HIERARCHICAL MPEG 2 VIDEO TRANSMISSION ON ADSL FOR A HIGHER QUALITY OF SERVICE (QoS)

M. Colin (*), M. Gharbi (*), M. Gazalet (*), C. Modlin (**)
(*)Département d'opto-acousto-électronique (IEMN-DOAE UMR-CNRS 9929), ENSIMEV
Université de Valenciennes, Le Mont Houy, B.P. 311 - 59304 Valenciennes, France
Tel :(33)3 27 14 14 44, Fax :(33)3 27 14 11 89, email: Marie.Colin@univ-valenciennes.fr
(**)Texas Instruments Broadband Access Group (Amati)
2043 Samaritan Drive - San-Jose, CA 95124, USA
Tel: (408)879 2000, Fax:(408)879 2900, email: cmodlin@ti.com

ABSTRACT

This paper considers the problem of improving the QoS of MPEG 2 video transmission over ADSL, which is an emerging technology that permits high bit rate transmission over subscriber lines. For this purpose, we propose to combine the use of the DP (Data Partitioning) MPEG 2 scalable mode and a modified coded DMT based ADSL modem that provides two different Bit Error Rates (BERs) for transmission: important video data such as headers and synchronization modules are better protected than less important data, resulting in a QoS improvement.

1 INTRODUCTION

As with internet access, video is taking a more and more important place among communication systems. The transport of video from the video provider to the customer is divided into two parts: the broadband network, generally fiber based and characterized by its long distances and very high data rates, and the access network which terminates the transmission over the last few kilometers to reach the customer. Our interest here is on the transport of MPEG 2 video over a particular access network which is ADSL (Asymmetric Digital Subscriber Line). ADSL is an evolving technology that lets ordinary phone lines transmit data around 150 times faster than today's typical analog voiceband modems. Its primary advantage is to use subscriber lines without any rewiring while achieving bit-rates that allow multimedia transmission (6-8 Mbits/s) [1].

This paper addresses the question of improving the global QoS of MPEG 2 video transmission over ADSL by use of the MPEG 2 scalability facility and unequal Bit Error Rate (BER) ADSL transmission. Section 2 briefly reviews MPEG 2 video and presents its scalable modes. Section 3 presents a coded ADSL system based on DMT (Discrete MultiTone) modulation that provides two different BERs for transmission. The dual BER ADSL system is then combined to the Data Partitioning (DP) MPEG 2 scalable mode in section 4 to improve the global QoS of the video transmission link.

2 DATA PARTITIONING MPEG 2 SCALABLE MODE

2.1 Basic MPEG 2

MPEG 2 is a well known video compression technique based on DCT and motion compensation standardized by ISO in 1995 [2]. Motion compensation is used to reduce the temporal redundancy between images whereas the spatial redundancy is reduced by DCT transformation which provides almost decorrelated coefficients. Then, quantification of the DCT coefficients associated with Variable Length Coding (VLC) compresses data at the cost of some information loss in the images.

2.2 MPEG 2 scalability and the DP mode

Scalability is intended to provide embedded hierarchical image quality and/or to improve error resilience in the receiver. This is realized by providing an ordered set of bit streams (typically 2 or 3) for the coding of only one video sequence:

- bit stream n°1 ("base layer"): contains the basic information. Can be decoded by itself to provide a low resolution video sequence.
- bit stream(s) n°2 (& 3) ("enhanced layer(s)"): contains enhanced information. Can't be decoded by themselves. The decoding of all layers (base + enhanced) will provide the full resolution video sequence.

There exist four scalable modes: temporal, spatial, SNR and DP, which differ from the contents of the base and enhanced layers. Temporal, spatial and SNR scalable modes provide hierarchical temporal, spatial and image resolution qualities. The DP mode is provided by splitting the basic MPEG 2 stream into two treams that are affected to the base and enhanced layers. Splitting is done so that critical information (headers, motion vectors, low frequency DCT coefficients) go to the base layer and less important information (higher DCT coefficients) go to the enhanced layer. The exact repartition of data among the layers is associated with the Priority Break Point (PBP) parameter in the standard.

As DP is clearly the simpler MPEG 2 scalable mode in an implementation point of view, and as the dual BER ADSL system shall not introduce much complexity, we only consider the DP mode in this paper.

3 ADSL TRANSMISSION WITH UNEQUAL ERROR PROTECTION

ADSL chose the DMT (Discrete MultiTone) as its line code [3]. A DMT signal can be considered as the sum of independent QAM signals which are transported over different carriers. The implementation of DMT through IFFT leads to equally spaced carriers and to a great flexibility in the choice of the bits and power allocation to the tones. ADSL modems also use error correction to improve their performances: the ADSL standard imposes the use of byte oriented Reed Solomon (RS) codes for FEC, and optionally proposes inner trellis coding to improve the coding gain (not studied here). A RS code is characterized by its (N, K) parameters where N is the codeword length in bytes and K is the number of information bytes per codeword. An (N, K) code can correct up to $(N - K)/2$ bytes in error per codeword [4].

This paper considers an ADSL transmission system that provides simultaneously two different BERs. The idea of unequal error protection for transmission over different media has been the subject of previous work [5–9].

The indices used in the following are: 0 for the mono error rate system, HP (High Priority) and LP (Low priority) for the dual error rate system. The dual error rate ADSL DMT system's principle is as follows: instead of encoding all the data with the same (N, K_0) RS parameters as in the mono error rate system (Fig. 1a), the HP and LP streams in the dual error rate system (Fig. 1b) are differently encoded by two different RS codes (N, K_{HP}) and (N, K_{LP}) respectively. N is chosen equal to 255. Now, because we work at the given data rate imposed by the application, the coded data rates of both systems R'_0 and $R'_{HP} + R'_{LP}$ are equal.

The procedure is the following:

- fix BER_0 and the target BER_{HP}.
- given the total bit rate $R_0 = R_{HP} + R_{LP}$, chose K_0 such as the RS code (N, K_0) has the best coding gain. The noise margin is γ_m [8] and the uncoded BER is BER'_0.
- Given the target BER_{HP} and BER_0, calculate K_{HP} such that the real BER_{HP} is as close as possible to the target BER_{HP}.
- Given K_{HP} and K_0, calculate K_{LP} such as $R'_0 \approx R'_{HP} + R'_{LP}$ (exact equality is generally impossible since K takes discrete values). Then, deduct BER_{LP}.

4 RESULTS

Here, we present simulation results of an MPEG 2 video transmission with the dual error rate DMT system of section 2 on two different ADSL channels. The architecture of the overall transmission system appears on figure 2:

- The basic MPEG 2 stream is split into the base and the enhanced streams according to a PBP which here is equal to 64. This means that within an image, the DC DCT coefficient plus the first VLC DCT code are in the base layer, and that all higher order DCT coefficients are in the enhanced layer.
- The HP and LP streams are transmitted via ADSL with BERs equal to BER_{LP} and BER_{HP} respectively. Figures 4 and 5 represents respectively one image of the full resolution (HP+LP) and low resolution (HP only) football video sequences for a compression ratio of 44.5 (leading to a total bit rate $R_0 = 6.2$ Mbits/sec from which 27% are HP data).

The two ADSL channels that we use for transmission are:

- Channel 1 is a 8000 feet 26 AWG channel corrupted by 9 Forward End XTalk (FEXT) and -130 dBm/Hz of AWGN.
- Channel 2 is the ANSI CSA 4 reference model [10], also corrupted by 9 FEXT and -130 dBm/Hz of AWGN.

Channels 1 and 2 SNRs are given on figure 3 with -40 dBm/Hz of signal power.

Table 1 gives simulation results for the football video sequence transmission over channels 1 and 2 according to the procedure described in section 3, with two different values of BER_0 and a BER_0 to BER_{HP} ratio of around 1000.

	TEB_0	K_0	TEB'_0	γ_m dB
Channel 1	10^{-7}	235	$1.1\ 10^{-3}$	6.2
	10^{-5}	239	$1.4\ 10^{-3}$	7.4
Channel 2	10^{-7}	241	$5.6\ 10^{-4}$	12.4
	10^{-5}	243	$9\ 10^{-4}$	13.7
	TEB_{HP}	K_{HP}	TEB_{LP}	K_{LP}
Channel 1	$8\ 10^{-11}$	227	$4.7\ 10^{-7}$	237
	$8\ 10^{-9}$	229	$8\ 10^{-5}$	243
Channel 2	$1.8\ ^{-10}$	235	$6.3\ 10^{-7}$	243
	$3\ 10^{-9}$	233	$1\ 10^{-4}$	247

Table 1 : Simulation results of the Football video sequence transmission over channels 1 and 2.

We see that BER_{HP} is highly decreased whereas BER_{LP} is only slightly increased, which leads us to think that the dual error rate system is gainful.

One important issue when considering transmission from a service point of view is to find a correlation between the transmission network performances and the service quality as perceived by the user (in other words, the user's satisfaction) [11–13]. In this paper, the service is video and the network performance parameter is the BER.

For example it would be interesting to relate the QoS to the "error-free" duration, defined by the transmission duration with no complete image or part of an image lost. This "error-free" duration can be computed from the knowledge of the MPEG 2 bit stream structure (size of headers and synchronization modules) and the MPEG 2 sequence order (intra images and predicted images). Regarding the results of table 1, we can say that the degradation in BER for LP data is very low compared to the factor 1000 by which the "error-free" duration is approximately increased.

5 CONCLUSION

In this paper, we proposed and analyzed a dual BER ADSL DMT system designed for MPEG 2 transmission in the Data Partitioning scalable mode. We showed that thanks to the minority of HP information, it was possible to obtain a very low BER for HP data while increasing only slightly the BER of LP data. Future work is now necessary to clearly relate these results to subjective quality as perceived by the user.

6 REFERENCES

References

[1] W.Y. Chen, D.L. Waring, "Applicability of ADSL to support video dial tone in the copper loop", IEEE Communications Magazine, May 1994.

[2] ISO-IEC 13818-2 MPEG-2 standard - video, 1995.

[3] ANSI T1.E1.4 97-007R4 ADSL standard, 1997.

[4] S. Lin, J. Costello, "Error Control Coding: fundamentals and applications", Prentice-hall, 1983.

[5] M. Barton, "Unequal Error Protection for Wireless ATM Applications", Globecom'96, Westminster, London, 1996.

[6] K.P. Ho,"Optimal Utilization in Subcarrier and Multicarrier Systems", PhD. dissertation, University of California, Berkeley, 1995.

[7] Morelos-Zaragova, "Multilevel Block Coded Modulation with Unequal Error Protection", ISIT'97, Ulm, Germany, June 29-July 4, 1997.

[8] M. Colin, C. Modlin, M. Gharbi, M. Gazalet, "QoS considerations for DMT-based ADSL and VDSL systems", ICASSP 98, 11-15 May 1998.

[9] V. Parthasarathy, J. Modestino, K.S. Vastola, "Design of a Transport Coding Scheme for High-Quality Video over ATM Networks", IEEE Transactions on Circuits and Systems for Video Technoligy, vol.7, N°2, April 1997.

[10] J.M. Cioffi, "Asymmetric Digital Subscriber Lines", Draft chapter from the CRC Handbook, 1996.

[11] N. Jayant, "High Quality Networking of Audio-Visual Information", IEEE Communications Magazine, September 1993.

[12] N.B. Seitz, S. Wolf, S. Voran, R. Bloomfield, "User-Oriented Measures of Telecommunication Quality", IEEE Communications Magazine, January 1994.

[13] F.U.Bordoni, "On the Correlation between Transmission Quality-of-Service (QoS) and image quality of the digitally transmitted video in radio terrestrial broadcasting", ICIP'96.

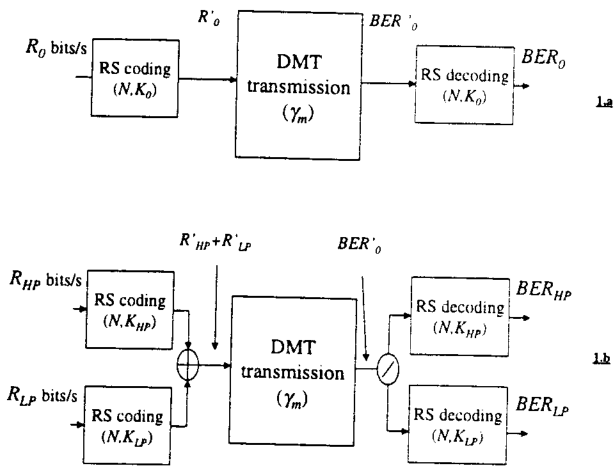

Figure 1: Structure of the mono (1.a) and dual (1.b) error rate ADSL DMT systems.

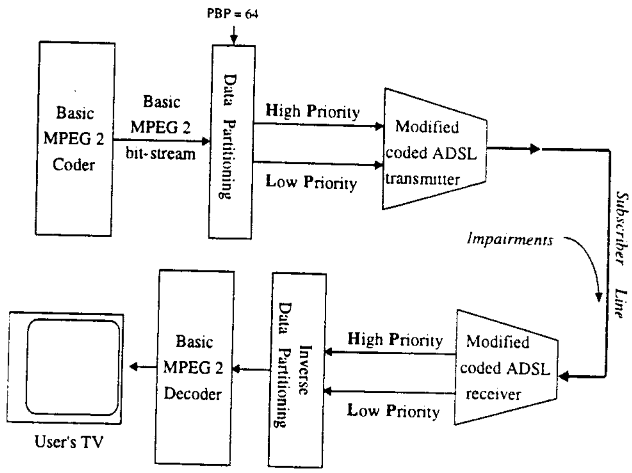

Figure 2: Dual error rate ADSL MPEG 2 video transmission system architecture.

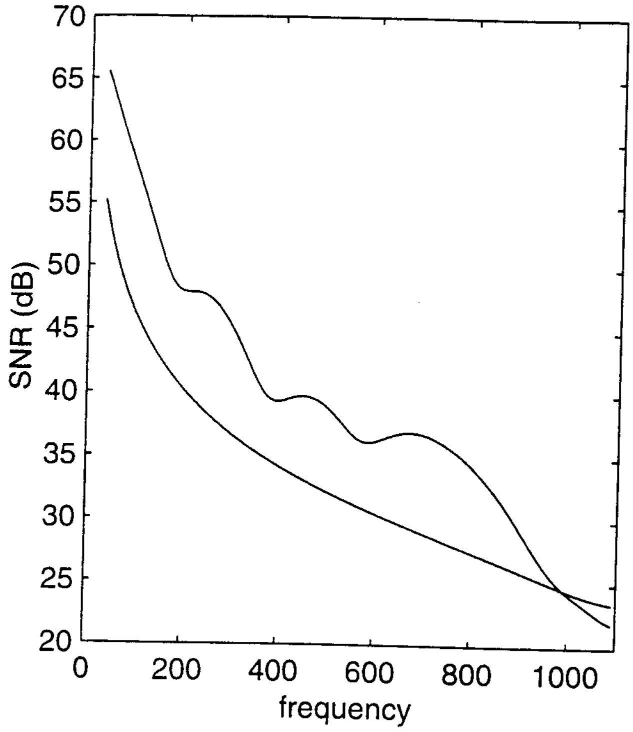

Figure 3: : Channel 1 and channel 2 SNRs with 9 fext, -130 dBm/Hz of AWGN and -40 dBm/Hz of input power.

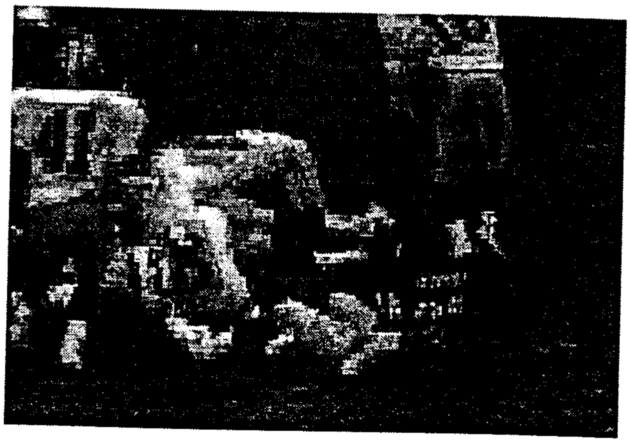

Figure 5: Low resolution image reconstructed thanks to the HP stream only.

Figure 4: Full resolution image reconstructed thanks to the HP and LP streams.