A New Packet Marking Scheme with Fairness Guarantee for DiffServ Network

M.S. Cheong[1], B.G. Kim[2], C. Pan[1], K.T. Chung[2], K.H. Pyun[1], S.T. Lee[3] and B.S. Chon[1]

[1] School of Electronics & Information Engineering, Chonbuk National University,
Duckjin-Dong Duckjin-Gu Jeonju Jeollabuk-do 561-756 South Korea
{sua,pance,khpyun,bschon }@chonbuk.ac.kr
[2] Faculty of Electronic & Information Engineering, Kunsan National University,
Miryong-dong Kunsan Jeollabuk-do 573-701 South Korea
{bgkim,eoe604}@kunsan.ac.kr
[3] Technical Information Team, Korea Research Institute of Standards and Science
Yuseong Daejeon 305-340 South Korea
stlee@kriss.re.kr

ABSTRACT

Conventional works for the AF (Assured Forwarding) service in the Differentiated Services (DiffServ) have no sufficient consideration on the fairness of bandwidth share based the target rate and the impact of RTT and UDP. In order to solve these problems, we proposed a new packet marking scheme with fairness guarantee. The proposed scheme based on average transmission rate, using the achieved rate and fairness of each flow to provide fairly marking for Assured Forwarding services in DiffServ network. By adding a record unit and a promotion/demotion probability generator to the conventional traffic conditioner, the impacts of RTT, UDP/TCP interactions, and different target rates can be mitigated effectively. The performance of the proposed scheme, compared with TSW3CM, is evaluated with the ns-2 simulator.

1. INTRODUCTION

Recently, the Differentiated Services (DiffServ) architecture has become a preferred method to address Quality of Service (QoS) in IP networks. The packet marking scheme for IP-QoS is attractive due to its simplicity and scalability. An end-to-end DiffServ is obtained by the connection of per-domain services and Service Level Agreements (SLA) between adjoining domains along the source-to-destination traffic path [1].

Per domain services are implemented by traffic conditioning and simple differentiated forwarding mechanisms on the network edge and core respectively. The Expedited Forwarding (EF) and Assured Forwarding (AF) Per-Hop Behaviors (PHB) were standardized by the Internet Engineering Task Force (IETF) as the forwarding mechanisms.

The conventional marking policy for the AF services in DiffServ network takes insufficient considerations to the interaction among them, that is Committed Information Rate (CIR), Round Trip Time (RTT), mixed Transmission Control Protocol (TCP)/ User Datagram Protocol (UDP), and the allocated link bandwidth [2-6]. TCP flows with different RTT may be assigned to different bandwidth. The impact due to these factors should be mitigated before bandwidth is guaranteed to a user. This could be articulated to the SLA.

The proposed scheme is designed to provide fair marking for AF services in DiffServ network. The proposed scheme based on estimation of average transmission rate meters the per-flow packet arrival rate at the ingress edge router at each control cycle, also records the states of flows and routers individually. TCP throughputs can be achieved closely to the UDP without distinguishing from each other. The impacts of RTT, TCP/UDP interaction, and different target rates can be mitigated effectively.

The rest of the paper is organized as follows. In section 2, proposed packet marking scheme based on the average transmission rate and fairness of each flow is introduced. Simulation and performance evaluation are discussed in section 3. Conclusion is made in section 4.

2. PROPOSED PACKET MARKING SCHEME

Conventional schemes have the problem on the end-to-end QoS which can not be fairly guaranteed. Time Sliding Window Three Color Marker (TSW3CM) takes two traffic parameters: CIR and Peak Information Rate (PIR) [7]. It marks packets to one color among Green, Yellow, and Red. In TSW3CM, the meter estimates the average transmission rate with a sliding window. The packets that arrival rate is

1-4244-1017-7/07/$25.00

less than the CIR are marked Green, packets that arrival rate is being between the CIR and PIR are marked Yellow, and packets that arrival rate is greater than the PIR are marked Red.

Fig. 1 shows the block diagram of traffic conditioner. A record unit and a promotion/demotion probability generator in proposed scheme are added to the conventional traffic conditioner. The record unit records and calculates the fairness (x_i, equation (2)) and mean fairness (m_x, equation (3)) at each control cycle. The probability generator calculates the promotion (equation (4)) and demotion (equation (5)) probability in order to increase or decrease the in-profile marking probability.

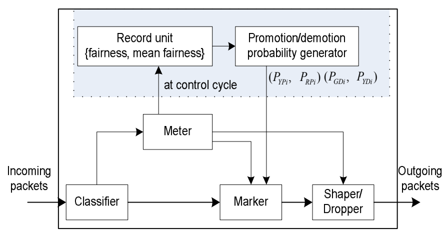


Fig. 1. Traffic conditioner.

The estimation value for achieved rate of flow i is denoted by R_{ai}, it is defined as

$$R_{ai} = R_{aGi} + R_{aYi} + R_{aRi}, \quad \begin{cases} R_{aGi} = R_{vGi} \times (1 - Max_{PG}) \\ R_{aYi} = R_{vYi} \times (1 - Max_{PY}) \\ R_{aRi} = R_{vRi} \times (1 - Max_{PR}) \end{cases} \tag{1}$$

where $R_{a\{G,\ Y,\ R\}i}$ denotes the achieved rate of flow i distinguished by each individual color, $R_{v\{G,\ Y,\ R\}i}$ denotes the arrival rate at ingress edge router, and $Max_{P\{G,\ Y,\ R\}}$ denotes the maximum dropping probability obtained by RED algorithm [8].

$$x_i = \frac{R_{ai}}{U_i}, \quad U_i = R_{ci} \times \frac{\sum_{j=1}^{n} R_{aj}}{\sum_{j=1}^{n} R_{cj}} \tag{2}$$

Equation (2) defines the fairness of flow i, where U_i is the ideal service rate for flow i, CIR is denoted by R_{ci}, where $i, j = 1, 2, 3 \ldots n$, n denotes the number of active flows.

The mean fairness is defined as below:

$$m_x = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{R_{ai}}{U_i}\right) \tag{3}$$

In equation (4), the P_{YPi} denotes the probability for Yellow-to-Green packet remarking, and the P_{RPi} denotes the probability for Red-to-Yellow packet remarking. In equation (5), the P_{GDi} denotes the probability for Green-to-Yellow packet remarking, and the P_{YDi} denotes the probability for Yellow-to-Red packet remarking. Max_{GD}, Max_{YD}, Max_{YP} and Max_{RP} are the constant to control the probability used in router.

$$P_{YPi} = \frac{(m_x - x_i) \times Max_{YP}}{m_x}, \quad P_{RPi} = \frac{(m_x - x_i) \times Max_{RP}}{m_x} \tag{4}$$

$$P_{GDi} = \frac{(x_i - m_x) \times Max_{GD}}{x_i}, \quad P_{YDi} = \frac{(x_i - m_x) \times Max_{YD}}{x_i} \tag{5}$$

In the proposed scheme, the service state is classified to State-High, State-Low and State-Steady by comparing the fairness of each flow with mean fairness at the ingress edge router. When δ denotes the control threshold, here we choose 0.05 as the value of δ, if $x_i > m_x + \delta$ the state of flow i is set to State-High and packet of green or yellow demote with equation (5). Contrastively, if $x_i < m_x - \delta$ the state of flow i is set to State-Low and packet of yellow or red promote with equation (4). Otherwise, if $m_x - \delta < x_i < m_x + \delta$ the state of flow i is set to State-Steady. The service state is decided by comparing the current service rate with the target transmission rate corresponding to the network state. If more services have been received at this time, the service rate will be reduced till next cycle. Reversely, if less services have been received, then the service rate will be increased during the next cycle. By doing this, we can keep the fairness for all the services during a certain period.

3. THE SIMULATION AND PERFORMANCE EVALUATION

3.1. Simulation Model

We implemented our scheme in the ns-2 network simulator [9] with the network model shown in Fig. 2. Average packet size is set to 256 bytes. It is assumed that all TCP flows are within a same AF class, Time-window of TSW3CM is set to 1.0 second, and TCP window size is set to 400 bytes. Delay in the links between sources and the edge router is set in a range of 2~97ms. All the RTT values are chosen from 20~210ms. The bandwidth between the core and edge routers is assigned to 5Mbps, 10Mbps, 15Mbps for Under Provisioned Network (UPN), 20Mbps for Well Provisioned Network (WPN), and 25Mbps, 30Mbps for Over Provisioned Network (OPN) separately.

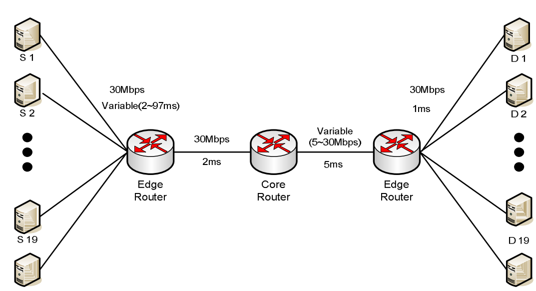


Fig. 2. Simulation network model.

3.2. Fairness Index

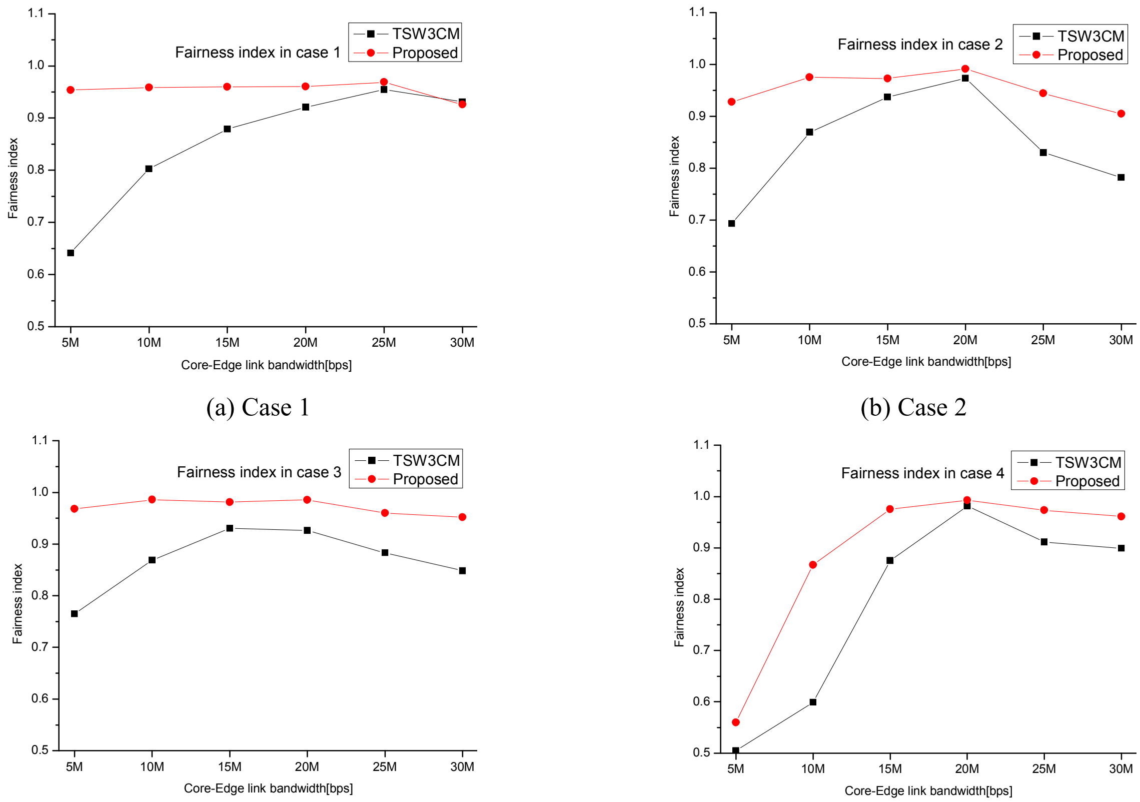
The fairness index [10] is defined as below:

$$fairness\_index(FI) = \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n \times \sum_{i=1}^{n} x_i^2} \tag{6}$$

The range of *FI* is between 0 and 1, 1 means that ideal fairness could be achieved for the flows.

Considering the various network environments, the flow with different CIR, RTT and Constant Bit Rate (CBR) are set as below:

- Case 1: Flow with same CIR but different RTT(CIR and PIR are set to 1.0Mbps and 1.25Mbps respectively; RTT is set to 20~210ms according to flow ID)
- Case 2: Flow with different CIR but same RTT(CIR is set to 95kbps~1.9Mbps and PIR is set to 345kbps~2.15Mbps according to flow ID; RTT is set to 20 ms)
- Case 3: Flow with different CIR and different RTT(CIR is set to 95kbps~1.9Mbps and PIR is set to 345kbps~ 2.15Mbps according to flow ID; RTT is reduced from 210ms to 20ms according to flow ID)
- Case 4: Similar to Case 2 with co-existing UDP flows (Flow 1~5, 11~15 are TCP flows and flow 6~10, 16~20 are UDP flows; CBR of UDP is set to 1.14~1.90Mbps and 3.04~3.80Mbps according to flow ID)



(a) Case 1

(b) Case 2

(c) Case 3

(d) Case 4

Fig. 3. Fairness index.

Table 1. Fairness index.

	BW[bps]	5M	10M	15M	20M	25M	30M
Case 1	TSW3CM	0.641166	0.802683	0.878769	0.92074	0.954735	0.930922
	Proposed	0.953468	0.958387	0.959713	0.960246	0.968532	0.925841
Case 2	TSW3CM	0.693262	0.869282	0.937183	0.973159	0.830004	0.781953
	Proposed	0.927444	0.975508	0.972892	0.991327	0.944152	0.904953
Case 3	TSW3CM	0.764544	0.869041	0.930307	0.926345	0.882973	0.848333
	Proposed	0.968031	0.985904	0.981334	0.985682	0.960393	0.951814
Case 4	TSW3CM	0.50499	0.599119	0.875228	0.981698	0.911377	0.899237
	Proposed	0.559697	0.866794	0.975523	0.992917	0.97348	0.960918

In Fig. 3(a) Case 1 and 3(c) Case 3, the proposed scheme mitigates the impact of RTT and provides more fairly service against TSW3CM. In Fig. 3(b~d) Case 2~4, proposed scheme serves bandwidth in proportion to target rates. In Fig. 3(d) Case 4, TCP traffics are protected in the fairness guarantee function and mechanism improves the throughput. Fairness index of TSW3CM in UPN is smaller than the proposed scheme. In WPN it is good as same as each other. Fairness index of TSW3CM in OPN is not good but the propose scheme serves well excess bandwidth.

4. CONCLUSION

Seeing from the simulation results, the proposed scheme improved the *FI* about 9.99% averagely. The maximum *FI* of TSW3CM was 0.930 while ours almost reached to 0.986 in Case 3, and the conventional was 0.982 while ours was 0.993 in Case 4. Similarly, the minimum *FI* of TSW3CM was 0.765 while ours reached to 0.952 in Case 3, and the conventional was 0.505 while ours was 0.560 in Case 4. Consequently, as compared to TSW3CM, our scheme improved fairness more effectively. The proposed algorithm still needs to reduce the implementation complexity of remarking probability. The future work about our research is not only focused on packet marking policy but also on traffic control with queue management and scheduling policy.

5. REFERENCES

[1] S. Blake et al., "An Architecture for Differentiated Services," *RFC 2475*, Dec. 1998.

[2] N. Seddigh, B. Nandy, and P. Pieda, "Study of TCP and UDP Interaction for the AF PHB," *Internet Draft <draft-nsbnpp-diffserv- tcpudpaf-01.txt>*, Aug. 1999.

[3] B. Nandy, N. Seddigh, P. Pieda, and J. Ethridge, "Intelligent Traffic Conditioners for Assured Forwarding based Differentiated Services Networks," *Proc. of IFIP High Performance Networking*, June 2000.

[4] A. Habib, B. Bhargava, and S. Fahmy, "A round trip time and timeout aware traffic conditioner for differentiated services networks," *Proc. of IEEE Int. Conf. on Communications*, Apr. 2002.

[5] C.J. Chang, Y.H. Cheng, and L.F. Lin, "The Traffic Conditioner with Promotion and Fairness Guarantee Schemes for DiffServ Networks," *ICC '03. IEEE International Conference*, vol. 1, pp. 238-242, May 2003.

[6] G. Cheng, K. Xu, Y. Tian, and N. Ansari, "Core-Stateless Proportional Fair Queueing for AF Traffic," *Proc. of the IEEE GLOBECOM*, vol. 2, pp. 732-736, Dec. 2004.

[7] W. Fang, N. Seddigh, and B. Nandy, "A Time Sliding Window Three Colour Marker (TSWTCM)," *RFC 2859*, June 2000.

[8] O. Elloumi, S. De Cnodder, and K. Pauwels, "Usefulness of Three Drop Prededences in Assured, Forwarding Service," *Internet Draft <draft-elloumi-diffserv-threevstwo-00.txt>*, July 1999.

[9] VINT project, The Network Simulator-ns-2, http://www.isi.edu/nsnam/ns/.

[10] R. Jain, *The art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling*. John Wiley and Sons Inc., 1991.