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Document # AVC-393

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**TITLE:** Experimental results with leaky prediction
**PURPOSE:** Informational

# 1 Introduction

We present the results of some experiments using leaky prediction. All results are presented using frame-based coding with frame-based motion vectors, coded at 4 Mbps using TM2. The SNR values are averaged over 148 frames.

We examine (i) quality without cell losses or channel changing, (ii) quality with cell losses, and (iii) the reduction of drift in the lower layers of frequency scalable sequences.

# 2 Equivalent quality with and without leak

We have coded several sequences with and without leak, and determined the leak factor necessary to obtain equivalent quality. The SNR results are shown in Table 1. Visual quality is demonstrated on D1 tape for selected sequences. Without leak, Mobile, Tennis, and Flower were each coded with $N = 15$ and $M = 3$ (at 4 Mbps), and the equivalent leak factor (without I pictures) was found to be $\alpha = 7/8$. Without leak, Bus and Hockey were each coded with $N = 15$ and $M = 1$ (at 4 Mbps), and the equivalent leak factor (without I pictures) was found to be $\alpha = 15/16$.

| Sequence | $M$ | LF | No Leak | With Leak |
|---|---|---|---|---|
| Mobile | 3 | 7/8 | 27.96 | 28.04 |
| Flower | 3 | 7/8 | 28.75 | 28.91 |
| Tennis | 3 | 7/8 | 30.16 | 30.41 |
| Bus | 1 | 15/16 | 28.33 | 28.44 |
| Hockey | 1 | 15/16 | 36.47 | 36.58 |
| Flower | 1 | 15/16 | 27.20 | 27.50 |

Table 1: SNR of sequences without cell losses or channel changes

### 2.1 Noisy Background

For Flower with $M = 1$, when the sequence with leak factor $\alpha = 15/16$ was visually compared to the sequence with $N = 15$, there was significant noise in the sky, as previously reported in AVC-331 and -333. This effect is caused by the combination of a large quantizer step size and a small but time-varying error produced by the leaky prediction. To minimize this effect, we coded Flower with a leak factor of $\alpha = 7/8$ in every third frame. The remaining frames are coded without leaky prediction. By using a stronger leak, the prediction error increases and is more likely to be updated by a large quantizer step size. However, since the frames with a stronger leak factor have larger prediction error than frames without leaky prediction, the rate control must be modified.

For this experiment, we modify the rate control in TM2 by assigning $K_b = 1.2$ and using the variables with "b" subscripts for the P-frames without leak, while the variables with "p" subscripts are used for the P-frames with leaky prediction. There are no B-frames in the experiment. The D1 tape demonstrates that the quality with temporally-variable leaky prediction is noticeably better than with temporally-constant leaky prediction, although some noisy sky still remains. The SNR also improves from 27.50 (with constant leak) to 27.65. More study is required to further understand the rate control with leaky prediction, as well as the combined effect of quantizer step size and prediction error.

## 3 Cell losses

Next, we compare the effect of cell losses in sequences with and without leak. In each case, we compare sequences that have equivalent visual quality without any cell losses, as described above. Cell losses are generated as described in MPEG92/494 (AVC-350), with cell losses in identical image locations between two sequences. The sequence with leaky prediction was subjected to cell losses according using the method of Appendix F in TM2, and equivalent errors were imposed on the sequence with intraframes. This tends to favor the sequence with intraframes, since if cell losses had been generated using the sequence with intraframes, more cell losses would appear in intraframes.

We use the method described in MPEG92/342 for error concealment; that is, missing blocks are filled in using a motion vector that is the average of the motion vectors above and below the current block, for predictive pictures. A similar averaging method is used to replace missing B-frame motion vectors.

A D1 tape demonstrates that cell losses are more visually objectionable in sequences without leak, since (i) the errors are visually stronger for a longer period of time, and (ii) when the errors disappear, they disappear violently (with an intra-update) instead of gradually. Therefore, visual image quality is better with the leak, even if the SNR can sometimes be less. Table 2 shows the SNR of the sequences with and without leak when affected by cell losses.

The results in MPEG92/494 (AVC-350) showed that leaky prediction is more effective than intraframes for temporal error localization using a simple error concealment technique. These results indicate that the same is true when more sophisticated error concealment techniques are applied.

## 4 Reduction of drift in frequency scalable sequences

The *drift* problem in frequency scalable coding is caused primarily when the lower resolution scales do not have individual interframe feedback loops. Then, motion compensation and inaccuracies in the motion compensation can case errors to accumulate in the low resolution images. These errors can be significant if the distance between the intra frames is large. Furthermore, periodic updates in the form of intra frames are often seen as temporal flicker in the low resolution images. While the error accumulation problem can be corrected using several feedback loops in the encoder, a much less complex solution can be obtained using leaky prediction.

| Temporal localization | Concealment method | Mobile $M = 3$ | Flower $M = 3$ | Bus $M = 1$ | Hockey $M = 1$ | Football $M = 1$ |
|---|---|---|---|---|---|---|
| Intraframes | prev. MB | 26.27 | 25.38 | 26.78 | 32.85 | 30.51 |
| Leaky prediction | prev. MB | 26.02 | 25.40 | 27.06 | 33.44 | 30.82 |
| Intraframes | MPEG92/342 | 27.33 | 26.93 | 27.36 | 34.54 | 31.18 |
| Leaky prediction | MPEG92/342 | 27.52 | 27.69 | 27.74 | 35.23 | 31.49 |

Table 2: SNR of sequences with cell losses

In our experiments, we applied leak to frequency scalable codecs. A frequency scalable bitstream is obtained by partitioning the DCT coefficients into layers in MPEG-like coding schemes. The partitioned coefficients are then encoded and layered to facilitate easy demultiplexing of various scales. An efficient implementation of frequency scaling is comparable to single layer coding in terms of its coding efficiency and complexity while it provides useful lower resolution scales; however, unless the distance between the intra coded frames is limited, drift causes significant degradation at these scales.

We applied 15/16 and 7/8 leak factors in frequency scalable coding of various sequences and observed that the number of frames that can be encoded without intra frames can be increased approximately 3 and 5 times respectively before the low resolution layer drift reaches the same level with that of encoding without leak. These results are demonstrated on D1 tape for Flower. Considering that the degradation to the high resolution layer caused by these leak factors is hardly noticeable, leak seems to be a simple and efficient mechanism for combating the drift problem in scalable coding.