A Fair QoS Architecture

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1 Abstract

In recent research works an emphasis on DiffServ's inability to provide preferential treatment and fairness for aggregates of micro flows requiring premium and assured services. Responsive TCP traffic is unable to take advantage of the privileged treatment EF and AF classes provide, when QoS is configured. This is due to the performance degradation of TCP flows when integrated with non-responsive UDP traffic. UDP flows are more likely to achieve their target rates than TCP flows under traffic congestion. In this paper we propose a design of a fair DiffServ-aware-MPLS TE architecture which protects responsive traffic from non-responsive traffic by assigning different drop precedence of the same EF class to TCP and UDP, and mapping TCP and UDP to different EF class-type queues. We also attempt to improve the fairness and guarantee the privileged treatment for the flows belonging to the assured services.

2 Introduction

In DiffServ-aware-MPLS TE, premium services and assured services may suffer from unfairness caused by the aggregation of *Responsive traffic* (e.g., TCP) and *non-responsive traffic* (e.g., UDP) [1]. Several research works have made an effort to solve the unfairness problems. However, most of the previous research results have shortcomings such as taking into account only TCP flows [2] [3] [4], requiring an additional control mechanism [5], and modifying TCP flow control mechanism [6]. In order to solve the fairness problems in QoS architectures, we propose a fair per class-type queuing and a combination of active queue management disciplines and scheduling schemes. The proposed architectural design is of fair DiffServ-aware-MPLS TE which protects responsive traffic from non-responsive traffic by assigning different drop precedence of the same EF class to TCP and UDP, and mapping TCP and UDP to different EF class-type queues. Thus, for premium service 2 LSP's will be created for each (source, destination) pair. One LSP for premium service TCP flows and another LSP for premium service UDP flows. Our proposed architecture also attempts to improve the fairness and guarantee the privileged treatment for the flows belonging to the assured services through the use of *Selective Fair Early Detection* (SFED)[7].
The rest of this paper is organized as follows: sections 3, 4, and 5 give a brief description of the DiffServ, MPLS and DiffServ-aware-MPLS architectures. Section 6 describes the proposed fair QoS architecture. Finally, we conclude this paper in section 7.

3 Differentiated Services

Differentiated services (DiffServ) framework provides a scalable methodology for providing *quality of service* (QoS) in IP networks. The essence of DiffServ is to divide traffic into several classes and treat them differently especially in the presence of congestion [8]. Several classes could be provided using different standardized *per-hop behaviour* (PHB) groups through classification, policing, shaping and scheduling rules. In order for a customer to receive differentiated services from its ISP, it must have a *service level agreement* (SLA) with its ISP. A SLA may explicitly or implicitly specify a *traffic conditioning agreement* (TCA) which defines classification, metering, policing, marking and shaping rules. The standardized PHBs are e*xpedited forwarding* (EF) [9], a*ssured forwarding* (AF) and the classic *best effort* (BF). Traffic in the premium service will exhibit the EF PHB which provides reliable, low-delay and low-jitter service for real-time and mission-critical applications. Assured service exhibits the assured-forwarding AF PHB which provides reliable and predictable packet delivery for non-real time interactive applications. There are several problems with DiffServ: (1) Uneven distribution of traffic in the network which may cause concentration of high priority traffic at some routers even though policing and shaping are done at the edge. This can excessively affect performance of low priority traffic, and can even cause performance degradation of high priority traffic at those routers. (2) Responsive TCP traffic is unable to take advantage of the privileged treatment premium and assured services provide, when QoS is configured. This is due to the performance degradation of TCP flows when integrated with non-responsive UDP traffic. UDP flows are more likely to achieve their target rates than TCP flows under traffic congestion [10]. Hence, DiffServ alone is not sufficient for providing QoS in the Internet, as it essentially provides differentiated performance degradation for different traffic when there is network congestion. If congestion can be avoided, performance of all traffic will be good even without DiffServ. TE is useful for providing QoS as it can avoid congestion caused by uneven traffic distribution and optimize resource efficiency and network performance.

4 Multi-Protocol Label Switching

MPLS is an advanced forwarding scheme achieving the simplified connection-oriented forwarding characteristics of layer 2 switching while retaining the equally desirable flexibility and scalability of layer 3 routing [11]. MPLS adds a *shim label header* (SLH) to each packet and the forwarding decision is made solely based on this label. The label field identifies the *forwarding equivalence class* (FEC), which is a group of packets that are forwarded to the same next hop, specified by the *next hop label forwarding entry* (NHLFE), over the same path with the same forwarding treatment. A *label switched path* (LSP) is set up by the ingress *label edge router* (LER) which sends a label request message toward the egress LER, which in turn sends back a label mapping message to the ingress LER. As these label messages propagate along the path, all *label switch routers* (LSR) use these label information to set up *label-to-NHLFE mapping* (ILM) to forward labelled packets. The ingress LER pushes a label to a packet and the egress LER pops a label from a packet. Intermediate LSR's perform both a label pop and label push.

5 DiffServ-aware-MPLS

The combination of DiffServ and MPLS [12] presents a very attractive strategy to backbone network service providers with scalable QoS and traffic engineering capabilities using fast switching technology. The mapping of DiffServ class-types into MPLS LSP can be implemented in either *Exp-inferred-LSP* (E-LSP) or *Label-only-inferred-LSP* (L-LSP) model. In E-LSP model, multiple class-types are mapped onto an MPLS LSP, and the EXP field of the MPLS SLH conveys the PHB to be applied to the packet at each LSR; the PHB conveys both information of the packet scheduling treatment and the drop precedence. In L-LSP model, each LSP only transports a single class-type, so the packet treatment is inferred exclusively from the packet label value. The Exp field of the MPLS SLH specifies the packet drop precedence. Results from the evaluation conducted in [13] show no difference between E-LSP and L-LSP if the same route computation algorithm is used, although L-LSP has an advantage that its path unit is smaller than E-LSP. Studies in [10] and [14] suggest that the use of DiffServ-aware-MPLS to segregate traffic into LSP's (using E-LSP or L-LSP) will improve the fairness amongst competing flows (UDP and TCP). In L-LSP the deficiency seen in DiffServ to provide aggregate micro flows with the privileged treatment of premium and assured services is noticeably improved, than with E-LSP. This is due to the fact that in E-LSP all classes are grouped in one LSP from source to destination and within the fine granularity of the LSP, UDP flows to will aggressively take over the bandwidth of the LSP despite the QoS configuration. Therefore, the unfairness problems must be solved in DiffServ-aware-MPLS TE to guarantee QoS.

6 A Fair QoS architecture

Several architectures have been proposed for the efficient traffic engineering in the Internet [15]. DiffServ-aware-MPLS TE has been standardized by IETF to provide guaranteed end-to-end QoS using multiple LSPs in parallel.

6.1 DiffServ Packet Processing Model:

Figure 1 depicts the per-class-type packet processing structure of DiffServ-aware-MPLS router. We assumed only three classes of service: premium, assured and best effort. We also assume that the user defines the traffic/QoS parameters and the aggregation of multiple DiffServ class types according to SLA/TCA. Multi-field classification rules used at the ingress LER are specified in TCA. The resulting DiffServ classification will specify the traffic parameters of each micro-flow and the traffic parameters and the priorities of the overall aggregates class-types. Metering will be conducted by class-type priority; premium services have the highest priority. SFED is a rate control based queue management discipline which ensures a fair bandwidth allocation amongst competing flows even in the presence of non-adaptive traffic. SFED can be used to partition bandwidth in proportion to class-type priority and is well-suited for allocation of bandwidth to aggregate flows as required in DiffServ. The *premium queue* (PQ), *assured queue* (AQ) and *best effort queue* (BQ) are scheduled by *weight fair queuing* (WFQ) or a variant of it. The rate of these queues is set by the network administrators based on traffic statistics and domain policy. If we define the provisioning factor of a queue, *pf*(queue), as the ratio

between the configured output rate and the actual input rate, then the following order must be maintained: *pf* (PQ) > *pf*(AQ) > *pf*(DQ) > 1.0
The rate and size for the PQ, AQ, BQ and the parameters for the buffer management scheme for interfaces to the core routers may have to be set based on some measured statistics.

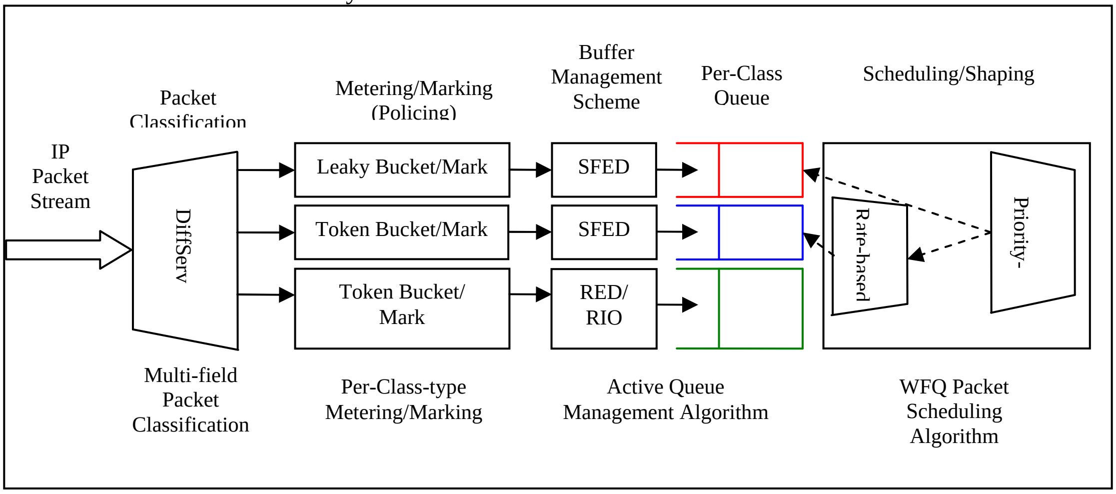

Figure 1: DiffServ Packet processing in the fair DiffServ-aware-MPLS architecture

6.2 MPLS Packet Processing Model

The proposed architectural protects responsive traffic from non-responsive traffic by assigning different drop precedence of the same EF class to TCP and UDP, and mapping TCP and UDP to different EF class-type queues. The drop precedence for the TCP and UDP flows are specified in the DiffServ configuration which are in accordance with the SLA/TCA. Thus, for premium service 2 LSP's will be created for each (source, destination) pair. One LSP for premium service TCP flows and another LSP for premium service UDP flows. Figure 2 depicts the MPLS packet processing structure. L-LSP mapping is implemented to map DiffServ class-type into MPLS LSP. In the mapping process, if the DiffServ class type was found to be premium service, then the protocol ID field in the IP header is read. If it was TCP then appropriate marking should be applied in addition to the MPLS service classification. SFED is also used as a queue management discipline to ensure fairness in portioning the bandwidth.

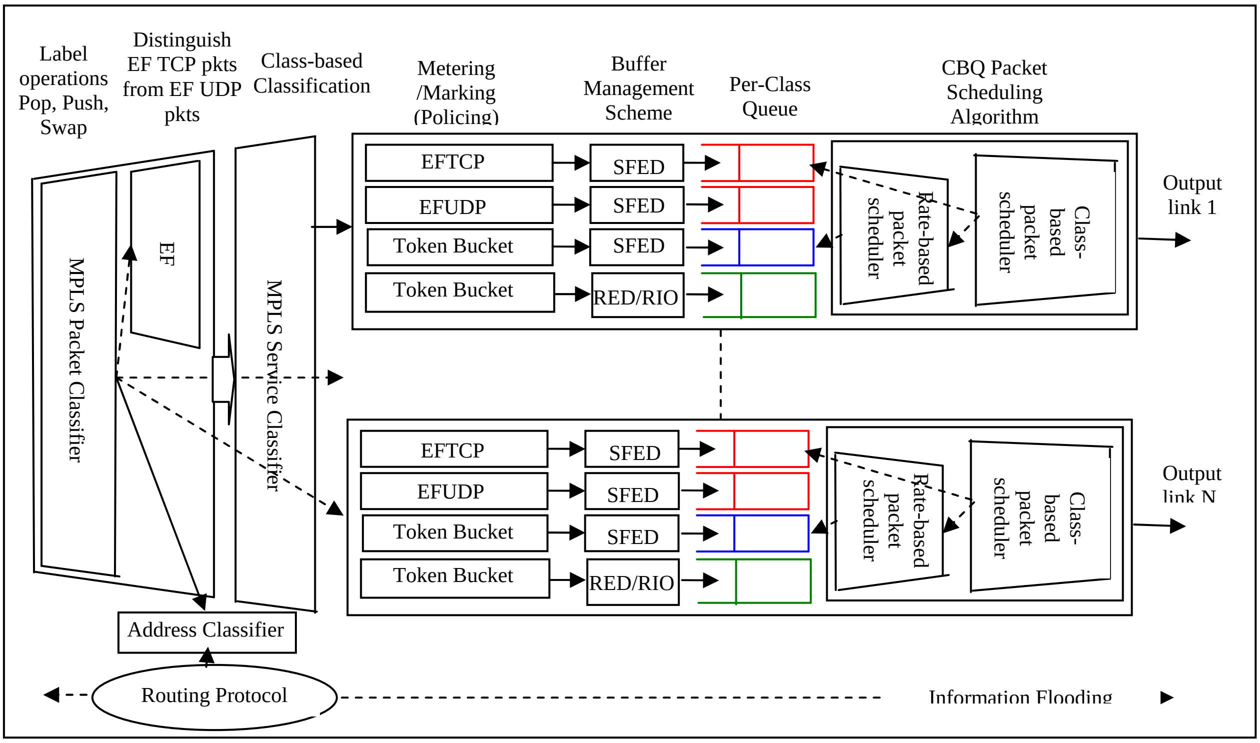

Figure 2: MPLS Packet Process in the fair DiffServ-aware-MPLS architecture

7 Conclusion and future work

In this paper we propose a design of a fair DiffServ-aware-MPLS TE architecture which protects responsive traffic from non-responsive traffic by assigning different drop precedence of the same premium service of TCP and UDP, and mapping TCP and UDP to different premium service queues. It is our aim to implement the proposed architecture and evaluate its performance. As part of our future work, we plan on investigating the following: (1) The performance of the proposed architecture in networks with high bandwidth-delay-product (BDP) paths. (2)The fair sharing of bandwidth among flows with different round trip times (RTTs) in an aggregated flows of a class-type. (3)The effects of introducing flows containing new TCP protocol variants to the traffic load.

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