we use three classes, i.e. for video, voice and Internet traffic, respectively.

II. Adaptive scheduling scheme

The general concept of scheduling is shown in figure 1. The weights are associated with the amount of bandwidth that each class gets. The figure shows the scheduling for a DiffServ environment.

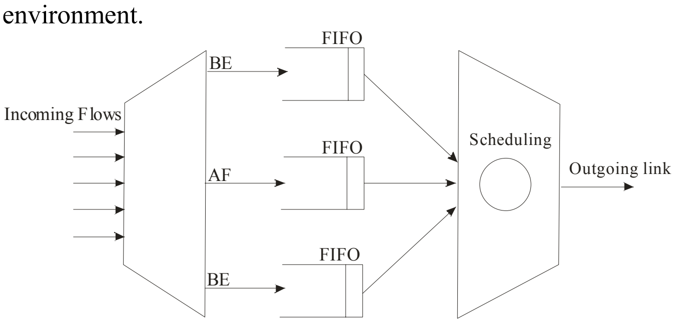

Fig. 1. Scheduling for DiffServ environment

WRR or weighted Round Robin is a discipline in which the packets are served in round robin manner. The service time that each class gets is derived from the weights of that particular class. The serving algorithm first calculates the normalized weights by taking into account the class average packet size i.e. $w_i = w_i / P_i$. Then, it finds the minimum normalized weight. For each nonempty connection every round WRR serves the minimum between the packets that are weighting and the packets to be served.

We propose an adaptive schema that adjusts the weights for each connection. It this schema the normalized weights are given as:

$$w_i = K\rho_i / P_i \qquad (1)$$

where K is a adjusting constant, P_i is an average packet size of class i and ρ is:

$$\rho_i = \frac{r_i}{\sum_i r_i} \qquad (2)$$

We propose another schema that takes buffer behavior in to account. We use the average buffer state of all classes:

$$avg = \frac{\sum_N avg_i}{N} \qquad (3)$$

When the average is calculated the weights are calculated according as follows:

$$w_i = K\rho_i / P + avg_i - avg \qquad (4)$$

The average queue size is calculated as in the case with Random Early Detection. The average queue size is calculated by using low-pass filter. In such case, assuming q as instantaneous queue size and f_l for low-pass filter, we obtain:

$$avg \leftarrow (1 - f_l) \cdot avg + f_l \cdot q \qquad (5)$$

The adaptive schema according to (4) is shown in Figure 2. The class's average packets in the buffer are checked prior to weights' settings and implementing the WRR.

III. Simulation Results

For the purpose of demonstrating the behavior of the adaptive scheduling we used ns-2 network simulator. We set a topology with DiffServ, Admission Control and two scheduling disciplines defined by (1) and (4). The topology consists of source nodes, access node and destination node. We analyze the queue at the access node. The queue is formed from the packets from the source nodes send to the destination node. We recognize three form of source nodes. Internet traffic is presented with a single node that generates packets with Poisson arrival process and Pareto distributed packet length.

The intensity of the traffic is 0.33 meaning that the incoming traffic is 33% of the outgoing link. The outgoing link is 8.192 Mbps. The packet size is Pareto distributed with mean packet size 128 bytes. The mean arrival time is calculated from the mean packet size and incoming traffic rate. The shape factor is set to two which provides self similarity to the packet size [6], [7].

IP Telephony traffic is presented with audio source nodes and each source node presents a single audio source. We used on/off audio sources.

The mean packet size is 64 bytes and is distributed according to Exponential model. Silent period or idle time is set to be 650 ms and the burst period is 352 ms. During the burst period the source generates traffic with 32 Kbps rate.

For video streaming flows we used MPEG-4 traces [8]. The trace is taken from the movie Jurassic Park. Its parameters are given in Table II.

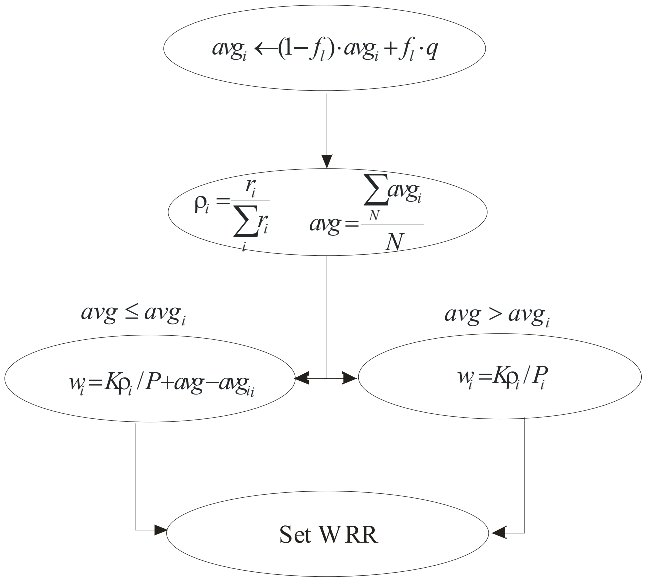

Fig. 2. Adapting the weights

TABLE II
MPEG – 4 SOURCE PARAMETERS

File Size	byte	3.4e+08
Video run time	msec	3.6e+06
# of Frames	-	89998
mean frame size	byte	3.8e+03
var frame size	-	5.1e+06
CoV of frame size	-	0.59
min frame size	byte	72
max frame size	byte	16745
Mean bit rate	bit/sec	7.7e+05
Peak bit rate	bit/sec	3.3e+06
Peak/Mean of bit rate	-	4.37

From the source nodes the traffic is accepted in the access node at which point we do our analysis. At the access node traffic is grouped into three classes and each class is representing different media type. The grouping is available by implementing DiffServ.

The next mechanism implemented is Admission Control. Every source, VoIP or MPEG-4, tries to establish a connection with duration of 20 seconds. If it establishes a connection, at the end of the connection, it tries to establish a new one. This means that connections always are incoming.

Also, connections are allowed if the measured capacity plus the rate of the connection is greater then 90% of outgoing link capacity, a measurement based admission control is implemented.

In this paper we analyze the behavior of the packet loss and the average packets in the buffer. Four scenarios are used. In the first one we use RR, while WRR is used in the second case. When RR is used in each round a packet gets served from each nonempty connection. WRR introduces weights and packets are served according to class weights.

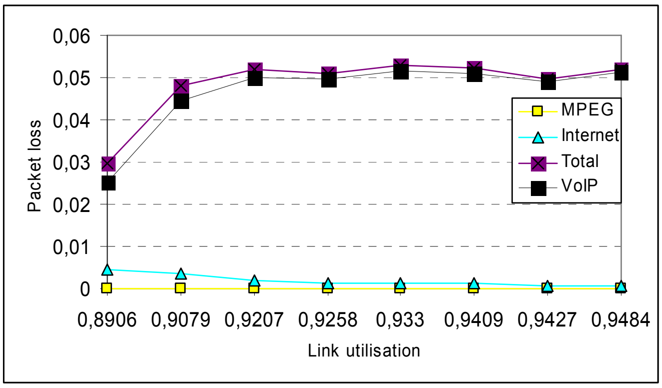

Fig. 3. Packet losses for RR scheduling

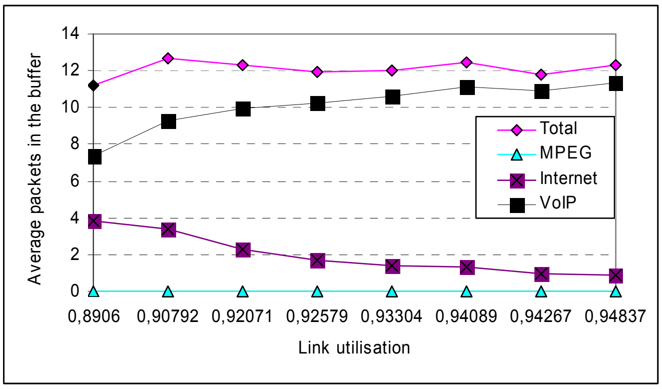

Fig. 4. Average packets in the buffer for RR scheduling

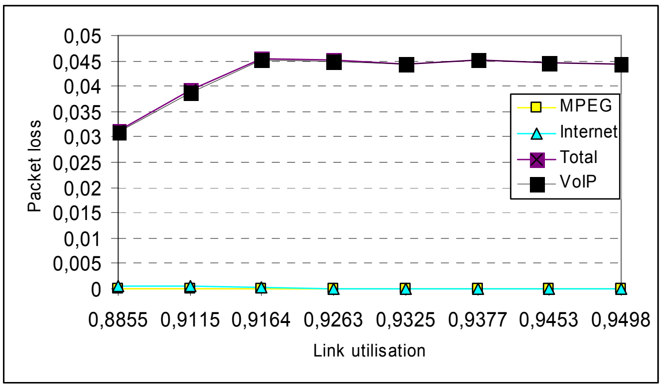

Fig. 5. Packet losses for WRR scheduling

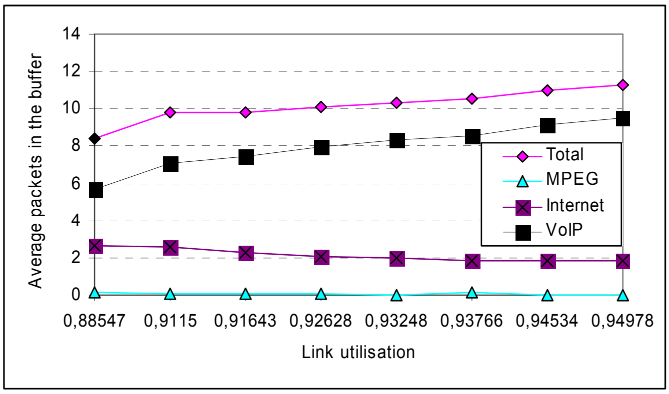

Fig. 6. Average packets in the buffer for WRR scheduling

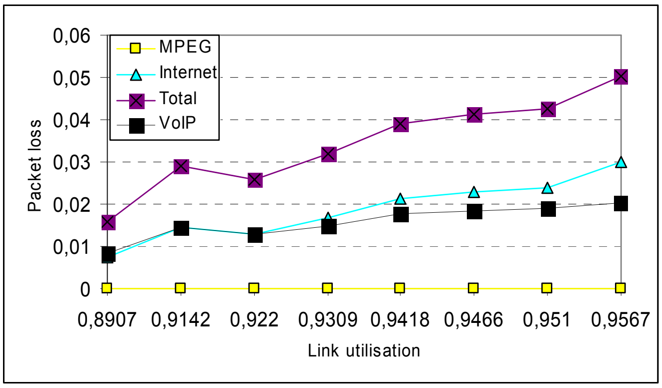

Fig. 7. Packet losses for scheduling according to (1)

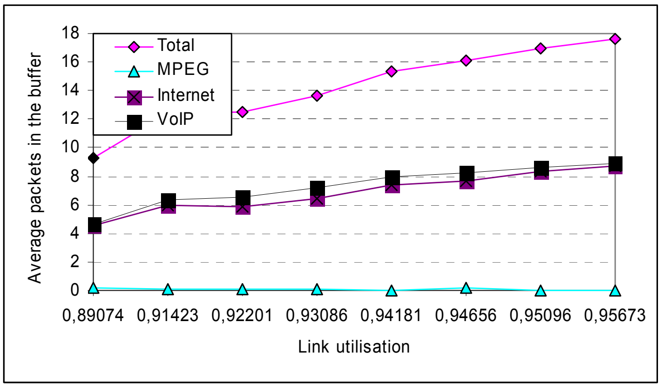

Fig. 8. Average packets in the buffer for scheduling (1)

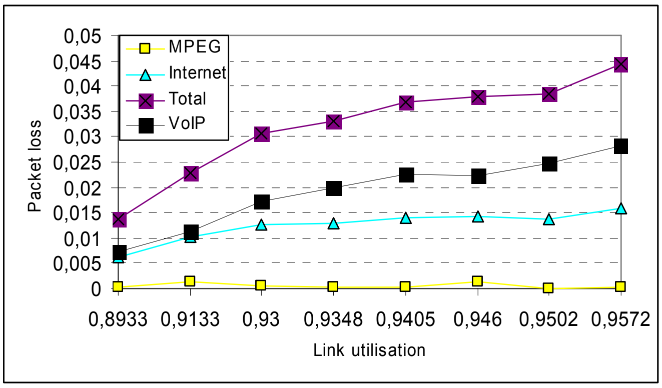

Fig. 9. Packet losses for scheduling according to (4)

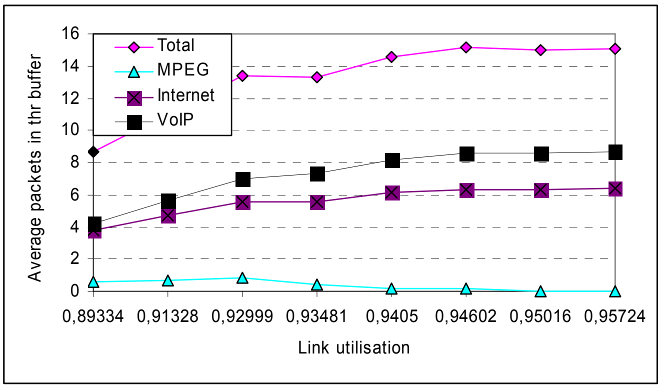

Fig. 10. Average packets in the buffer for scheduling (4)

Such approach solves the problem when classes have different packet sizes. Difficulty appears when WRR is combined with admission control mechanism. Then, this becomes a problem of setting the weights. In our simulation the proposed algorithm sets the weights proportional to the maximum bandwidth that each class demands, and at the same time not calculating the traffic that is to be denied.

We try to avoid the weights problem by using adaptive scheduling according, where the weights are adjusted every time a connection starts or ends, according to (1). Another way to avoid the weights adjusting problem is the fourth scenario where we implement adaptive scheduling that takes into account the behavior of the buffer according to (4). This schema uses the same approach of setting the weights dynamically, but it also uses the buffer behavior to improve the weights settings. The schema finds the class with largest queue length in the buffer and favorites it by giving it larger scheduling weights. This improves performance of the class that has the worst performance and that might have been underestimated by other scheduling disciplines. Results are shown in Figures 3 to 10.

In Figures 3, 5, 7 and 9 are shown packet losses for all disciplines. We can notice that total packet loss varies from 0.045 to 0.05 in the used scenarios. The interesting point is that the RR and WRR discipline show poor performance of the voice class.

When RR is used the voice class gives worst performance because it has smallest packet size. RR serves one packet from each class giving advantage to classes with higher packet size like the class for video traffic. When WRR is used, the lack of knowledge for each class bandwidth usage ends up in bad setup of WRR weights.

Better performance are seen when weights are adopted when traffic changes. Now the total packet loss is split between the voice class and the Internet class. The video class presents traffic with large average packet size. The number of packets that belong to this class is low compared to other classes. This results with low packet loss for the video class.

We can draw the same conclusions when an average packets in the buffer. This can be seen in Figures 4, 6, 8 and 10. When RR and WRR used this class builds up the buffer. We can see that there exist significant difference between this class and other classes. Such difference can be up to 10 packets when RR is used. Adjusting the weights closes the gap between classes.

It is interesting to compare the two disciplines that adjust the weights. When the first adaptive WRR discipline is used the Internet class has the worst performance. Using the second discipline gives less service to the voice class and now it has worst performance. This is expected since the schema favorites the class with worst performance from the buffer point of view. Such performance improvement of the Internet class is followed by degradation in the performances of the video class and the voice class. But, this is significant compared to overall performance. We can notice that overall packet loss is smaller when we use the scheme that uses the buffer state as well.

The same behavior can be seen when the average buffer queue size is analyzed. Figure 4 and 6 show the behavior of the average number of packets in the buffer.

Also there is a large improvement of the Internet class whose value decreases when we use adaptive scheduling scheme with buffer knowledge.

IV. Conclusions

In this paper we described QoS mechanisms that improve the performance of the real time media. At the beginning we explained the DiffServ mechanism that differentiates the services in to classes so that they get different treatment. This allows us to favor some of the classes. Different scheduling schemas contribute to the goal of improving the performance with the same approach of letting us to favor some class and utilize the service time more efficient. We presented two adaptive scheduling schemes that are based on WRR. The first one adapts the weights to the data rates and the second one adds to the scheduling scheme the behavior of the buffer state. We compared the schemas in an environment where we implemented an admission mechanism that allows us to accept or deny the establishment of new connections according to the available resources in the network. This way we control how much traffic we let in the network and provide an environment where class rates change so often that the difficulty of setting the weights is always present.

Simulations are presented to confirm how these mechanisms contribute to network performance. The first scenario uses the schema where weights are set proportional to the rates of each class. The second schema takes into account the buffer state. We compare the schemas with RR and WRR with statically assigned weights.

The analyses showed that the second adaptive scheduling schema (the one with buffer state) gives better performance. The improvements can be seen in the behavior of the packet loss and the average queue size. Also, these disciplines have better performance compared to RR and WRR.

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