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Working Party XV/1
Experts Group for ATM Video Coding

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**INTERNATIONAL ORGANISATION FOR STANDARDISATION**
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**CODING OF MOVING PICTURES AND ASSOCIATED AUDIO**

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**Source:** Chair, MPEG Ad-hoc Group on ATM, Packet Loss and General Error Resilience (Michael Biggar, Telecom Australia)

**Title:** Progress Report for Ad-hoc Group on ATM, Packet Loss and General Error Resilience

**Purpose:** Report

## Mandate

The Ad-hoc Group on ATM, Packet Loss and General Error Resilience was established at the July (Angra Dos Reis) MPEG meeting with the mandate to exchange results and coordinate experiments relative to error resilience including the impact of layered coding, priorities, leaky predictors and error concealment schemes.

Consideration should be given to whether the present title accurately reflects the activities of the group, since "packet" as distinct from "cell" loss implies investigation of a wide range of issues beyond that understood to be in the current work programme.

## Outcomes

The Group is responsible for investigating and confirming methods by which the MPEG video bitstream may be transported reliably over transmission links that involve cell/packet loss (specifically, the ATM-based B-ISDN) and other errors (e.g. radio, satellite transmission). Standardisation of these aspects of a communication link is beyond the scope of MPEG, so the group's work will result in:

- Confirmation that the evolving MPEG syntax can be carried in these lossy transmission environments while still providing acceptable picture quality, or recommendation of any changes to the syntax to allow it to do so;
- Preparation of informative text for the CD, outlining example methods to achieve error/loss resilience;
- Recommendation of appropriate liaisons to other groups (CCITT SGXV and SGXVIII, for example) advising of results of the experiments and conclusions that may assist harmonisation of the work (e.g. functionality required of the AAL).

## Membership

17 members were noted at the July meeting. This has since expanded to 24:

| | | | | |
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**Result of July meeting**

The ad-hoc group was established at the July 1992 (Angra Dos Reis) meeting, and two experiments were defined:

*Layered Coding*: to assess the benefit of using layered as against non-layered coding in a cell loss environment. David Sarnoff Research Centre and the Australian UVC consortium indicated their willingness to carry out this experiment.

*Leaky Prediction*: to compare the performance and efficiency of leaky prediction and Group-Of-Pictures as means of refreshing the picture and correcting impairments due to cell loss. AT&T indicated its willingness to carry out this experiment.

**Inputs since the July meeting**

There have been only three contributions (12.5% of participants) to the discussion since the July meeting:

- RTT Belgacom (B) indicated willingness to participate in the layered coding experiment.
- Siemens Ltd. (AUS) provided a discussion of factors leading to a selection of an AAL for cell loss experiments.
- Matsushita (J) provided a discussion and results of experiments concerning localisation of the effects of cell loss. Experimental results were based on the use of SM3.

**Framework for Experiments**

The experiments on cell loss resilience involve network characteristics and any adaptation between the network and the standard MPEG bitstream(s).

Assumptions must be made about the network loss characteristics and the functionality of the ATM Adaptation Layer (AAL),which impacts on cell loss tolerance, and any further network adaptation must be specified. Note that, since the AAL and other layer(s) are not being standardised by MPEG, we need only specify the functions carried out by these layers; the distribution of these functions between the layers (e.g. whether they reside in the AAL or above) is not important to us unless it impacts on the syntax.

A detailed discussion of AAL functionality was distributed through email by Stuart Dunstan (Siemens Ltd., Australia), which identified those functions that could be neglected for the purpose of the cell loss resilience studies. The conclusion of this investigation was consistent with the "implicit" AAL defined in TM2, Appendix F, where only a 4 bit sequence number is provided.

## Network Cell Loss Characteristics

Network loss characteristics, both average and burst, are defined in TM2, Appendix F. Average cell loss ratios of $10^{-2}$ and $10^{-3}$ are to be studied.

## Approaches to Cell Loss Resilience

There are five basic approaches to cell loss resilience that have been identified, as discussed below.

*A. Forward Error Correction*

This method provides protection at the encoder, by the use of error correction bits and interleaving to permit correction of consecutive errored or lost bits. It provides protection prior to transmission to correct any losses completely, whereas all other methods aim to minimise the damage once the loss has occurred.

*B. Concealment*

The decoder provides cell loss error concealment by taking some action to disguise the fact that a loss has occurred, by appropriate estimates of the lost data. An example would be estimation (from neighbouring MBs) of the motion vector applying to lost MB data, and using a motion compensated prediction from a previous frame as an attempt to hide the loss of the MB data.

*C. Refresh*

By relying on the periodic refresh provided by the standard GOP structure (i.e. periodic I-frames), by cyclic intra slices or by introducing a continuous picture refreshing function through leaky prediction, any picture errors will be erased after some short period of time.

*D. Spatial Layered Coding*

By separating the most important (low frequency) from the least important (high frequency) spatial information and transmitting these in channels of different priority, then cell loss can be largely restricted to the less important low priority channel. Loss is characterised by a temporary reduction in spatial resolution in the affected part of the picture, rather than shearing or other spatial displacement errors.

*E. Prioritised Encoding of Standard Bitstream*

An encoded bit stream that is not explicitly layered already contains some elements (motion vectors, addressing data, low frequency coefficient VLCs, I-frames) that are more important than others (high frequency coefficient VLCs, B-frames). There is, therefore, the potential to transmit these data in different priority channels and provide protection similar to that offered by "formal" layered coding. In practice, however, this is not straightforward due to the integrated nature of the MPEG syntax (see below).

Note that some of these techniques may, and almost certainly will, be used in combination. For example, a layered coder may also incorporate leaky prediction, and some form of cell loss concealment can be used with any other approach.

A summary table of the different techniques appears as Table 1.

## Cell Loss Error Localisation

Yutaka Machida and Takeshi Yukitake of Matsushita distributed a document that highlighted the importance of localising (in both space and time) the effect of cell loss upon the reconstructed picture. Time localisation is achieved through the refresh techniques mentioned above. Space (i.e. Macroblock) localisation is achieved by ensuring rapid resynchronisation after the cells are lost so that subsequent information can be used. Periodic use of Absolute MB addressing and resetting of parameters is advocated in the Matsushita document.

These approaches (and any others) should be considered, along with their impact on coding efficiency and the MPEG syntax.

| Resilience Method | Impact on TM Syntax | Cost | Tolerance to high and burst cell loss | Notes |
|---|---|---|---|---|
| FEC | None | Transmission efficiency | Unsuitable? | Not suited to burst cell loss due to large overhead and delay. |
| Concealment | None | Decoder complexity, processing burden | May not perform well for burst cell loss | Not subject to standardisation. Could be used in conjunction with other techniques. |
| Refresh | Leak factor must be transmitted | Coding efficiency | Can adapt parameters to cope with high cell loss (at expense of efficiency). Tolerant to bursts? | Also satisfies rapid channel acquisition requirement (channel grazing). |
| Layered Coding | Scalability or Compatibility syntaxes may be used. | Coding efficiency, complexity | Tolerant of high/burst cell loss (in low priority channel). | Independent control of rates for different layers required. |
| Prioritised Encoding | Would require syntax translation | Complexity and possible transmission inefficiency. | Tolerant of high/burst cell loss (in low priority channel). | Independent control of rates for different layers required. |

Table 1. Summary of Cell Loss Resilience Techniques.

### Cell Loss Priority and MPEG Syntax

In principle, it is possible to allocate any portion of a coded video signal to either of two transmission channels of different loss probability as a means of controlling the effects of cell loss. It should be noted that the rates (whether constant or varying) allocated to each priority channel must be independently controlled for negotiation and control of network resource usage.

In practice, however, this may not be straightforward:

- At the macroblock level, the DCT coefficients are run-length encoded so their segmentation would require interpretation and partial decoding of the bitstream. Different approaches to frequency scanning and coefficient coding may get around this problem and should be investigated.
- At the frame level, I, P and B frames may be allocated to different priorities (as discussed in MPEG92/325), but large buffers and cell resequencing may be necessary to smooth the rate in each of the priority channels.

There may be potential for a mid-way solution based on slice-level priority segmentation. It should be recognised, however, that the adaptation to prioritised transmission could involve bitstream interpretation, recoding, resequencing and additional delay, and these costs must be assessed. Further work is required.

Similarly, in principle, it is possible to decouple Cell Loss Priority from the layers defined in the scalability or compatibility studies. That is, one scalable layer need not necessarily map directly onto one priority level. In practice, however, similar considerations to those just discussed suggest that any other approach would introduce additional penalties that need to be quantified.

For the present, we therefore assume that the boundary between ATM network priority levels corresponds to a boundary between layers in a multilayer scalable or compatible coder.

### Cell Loss Resilience Experiments

Experiments are required to determine the relative merit and effectiveness of the approaches to cell loss resilience described above. Specific aspects identified so far are:

- Examination of the merits of layered coding compared with non-layered coding in a cell loss environment (UVC Australia, DSRC and RTT Belgacom have expressed a desire to investigate this, but no results have yet been presented);
- Determine the relative merits of the two approaches to "refresh" - GOP and leaky prediction (AT&T have expressed an interest, but no results have yet been presented);
- Investigation of the suitability of FEC for cell loss protection, for both isolated and bursts of cell loss;
- Investigation of increased complexity resulting from use of explicit cell loss concealment techniques at the receiver;
- Comparison of effectiveness and costs (efficiency, complexity) of the remaining techniques;
- Determine whether any change to the MPEG-2 syntax is required to provide adequate cell loss protection.

### General Error Resilience

The MPEG-2 bitstream must also be tolerant of errors encountered in transmission over other media. In particular, satellite transmission is expected to be the most hostile environment because burst errors can be expected. No input has been received on the error characteristics to date, so information is requested on the error characteristics that are expected, so that further investigations into appropriate FEC schemes and the extent to which cell loss resilience approaches may be applicable in this environment can be determined.