A Protection Scheme for Multiple Description H.264/AVC Video Delivery over Bursty Channels

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Abstract*— *An efficient error protection scheme is proposed for video delivery over lossy channels. Flexible Macroblock Ordering is used to generate spatial descriptions that are sent over disjoint paths. Additionally, descriptions are partitioned to allow unequal error protection against burst errors. Experimental results show that a significant quality gain can be achieved (up to 3 dB) in the presence of burst errors.

Fig. 1. Multiple description using FMO with checkerboard.

I. Introduction

The H.264/AVC (Advanced Video Coding) standard introduced a new set of error resilience tools [1] to improve robustness against packet losses. Flexible Macroblock Ordering (FMO) [2] enables arbitrary macroblock grouping into individually decodable slices. This tool can be used to generate spatial descriptions of the video. Data partitioning on the other hand allows the packetization of the bitstream into three different partitions A, B, and C of decreasing order of importance for decoder reconstruction purposes. Data partition A (DP-A) contains the most important information for error concealment such as headers and motion information. Data partitions B and C carry the less important coded transform coefficients. If partition A is lost, motion vectors are to be estimated from the neighboring blocks, resulting in lower quality error concealment. Thus, DP-A packets are usually given higher protection.

A combination of hierarchical modulation and forward error protection has been used in [3] to give higher protection to DP-A packets, while in [4], DP-A packets were simply duplicated. However, these techniques cannot cope with link disruption or long error bursts. In [5], layered video was transmitted over two paths, the base layer packets over one path and the enhancement layer packets over the other path. Selective ARQ requests were returned to the sender to report base layer packet losses. The requested base layer packet was then retransmitted over the enhancement layer path. This paper proposes a new error protection scheme by exploiting path diversity to provide a better protection for DP-A packets.

II. Proposed Method

Multiple Description Coding (MDC) is an efficient error resilient video coding technique for video transmission over error prone networks. Its basic concept is the splitting of video into two or more independent descriptions such that the video contents can be sent over multiple paths. Since descriptions are independent, the video can still be decoded even with the full link disruption in one path. However, in order to achieve the original video quality, all descriptions need to be received. Since this is not always possible, error concealment [1] comes into place to recover the lost slices based on the received information. *Frame Copy* error concealment technique simply copies the lost slice from a collocated frame. *Motion Copy* goes one step further by estimating the motion activity of the lost slice based on the available motion information. Since the estimated motion vectors might not accurately represent the original motion activity, a lower quality is then expected. Therefore, this paper gives a special emphasis on this point and tries to give a higher protection to those packets carrying motion information. Duplicating this information along the same path is not always effective as in the presence of long burst errors, the duplicated packets are probably lost as well when the original ones are lost. As a result, this paper proposes a new technique, packets containing motion information (DP-A packets) of each description are duplicated and sent over the paths of other descriptions.

For the sake of simplicity, this paper analyzes the scenario where two spatial descriptions are created and sent over two different paths. Each video description is created by spatially splitting the H.264/AVC stream using FMO with dispersed mode (checkerboard) as illustrated in Fig. 1. Data partitioning was also enabled to packetize the bitstream into data partitions A, B and C in order to allow protection for the motion information (residing in DP-A). When DP-A packets were duplicated, they were either sent with their corresponding description along the same path or sent along the other path.

III. Experimental Results

The simulated network scenario is presented in Fig. 2. Node 0 sends two video descriptions to node 5 along two disjoint paths, path1 (0-1-3-5) and path2 (0-2-4-5). 300 frames of the Common Intermediate Format (CIF) test sequence *Paris* were coded using the H.264/AVC reference software JM15.1

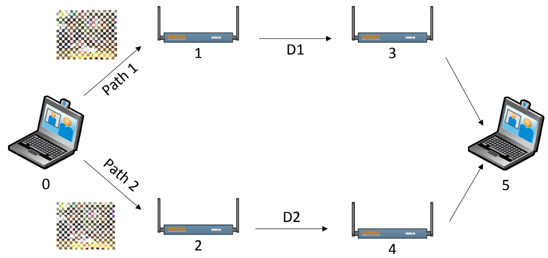

Fig. 2. Simulated network scenario. Node 0 sends video descriptions D1 and D2 via paths 0-1-3-5 and 0-2-4-5.

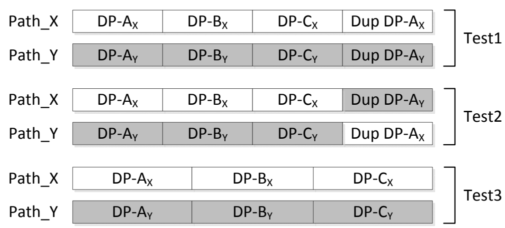

Fig. 3. Illustration of the experimental tests carried out.

at 30 frame/s. The encoder was configured to use an IPPP... picture coding structure. Periodic intra refresh lines have been used to mitigate error propagation. The descriptions were sent over two paths using the well-known network simulator NS-2. Dropped packets where removed from the original stream to create the erroneous received stream. The received stream was then decoded to assess the video quality at the receiver side. The nodes were equipped with 802.11b radios with a data rate of 11Mbps. The distance between individual nodes was 116 meters. For the wireless channel, the shadowing model [6] has been employed and the path loss exponent (β) was varied between (2.0-2.2) to simulate different channel conditions.

Three sets of experiments have been done as shown in Fig. 3. In the first set of tests (T1), DP-A packets for each description were duplicated (Dup DP-A) and sent along the same path as their description. In the second set of tests (T2), DP-A packets for each description were also duplicated but sent along the path of the other description. For tests T1 and T2, the video was coded with a target bitrate of 1Mbps. For the last set of tests (T3), the descriptions were sent without duplicating DP-A packets. To achieve a fair comparison, the video was coded at a higher quality with a target bitrate equivalent to the bitrate of the duplicated DP-A packets (for these tests, about 17 % of the whole bitrate) plus the original 1Mbps bitrate. Notice that in T3 the data were partitioned for comparison purposes even though this is not strictly necessary as there is no preference for any partition.

For each set of tests, 400 runs were conducted. The averages and standard deviations of the Peak Signal-to-Noise Ratio (PSNR) were calculated and plotted in Fig. 4 versus the percentage video data drop. For the first set of tests T1, if there is a packet loss in one path, that path is likely to be experiencing a packet loss burst. Therefore, transmitting the duplicated DP-A packet using the same path is likely to be unsuccessful. Therefore this method does not provide good

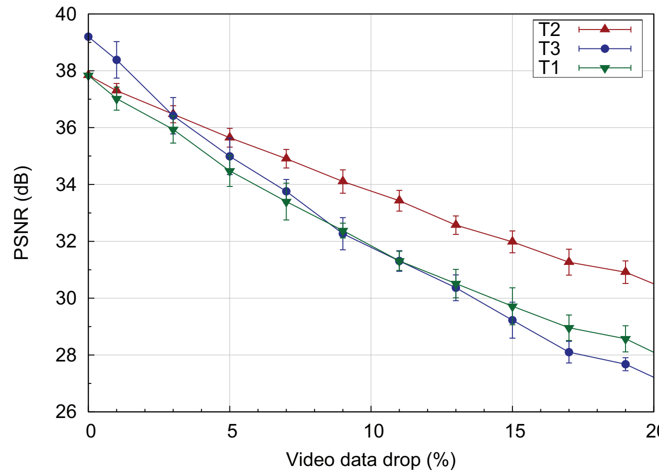

Fig. 4. Avg. PSNR vs. percentage video data drop, with standard deviation error bars included.

protection against burst errors. For the second test T2, since the loss patterns of the paths are not totally correlated, transmitting the duplicate DP-A packets using the other path could have higher success probability. In this case, more DP-A packets will survive resulting in better video quality. Comparing with test T3, the figure shows that at lower percentage drops (good channel conditions) and for the same available bitrate, it is better to spend the excess bitrate to get better video quality instead of sending duplicated DP-A packets. However, when the percentage drop increases due to bad channel conditions then this not the case. In such a condition, the figure shows that our proposed scheme (T2) can achieve up to 3dB video quality gain over (T3).

IV. Conclusion

This paper presented an improved error resiliency technique for delivering MDC video over lossy channels. It is shown that the proposed scheme achieves an increased error resiliency against burst packet drops. Although the proposed scheme introduces an initial quality penalty at low packet loss rates compared to the classical MDC, for higher loss rates (3 %), experimental results show that the proposed scheme is far superior and can achieve a quality gain up to 3 dB.

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