A Cell Discarding Strategy to Reduce Cell Error Rate in Wireless ATM Networks

Shiann-Tsong Sheu and Chang-Huang Wang

Department of Electrical Engineering, Tam Kang University
Tamsui, Taipei Hsien, Taiwan 251, Republic of China
E-mail : stsheu@ee.tku.edu.tw

Correspondence Address:

Professor Shiann-Tsong Sheu
Department of Electrical Engineering, Tam Kang University
Tamsui, Taipei Hsien, Taiwan 251, Republic of China
E-mail:stsheu@ee.tku.edu.tw
Fax:+886-2-6221565

0-7803-4196-1/97/$10.00 © 1997 IEEE

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

ABSTRACT

In this paper, we introduce a cell discarding strategy to reduce the number of error cells transmitted on wireless ATM networks. The proposed strategy is based on an 'interleaving' method which spreads each bit of a header field over the data field to reduce the cell loss probability. In such method, most burst errors are transformed into single-bit errors in header and the HEC is able to recover it. Intuitively, each corrected cell has a higher probability to contain incorrect payload due to burst errors. When network becomes congested, these dirty cells will be dropped first to reduce the number of error cells received by receiver. The number of retransmitted cells is also reduced. In this paper, the cell payload error probability of a corrected cell is analyzed and the performance of proposed strategy is investigated by simulation. The simulation results show that the proposed strategy substantially improves the cell error rate received by destinations.

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

1 Introduction

Wireless Asynchronous Transfer Mode (ATM) systems have been proposed for future broadband multimedia personal communication [1],[2]. The ATM cells are transmitted between a central station and user radio modules in radio frame, as shown in Fig. 1. The scheme of ATM cell header is shown in Fig. 2.

In a wireless ATM network, the bit error rate is high and burst errors may occur in transmission due to jamming and fading. When single-bit error occurs in header, it can be easily corrected by the CRC-8 code in HEC (Header Error Control) field. However, HEC can not recover the burst errors in cells, and they will be lost or mis-routed accordingly. For solving this problem, an interleaving method [3] was proposed to reduce the cell loss and cell insertion probabilities. The cell interleaving method distributes all header bits within a cell. Such method has the ability to deal with the burst errors. Therefore, the cell loss rate is further reduced.

Since the HEC only checks and corrects the header information, a corrected cell has a higher probability to contain incorrect payload. In this paper, the corrected cells are denoted as *dirty* cells. As the network becomes congestion, the dirty cells are the candidates to be blocked. This can be done by managing the Cell Loss Priority (CLP) bit in the ATM cell header [4]. Recall that the CLP bit in the ATM cell header indicates whether a cell is high priority (CLP=0) or low priority (CLP=1). The network can use selective cell discarding mechanism to ensure that connections that requests a guaranteed QoS (Quality of Service) for certain traffic parameters for the CLP=0 cell flow to achieve the performance. It is clear that the nonconforming cells (CLP=1) will be dropped when network is congested. Moreover, the network should drop the dirty cells before dropping the clean cells with the same priority. Therefore, if the CLP bits of a dirty cell with high priority and a clean cell with low priority can be changed, more dirty cells will be dropped in network congestion and the cell loss probability of the QoS parameter is still satisfied. In this paper, we employ the interleaving method [3] to find out which cell may contain incorrect payload (i.e., dirty cell). According to this information, the priority of each cell may be changed during the transmission. Based on this concept, a cell discarding strategy is proposed to select a proper cell to drop. Typically, if the receiver receives a error frame, it may ask the transmitter to retransmit this frame again. Therefore, the proposed strategy is very suitable for data transfer. However, it may not work well when transferring the data which is generated by hierarchical video coding method. This method encodes the critical information as the higher priority cells. In other words, this information is required to construct the major parts of the video image sequence which should not be dropped even it is dirty.

The rest of this paper is organized as follows. The employed interleaving method is addressed in section 2. In section 3, the cell payload error probability of a corrected cell is analyzed. The priority mechanism and the cell discarding strategy are described in section 4. The simulation model and results are reported in section 5. The conclusion is given in section 6.

2 Method of Interleaving

Since the burst errors in header can not be corrected by the HEC, a simple interleaving header and data bits

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

is proposed for wireless ATM networks. The 40 header bits are distributed into a cell. That is, the number of data bits inserted into two adjacent header bits is 10 (53/5=10). The cell format of an interleaved cell is shown in Fig. 3. Based on this technique, any burst error in header are spread out as isolated random errors in the header field of the cell. In other words, most burst errors are transformed into single-bit errors. Since these single-bit errors in the header are easily corrected by HEC, this interleaving can effectively reduce the cell loss and cell insertion probabilities. We note that this method is effective for burst errors shorter than 11 bits.

3 Analysis of Cell Error Probability

Though a cell may be survived by the interleaving method, the unprotected payload in it may be incorrect due to burst errors. In this section, we give analyses of the cell payload error probability (*CEP*) with interleaving method. When the cell is transmitted from user radio station to a central station, the burst error is occurred in the cell. If only one header bit is error in the cell ,we can suppose that the cell may has error payload after de-interleaving.(i.e., Fig. 4). Let *BER* and P_i denote as the single error bit probability and the *i*-bit burst error occurrence probability. To keep the eventual bit error rate the same, the *2*-bit burst error occurrence rate is assume to be one half of single error probability ($P_2 = BER/2$). Similarly, the *n*-bit burst error occurrence rate is BER/n ($P_n = BER/n$). For simplicity to express the cell error probability in a simple equation, different burst error lengths are classified into four cases. Consider the case of burst error length varies from 2 to 10, the error probability in a recoverable cell is $Q_1 = C_1^{40} \times (\sum_{i=2}^{10} p_i^i \times i) \times q^{39}$. ,where q is probability of the correct bit of the cell (q =1-BER). The error probability in a corrected cell when burst error length varies from 11 to 19 is $Q_2 = (C_1^{39} \times (\sum_{i=11}^{19} p_i^i \times (20\text{-}i)) + C_1^1 \times (\sum_{i=11}^{19} p_i^i \times 10)) \times q^{39}$. Consider the case with burst error length varies from 20 to 25, the error probability in a recoverable cell is $Q_3 = C_1^1 \times (\sum_{i=20}^{25} p_i^i \times 10) \times q^{39}$. In the last case, the burst error length is considered from 26 to 34, the cell error probability is calculated as $Q_4 = C_1^1 \times (\sum_{i=26}^{34} p_i^i \times (35-i)) \times q^{39}$. Thus, the total cell error probability can be easily obtained by the following equation : $CEP = Q_1 + Q_2 + Q_3 + Q_4$. The cell error probability in different bit error rate (BER) is shown in Fig. 5.

4 Cell Discarding Strategy (CDS)

For simplicity to describe the cell discarding strategy, four types of cells are classified: (1) dirty cell with low priority (DL) (2) dirty cell with high priority (DH) (3) clean cell with low priority (CL) (4) clean cell with high priority (CH). Obviously, CH and DL cells have the highest priority and the lowest priority, respectively. To provide the QoS of a connection, the specified cell loss probability should be maintained during transmission.

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

That is, if the cell discarding strategy considers not only the cell priority but also the cell status (clean or dirty) for dropping, more clean cells will be received by the receiver. Besides, a better quality of service is provided. According to the operations of CLP bit in header field, the CL cells will be dropped before the DH cells when buffer congested. Therefore, a CL cell is allowed to change its priority with a DH cell which is going to leave the buffer (i.e., .Fig. 6). As a result, the corresponding CL cell and DH cell will become a CH cell and a DL cell, respectively. The following cell discarding operation will scarify these dirty cells. This introduces the cell discarding strategy (CDS) for reducing the number of error cells received by destinations.

5 Simulation Model and Simulation Results

The performance of proposed cell discarding strategy was investigated by simulation. The simulation model is shown in Figure 7. In Fig. 7, sources A and B want to transmit data to station C. The traffic arrival rates in source A (B) is a Poisson distribution with a mean λ_A (λ_B). To investigate the effect of proposed strategy, only source A is mobile station and the transmitted cells from it have a chance to be dirty cells or low priority cells. Contrarily, sources B only generates the clean cells with high priority to cause the network congested. Besides, there are N ATM switches are considered between stations A and C. To investigate the effect of proposed strategy, the ratio of the number of dropped dirty cells (*RDD*) and the total number of dropped cells is measured. Fig. 8 shows the number of changing CLP between DH and CL cells in different *CEP* when N=3, N=4, N=5, N=6. We can see that a dirty cell with CLP=0 in N=6 will have a better chance to change its CLP with a clear cell with CLP=1. That is, the no. of dropped dirty cells in the case of N=6 will be higher than that of N=3,4,5.Fig. 9 shows the obtained *RDD*s by the proposed CDS and the original cell discarding mechanism when $N=3$ $\lambda_A=0.5$ and $\lambda_B=0.2$. In this case, the total network load excesses the entire network bandwidth ($\lambda_A+\lambda_B \times N=1.1$). In Fig. 9, we can see that the obtained *RDD* by the CDS is smaller than that of original cell discarding mechanism under different cell error probabilities.

6 Conclusion

In this paper, a simple cell discarding strategy to improve the cell error rate in wireless ATM networks was proposed. The cell payload error probability of a cell, which is corrected by interleaving method, was also analyzed. The simulation results shown that the proposed strategy substantially improves the cell error rate received by destinations.

References

[1] Satoru Aikawa, Yasushi Motoyama and Masahiro Umehira, "Forward Error Correction Schemes for Wireless ATM Systems," *Proceedings of IEEE ICC'96,* pp.454-458, June 1996.

[2] D. M. Chitreet et al., "Asynchronous Transfer Mode (ATM) operation via satellite : issues, challenges and resolutions", *International Journal of Satellite Communications*, Vol. 12, pp. 211-222, Feb. 1994.

[3] Sung HO Lim, Dong Myung Ahn, Duk Whan Kim, and Dae Young Kim, "Cell Loss Reduction by Cell

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

Unit Interleaving in Wireless ATM Networks," *Proceedings of IEEE ICC'96*, pp.449-453, June 1996.

[4] MARTIN de PRYCKER, "ASYNCHRONOUS TRANSFER MODE Solution for Broadband ISDN," Ellis Horwood Limited 1993.

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

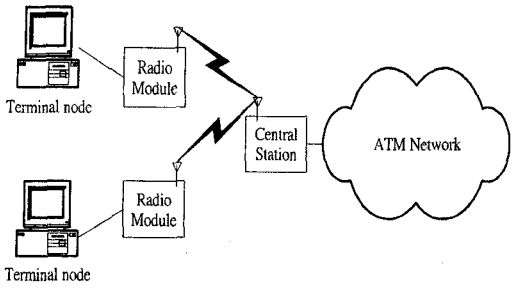

Figure 1. The wireless ATM network.

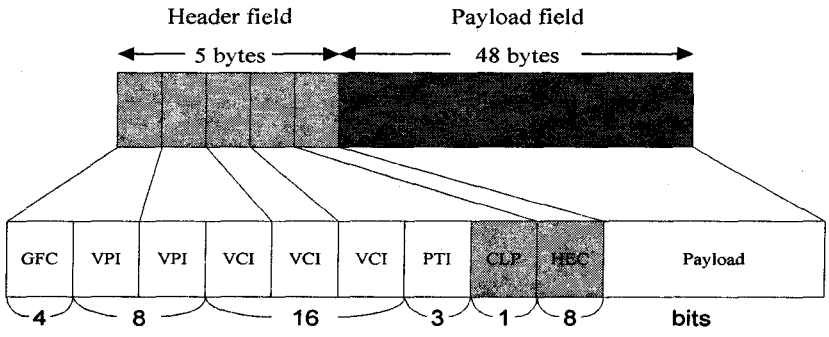

Figure 2. ATM cell format.

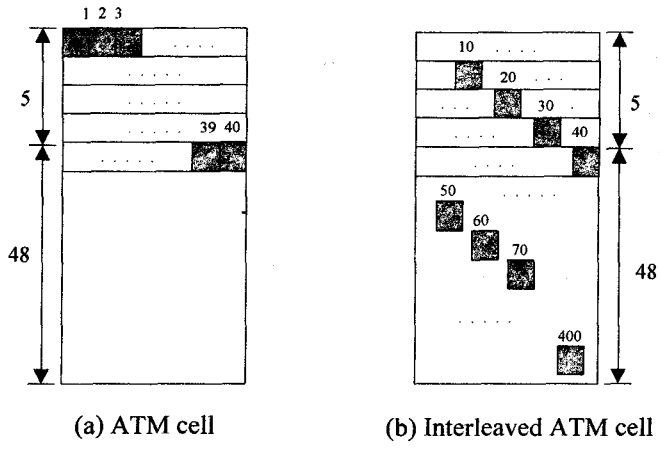

Figure 3. The cell format of interleaving method.

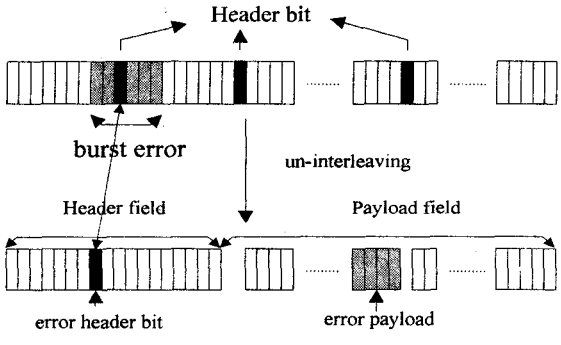

Figure 4. The cell after un-interleaving.

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

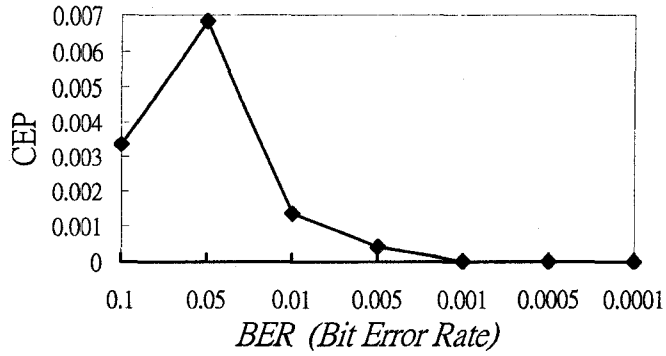

Figure 5. The *CEP* of different *BER*.

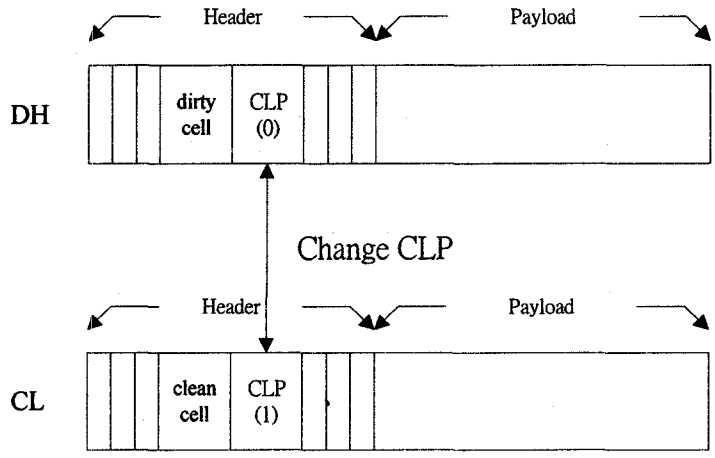

Figure 6. Changing CLP of the DH and CL cells.

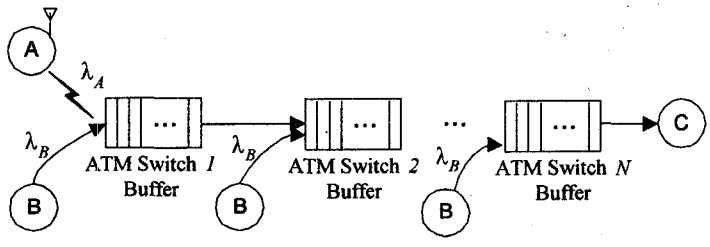

Figure 7. Simulation model.

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.

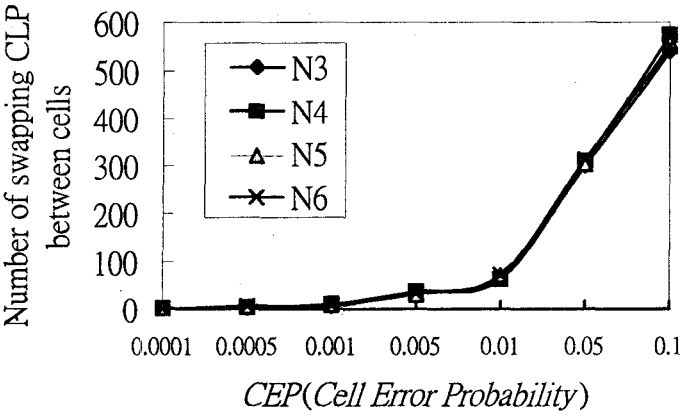

Figure 8. The number of swapped CLP between cells under different *CEP*.

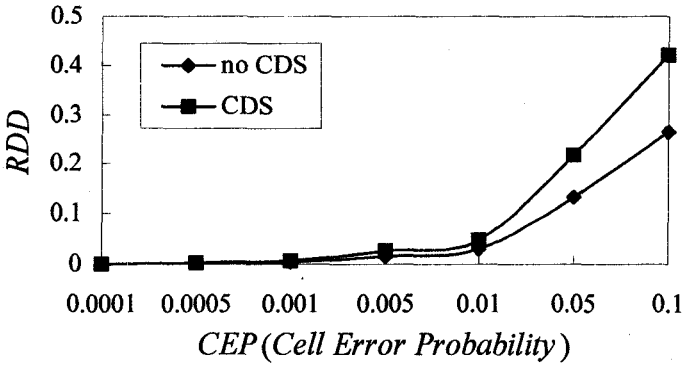

Figure 9. The obtained *RDD*s under different *CEP* when *N=3*.

Authorized licensed use limited to: Tamkang University. Downloaded on March 23,2010 at 21:08:16 EDT from IEEE Xplore. Restrictions apply.