# An Intelligent Cell Checking Policy for Promoting Data Transfer Performance in Wireless ATM Networks

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## Abstract

In this paper, the efficiency of transferring non-real-time data over Wireless ATM (WATM) networks is studied. Such services are sensitive to bit error as well as cell loss. The loss of a single cell due to congestion or a link error will result in the retransmission of the entire data frame by the end user. In this paper, we propose an intelligent cell checking policy (ICCP) with the existent congestion control algorithm to enhance the throughput of wireless ATM networks.

## 1. Introduction

With the growing bandwidth of networks, one usually accesses data through networks. Among various multimedia services, some of them require high accuracy in the received data. For example, applications for file transfer or E-mail are sensitive to bit error probability. To guarantee high quality transmission and reduce the retransmission overhead in low quality transmission links, some coding techniques are often used. However, these useful techniques result in extra overhead.

Recently, optical technology is evolving quite rapidly. It has the ability to enhance the transmission rate, the distance and the quality of transmission. Such transmission characteristics reduces the functions perform in the network from full error control (e.g., X.25) to a strict minimum in asynchronous transfer mode (ATM) network [1]. That is, based on the low bit error rate, ATM networks use the end-to-end basis error control instead of link-to-link error control. If a link of the connection, either the user-to-network link or the internal links between network nodes, introduces an error during transmission, no special action will be taken on that link. In particular, if an error occurs in the header field during transmission, the cell may be misrouted to a wrong destination. Such misrouting can have a negative impact on the performance since it will cause error multiplication. To protect such error, the standard defines that an 8-bit header error coding (HEC) in the header field to correct any single bit error in it. On the contrary, the payload in a cell does not protected at all to minimize the overhead.

In wireless ATM (WATM) networks [2], [3], the data are transferred over a worse transmission media, data may be corrupted by some inevitable interference. This causes a serious problem if ATM network does not protect the payload during transmission. Once error occurs in the payload, these corrupted cells still must be sent to the destination just as clean cells treated. In consequence, destination end initiates the retransmission process. It is desirable to design an intelligent strategy to determine whether the error checking/correcting process is needed during transmission. If the unrecoverable dirty cells are dropped before it reaches destination, more link capacity will be freed to support other services. In this paper, we study the impact on transferring data over WATM and propose an intelligent cell checking policy (ICCP) to improve the network performance.

The rest of this paper is organized as follows. In Section 2, the way of transferring ordinary data over WATM networks is addressed. In Section 3, the intelligent cell checking policy (ICCP) is introduced. In Section 4, the simulation results are reported. Finally, some conclusion remarks are given.

### 2. ATM Adaptation Layers (AAL) for Data Services

In ATM networks, the ATM Adaptation Layer (AAL) is defined to enhance the services provided by the ATM layer to the requirements of a specific service. The AAL is divided in two sublayers: SAR (Segmentation and Reassembly) sublayer and CS (Convergence Sublayer). The prime functions of the SAR are the segmentation into ATM cells of CS protocol data units (CS-PDUs) and reassembly of cells into a CS-

PDU. ITU-T recommends the use of AAL 3/4 for transfer of data which is sensitive to loss, but not to delay. The AAL 3/4 SAR-PDU carries 44 octets in the payload and 5 fields in the header and trailer. The 2-bit sequence number (SN) field in header is used for sequencing the traffic. The cyclic redundancy check (CRC) field in trailer is a 10-bit field use to determine of if an error has occurred in any part of the SAR-PDU. In the assured operation, any corrupted or lost CS-PDU is retransmitted. Obviously, the AAL 3/4 has a high overhead of 4 bytes per SAR-PDU of 48 bytes. Also, the 10-bit CRC for detecting corrupted segments, and the 4-bit sequence number for detecting lost and misinserted segments, may not offer enough protection for conveying very long blocks of data.

ATM Forum proposed AAL 5 to minimize the overhead of supporting data transfer over ATM networks. The AAL 5 structure is similar to the structure for AAL 3/4, but is simpler. The error protection in the AAL 5 is fully handled at the CS layer itself, instead of being shared between SAR and CS as in AAL 3/4. Moreover, AAL 5 SAR-PDU only uses a single bit (denoted as more flag) in payload type indicator (PTI) to indicate the cell position in CS-PDU. A cell with value '0' in this bit means the begging or continuation of a SAR-SDU. The cell containing the EOM (end of message) is identified by setting the more flag to '1'.

Since the loss of a single cell will corrupt an entire AAL 5 CS-PDU, there should be some way to intelligently discard cells in ATM switch. A well known solution, named as Early Packet Discard (EPD) [3], inspects the ATM cell headers and will drop all remaining cells from a data frame. This has important implications in that useless data is no longer propagated across the ATM network. In detail, each ATM switch tracks the AAL 5 cell header for the payload type indicator (PTI) field, indicating the end of a higher-layer packet as mentioned above. If a cell must be discarded, the switch will proceed to discard all remaining cells until it reaches the cell with more flag set (i.e., the final cell). We note that if the final cell is also being discarded, this will result in a re-assembly error at the destination for the next frame. A simple solution would be to set the cell loss priority (CLP) in this cell to 0, providing it with a better chance of making it to the destination. In a word, the EPD can minimize the congestion at the ingress of an ATM switch by selectively discarding strategy as opposed to dropping cells at random from multiple frames.

In WATM, the EDP may partially effect to solve the possible reassemble problem. For example, in the case of all cells of a PDU are received at destination, the reassemble PDU may still be error due to no error detection is performed during cell transmission. In the next section, we will introduce an intelligent cell checking policy to find out potentially erroneous PDU and discard them as early as possible. For the sake of practice, the additional overhead should be minimized to achieve high-speed transmission.

## 3. Intelligent Cell Checking Policy (ICCP)

Before describing the proposed ICCP, we first address the cyclic redundancy check (CRC) briefly. In networks, we often take the input data (data frame) as a bit streams. While a frame entering the CRC arithmetic circuit, it will take turns in a single line, and do the logic arithmetic exclusive-or with a generating function bit by bit. After passing all bits, we will derive a remainder. This is what we used to append to the tail of the original data frame as the CRC checksum value. After the receiver retrieves the data frame (including CRC checksum value), it will perform the same process as previously described. If the remainder is zero, it is said to be correct; otherwise, it is an erroneous one. The basic CRC arithmetic circuit is shown in Fig. 1.

Since cells belonging to the same PDU may not arrive consecutively. How to detect them by CRC circuit in each ATM switch is an interesting problem. Based on the linear processing property of CRC circuit, the whole PDU can be calculated block by block. If the intermediate values in CRC arithmetic circuit can be recorded and restored. That is, one may terminate the CRC process after parsing a cell/segment, say $S_a$, and record the temporary value in the block from $C_0 \sim C_n$ as shown in Fig. 1. At this time, the CRC arithmetic circuit is able to check another incoming data stream (cells/segments). Once the next cell, which follows $S_a$, arrives, the switch restores previous intermediate values immediately and performs the checking process as usual. There is one thing to be interest, the final CRC checksum value is just equal to the normal process.

In ATM network, it is not necessary to check all incoming cells to increase the switching overhead. The timing of checking data should depend on the degree of congestion. Once congestion occurs, cells will be queued in the buffer longer. In its waiting period, we could do some check to find out the erroneous cells and discard them. As a result, the congestion may be released and the buffer utilization can be enhanced.

In this paper, we use the congestion notification scheme which is carried in the PTI field of header of AAL 5 SAR-PDU. Once congestion is detected by ATM switch, the following incoming cells which belong to new PDU will be checked by this ATM switch. We note that if any cell of a PDU has passed the ATM switch, the checking process should be prohibited. Therefore, an 'Active' field is required in the lookup table. Since the more flag information only distinguishes the beginning/continuous and end cells, a 'Begin' field is also needed in the lookup table to determine a cell is beginning or not. Initially, this field is set to one as soon as this connection is established. In the lookup table, we also need an extra filed, named as Intermediate Remainder Value (IRV), to perform the discrete CRC checking process in ATM switch. If the final cell arrives, the last remainder is investigated to determine the whole PDU is correct or not. If the remainder is not zero, all cells belongs to same PDU (i.e., with the same VPI/VCI) in buffer will be dropped except the front one. The front cell will be marked as the 'end' cell (via set more flag) to speedup the notification. When the next ATM switch receives the 'end' cell, it will also find an error occurs in the PDU (by the last remainder is not zero) and discard the corresponding cells except the front one as mentioned above. Since the EPD is useful for dealing with cell loss, a 'Status' filed is also needed in the lookup table. The flowchart and the lookup table of ATM switch of ICCP is shown in Fig. 2 and 3, respectively.

## 4. Simulation Results

In the simulation process, we observe the cell transmission process for a period of time, and record some parameter that can show the transmission quality, such as the cell loss number. Fig. 4 shows the effect of the Poisson arrival rate. In this case, the Poisson arrival rate handles the congestion level of a network environment. With the increasing of Poisson arrival rate, average incoming cells in a time slot become more frequent, in consequence, the probability of a buffer to be full is also increased. From the figure, we see the overflow is delayed in compared with the simulation model without ICCP. Fig. 5, we show the influence of the PDU length. As the PDU length approaches to infinite, it's impossible to remove cells if there is no overflow occurred. So, the longer the PDU length are the more disadvantage to ICCP. Finally, the two lines will combine in a single line. Fig. 6 we compare the influence of the arrival rate and cell number we can remove by ICCP. The Y-axis is the cell number we can remove by the ICCP. Where "*l*" (in cells) is the average length of a CPCS-PDU as previously described.

## 5. Conclusion

Due to the limited bandwidth in the wireless transmission media, transmission quality has strong effect on the utilization of the bandwidth. In this paper, we propose a new technique to enhance the transmission quality in the ATM transmission protocol, at the same time, it also improves the wireless transmission quality, since the guarantee of the accuracy of the transmitted data also guarantee the utilization of the bandwidth.

## 6. Reference


[1] M. DePrycker , *Asynchronous transfer mode solution for broadband ISDN*, Prentice Hall, 1995

[2] Dellaverson L., "Wireless ATM Networking and Selected Service Aspects", Contribution to ATM Forum Technical Committee, pp. 95-1569, ATM Forum, 1995.

[3] David Ginsburg, "ATM: solution for enterprise internetworking", Addison Wesley.


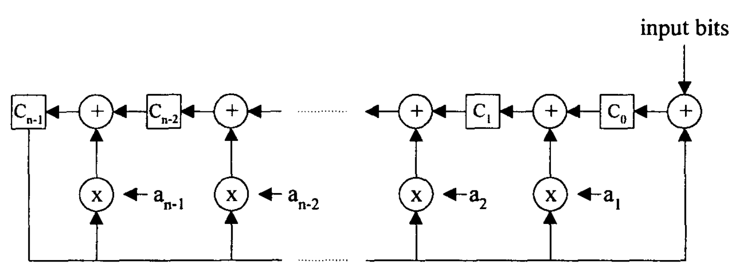


Figure 1. General CRC architecture to implement divisor $1+a_1x+a_2x^2+\cdots\cdots+a_{n-1}x^{n-1}+x^n$.

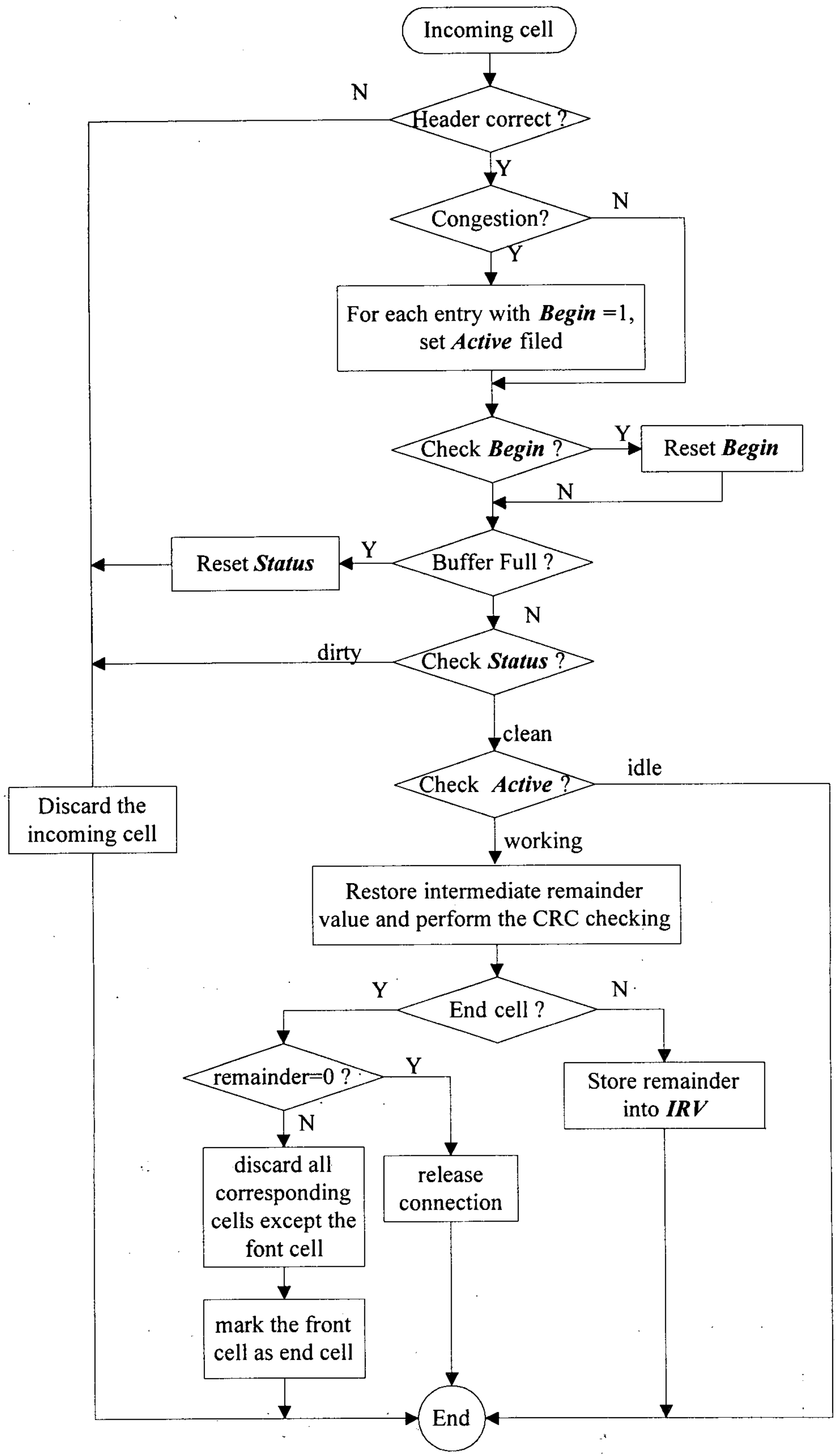


Figure 2. Flowchart of judging CRC checking process.

| VPI/VCI transfer | **Begin** | **Status** | **Active** | **IRV** |
|---|---|---|---|---|
| 23/87 | 1 | 0 | 0 | NULL |
| 141/85 | 0 | 0 | 1 | 101....1000 |
| 54/29 | 0 | 1 | 0 | NULL |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 66/28 | 0 | 0 | 1 | 010....1010 |

Status = 0 : clean
= 1 : dirty
Active = 0 : idle
= 1 : working
Begin = 0 : continue
= 1 : beginning

Figure 3. The lookup table in internal ATM switch.

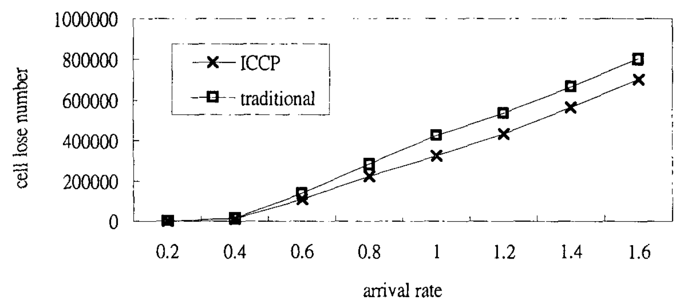


Figure 4. The number of cell loss due to buffer overflow vs. the Poisson arrival rate

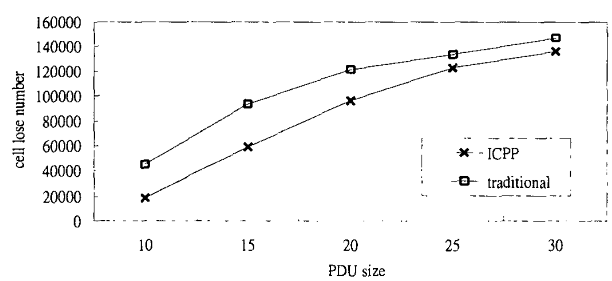


Figure 5. The number of lost cells due to buffer overflow under different PDU lengths.

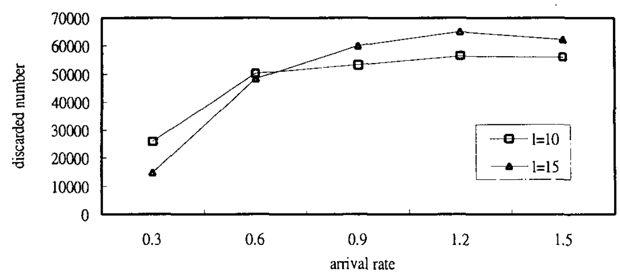


Figure 6. The number of discarded cells obtained by ICCP under different arrival rate.

***Session 5-A***

# ATM Switch 2
# (Architecture and Performance)