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Performance Evaluations of FEC Codes in Mobile Video Broadcast

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***Abstract*— In mobile TV services, the bit stream structure of layered media format like Scalable Video Coding (SVC) opens up new opportunities. The SVC permits the division of a single stream into sub-streams with smaller size. These sub-streams or layers represent dissimilar quality levels across the overall video stream. The information received over any transmission channel may be exaggerated by losses due to number of different factors such as network congestion, faulty networking hardware and signal degradation. Thus, the decoding of some parts of the lost bit stream is possible, if the corresponding significant parts of bit stream are correctly received.Forward Error Correction (FEC) is applied to handle these transmission errors in mobile video broadcast systems. In this paper, we categorize Low Density Parity Check (LDPC) codes and Luby Transform (LT) as FEC codes to correct transmission errors. The performance of LDPC codes and LT codes are analyzed and simulated in terms of Bit Error Rate (BER) for different code rates. LT codes perform better than LDPC codes.**

Keywords— **Layered media, SVC, LDPC, FEC, BER, LT.**

I. INTRODUCTION

In mobile video broadcast, a variety of proposals have been illustrated as different video coding solutions to enhance the consistency of data transmission over erroneous channels in the last few years. A well-known video coding standard called H.264/AVC standard is the most recentamong all the video coding standards. It encodes video data, in such a way that it outperforms all its predecessors significantly. H.264/AVC is designed such that all the source data is encoded within one single data stream. In such a stream, the video is encoded with only one certain spatial and temporal quality level. In order to improve this feature, the new Scalable Video Coding (SVC), an extension of the H.264/AVC video coding standard has been created [1].

A.Forward Error Correction

In mobile broadcast systems, ForwardErrorCorrection (FEC) is used to attain a well-organized deliverance of data on layered media (SVC).Retransmissions of lost packets are generally not possible due to non-availability of return path in broadcast systems [2]. Therefore, FEC mechanism is used to achieve error correction by transmitting redundant data in the form of parity data. This parity data enables the receivers for retrieving the original data even if some data are not appropriately received due to transmission errors. The error correction is “forward” in the intellect that no feedback (return channel) from the receiver to the transmitter is required. FEC mechanisms can be applied to physical layer and upper layers, specifically in application layer and data link layer [2].Physical layer FEC codes that work at the bit level are traditionally implemented as part of the radio interface of wireless communication systems. Examples of physical layer FEC codes that are adopted in standards for mobile broadcasting are: convolution codes in DVB-H [3], turbo-codes in DVB-SH [4] or 3GPP [5], and low-density-parity-check (LDPC) codes in DVB-T2 [6].

II. LDPC CODES

A. Introduction

LDPC codes provide near-capacity enactment on a large collection of data communication and channel capacity while still maintaining implementable decoders. Due to the powerful error-correcting capability, LDPC [7] codes have become best error-correcting codes for applications in wireless communication and digital television.A low-density parity check code is a long linear binary block code whose parity checksmatrix H has low density of non-zero elements. Specifically H is sparse and contains a trivial fixed number of non-zero elementsin its rowsand column. The number of non-zero elements in its column and row referred to as column weight (w_c) and row weight (w_r) respectively. If the block length is n, then H characterizes an (n, w_c, w_r) code. These codes may be mentioned to as regular LDPC codes to distinguish from irregular codes whose values of w_c and $w_r$are not constant.

B. Encoder

The sparse parity check matrix H of LDPC codes in a finite Galois field $GF(q)$ consists of M mutually self-governing rows and N columns. From H, a systematic N xK *(with K=N-M)* generator matrix G^T can be assembled such that the rows of H generate the null-space of G^T, i.e. $HG^T=0$. We consider irregular LDPC codes over binaryextension fields *GF (q).* A block of *Kb* bits is converted to a sequence of K $GF(2^b)$elements according to some mapping $(GF(2))^b \to GF(2^b)$. The attained information is encoded using the generator matrix $b \in (GF(2^b))^K$, resulting in a code word $C \in \zeta$, with ζ denoting the set of code words. Clearly, ζ is a linear subset of $b \in (GF(2^b))^N$. In matrix notation, this is given by the equation (2.1)

$$c = G^T b \qquad (2.1)$$

It can be easily shown by the equation (2.2) [7]

$$c \in \zeta \Leftrightarrow (s =)Hc \qquad (2.2)$$

The elements of S and C are the checksand variables, respectively. If a given check is zero, the contributing variables content that particular check. The code word is now mapped to a signaling constellation Ω, resultant in a vector ***t*****.** Binary Phase Shift Keying(BPSK) signaling, although extensions to higher order constellations are straightforward. Thus, $\psi : GF(q) \to \Omega^b$ such that withΩ={-1,+1} such that $\psi(c_k) = [t_{kb},....t_{(k+1)b-1}]^T$ and $t_i \in \Omega$ When the vector t is communicated through an Additive White Gaussian Noise channel [7], it is corrupted by noise, yielding a received vector x.

$$X = t + n \qquad (2.3)$$

With n a real vector of independent white Gaussian noise samples with power $\sigma^2 = N_0 / 2E_b K / N$ where E_b / N_0 the Signal to Noise Ratio (SNR) is per information bit and K/N is the code rate.

B. Decoder

Input:H, channel posterior probabilities $p_n(x) = P(c_n = x \mid r_n)$and the maximum number of iterations, L [7].

Step 1:Initialization: set $q_{mn}(x) = p_n(x)$ for all *(m,n)* with *H(m,n)=1.*

Step 2:Horizontal step: For each *(m,n)* with *H(m,n)*=1

$$\text{Compute: } \delta q_{ml} = q_{ml}(0) - q_{ml}(l) \qquad (2.4)$$

$$\text{Compute: } \delta r_{mn} = \prod_{n \in N_{m,n}} \delta q_{mn'} \qquad (2.5)$$

Compute:

$$r_{mn}(1) = (1 - \delta r_{mn}) / 2 \qquad (2.6)$$

$$r_{mn}(0) = (1 + \delta r_{mn}) / 2 \qquad (2.7)$$

Step 3 :Vertical step:

Compute:

where α_{mn} is chosen so that $q_n(0)+ q_n(1)=1$

Step 4 :Tentative decoding

Set $\hat{c}_n$ =1 if $q_n(1)$ >0.5 , else set $\hat{c}_n$ =0

Step 5:Decision

If $A\hat{c}=0$ then stop. Otherwise,if number of iterations < L loop to step 2. Otherwise, the deocoder declare it as a decoding failure and stops[7].

III. LT CODES

A. *Introduction*

Luby transform codes (LT codes) are the first class of practical fountain codes that are neighboring optimal erasure correcting codes invented by Michael Luby [8]. Like some other fountain codes, LT codes rest on on sparse bipartite graphs to trade reception overhead for encoding and decoding speed. The unique characteristic of LT codes is in employing a particularly simple algorithm based on the operation to encode and decode the message. LT codes are rateless because the encoding algorithm can produce an inestimable number of message packets (i.e., the percentage of packets that must be received to decode the message can be arbitrarily small).

B. *Encoding algorithm*

Each encoding symbols is generated independently of all other symbols by the following process.

For each code symbol:

- Randomly select the number of information packets to be XORed conferring to the robust soliton distribution.
- Randomly select the positions of the information packets to be XORed according to a uniform distribution.
- XOR the selected bits to generate the code symbol.

C. *Degree Distribution*

The degree of distribution used by the encoder is a very significant factor in the LT code's performance. LT Codes do not have fixed rate. The probability of success recovery is as high as possible while the number encoding symbols is kept small. There are two types of soliton distribution namely Ideal soliton distribution and robust soliton distribution.

Ideal soliton distribution is given by

$$\rho(1), \ldots, \rho(K) = \begin{cases} \rho(1) = \frac{1}{K} \\ \rho(d) = \frac{1}{d(d-1)} \quad for\ d = 2, \ldots, K \end{cases}$$

The robust soliton distribution has two extra parameters, c and δ it is designed to confirm that the predictable number of degree-one checks and it is given by

$$S \equiv c\ln(K/\delta)\sqrt{K}$$

Where the parameters c and δ are empirical constant. The parameter δ denote the decoding failure. The parameter *c is* the positive constant.

We define a positive function $\tau(d) =$

$$\begin{cases} \frac{S}{K}\frac{1}{d} & for\ d = 1,2,\dots,\left(\frac{K}{S}\right)-1 \\ \frac{S}{K}\ln\left(\frac{S}{\delta}\right) & for\ d = K/S \\ 0 & for\ d > K/S \end{cases}$$

Then add the ideal soliton distribution ρ to τ and normalize to obtain the robust soliton distribution, μ:

$$\mu(d) = \frac{\rho(d) + \tau(d)}{Z}$$

where $Z = \sum_d \rho(d) + \tau(d)$.

D. Decoding Algorithm

- Find a code symbol c_i that is connected to only one information packet v_j .
- Set $v_j = c_i$.
- Add v_j to all code symbols c_i's that are connected to v_j .
- Remove all edges connected to the information packet v_j.
- Repeat steps 1-4 until all information packets are recovered.

If a code symbol has no one degree the decoder declares a decoding failure.

V. SIMULATIONS AND RESULTS

1.Bit ErrorRate

In digital transmission systems, the number of bit errors is defined as the number of incorrectly received bits of data stream over a communication channel that have been changed due to noise, interference andthe distortion. The Bit Error Rate (BER) is the number of bit errors divided by the total number of transmitted bits during a premeditated time interval. BER is a unit less performance measure, often expressed as a percentage. The Fig. 2. Shows the BPSK Bit Error Rate performance at the code rate of 0.33, 0.5, and 0.75. These simulations were made by adding Gaussian Noise to a code word.

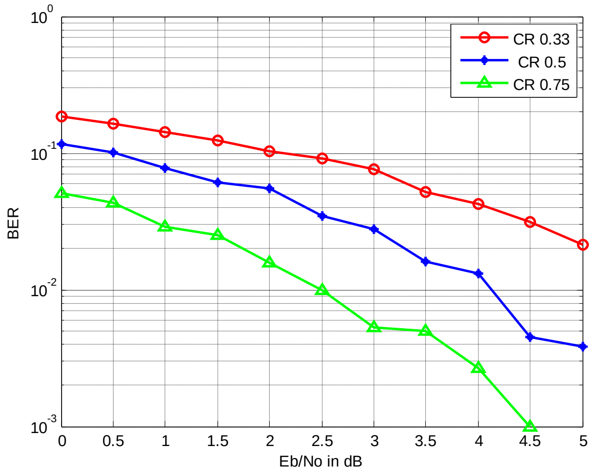

Fig.2 BER performance for LDPC Codes

IV. CONCLUSION

In this work, the performance of the FEC codes such as LDPC codes and LT codes have been analyzed. The BER performance for different code rates is simulated on an erasure channel model. From the analyses it is clearly shown that the performance of LT codes is better than the LDPC codes.

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