Proposal of an Extended AAL5 for VBR MPEG-2 over ATM

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Abstract

Transmission of VBR MPEG-2 applications over ATM networks requires efficient mechanisms to minimize video quality degradation in situation of loss. The key factor that controls the end-to-end performance is the ATM adaptation layer. AAL 5 is currently the most commonly used but is still inadequate for variable bit rate video. In this paper, we propose a new service specific convergence sublayer to improve AAL5 capabilities. An MPEG-2 video stream encapsulation strategy and a new cell priority assignation scheme are also presented.

Keywords : AAL5, SSCS, VBR, MPEG-2, CLP

Introduction

The transport of VBR MPEG-2 applications over ATM introduces several issues that must be addressed in order to ensure a high end-to-end quality of service. These include the choice of the adaptation layer, method of encapsulation of MPEG-2 packets in AAL packets, choice of scheduling algorithms in the network for control of delay and jitter, and the choice of traffic management policies for congestion avoidance.

AAL5 is currently the most commonly used adaptation layer in the industry. It is used for encapsulating UNI 4.0 signaling messages and, in most cases for transporting non-real time data traffic [1]. In 1995, the ATM Forum has recommended the carrying of constant bit rate MPEG-2 streams over AAL5 with a null convergence sub-layer [2]. However, VBR MPEG2 transmission requires higher adaptation features. Forward error correction, jitter removal, multiplexing and priority support are some of them. AAL2 is supposed to address these requirements but is not yet standardized. The alternative is to improve AAL5 by introducing a service specific convergence sublayer (SSCS) and an efficient encapsulation strategy.

The outline of this paper is as follows : in Section 2, we present an encapsulation method for VBR MPEG-2 streams over AAL5. Section 3 is devoted to the description of the proposed service specific convergence sublayer and the multi-level priority assignation scheme.

Proposal of an Encapsulation Method

There is no specific requirements for encapsulating encoded data in a Packet Elementary Stream (PES). This means that an access unit (i.e. a compressed frame) may start at any point within a PES packet. In addition, more than one access unit may be present in one PES packet. Nevertheless, the way this packetization is done can significantly affect the performance of the decoding process and the quality of the service provided by the network. For instance, if each PES packet contains exactly one MPEG data unit (i.e. frame, slice, macroblock or bloc) the decoder can easily determine the start and end of the units. Similarly network transport and control policies can take benefit of this structure to offer a guaranteed packet-oriented service. This requires use of variable size packet.

In this paper we propose that each PES is built from a single encoded video slice. Indeed, slice is the main coding processing unit in MPEG. Coding and decoding of blocks and macroblocks are feasible only when all the data of a slice are available [3]. Besides, coding of a slice is done independently from its adjacent slices, making it the smallest autonomous unit. Therefore during decoding process, slices serve as resynchronization units if lost or corrupted data occur during transmission.

We propose to segment the PES packet into a number of Transport Stream (TS) packets. In respect to the standard [4], every TS packet embeds data from only one PES packet. In our case, the last transport packet may not be completely full since it is unlikely that a variable PES packet will fit exactly into an integer number of transport packets. Thus, stuffing bytes are placed in the adaptation field to complete the payload.

In the worst case, i.e. padding 183 bytes, we evaluate the average overhead to 0.2 % with a single slice per frame, and to 3.5 % with 15 slices per frame. We assume a NTSC TV broadcast quality of 512x480. The introduced overhead is highly dependent on the distribution and the number of slice per frame. It can be avoided using Program Stream (PS) packets.

Proposal of an Extended AAL Type 5

At the AAL-SAP, the transport layer passes the TS packets to the SSCS using message mode service with blocking/deblocking internal function [1]. The following AAL-UNIDATA-REQUEST (ID, M, SLP, CI) primitive is used. The 'Interface Data' parameter specifies the exchange TS packet. The 'More' parameter indicates if it is the last AAL SDU of the upper message (i.e. end of the slice). The 'Submitted Loss Priority' parameter gives the priority level of the TS packet. We propose to extend its range from two to three values and to initialize it in respect to the 'picture_coding_type' field located in the MPEG frame header [3]. This field specifies for each frame, the used coding mode (i.e. Intra, Predictive or Bi-directional Predictive). Thus, 'SLP' defines three types of SSCS-PDUs : high-priority (I-frames), medium-priority (P-frames) and low priority (B-frame). This parameter also indicates how the 'SLP' parameter of the CPCS_UNIDATA_invoke primitive shall be set. Finally, the 'Congestion Indication' indicates how the 'CI' parameter of the CPCS_UNIDATA_invoke primitive shall be set.

At reception of AAL SDUs, the SSCS groups every three TS packets and adds a header and a trailer. The header is composed of a 4-bit Sequence Number (SN), and a 4-bit SN Protection (SNP). The trailer consists of a 3-byte Forward Error Correction (FEC).

The FEC scheme uses a Reed-Solomon (RS) code, which enables the correction of up to 2 loss bytes in each block of 564 bytes. The addition of a sequence number modulo-16 of 4 bits enables the AAL5 receiver to detect and locate up to 15 consecutive SSCS PDU losses. When losses are detected, dummy bytes are inserted in order to preserve the bit count integrity at the receiver. The SNP contains a 3-bit CRC generated using the generator polynomial $g(X)=X^3+X+1$, and the result is protected by an even parity check bit. The SNP field is then capable of correcting single bit errors and detecting multiple bit errors.

The overhead introduced by the SSCS is 0.7 % and the delay is three TS packets (about 12 cells) at the transmitter and the receiver.

The SSCS-PDU are then transmitted to the common part convergence sublayer (CPCS) using the CPCS_UNIDATA_Invoke primitive. In association with the SSCS_UNIDATA_Invoke primitive, the 'SLP', 'CI' and 'More' indicators are updated. The 8-byte CPCS trailer information is appended to the CPCS SDU and no byte padding is required. The resulting CS PDU is passed to the segmentation and reassembly (SAR) layer using SAR_UNIDATA_Invoke primitive.

The under-laying SAR protocol will subsequently segment the CS-PDU into exactly twelve (12) 48-byte ATM SDUs.

The ATM layer will then marked the Extended CLP field [5] of each cell using the 'AUU' and the 'SCLP' parameters of the AAL_DATA_Request. This field is located in the cell header and comprises the former CLP bit and the adjacent PTI-AUU bit.

This new definition of the two bits ensures a better utilization of the cell header. Using the ExCLP indicator, three priority services are now available in a single connection (see Table 1), whereas the former utilization restricts the number of priority levels to only two.

Cell Type	CLP	PTI-AUU	Priority Level
Intra-frame	0	0	High
Predictive	0	1	Medium
Bi-directional	1	0	Low
End of Message	1	1	n/a

Table 1 - ExCLP field Mapping

Conclusion

In this paper, we have proposed a new multi-priority slice-based service for VBR MPEG-2 transmission over ATM networks. A service specific convergence sublayer and a new priority scheme are proposed to support this service. The additional features supported by the extended AAL5 are the ability to distinguish video frame types and slice boundaries at the cell level, as well as the detection and the correction of byte errors at the adaptation layer.

References

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