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SOURCE : RTT Belgium
TITLE : CLR AND BER PROTECTION FOR ENHANCED END-TO-END USERS QOS
PURPOSE : Information

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1. Introduction

The object of this paper is firstly to give some enlightenments on the way to provide a type 2 ATM Adaptation Layer with the right protection against cell losses and bit errors in order to achieve a resulting good end-to-end user Quality Of Service (QOS). This paper describes also the simple method which is implemented in the Belgian Broadband Experiment video codec for type 2 AAL (VBR video). Example of type 2 AAL is presented at figure 1.

The assumed quality of service offered by the network is : BER : 10^{-6}, CLR : 10^{-6}.

To ensure the transparency of the transmissions, and, therefore, a sufficient end-to-end user QOS, there is a need for protection against BER and CLR in order to reach at least **two hours errors free** transmission for bit rates range of **2 up to 140 Mbit/s**.

First of all, protection against bit error and cell loss are described independently of each other; thereafter, the cross resulting protection is explained giving the critical case limiting the transmission performances.

2. Protection against bit error

2.1. Requirements

- Network QOS : BER 10^{-8}, provision for 10^{-6}, is to be envisaged
- No statistical BER distribution is available
- Payload scrambling polynominal $X^{-43} + 1$ produces double correlated errors
- End-to-end user QOS : 2 hours errors free.

2.2. Solution

We propose to use a simple forward bit error correcting code based on a CRC (10 bits) whose generator polynominale is

$$G(x) = 1 + x + x^4 + x^5 + x^9 + x^{10} \quad (1)$$

Correction is therefore not performed on the cells containing more than two bit errors, this event occuring with the probability

$$P_{i\geq 2} = 1 - P_{i=0} - P_{i=1} = 1 - C_n^0(1 - P_B)^n - C_n^1 P_B(1 - P_B)^{n-1}$$
$$\simeq P_{i=2}$$

where C is the combination symbol, i is the number of erroneous bits within a cell of $n = 384$ bits and P_B the bit error probability.

Table 1 gives the value of $P_{i\geq 2}$ for different level of bit error. Events with three or more bit errors occur with a probability proportional respectively to P_B^3, P_B^4, ... and are negligeable.

P_B	$P_{i\geq 2}$
10^{-6}	$7.4\ 10^{-8}$
10^{-9}	$7.4\ 10^{-15}$

-Table 1-

3. Protection against cell loss

3.1. Requirements

- Network QOS : CLR 10^{-8}, provision for 10^{-6}, is to be envisaged
- No statistical CLR distribution is available
- End-to-end user QOS : 2 hours errors free

3.2. Solution

→ A. Sequence Number - SN (4 bits)

The SN field is consecutively numbered modulo 16. This sequence number enables to detect cell missequence (lost or misinserted cells). Therefore, a 4 bits SN enables up to 15 cells loss burst detection.

→ B. Parity cell

The protection mechanism is based on a odd parity cell built from 31 consecutive service cells and shuffled into the cells flow to form a 32 cells block. The overhead is 1/32 = 3.1 %.

The parity cell format is shown on Figure 2. At the receiving end, after bit error correction process (Figure 3,4) :

- the SN sequence integrity is checked; therefore if either a lost cell is detected or a multiple bit errors occurs within one cell in the 32 cells block, the faulty cell is replaced by a dummy cell
- the parity cells are identified by the Redundancy Cell indicator (IT)
- the faulty cell (replaced by a dummy cell) is therefore reconstructed from the 30 other cells and the parity cell of the block.

→ A and B allow to correct one cell lost or one burst of bit errors lower than 384 consecutive bits.

The probability of two cell losses within a block of 32 cells is given by

$$P_{i=2} = C_M^2 P_{CL}^2 (1 - P_{CL})^{m-2} \quad (2)$$

where m is the size of the block i.e. $m = 32$ and P_{CL} is the cell loss probability. As in section 2.2, $P_{i\geq 2}$ is given by the same formula exchanging $n = 384$ with $m = 32$. Protection against inserted cells is simply realized by the cell numbering. No special bit protection is required for this number, the previous FEC is sufficient. Table 2 gives a few numerical values.

P_{CL}	$P_{i=2}$
10^{-6}	$4.9\ 10^{-10}$
10^{-9}	$4.9\ 10^{-16}$

-Table 2-

4. Cross protection for end-to-end user QOS

Combining the two previous protections leads to the two hours errors free end-to-end user QOS for BER and CLR $\leq 10^{-6}$.

After having enumerated all the errors and loss configurations, three critical cases inducing eventual non corrected errors are subject to investigation : they are those of them which follows :

1. among the block of 32 cells, two of them have simultaneously a double bit error, this event occurs with a probability

$$P_1 = C_m^2 P_{DBE}^2 (1 - P_{DBE})^{m-2} \quad (3)$$

with $m = 32$, P_{DBE} the probability of a double bit error within one cell which is given by

$$P_{DBE} = C_n^2 P_B^2 (1 - P_{CL})^{m-2} \quad (4)$$

with $n = 384$

2. among the block of 32 cells, two different cells are lost, the event has the probability

$$P_2 = C_m^2 P_{CL}^2 (1 - P_{CL})^{m-2} \quad (5)$$

3. among the block of 32 cells, one cell is lost and another one presents a double bit error, the event has the probability

$$P_3 = P_{DBE} P_{1CL/32} \cong P_{DBE} C_m^1 P_{CL} \quad (6)$$

It appears immediately that the third case occurs with a probability negligeable with respect to the first two cases. Table 3 furnishes the main outlines of the resulting protection at 140 Mbit/s the worst transmission configuration.

Nb of hours error free	Nb of cells at 140 Mbits	P_B	P_{CL}
2 hours	2.63 10^9	3.5 10^{-6}	8.8 10^{-7}
24 hours	31.5 10^9	1.8 10^{-6}	2.5 10^{-7}
96 hours	126.0 10^9	1.3 10^{-6}	1.3 10^{-7}

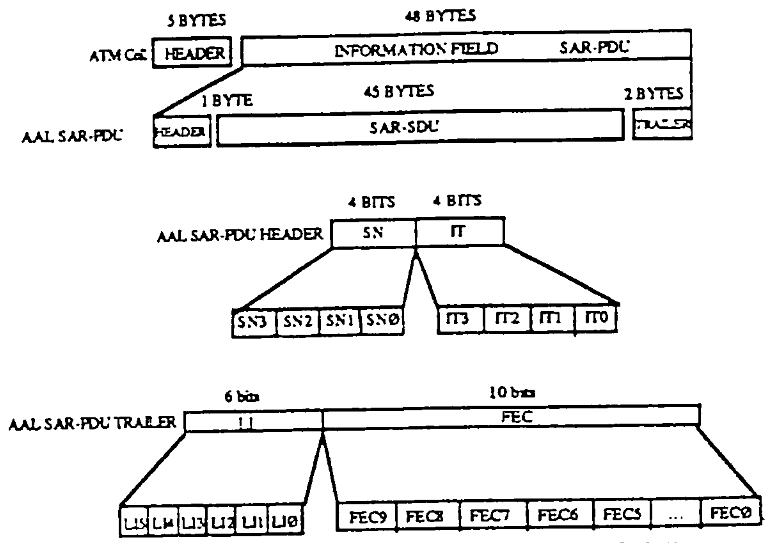
-Table 3-

5. Conclusion

This document presents a simple transmission protection for a type 2 AAL which leads to a resulting end-to-end user QOS of two hours errors free video transmission.

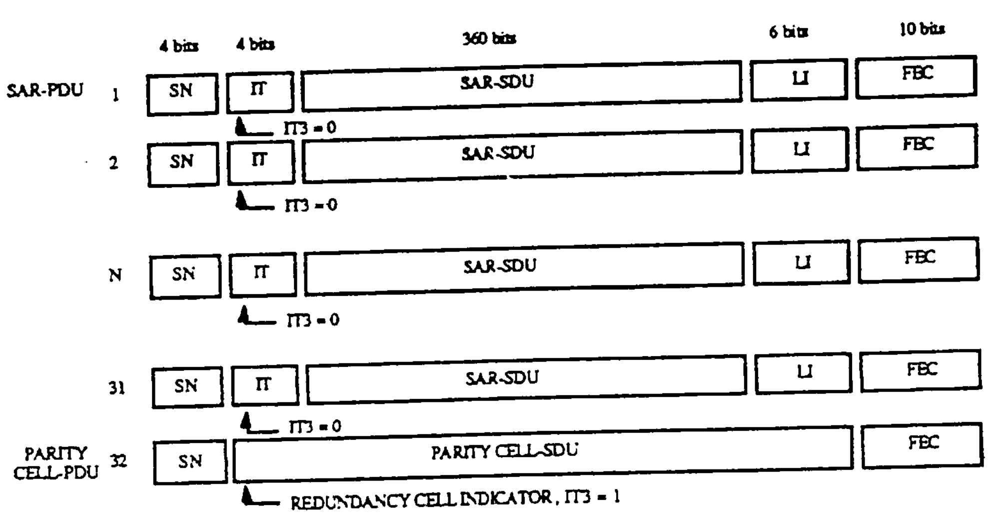
References

- RTT Belgium, D523 CCITT COM XVIII, Geneva, January 1990
- S. D'AGOSTINO, G. LIZIN, "Cell packetizer for B-ISDN ATM videocodec", PACKET VIDEO 91, KYOTO, 29-30 August 1991
- P. DELOGNE, J.P. LEDUC, "CLR and BER protection for end-to-end user QOS", RACE 1018, Hanover, August 1990



$$CRC : G(x) = 1 + x^4 + x^5 + x^9 + x^{10}$$

Figure 1: Example of type 2 AAL



$$\text{PARITY CELL SDU} = \sum_{1}^{31} \oplus \overline{\text{IT/SAR-SDU/LI}}$$

Figure 2: Cell protection

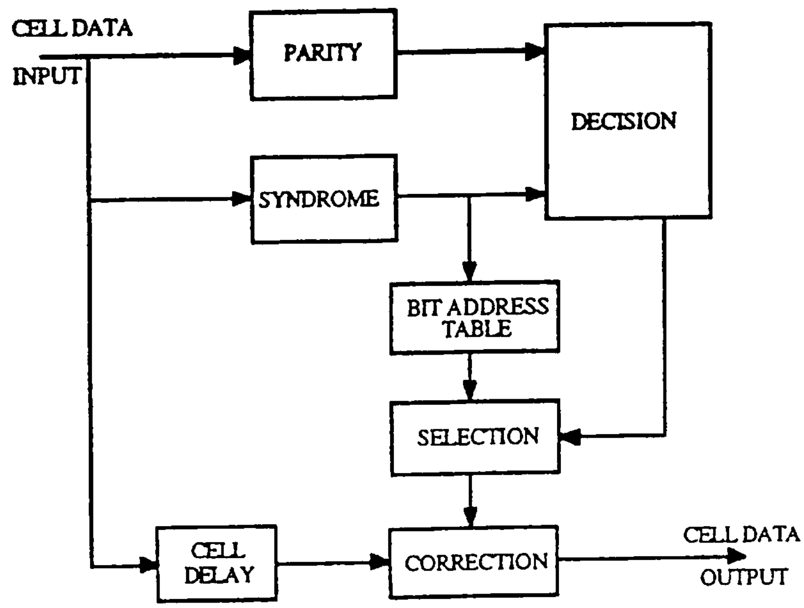


Figure 3: Bit error correction

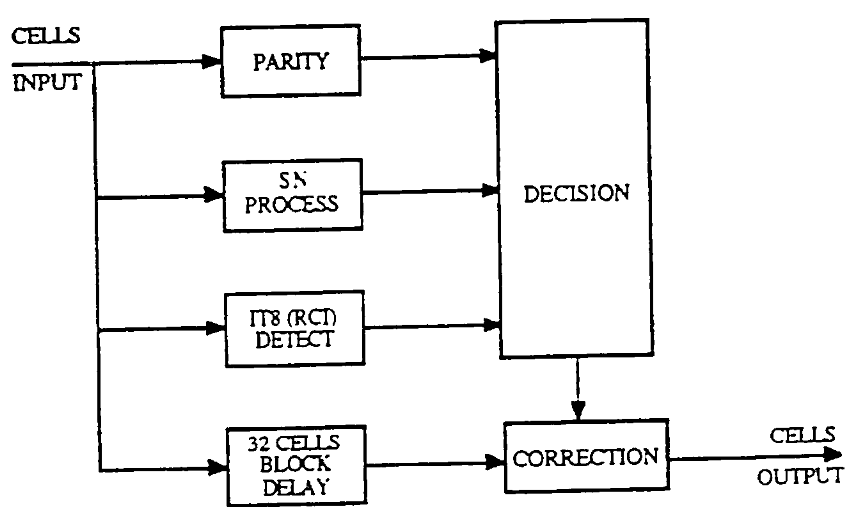


Figure 4: Cell error correction