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TITLE : Outstanding Issues on Low Bit Rate Video Coding for ATM Networks
PURPOSE : Discussion

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1. Introduction

A number of organizations within Europe (COST 211bis, RACE 1018, etc.) are studying the possibilities of variable bit rate video coding for transmission over Asynchronous Transmission Mode networks. The aim is to determine if such coding schemes are viable and whether they offer benefits to the customer and network operator. The perceived improvements which hope to be realized are near constant picture quality, shorter transmission delay and more efficient use of network resources. This document presents some of the findings from current studies and highlights important issues which still need to be resolved.

2. Current status on coding schemes

The coding schemes considered here are targeted at low bit rate applications such as videotelephony, videoconference and low quality TV (Electronic News Gathering). A variety of video coding schemes are currently under study ranging from 1-layer to multilayer designs. A comparison of the advantages and disadvantages of 1-layer and 2-layer schemes are listed below. Other multi-layer schemes have not been considered here.

2.1 One-Layer CBR - Class A

Advantages

1) Existing H.261 codecs can be used.

2) By using CBR a near 100% network loading is achievable.

3) Compatibility with H.261 codecs working over STM networks.

Disadvantages

1) No improvement in picture quality over what is obtained with H.261 codecs working on STM networks.

2) No significant reduction in transmission delay.

2.2 One-Layer VBR - Class B

Advantages

1) Near constant picture quality is achievable.

2) A possible reduction in transmission delay, due to reduction in buffer size. Small buffers (or FIFOs) will still be required for Information Field packetization at the encoder and to remove 'cell jitter' at the decoder.

3) Efficient use of bits, as all the transmitted bits add to the predicted picture.

Disadvantages

1) Requires a source policing function in the encoder. This function has to provide a statistical model of the application's bit rate requirements for the duration of the connection. It is very doubtful whether such a statistical model can ever be practically realized due to the random nature of call length and video source material.

2) The bit rate capacity specified by the source policing function can never be fully achieved in practice.

3) Cell loss protection may be required.

4) The generated encoder bitstream may not be compatible with a H.261 (CBR) bitstream if cell loss protection mechanisms are invoked.

2.3 Two-Layer CBR/VBR - Class A/B

Advantages

1) A source policing function for the VBR channel at the encoder is not essential. The reason is that the base layer picture transmitted at CBR is guaranteed delivery to the receiving decoder. The enhancement data transported over the VBR channel only adds detail to the base picture and not structural information. Consequently, in an extreme case all the enhancement VBR data may be lost and a viewable base picture can still be reconstructed at the decoder.

2) Near constant picture quality is achievable.

3) A possible reduction in transmission delay compared to CBR H.261 may be realized if the receiving codec is of a similar type (ie. 2-layer CBR/VBR). This reduction in transmission delay may be achieved by reducing the size of codec's buffers.

4) The base layer bitstream is compatible with H.261, ie inter-operability between 2-layer (CBR/VBR) and H.261 (CBR) is possible.

5) This scheme has a higher resilience to cell loss than 1-layer VBR coding. For videotelephony and videoconference applications a cell loss rate of 10^{-3} or worse is still usable.

6) Based on one network model, this scheme can achieve a higher network loading than 1-layer VBR if its advantage of operating at higher cell loss rates is utilized.

Disadvantages

1) More bits are required to code a source than for 1-layer VBR coding because the enhancement VBR data can not be used recursively to contribute to the prediction at the decoder. However when considering working over a practical ATM network, the advantage of higher cell loss resilience may counter-balance this disadvantage.

2) This scheme is functionally more complex than for 1-layer VBR coding due to requirement for an enhancement layer. However, this functionality may not be a constructional overhead if VLSI design techniques are applied. Further it is debatable whether the requirement of source policing for 1-layer VBR coding would be any less complex to implement (this function is not essential for 2-layer CBR/VBR coding).

2.4 Two-Layer VBR/VBR - Class B

Advantages

1) Near constant picture quality is achievable.

2) A possible reduction in transmission delay, due to a reduction in buffer size. Small buffers (or FIFOs) will still be required for Information Field packetization at the encoder. Buffers will also be required at the decoder to remove 'cell jitter' and to assist in the synchronization of the two layers which may have differing delivery times.

Disadvantages

1) Requires a source policing function in the encoder for both layers. This function has to provide a statistical model of the application's bit rate requirements for the duration of the connection. It is very doubtful whether such a statistical model can ever be practically realized due to the random nature of call length and video source material.

2) The bit rate capacity specified by the source policing function can never be fully achieved in practice, particularly with 2-layers.

3) The generated encoder bitstream may not be compatible with a H.261 (CBR) bitstream if cell loss protection mechanisms are invoked.

4) Cell loss protection may be required for the base layer but certainly for the second layer.

3. Implications

There are many inter-related factors to be considered when coding video for use on ATM networks. The coding algorithm has to compensate for ATM's loss characteristics such as bit error rate and more importantly cell loss. The action of cell loss can result in large sections of the highly compressed video bitstream being lost which means that the receiving decoder has to take corrective action. The decoder can overcome this loss by implementing a concealment technique. Unfortunately a successful concealment scheme for 1-layer coding has still to be found. Studies into 2-layer (CBR/VBR) have shown that this coding scheme offers a better cell loss performance by virtue of a base picture always being reconstructed at the decoder. However it has also been shown that for a 2-layer scheme the VBR enhancement picture rate must match that of the CBR base layer otherwise major disturbances will result when cell loss occurs on the VBR channel.

It should be noted that coding for minimum bit rate does not necessarily offer the best performance on ATM networks as is the case for STM networks, and that gains can be made if ATM network aspects are considered at the same time.

4. Unresolved Issues

From the studies carried out over the past year a number of unresolved issues have been exposed, some of which are listed below. The issues cover specifics both in the ATM arena and in the video coding area. To assist in the process of determining a sensible video coding algorithm for use on future ATM networks it is essential that determined efforts are made to resolve these questions as soon as possible.

4.1 ATM Network Issues

Tariffs

1) Is ATM transmission cheaper per information bit than for STM?

2) Will VBR bits be cheaper than CBR bits ?

3) Is the network's loading efficiency a major contributory factor in determining customer tariffs for the various supported services ?

4) How are VBR services going to be charged (by mean bit rate, negotiated bit rate, QOS, etc) ?

Implementation

5) How is the priority bit used (by the user or network control) ?

6) Can ATM networks support differing services with differing QOS or do they have to operate at the best QOS for the range of services supported ?

7) Will Class 0 be supported by all networks?

8) What is the difference in delivery times at the receiver between 2 channels (ie. 2 VCIs - this is applicable to 2-layer coding) ?

9) Is the proposed sequence number comprising of 4 bits of sufficient size to cope with a burst of lost cells ?

10) Which policing mechanism is the most probable?

11) Which parameters will be policed?

12) Will policing functions or policing parameters be standardized?

4.2 Video Coding

1) What does the customer perceive as 'constant picture quality' ?

2) Does a realistic ATM network loading reference model exists so that the performance of various coding schemes can be assessed ?

3) Does VBR offer significant improvements (picture quality, shorter delay, etc) over CBR?

4) How do codecs specify to the network their call requirements (total mean bit rate , peak bit rate, etc) ?

5) What coding scheme offers the best network loading characteristic ?

5. Summary

Progress has been made by the video coding experts on VBR video coding, however it is becoming increasingly important to have answers or opinions on the issues outlined here.