A TWS3CDM based Marking Policy in DiffServ Networks

Byun-Gon Kim[1] , Kwan-Woong Kim[2], Tae-Su Jang[3] and Yong-Kab Kim[3]

[1]School of Electronic and Information Engineering, Kunsan National University, Kunsan, Korea
[2]Thunder Technology Director in Digital Signal Processing Team, ChonJu, Korea
[3]School of Electrical and Information Communication Engineering, Wonkwang University, Iksan Korea
bgkim@kunsan.ac.kr, watchbear@wku.ac.kr, ykim@wku.ac.kr

Abstract

Previous marking policy for the AF service of TCP traffic in the Diffserv network has no sufficient consideration on the effect of RTT and target rate of TCP connections. In this paper, in order to improve fairness index of TCP flows, we propose the TSW3CDM_FS(Time Sliding Window Three Color Dynamic Marker with Flow Status) based on average transfer rate estimation. The proposed algorithm is based on dynamic marking policy that allocates band-width in proportion to transmission rate of flows. We implement the proposed marking policy and evaluate the performance of the proposed marking policy by a computer simulation using NS2. From simulation results, the TSW3CDM_FS algorithm improves fairness index by comparison with TSW3CM.

***Keywords**: Diffserv, Marking Policy, TCP.*

1. Introduction

DiffServ provides a classification of service that based on required quality of service and differential service to flows in each class based on SLA(Service Level Agreement). Nevertheless, differences occur in the occupied bandwidths due to influences of UPN properties, differences of targeted transmission and RTT(Round Trip Time) between TCP flow in actual network environments[1]. Moreover, it has problems of operating like the best effort services during UPN(Under-Provisioned Network) occurrences, where the bandwidth of bottleneck link in the Diffserv domain is smaller than the sum of target transmission rates, which disables differentiated marking. Up until now, great efforts have been placed to improve such issues[2, 3].

In this paper, we propose a mechanism that determines the status of each flow by using the achieved rate and fairness of TCP flow based on average transfer rate estimation. The status of each flow can be classified to High, Steady or Low. “High” status indicates that a flow is served more than other flows in the same class, and “Low” status indicates that a flow get lower service than other flows in the same class. Therefore, different dynamic marking policies can be conducted in accordance with the status of each flow. Since these estimated values are enabled to calculate the bandwidth of the bottleneck link in the Diffserv network, it is possible to detect the UPN conditions without receiving feedback information from the network.

2. Proposed Marking

The proposed scheme determines the status of each flow by measuring the rate of TCP flow based on average transfer rate estimation to meet the requirements of AF service class for TCP flow in the Diffserv network. By using the status information of the TCP flow, the proposed dynamic marking policy is implemented in accordance with the status of each flow.

2.1 Status Controller

Status Controller renews the status information of each TCP flow at the control time of fixed intervals. The record unit measures the input rate and targeted transmission of each TCP flow and provides those information to the status controller to calculate the fairness(X_i) of each flow. Fairness of flows can be calculated by formulas (1) and (2). We can get the average fairness(XI) from formula (3).

$$X_i = \frac{g_i + y_i + r_i}{R_{ci}} \quad (1),$$

$$\begin{aligned} g_i &= gRate_i \times (1 - MaxP_G) \\ y_i &= yRate_i \times (1 - MaxP_Y) \\ g_i &= rRate_i \times (1 - MaxP_R) \end{aligned} \quad (2),$$

$$XI = \frac{\sum_{i=1}^{N} X_i}{N} \quad (3)$$

Where, X_i is fairness index of flow i, $gRate_i$ is green traffic rate, $yRate_i$ is yellow traffic rate and $rRate_i$ is red traffic rate. $MaxP_G$, $MaxP_Y$ and $MaxP_R$ are the maximum green probability, the maximum yellow probability and the red probability respectively. These parameters are used to calculate packet drop probability of MRED(Random Early Detection) queue. Whenever a packet arrived to MRED queue, MRED calculates average queue length (Qavg) then compare it with predefined thresholds: the minimum queue (Qmin) threshold and the maximum queue threshold (Qmax). If Qavg is lower than Qmin, it means that available link capacity is sufficient. Therefore, all packets are handled normally. Whereas, Qavg is between Qmin and Qmax, newly arrived packets are randomly dropped with the maximum drop probability of RED algorithm. The status value of each TCP flow is determined by using the maximum probability value for each color of RED.

2.2 Dynamic Marking Policy

If the status of flow *i* is “High”, flow *i* receives more service than it deserve. Therefore, to reduce service quality of flow *i*, marking policy reduces green & yellow marking probability of flow *i* dynamically by formula (4). If the status of flow *i* is “Low”, marking policy raises green & yellow marking probability of flow i by formula (5).

$$DP_i = \frac{(X_i - XI) \times \alpha}{X_i}, \quad sR_{ci} = R_{ci} \times DP_i, \quad sR_{pi} = R_{pi} \times DP_i \quad (4),$$

$$UP_i = \frac{(XI - X_i) \times \alpha}{XI}, \quad sR_{ci} = R_{ci} \times UP_i, \quad sR_{pi} = R_{pi} \times UP_i \quad (5)$$

Where DP_i is down factor of flow *i*, and UP_i is up factor of flow *i*. In the formula, the range of α is between 0 and 1. As the target transmission and maximum target transmission rate is calculated according to status of flow *i*, sR_{ci} and sR_{pi} are dynamically calculated according to status of flow. The flow of STEADY status holds the same R_{ci} value and R_{pi} value as the existing TSW3CM policy. In such way, the marking algorithm according to the status of flow can be implemented as the existing TSW3CM in the following, after calculating the target transmission(sR_{ci}) and maximum target transmission(sR_{pi}) according to each TCP flow.

3. Performance Evaluation

Simulation of the TSW3CMD_FS algorithm proposed in this study is performed by using NS-2 and the network model is shown in Figure 1. Table 1 shows value of parameters used for network simulation. Each simulation was run for 100 seconds and was conducted by dividing the bandwidth of core-edge link in UPNs of 5Mbps and 10MPs and OPN status of 25Mbps. Furthermore, the background traffic was used to investigate the effect of backlogged traffic for variable bandwidths of 25Mbps(0-20sec)-> 5Mbps(20-80sec)->25Mbps(80-100sec). The simulation was implemented by dividing the RTT_i and R_{ci} values of TCP traffic sources into 3 different cases of the following and the sum of overall R_{ci} was set in the proximity of 20Mbps.

CASE 1 : R_{ci} fixed, RTT_i variable,
CASE 2 : R_{ci} variable, RTT_i fixed,
CASE 3 : R_{ci} variable, RTT_i variable

The fixed R_{ci} value was set at 1Mbps and variable R_{ci} was ranging from 0.095Mbps to maximum of 1.9Mbps, with the RTT_i fixed value set at 20ms and the variable value set with value ranging from 20ms to maximum of 210ms in implementing the simulation.

The status of BD(Bottleneck Detect) is impossible for differentiated marking since the sum of target transmission has grown larger than the bandwidth of the bottleneck link. In this study, the bottleneck status was detected by using the congestion control mechanism of the TCP protocol and the fact that most packets of TCP flow are marked green in the bottleneck link status.

Table 1. Parameters for Simulation

Parameter	Value
$MaxP_G$, $MaxP_Y$, $MaxP_R$	0.01, 0.05, 0.1
α, β	0.8, 0.8
ThXI, ThBot,	0.2, 0.6
ThNoBot, ThGR	0.7, 0.95
packet size	256byte
simulation time	100sec

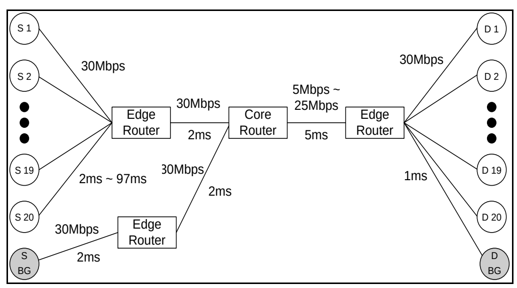

Figure 1. The Network Model for Simulation

The simulation was performed by varying the RTT and target transmission of the TCP source and core link bandwidth. Moreover, the result analysis was conducted by using the fairness index for cases applied and not applied with the UPN detection method of TSW3CM and the proposed TSW3CMD_FS algorithm.

The fairness index is defined as the follows.

$$x_i = \frac{achieved\ rate_i}{ideal\ rate_i} \quad (6), \qquad fairness\ index = \frac{(\sum_i^n x_j)^2}{n \times \sum_i^n x_j^{\ 2}} \quad (7), \qquad ideal\ rate_i = R_{ci} \times \frac{\sum_i^n achieved\ rate_i^{\ 2}}{\sum_i^n R_{ci}} \quad (8)$$

Where, achieved rate *i* is the average transmission of flow *i* and ideal_ratei is the ideal transmission rate of flow *i* and it is proportional to the target transmission rate and can be obtained by using formula (8). Rci is the utility rate of flow i and n is the number of flows during active status. Moreover, the fairness index holds the value between 0 and 1 and implies that the ideal distribution between flows has been accomplished.

Figure 2 displays the fairness index value in CASE 1. In CASE 1, the target transmissions of TCP flows were all identically determined as 1Mbps to determine the overall target transmission to be 20Mbps while setting different RTT values for each TCP flow. Here, the RTT value of flow 1 was set at 20ms and increased by 10ms according to rise of flow id for the RTT of flow from 20ms to 201ms.

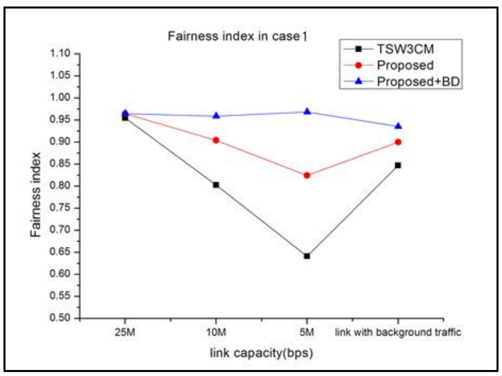

Figure 2. Fairness Index of Case 1

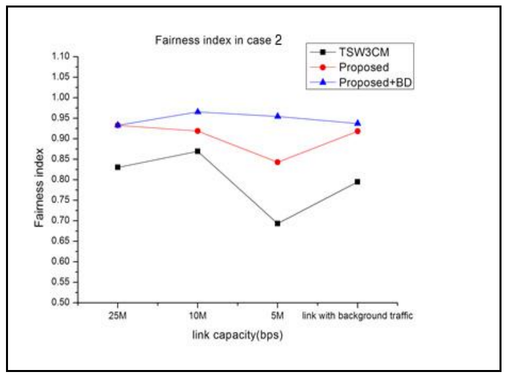

Figure 3. Fairness Index of Case 2

As shown in Figure 2, when the RTT values are all different while the target transmission rates of all TCP flows are the same, the flows with smaller RTT values receive greater amount of service in comparison. The proposed TSW3CDM_FS algorithm sets the flow status of these flows that receive greater service to "High" to lower the green or yellow marking probability of these flows and increase the green or yellow marking probability of flow that receives lesser services to enable them to receive fair service. Furthermore, the UPN detection (Proposed+BD) algorithm was applied to maintain over 0.90 in fairness by applying the marking probability to suit the UPN status. Figure 3 plots the fairness index of marking schemes in CASE 2. In CASE 2, the RTT of flows are set to 20ms, the target transmission rate of flow 1 is set at 0.095Mbps and is gradually increased according to flow id so that the value of flow 20 becomes 1.9Mbps and the overall target transmission rate becomes 19.95Mbps. Figure 4 plots the fairness index of CASE 3. As the case with all different target transmission rate values and RTT, CASE 3 set the value of flow 1 was set at 0.095Mbps and gradually increased according to increase of flow id for the value of flow 20 to become 1.9Mbps to make the overall target transmission rate of 19.95Mbps. At the same time, the RTT value of flow 1 was set at 210ms and reduced by 10ms according to increase of flow id. Thus, the RTT of flow 20 become 20ms. In CASE 3, the proposed TSW3CDM_FS method shows that the fairness index is more improved than the TSW2CM method.

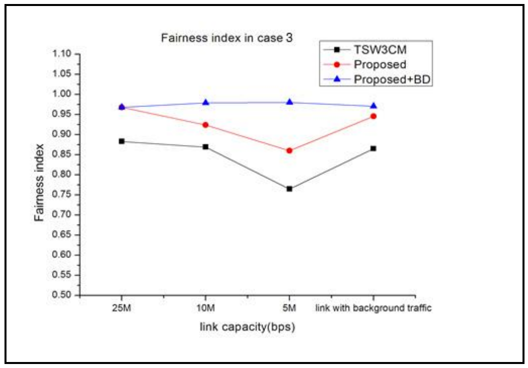

Figure 4. Fairness Index of Case 3

The TSW3CDM_FS method proposed in this study gives fairness improvement by an average of 6% in all cases when compared to the existing TSW3CM method and particularly gives results over minimum of 0.93 in cases applied with the UPN detection method and improvement in fairness of average 10% when compared to the TSW3CM method. As a result of the simulation for dynamic marking algorithm proposed in this study, the TSW3CDM_FS method in the Diffserv network was confirmed for providing the services suited for the various conditions.

4. Conclusions

In this paper, we proposed dynamic marking policies called The TSW3CDM_FS(Time Sliding Window Three Color Dynamic Marker with Flow Status). TSW3CDM_FS performs packet marking according to status of each flow by using the status information of each flow. The status of flows are decided by measuring the average service rate of TCP flow to satisfy the requirements of AF service class for TCP flow in the Diffserv network. From the simulation result, TSW3CDM_FS shows improved results with an average of 10% in various conditions when compared to the existing TSW3CM method. It was confirmed that such improvements occurred due to the fact that the effects of RTT were supplemented in proportion to target transmission rate of each flow in situations with flows with various target transmission rates and RTT of TCP traffic in the AF service of the Diffserv network.

Furthermore, the differential service QoS in the Diffserv network is not only influenced by the marking policy but also highly influenced by the queue management policy and the scheduling policy. Therefore, the study on packet marking policy must be conducted alongside studies on the queue and scheduling policy in future studies.

References

[1] X. Xiao and L. M. Ni, “Internet Qos: A Big Picture”, IEEE Network, Vol. 13, No. 2, pp. 8-18, **(1999)** March.

[2] I. B. H. Alves, J. F. Rezende and L. F. M. Moraes, "Evaluating Fairness in the Aggregated Traffic Marking", Proceedings of IEEE Global Telecommunications Conference, pp. 445-449, **(2000)** November.

[3] A. Habib, B. Bhargava and S. Fahmy, "A round trip time and timeout aware traffic conditioner for differentiated services networks", Proceedings of IEEE Int. Conf. on Communications, pp. 981-985, **(2002)** April.

[4] H. D. Hai, P. V. Thuong and You-Sik Hong, “A Study on Bandwidth and Buffer Management Mechanisms of IP Networks”, The Journal of IWIT, Vol. 10 No. 2, pp. 143-149, **(2010)** April.

[5] Chung-Ju Chang, Yung-Hong Cheng, and Li-Fong Lin, "The Traffic Conditioner with Promotion and Fairness Guarantee Schemes for DiffServ Networks", Vol. 1, pp. 238-242, Communications, ICC '03. IEEE International Conference, **(2003)** May.

[6] C. Lim, “TCP Performance Improvement in Network Coding over Multipath Environments”, The Journal of IWIT, Vol. 11 No. 6, pp. 81-86, **(2011)** December.