VIDEO PRIORITIZATION FOR UNEQUAL ERROR PROTECTION

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ABSTRACT

We analyze the effect of packet losses in video sequences and propose a lightweight Unequal Error Protection strategy which, by choosing which packet is discarded, reduces strongly the Mean Square Error of the received sequence.

Index Terms— Unequal Error Protection, Priority, Quality of Experience

1. INTRODUCTION

Sending multimedia streams over networks, there are some situations when video packets are discarded: traffic congestion, transmission losses, buffer management... In such cases, it is desirable to control the effect of packet losses to minimize its impact in media Quality of Experience (QoE). This is especially relevant in short-term drop decisions, as the loss of one packet or another may have quite different effects on the decoded video; while, for a high number of random packet losses, their impact tends to depend mainly on packet loss rate [1] and loss burst structure [2].

The understanding of how packet loss can affect video quality has been used to propose several unequal error protection (UEP) schemes, where packets with higher impact in quality are protected better [3][4]. However they usually require an in-depth video analysis which is difficult to integrate in cost-effective consumer electronic devices.

In this work we will show how it is possible to reduce strongly the effect of packet losses by applying quite simple analysis techniques to label video packet priorities (and even using a low number of bits to encode them). This approach requires quite low processing capabilities (and therefore power consumption) while clearly outperforming a random packet drop. It can be applied to congestion control in home gateways or buffer management in http adaptive streaming clients.

The scenario considered is the transmisssion of SDTV-quality H.264 video over MPEG-2 Transport Stream, grouping N MPEG-2 TS packets. This is a common situation for DVB/ATSC television, IPTV or http adaptive streaming. In order to make modeling and analysis, we will particuarlize the scenario for $N = 7$, which is the typical case in IPTV. However, the proposed approach can be generalized to other similar coding, multiplexing and transport standards.

2. PRIORITY MODEL

The priority model proposed is based on the type of video slice carried by the packet and the position of the packet within the slice (assuming that typically a video slice is carried in several transport packets). Losses have higher effect in reference slices than in no-reference ones, and at the beginning of the slice and of the GOP, where error propagation effects are higher [3][5]. Thus it is possible to define a priority model:

$$P = \alpha P_S + \beta H + \gamma \hat{T}_S + \delta \hat{T}_G$$

where P_S is the priority of the slice type ($P_S(\text{IDR}) = 1$, $P_S(\text{ref}) = 0.5$, $P_S(\text{no-ref}) = 0$), H is a flag indicating whether the packet contains a NALU header, $\hat{T}_S$ indicates the number of packets until the next slice in the stream and $\hat{T}_G$ is the number of packets until the next GOP. All the parameters are normalized between 0 and 1. According to their relevance, the following coefficients are selected: $\alpha = 10^3$, $\beta = 10^2$, $\gamma = 10$, $\delta = 1$. It is important to remark that it is not a *scale* of priorities, but only an *ordering*. It is also worth noting that, in order to assign a priority to a packet, only the NALU header has to be read and analyzed, which is quite low consuming.

3. EXPERIMENT AND RESULTS

To test the performance of the model, 4 different short video sequences (4-12 seconds), encoded by commercial IPTV encoders, have been selected. For each of them, a single packet loss has been simultated, by dropping the lowest-priority one in a k-packet window. Mean Square Error (MSE) of the resulting impaired sequence has been computed, and compared with the MSE resulting from a random-drop within the same window. All possible windows within a video GOP in the sequence have been exhaustively tested, thus generating more than 1500 impaired sequences.

The results for one of the sequences and several values of k are shown in figure 1. It can be shown that 20dB gains in

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[*] This work has been partially supported by the Spanish Administration agency CDTI, under project CENIT-VISION 2007-1007.

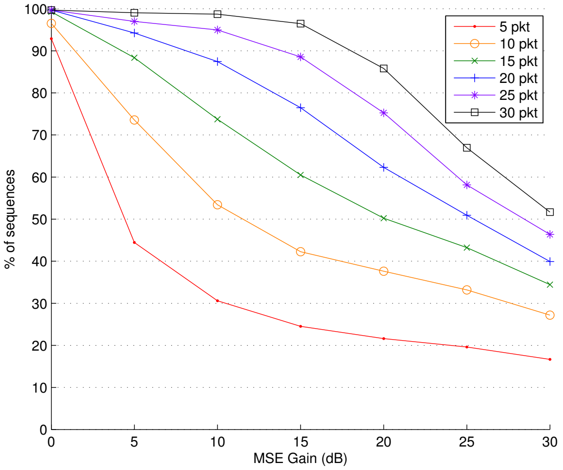

Fig. 1. % of sequences where MSE decreased at least some dB (x axis), for several gain values and window sizes.

MSE can be reached for from 20% of the packets ($k = 5$) up to 85% ($k = 35$), using window sizes which are reasonable for a home network device. Other sequence provided results within a +/- 10% margin for the 20dB cut.

These results are useful in an scenario where the system which provides unequal error protection (i.e., which decides which packet can be dropped), is able to do the analysis by itself. However, there might be situations where it is preferrable that the analysis is done in another place in the distribution chain and the priorities are stamped in each of the packets. This will result in a limited bit budget to encode priority, which can managed as shown in Table 1.

For each of the budgets mentioned, the same experiment has been repeated. Its results for $k = 15$ are shown in Fig. 2. It can be shown that, even with a 2-bit budget (considering only P_S) results are clearly better than using random drop; and that a 6-bit budget could be enough to signal priorities. $\hat{T}_G$ has very little effect in this kind of sequences (being more determinant for higher values of k).

4. CONCLUSIONS

Unequal Error Protection techniques can reduce significatively the impairments caused by video packet dropping. We have proposed a simple lightweight strategy whose results are significatively enough to be worth considering, even with limited bit budgets allocated to encode packet priority.

Future work will focus on more complex loss scenarios and a wider range of test sequences, in order to improve the model and make it address a higher range of applications.

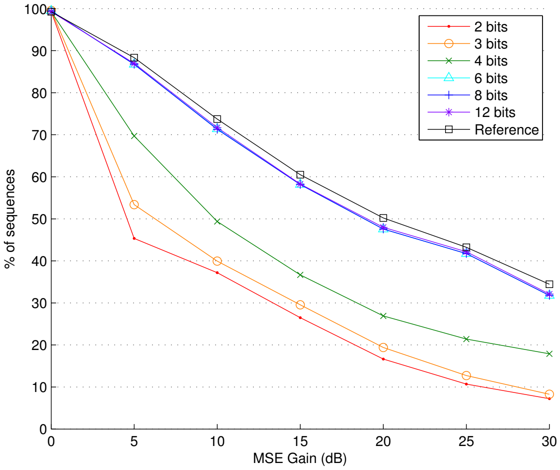

Fig. 2. Results when encoding priority with different values of bits per packet. Window size is $k = 15$.

Total	P_S	H	$\hat{T}_S$	$\hat{T}_G$
2	2	0	0	0
3	2	1	0	0
4	2	1	1	0
6	2	1	3	0
8	2	1	3	2
12	2	1	5	4

Table 1. Bit budget assignation

5. REFERENCES

[1] A. R. Reibman, V. A. Vaishampayan, and Y. Sermadevi, "Quality Monitoring of Video Over a Packet Network," vol. 6, no. 2, pp. 327–334, 2004.

[2] Fenghua You, Wei Zhang, and Jun Xiao, "Packet Loss Pattern and Parametric Video Quality Model for IPTV," in *IEEE/ACIS Int. Conf. on Computer and Information Science*, 2009, pp. 824 –828.

[3] T. L. Lin, S. Kanumuri, Y. Zhi, D. Poole, P. C. Cosman, and A. R. Reibman, "A versatile model for packet loss visibility and its application to packet prioritization.," *IEEE Trans. on Image Processing*, vol. 19, no. 3, pp. 722–35, march 2010.

[4] H. Ha, J. Park, S. Lee, and A. C. Bovik, "Perceptually Unequal Packet Loss Protection by Weighting Saliency and Error Propagation," *IEEE Trans. on Circuits and Systems for Video Technology*, 2010.

[5] P. Perez, J. Macias, J. J. Ruiz, and N. Garcia, "Effect of Packet Losses in Video Quality of Experience," *Bell Labs Technical Journal (accepted)*, june 2011.