A Two Markers System for Improved MPEG Video Delivery in a DiffServ Network

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***Abstract*— The failure of legacy packet markers such as the Single Rate Three Color Marker (SRTCM) and the Two Rate Three Color Marker (TRTCM) to distinguish important and less important data renders them unsuitable for MPEG video transmission in a DiffServ network. Therefore, we propose a Two Markers System (TMS) to improve the delivery quality of MPEG video streams. We use authentic MPEG4 video traffic traces to compare the performance of the proposed TMS system with those of legacy packet markers. Results show that TMS outperforms the legacy traffic markers in terms of the quality of the delivered MPEG video streams.**

***Index Terms*— QoS, MPEG video, DiffServ.**

I. Introduction

With the increasing tendency for data transmissions to comprise an amalgamation of various contents, using the standard best-effort mechanism to execute their transmission becomes a less satisfactory experience for the end user. Therefore, the IETF has defined two service models for network Quality of Service (QoS), namely the IntServ model [1] and the DiffServ model [2]. However, the complexity and scalability problems of IntServ have made DiffServ more attractive as a means of providing scalable network QoS.

QoS for video transmission has been the focus of several previous studies [3], [4]. In particular, MPEG video transmission in a DiffServ network has seen various QoS mappings for streamed MPEG video at the video server prior to transmission depending on the contribution made by each frame type to the perceived picture quality [5]. Standard MPEG encoders generate three distinct types of frames, namely *I*, *P*, and *B* frames. Due to the hierarchical structure of MPEG, *I* frames are more important than *P* frames, and in turn *P* frames are more important than *B* frames. Therefore, in [6] the delivered quality of the MPEG video stream is enhanced by marking the *I* frame packets as green, the *P* frame packets as yellow, and the *B* frame packets as red. However, the main problem associated with these MPEG video source QoS mappings is that there is no policing algorithm involved at the edge of the DiffServ domain to check the conformance of the incoming packets. If legacy packet markers such as the Single Rate Three Color Marker (SRTCM) [7] or the Two Rate Three Color Marker (TRTCM) [8] are applied at the ingress of the DiffServ domain, the importance indication of a frame packet is disregarded. For example, an *I* frame packet with a green mark may be downgraded to a yellow or red mark if it is measured as out of profile.

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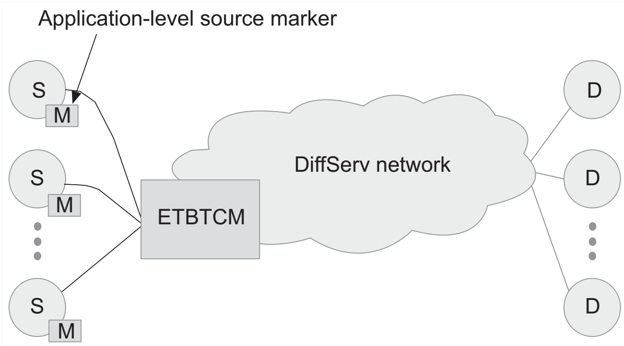
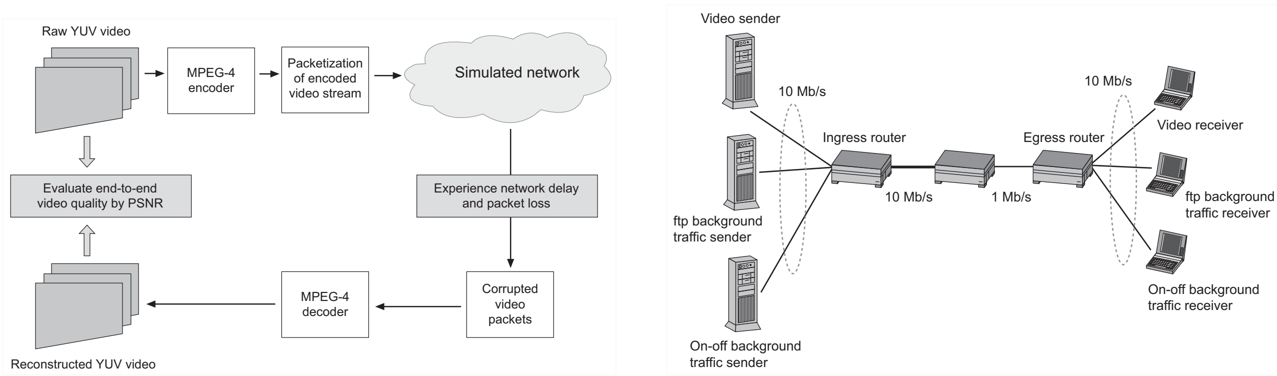


Fig. 1. The Two Markers System framework.

In this paper, we propose a Two Markers System (TMS), an enhanced marking scheme for MPEG video transmission in a DiffServ network. The aim of this scheme is to overcome the limitations of legacy packet markers in multimedia traffic applications like those using MPEG video streams. The legacy packet markers make no distinction between important and less important data at the edge of a DiffServ domain, and hence may fail to appropriately mark packets to optimize the delivery quality of an MPEG video stream. Therefore, important frame packets may be dropped before less important ones under network congestion conditions, strongly penalizing the MPEG video stream. The proposed TMS places marker modules at both the video source and the edge of a DiffServ network to act at different levels of the video stream. The source marking modules act at the application level to set an importance indicator in the IP header of the MPEG frame packet by evaluating the contribution of the packet to the expected picture quality to be perceived by an end user. Meanwhile, to act at the edge of the DiffServ network, we propose the Enhanced Token Bucket Three Color Marker (ETBTCM) to perform packet marking at the network level in accordance with the pre-assigned importance of each video frame packet. When the network is busy and there are insufficient tokens in the bucket, less important frame packets are marked with a higher drop probability than packets of greater importance. As a consequence, in the event of network congestion, less important frame packets are dropped before important ones.

The remainder of this paper is organized as follows. Section II introduces the proposed Two Markers system, while



(a) Simulation setup

(b) Simulation topology

Fig. 2. Simulation model.

Section III describes the simulation model utilized to compare the performance of the proposed marker system with that of two legacy packet marking algorithms. Finally, Section IV presents some brief conclusions.

II. Two Markers System (TMS)

Fig. 1 shows the framework of TMS, whose components are described in this section.

A. Enhanced Token Bucket Three Color Marker

The Enhanced Token Bucket Three Color Marker (ETBTCM) is based on the conventional leaky bucket for packet marking. It marks individual frame packets at the edge of the DiffServ domain according to their relative importance within the MPEG video stream. The ETBTCM retains the CIR and CBS parameters of the leaky bucket packet marker, but modifies the original marking algorithm. The fundamental principle of ETBTCM is that all frame packets are marked as green provided that sufficient tokens are available in the bucket. However, when there are insufficient tokens for the packet to pass, less important packets are marked with a higher drop probability, *i.e.* red for *B* frame packets and yellow for *P* or *I* frame packets. Therefore, in the event of network congestion, less important frame packets are dropped before more important ones.

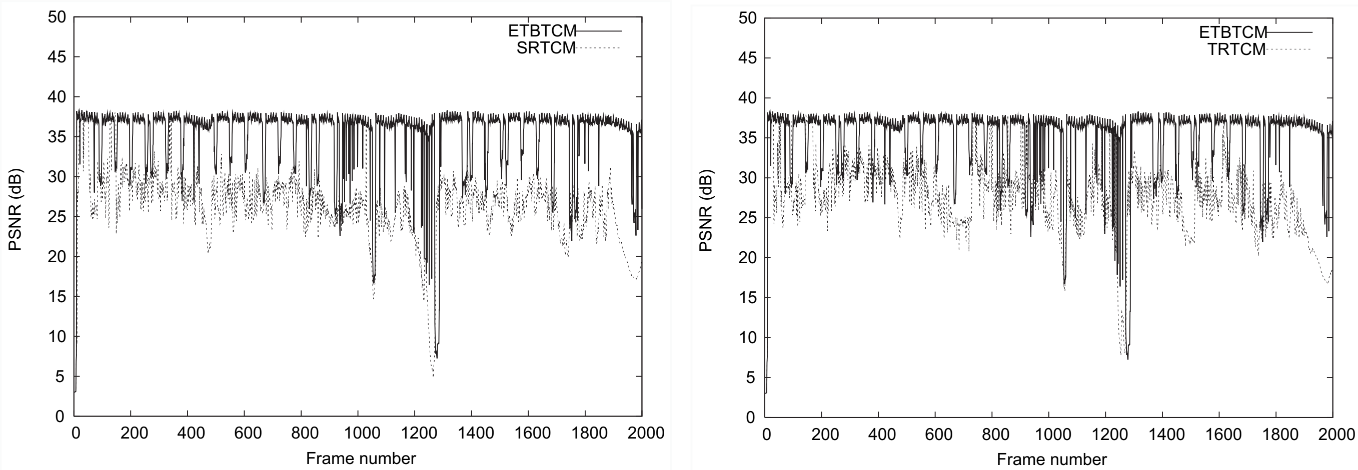
B. Application-level Source Marker

In order to enable the ETBTCM module to recognize the importance of a packet during the packet marking process without checking its application header, the packets are pre-marked at the video source before they are transmitted. In contrast to previous source QoS mapping schemes that directly mark frame packets as green, yellow, or red, we propose to pre-mark packets using the significance indicator of each packet. This information can be carried on the DSCP, which is a 6-bit field in the IP header having a maximum of 64 distinct values. These values are divided into three pools for codepoint assignment and management purposes, *i.e.* codepoints in Pool 1 which are standardized, codepoints in Pool 2 which are reserved for experimental or local use, and codepoints in Pool 3 which are available for experimental and local use, but which may also be subject to standardization in the event that Pool 1 becomes exhausted.

In the present study, the fourth bit of the DSCP in Pool 3 is redefined as a significance bit. This bit is used as the importance indicator of the MPEG frame packet. If the packet is important, *i.e.* it is an *I* or a *P* frame packet, this bit is set to 1. Otherwise, in the case of a *B* frame packet, the bit is set to 0. The first three bits of the DSCP in Pool 3 are used to indicate the packet drop precedence after traffic conditioning at the ingress to the DiffServ domain. When the first bit is set, the packet is marked as green. Similarly, when the second bit is set, the packet is marked as yellow, while when the third bit is set, the packet is marked as red.

III. Simulation Results

We used MPEG4 video traffic traces to compare the performance of the proposed TMS with those of legacy packet markers using the NS2 simulator [9]. The overall simulation model is shown in Fig. 2. The test video trace was a Highway CIF format sequence [10], which has 2000 frames. The encoded stream has a mean bit rate of 412 kb/s and a peak rate of 1116 kb/s. Each frame was fragmented into packets of 1000 bytes before transmission. This video flow competed with one on-off background traffic flow, which has an exponential distribution with mean packet size of 1000 bytes, burst time of 500 ms, idle time of 0 ms, and rate of 64 kb/s, and one FTP traffic flow. The ETBTCM, SRTCM, and TRTCM schemes were all implemented on the ingress router for performance comparison purposes. The corresponding parameters were set as follows: ETBTCM CIR and CBS parameters of 412 kb/s and 1000 bytes, respectively, SRTCM CIR, CBS, and EBS parameters of 412 kb/s, 1000 bytes, and 1000 bytes, respectively, and TRTCM CIR, CBS, PIR, and PBS parameters of 412 kb/s, 1000 bytes, 1116 kb/s, and 1000 bytes, respectively. The core router implemented the Weighted Random Early Detection (WRED) mechanism for active queue management. The WRED parameters include a minimum threshold, a maximum threshold, and a maximum drop probability. In the current simulations, these parameters were specified respectively as 2, 4, 0.1 for red packets, 4, 6, 0.05 for yellow packets, and 6, 8, 0.025 for green packets.



(a) ETBTCM *v.s.* SRTCM

(b) ETBTCM *v.s.* TRTCM

Fig. 3. End-to-end video delivery quality comparison.

The simulation results are shown in Fig. 3. In terms of average PSNR, ETBTCM measured 35.28 dB, SRTCM measured 26.14 dB, and TRTCM got 27.33 dB. The proposed method outperforms the SRTCM by 9.14 dB and the TRTCM by 7.95 dB. We repeated the simulation study for the Akiyo and Foreman sequences. Similar results were found.

IV. Conclusion

This paper has proposed a Two Markers System (TMS), a simple yet efficient packet marker system to improve the delivery quality of MPEG video transmissions. Through an extensive simulation study, we compare the performance of TMS to those of legacy packet markers for MPEG video transmission, such as SRTCM and TRTCM, in a DiffServ network. Simulation results show that the TMS outperforms both SRTCM and TRTCM in terms of the delivered MPEG video quality. The improvement in delivered quality is obtained by giving preference to more important frame packets of the video stream when the traffic flow is measured as out of profile. Therefore, in the event of network congestion, less important frame packets are dropped before more important ones. As a consequence, TMS provides a smoother degradation in the delivery of quality as compared to SRTCM and TRTCM.

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