# An Encoding Method to Signal 3 States with a Single PCN Bit

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***Abstract*—Pre-Congestion Notification (PCN) is currently being developed by the IETF to provide admission control in DiffServ networks for non-elastic flows. Various marking schemes are being proposed as part of this effort. We evaluate a new marking behaviour that could be used to signal three different states by means of a single bit. This scheme is of interest to networks operating with MPLS as the Label QoS coding space is limited to three EXP bits. Similar to the ECN standard for MPLS, this research assumes that just two codepoints will be available to indicate different congestion states. Of these two codepoints, one would be used to differentiate between PCN and non-PCN traffic and the other would be used for PCN marking. This paper outlines the approach and presents the advantages and limitations of the proposal using the evaluations performed. A comparison of the method with a two bit PCN marking approach is also studied.**

## I. Introduction

The basic idea behind Pre-Congestion Notification (PCN) [1] being developed by the IETF, is that congested core routers mark packets and the ingress/egress router uses this information to perform Admission Control (AC - decide whether to accept or reject a request for a new flow) and Flow Termination (FT - terminate existing flows in case of extreme congestion). The PCN marking performed by core routers can either be threshold marking or excess marking [1]. Though there are various other proposals, this paper evaluates a scenario such as in an MPLS environment with one available bit for PCN marking. This paper does not explain AC and FT in detail due to space limitations. Please refer to [1] for a detailed explanation of the terminology used.

## II. State of the art and Motivation

DiffServ and MPLS are state of the art technologies operated in many carrier backbones. The IETF standard specifies ECN for MPLS [2] using just two codepoints to differentiate congestion states. According to PCN's base line encoding [3], one of the two QoS codepoints available in an MPLS packet header is used to differentiate between PCN flows and non-PCN flows. Therefore only one bit is available to perform PCN marking by the core routers. The limitation of one available bit restricts the possibility of performing PCN marking to signal AC and FT simultaneously. It may be still desirable to differentiate operation of a pre-congested PCN domain interface in admission control state from the flow termination state at the egress router using just PCN marking without extra signalling. Out of band signalling is used by the egress router to send feedback to the ingress router, to thereby initiate the start of AC or FT.

## III. Proposal: Three state signalling with one bit

The proposal aims to provide AC and FT functionality to a PCN enabled MPLS network. Therefore three states (No congestion, AC, FT) have to be signalled using the available 1 bit. A gist of the protocol is given below.

**Admission Control:** Once the PCN traffic rate is above a link's AC threshold (Fig. 1.a.), admission control is realised by threshold marking (marking all packets) of the AC bit of the packets. When a new flow arrives at the ingress router, it sends a control packet to the egress router. If it reaches the egress router without the AC bit marked, the flow is accepted. In the AC mode, the egress router doesn't need to meter any packets.

**Flow Termination:** When the PCN traffic rate crosses a link's FT threshold, the core router un-marks the pre-set AC bit for packets that exceed the FT threshold (excess marking). This will trigger the egress router to go to FT mode, wherein it will start metering the traffic. Based on the percentage of unmarked to marked packets, the egress router informs the ingress router to terminate a certain amount of flows that were received with unmarked packets. The main aim of this proposal is to inform the egress router that traffic has crossed the FT threshold and that it is time for flow termination. It is then the responsibility of the egress router to meter the traffic and perform the termination of the excess flows. Note that the threshold marker still continues to mark all packets crossing the link to indicate AC and therefore the excess marker would have to un-mark the packets again (if marking is realised eg. by sequential single rate token buckets). The detailed proposal is outlined in [4].

## IV. Evaluation

### A. Experimental setup

We have modelled the evaluation parameters based on [5]. A bottleneck link with a capacity of 10 Mbits/s, a supportable capacity of 8.0 Mbits/s (FT-threshold rate) and an admissible rate of 5 Mbits/s (AC-threshold rate) are assumed. Voice traffic is modeled based on IP-telephony encoded by G.711 with silence suppression. On and off periods are exponentially distributed with expected lengths of 350 and 650 ms respectively and with a 64 kb/s peak rate. The call holding time is exponentially

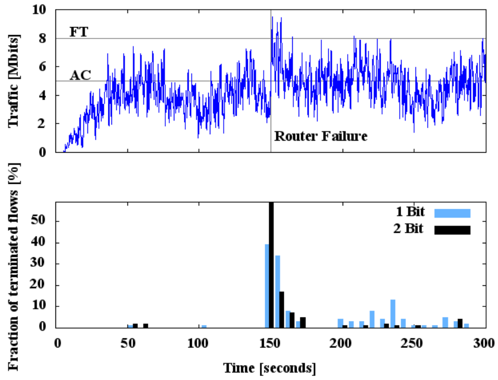


Fig. 1.
a. (top figure) : Outgoing traffic at core-router-1. The peak at 150 seconds is caused by a router failure. The two horizontal lines indicate the AC (5 Mbit) and the FT (8 Mbit) thresholds.
b. (bottom figure) : Histogram of the point in time when flows were terminated

distributed with an expected value of one minute and the packet size is 160 bytes. An average of 10 runs with varying random seeds were performed to obtain the results.
The evaluation topology consists of two ingress routers that have traffic flowing to the same egress router, but using different core routers. The network performs normal AC and thus ensures that the ingress routers accept about 5 Mbits/s of data to be sent to the egress router. Results using background traffic are not shown in this evaluation since it does not affect the current scenario. To simulate FT mode, a node failure (core-router-2) at 150 seconds is introduced. This results in twice the traffic traversing core-router-1 since traffic from ingress router-2 is diverted to core-router-1.
Fig. 1.a. shows the normal traffic through the congested core-router-1 along with its AC and FT thresholds. It should be noted that the router failure at 150 seconds introduces more traffic and in due time the network achieves stability, after performing FT (some flows are released by the users themselves).

### B. Flow termination rate

To evaluate and compare the performance of the encoding scheme evaluated in this paper, the flow termination time was measured. It is the time taken by the network to arrive at the expected behaviour (traffic rate below the FT-threshold) after a route or node failure. Fig. 1.b. shows the comparison of the one bit proposal and the two bit proposal[3]. The X-axis represents the time and on careful observation it is noticed that the one bit approach though not as fast as the two bit approach is still able to terminate the extra flows in roughly the same time as it takes for the two bit approach. Measurements show that it takes an average of 11.39 seconds for the network using the one bit approach to terminate the extra flows whereas the two bit approach takes an average of 2.67 seconds.

### C. Identify flow termination from normal behaviour

Fig. 1.b. also shows that the one bit approach is able to detect the FT mode well by performing most of the FT requests after the node failure occurs. There are some FT requests before the occurrence of route failure and much later. This is due to the highly fluctuating incoming traffic rate, but the numbers are not very significant.

### D. Number of falsely accepted flows

We also evaluated the number of falsely accepted flows that the network admits during FT mode and compared it to the two bit proposal. During flow termination mode, there is a chance for control packets to reach the egress router unmarked thereby resulting in the admission of new calls adding to the congestion. In the two bit approach, there is no possibility of a falsely accepted flow.
Evaluations show that the mean percentage of falsely accepted flows in the one bit approach is zero. This could be due to the relatively low number of unmarked packets, when traffic crosses the FT threshold rate. Though more tests in complicated scenarios are required for proper validation, the result implies that the effect of AC is comparable to the two bit-approach and that the un-marking approach has an acceptable effect on AC. In any case, even if some flows are falsely admitted during FT mode, these falsely accepted flows may also get terminated in due course, but nevertheless this might increase the time the network takes to achieve stability.

## V. Conclusion and Future Work

A standard conformant MPLS domain only has two code-points available to encode different congestion states. This paper analyses the use of a single bit approach and aims at achieving nearly the same functionality as the two bit approach. The proposal has some obvious limitations leading to errors closer to the threshold rates and in differentiating states, when traffic fluctuates around either AC or FT threshold, which may lead to similar traffic patterns.
We have shown in this paper that the proposed encoding for a single bit approach[4] works as well as the two bit approach[3] and that it does not have a huge negative impact on the network.
This paper is a first attempt to study the impact of the limitations and the feasibility of providing an MPLS network with the option of AC and FT to improve its performance. Work is currently being done to perform a detailed evaluation of the pros and cons of [4] with respect to the two-bit approach [3]. Further study of the effects of this proposed method in more complicated scenarios is being done.

## References


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