PROVISIONING QOS USING DIFFSERV WITH HIERARCHICAL SCHEDULING

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ABSTRACT

Internet was designed mainly for data communication applications such as file transfer and electronic mail that does not guarantee any specific quality-of-service (QoS). QoS such as end-to-end delay might be important for other types of multimedia communications that involve real-time traffic such as voice and video. Differentiated Services (DiffServ) is one of the mechanisms that could provide QoS. In DiffServ, traffics are treated differently based on their QoS requirements. This paper suggests the use of hierarchical scheduling technique in DiffServ in order to provide QoS in IP network. Network performance is observed based on our simulation work using Network Simulator (ns2).

1. INTRODUCTION

Future Internet would be dealing with real-time and multimedia traffic such as voice, video, videoconferencing, telemedicine, distance learning, e-commerce and many more. The existence of interactive multimedia applications that comprises of real time traffic has lead to the need of Internet Quality of Service (QoS). Based on the current system, all data packets are treated equally on best effort basis. However, different Internet applications have different bandwidth and delay requirements. Hence, the traffic cannot be treated equally. Differentiated Services (DiffServ) is introduced by the Internet Engineering Task Force (IETF) to improve this problem by treating the traffic according to their QoS requirements.

Hierarchical scheduling is normally used in scheduling different applications in a processor. In data communication area, some researchers have introduced this algorithm to provide QoS such as in Multiple Input-Queued (MIQ) [2] and ad-hoc network [3]. This paper suggests the uses of hierarchical scheduling in DiffServ ingress edge router where the design is based on the Diffserv network model shown in [4]. Rate based scheduler and priority scheduler are considered here where rate based scheduler will schedule the three Assured Forwarding (AF) classes before priority scheduler schedules the whole traffics. This will be explained thoroughly later. Network performance in terms of bandwidth allocation fairness and throughput given by our proposed model are compared with network performance given by DiffServ with Weighted Round Robin (WRR) only. The average end-to-end delay is compared with the delay specified by reference [4].

The rest of the paper is organized as follows. Section 2 briefly describes DiffServ while section 3 dwells on scheduling algorithms. Then, section 4 mainly focuses on our simulation work and finally section 5 concludes the paper.

2. DIFFERENTIATED SERVICES (DIFFSERV)

DiffServ offers QoS by allowing prioritized scheduling to facilitate the multimedia applications over the Internet. Figure 1 shows the structure of a DiffServ domain. The DiffServ specifications refer to the forwarding treatment provided at a router as per-hop behaviour (PHB). PHB must be available at all routers and normally PHB is the only part of DiffServ implemented in core router.

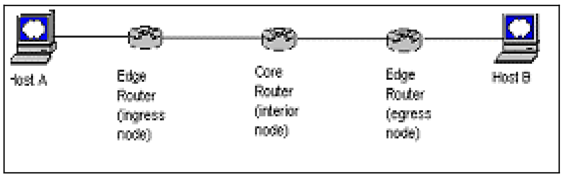

Figure 1: DiffServ Domain

The IETF has currently specified two different PHBs known as Expedited Forwarding (EF) and Assured Forwarding (AF). EF traffics are normally given strict priority over the traditional best-effort (BE) traffic inside the DiffServ domain. Each flow has to specify the required bandwidth in advance so that the appropriate resources can be reserved inside the network. The edge router will police each flow and the non-conformant packets will either be dropped or shaped. Since AF does not offer hard QoS guarantees, IETF has specified four different AF class. However, this project only considers three AF classes. Each class is assigned a certain amount of bandwidth at each node. When the amount of traffic exceeds this bandwidth, packets will be dropped according to their drop precedence value. In our

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simulation work, EF and BE will be represented by CBR and Exponential traffics respectively. AF will be distributed into three different classes known as AF3, AF2 and AF1 which are represented by VBR, Telnet and FTP traffics respectively.

3. SCHEDULERS

A router is a shared resource in a network and most network problems are related to the allocation of a limited amount of shared resources such as buffer memory and bandwidth. Scheduler allows you to manage access to a fixed amount of bandwidth by selecting the next packet to be transmitted. There are numerous types of scheduling techniques that try to find correct balance between complexity, control and fairness.

Fairness is a desirable property in the allocation of bandwidth on a link among multiple flows of traffic that share the link. An unfairness problem of aggregate flows affects the traffic classes. This can cause unfair bandwidth allocations in a packet marking mechanism such that an individual flow cannot be assured of reserved bandwidth and fair proportion of the spare bandwidth [5].

In recent years, classes of fair queuing scheduling algorithms are proposed. The advantage of a fair queuing method is that a worst case delay bound can be guaranteed to a leaky bucket shaped session regardless of the behavior of all other connections sharing the same output link. However, this method is too complex to be implemented. The maintaining per-flow queuing become more complex and the scheduling method become not scalable to a large number of connections

This project used rate based scheduler and priority scheduler for the hierarchical scheduling technique. Rate based scheduler are basically scheduler with weight assigned to each service classes such as Weighted Fair Queuing (WFQ) and Weighted Round Robin (WRR) while Priority Queueing (PQ) is an example of priority scheduler. WRR is used in this project to schedule different classes of AF traffics before it is scheduled using PQ with other EF and BE traffics.

3.1. Weighted Round Robin (WRR)

Weighted Round Robin (WRR) is the fundamental of a class of queue scheduling disciplines that is designed to improve the limitation of the Fair Queueing and Priority Queueing [1]. In WRR, packets are first classified into different service classes before they are assigned to a queue that is specifically dedicated to that service class. WRR allocates different amounts of bandwidth to different class and each queue is then served in a round robin manner.

3.2. Priority Queueing (PQ)

Priority Queueing (PQ) is the basis for a class of queue scheduling algorithms that are designed to provide a simple method of supporting DiffServ classes. In classical PQ, packets are first classified and placed into different priority queues. Packets are then scheduled from the head of a given queue only if all higher priority queues are empty. Packets are scheduled in First in First out (FIFO) order within each of the priority queues.

4. SIMULATION WORK

4.1. Network Topology

Figure 2 shows the simulation network model and the three types of sources used are described below:

- Source 1 (EF): CBR traffic is based on UDP transport protocol with a rate of 6.4Mbps and mean packet size of 1000 bytes. This traffic is suitable to represent voice application.
- Source 2 (AF3): Pareto is used to represent VBR traffic based on UDP transport protocol with a mean rate of 3.76Mbps and mean packet size equal to 1000 bytes. ns2 suggests using Pareto traffic agent to represent the VBR traffic model which is suitable to represent video application.
- Source 3 (AF2): Telnet based on TCP.
- Source 4 (AF3): FTP based on TCP
- Source 5 (BE): Exponential traffic agent is used to represent the non real-time traffic with rate of 3.2Mbps and packet size of 1000 bytes.

All links bandwidth are 10Mbps.

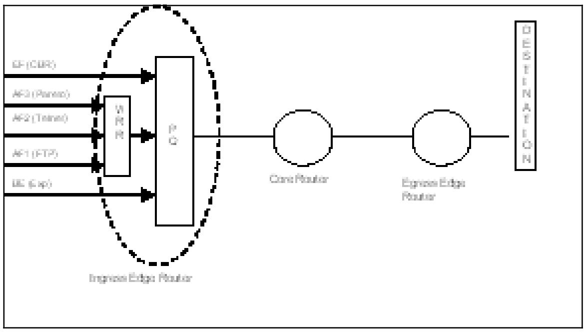

Figure 2: Proposed Network model

4.2. Simulation Results

Network performance of hierarchical scheduling method is observed in terms of fairness bandwidth allocation, throughput and average end-to-end delay for each traffic.

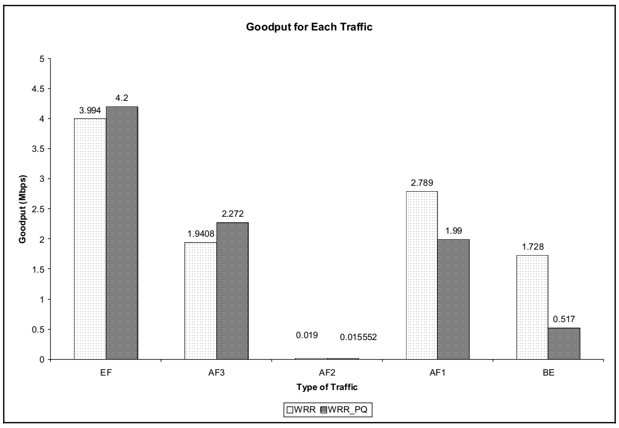

Figure 3: Goodput for Each Traffic

Figure 3 shows the goodput for each traffic which could represent the amount of bandwidth allocated for different services. The amount of bandwidth allocated to each service seems to be unfair when WRR is used. This is due to the amount of bandwidth are not allocated based on the service requirement. For example, it can be seen that AF1 higher bandwidth compared to AF3. On the other hand, hierarchical scheduler allocates bandwidth based on the service requirement such as AF3 got higher bandwidth compared to AF1. In order to achieve this, bandwidth allocated to AF2, AF1 and BE traffics are reduced. Thus, it is clearly shown that fairness could be achieved by using hierarchical scheduler. Hierarchical scheduler assigned weight to each AF packet before it is given a priority. Thus, they have certain level of treatment compared to other scheduler, where it only gives certain level of treatment to certain queue. Reference [5] has shown that fairness also could not be achieved using Priority Queueing and Round Robin.

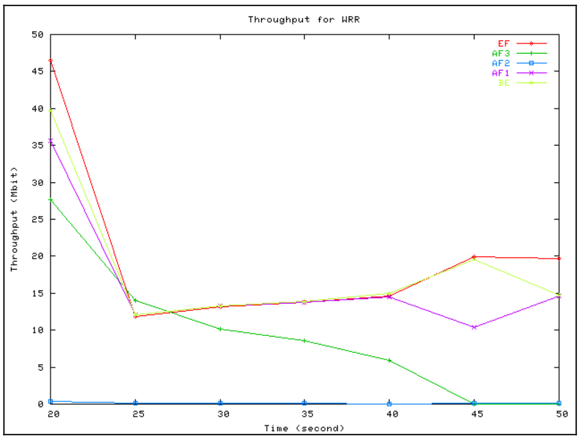

Figure 4: Throughput for WRR

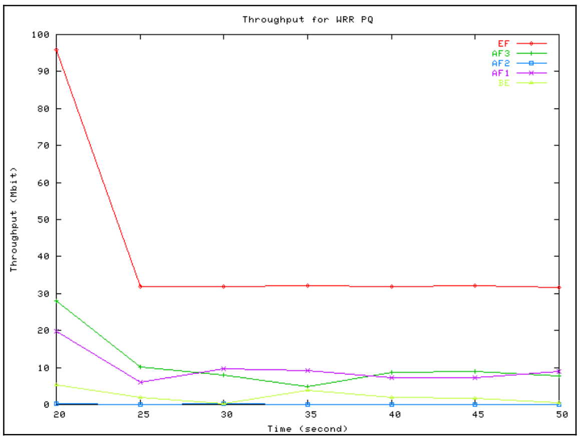

Figure 5: Throughput for Hierarchical scheduler

Figure 4 and 5 illustrate throughput for each type of traffic for WRR and hierarchical scheduler respectively. The figures show that hierarchical scheduler gives more throughput compared to WRR particularly for real time traffics represented by EF and AF3. Higher throughput consequently will give lower packet loss.

TABLE I. AVERAGE END-TO-END DELAY FOR EACH TRAFFIC

Class Type	Average End-to-End Delay (msec)
EF (CBR)	65
AF3 (Pareto)	95
AF2 (Telnet)	130
AF1 (FTP)	130
BE (Exponential)	500

The average end-to-end delay for each traffic class given by the hierarchical scheduler is shown in Table I. These values are compared with the specification given by reference [4] as shown in Table II. The hierarchical scheduler results show that the average end-to-end delay for real time traffic does not exceed the specification. Hence, it can be concluded that hierarchical scheduler gives lower end-to-end delay which is the important feature in provisioning QoS for real time traffic.

This specification does not outline the specific values for AF2 and AF1. However, end-to-end delay for non real time traffics which are represented by AF2, AF1 and BE are not really concerned in this paper because these traffics are not sensitive to time, thus the end-to-end delay for these traffics are not that crucial.

TABLE II. DIFFSERV CLASS-TYPE SPECIFICATIONS

Class Type	Objective	Example	Delay (msec)
EF	Jitter sensitive, real-time high interaction	VoIP	100
AF (rt)	Jitter sensitive, real-time high interaction	Video Conferencing	100
BE	Best effort	Best effort	400

5. CONCLUSIONS

Hierarchical scheduling in DiffServ ingress edge router is introduced in this paper in order to provide IP QoS. Network performance in terms of bandwidth allocation fairness, throughput and average end-to-end delay are observed based on our simulation results. Results show that hierarchical scheduling technique are more fair in allocating bandwidth compared to WRR and it gives higher throughput for real time traffics compared to WRR. Hence, this will lead to lower real time traffic packet loss. The average end-to-end delay for real time traffics are also within the specific value given by reference [4].

In conclusion, it can be said that, hierarchical scheduling technique offers better treatment particularly to the higher QoS requirement traffics. Thus, it is clearly shown that granularity could be achieved by deploying rate based scheduler and priority scheduler in different scheduling layers in DiffServ ingress edge router.

6. ACKNOWLEDGMENTS

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