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1. Introduction

There is currently a great deal of concern over how to transport MPEG (particularly MPEG-2) bitstreams over Asynchronous Transfer Mode (ATM) networks. The main issues revolve around the following questions:

1. What is the most appropriate MPEG datastream format to convey over ATM?
2. Is there a benefit in maintaining a common access point for the datastream with other transport technologies such as cable and satellite?
3. What is the most appropriate ATM Adaptation Layer (AAL) for the transportation of MPEG datastreams, with particular regard to maintaining MPEG timing requirements?

Several contributions to the ATM Forum[1,2] have questioned the relevance of AAL Type 2 for VBR transmission and others have suggested a new AAL (i.e. Type 6) especially designed for MPEG-2 transport at constant and variable bit rates (CBR & VBR).

2. Stated requirements

The above questions have great significance for the effective transmission of MPEG-2 coded programme material. It is very important that answers are found to these questions very soon otherwise ATM transmission may be discounted for some MPEG based services.

2.1. Common access points

The MPEG-2 Committee Draft (ISO/IEC CD 13818-1) states that the Elementary Streams (i.e. Audio, Video, etc.) are packetized into Packetized Elementary Streams (PES) and then have the option of being formatted into Program Streams (PS) for error free storage applications or Transport Streams (TS) for transmission systems that may incur transmission errors and jitter.

A number of service providers have already decided to utilise the TS format for transportation over cable and satellite systems, and this format is therefore rapidly being accepted as a common access point.

2.2. Support for MPEG timing

MPEG-2 has been accepted as a candidate audio-visual coding scheme that can accommodate a wide variety of applications and services, ranging from videotelephony to HDTV distribution. This coding flexibility was, in fact, a design aim for the MPEG standard. However this inherent flexibility raises issues of differing timing requirements for different service applications. For example, it is quite likely that videotelephony will not need such precise timing for synchronisation purposes as that required for

TV distribution and contribution applications. The reason is that there are basically two timing requirements, namely:

a) to decode a bitstream for display directly on a monitor, and
b) to decode a bitstream and construct a video signal conforming to the standards and tolerances normally employed by the TV broadcasting industry. This is particularly appropriate when further processing of the video signal will occur (e.g. mixing).

Currently videotelephony services based on ITU-T H.320 use constant bit rate transmission at 64 - 1920 kbit/s over narrowband ISDN (N-ISDN). It is a requirement of the ATM standards being developed by ITU-T SG13 to provide circuit emulation and support for N-ISDN interworking. AAL Type 1 provides the necessary adaptation for constant bit rate services and offers facilities for timing control, cell loss detection and mechanisms for payload protection using frame interleaving with forward error correction (FEC).

However, for other video applications the issue is not so clear cut as the required timing tolerances may be significantly tighter[3].

An informal discussion on the jitter requirements for composite video and audio is given in Annex 1, together with a simple mathematical illustration.

2.3. An AAL for MPEG

Is it an advantage to develop an AAL specifically for MPEG operating at CBR and VBR or should AAL Type 1 be used for CBR and another AAL (i.e. Type 2) for real-time variable bit rate services?

A contribution[2] to the ATM Forum has suggested a new AAL specifically to cater for the transport of MPEG bitstreams at CBR or VBR over ATM networks. This approach goes against the concept of specifying a set of general purpose AALs for various applications and services operating over ATM networks.

3. Candidate solutions and discussion

The following comments outline various candidate solutions to the issues raised in the preceding section.

3.1. Common access points

It has been suggested that is may be desirable to use MPEG's Packetized Elementary Streams (PES) as the interface point for ATM network adaptation. The reason for this approach is that it would give better transmission efficiency, relying on the AAL to provide the necessary transmission protection. However, the MPEG TS is becoming the common access point for a number of services and applications and the transmission efficiency benefit may be offset by the ease of bitstream transfer between transmission technologies brought about by a common access interface.

3.2. AAL Type 6

The proposed benefits of this AAL are that it can offer protection to the payload and support the timing synchronisation constraints imposed by the MPEG standard. The AAL Type 6 proposal complies with the MPEG standard for maintaining the integrity of the elementary streams' timestamps by assuming that the ATM nodes will update the packetized bitstreams' timestamps with the additional delay incurred by traversing the ATM node.

In principle this technique does overcome the jitter imposed by the ATM network and maintains the integrity of the timestamps at each access point. However, the concept is flawed by the fact that it is totally impractical based on current ITU-T SG13 recommendations and ATM Forum standards.

There are three fundamental problems with the proposal:

a) Current ATM networks have no means of determining the absolute delay incurred on a specific bitstream through each individual node and even if they could, there is no standardised measuring point.
b) The current ATM network recommendations state that the network operation and management task can only access the ATM Header of each cell. It is therefore impossible for the network management function to access the ATM payload, identify the bitstream timestamp and update it just as the bitstream leaves each node.
c) There is further jitter arising from the transport of ATM cells over physical networks such as SDH. As the jitter is incurred at a level below that of the AAL, the AAL cannot compensate for it.

4. Conclusions

From the comments previously stated the following conclusion can be drawn:

- The benefit of a Common Access Point for MPEG packet streams may be of great benefit when transferring from differing transmission technologies (e.g. satellite, cable, and ATM networks). Therefore unless there is a major advantage to using PES packets for adaptation over ATM it is proposed that TS packets should be adopted as the prime interface point.
- A specific AAL (i.e. Type 6) for MPEG bitstream transport over ATM networks is not the way to go. The more generalised view of developing an AAL for real-time VBR transmission (e.g. AAL Type 2) should be pursued.
- A more robust method of maintaining timing synchronisation has to be developed for the more critical applications such as TV distribution and contribution. The technique proposed for AAL Type 6 is impractical.

Annex 1

Although MPEG works on video signals in component form, some users wish to reconstruct composite video. Composite signals convey the colour information by the combination of analogue amplitude modulation and analogue phase modulation of a colour subcarrier. The subcarrier has a frequency of approximately 3.58 MHz in NTSC and 4.43 MHz in PAL. The corresponding periods are about 280 and 225 nanoseconds respectively. To achieve a SNR of better than 30 dB the jitter must be less than arcsine(10**(-30/20))/(2*pi)=5E-3 of a cycle. This is in the 1 nanosecond region.
Video is not the only signal which requires recovery of low jitter clocks. Another is high quality audio where clock jitter negates the use of high accuracy analogue to digital and digital to analogue converters. Consider 16 bit linear PCM as used in Compact Discs applied to a maximum amplitude sine wave. At the steepest places, a change of 1 quantisation level in 2**16 is caused by moving the sampling point by arcsine(1/32768). Relative to the period this is 5E-6. This means that on a 1 kHz sinewave a jitter of 5 nanoseconds makes the 16th bit spurious.

The above simple calculations have not considered the frequency spectrum of the jitter.

References

1. ATM Forum Doc. 94-0100; "AAL, Timing Recovery and Error Detection/Correction for MPEG over ATM", NYNEX

2. ATM Forum Doc. 94-0128; "MPEG in ATM Networks and a Proposal for a VBR Video Adaptation Layer: AAL 6", Scientific-Atlanta

3. BBC Research Dept. Report (BBC RD 1977/14), March 1977;"Permissible timing jitter in broadcast PAL colour-television signals", V.G. Devereux.

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