Internetworking with Different QoS Mechanism Environments

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Abstract: - Nowadays, many capable mechanisms to provide Quality of Service (QoS) at the Internet are emerging. So, it's very important to have internetworking among different QoS environments, as Differentiated Services (DiffServ) and MultiProtocol Label Switching (MPLS) based networks. DiffServ is scalable for the today's Internet and MPLS provides fast packets routing. In this paper, we attempt to explain the concepts of DiffServ and MPLS and its effectiveness by performing a simulation study based on NS (Network Simulator). The results show the fast rerouting feature of MPLS and the internetworking behavior using or not QoS mechanisms.

Key-Words: Quality of Service (QoS), MPLS, DiffServ, Internetworking, BA, PHB

1 Introduction

In the era of the Internet, an increasing number of requirements for real time applications, such as, voice and video, call for a network service that provides some Quality of Service (QoS). However, the current best effort Internet architecture isn't suitable for meeting these requirements.

DiffServ (Differentiated services) architecture, as proposed by the DiffServ Working Group from the IETF (Internet Engineering Task Force), allows the IP traffic flow classification into finite classes of services, which receive different treatments through the link. The QoS guarantees are given to flow traffic aggregates, and for this reason, DiffServ is scalable.

MPLS (MultiProtocol Label Switching) goal is fast packet forwarding and traffic engineering (TE). This mechanism proposed by the IETF integrates the label switching with the layer 3 IP routing. It replaces traditional IP routing, which uses the network layer address, with a simple routing algorithm based on label switching, which is a short, fixed length identifier [1]. Both mechanism (DiffServ and MPLS) treat traffic flows into groups. DiffServ groups the traffic flows into sets called BAs (Behavior Aggregates) and MPLS groups then into FECs. Another point in common between these mechanisms is the way to encode traffic flows. DiffServ does this by the DSCP (DiffServ Code Point) and MPLS does this by the labels. The interior nodes don't execute another type of classification, only do a differentiated treatment to each packet aggregate according to the label or the DSCP carried with the packets and corresponding with the initial classification at the edge routers. These characteristics make the internetworking between DiffServ and MPLS environments relatively easier [2].

To do this internetworking, it's necessary to do a mapping between DiffServ and MPLS network parameters. MPLS uses the link layer to put its encapsulated header, and DiffServ uses the network and transport layers information to define its DSCP, so, MPLS routers can't see the information at these layers without a mapping. Here, we aim to show the benefits from this mapping, which has to be done between EXP field from MPLS header and DSCP field from DiffServ header [6], [7].

This paper first explains the concepts behind the DiffServ, MPLS and internetworking with

DiffServ/MPLS environments issues. It then presents results from an event-driven simulation using NS (Network Simulator) to show the fast rerouting feature of MPLS and the internetworking behavior using or not QoS mechanisms. Finally, to end this paper, a brief conclusion is presented in Section 6.

2 Differentiated Services

DiffServ provides QoS to the Internet without signalizing per node or flow state, and it also puts flows in a set called Behavior Aggregate (BA) [4]. All these characteristics make it scalable. DiffServ just storages state information per service class at the routers instead of doing per flow and it also provides resources to the BA. Since there are a limited number of classes, defined by DSCP in the DS (DiffServ) field, the quantity of stored state information is minimum. The DSCP identifies the PHB (Per Hop Behavior) carried by the packet, which is used to specify queuing, scheduling and drop precedence. There are three types of PHBs defined by the IETF: (a) AF - Assured Forwarding, (b) EF – Expedited Forwarding and (c) BE – Best Effort. PHBs must be implemented at all routers. It is the only piece of the DiffServ, which must be present at the interior routers. The goal of the PHB AF is to guarantee packets delivery at the foreseen time. Packets are marked with a value, which indicates the drop precedence. There are three distinct values to indicate the drop precedence. In congestion case, the packets will be discarded according to their classes and their drop precedence. DiffServ PHB AF uses Olympic Service, with four classes: Gold, Silver and Bronze and the 4th class. It's showed in the table 2.1.

The PHB EF is also called Premium Service (PS) and its goal is to provide an end-to-end service through a DiffServ network with low discards, low jitter and assured bandwidth [4]. It is recommended to video, voice and multimedia flows, which need some QoS guarantees.

2.1 Service Level Agreement (SLA)

The services provided by a DiffServ network are defined into a SLA (Service Level Agreement). It is a service agreement firmed between the ISP (Internet Service Provider) and the customer to specify the forwarding service that the customer wants to receive in his/her packets [4].

DiffServ Classes				
	Olympic Service			
Drop Precedence	Gold Class	Silver Class	Bronze Class	4th Class
Low	AF11 001010	AF21 0010010	AF31 011010	AF41 100010
Medium	AF12 001100	AF22 010100	AF32 011100	AF42 100100
High	AF13 001110	AF23 010110	AF33 011110	AF43 100110

Table 2.1: DiffServ Classes and DSCP

He/she can contract more than one class of service for different packets. Once firmed a SLA, the customer sends packets with the DiffServ field marked, indicating the packet's service class. The part of the SLA dealing with technical details is referred to as SLS (Service Level Specification). Into the SLS, the TCS (Traffic Conditioning Specification) specifies the expected performance (throughput, drop precedence, latency...), the profile of the traffic to be used (peak data rate, burst size...) and actions to perform in case of excess traffic [13].

The ISP must guarantee to the customer that he will receive, at least, the QoS established at the agreement for each packet class.

2.2 Traffic Conditioning

The network's edge undertakes the classification of flows and check if they are according to the TCS into the SLA. A set of components is implemented in the edge routers to do this. They are classifiers, meters, markers, droppers and shapers. (a) Classifiers select the packets received at the ingress interface by some part of the header's content. There are two types of classifiers: BA Classifier, which classifies the packets based only on the DSCP contents. This happens when the previous network is DiffServ compatible and the packets are already marked. Otherwise, the classifier evaluates other fields. In this case, it is called MF Classifier (Multi-

Field). (b) Meters measure the incoming traffic paying attention to the parameters that appear into the TCS. Depending on the applicable actions, excess traffics or not conforming to the TCS traffics are passed to a marker, a shaper or a dropper. (c) The marker remarks the traffic with a different DSCP. This implies this traffic will get a different PHB in the network. (d) Shapers delay the traffic so that traffic in the network conforms to the TCS. (e) Droppers simply discard the packets [3].

3 MultiProtocol Label Switching

The MPLS goal is to speed up the routing process at a network. Here, The IP address header is replaced with a label, when the packet ingress a MPLS network. This label has a fixed length. A Label Edge Router (LER) at the ingress of the network classifies the packets and put the appropriated label in them. The packet will be forward through the network using labels instead of the conventional IP header. The label is valid only at a router. When the packets are forwarded to the next router, the label is changed for another one. This is done until the last LER, at the other MPLS edge. When the packet leaves the MPLS network and the conventional IP header will be read normally. The interior routers are called LSRs (Label Switching Routers) and they do the label switching. They construct the LIB (Label Information Base), which storages the information of each node about their LSP (Label Switching Path). For a LSP to be set up, first the ingress LER sends a Label Request message through the egress LER, which sends back a Label Mapping message to the ingress LER. During the propagation of these label messages, all LSRs on this path use these label information to set up their LIBs so that packets can be forwarded using the label headers. After incoming a MPLS network, the packet is associated with a FEC (Forwarding Equivalence Class), and this occurs only this time. Once the packet is inside the MPLS network, at each hop there is not additional analysis in the network layer header of the packet.

There is also a protocol that distributes and maintains the information about the label association at the LSRs, it's the LDP (Label Distribution Protocol).

The NHLFE (Next Hop Label Forwarding Entry) table is used to forward a labeled packet. It contains the next hop and some information about label stacking.

The FTN (FEC To NHLFE) is another table used to map each FEC to NHLFE. It is used in packets which are not still labeled, but will be labeled before forwarding.

4 Internetworking MPLS and DiffServ

The MPLS uses the link layer to put its encapsulated header in this layer and DiffServ uses the network and transport layers information to mark the appropriated services in the PHB, this is a problem to MPLS supports DiffServ. Another difference between these two technologies is the header. DiffServ DSCP field has 8 bits, where 6 are used and 2 are for future uses [3]. MPLS header has 32 bits, and the EXP field inside the header has 3 bits, which can be mapped to the DiffServ purposes. Since the EXP field has only 3 bits (8 service classes) and the DSCP has 8 bits (64 service classes), a mapping between these two technologies must be done.

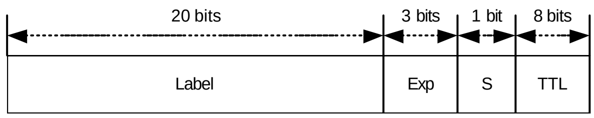

Fig. 4.0: MPLS header

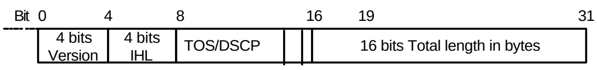

Fig. 4.1: DiffServ header

Actually, the ISPs use few service classes that are sufficient to provide QoS. It could use Service Classes to High Priority Classes, Delivery Guarantee and Low Priority Classes. The MPLS and LSPs characteristics answer the aggregate flows support easily. When a flow aggregate ingresses a LSP, it results in a traffic trunk [4]. Different traffic trunk, each one with its own traffic class, can use a common LSP, and the 3 bits of the MPLS header EXP field can be used to indicate the service class of each packet. In this case, no more than 8 BAs can be defined at the MPLS network [5]. If more than 8 BAs are needed, the service class must be inferred by both, the MPLS label and the EXP field. But, this reduces the model scalability, thus, this is not the right moment to take it into consideration.

4.1 EXP Inferred PSC LSP (E-LSP)

The PHB Scheduling Class (PSC) is a PHB group such that the order of packets in the group must be preserved, and are no place in common queue. For example: AF1x is the PSC of AF11, AF12, AF13 [1].

E-LSP determines the packet's PHB only from the EXP field, and it can support up to 8 PHB per E-LSP. The EXP field conveys the queuing, scheduling, and drop precedence to the LSR. The LSR determines the PHB to be applied to the incoming packet by looking up the EXP field in the EXP to PHB mapping [1].

4.2 Label Only Inferred PSC LSP

When it's necessary to offer more than eight PHB to do the DiffServ – MPLS mapping, or MPLS-DiffServ mapping, to the link that doesn't support MPLS Shim header, like in ATM networks, E-LSPs can't be used. The solution is to use the label as information to the different PHBs [3]. This LSP that uses the labels to support DiffServ functionality is called L-LSP. But, it's still necessary the use of the EXP field, or in ATM networks, the Congestion Loss Priority (CLP). The drop precedence to be applied by the LSR to the labeled packet is conveyed by the MPLS Shim header from the labeled packet, using the EXP field. A LSP is a L-LSP when the PSC is completely inferred from the label, without any other additional information [1].

4.3 Label Forwarding

Since different BAs can be forwarded by distinct LSPs, the label switching decision of a LSR that supports DiffServ, depends on the packet forwarded BA. Moreover, the IP header DS field of a forwarded packet can't be directly visible for a LSR, thus, the way to determine the PHB to be applied to the received packet and to codify the PHB in a forwarded packet is different in a MPLS router that does not support DiffServ. The label forwarding by a DiffServ LSR has four stages: (a) Incoming PHB determination, (b) Outgoing PHB determination; (c) Label Forwarding; (d) Codifying of DiffServ information at the EXP field. A label analyses DiffServ information in the following way: (a) LSP type (i.e. E-LSP or L-LSP), (b) Supported PHBs, (c) EXP to PHB mapping for an incoming label, (d) PHB to EXP mapping for an outgoing label. This information is populated into the LIB and FTN during label setup and is used to forward packets to the next hop. DiffServ information is stored in the NHLFE for each outgoing label, which is swapped or pushed [5].

If the label corresponds to an E-LSP for which an EXP-PHB mapping has been explicitly signaled at LSP setup, the supported PHB is populated with the set of PHBs of the signaled EXP-PHB mapping.

If the label corresponds to an L-LSP, the supported PHB is populated with the set of PHBs forming the PSC that is signaled at LSP set up.

5 Simulation Experiment

The aim of this simulation experiment is to underline the need of internetworking the MPLS and DiffServ environments.

Assuming that different mechanism of QoS at the access and backbone networks will exist, it's necessary to do a mapping between these mechanisms that provides end-to-end QoS. MPLS can enrich DiffServ with link protection while DiffServ proceeds like a QoS mechanism to MPLS.

In this simulation experiment, the NS (Network Simulator) version 2.1b6 was used. MPLS patch and DiffServ patch were also used. It was used the topology bellow, with two DiffServ access networks and a MPLS backbone network.

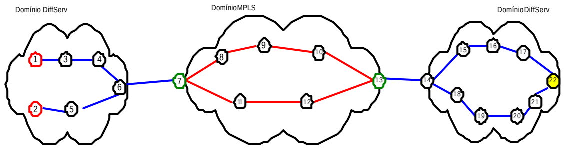

Fig. 5.0: Simulation Topology

At each simulation, it was introduced a link fail at 0.8 seconds a revived at 1.1 seconds to see the MPLS routing performance.

Simulation results are in the form of bandwidth graphs with the bandwidth in Mbps in Y-axis and time in seconds in the X-axis. In the first simulation, it is showed only UDP (User Datagram Protocol) traffic without any QoS mechanism. It consumed high bandwidth from the network (figure 5.1).

In the next figure we can compare the bandwidth of UDP traffic using DiffServ PHB EF. At figure 5.1 (a), the traffic spends 80% of the bandwidth almost all the time, and on the figure 5.1 (b), it is consumed just in form of peaks.

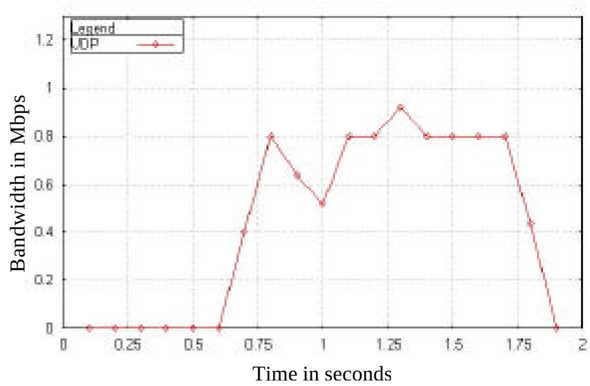

Fig. 5.1 (a): UDP traffic without DiffServ.

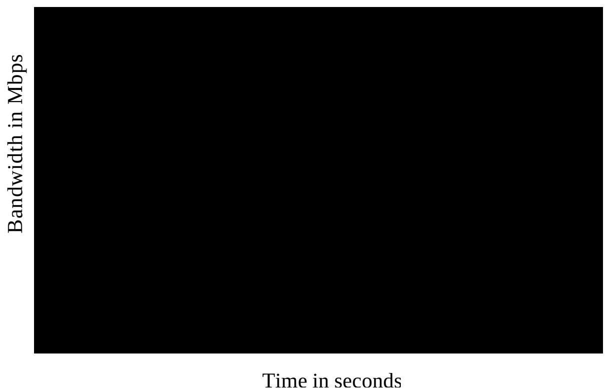

Fig. 5.1 (b): UDP traffic using DiffServ PHB EF.

The next two figures show TCP traffic without any QoS mechanism and TCP traffic using DiffServ PHB AF11.

We can notice that the bandwidth used on the second case is smaller than the bandwidth used on the first case.

Figure 5.3 shows the following simulations results. It is showed TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) traffics together at the same link, without DiffServ and MPLS. Figure 5.4 shows the simulations results considering DiffServ and MPLS enabled.

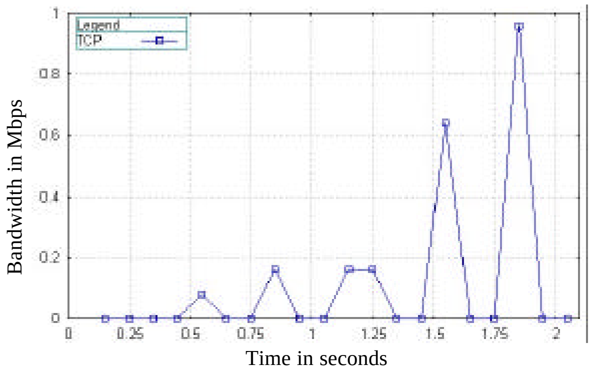

Fig. 5.2: TCP traffic without DiffServ.

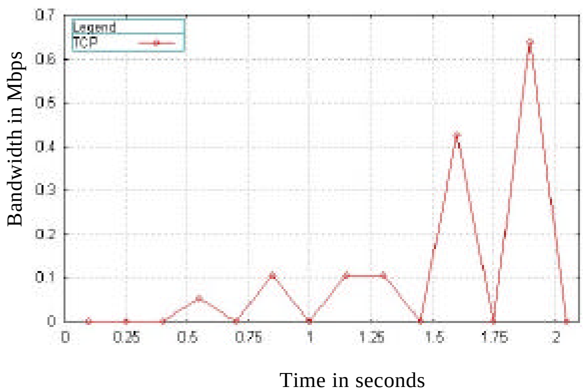

Fig. 5.2 b: TCP traffic using DiffServ PHB AF11

As shown in the figure 5.3, the UDP traffic has an ill behavior, because it takes as much bandwidth as possible, impacting negatively on the TCP traffic. The presence of UDP traffic damages TCP traffic, which was well-behaved traffic. This occurs because TCP has a congestion control mode mechanism, that answers the network warnings about possible congestion, and UDP doesn't have this mechanism. Thus, it's necessary to use some

QoS mechanism in the network to put uniformity to these traffics.

The following figure 5.4 shows the effect of using the PHB EF in the UDP traffic and the PHB AF11 in the TCP traffic, the bandwidth is just shared, and the TCP traffic is not damaged.

6 Conclusions

In this paper, we attempt to explain the concepts of DiffServ and MPLS and its effectiveness by performing a simulation study based on NS (Network Simulator).

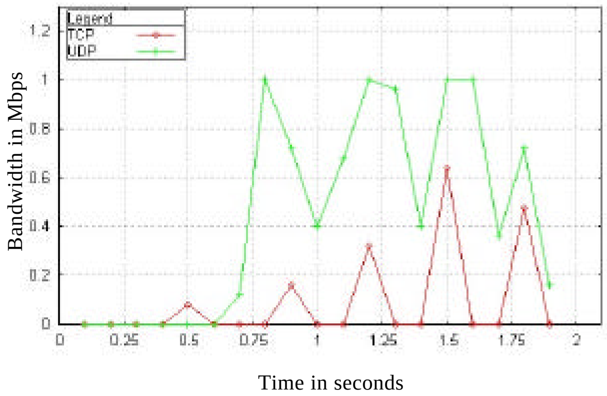

Fig. 5.3: Traffics UDP and TCP without DiffServ and MPLS

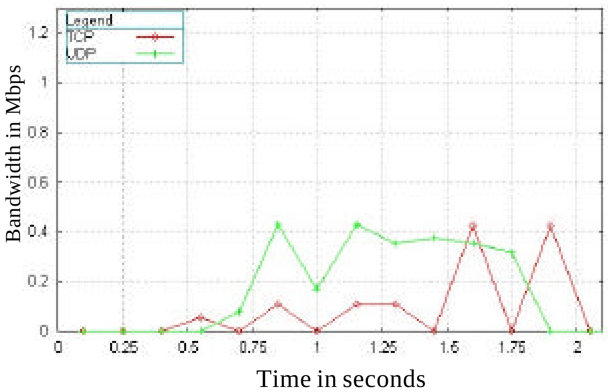

Fig. 5.4: Traffics UDP and TCP using DiffServ and MPLS

The simulations focused on internetworking aspects considering DiffServ network as an access network and MPLS network as backbone network, to maintain end-to-end QoS. Simulation results in the form of graphs were also presented.

Analyzing the simulation results, we can see the difference between the traffics without and with the DiffServ QoS mechanism. Under the same traffic conditions, the importance of a fast routing feature of MPLS in case of link fail was also observed.

Future work should concentrate on simulations with different LSPs to different types of traffic.

References:

[1] R. Le Faucheur, *Multi-Protocol Label Switching (MPLS) Support of Differentiated Services*, RFC 3270, May 2002.

[2] I. Andrikopoulos, G. Pavlou, *Supporting Differentiated Services in MPLS Networks*, CCSR, University of Surrey, UK.

[3] B. Williams, *Quality of Service – Differentiated Services and Multiprotocol Label Switching*, Ericsson Australia - White Paper, march 2000. http://www.ericsson.com/iptelephony

[4] IETF DiffServ Working Group, *A conceptual Model for DiffServ Routers*, Internet Draft <draft-ietf-diffserv-model-01.txt>, 33 p.

[5] S. Raghavan and R. Law, *DiffServ and MPLS – Concepts and Simulation*, Virginia Polytechnic Institute and State University, 6 p.

[6] K. Kilkki, *Differentiated Services for the Internet*, Macmillan Technical Publishing, 1999.

[7] G. Armitage, *Quality of Service in IP Networks: Foundations for a Multiservice Internet*, Macmillan Technical Publishing, 2000.