AN EFFICIENT HYBRID ARQ FOR WIRELESS ATM NETWORK

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ABSTRACT

Wireless ATM (WATM) Networks support several types of traffic streams including data, voice and video with different quality of service (QoS) requirements. Due to the effects of fading, multi-path propagation and interference, the wireless link is characterized by a higher and more variable error rate. It is also fundamentally limited in bandwidth resource, when compared with wired ATM .Such differences in error characteristics and bandwidth limitations have necessitated a Data Link Control Protocol and error control coding for WATM Networks in order to insulate the ATM Network layer from wireless channel impairments. In this work, an adaptive forward error correction (FEC) is proposed using Rate Compatible Punctured Convolution (RCPC) code at the physical layer and ARQ (selective -repeat) techniques at the Data Link control layer. Rate Compatible Punctured Convolution (RCPC) code provides variable code rates ,useful for unequal error protection (UEP) of ATM cells .This type of coding scheme support a broad range of QoS levels consistent with requirements of multimedia services and minimize the loss information on wireless access segment. This RCPC can be combined with DLC sub layer to form a hybrid ARQ because of its incremental redundancies which is suitable for non-delay sensitive traffic data. An adaptive hybrid ARQ is analyzed in which optimum retransmission packet size is selected according to channel state information. Hybrid ARQ using RCPC code is used with retransmission packet size and code rate variation according to channel condition. For this Adaptive scheme, the cell loss rate and throughput efficiency are analyzed and found to be better than existing ones.

1. INTRODUCTION

Wireless channel has much stronger error prone characteristics than the wired one; therefore, it is not sufficient to have only header error control (HEC) for WATM. A flexible error control is required in the DLC protocol. Since the channel state changes from time to time, hybrid ARQ (HARQ) should be applied. HARQ scheme combines FEC and ARQ technologies, which are used to deal with frequent error-patterns and less-frequent error-patterns, respectively. Based on the HARQ scheme using RCPC codes for WATM networks in, this paper proposes an HARQ scheme with variable encoding rate and packet size. Error control requirements for the non delay critical services are effectively met by a data link control sub-layer feedback protocol such as ARQ which augments FEC on the wireless PHY layer. This protocol is frequently referred to as hybrid ARQ/FEC. Of interest in this work are hybrid ARQ/FEC schemes that utilize RCPC coding at the PHY layer, maintains the rate compatibility restriction, and provides a single encoder/decoder implementation.

Code puncturing allows an encoder /decoder pair to change code rates i.e. the code error correction capabilities without changing their basic structure. It is a procedure used to periodically discard a set of predetermined coded bits from the sequence generated by an encoder for the purpose of constructing higher code rates. With the rate compatibility restriction on the puncturing tables ensures that all code bits of high rate codes are used by the lower rate codes. Thus formed code allows transmission of incremental redundancies in Hybrid ARQ scheme and continuous rate variation to change from low to high error protection with in a data frame. The same Viterbi decoder is used for all RCPC codes of same memory by controlling metric memory access through puncturing. In such a way the whole family of codes with different code rates is available using the same encoder and the same Viterbi decoder except for only the puncturing rule being changed. The RCPC encoder encodes in Hybrid ARQ the previous stored source data in the buffer for retransmission and sends the additional incremental redundancy bits which are punctured at previous transmission..If the decoding is not successful ,the system repeats the retransmission steps and further redundancy bits are transmitted until the packet is successfully received .If the decoding still not successful when the transmitter can not transmitting more incremental bits corresponding to the source data, the receiver discards the first retransmitted packet and the first retransmission is repeated. If the decoding is not successful, the retransmission is repeated similarly until decoding is successful.

The Fig.1 shows how Hybrid ARQ is implemented.

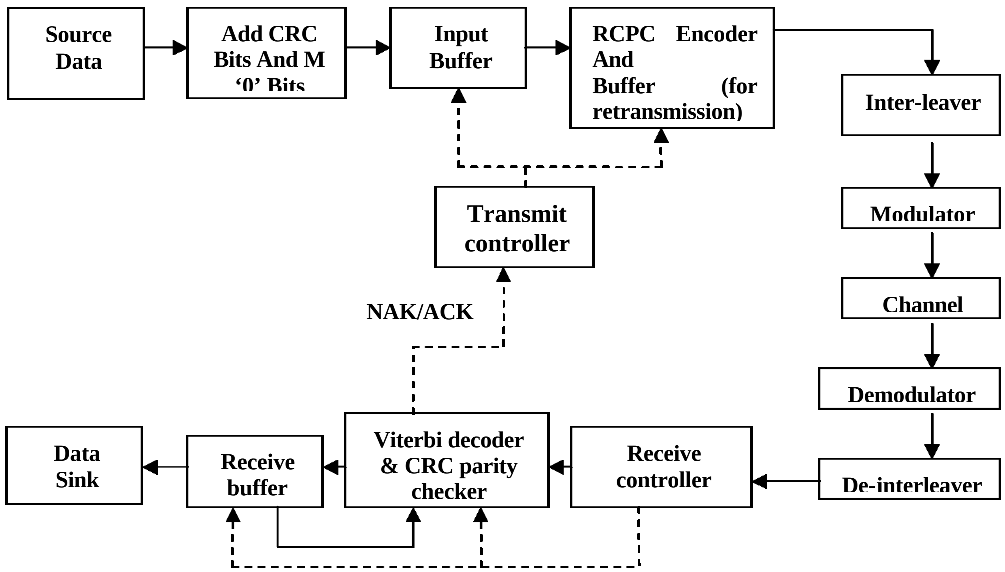

Fig. 1. System Model For Hybrid ARQ \ FEC Protocol Using RCPC Code

2. ADAPTIVE HARQ SCHEME USING RCPC CODES

Hybrid ARQ schemes are on the basis of cell-by-cell transmission in ATM networks, i.e., retransmissions are in the unit of an ATM cell (constant information packet size: *S0* = 48 bytes = 384 bits). The throughput efficiency is very sensitive to the packet size, i.e., when a packet size becomes larger, there is an increasing need for retransmissions, while a small packet is inefficient because of the large overhead over the actual data. Therefore, there exists an optimal packet size in the sense of maximizing the throughput .When the channel BER is large; the scheme operates in the state with smaller packet size. As it is becoming small, the system moves to the state with larger packet size. If we define the CLR threshold values, we can get available value of channel BER according to the optimal packet size to maximize the throughput. If it finds out that there still exist errors in the fields, the receiver will ask for retransmission of the cell. Adaptive hybrid ARQ scheme utilizes the different packing schemes for ATM cells with the packet size of $8S_0$*(3072 BITS)*, S_0*(384 BITS)* and $S_0/8$(48 BITS).In this scheme, the coding rate is selected according to the system parameters, such as channel SNR, round delay and buffer size at the receiver. Adaptive Hybrid ARQ scheme is shown in Fig. 2.

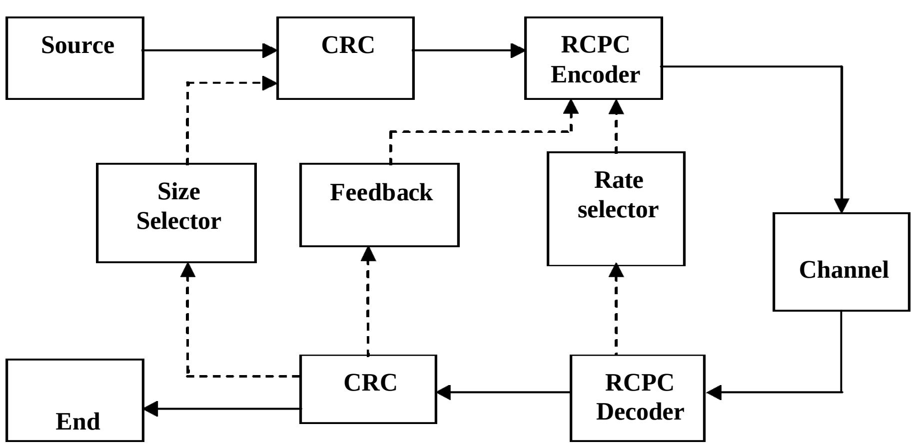

Fig. 2. The Main Processes in Adaptive Hybrid ARQ Scheme

3. PERFORMANCE ANALYSIS

Each RCPC code with rate *Rl*: {8/9, 8/10, 8/12, 8/16, 8/24}, in AHA comes from 1/3 original CC then, the HARQ protocol performs by the following steps:1) According to the types of services, the retransmission packet size is determined in terms of. For weak time-sensitive services, it should be smaller, i.e., *S0*/8. For time-insensitive services, it is larger, i.e., 8*S0*.2) Encode information bits using CRC.3) Input the packet with bits into the rate 1/3 CC encoder. Store the resulting two parity streams at the transmitter, possibly in matrices for potential transmission. Let q=0, where q represents the number of all code symbols being transmitted (reaching the lowest code rate 1/3).4) Set up L according to the threshold BER values so that the last coding rate of the transmission is *RL*. For example, set L=2, *RL*=4/5.5) Initialize l=1, *Sp* information bits and *Sp*/8 parity bits should be sent. Here, *Sp* - {*So*/8, *So*, 8*So*}.6) Keep sending the additional parity bits to achieve the coding rate corresponding to l.7) Attempt to decode the code with rate *Rl* using the code symbols received thus far, and insert erasures for all those symbols not yet received. If there is an all-zero syndrome, output the *Sp* decoded information bits and send a positive acknowledgment (ACK) to the transmitter. Otherwise, when one or more bit errors are detected in either the header or the payload, send a negative acknowledgment (NAK) to the transmitter.8) At the transmitter, if an ACK is received, reset the protocol and proceed to step 2. Otherwise, if a NAK is received, switch to the next lower rate and proceed to step 6.9) If decoding is not successful after the transmission of all code symbols (i.e. l=L),. $q \rightarrow q+1$.When $q < Q$, the protocol resets, then commence with step 4 and retransmit the entire codeword. The receiver may reset its receive buffers. If $q > Q$, discard this cell. Then, a higher order protocol could take over the error control. Where, the parameter Q is defined as the maximum number of all code symbols being transmitted. When Q becomes larger, the extremely low CLR could be obtained, but longer delays may occur. On the basis of above protocol, the average throughput is analyzed, which is another important parameter for the HARQ scheme when selective repeat (SR) retransmission protocol is applied to the HARQ scheme.

4. RESULTS AND CONCLUSION

In this scheme, one of the most important performance parameter in ATM cell transport is cell loss ratio (CLR), which is defined by the ratio of total lost cells to total transmitted cells. And the throughput efficiency is also analyzed with the channel Bit Error Rate (BER) for different packet size namely 3072 bits, 384 bits, and 48 bits. The throughput is defined as the ratio of the number of information bits received correctly at the receiver to the total number of bits transmitted. The CLR and the throughput efficiency are analyzed for different block size. In figure 3&4 CLR is constrained to 10^-6 and the threshold channel BER values are found in order to achieve better throughput. For better throughput, the time-insensitive services require HARQ scheme with long packet size, and the weak time-sensitive services are only with short packet size. This paper proposes an adaptive HARQ scheme with variable retransmission under the constraint of accepted CLR<10^-6. When the channel is quiet with low BER, it behaves like HARQ scheme. The Rayleigh fading channel and BPSK modulation are considered.Fig.3 gives CLR performance of four different code rates for different block size.

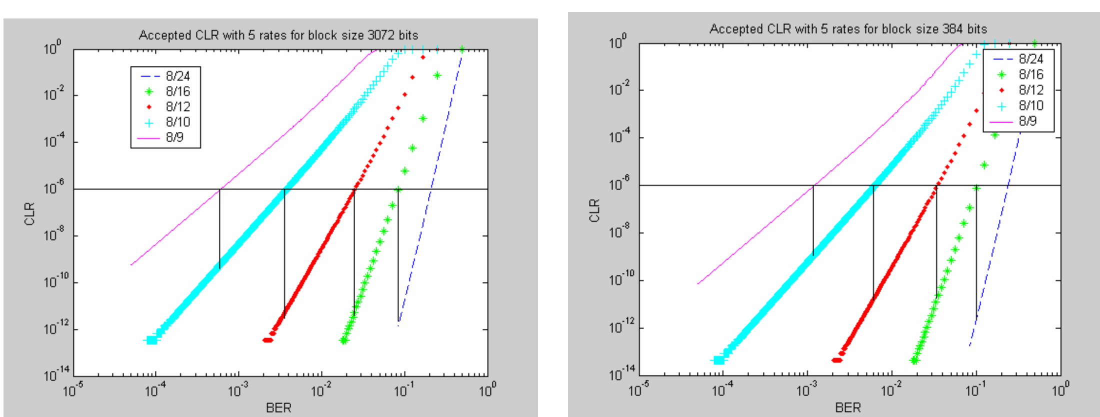

Fig. 3.Accepted CLR with 5 rates for block 3072 bits and 384 bits

As the channel becomes noisy with high BER, such as handoff, high speed and sudden channel infection, the powerful error control with lower coding rate should be used. The proposed scheme provides improved throughput over the general ones. In Figs. 4&5, throughput 0f Hybrid ARQ and ARQ for different block size are compared. The performance of adaptive hybrid ARQ is better than ARQ technique.

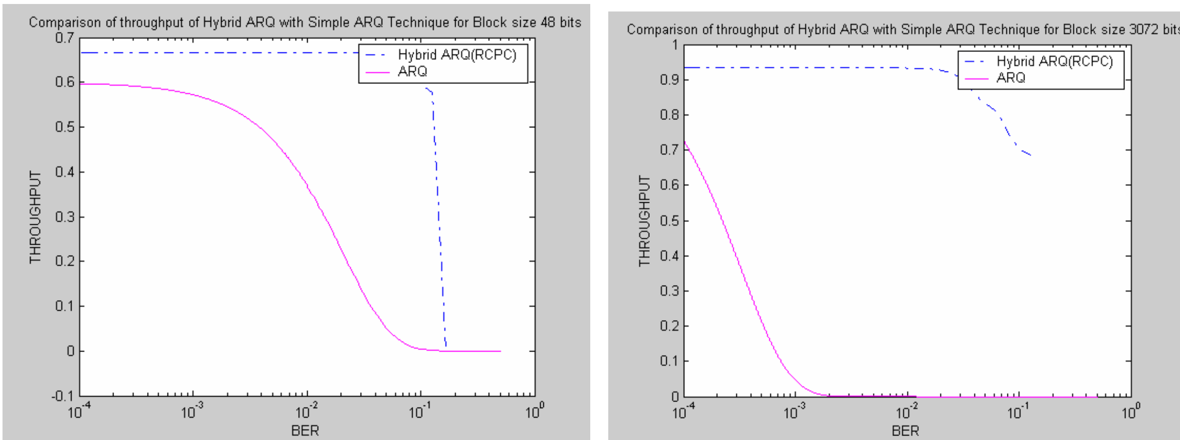

Fig.4. Throughput of Hybrid ARQ (RCPC) for block 48 bits & 3072 bits

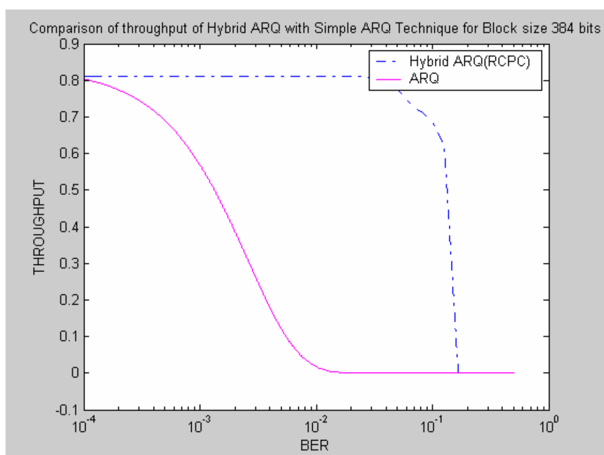

Fig.5. Throughput of Hybrid ARQ (RCPC) for block 384 bits

5. REFERENCES

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