PACKETIZATION SCHEMES FOR FORWARD ERROR CORRECTION IN INTERNET VIDEO STREAMING

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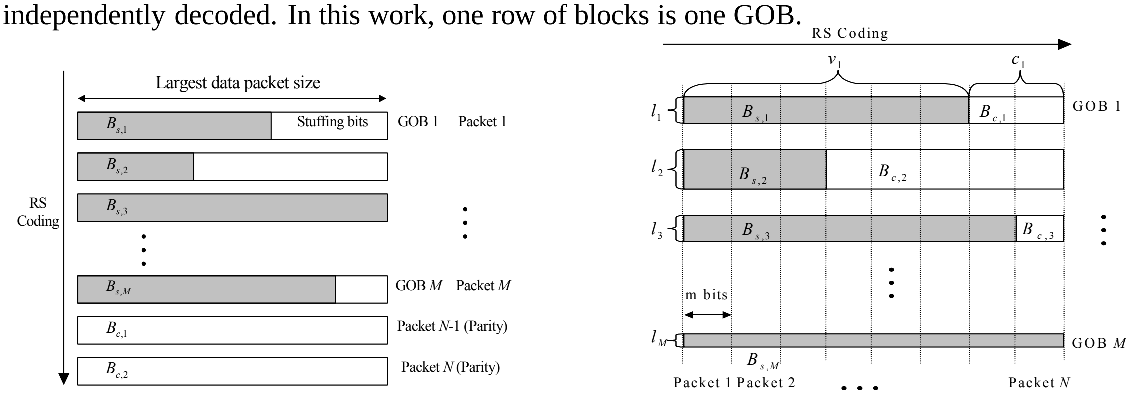
1. INTRODUCTION

In this work, our focus is on video streaming applications with relatively strict delay constraints; for such applications, forward error correction (FEC) is the preferred channel coding technique to recover from packet losses. Moreover, since video packets are usually of different importance, optimal bit allocation across video packets results in different packets receiving unequal error protection (UEP).

For Internet video, cross-packet FEC in addition to source packets can be performed by generating parity packets [1]. Alternatively, a source packet can be partitioned into different transport packets to achieve prioritized protection, which has been studied for scalable video in [2]. In this paper, we compare the performance of these two packetization schemes applied to single-layer video. The comparison is carried out in a joint source-channel coding (JSCC) framework, where error resilient source coding and FEC are jointly designed. We show that either packetization scheme may be optimal depending on the packet loss rate.

2. TWO PACKETIZATION SCHEMES

In a video streaming system, video packets (or *source packets*) are generated by a video encoder. In the application layer, parity packets may also be generated for FEC. After passing through the network protocol stack (e.g. RTP/UDP/IP), *transport packets* are formed to be sent over a lossy network. In this work we use Reed-Solomon (RS) codes for FEC. We consider the following two packetization schemes. In both schemes, each GOB (group of blocks) is coded as one source packet, and every packet is independently decoded. In this work, one row of blocks is one GOB.



(a) (b)

Fig. 1. Packetization schemes: (a) scheme 1 (b) scheme 2.

Scheme 1: Figure 1(a) illustrates packetization scheme 1. One row corresponds to both one GOB and one transport packet. RS coding is performed vertically. Transport packets are padded with stuffing bits to make their sizes equal. The stuffing bits are removed after the parity packets are generated and so are not transmitted. Each source packet is protected by an RS(N, M) code, and so has the same probability of loss, ρ. For a fixed probability of transport packet loss, ϵ, ρ is then defined as $\rho = \sum_{i=N-M+1}^{N} \frac{i}{N}\binom{N}{i}\epsilon^i(1-\epsilon)^{N-i}$.

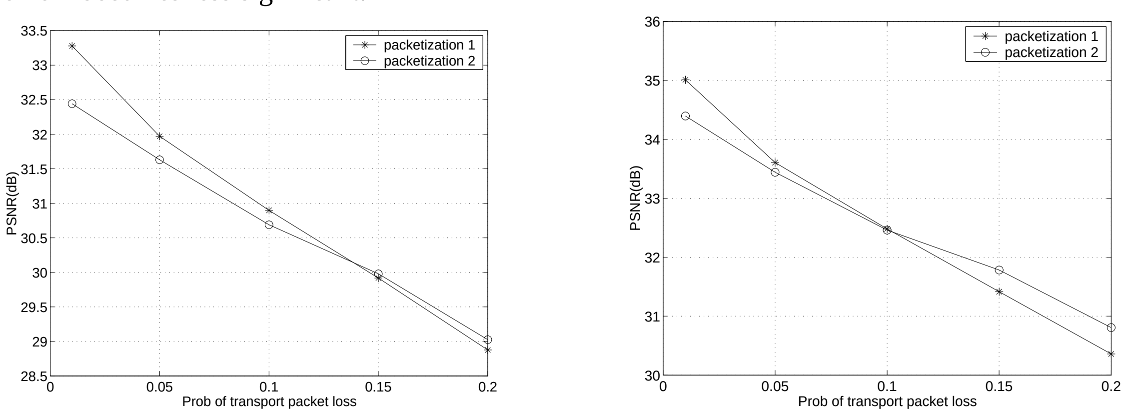
Scheme 2: This packetization scheme is shown in Fig. 1(b). One row corresponds to one GOB, one column corresponds to one transport packet, and RS coding is performed horizontally. The source bits $B_{s,k}$ and parity bits $B_{c,k}$ for the k-th source packet are distributed into v_k and c_k transport packets, respectively. When the k-th source packet is protected by an RS(N, v_k) code, the probability of losing this source packet is given by $\rho_k = \sum_{i=N-v_k+1}^{N} \binom{N}{i} \epsilon^i (1-\epsilon)^{N-i}$.

Clearly for any given transport packet loss probability, scheme 1 always produces a lower residual packet loss probability than scheme 2. However, the advantage in applying scheme 2 is that each source packet can be protected differently. We compare these two approaches, where each uses a rate-distortion optimized bit allocation, which takes into account error concealment and the delay constraints of the application.

3. EXPERIMENTAL RESULTS

We use an H.263+ video codec and the Foreman test sequence with QCIF format at a frame rate of 30 fps. For error concealment, the lost MB is recovered from the MB with the same spatial location in the previously reconstructed frame. Transport packet loss is modeled by a Bernoulli process. Assuming the mean squared error (MSE) criterion, the distortion measurement based on an algorithm called ROPE [3] is used to recursively calculate the overall expected distortion of each pixel. We assume that channel feedback is available to the encoder in the form of which packets are received or lost. In all experiments, the round trip time is set as two frames, which is long enough to preclude retransmissions. An RTP/UDP/IP header of 40 bytes is included for each transport packet.

Fig. 2 shows the average PSNR versus probability of transport packet loss at different channel transmission rates, R_T. It can be seen that at low loss rates, packetization scheme 1 performs better. This is because scheme 1 results in a lower residual packet loss probability than scheme 2 at various channel code rates. However, when the packet loss probability gets greater, scheme 2 starts to outperform scheme 1. The gain comes from two sources: 1) scheme 2 is more flexible in performing UEP than scheme 1; 2) in scheme 1, the size of the parity packets has to be the maximum size of the source packets. A substantial number of bits are wasted in the application of scheme 1, because some part of the parity packets are used to protect the stuffing bits. Another observation is that the cross point of packet loss probability at higher transmission rates is smaller. This is because at higher transmission rate, more bits are available for each packet and thus the effect of overhead limiting the flexibility of packetization scheme 2 becomes less significant.



(a) (b)

Fig. 2. Average PSNR vs. transport packet loss probability (a) R_T=360Kbps (b) R_T=480Kbps.

4. REFERENCES

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