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

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TITLE: Impact of ATM Networks on Video Coding.

PURPOSE: Information

Abstract

An ATM-based B-ISDN offers many features that impact on the provision of video services. The major characteristics and their impacts are identified in this document. Study programmes can be identified to determine the feasibility and quantitative advantage of the approaches permitted by the new network. This will permit the definition of a long-term goal for video communications on ATM networks, and therefore a path to lead there. A key component will be consistency with the directions of B-ISDN.

1. Introduction

Before deciding on coding schemes for audiovisual communications over ATM networks, it is necessary to consider the features of the network, and the impact that these might have, be they opportunities or limitations. We assume a long term goal to be the development of new video coding techniques optimally matched to ATM networks. Knowing the possibilities, a target video coding system can be identified and a study programme developed.

The chief characteristics of ATM networks are:

- Ability to support variable rate video coding;
- Differing error conditions from circuit switched networks;
- Capacity to support broad integration of services;
- Flexible carriage of all services.

These features are discussed in more detail below.

2. Variable Rate Video Coding

Since all information is transported in cells on an ATM network, and the network will accept as many cells as desired within negotiated or physical limits, it has the potential to support variable bit rate (VBR) video coding. Variable rate is the "native" mode of coded video; removal of redundant and irrelevant information leaves an inherently varying signal rate since it reflects the information content of the video source. It varies with complexity of the image, degree of motion, etc. This rate variation is ordinarily smoothed by buffering and by use of dynamically varying quantisers to avoid buffer overflow and underflow, and the picture quality varies accordingly. This is the case with all fixed bit rate (FBR) codecs for circuit-switched networks.

2.1 Picture Quality/Rate trade-off.

The ability to reduce a transmitted bit rate when a higher rate is not necessary to provide adequate fidelity for a given segment of a video signal, and yet the capacity to send high peak rates when necessary to represent demanding material, intuitively suggests that the rate/quality trade-off for variable rate should be better than that for fixed bit rate. Some published results in the literature support this, but it will be necessary to better quantify this advantage, if it exists, and to consider the impact of the type of video material being coded. For example, perhaps the benefits of VBR over FBR are greater for high-motion scenes (e.g. entertainment television) than for the more limited motion encountered in a videoconference. On the other hand, the difference between a still, listening conferee and an active, talking one may lead to a valuable advantage of VBR over FBR in videoconferencing also.

Of course, if the buffering is long enough, the quality and average rates of FBR and VBR will converge. However, if the subject of the video source is human motion, or it is to be viewed comfortably by a human observer, then motion is commonly correlated over a time of one second or more. The end-to-end delay caused by buffering the video signal over such a long period would be unacceptable in communicative video services, and would at present be too demanding of memory for distributive services.

2.2 End-to-End delays.

Temporary Document TD.6 (liaison from SGXVIII) "QOS considerations of layered coding and variable bitrate coding" discusses delays for video on ATM networks. The support of a FBR codec over an asynchronous network would add to the total end-to-end delay, since a buffer is required at the receiving end to smooth cell arrival time jitter that might occur within the network.

The use of VBR coding could lead to a significantly reduced end-to-end delay, since the dominant rate-smoothing buffers at transmitter and receiver can be reduced significantly, if not removed.

This highlights the need for studies of the acceptability of end-to-end delays (and, for that matter, differential delays between audio and video) for communicative services. Figures have been proposed as upper bounds for voice-only connections, but the subjective effect of additional video information is not well understood. Limits on these delays need to be known to identify how important will be the different delays for FBR and VBR.

3. Cell loss

The error conditions to be encountered in ATM networks are very different to those in traditional circuit-switched networks. In particular, a low probability of cell-loss must be tolerated. Temporary Document TD.6 (liaison from SGXVIII) "QOS considerations of layered coding and variable bitrate coding" presents means of protecting against, or recovering from, cell loss, and advises that loss protection based on layered coding and cell priority assignment is likely to be most suitable in an ATM environment.

The draft B-ISDN specifications allow for 1 bit (i.e. 2 layers of priority) for this purpose (see SGXVIII draft Recommendation I.361). Studies will be necessary to determine whether the one bit of priority available in the ATM cell header is sufficient to provide effective loss protection for the range of services to be supported.

Consideration must also be given to the segmentation of coded, layered video data into cells for transmission. The cells should be self-contained to minimise error propagation in the event of a cell loss, and yet coded video information should be packed into cells as efficiently as possible to minimise the overhead of cell transport.

4. Service Integration

SGXVIII draft Recommendation I.211, "B-ISDN Service Aspects", establishes the objective of maximum service integration across the full range of interactive and distribution video services. The objective is to achieve the highest level of service integration through minimising the number of coding techniques used across a wide range of video services and maximising commonality of display devices. Comformity of video coding studies with the B-ISDN studies will be necessary if this objective is to be achieved.

The B-ISDN will provide many features conducive to the integration of video services.

4.1 Capacity.

Most fundamental is the capacity available. Customer access to the B-ISDN is expected to be at rates of about 130 Mbit/s in a 155.52 Mbit/s channel. This is likely to provide the capability to support all envisaged image and video services, with the possible exception of contribution quality HDTV which may require 600 Mbit/s channels. Thus the network allows all services to be carried over the one medium (presumably an optical fibre).

4.2 Transport mechanism

All services will be carried in fixed length similarly structured cells, and all cells will be treated similarly, independent of their service application.

4.3 Signalling and Control

Work currently underway in CCITT SGXVIII and SGXI is aimed at providing a single unified method of establishing and maintaining connections across the B-ISDN, so that again each service is treated identically.

4.4 Integration of coding method

The remaining link to create a fully integrated video communications system is a common coding method, whereby different service classes are defined by how many layers of a hierarchical signal representation are used. Such a system would allow for:

- single-terminal access to a range of video services, with consequent overall cost reductions;
- 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.

This concept, of **Universal Video Coding**, is discussed in more detail in companion Document AVC-5.

5. Flexibility

ATM transport provides for very flexible carriage of services. This would mean that video quality (rate) could be varied during a connection, audio channels could be added or dropped without impacting on the video signal, and data channels can similarly be established as and when required. (Audio/video synchronism is, of course, an important issue here.) Within such an environment, multimedia connections are likely to be established and maintained in a manner very different from, for example, the Rec. H.221 framing structure.

Given the degree of flexibility available from the network, and that some of the features of a structure like Rec. H.221 are inherently provided by the network, careful consideration of the method of handling multimedia or multichannel connections is required.

6. Conclusion

This Contribution considers some of the major features of an ATM-based B-ISDN, and how these may impact upon the delivery of image and video services. Many opportunities present themselves in terms of bandwidth efficiency, service quality, flexibility and integration.

Careful consideration of the capabilities of the network, and its impact on the various video services, will allow identification of a target coding scheme taking maximum advantage of these capabilities. Appropriate study areas and a migration path that will utilise existing and emerging video service developments will follow.

Of overriding importance will be consistency with the direction of B-ISDN standards development if the advantages available from an integrated network are to be extended to the user by minimising the number of video terminals needed to access a range of interactive and distribution services.