Best packetization scheme for H.263 internet video communication

M. Paredes-Farrera, M. Fleury, M. Mbise and M. Ghanbari.

The H.263 codec is an efficient way to stream variable bit-rate video sequences. This letter proposes that, for equivalent bandwidth and frame rate, a two-slice packetization scheme results in superior peak signal-to-noise ratio, rather than the conventional one-slice scheme, and that constant inter-packet gap rather than 'bursty' delivery is preferable.

Introduction: Studies of packetization schemes for the H.263+ video codec, for example [1], tend to assume the one slice per packet recommendation contained in RFC 2429 section 3.2 [2], whereas in this letter a two-slice scheme is proposed. In [3], the burst length is identified (for H.264) as a source of peak signal-to-noise ratio (PSNR) degradation, as much as the average packet loss rate. In this letter, the method of delivery, either per frame bursts, or uniform (constant) inter-packet gap (IPG) is shown to be an additional determinant of PSNR performance. When a uniform scheme was deployed with a two slice per packet scheme, tests for an "Interview" video clip resulted in superior video quality. The tests were conducted on a network test-bed with precise real-time packet generation to examine video communication across a bottleneck link in a path across an internet. The proposed two-slice scheme has the effect of better bandwidth utilization through reduced header overhead, which also critically contributes to a reduction in packet loss. A uniform IPG compared to a 'bursty' delivery, reduces the stress on a router by smoothing the arrival rate, which otherwise leads to harmful packet loss patterns. The test on the video clip for some frames resulted in as much as 20 dB improvement in PSNR, when using a two-slice scheme with uniform delivery. The proposals are expected to be applicable to a variety of video structures.

Methodology: The variable bit-rate (VBR) H.263+ video sequence characteristics, with every CIF frame split into the usual 18 macro-block row-wise slices, are recorded in Table 1 for this particular set of experiments. If slices were to be split between packets then the presence of the slice header in one of the packets and the use of variable length coding would cause more data to be lost than present in any single packet. The slice statistics by intra-coded (I) picture slices, occurring every ten frames, and prediction (P) picture slices are given in Table 2. Biased experimental results were avoided by a clip with moderate motion, thus potentially avoiding packet lengths over 1500 B, which on an Ethernet network would naturally result in packet fragmentation. Apart from the 42 B frame and UDP header, the packet payload included a 17 B header, as is normally added to allow reconstruction of the video sequence at the decoder end. (An RTP header, which serves a similar purpose, would be 12 B in size.) The one- and two-slice experiments were both varied by delivery scheme: 1) Burst: all packets in a frame sent with inter-frame gap 1/30 s 2) Uniform: IPG of 1/540 s. The KURT real-time patch for Linux kernel 2.4 ensured an accurate gap between packets and frames.

The network test-bed was formed with two Cisco 2600 series routers operating drop-tail FIFO output queues at either end of a 2 Mb/s link, with 100 Mb/s access links from sender and to receiver. The output queue onto the 2 Mb/s link was set with the default maximum 75 packets. Background traffic at 1.8 Mb/s with a Gaussian distribution (mean1000 B, S.D. 100 B) with constant IPG was generated for the reported experiments, thus testing video communication under difficult conditions. Other background traffic bandwidths were tested but did not seriously perturb the video session.

Results: Table 3 presents packet losses for the test Interview video, again analysed by picture type. There was at the very least a twofold reduction in total packet losses, when using the two-slice rather than the one-slice scheme. In part, this was due to the reduced header overhead, illustrated by the constant offset between one- and two-slice scheme bit rates in Figure 1 for a uniform delivery method. Table 3 also shows that the uniform method reduced packet losses, by 44 or 60%, depending on packetization scheme. We postulate that this effect occurs due to router queue behaviour when faced with a sudden rush of packets. Notice that the more important I-pictures are more favourably treated by the two-slice scheme.

Figure 2 plots the PSNR on a frame-by-frame basis of the worst (one-slice burst) and best (two-slice uniform) cases in terms of total packet loss. The plot marked "Original" is the PSNR of the source video clip. The best-case plot consistently tracks the original PSNR curve, as becomes clearer when the plot is restricted in range, Figure 3. The behaviour of the one-slice burst PSNR plot is erratic and most of the time remains below the best-case plot, in some frames being 20 dB below the original PSNR.

Conclusions: In network test-bed experiments designed to model critical internet conditions, an H.263+ encoded video sequence suffered less packet losses and was better able to track ideal PSNR performance when using two slices per packet. PSNR performance further improved when a constant inter-packet gap was applied, with no reduction in delivered frame rate. The results are applicable provided that in the two-slice scheme the total packet size does not exceed the maximum transport unit, when clearly it is preferable to avoid packet fragmentation, possibly reverting to one-slice packetization.

References

1 E. Masala, H. Yuang, K. Rose, J. C. De Martin, Rate-Distortion Optimized Slicing, Packetization and Coding for Error Resilient Video Transmission, Proc. of Data Compression Conf., 2004, pp. 182-191

2 C. Borman et al., RFC 2429 – RTP Payload Format for the 1998 Version of ITU-T Rec. H.263 Video (H.263+), 1998

3 Liang, Y. J., Apostopoulos, J. G. and B. Girod, 'Analysis of Packet Loss for Compressed Video: Does Burst-Length Matter?', Proc. ICASSP, 2001,Vol. V, pp. 684-687

Authors' affiliations:

M. Paredes-Farrera, M. Fleury, M. Mbise and M Ghanbari are with the Department of Electronic Systems Engineering, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, United Kingdom.

e-mail of corresponding author: fleum@essex.ac.uk

Table Captions:

Table 1: “Interview” encoded video stream characteristics.

Table 2: Slice structure characteristics by I- and P-pictures.

Table 3: Packet loss numbers by slice and delivery method, and picture type.

Table 1:

Average bit-rate	187 kbps
Frame size (CIF)	352x288
Frame rate	30 f/s
Video duration	60 s
Intra refresh period	10 f

Table 2:

	1-Slice I	*1-Slice P*	*2-Slice I*	*2-Slice P*
Total slices (n)	3240	29160	1620	14580
Min. size	159 (B)	6 (B)	345 (B)	13 (B)
Max. size	750	178	1123	346
Mean size	281.5	16.9	563.1	33.7
Std. Dev.	89.3	18.9	163.2	36.7
Median	266	11	544	23

Table 3:

	1-Slice				*2-Slice*			
	burst		*uniform*		*burst*		*uniform*	
	I	*P*	*I*	*P*	*I*	*P*	*I*	*P*
Packet Loss (PL)	538	7992	304	4456	259	2946	41	1255
PL %	16.7	27.4	9.4	15.3	16.0	20.2	2.5	8.6

Figure captions:

Fig. 1 Bit-rate comparison between the 1-Slice and 2-Slice schemes, both with uniform delivery.

——— 1-Slice
– – – – 2-Slice

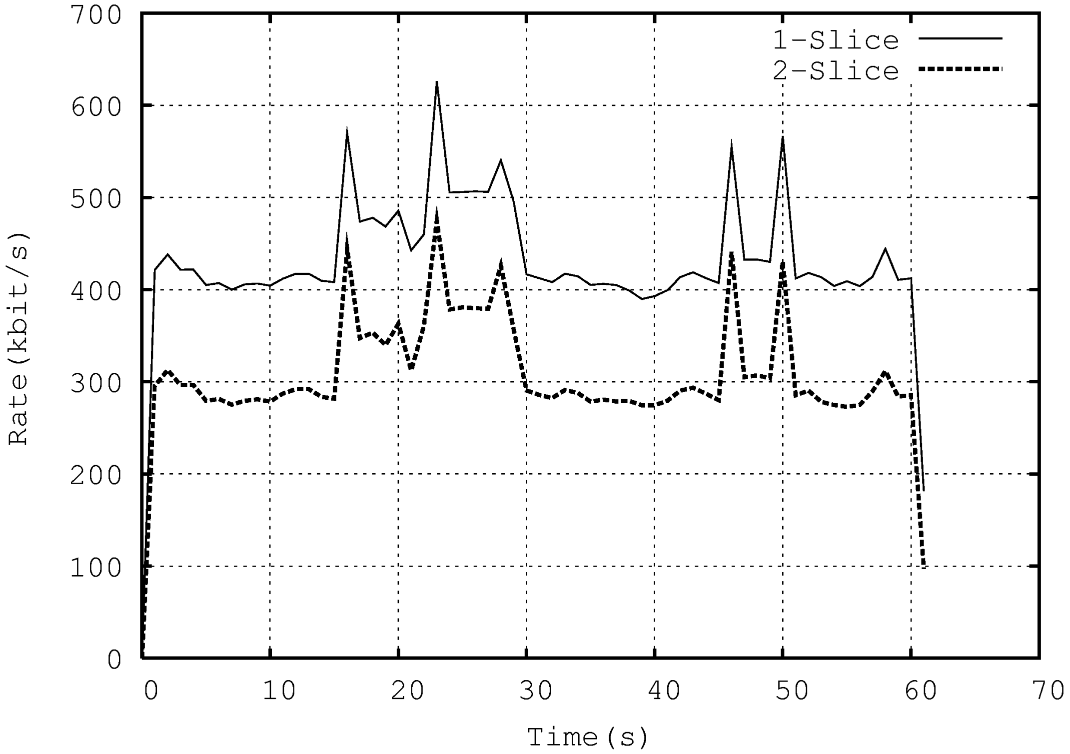
Fig. 2 PSNR comparison for the worst- and best-case packet loss schemes for the “Interview” video clip.

——— Original
– – – – 1-Slice Burst
·········· 2-Slice Uniform

Fig. 3 PSNR comparison for the worst- and best-case packet loss schemes, over the range of frame numbers 800—900.

——ı—— Original
– –x– – 1-Slice Burst
·····*······ 2-Slice Uniform

Figure 1:



1-Slice
2-Slice
700
600
500
400
300
200
100
0
Rate(kbit/s)
0
10
20
30
40
50
60
70
Time(s)

Figure 2:

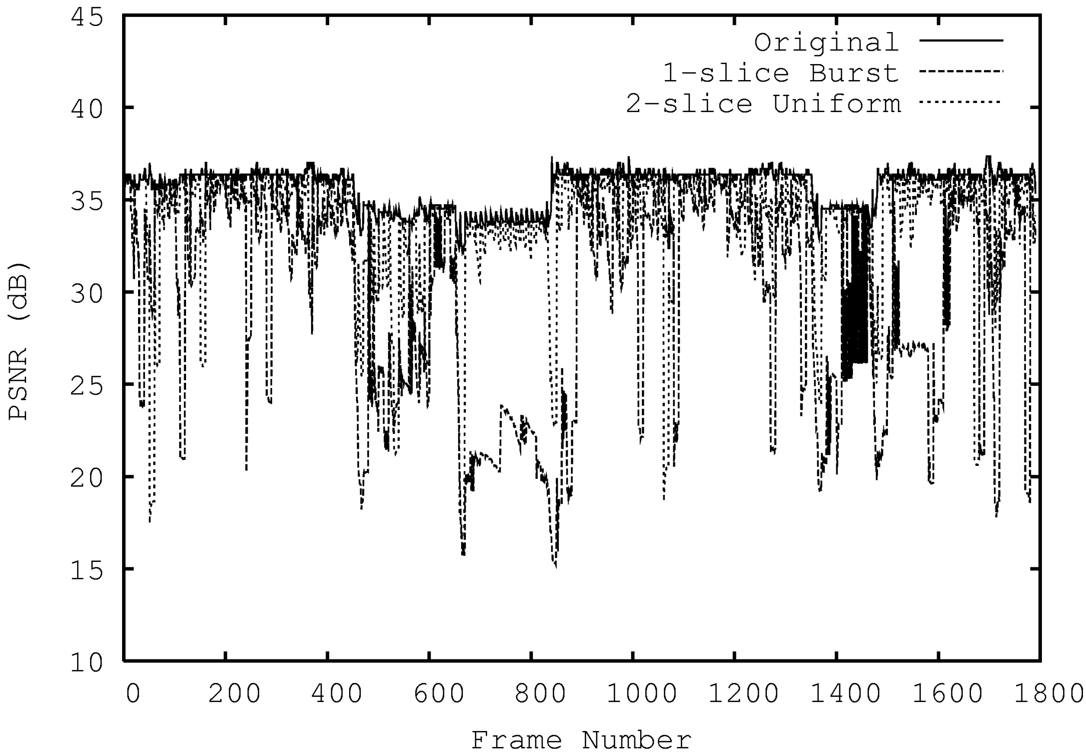
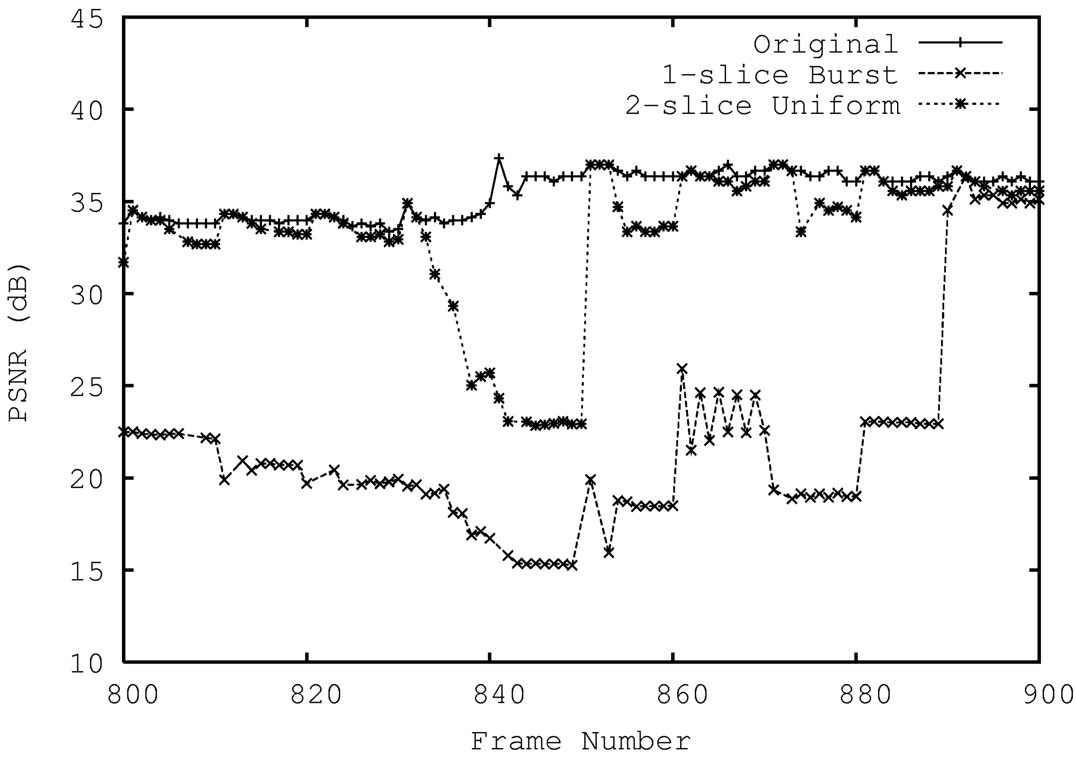

45
40
35
30
25
20
15
10
0
200
400
600
800
1000
1200
1400
1600
1800
PSNR (dB)
Frame Number
Original
1-slice Burst
2-slice Uniform

Figure 3



Original
1-slice Burst
2-slice Uniform
PSNR (dB)
Frame Number
45
40
35
30
25
20
15
10
800
820
840
860
880
900