CCITT SGXV
Working Party XV/1
Experts Group for ATM Video Coding

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TITLE: Universal Video Coding for ATM Networks

PURPOSE: Proposal

Abstract

The ATM based B-ISDN provides the underlying capability to provide integration of all image and video services supported on it. The remaining critical element is an integrated approach to video signal representation and coding. In this Contribution, a Universal Video Coding approach is proposed, based on a hierarchical, layered coding approach with different sets of layers corresponding to different service classes. The basic approach is outlined here, but much work is required to develop it further and assess the costs and benefits involved.

1. Introduction

An ATM-based B-ISDN will provide commonality of cell transport, transmission medium, and signalling and call control functions, which are prerequisites to full service commonality and interworking. The remaining barrier is in the coded video representation itself.

However, ATM cell transport can support a layered coding scheme, in which different service qualities correspond to different layers in the hierarchy.

If such an approach is realisable, then the resultant interworking capability will mean:

- single-terminal access to a range of video services;
- distribution, or multipoint connections, to an unknown variety of receivers;
- flexible migration of particular applications across different service quality levels;
- open-ended forward compatibility for the introduction of new services of greater quality.

Maximum integration, including requirements for service interworking, of video services has been recognised by CCITT SGXVIII in Draft Rec. I.211 "B-ISDN Service Aspects" as an important aim for video service provision on the B-ISDN.

2. Layered Video Coding

Layered video coding involves the separation of video information of differing perceptual importance. For example, low and high spatial frequencies could be separated into different "layers".

2.1 Tolerance to cell loss.

In the recent past, most research in layered coding has been directed towards its inherent tolerance to cell loss. If the different layers are transmitted in different cells, and particularly if a priority indicator can be used to inform the network as to which cells may be sacrificed if necessary in the event of congestion, then the most important information can be preserved. This appears to be the most appropriate means of error control, as discussed in companion Document AVC-4 "Impact of ATM Networks on Video Coding" and the liaison from SGXVIII TD.6 "QOS considerations of layered coding and variable bitrate coding".

2.2 Interworking

The same layered coding approach can be extended so that each layer corresponds to the necessary information to achieve a given service quality level. In this way, a lower grade service quality, such as that for a videotelephone, could appear as a subset of a higher grade service, such as a videoconference. This is shown in Figure 1.

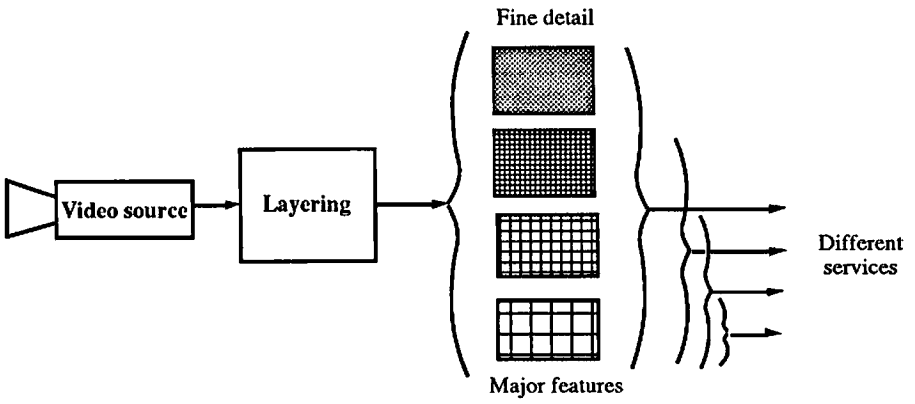

Figure 1. Layered video coding for service interworking.

There are two important consequences for interworking that follow from this general approach:

Point-to-Point

In a simple point-to-point, two party connection, the two terminals can negotiate, either automatically or under manual control, on the grade of service to be used for the connection. Removal of unused layers, at the transmitting end, can easily be performed since this will simply involve not transmitting them.

Point-to-Multipoint

In a multipoint connection, or distribution service, a transmitter can send as many layers as it wishes, oblivious of the capabilities of the variety of receiving devices that may be accepting the signal. Those layers that cannot be used may be rejected at the receiver.

By using this hierarchical signal structure, it may be possible to provide a universal interworking capability. Note that this approach does not require a single "codec" to cover the entire range of video services by appropriate selection of quantisers, etc. Rather, an architecture has been suggested, in which appropriate coding of each layer resulting from a decomposition of the original signal allows interworking without demanding premium performance from a low-grade terminal device.

3. Studies Required

Many issues need to be investigated to determine the practicality, limitations and costs of providing a universal video coding system.

3.1 Investigations of methods.

Studies are required to identify the range of parameters defining the service classes to be encompassed by the scheme, and the appropriate hierarchies that could be used to represent them as described above. For example, the most obvious hierarchy concerns spatial resolution, and it is significant that the existing service definitions (QCIF and CIF used in CCITT Rec. H.261, and television sampling parameters defined in CCIR Rec. 601) are (approximately) related by factors of 2, making conversion between them straightforward. However, a universal video coding scheme would have to accommodate services using different aspect ratios, and with different temporal parameters (frame/field rates). Can these variations be accommodated within a single hierarchy?

3.2 Coding of the Resulting Layers

"Upper" layer signals, those differential signals needed to define the higher quality (e.g. high resolution) services, are likely to have statistics that differ from those of lower layers. A good analogy is the difference in statistics of the bands resulting from subband decomposition. (In fact, subband decomposition may be directly applicable here.) Such analysis will assist in the choice of appropriate compression algorithms for each layer.

3.3 Costs, Benefits and Practical Implications

Considerable benefits, as listed in the Introduction, could follow from the adoption of a universal video coding scheme. However, the costs must also be quantified. For example, would the universal scheme be restrictive regarding choices of spatial and temporal resolution? If different coding schemes were considered appropriate for each layer, what would be the cost of providing this in a terminal device capable of processing the higher layers? If the same coding scheme is used for each layer, could the same hardware be reused? Some other important issues are discussed in Section 4 below.

Questions such as this would need to be answered with the timeframe of introduction in mind. B-ISDN is not expected to begin to impact on the end-user directly until the mid to late 1990's. In this same timeframe, codecs capable of efficient compression and decompression of lower grade services such as videotelephony or videoconferencing may be achievable in single-chip form.

3.4 Compatibility with Existing Coding Schemes.

If the Universal Video Coding approach is accepted as the long term target for provision of image and video services on the B-ISDN, then an appropriate evolution strategy must be developed. In particular, compatibility with existing and emerging standards such as JPEG, MPEG, H.120, H.261 and CMTT digital television coding schemes should be taken into account.

4. Major Issues

Given the expected capacity, capability and ultimate penetration of the B-ISDN, video coding standards for ATM can be expected to apply for the foreseeable future. The importance of addressing all the important issues must, therefore, be emphasised. As well as the capabilities discussed earlier, possible compromises must also be considered:

- The cost/complexity trade-off to introduce universal video coding may be different in different sectors (most obviously, residential compared with business);
- Incorporation of, or migration from, existing or emerging standards must be considered;
- Flexibility to accommodate future improved algorithms or techniques should be considered;
- Accommodation of all services in the one framework may mean that the coding scheme is optimal for none;
- It is desirable to accommodate still images services in the same framework. An approach based on treating the still image as a video signal has been proposed in Draft Rec. I.211 "B-ISDN Service Aspects", but this will have to be studied in greater detail.

5. Conclusion

Given that the B-ISDN is seen as the means of delivering all communications services for the foreseeable future, and that widespread penetration of a broad range of video services is likely to finally be available as a result of this development, it is very important that a flexible video coding system be adopted.

It is proposed that the SGXV ATM Video Coding Experts Group investigate the practicality of the Universal Video Coding approach, and further develop the concept to assess its suitability as a target architecture for video service provision on the B-ISDN. The concept is attractive because it builds on the features of ATM to provide an extremely flexible service category, with common delivery, transport, signalling and control, and coding. Studies are required to develop it further and identify the advantages and disadvantages.