Study of TCP and UDP Flows in a Differentiated Services Network Using Two Markers System[1]

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Abstract. There are two cruxes of issues identified in differentiated services (diffserv) networks: One is TCP dynamics over Assured Services, and the other is the interaction of TCP and UDP flows for Assured Forwarding Per Hop Behavior (PHB). Therefore, we argue unfair distribution of excess bandwidth in an over-provisioned networks as well as unfair degradation in an under-provisioned network for TCP and UDP flows traffic. First, we consider *Two Markers System (TMS)* that we have proposed, which is able to properly mark packets and fairly share the bandwidth to each flow for their targeted sending rates. Next, we present simulation results to illustrate the effectiveness of TMS scheme over TCP and UDP interaction. That is, flows in Two Markers System somewhat fairly share the excess bandwidth and experience degradation in proportion to their target rates.

1 Introduction

TCP's complex response primarily to packet losses in a differentiated Services Network affects the Assured Services. TCP reacts to congestion by halving the congestion window (cwnd) and increases the window additively when packets are delivered successfully[1]. However, in the diffserv network these additive-increase and multiplicative-decrease make it hard to protect the reservation rate for Assured Services. When TCP reacts to an OUT packet drop by halving its congestion window and increases additively, it may not reach its reservation rate. In [2], in order to alleviate the issue, it focused on several strategies used to mark packets in order to consider TCP dynamics and adapt fairness for sharing a bottleneck link of a network, and proposed a modified marking scheme, so called, Two Markers System (TMS); the first marker (TMS_I) is located at sources of a network to adapt TCP congestion control algorithm, and the second marker (TMS_II) at edge to fairly mark the aggregated flow as shown Figure 1. In addition, one of the cruxes identified in the diffserv network is the effect of congestion insensitive flows such as UDP when they share the same AF class with TCP

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flows. TCP and UDP interaction for the AF PHB have become the important issue in the fairness of diffserv context.

In this paper, we take the problem into consideration between the transport control protocol (TCP and UDP) and the differentiated drop policies of the network in realizing the reserved throughputs, using modified scheme called, Two Markers System for improving the realization of target rates in a differentiated services network.

The rest of this paper is organized as follows: Section 2 reviews the state of the art in the Two Markers System. Section 3 explores for responsive traffic flows such as TCP and non-responsive traffic flows such as UDP interaction and presents the results using TMS algorithms in simulated environments, and performs analysis for simulated results. Section 4 concludes our work.

2 Two Markers System

This system has two marking modules that are located in the source and at the edge of differentiated services network, respectively, and each marking module plays different roles to achieve the reservation rate and the target rate of Assured Services. First, a virtual- source marker (TMS_I) carries out two main roles: One is to control a flow and congestion, so called s*uitable-marking strategy* and the other is to give the marking probabilities to the edge-embedded marker (TMS_II). In [3], it showed that a source-integrated packet marking engine (PME) properly kept up marking rate rather than a source-transparent PME, because the measurement of throughputs against the reservation rate at the source is accomplished more exactly than at the edge of a network. Therefore, TMS_I decreases TCP impacts in the underlying AF services, and helps the TMS_II to properly mark packets. So to speak, TMS_I can be not a marker used to mark packets in order to classify the service in the core of a network, but an indicator that notifies TMS_II in the edge of a network of the marking rate. Second, the edge-embedded marker (TMS_II) elaborates a fairness strategy for sharing excess bandwidth of a bottleneck link called *marking rate-based fairness,* so it monitors incoming traffic flows from users at the edge of the network against the profile that the users have agreed with the service provider. It measures the number of the marked packets (m_i) from sources and partly re-marks aggregated flows for the profile that the users have agreed with the service provider. IN marking (In-profile), for example, may change into OUT (Out-of-profile) or reverse. Therefore, a datum point of fairness strategy is the marking information (X_{mi}) of traffic flows from users, as fallows:

$$X_{mi} = m_i / (2E[m_i]) \qquad \textbf{(1)}$$

where $E[m_i]$ represent the average marking rate of all the flows at the edge of network. Therefore, X_{mi} is used in the computation of a flow's target rate(T_i) in the edge of a network, as fallows:

$$T_i = R_i + X_{mi}(C - \sum R_i) \qquad \textbf{(2)}$$

where, C and R_i represent the capacity of a bottleneck link in the network and reservation rate of each flow, respectively.

3 Interaction of TCP and UDP Flows

In this section, we present the simulation results for TCP and UDP traffics in Two Markers System we have described in the previous section. The simulation was done with the Network Simulator-v2(ns-v2.1b8a). For the sake of simulation, we used a network with the configuration shown in Figure 1. In the simulation, we have 6 sources (1 through 6 counting downwards) that communicate with one of six different destinations. Long-lived packet streams generated by an infinite file transfers are originated at source 1 through 4, and destined to source 7 through 10. Constant rate UDP packet streams are originated at source 5-6, and destined to source 11-12. We carried out two scenarios: over-provisioned and under-provisioned network. In the first scenario, the aggregate reservation rate is 6Mbps, and the bottleneck capacity is set to 8Mbps so that the bottleneck is not oversubscribed. In the second scenario, the aggregate reservation rate is 6Mps, and the bottleneck capacity is also set to 3Mbps so that the bottleneck link experiences congestion. The UDP flows source traffic at the rate of 1Mbps. We assume that the RTT without queuing delay of each flow is randomly pocked from 80 to 220 ms. The sources 1 through 4 are all TCP-Reno sources (unless specified otherwise). For the RIO implementation, the routers use RED with the values of 200 packets, 400packets, and 0.02 for *min_in*, *max_in*, and P_{max_in} and 50 packets, 100 packets and 0.5 for *min_out*, *max_out*, and P_{max_out}.

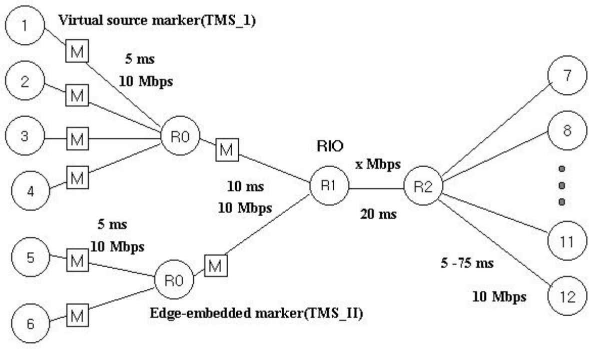
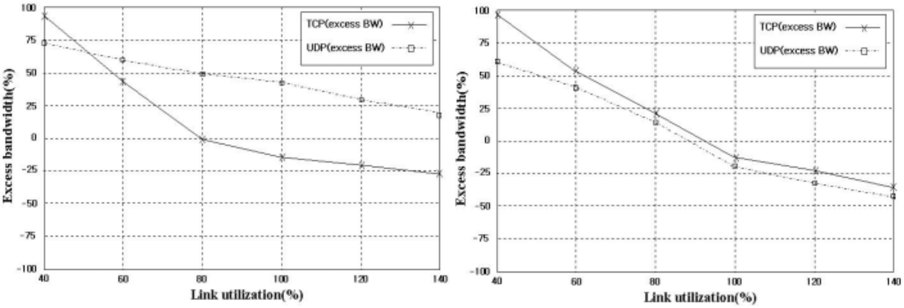


Fig. 1. Simulation topology using the Two Markers System

First of all, we investigate the simulation results of the issues for sharing excess bandwidth according to the link utilization. We define the link utilization(ρ), as fallows:

$$\rho = \sum T_i \big/ C \tag{3}$$

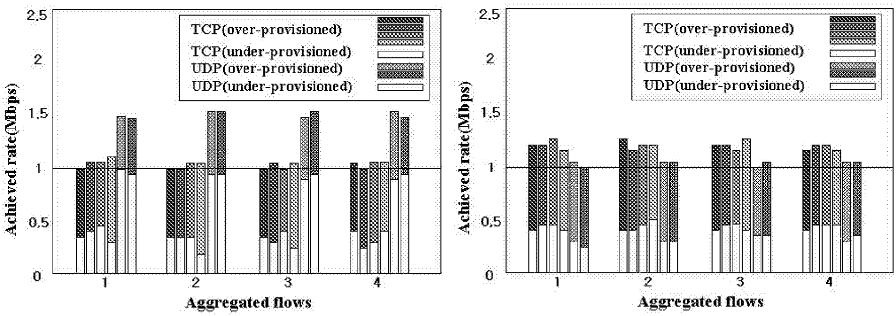
where T_i and C represent target rate of a flow and the capacity of a bottleneck link in the network, respectively. As the network approaches an under-provisioned state, the TCP flows suffer acute degradation compared to UDP flows and fall under their target rates at (? > 80%) as shown in Figure 2(a). However, UDP flows meet their target rates and the only degradation they experience is reduction of excess bandwidth they receive, and in the figure 2 the excess bandwidth a flow receives is expressed as percentage of its target rate. We assume as fallows: (i) UDP flows in TMS are only dealt with OUT marking (out-of-profile), (ii) the magnitude of marking rate represents increase or decrease in demand for bandwidth. If the number of marked packets, for example, exceeds the threshold value, that is the average marking rate, $E[m_i]$, the edge-embedded marker considers that the flow wants more bandwidth than others in order to achieve its reservation rate. Therefore, the flow is marked more and has a higher target rate than others The distribution of excess bandwidth in the over-provisioned network is more fair than in the Figure 2(a). That is, the idea behind TMS is to preferentially drop UDP and TCP packets marked OUT which are outside of their contract when congestion occurs. The excess bandwidth in the Figure 2(b) is percentage-wise almost equally divided between TCP and UDP flows. Both traffic types achieve their target rates in the over-provisioned network, and both suffer the same level of service degradation in the under-provisioned network.



a) Two Rate Three Color Marker b) Two Markers system

Fig. 2. Sharing excess bandwidth according to the link utilization

Next, we present the simulation results considering of marking rate-based fairness strategy described in the previous section. We set that reservation rate of each flow is 1Mbps, and compare two marking schemes: One is the TRTCM, the other is marking strategy of TMS. As stated above, the target rate of a flow *i* in TMS varies in proportion to the probability of marking from the sources. Figure 3 represents the results that the throughputs of all individual flows of aggregated traffic realize their target rates in over-provisioned networks. In the figure 3(a), UDP flows captured all excess bandwidth, but TCP flows in the figure 3(b) fairly share excess bandwidth elaborating *the marking rate-based fairness strategy* against UDP flows Each flow also satisfies its reservation rate and shares the excess bandwidth of the bottleneck link according to the probability of his marking in over-provisioned network. Each TCP flow in Figure 3 (a) often fails to achieve their target rates in under-provisioned networks, because UDP flows are transmitted constantly irrelative to congestion. That is, UDP gains unfairly at the advantage of TCP flows. However, Figure 3 (b) shows that each flow in under-provisioned network is distributed fairer than in the Figure 3 (a), by dint of dealing with UDP as out-of-profile.



a) Two Rate Three Color Marker b) Two Markers System

Fig. 3. Throughput according to network conditions

4 Conclusion

We have described the analysis for the interaction of TCP and UDP flows in a diffserv Network using the Two Markers System. We have also simulated a TMS model to study the effects of several factors on the throughput rates of TCP and UDP flows in a RIO-based Differentiated Services network. First, in over-provisioned network, as TMS elaborates *the marking rate-based fairness*, TCP could fairly share excess bandwidth that UDP almost dominated and achieve their target rates. Next, although all the flows couldn't achieve their target rates, they fairly experienced degradation in proportion to their target bandwidth.

In the near future, we will study the effect of the interaction of TCP and UDP flows for values of scaling factor,□ α, β, and γ□ issued in the Two Markers System.

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