A Study on MPE-FEC decoding base on LLR method in DVB-SSP system

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Abstract: In this paper, we described DVB-SSP system for mobility. The DVB-SSP for mobility system used cross layer scheme which is consist of e-RS(erasure Reed-Solomon), virtual interleaver and LDPC.

Erasure data for e-RS decoding is detected by CRC check in conventional DVB-SSP system. However, this paper proposed erasure data detecting method by LLR value of LDPC. It is called LLR method.

Through the simulation results, we know that the performance of LLR method is better than conventional CRC method as 0.2dB.

1. Introduction

Research for the new DVB-SSP standard that is combined with DVB-S2, DVB-H[1] and DVB-T[2] is studied actively to provide continuous satellite broadcasting and internet services to mobile object.

Mobile DVB-S2 standard called DVB-SSP[3][4]. DVB-SSP established communication methods using the satellite about mobile objects and cross layer coding is divided into two kinds of level. First level is physical layer coding and, second layer is link layer or upper layer coding. Error correction capability of physical layer is better than upper layer. In DVB-SSP system for data transmission, upper layer uses erasure Reed-Solomon(e-RS) code with virtual interleaver, MPE-FEC, and physical layer uses LDPC(low density parity check) code(N=16200). In the conventional algorithm, e-RS coded data with CRC coded data is transmitted through LDPC encoder after virtual interleaving. In the receiver, CRC code words checks after LDPC decoding. However, in this paper we propose that LLR method using the LLR value at the LDPC output. This paper presents the selective erasure by LLR method. Through simulation compared with the existing methods and CRC methods.

2. DVB-SSP system model

Fig. 1 shows the DVB-SSP system block diagram.

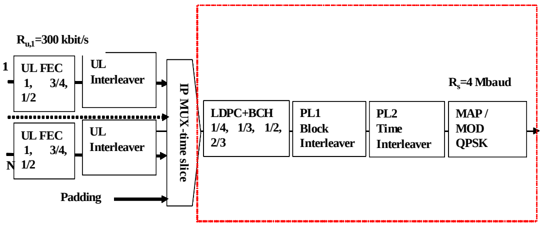

Fig. 1 System block diagram

Interleaver of upper layer is virtual interleaver.

2. 1 e-RS

Error correction capability of RS code is t, the number of errors symbol is x, then t=(n-k)/2, when t>x, error correction is possible. Error correction capability of e-RS code is t, the number of errors symbol is x, then t=(n-k), when t>x, error correction is possible. If erasure locates was not known, performance of e-RS codes can degrade.

2. 2 Virtual interleaver

With reference to Fig. 2, the MPE-FEC frame is arranged as a matrix with 255 columns and a flexible number of rows; in DVB-H the maximum allowed value for this is 1024. Firstly, MPE-FEC is filled up with data vertically, secondly the data is coded horizontally by RS code. In the end, data is read vertically. The procedure hides an interleaving and de-interleaving process on the data respectively before and after the RS-code, and is generally indicated as “virtual interleaving”.

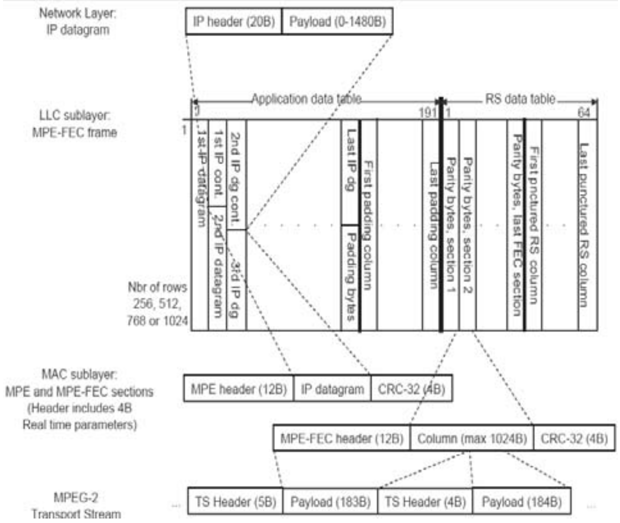

Fig. 2 MPE-FEC memory structure

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2. 3 LDPC

The high definition television (HDTV) standard, known as The Digital Video Broadcasting (DVB-S2) transmission system, employs a LDPC coding technique as a channel coding scheme [5]. LDPC codes are linear block codes with sparse parity check matrix H(n-k)xn. As an example (see Fig.3), an LDPC code of length N=8 and rate ½ can be specified by the following parity check matrix. The same code can be equivalently represented by the bipartite graph in Fig.4 which connects each check equation (check node) to its participating bits (bit nodes).

$$
H = \begin{array}{c} \begin{array}{cccccccc} \mathrm{n}_1 & \mathrm{n}_2 & \mathrm{n}_3 & \mathrm{n}_4 & \mathrm{n}_5 & \mathrm{n}_6 & \mathrm{n}_7 & \mathrm{n}_8 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 \end{bmatrix} \end{array} \begin{array}{c} \\ \mathrm{m}_1 \\ \mathrm{m}_2 \\ \mathrm{m}_3 \\ \mathrm{m}_4 \end{array}
$$

Figure 3. Example of parity check matrix (N=8 and R=1/2)

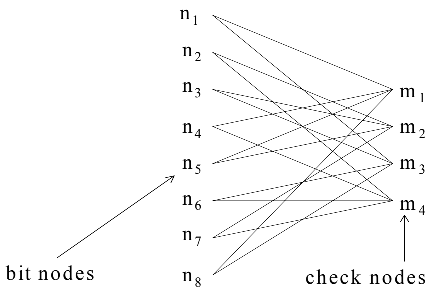


Figure 4. Bipartite graph of LDPC

Bit nodes and check nodes communicate with each other to accomplish that. LDPC decoding shown as Fig.5 has three procedures which are initialization, CNU (check Node Update) and BNU (Bit Node Update).

Step 1. Initialization

$$u_n = -L_c \cdot r_n (L_c = \frac{2}{\sigma^2}), \quad n = (0,1,..,N-1) \quad . \qquad (1)$$

The decoding starts by assigning the channel transmit values to the outgoing edges from bit nodes to check nodes. The initial channel value is shown in (1).
Where, N is codeword size and σ is Gaussian noise variance.

Step 2. Check node update (CNU)
Let us denote the incoming messages to the check node k from its dc adjacent bit nodes by $v_{n_1 \to k}$, $v_{n_2 \to k}$, …, $v_{n_{dc} \to k}$ (see Fig. 5(b)). Our aim is to compute the outgoing messages from the check node k back to dc adjacent bit nodes. Let us denote these messages by $w_{k \to n_1}$, $w_{k \to n_2}$,…, $w_{k \to n_{dc}}$. Each outgoing message from check node k to its adjacent bit nodes is computed as

$$w_{k \to n_i} = g\left(v_{n_1 \to k}, v_{n_{12} \to k}, \ldots, v_{n_{i-1} \to k}, v_{n_{i+1} \to k}, \ldots, v_{n_{dc} \to k}\right),$$
$$g(a,b) = sign(a) \times sign(b) \times \{\min(|a|,|b|)\} + LUT_g(a,b),$$
$$LUT_g(a,b) = \log(1 + e^{-|a+b|}) - \log(1 + e^{-|a-b|}), \quad (2)$$

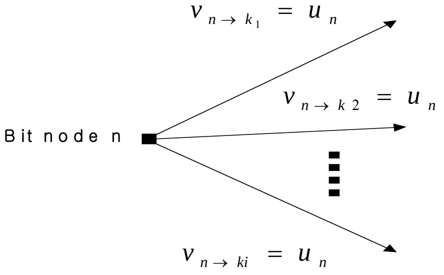
In practice, LUTg(.) function is implemented using a small look up table.

Step 3. Bit Node Update (BNU)

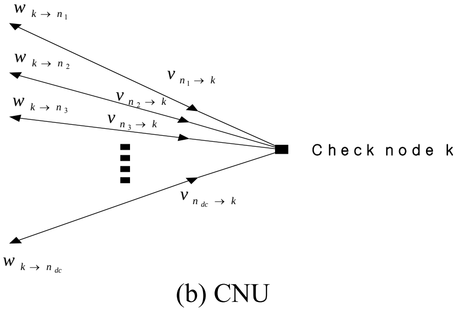
Let us denote the incoming messages to the bit node n from its dv adjacent check nodes by $w_{k_1 \to n}$, $w_{k_2 \to n}$, …, $w_{k_{dv} \to n}$ (see Fig. 5(c)). Our aim is to compute the outgoing messages from the bit node n back to dv adjacent check nodes. Let us denote these messages by $v_{n \to k_1}$, $v_{n \to k_2}$,… , $v_{n \to k_{dv}}$ .They are computed as follows:

$$v_{n \to k_i} = u_n + \sum_{j \neq i} w_{k_j \to n} \quad . \qquad (3)$$

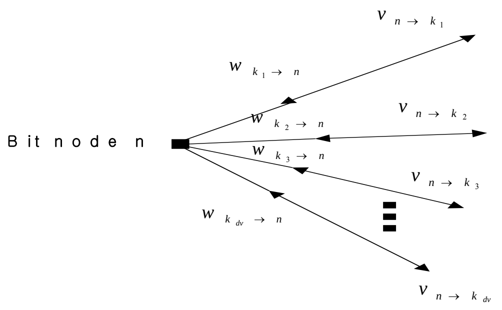
Intuitively, this is a soft majority vote on the value of the bit n, using all relevant information expect $w_{k_j \to n}$.



(a)Initialization



(b) CNU



(c) BNU

Figure 5. LDPC decoding procedure

DVB-S2 standard employs LDPC coding algorithm proposed by HNS (Hughes Network Systems), therefore this paper analyzes performances of soft symbol split methods for coding rate R=2/3 with 8PSK.

3. MPE-FEC decode th techniques by LLR method proposed

In the receiver, if it is detected error from the received data(CRC check), all data packet is erasure, and then e-RS decoding begins. These structures are inefficient.
Fig. 6 shows the structure of receiver and erased MEP-FEC memory form by CRC method.

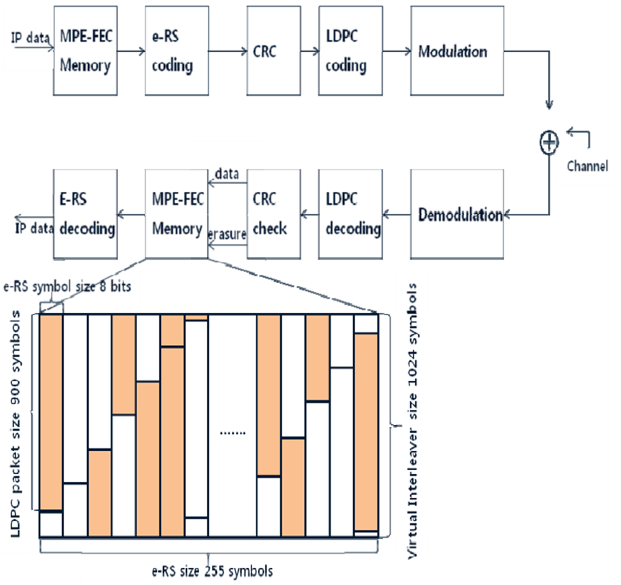


Fig. 6. MPE-FEC memory base on CRC method

MPE-FEC memory structure of proposed LLR method is the Fig. 7. This approach is only using the LLR value without that conventional CRC part. Fig. 7 shows the structure of receiver and erased MEP-FEC memory form by LLR method. It is erased unit symbols by LLR method.

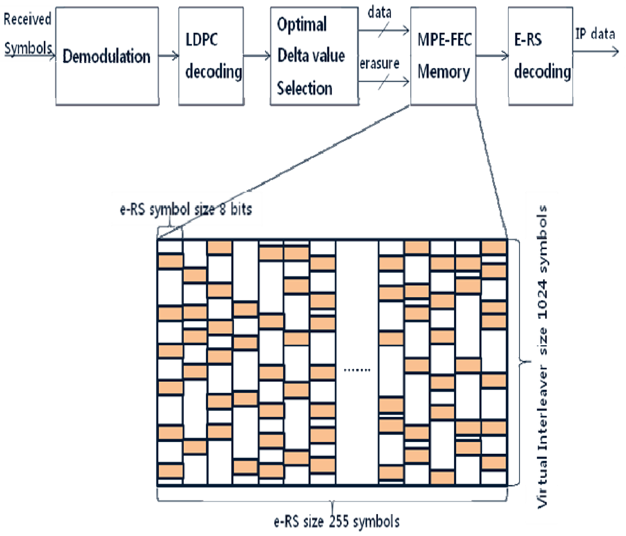


Fig. 7. MPE-FEC memory base on LLR

4. Simulation results

Fig. 8 shows the simulation results in order to determine the LLR value for the LLR method. At the simulation results, delta = 4 is optimal results. It means that symbol including bit, has absolute value of LLR is less than 4 in LDPC decoder, is erased.
The number of total erasure is the number of symbol that is less than value of delta. If delta is too large, the number of total erasure is exceeded maximum error correction capability. And if delta is too low, error correction is failed.
Fig. 9 shows comparison LLR method with CRC method. In this figure, the BER performance of LLR method is better than CRC method as 0.2 dB.

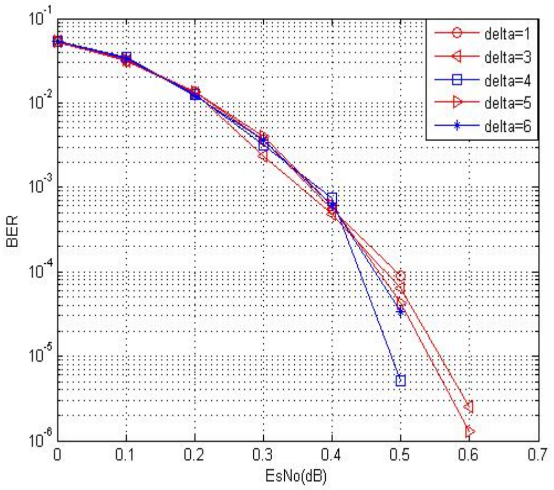


Fig. 8. The performance of LLR method by value of delta.

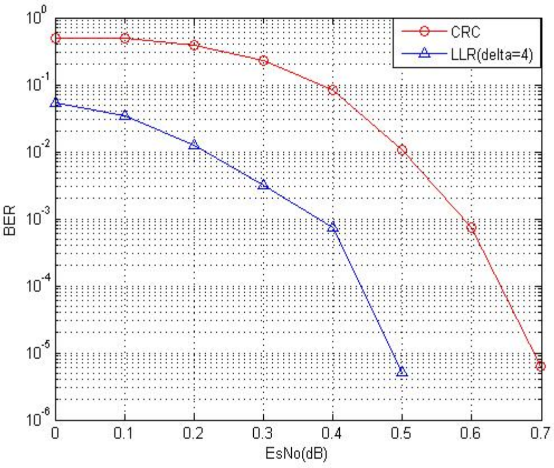


Fig. 9. Comparison LLR method with CRC method

5. Conclusions

In this paper, we propose that LLR method using the LLR value at the LDPC output and proposed the selective erasure by LLR method.
We simulated proposed DVB-SSP scheme that is used the e-RS(255,191,64) as UL-FEC and the LDPC(N=16200) code of DVB-S2 as PL-FEC. At the simulation results, optimal value of delta is 4, and the performance of LLR

method is better than conventional CRC method as 0.2dB. Moreover using LLR method can improve data process speed and data rate.

References

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