Dynamic Swapping and Marking Queue Management

Jui-Pin Yang

***Abstract*—In this paper, we propose a simple and effective queue management scheme to provide fairness and differentiated drop precedence at the same time, that is, Dynamic Swapping and Marking (DSM). The DSM dynamically swaps the counts of current queue length between both packets according to their drop precedence within the same flow. In addition, the DSM selectively marks a resided packet with the maximum count among competing flows. Simulation results show that DSM achieves good fairness and sufficient differentiated drop precedence under various traffic conditions.**

***Index Terms*—Queue management, fairness, differentiated drop precedence.**

I. Introduction

In the past, many studies have been proposed in order to deal with fairness on bandwidth sharing among competing flows. The queue management algorithms are the promising solutions because they are easy to implement and suitable for high-speed networks [1]-[7]. The main idea behind the queue management algorithms is that arrival packets will be judged as acceptance or discard according to specific algorithms before they are admitted to enter the buffer. In general, they often work with a simple FIFO scheduling. Many applications nowadays need differentiated drop precedence between packets that contributes to enhance QoS. Accordingly, many studies have been proposed to deal with this issue such as RIO (RED with In/Out), Adaptive RIO (A-RIO), and RIO-C (RED with In/Out and Coupled queue) [8]-[13]. They often discard the packets with higher drop precedence earlier when the average queue size is smaller. Consequently, the packets with lower drop precedence possess lower packet drop rate that achieves differentiated drop precedence. However, the well-known schemes only cope with fairness or differentiated drop precedence. In other words, a queue management scheme that is able to deal with two issues at the same time is attractive and practicable. As a result, we propose the dynamic swapping and marking (DSM) algorithm in this paper.

II. Dynamic Swapping and Marking

The DSM algorithm focuses on providing good fairness among competing flows and sufficient differentiated drop precedence within a flow simultaneously. The DSM algorithm is one of the queue management schemes, so it keeps simplicity. When the buffer is full in a router and then a packet is arriving, the DSM algorithm will discard the arrival directly. On the other hand, the DSM denotes Q_u which represents the sum of current queue length of unmarked packets and size of the arriving packet.

If $Q_u < Th$, any arriving packet will be admitted to enter the buffer and identified as unmark type where Th denotes a control threshold. When a larger Th is chosen, the DSM algorithm obtains better fairness and differentiated drop precedence. However, this increases packet comparisons and waiting time. If $Q_u \geq Th$, the DSM algorithm executes a swapping policy and then a marking policy in sequence. When a packet arrives, the swapping policy selects an unmarked packet that possesses the highest drop precedence with maximum count of current queue length from the same flow. If the drop precedence of the arriving packet is smaller than that of the candidate, both counts should be compared further. If the count of the arriving packet is smaller, they both swap the count values. Next, the arriving packet is admitted to enter the buffer and labeled as unmark type. On the other hand, no additional operation is needed. The functionality of the swapping policy is used to support packets with differentiated drop precedence within a flow. Here, Green, Yellow and Red drop precedence represent the high, medium and low priority packets respectively. Furthermore, the DSM algorithm uses a marking policy that searches an unmarked packet with the maximum count of current queue length and then marks it as mark type. The search direction is from tail to head because it contributes to enhance fairness. By marking that packet, the DSM algorithm can achieve fairness. The marking policy is similar to the DDE algorithm. Therefore, the DSM algorithm is able to provide good fairness like that of the DDE.

The DSM algorithm works with a simple FIFO packet scheduling, but there is little difference. When a marked packet reaches the head of the buffer, it will be discarded immediately. Otherwise, only the unmarked packet is eligible for transmission. In addition, the DSM uses simple drop-tail buffer management scheme to manage the buffer. In another word, all accepted packets stay in the buffer including mark and unmark type. The DSM algorithm may have worse fairness and differentiated drop precedence because of insufficient buffer size. To improve the impact of small buffer size, the DSM algorithm can apply the PO buffer management scheme to overcome the mentioned issue [14]. The way is to replace the marking policy by the pushout policy. If the queue length of unmarked packet is equal or larger than the Th, the PO will involve a pushout operation. As we have mentioned in the DDE, the PO is too sophisticated to implement in future networks with high-speed requirement. In order to keep consistent simplicity

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with the DSM algorithm, we choose the FIFO scheduling and drop-tail buffer management scheme herein.

III. Simulation Results

The network topology is depicted in Fig. 1. Furthermore, the input traffic for each flow is generated from a specific ON-OFF model and total simulation time is 100 seconds. There is no suitable scheme capable of dealing with both issues at the same time, so we mainly study the fairness and differentiated drop precedence of the DSM under different traffic conditions. We use normalized bandwidth ratio (NBR) [7] and packet drop rate (PDR) of per drop precedence to show the performance.

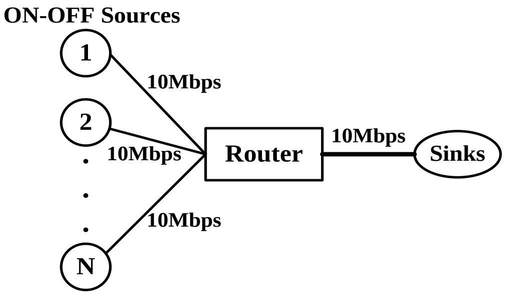

Fig. 1. A single congested link.

In Fig. 2(a), we show the normalized bandwidth ratio of each flow under different buffer sizes. The red dash line represents the optimal fairness because the NBRs of all flows equal 1.0. In addition, *B* denotes total buffer size. When *B* is set at 64 KB, it results in the most frequent drop-tail behavior because of greatly insufficient buffer size. Therefore, the DSM has worse fairness. When *B* is larger than 128 KB, the fairness is improved remarkably. When *B* is set at 192 KB or 256 KB, the DSM provides good and approximate fairness because the drop-tail effect of insufficient buffer size is negligible. In other words, the DSM completely develops the fairness.

In Fig. 2(b), we show the PDRs of Green, Yellow and Red drop precedence with respect to Fig. 2(a). When *B* is set at 64 KB, it leads to drop-tail behavior for each flow especially for flow 1. As a result, the PDRs of Green, Yellow and Red drop precedence of flow 1 are very close. As for the other flows, they have better differentiated drop precedence because their mean input rate is relatively larger. The reason is that their Green packets have relatively sufficient Yellow and Red packets to be swapped and Yellow packets have relatively sufficient Red packets to be swapped, too. When *B* is set at 128 KB or 192 KB, each flow keeps approximate PDRs of per drop precedence because their NBRs are very close. In a word, the DSM is able to provide sufficient differentiated drop precedence if buffer size is sufficient.

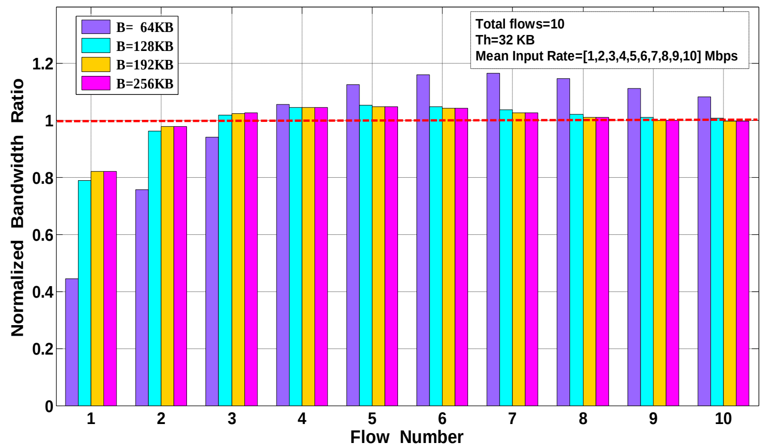

Fig. 2(a). Normalized bandwidth ratio vs. per flow under different buffer sizes.

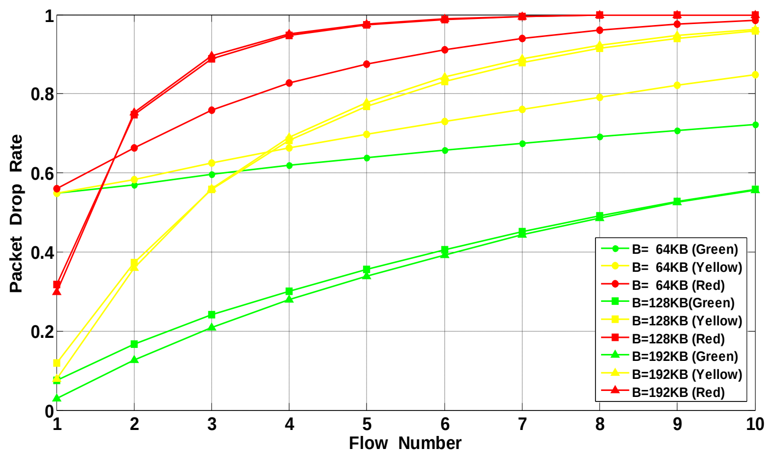

Fig. 2(b). Packet drop rate vs. per flow under different buffer sizes.

In Fig. 3(a), we show the normalized bandwidth ratio of each flow under different *Th*. When *Th* is set at 16 KB, flow 1 gets the smallest NBR but the flow 10 gets the largest NBR. The reason is that flow discrimination with respect to queue length isn't enough due to a small *Th*. When *Th* is set at 32 KB, the DSM is able to provide good fairness. When *Th* is set at 48 KB, flow 1 gets the largest NBR but flow 10 gets the smallest NBR as compared with the individual self. A large *Th* contributes to improve flow discrimination, so that more arrival packets of the flow 1 could be accepted. On the other hand, the packets of flow 10 have a higher probability to be marked and then discarded herein. When *Th* is set at 64 KB, the DSM has quite sufficient flow discrimination beneficial to flow 1. However, it also causes more serious drop-tail behavior. As a result, the NBR of flow 1 decreases. Inversely, the NBR of flow 10 increases because it has the largest mean input rate that contributes to obtain more bandwidth.

In Fig. 3(b), we show the PDRs of Green, Yellow and Red drop precedence with respect to Fig. 3(a). When *Th* is set at 16, 32, 48 or 64 KB, the DSM always provides sufficient differentiated drop precedence for all flows except for flow 1. The PDRs of Green, Yellow and Red drop precedence of flow 1 are approximate when the *Th* is set at 64 KB. The reason is that the effect of drop-tail behavior is relatively serious to flow 1 because its mean input rate equals the max-min fair share rate. Therefore, the swapping policy is unable to work efficiently. In a word, the DSM is able to provide sufficient differentiated drop precedence when it collaborates with a proper *Th*.

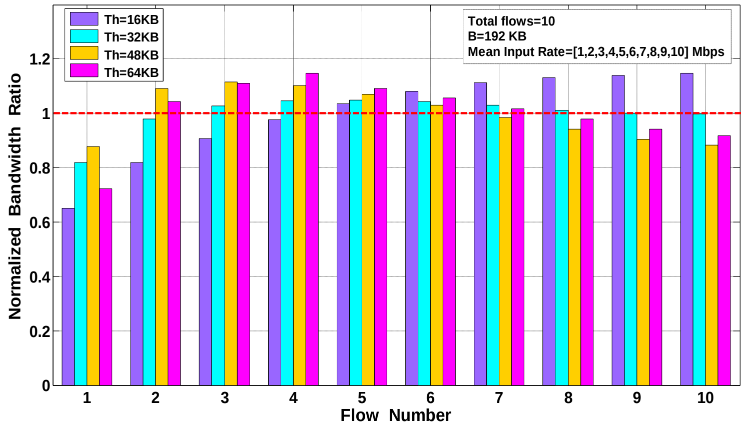

Fig. 3(a). Normalized bandwidth ratio vs. per flow under different control thresholds.

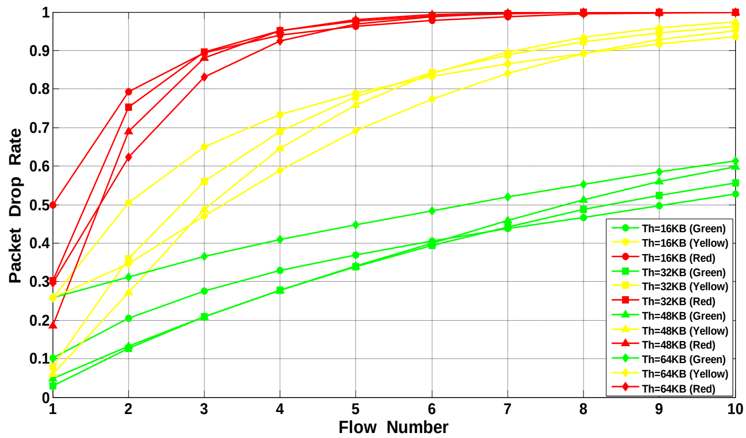

Fig. 3(b). Packet drop rate vs. per flow under different control thresholds.

In Fig. 4(a), we show the normalized bandwidth ratio of each flow with different ratios of drop precedence. In the ratio of [3, 3, 4], it means that the probability of an arrival packet has thirty percentage of being a Green packet, thirty percentage of being a Yellow packet and forty percentage of being a Red packet. When the ratio of Green packets increases and the ratio of Red packets decreases, flow 1 to flow 3 get smaller NBRs. These flows have lower mean input rate, so their Green packets have lower chance to swap with that of Yellow and Red packets. Similarly, their Yellow packets have lower chance to swap with that of Red packets. Accordingly, flow 6 to flow 10 will get larger NBRs. From Fig. 2(a) to Fig. 4(a), we conclude that the DSM is able to provide good fairness under various traffic conditions.

In Fig. 4(b), we show the PDR of Green, Yellow and Red drop precedence with respect to Fig. 4(a). When the ratio of Green packets increases and the ratios of Yellow and Red packets decrease, the PDRs of Green, Yellow and Red packets all increase with respect to each flow. The reason is that most of Yellow and Red packets are swapped by the Green packets. Consequently, they both PDRs increase. In addition, we also find that PDR of Green packets for each flow increase. The reason is that the ratio of Green packets increases, hence they have lower chance to swap with that of higher drop precedence. From Fig. 2(b) to Fig. 4(b), we conclude that DSM is able to provide sufficient differentiated drop precedence under various traffic conditions.

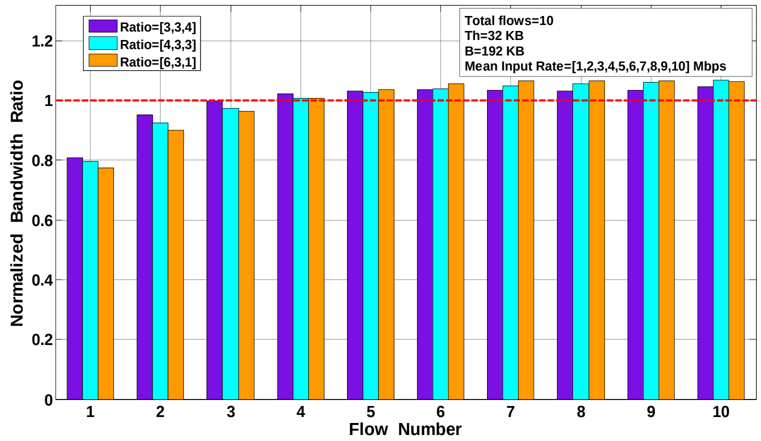

Fig. 4(a). Normalized bandwidth ratio vs. per flow under different ratios of drop precedence.

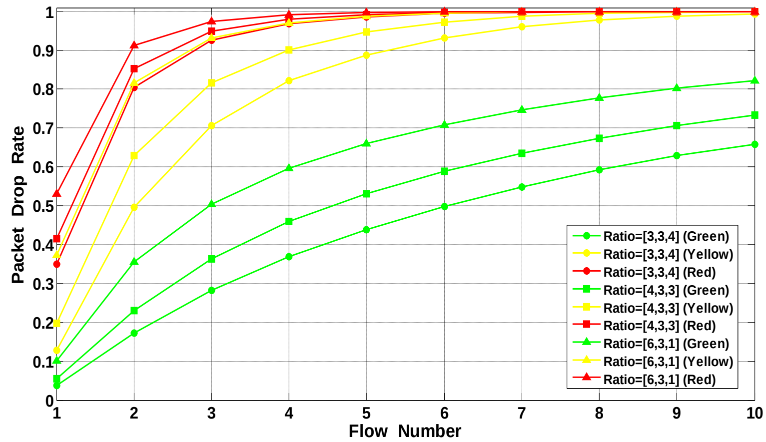

Fig. 4(b). Packet drop rate vs. per flow under different ratios of drop precedence.

IV. CONCLUSIONS

In this paper, we propose a novel queue management algorithm, that is, Dynamic Swapping and Marking. The DSM collaborates with the simple FIFO scheduling and drop-tail buffer management, hence it is simple to implement. Simulation results validate that the DSM effectively provides good fairness and sufficient differentiated drop precedence under different traffic conditions. In the future, we would like to extend the DSM whose control threshold adapts dynamically in order to cope with changing traffic conditions. In addition, we would like to verify the robustness of the DSM in more complicated network environments.

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