Qos Enhancement Algorithm of CBR HDTV Transport Packet Stream on AAL5

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Abtract

We propose the dejittering method against the jitter originated from the cell losses in ATM network when CBR traffic is transferred on AAL5. Cell numbering along with maintaining a timer at receiver side introduces 0.669 times peak-to-peak PDV of the AAL5 PDU to that in ITU-T AAL5 standard, and the AAL5 user - HDTV decoder - receives the same or more error-free transport packets in the proposed algorithm than those in the ITU-T AAL5 standard for the same network simulation environment

I. Introduction

ATM is the vital network protocol in the implementation of B-ISDN (Broadband Integration Digital Network). To communicate the user data via ATM network, the user data is processed to form AAL PDU(ATM Adaptation Layer Protocol Data Unit)s. The AAL5 is proposed as a network adaptation layer for the single program transport packet stream (SPTS) by the ATM forum [1]. The HDTV (High Definition TeleVision) generates 19.39 Mbps CBR multi-program transport packet streams (MPTS) [2] and is expected to make use of the same network adaptation layer as SPTS uses. However, according to the AAL5 specified in ITU-T, the receiver AAL discards the entire AAL PDU even when a single bit error or loss occurs among the cells comprising the AAL PDU [3]. This standard algorithm has a problem making an excessive transport packet losses transparent to the application layer in the receiver side. We modified the AAL5 PDU (Protocol Data Unit) trailer fields so that each cell composing the AAL5 PDU has a sequence number field. We also propose that the receiver AAL maintain a timer whose expiration time is proportional to the cell time of the source traffic plus the standard deviation of the 1-point CDV (Cell Delay Variation) of the received ATM cells to reduce the jitter originated from cell losses in ATM network when CBR traffic is transferred on AAL5.

II. Sequence number method

In AAL5, the error (or loss) detection mechanism operates at PDU level, the whole PDU, containing two HDTV TS packets, in reassembly buffer is discarded when CRC checksum errors or length errors are detected. This leads to an excessive data loss seen by the application (HDTV decoder side). This mechanism is clearly not suitable for HDTV application because a single cell loss causes the loss of two TS packets.

To cope with this unwanted loss, a different scheme for the AAL5 is considered. The basic idea is to attach sequence numbers to every cell composing CPCS-PDUs. Each cell comprising a CPCS-PDU contains a sequence number field of 4 bits wide. Hence, the sequence number fields in eight cells which comprise one CPCS-PDU occupy 4 bytes of the trailer. The remaining 4 bytes of the trailer are used for CRC checksum for the entire CPCS-PDU including sequence numbers and the payload. The modified structure of CPCS-PDU which have sequence number fields is shown in figure 1.

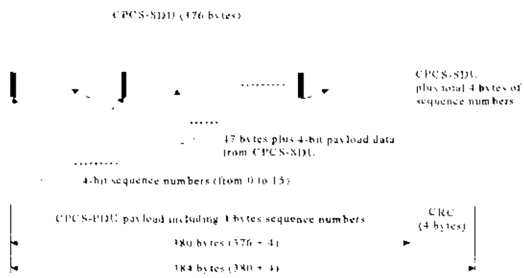

Figure 1 : Structure of CPCS-PDU using sequence number

This scheme reduces the data loss at the receiver's AAL, because it enhances the resolution of the data loss detection to the cell level. The sequence numbers are used by the receiver to monitor cell arrivals, and to find out exactly how many cells have been lost along with their position within a PDU. The main advantage of this mechanism is that the corrupted PDUs are not discarded and data loss is kept at minimum as the network cell loss ratio..

By using the sequence number mechanism, the location of cell loss in the PDU is known to the receiver AAL. Furthermore, it is also known that which TS packet in the constructed PDU is corrupted one. The receiver AAL sends this data-corruption information to the Higher Layer by setting the transport_packet_error_indicator field in the TS packet header. Since the location of 1-bit transport_packet_error_indicator field is fixed in a HDTV TS packet as shown in figure 2, the position of this field in the received CPCS-PDU is always mapped to a fixed bit position of cells whose sequence numbers are 0, 3, 8 and 11.

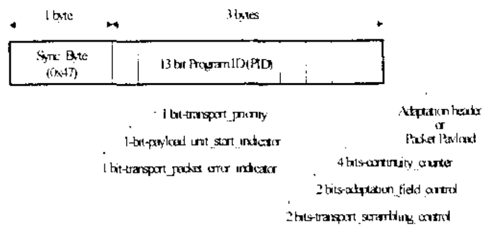

Figure 2 : Link header format for the GA system transport packet

III. De-jittering by a timer

Each cell with delay originated from pure delay or accumulated cell losses, is assembled to form a complete CPCS-PDU with PDU Delay Variation (PDV). This PDV is seen as a jitter to the HDTV decoder system, and it may deteriorate the quality of the HDTV data when it is presented. The jitter generated by accumulated cell losses is reduced by using a timer.

The timer makes an upper bound in waiting cell arrivals, so that PDV is reduced to the difference between the upper bound and the PDU reference arrival time in 1-point PDV.

When receiver AAL starts to receive cells from ATM Layer, the CDV is calculated from the actual cell arrival time by the receiver AAL. Then, the timer is initialized with the value as below when the standard deviation of 1-point CDV at the receiver AAL is stabilized.

timer_limit (upper bound) = 8.0 × (7.0 + standard deviation of CDV of the cells received)

Where, 7.0 is the cell slots and the 155.52Mbps SDH or SONET is used.

We define a cell slot as the total network clock cycles needed to transmit an ATM cell consisted of 53 bytes, and the cell slot is calculated as below.

$$
\begin{aligned}
cell\_slot &= \frac{155.52M}{53 \times 8} \times \frac{1}{19.39M} \times 188 \times 2 \\
&= 7.1126 \text{ cell\_slots} \\
&\cong 7 \text{ cell\_slots}
\end{aligned}
$$

Timer-limit for each cell is given a margin of standard deviation of CDV, and is multiplied by 8, since one CPCS-PDU is composed of 8 cells.

IV. Performance Evaluation

<simulation environment>

In order to evaluate the performance of the proposed algorithm using sequence number along with a timer, a

ATM network model is considered.

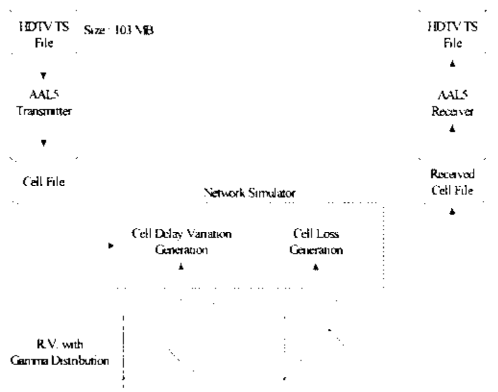

Figure 3 : A simple ATM network simulation model

The prior study [4] shows that the traffic via ATM network experiences a CDV with a Gamma distribution when all background traffic have the CBR characteristics. Assuming the same network environment, the CDV is generated to have a Gamma distribution with desired mean and variance by the network simulator. At the same time, the cell loss is generated to simulate the lossy ATM network. Since the loss at the network tends to occur in burst, these cell losses are generated with the probablity density function as shown in figure 4.

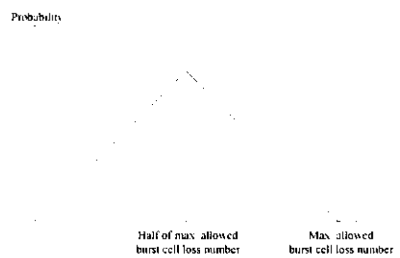

Figure 4 : Probability density function for burst cell loss generation

1. Evaluation by the number of error-free TS packets received

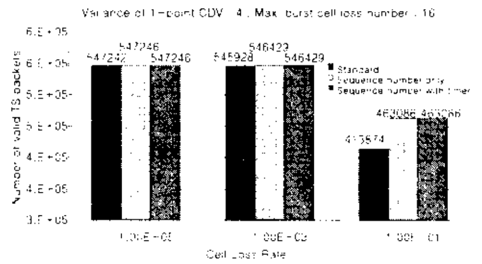

Figure 5 : Variance of 1-point CDV : 4, Max. burst cell loss number : 16

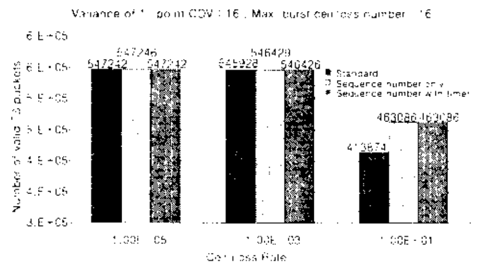

Figure 6 : Variance of 1-point CDV : 16, Max. burst cell loss number : 16

Figure 5 and 6 show the number of error-free TS packets delivered to High Layer when maximum allowed burst cell loss number is fixed to 16. When cell loss rate is 1.0e-5 or 1.0e-3, the differences between three algorithms are not distinctive, in both cases the variance of 1-point CDV is varied from 4 to 16. However, when cell loss rate is increased to 1.0e-1, the differences between three algorithms in the number of error-free TS packets become more distinctive. This is because the standard mechanism discards two TS packets when one or more cells comprising the TS packets are lost. Sequence number mechanism used with the timer, gives slightly less number of total error-free TS packets than that of sequence number mechanism, since timer expiration makes an extra loss along with the network loss when a cell arrives late.

2. Evaluation by the PDV at the receiver side

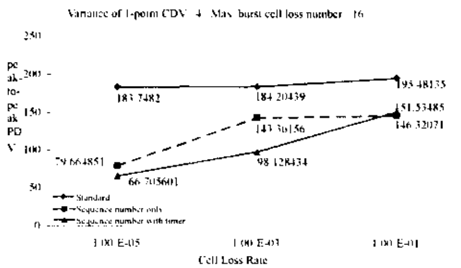

Figure 7 : Variance of 1-point CDV : 4, Max. burst cell loss number : 16

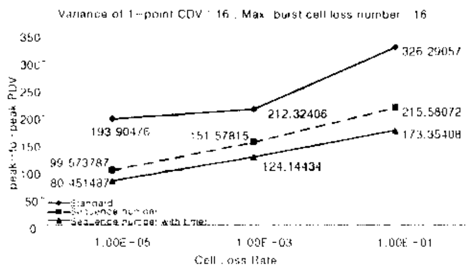

Figure 8 : Variance of 1-point CDV : 16, Max. burst cell loss number : 16

Since the mechanism using sequence number guarantees the CPCS-PDU integrity, the variations of inter-departure time between consecutive CPCS-PDUs in the receiver are reduced in comparison with those of standard algorithm. However, the mechanism using both sequence number and the timer further reduces this peak-to-peak PDV by limiting the waiting time for cells. However, in the case where variance of 1-point CDV is four with cell loss rate of 10e-1, this is not true as shown in figure 7. In this case, the variance of 1-point CDV is small compared to the cell slot of 7.0 and the difference of peak-to-peak PDV between the sequence number mechanism and the proposed mechanism becomes negligible.

V. Conclusion

In this paper, we proposed a new mechanism for the communication of HDTV TS packets via ATM network using AAL5. In order to justify the use of a timer along with the sequence number mechanism, simulation is done for various scenarios, and two performance parameters - total number of error-free TS packets and peak-to-peak PDV - are measured to compare the performances of three different algorithms. For the practical cases, where cell loss rate is equal to or less than 1.0e-3, the maximum reduction of the peak-to-peak PDV using the proposed algorithm was 53.27% from that of the standard algorithm. In a viewpoint of the number of error-free TS packets, the maximum difference between the values obtained by using only the sequence number mechanism and the proposed algorithm is 11, which is negligible considering that the total number of TS packets transmitted is 547,252. In addition, the number of error-free TS packets when the proposed algorithm is used, is always the same or greater than the value obtained by using the standard algorithm.

References

[1] The ATM Forum, "Audiovisual Multimedia Services : Video on Demand Specification 1.1," March,1997.

[2] "Grand Alliance HDTV System Specification," Version 2.0, December, 1994.

[3] ITU-T Recommendation I.363, "B-ISDN ATM Adaptation Layer(AAL) Specification,", March, 1993.

[4] H. Naser, A. Lean-Garcia, "A Simulation Study of Delay and Delay Variation in ATM Networks, Part I : CBR Traffic," proceedings of IEEE Infocom'96, vol.1, San Francisco, USA, March, 1996.