Enhanced Adaptive FEC based Multiple Description Coding for Internet Video Streaming over Wireless Network

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Abstract—**This paper proposes a video streaming mechanism with packet recovery which extends the Enhanced Adaptive Forward Error Correction (EAFEC) scheme by involving Multiple Description Coding (MDC) with path diversity. The proposed mechanism transmits multiple video sub-streams along multiple disjoint paths, then recovers the sub-streams using EAFEC separately, and at last merges and reconstructs the whole video stream at the receiver. It provides resilience to packet loss and overcomes the defect in EAFEC method that it cannot recover the lost packets which should arrive at wireless access point. The simulation results show that the proposed mechanism performs better than EAFEC within narrow bandwidth varying from 0.01Mbps to 0.064Mbps reflecting in smaller packet loss rate and higher PSNR.**

Keywords-packet recovery; enhanced adaptive FEC; multiple description coding; path diversity

I. INTRODUCTION

Packet loss tends to happen due to the limited network condition for video streaming, e.g. limited bandwidth, long queue length, link loss rate. Even a single packet loss will cause consecutive packet loss. It affects the decoding of the frame and its decoding-dependent frame. And it greatly degrades the decoded video quality consequently. Decreasing the influences of packet loss is an important issue in robust video streaming.

Burst packet loss for video streaming is owing to the decoding dependency. For MPEG-4 coding standard, raw video source is encoded into I, P, B frames. For video transmission over the network, I frames are usually packetized into several packets. If one packet is lost in I frame, it not only causes I frame itself not totally decodable, but it also causes the following frames whose decoding depends on that frame undecodable, e.g. P, B frame in the same GOP for MPEG-4 coded video. Packet loss of P frame will affect the current P frame and its decoding-dependent P and B frames.

There have been many studies trying to solve the packet loss problem. FEC (Forward error correction) and retransmission are the two fundamental methods to alleviate the packet loss problem and they are combined to recover the lost packets in [1]. In FEC-based method, it recovers the lost packets from the transmitted FEC redundant packets at the receiver. Because of its unchanged FEC redundant packets, the method may waste bandwidth if the number of lost packets is small. There are some schemes to improve the FEC recovery efficiency [2, 3].Enhanced adaptive FEC (EAFEC) scheme [3] dynamically generates the FEC redundant packets according to the current queue length (i.e. packet number) and unicast retransmission time at MAC layer at the processing node. Those packets which are lost before arriving at the processing node could not be recovered. However, FEC-based methods have poor performance when burst packet losses happen [4]. In order to overcome the burst packet loss, schemes proposed in [5] tries packet interleaving to transform the burst losses to independent losses with the same number and delivery the ordered frames out of order. In [6] it further combines the FEC and interleaving method to recover lost packets for video streaming without increasing bandwidth consumption. However, interleaving increases the latency due to additional buffering at the sender and is not suitable for delay-sensitive interactive applications.

In this paper, by involving Multiple Description Coding (MDC) with path diversity scheme [7, 8, 9], we extend the EAFEC scheme to improve the recovery efficiency after packet lossy transmission. To recover the lost packets that should receive the Access Point, we transmit the two sub-streams along two disjoint paths separately before the Access Point. And the EAFEC deployed at the Access Point generates FEC redundant packets for each sub-stream respectively. The lost packets between the video sender and receiver are recovered by first using EAFEC for each sub-stream separately and then using the MDC decoding method to recover the total video stream.

II. THE PROPOSED SCHEME

The proposed packet recovery scheme (we call it "EAFEC-MDC") is suitable for video streaming over wireless network. It extends the EAFEC mechanism by bringing in MDC with path diversity method to transmit video stream over lossy links. There are three components in the EAFEC-MDC video transmission system as shown in Fig. 1.

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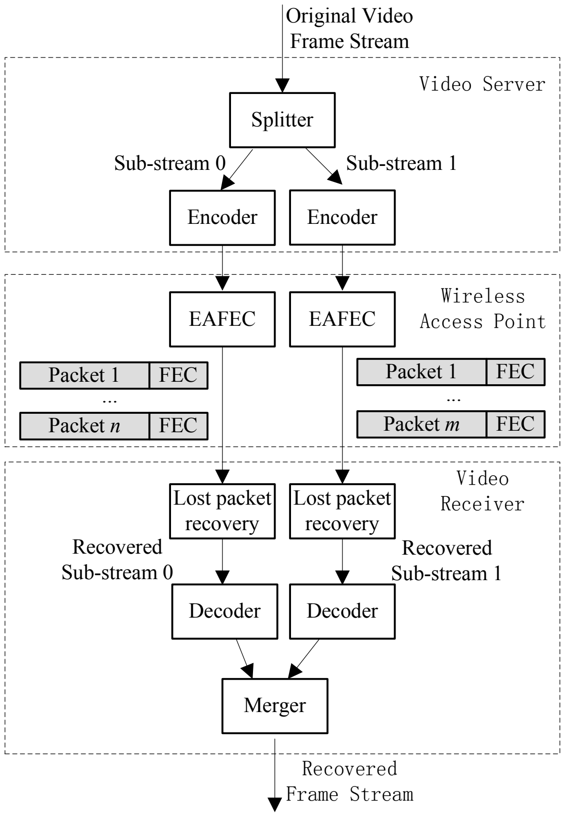

Figure 1. Infrastructure of the EAFEC-MDC video transmission system

A. Video Server

To overcome the defect that it cannot recover the lost packets which should arrive at wireless access point in EAFEC method [3], we adopt MDC method with path diversity. At the video server, the splitter first splits the original video frame into two sub-streams [10]. For an original video source with 2000 frames, for instance, it is split as shown in Fig. 2. The splitter splits all the 2000 frames into two sub-streams, one stream with frame 0, 2, 4,…, 1998, and the other stream with frame 1, 3, 5,…, 1999.

After obtaining the two sub-streams, the video server encodes each sub-stream (in the simulation we use MPEG-4 encoding standard) and transmits the encoded video packets to the wireless access point over two disjoint paths as shown in Fig. 3, where node *S* denotes video server and node *R* denotes the wireless access point.

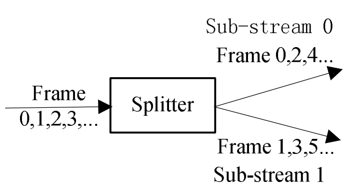

Figure 2. Video splitter

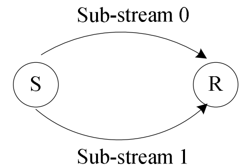

Figure 3. Stream transmission with MDC over two disjoint paths

B. Wireless Access Point

At the wireless access point, it receives the video packets transmitted from video server. Then it processes the two sub-streams separately. It generates the FEC redundant packets for each received packet of each sub-stream by adopting the EAFEC method proposed in [3].

C. Video Receiver

In the proposed EAFEC-MDC video transmission system in Fig. 1, a whole video stream is divided into two sub-streams and each sub-stream is then transmitted in the error-resilient form where FEC redundant packets are introduced. Therefore, the video receiver should finish two things in order to obtain the whole video stream with better decoded video quality: one is merging the two sub-streams, and the other is trying to recover the lost packets. In this paper, it first recovers the lost packets by using the FEC redundant packets. The recovery method first determines which packets are lost and then replaces the lost packets by those corresponding received FEC redundant packets. After recovering part of the lost packets and decoding current packets, a recovered video sequence with error is obtained for each sub-stream. Lastly, the two recovered video sequence are merged by reordering the frames in ascending order according to the frame sequence number [10] and the merging process is shown in Fig. 4. If sub-stream 0 is lost, it is replaced by the received sub-stream 1.

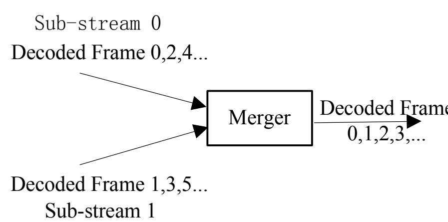

Figure 4. Video merger

III. EXPERIMENTAL RESULTS AND ANALYSIS

A. Simulation Topology and Setting

The proposed EAFEC-MDC scheme is verified and compared with EAFEC using NS-2 simulator. Fig. 5 shows the simulation topology that is used in this paper.

In this simulation, the video server first splits video stream into two sub-streams and then transmits each sub-stream over the wired Internet. There are two interference video traffics for video streaming, which are FTP traffic transmitted with TCP packets and exponential traffic with UDP packets. All the streams are first transmitted over wired network until arriving at the interface with wireless network (i.e. node *r*1). Then the streams are sent over wireless network through wireless access point and finally arrive at the video receiver. Random uniform model is used to simulate the packet loss characteristic of link 6.

In this simulation, the original video source “Highway.yuv” is CIF format and encoded using MPEG4 video coding with ffmpeg tool. Highway video source consists of 2000 frames. Each frame is divided into several packets with maximum fragmented size 1028 for each packet. Each packet is transmitted via RTP/UDP/IP by unicast transmission.

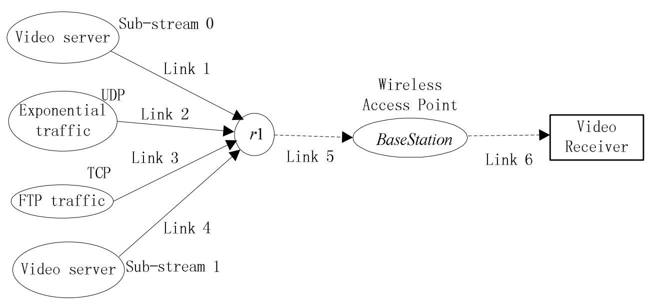

Figure 5. Simulation topology

TABLE I. SIMULATION TOPOLOGY PARAMETERS

Parameters	Value
Link 1, 2, 3, 5, 6 bandwidth	10Mbps, 10Mbps, 10Mbps, 100Mbps, IEEE 802.11b 11Mbps,
Link 4 bandwidth	Minimum: 0.01 Mbps Maximum: 0.1Mbps
EAFEC thresholds	5<qlen<15, 5<rT<15, Max_FEC=6
Loss rate, loss model of link 6	0.3, random uniform distribution
GOP length	12
GOP structure	IBBPBBPBBPBB
Frame rate	30 frames/sec

When performing the EAFEC-MDC scheme proposed in this paper, the parameter values adopted in this simulation are listed in Table I. The two sub-streams are transmitted through link 1 and link 4 separately, where link 1 has constant bandwidth 10Mbps while link 4 has bandwidth varying from 0.01Mbps to 0.1Mbps.

When performing the EAFEC method for video stream transmission, the video is not split and transmitted in the whole stream pattern. Different from the values shown in Table I, link 1 is disconnected, and the whole stream is transmitted only along link 4 with bandwidth varying from 0.01Mbps to 0.1Mbps.

B. *Results and Analysis*

The simulations for both EAFEC method and the proposed EAFEC-MDC scheme in this paper are performed according to the simulation topology and parameter setting in section III-A. The performance of the two methods are compared and analyzed in this section.

Fig. 6 shows the packet loss rate curves for different link bandwidths varying from 0.01Mbps to 0.1Mbps, in which packet loss rate is the ratio of lost packets number to the total packets number. In Fig. 6, “bandwidth-pktloss-twopath” means the simulation for EAFEC-MDC method with two sub-streams transmitted along two disjoint paths respectively, while “bandwidth-pktloss-singlepath” means the simulation for EAFEC method with only one whole stream transmitted along one path. As shown in Fig. 6, the two curves intersect at bandwidth near 0.064Mbps. At bandwidth smaller than 0.064Mbps, the EAFEC-MDC method performs better than EAFEC method, and vice versa. This result could be explained as follows.

As obtained in the simulation, each sub-stream has the same frame number and the total frame number is the same as that of the whole stream. After encoding, two sub-streams has similar sending packets number and total number of sending packets is a litter larger than the number of the whole stream.

With smaller bandwidth for link 4, both EAFEC and EAFEC-MDC schemes have higher packet loss number. For EAFEC, the whole stream is always transmitted on the bad link 4 with small bandwidth, thus EAFEC method has high packet loss rate. For EAFEC-MDC method, in contrast, one sub-stream is transmitted over bad link 4 with small bandwidth as the same in EAFEC while the other one is transmitted over good link 1 with large bandwidth. Therefore, the total packet loss rate of EAFEC-MDC is smaller than that of EAFEC method with small link bandwidth.

With larger bandwidth for link 4, lower packet loss number is obtained for both EAFEC and EAFEC-MDC schemes. In EAFEC-MDC, number of lost packets along link 1 is smaller than that of link 4. But it does not help with the packet loss number because total number of lost packets for two paths in EAFEC-MDC is larger than that for single path in EAFEC. In addition, packet number for EAFEC is only a little smaller than that of EAFEC-MDC as presented before. Therefore, the packet loss rate of EAFEC is smaller than that of EAFEC-MDC method.

Fig. 7 shows the PSNR curves for different bandwidths varying from 0.01Mbps to 0.1Mbps. It has similar characteristics to the packet loss rate curve in Fig. 6. Bandwidth which is smaller than 0.064Mbps results in higher PSNR for EAFEC-MDC than EAFEC. This could be also explained as follows. At the receiver, the lost packets could be only recovered by the FEC redundant packets in EAFEC. Nevertheless, for EAFEC-MDC transmission, the damaged sub-stream over the bad link could be recovered from the other sub-stream over good link, which improves the final decoding video quality.

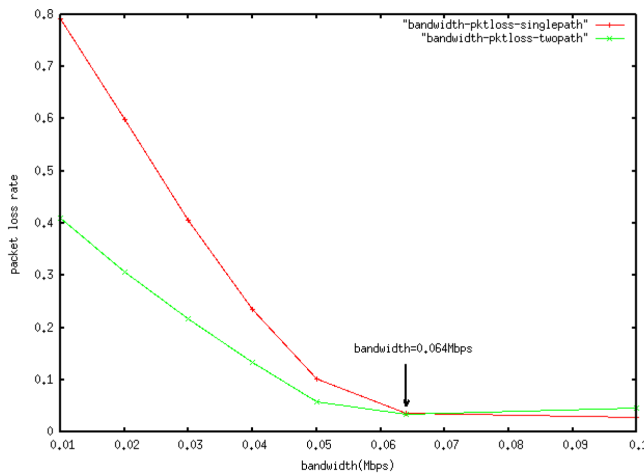

Figure 6. Packet loss rate for different link bandwidth for single-path and two-path transmission

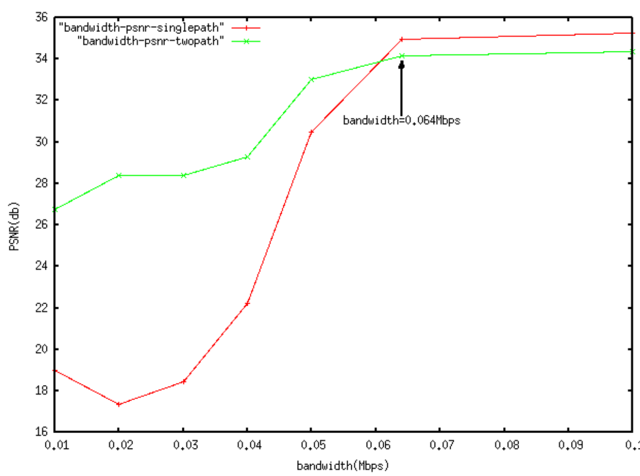

Figure 7. PSNR for different link bandwidth for single-path and two-path transmission

As an exception observed for EAFEC curve (singlepath) in Fig. 6 and Fig. 7, the packet loss rate is smaller but PSNR is lower at bandwidth 0.02Mbps than 0.01Mpbs. This is because at extreme bad condition, some important packets may be lost at 0.02Mbps, e.g. P type packets are lost instead of B type packets.

Another exception observed from Fig. 6 and Fig. 7 is the performance at 0.064Mbps. The packet loss rate is smaller but PSNR is lower for two-path than single-path. This is because in EAFEC-MDC method it simply merges the two sub-streams by reordering the decoded frame number without considering the decoding dependency.

It is concluded that EAFEC-MDC performs better than the EAFEC if not all of the condition of links are bad, especially for the narrow bandwidth between 0.01Mbps and 0.064Mbps.

IV. Conclusions and Future Work

This paper describes a loss-resilient video streaming system and provides protection for the lost packets. Our work shows the efficiency of MDC plus path diversity involved in EAFEC in recovering the video frames. Lower bit rate coding will generate less number of packets, and it could adapt to narrow bandwidth. However, less number of lost packets does not mean higher PSNR, e.g. without considering the decoding dependency. In the future work, we will take decoding dependency into consideration to merge sub-streams. Besides, we will try to extend the work into wired network since the EAFEC is inefficient for the situation in which MAC retransmission is not allowed.

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