Hybrid ARQ System using the Cross Layer Coding

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Abstract: Hybrid automatic repeat request (H-ARQ) system using the cross layer coding suitable for future mobile communication and radio data communication system. In this paper introduce cross layer coding and H-ARQ type, proposed H-ARQ system using cross layer coding methods. Simulate BER performance and Throughput. And we suggest that according to channel condition suitable H-ARQ type.

1. Introduction

Recently, H-ARQ techniques are adopted in mobile and wireless communications to improve throughput, such as burst error occurs in the communication packet data service. 3.5G HSDPA technology is controlled by the error in the adoption of the H-ARQ system. Wibro, and IEEE standards group affiliated with the IEEE 802.16d/e specification is active in the H-ARQ being adopted as a standard. H-ARQ scheme is generally classified into three categories such as Type-I, Type-II, Type-III. [1]

Concatenate coding schemes are considered as being the best solution for powerful protection of digital information against nonlinear and fading noise. However, the performance of concatenate coding scheme is away from Shannon's limit. The emergence of the turbo codes and iteration decoding algorithms for them has changed our view of the Shannon capacity which has become a practical benchmark for a coding system not only for power limited channels but also for bandwidth channels. The low density parity check (LDPC) codes have different characteristics compared with the turbo codes. The LDPC codes have better block error performance than that of the turbo codes. This is because the minimum distance of an LDPC code increases proportionally to the code length with high probability. Such a property is desirable for high-speed data transmission which requires very low frame error probability.

Cross layer is used to overcome deep fading channel in mobile DVB system. In this paper, we propose the H-ARQ techniques (Type-II and Type-III) which are applicated cross layer system and simulate proposed system. This simulation result will be possible to apply in the mobile communication and radio data communication system that require real-time process and high performance.

2. Cross Layer system

Encoding and decoding process of cross layer technique is consisting of two steps such as PL-FEC (Physical Layer-Forward Error Correction) and UL-FEC (Upper Layer-FEC). Error which is not corrected in PL-FEC by deep fading is corrected in UL-FEC, thus error correction rate is much better. [2]

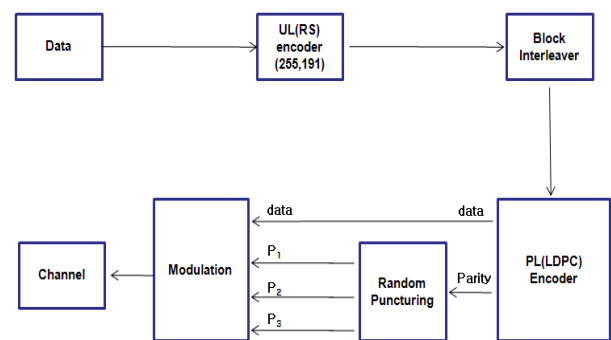Figure 1 shows the general transmission structure of cross layer system.

Figure 1. Transmission block of cross layer system

Table 1 list the coding method and parameter which are applied in H-ARQ.

Table 1. The coding method and parameter which are applied in H-ARQ.

| Method	Parameter	
UL-FEC	RS(255,191,32)	
PL-FEC	LDPC R=1/3	N=16200, K=5400, P=10800
	LDPC R=1/2	N=10800, K=5400, P=5400
	LDPC R=2/3	N=8100, K=5400, P=2700
Interleaving	Block Interleaver(row=30, colomum=17)	

3. H-ARQ system using cross layer coding methods

H-ARQ system is composed of ARQ and FEC system. Transmission rate is increased by H-ARQ system which

reduces retransmission number of times by continuous error according to error correction of FEC. If error which is not corrected by error correction of FEC is occurred, retransmission is required by NAK signal in ARQ method sent to transmitter, in fact, it is more reliable.[3][4]
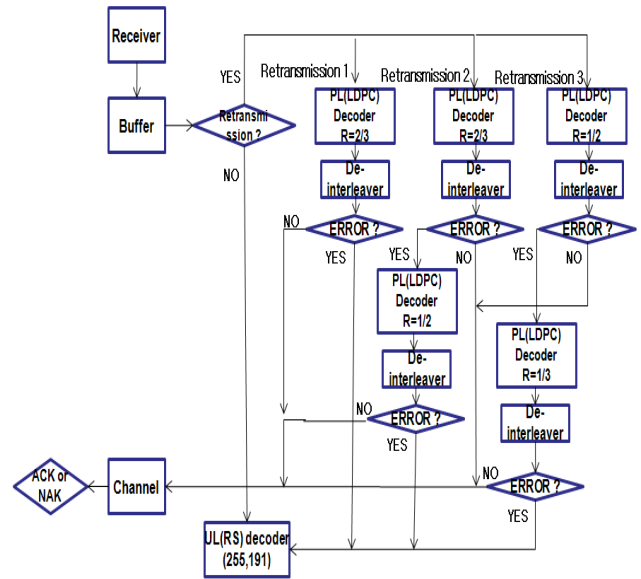
There are Type-I, Type-II and Type-III in general H-ARQ system. Furthermore, many papers suggest the modified H-ARQ method. Figure 2 shows three kinds of H-ARQ system block diagram using cross layer which proposed in this paper.
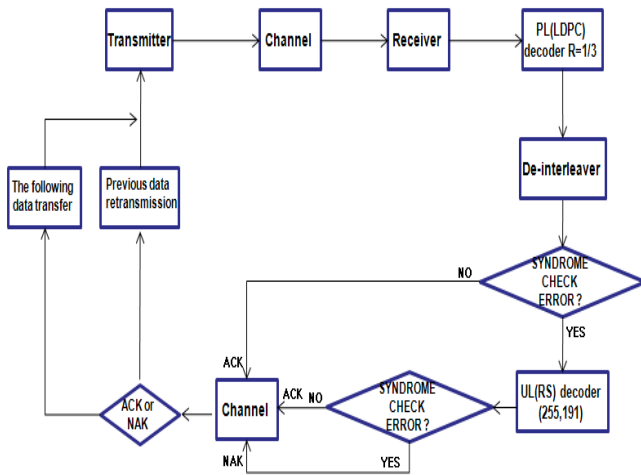
(a) H-ARQ Type-I System block
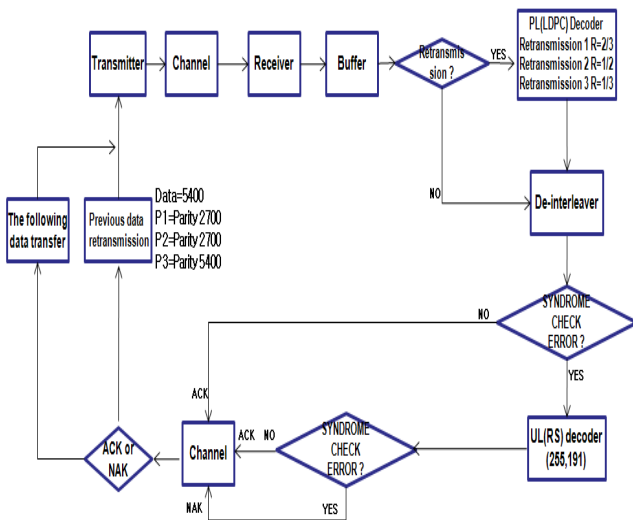
(b) H-ARQ Type-II System block

(c) Type-III System block

Figure 2. Three kinds of H-ARQ method using cross layer

Transmission efficiency Type-I method has disadvantages in the high SNR environment. To compensate for these disadvantages, In Type-II, receiver requires additional information, when error is not corrected perfectly. At this time, the number of additional information depends on receiver's requirement by channel condition.

In addition, Type-II's error correction rate depends on parity packet, when LDPC decoding is working by retransmission. If transmitted data is lost at first transmission or seriously damaged by noise, Type-II's efficiency is rapidly down. Therefore, Type-III method is better than Type-II method, because only retransmission data are decoded when the first transmission data has failure.

4. Throughput Analysis

Not only FEC efficiency but throughput also is important in H-ARQ system. Throughput is calculated with equation (1). [5]

$$\eta = \frac{\text{average of the transmitted bit}}{\text{transmitted channel bit}} \quad (1)$$

Define p_i ($i=0,1,2,\cdots$) as the probability that the decoder succeeds after the i_{th} retransmission but fails at all previous attempts (the initial transmission is considered 0_{th} retransmission). We have $p_i = (1 - F_i) \sum_{j=0}^{i-1} F_j$, where F_i is the word/frame error rate (WER/FER) after the i_{th} retransmission. The system throughput, η, is given by:

$$\eta = K_0/(N_0 + \sum_{i=1}^{\infty} \mathcal{P}_i M_i)$$

$$= R_0/(1 + F_0 \sum_{i=1}^{m} \frac{M_i}{N_0}(1 - F_i) \sum_{j=1}^{i-1} F_j) \qquad (2)$$

Where K_0, N_0, and M_i denote the number of data bits in a frame/codeword, the packet size of the initial transmission, and the packet size of the i_{th} retransmissions, respectively.

5. Simulation Results

RS(255,191,32) is used for UL-FEC, and LDPC(N=16200, R=1/3) is used for PL-FEC. LDPC parity part divided three parts that is non-overlapping each other through random puncturing.

Block interleaver size is row=30 and column=17 and we simulated proposed H-ARQ system under the AWGN channel. Maximum times of H-ARQ retransmission request are limited to three times. The length of retransmission packet depends on what kinds of H-ARQ type.

Figure 3 and Figure 5 shows BER performance of Type-II and Type-III methods under the AWGN Channel by the retransmission number of times. When the retransmission time is increased to maximum times, the BER performance is similar with LDPC code performance that has original coding rate. And BER performance of Type-III method show better than Type-II method, because retransmission data are comprised of information data and packet data.

Figure 4 and Figure 6 shows throughput of Type-II and Type-III methods under the AWGN Channel by the retransmission number of times. This Figure 4 and Figure 6 shows that high Es/No is good throughput of efficiency. Throughput approaches 1, because decoding using only RS decoder is possible without error at 8dB.
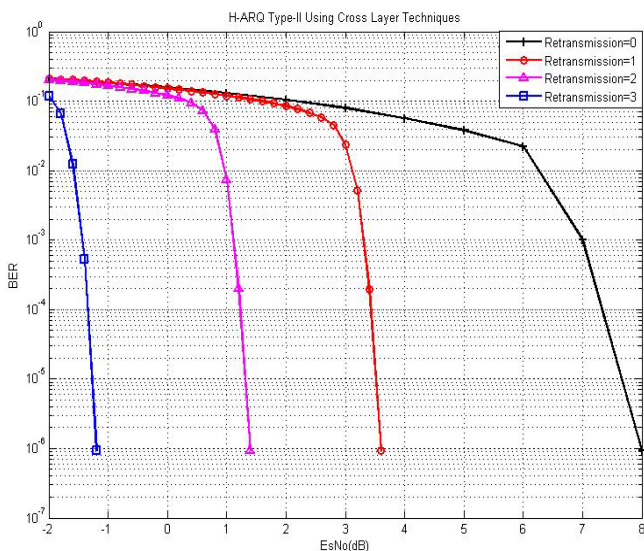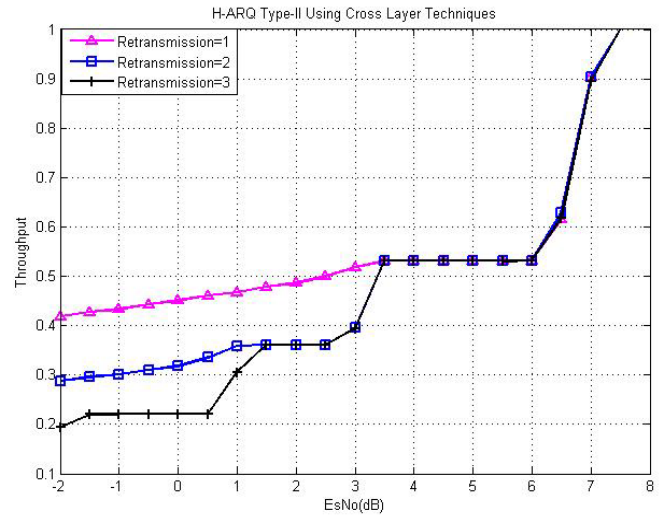

Figure 4. H-ARQ Type-II using cross layer techniques Throughput performance

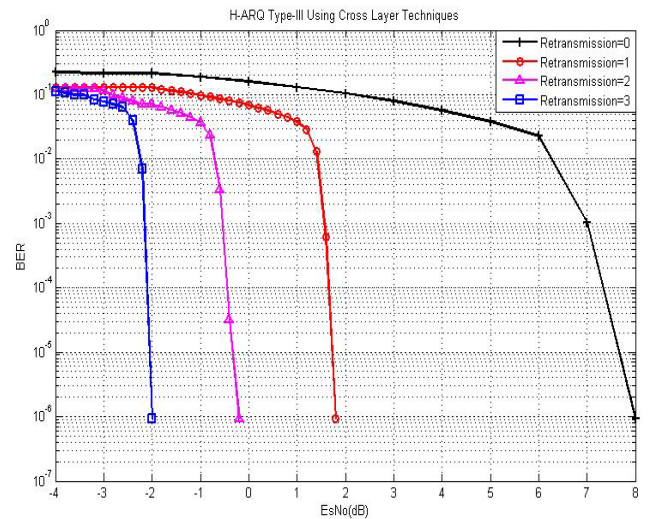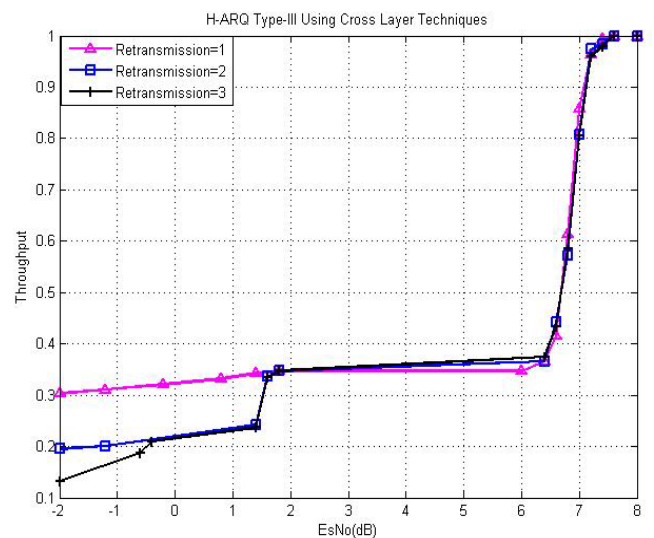Figure 5. H-ARQ Type-III using cross layer techniques BER performance

Figure 3. H-ARQ Type-II using cross layer techniques BER performance

Figure 6. H-ARQ Type-III using cross layer techniques Throughput performance

5. Conclusion

In this paper, we proposed H-ARQ system using cross layer coding scheme. At the simulation results, efficiency of H-ARQ system using cross layer coding methods are better than efficiency of H-ARQ system using LDPC codes. Moreover, different type of H-ARQ's efficiency is considered, Type-II is suitable when channel condition is good, and Type III is suitable when burst error channel or deep fading channel.

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