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TITLE: Considerations on ATM cell loss experiments

PURPOSE: Information

1. Introduction

In the MPEG Ad-hoc group on ATM, Packet Loss and General Error Resilience, it is proposed to investigate spatial layering as a means of cell loss resilience in ATM. This document raises issues that must be considered in comparing the performance of a single layer codec, to that of a layered codec, under conditions of ATM cell loss.

2. Rate distortion

Work to date suggests that spatial layered coding produces a bit rate overhead compared to single layered coding. The cell loss performance comparison between single layered coding and spatial layered coding might be done at,

- equal qualities i.e., layered coder has higher bit rate
- equal bit rates i.e., layered coder has lower quality,

(Reference is being made here to the codec output i.e., before error conditions are applied).

To be conclusive, it may be necessary to perform both comparisons.

3. Constant or variable bit rate

The experiment might be performed at,

- constant bit rate, i.e., variable quality
- variable bit rate, i.e., constant quality

With constant bit rate it is necessary to be able to distinguish between quality changes due to rate control, and quality changes due to cell loss. This may require each sequence to be decoded with and without cell loss applied.

Where variable bit rate is used, errors due to cell loss should be clearly seen as changes in received quality. An experiment using the same qualities/different bit rate may be relatively straightforward using variable bit rate: the MPEG TM2 reference quantization parameter Q_j would be held constant. Unconstrained variable bit rate might be examined first, though constrained variable bit rate should also be investigated.

4. Presentation of results

Objective results might be presented as a frame by frame SNR result, or as an average sequence SNR. The frame by frame SNR difference becomes important when performance is compared at different absolute qualities. In this case it might be expected that the SNR change due to cell loss in the layered coder is less than that in the case of the non-layered coder, when compared at the same average bit rates.

Average SNR results may be useful for plotting the relationship between SNR change and cell loss rate.

Subjective evaluation of results is also required.

5. Spatial layer bit rate distribution

The advantage of spatial layering may vary according to the distribution of bits in each layer.

The distribution of bitrates in the MPEG TM2 multichannel scalability experiment is 0.75, 1.5, and 4 Mbits/s, for the QCIF, SIF, and 601 resolution respectively. These figures may be useful in determining bit rate distributions.

6. Coding mode

The effect of cell loss may be different in different frame coding modes i.e., I, P, and B. Given the difficulty in obtaining conclusive results from short test sequences, it is proposed to use only I and P frame coding modes. This should help to minimise the effect of position of cell loss within the coded sequence. Other frame coding modes might later be investigated.

It is proposed to use P frames, with every 12th frame set to intra i.e., N=12, M=1.

7. Cell loss model

For this experiment, the precise characteristics of cell loss is not considered to be important: it is only important that cell loss can be reliably detected. MPEG TM2 specifies the Gilbert Model as a model of cell loss, and is a convenient model for use in this experiment.

8. Application of cell loss ratios

8.1. Initial cell loss ratios

MPEG TM2 suggests cell loss ratios of 10E-3 and 10E-2 for the single layer codec, and scaling of these values for the low priority cells of the layered coder according to the layered bit rate distribution. This is considered appropriate as an initial experiment.

8.2. Equivalence between single layer and layered coder error conditions

A convenient relationship between the cell loss ratio of a single layer coder and the cell loss ratio of a two layered coder, that allows equivalence between the two cases, is as follows; if CLR_{sl} is the cell loss ratio applied to the output of a single layer coder, then the equivalent cell loss ratios for layer 0 and layer 1 of the two layered codec are:

$$CLR_0 = \frac{b}{a} \times CLR_{sl}$$

$$CLR_1 = \frac{(1-b)}{(1-a)} \times CLR_{sl}$$

respectively, where

$$a = \frac{\text{number of bits in layer 0}}{\text{number of bits in layer 0} + \text{number of bits in layer 1}}$$

and

$$b = \text{fraction of cell loss applied to layer 0}$$

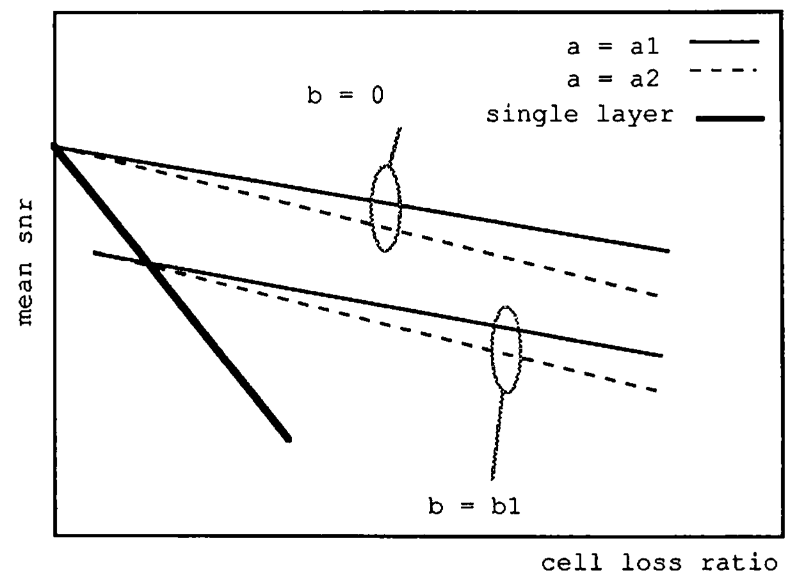
These relationships ensure that the total cell loss ratio of the two layered codec is equal to the cell loss ratio of the single layered codec.

As an example, if no cells are to be lost from layer 0 (b=0) and layer 0 takes up half the bandwidth of the layered codec (a=1/2), then $CLR_0 = 0$ and $CLR_1 = 2 \times CLRsl$ for the cell loss conditions of the two coders to be equivalent.

It could be expected that

- the higher the proportion of bits carried in layer 1 of the layered codec the more sensitive is the layered codec to a change in cell loss ratio.
- the quality of the layered codec to change in the layer 1 cell loss ratio is less sensitive than the single layer coder is to change in its cell loss ratio. Similarly the quality of the layered codec to change in the layer 0 cell loss ratio is more sensitive then the single layer coder is to change in its cell loss ratio.

These relationships are illustrated in Figure 1.

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Notes:
  1.  'a' is the proportion of the total bit stream
      carried in layer 0. Note that a2 < a1.
  2.  'b' is the proportion of the total cell loss
      applied to layer 0. Note that b1  > 0.
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Figure 1. Possible relationship between mean SNR and cell loss ratio in a one and two layered coder

9. Concealment

Layered coding is said to offer inherent error concealment properties. An appropriate cell loss concealment action, that still allows a fair comparison must be selected for the single layer codec. The same is true for layer 0 of the layered codec, where that is also errored. Concealment actions include

- spatial concealment i.e., interpolation from adjacent macroblocks
- temporal concealment i.e., replay of the information from the last frame. This information could be motion compensated, even where motion vectors are estimated.

It is proposed to replay macroblocks from the last frame, in the case of lost cells in the single layer codec and layer 0, and to add nothing in the case of loss in layer 1.

10. AAL functionality

Some AAL functionality is required to support cell loss experiments.

10.1. Service mode

Two service modes are possible, being streaming and message mode.

In the streaming mode cell payloads are filled with data as it becomes available at the coder output. In general there is no synchronization between the coder multiplexing structure and the cell segment boundaries, except for that enforced by the coder, given a priori knowledge of the cell payload capacity. A cell payload in general carries data from one or more slices.

In the message mode a unit of data from the coder video multiplex is handled in the AAL, independently of other data units. A cell payload carries data from only one data unit, with the possibility of the last cell segment being only partially filled. The AAL provides functionality to assist in reassembling data units, and may be able to preserve timing between data units.

The slice is an appropriate data unit since it provides resynchronization capability and is large enough to introduce minimal inefficiencies (the last cell segment may be only partially filled). Slice start codes are not required for purposes of synchronization (though vertical slice position is still required). If the size of an input slice area is constant then the time between slices at the coder is constant. The AAL may be able to preserve slice timing at the decoder. In message mode loss of one cell effects only one slice, whereas more than one slice might be effected in streaming mode.

It is suggested that for the purposes of layered coding cell loss experiments the decision of which service mode to use has little impact.

Streaming service mode is proposed for this experiment.

10.2. Cell loss detection

A Segmentation And Reassembly (SAR) sublayer sequence number field is proposed to detect lost cells. In general the sequence number field length should be selected according to the probability of consecutive cell loss. The sequence number field length in AAL type 1 (for constant bit rate real time services) is 3 bits. For AAL type 3/4 (data services) it is 4 bits. Work needs to be done to justify the field length for real time variable bit rate services.

For this experiment a sequence number field length of 4 bits is proposed.

10.3. Bit error detection

Cell payload bit errors affect codec data being carried and AAL fields. Bit errors in AAL fields may result in cell loss within the AAL e.g., errors in segment type or multiplexing fields.

It is proposed for this experiment that no bit errors are introduced to the cell payload. No bit error detection is required within the AAL.

10.4. Cell delay variation

It is proposed for this experiment that no cell delay variation be introduced at the ATM layer. The AAL is not required to provide any cell delay variation correction function.

10.5. Timing recovery

It is proposed for this experiment that a clock is assumed to be available at the receiver. The AAL is not required to provide a source clock recovery mechanism.

10.6. Multiplexing

Multiplexing of the layered data produced from a layered codec might be done within the AAL or within the ATM layer.

It is proposed for this experiment that the AAL contain no multiplexing function. Multiplexing of layers will be done at the ATM layer i.e., separate VCIs.

10.7. AAL proposal

Considering the above, the following simple procedures for simulating the AAL and ATM layers are proposed:

- the ATM cell payload consists of a one byte SAR-PDU header and a 47 byte SAR-PDU payload
- the SAR-PDU header holds a four bit sequence number.
- at the sending end, the coder requests the AAL to deliver a 47 octet block of data.
- at the receiving end, the AAL indicates to the receiver that a 47 octet block of data is available, or that a lost cell has been detected.

These procedures provide the same functionality as in TM2 Appendix F.

11. Resynchronization capability

In TM2, where the bit stream is errored, resynchronization occurs on the next slice start code. Proposals exist to modify the TM2 syntax, or provide functionality within the AAL, that insert absolute address information at the first macroblock following a cell segment boundary.

For this experiment, in the case of cell loss, it is proposed to resynchronize on the next slice start code. The decoder ignores the first errored macro block in the slice, and all following macroblocks in the slice.

12. Conclusion

The comparison of the error resilience properties of a spatial layered codec to those of a single layered codec requires careful consideration if a fair comparison is to be made. Important issues have been raised in this document.

In summary Table 1 lists parameters and their values required in performing a first MPEG TM2 spatial layered codec cell loss resilience experiment.

number of layers:	two
rate-distortion comparison:	same bit rate
constant or variable bit rate:	constant bit rate
spatial layered bit rate distribution:	1.5, 4.0 Mbits/s
coding mode:	N=12, M=1
cell loss model:	Gilbert Model as per TM2
cell loss ratios:	10E-3 and 10E-2 as per TM2
application of cell loss ratios:	no loss on baseband layer, equivalent cell loss rate applied to enhancement layer
concealment action:	single layer and baseband layer - display from previous frame enhancement layer - add nothing for this frame.
resynchronization:	at next slice start code
AAL functionality:	streaming mode plus 4 bit sequence number

Table 1. Proposed parameter values for a first MPEG TM2 spatial layered codec cell loss resilience experiment

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