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An innovative Accession intended for FEC Decryption predicated on the BP Contrivance in LTE as well as WiMAX Conformity

G. Kumar,
M.Tech Student,
Department of CSE,
ASCET, Gudur,

Prof. C. Rajendra,
Head, Department of CSE,
ASCET, Gudur

Abstract—**Numerous wireless contact systems such as IS-54, superior data tariff for the GSM succession (EDGE), universal interoperability for microwave access (WiMAX) and long term progression (LTE) have adopted low-density parity-check (LDPC), tail-biting intricacy, and turbo codes as the forward error correcting codes (FEC) method on behalf of information and transparency channels. Consequently, several well-organized algorithms have been projected for decoding these codes. Conversely, the dissimilar decoding approach for these two families of codes frequently pilot to dissimilar hardware frameworks. From the time when these codes work side by side in these new broadcasting schemes, it's an tremendous suggestion headed to forge a universal decoder to seize these two heirs of codes. The current work exploits the parity-check matrix (H) illustration of tail biting helix and turbo cipher thus permitting decoding through a amalgamated belief propagation (BP) algorithm. undeniably, the BP algorithm provides a exceedingly efficient wide-ranging slant for devising low-intricacy iterative decoding algorithms in favor of all gyration code classes in addition to turbo codes. Where as a miniature recital thrashing is pragmatic when decoding turbo codes with BP as an alternative of MAP, It is counterbalance by the inferior complication of the BP algorithm and the inborn benefit of a amalgamated decoding structural design.**

I. INTRODUCTION

In anticipation of recently, most known decoding algorithms for helix codes were based on whichever algebraically manipulative the blunder prototype or on lattice graphical representations such the same as in the MAP and Viterbi algorithms. With the introduction of turbo coding , a third decode standard have appeared monotonous decoding. Monotonous decoding was furthermore originated in Tanner's revolutionary exertion [2], which is a universal agenda based on bisected graphs for the narrative of LDPC codes and their decoding passing through the conviction promulgation (BP) algorithm. In numerous compliments, helix codes are comparable to wedge codes. For instance, if we shorten the grille by which a helix code is emblematized, a wedge code whose watchwords match up to all grille paths to the truncation profundity is shaped. Nevertheless, this truncation instigates a setback in inaccuracy recital, in view of the fact that the last bits be deficient in error protection.

The predictable resolution to this setback is to predetermine a permanent amount of communication blocks L followed by m further all-zero blocks, where m is the restriction duration of the helix code [4]. This technique provides unvarying error fortification projected for every message blocks but causes a rate reduction for the block code as compared to the helix code by the multiplicative factor $L/(L+m)$. In the tail-biting helix code, zero-tail bits are not desirable and replaced by freight bits consequential in no velocity trouncing due to the tails. Therefore, the ethereal competence of the channel code is improved. Due to the compensation of the tail-biting technique above the zero-tail, it has been ratified as the FEC in toting up to the turbo code for records and transparency channels in numerous wireless interactions structures aforesaid like Back Haul technology, IS-54, EGPRS, and LTE [5,6,7]Equally turbo and LDPC codes have been expansively premeditated for more than fifteen years. However, the formal relationship between these two classes of codes remained indistinct in anticipation of Mackay in [8] justifies to facilitate turbo codes are LDPC codes. Also, Wiberg in [9] manifest an additional effort to relate these two classes of codes together by developing a amalgamated aspect graph adumbration for these two families of codes. In [10], Mc Eliece blazon in the midst of the objective of their decoding breakthrough drop into the similar grouping as BP on the Bayesian conviction network. Finally, Colavolpe [11] was proficient to make obvious the exploit of the BP algorithm to decode helix and turbo codes. The maneuver in [11] is restricted to unambiguous classes of helix codes, such as helix self orthogonal codes (CSOCs).Also, the turbo codes therein are based on the consecutive configuration while the analogous structure is more ubiquitous in matter-of-fact applications.

In LTE and WiMAX structures, the projected decoders forth tail-biting helix codes and turbo codes are hinge on the Viterbi algorithm and MAP algorithm correspondingly. Nevertheless, numerous other proficient contrivances have been projected to decode tail-biting helix codes in addition to turbo codes. For instance, in [3], the abridged complication twirl Viterbi algorithm was projected to decode tail-biting helix codes in the WiMAX structures to condense the typical figure of decoding recitation and memory convention. In totaling, further decoding algorithms for instance double trace back and bidirectional Viterbi algorithms were also projected for tail-biting helix codes in LTE [4]. Lastly in [5], the design and escalation of little-complication high recital rate-harmonizing algorithms based on globular fenders for LTE turbo codes was reconnoiter In this paper, we focus on the straight relevance of the BP algorithm used for LDPC codes to decode the tail-biting Helix codes and turbo cipher in WiMAX and LTE systems, correspondingly. Based on that, we intend a decoder with significantly lower accomplishment complication than that projected in the newest deliverances for these structures [5-7].The respite of this paper is prearranged as supervene. In Section II and III, the graphical depiction of the tail-biting helix and turbo cipher with the essential memorandum and elucidation used right through this paper are introduced, displace by an exploration of the coding architectures in WiMAX and LTE structures in Section IV. In Section V, mock-up consequences for the presentation of tail-biting helix and turbo cipher using the projected algorithm are introduced followed in Section VI by a complexity assessment between the proposed algorithm and the customary ones. Finally, the paper is concluded in Section VII.

II. HELIX CODES

First introduced by Elias in 1955 [15], binary helix codes are one of the most admired forms of binary error correcting codes that have found plentiful applications .A helix code is called tail-biting when its watchwords are those code catenation allied with paths in the grille that establish from a state identical to the last m bits of an in sequence trajectory of k data bits. Many proficient algorithms have been projected for untangle the tail-biting helix codes such as the Viterbi and MAP algorithms. As shown below, we symbolize the tail-biting helix code by its originator and parity-check matrices in organize to apply the BP algorithm unswervingly.

A. Parity-check matrix of tail-biting helix codes

To be able to signify a tail-biting helix code by a Saddle graph and then affect the BP algorithm to its decoding, a precondition is to attain its originator matrix **G** and its parity check matrix **H**. We introduce the matrix depiction by a basic example as follows: *Example 1:* Consider the helix code with rate $R = k/n = 1/2$, where k typify the number of input bits and n the output bits. Presume that the information consecution is $\mathbf{x} = (x_0, x_1, x_2, \ldots)$. The encoder will translate this to the catenation $\mathbf{y}^{(0)} = (y_0^{(0)}, y_1^{(0)}, y_2^{(0)}, \ldots)$ and $\mathbf{y}^{(1)} = (y_0^{(1)}, y_1^{(1)}, y_2^{(1)}, \ldots)$ .Note that if there are manifold input streams, we can refer to a single interleaved input $\mathbf{x} = (x_0^{(0)}, x_1^{(1)}, \ldots)$. Also, the output streams are multiplexed to create a single oblique data stream $\mathbf{y} = (y_0^{(0)}, y_0^{(1)}, y_1^{(0)} y_1^{(1)}, \ldots)$ where **y** is the helix codeword. In toting up each factor in the interleaved output stream **y** is a linear amalgamation of the rudiments in the input tributary $\mathbf{x} = (x_0^{(0)}, x_0^{(1)}, \ldots, x_0^{(k-1)}, x_1^{(0)}, x_1^{(1)}, \ldots, x_1^{(k-1)}, \ldots)$.An impulse response $g^{(j)}$ is procured from the encoder output by exploiting a single 1 at the input followed by a twine of zeros, then strings of zeros are applied to all the other inputs(in the case of multiple inputs). The impulse reverberations for the encoder in our example are

$$\begin{aligned} g^{(0)} &= (1011), \\ g^{(1)} &= (1101). \end{aligned}$$

The inclination responses are often referred to as originator sequences, because their affiliation to the code words generated by the corresponding helix encoder is similar to that flanked by generator polynomials and code words in a cyclic code. The generator sequences can be articulated in the subsequent universal form:

$$y_t^{(j)} = \sum_{l=0}^{m-1} x_{t-1} g_l^{(j)} \tag{1}$$

Each coded output progression $\mathbf{y}^{(j)}$ in a rate 1/n code is the Helix of the input progression **x** and the inclination response $g^{(j)}$,

$$y^{(j)} = x * g^{(j)} \tag{2}$$

In vector form, this is expressed

$$\mathbf{y}^{(j)} = \sum_{i=0}^{k-1} \mathbf{x}^{(i)} * g_i^{(j)}, \tag{3}$$

which can be developed thus

$$y_t^{(j)} = \sum_{i=0}^{k-1} \left[\sum_{l=0}^{m_i-1} x_{t-1}^{(i)} g_{i,l}^{(j)} \right] \tag{4}$$

We can articulate these forms as a matrix duplication procedure, thus as long as a originator matrix comparable to that urbanized for block codes .In fact, the crucial dissimilarity arises from the fact that the input progression is not unavoidably bounded in length, and thus the generator and parity check matrices for helix codes are semi inestimable. However, herein we commence the **G** and **H** matrices as counterpart to a tail-biting helix code having predetermined span. Consequently, the originator and parity-check matrices will be as follows [4]:

$$\mathbf{G} = \begin{bmatrix} \mathbf{G}_m & \cdots & \cdots & \mathbf{G}_0 & \mathbf{G}_1 & \cdots & \mathbf{G}_{m-1} \\ \mathbf{G}_{m-1} & \mathbf{G}_m & \cdots & & \mathbf{G}_0 & \cdots & \mathbf{G}_{m-2} \\ \mathbf{G}_{m-2} & \mathbf{G}_{m-1} & \mathbf{G}_m & \cdots & & \ddots & \ddots \\ \ddots & \ddots & \ddots & & & & \\ & \mathbf{G}_1 & \cdots & \mathbf{G}_{m-1} & \mathbf{G}_m & \cdots & \mathbf{G}_0 \\ \mathbf{G}_0 & \mathbf{G}_1 & \cdots & \cdots & \mathbf{G}_m & & \\ & \mathbf{G}_0 & \mathbf{G}_1 & \cdots & \cdots & \mathbf{G}_m & \\ & \ddots & \ddots & & & \ddots & \\ & & \mathbf{G}_0 & \mathbf{G}_1 & \cdots & \cdots & \mathbf{G}_m \end{bmatrix} \tag{5}$$

Where

$$\mathbf{G}_l = \begin{bmatrix} g_{1,l}^{(1)} & g_{1,l}^{(2)} & \cdots & g_{1,l}^{(n)} \\ g_{2,l}^{(1)} & g_{2,l}^{(2)} & \cdots & g_{2,l}^{(n)} \\ \vdots & \vdots & & \vdots \\ g_{k,l}^{(1)} & g_{k,l}^{(2)} & \cdots & g_{k,l}^{(n)} \end{bmatrix} \tag{6}$$

Note that each wedge of k rows in the **G** matrix is a circular shift by n positions of the preceding such block. In general, the parity-check matrix of a rate k/n tail-biting helix code with constriction length m is

$$\mathbf{H} = \begin{bmatrix} \mathbf{P}_0^T|\mathbf{I} & \cdots & \cdots & \mathbf{P}_m^T|\mathbf{0} & \mathbf{P}_{m-1}^T|\mathbf{0} & \cdots & \mathbf{P}_1^T| \\ \mathbf{P}_1^T|\mathbf{0} & \mathbf{P}_0^T|\mathbf{I} & \cdots & \cdots & \mathbf{P}_m^T|\mathbf{0} & \cdots & \mathbf{P}_2^T|\mathbf{0} \\ \ddots & \ddots & & \cdots & \ddots & & \\ \cdots & \mathbf{P}_1^T|\mathbf{0} & \mathbf{P}_0^T|\mathbf{I} & \cdots & \cdots & \cdots & \mathbf{P}_0^T|\mathbf{0} \\ \mathbf{P}_m^T|\mathbf{0} & \mathbf{P}_{m-1}^T|\mathbf{0} & \cdots & \mathbf{P}_1^T|\mathbf{0} & \mathbf{P}_0^T|\mathbf{I} & \cdots & \\ \ddots & \ddots & & \cdots & \ddots & & \\ & \mathbf{P}_m^T|\mathbf{0} & \mathbf{P}_{m-1}^T|\mathbf{0} & & \cdots & \mathbf{P}_1^T|\mathbf{0} & \mathbf{P}_0^T|\mathbf{I} \end{bmatrix}$$

Where **I** is the k x k identity matrix, **0** is the k x k all zero matrix, and P_i, $i = 0, 1, \ldots, m$, is a $k(n-k)$matrix whose entries are

$$\mathbf{P}_i = \begin{bmatrix} g_{1,i}^{(k+1)} & g_{1,i}^{(k+2)} & \cdots & g_{1,i}^{(n)} \\ g_{2,i}^{(k+1)} & g_{2,i}^{(k+2)} & \cdots & g_{2,i}^{(n)} \\ \vdots & \vdots & & \vdots \\ g_{k,i}^{(k+1)} & g_{k,i}^{(k+2)} & \cdots & g_{k,i}^{(n)} \end{bmatrix} \tag{8}$$

Here, $g_{p,i}$ is equal to 1 or 0 consequent to whether or not the i^{th} stage of the shift range for the input subsidize to production $j(i = 0, 1, ..., m; j = (k + 1), (k + 2), ..., n; p = 1, 2, ..., k)$. Since the last m bits serve as the preliminary state and are also fed keen on the encoder, there is an end-round-shift Occurrence for the last m columns of **H**. *Example 2:* Consider the preceding encoder shown in Example 1, assume that a block of $k = 6$ in sequence bits are encoded. Then the tail-biting assembly gives a binary (12,6) code with originator and parity check matrices

$$\mathbf{G} = \begin{bmatrix} 11 & 01 & 10 & 11 & 00 & 00 \\ 00 & 11 & 01 & 10 & 11 & 00 \\ 00 & 00 & 11 & 01 & 10 & 11 \\ 11 & 00 & 00 & 11 & 01 & 10 \\ 10 & 11 & 00 & 00 & 11 & 01 \\ 01 & 10 & 11 & 00 & 00 & 11 \end{bmatrix} \quad (9)$$

and

$$\mathbf{H} = \begin{bmatrix} 11 & 00 & 00 & 11 & 01 & 10 \\ 10 & 11 & 00 & 00 & 11 & 01 \\ 01 & 10 & 11 & 00 & 00 & 11 \\ 11 & 01 & 10 & 11 & 00 & 00 \\ 00 & 11 & 01 & 10 & 11 & 00 \\ 00 & 00 & 11 & 01 & 10 & 11 \end{bmatrix} \quad (10)$$

B. *Degree allocation of Tanner graph for tail-biting Helix Codes*

Looking at the **H** matrix of a tail-biting helix code, we can perceive that it is comparable to the **H** matrix of an asymmetrical LDPC code where the numeral of non-zero elements is not a fixed number per row and column. Our goal is to represent the tail-biting helix codes through Tanner graphs in regulate to decode them using the BP algorithm. Therefore, it is significant to get hold of the degree allocation of the Tanner graph which delineates the amount of edges into the bit and ensure nodes in asymmetrical LDPC codes. The portion of edges which are associated to degree-i bit nodes is denoted λ_i and the portion of edges which are associated to degree-i check nodes is denoted p_t. The functions

$$\lambda(x)=\lambda_1 x+\lambda_2 x^2+\ldots+\lambda_i x^{i-1}+\ldots \quad (11)$$

$$p(x)=p_1 x+p_2 x^2+\ldots+p^i x^{i-1}+\ldots \quad (12)$$

are distinct to portray the degree dispensations.

III. TURBO CODES

To restore the conventional decoders of turbo codes by the BP decoder, we boast to get hold of the parity-check matrix for the turbo code as was completed in the preceding segment for the tail-biting helix codes.

A. *Parity check matrix for turbo codes*

Let us consider a recursive systematic convolution (RSC) code C_0 of rate $R = 1/2$. It has two originator polynomials $_{g1}(X)$ and $_{g2}(X)$ of degree $v + 1$, where v is the memory of the encoder. Let $_{u}(X)$ be the input of the encoder and $_{x1}(X)$ and $_{x2}(X)$ its outputs. We believe this code as a block code annexed from the zero-tail truncation of the RSC. Using the parity check matrix **H** of the RSC, we can do some column metamorphosis and reword the **H** milieu as **H**new, where **H**new= [**H**1 **H**2]. As divulged before, we consider a conventional turbo code C, consequential from the parallel nexus of two indistinguishable RSC codes C_0 and whose common inputs are estranged by an interleaver of length N, represented by matrix **M** of size $N \times N$ with accurately one nonzero constituent per row and column. It is well known that the superior presentation of turbo codes is primarily due to the interleaver, i.e., due to the cycle organization of the Tanner graph. Hence, the parity check matrix of the whole turbo code is (for a comprehensive testimony, the reader is referred to):

$$\mathbf{H}_{turbo} = \begin{bmatrix} \mathbf{H}_2 & \mathbf{H}_1 & 0 \\ \mathbf{H}_2\mathbf{M}^T & 0 & \mathbf{H}_1 \end{bmatrix}. \quad (13)$$

Example 3: Let us currently deem the unique case of a RSC code C_0 of rate $R = 1/2$ whose input $_{u}(X)$ has a predetermined degree $N-1$ (i.e. the input vector has size N). Its parity-check matrix **H** can currently be written as an $N \times 2N$ milieu above GF(2) whose coefficients are predetermined by its originator. The first (correspondingly second) $N \times N$ part of **H** consists of diverged rows on behalf of the coefficients of $_{g2}(X)$ (respectively $_{g1}(X)$). For example, espousing $_{g1} = 101$, $_{g2} = 111$ and $N = 8$, we boast:

$$\mathbf{H} = \left[\begin{array}{c|c} 11100000 & 10100000 \\ 01110000 & 01010000 \\ 00111000 & 00101000 \\ 00011100 & 00010100 \\ 00001110 & 00001010 \\ 00000111 & 00000101 \\ 00000011 & 00000010 \\ 00000001 & 00000001 \end{array}\right]$$

Note to facilitate the quantity of non-zero rudiments per row and per column in the "diagonal" sub-matrices **H**1 and **H**2 is upper delimited by $L = v + 1$, the constriction span of the essential codes, which is always very small in assessment to the span of the interleaver. Also, the interleaver does not Modify the adiposity of the sub-matrix **H**2$\mathbf{M}^T$. As with the tail biting helix code, the **H** matrix for a turbo code can as well be discern as the **H** matrix of an unequal LDPC code, while the adiposity of non-zero rudiments per row and column is not sternly stable, but all the time very small ponder to the amount of the parity-check matrix. Then, the parity-check milieu for the designate turbo code in our model will be as follows:

$$\mathbf{H} = \begin{bmatrix} 10100000 & 11100000 & 0000000 \\ 01010000 & 01110000 & 0000000 \\ 00101000 & 00111000 & 0000000 \\ 00010100 & 00011100 & 0000000 \\ 00001010 & 00001110 & 0000000 \\ 00000101 & 00000111 & 0000000 \\ 00000010 & 00000011 & 0000000 \\ 00000001 & 00000001 & 0000000 \\ & & \\ 00001001 & 0000000 & 11100000 \\ 01010000 & 0000000 & 01110000 \\ 00000101 & 0000000 & 00111000 \\ 10010000 & 0000000 & 00011100 \\ 00000110 & 0000000 & 00001110 \\ 10100000 & 0000000 & 00000111 \\ 00000010 & 0000000 & 00000011 \\ 00100000 & 0000000 & 00000001 \end{bmatrix}$$

Following (9) and (10) provided in the earlier section, the grade allocation of this turbo code is given by

$$\lambda(x) = 0.219667x+0.083333x^2+0.25x^3+0.166667x^4+0.208333x^5 \quad (14)$$

$$p(x) = 0.083333x^2+0.125x^3+0.033333x^4+0.208333x^5+0.25x^6 \quad (15)$$

IV. WIMAX AND LTE CLASSIFYING COMPOSITION

To deal with the low and high rate supplies of LTE, the 3rd Generation Partnership Project (3GPP) functioning group Covenant meticulous study of sophisticated channel tabulate candidates such as tail-biting helix and turbo codes for low and high data tariff, correspondingly. We scrutinize here the relevance of the BP decoder for the projected turbo code in LTE structures. Meanwhile, a rate ½, memory-6 tail-biting helix code has been espoused in the WiMAX (802.16*e*) structure, because of its best lowest aloofness and the smallest number of least weight watchwords for superior than 32-bit Payloads which are used for equally frame control header (FCH) and data canyons. In fact, we will cynosure at this juncture on the FCH which has a great deal condensed payload sizes (12 and 24 bits) as exposed in the next section.

A. Tail-biting Helix code in 802.16e

Here, we in brief explain the WiMAX frame control header arrangement. In the WiMAX Orthogonal Frequency Division Multiplexing (OFDM) corporal layer, the payload size of the frame control header is moreover 24 bits or 12 bits and the minimum unit for basic data packet broadcast is one sub channel. A sub channel abides of 48 QPSK cryptograms (96coded bits). At a cipher rate of ½, one sub channel elucidates to48 bits as the nominal in sequence wedge size. Presently, the FCH payload bits are recurring to meet the least digit (48) of encoder in sequence bits. The originator polynomials for the rate ½ WiMAX tail-biting helix code are given by g_1 = (1011011) and g_2 = (1111001) in binary information Conceded to, these originator polynomials have the paramount d_{min} (minimum distance) and nd_{min}(number of code words with weight d_{min}) for payload sizes 25 and 33 bits and for several payload sizes flanked by 25 and 33 bits, beneath the limitation of reminiscence amount m = 6 and code rate ½.

B. Turbo code in LTE classification

The 3GPP turbo code is a methodical parallel concatenated convolution code (PCCC) with two 8-state vital encoders and one turbo code marital inter leaver. Each constituent encoder is autonomously finished by tail bits. For an input wedge size of K bits, the output of a turbo encoder recline of three extent K drifts, equivalent to the meticulous and two similarity bit rivulets(referred to as the "Systematic", "Parity 1", and "Parity 2" streams in the following), likewise, as well as 12 tail bits suitable to trellis extermination. Thus, the authentic mother code rate is barely inferior than 1/3. In LTE, the tail bits are multiplexed to the ending of the three streams, whose lengths are accordingly augmented to (K + 4)bits each [5]. The shift task of the 8-state essential code for the PCCC is

$$G(D) = \left[1, \frac{g_1(D)}{g_0(D)}\right]$$

Where

$$g_0(D) = 1 + D^2 + D^3.$$

$$g_1(D) = 1 + D + D^3$$

The preliminary assessment of the budge registers of the 8-state component encoders force be all zeros after untimely to predetermine the input bits. The manufacture from the turbo encoder is $d^{(0)}_k = x_k$, $d^{(1)}_k = z_k$, and $d^{(2)}_k = z_{,k}$ for k = 0, 1, 2, . . .,K−1. If the code wedge to be encoded is the 0-th code wedge and the sum of stuffing bits is superior than zero, i.e., F > 0, subsequent so as to the encoder will set ck = 0, k = 0,. . . , (F-1) at its input and will set $d^{(0)}_k$ =<NULL >, k = 0,. . . , (F-1) and $d^{(0)}_k$ =< NULL >, k = 0,. . . ,(F-1) at its output [5]. The bits input to the turbo encoders are denoted by c_0, c_1, c_2, c_3, . . . , c_{K-1}, and the bits output from the first and second 8-state component encoders are gesticulated by z_0, z_1, z_2, z_3, . . . , z_{K-1} and $z_{,0}$, $z_{,1}$, $z_{,2}$, $z_{,3}$, . . . , $z_{,K-1}$,likewise. The bits output from the turbo code interior inter leaver are denoted by $c_{,0}$, $c_{,1}$, . . . , $c_{,K-1}$, and these bits are to be the input to the second 8-state component encoder.

V. SIMULATION RESULTS

Considering the preceding illustration of the tail-biting helix code in WiMAX systems and twofold broadcast in excess of an AWGN conduit, the BP algorithm as in [4] is contemplated between the maximum-likelihood (ML) Viterbi type algorithms to decode the identical tail-biting helix code [9, 12]. To conclude by replication the utmost decoding concert potential of every algorithm, as a minimum 300 watchwords errors are fathomed at every SNR assessment. Figure 1 shows a recital assessment flanked by the two mentioned decoding algorithms for a payload size of 24 bits. Note to facilitate the most number of replications for the BP algorithm is 30 replications. The simulation consequences illustrate that the projected BP algorithm manifests a slender recital sentence with reverence to the ML Viterbi category algorithm. Nevertheless, since the BP decoder is less multifarious than this conventional decoder and enables a amalgamated decoding advance, this loss in BER recital is affirmed satisfactory.

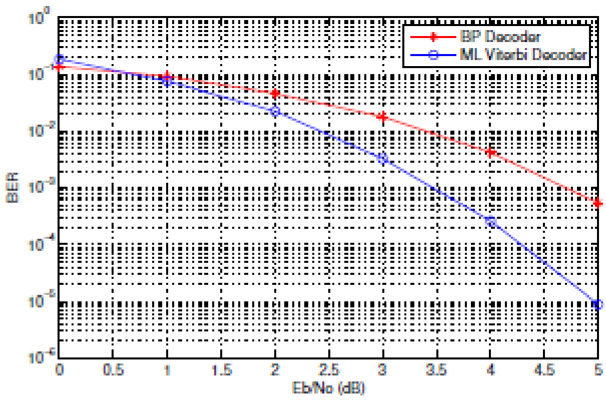

Figure 1: comparisions of BER for length-24 rate ½ tail biting helix code

In toting up, a assessment flanked by the equivalent petite duration code by means of the BP and ML Viterbi algorithms has been perpetrated in Figure 2. In this crate, a loss of 1.85 dB or less in FER contrasted with the conventional decoder is pragmatic

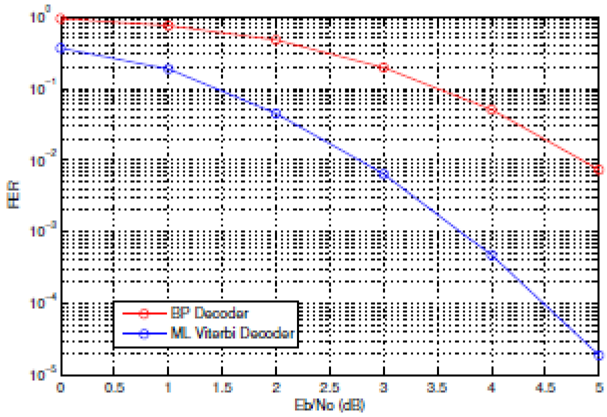

Figure 2. Comparisons of FER for length-24 rate ½ tail-biting helix code

In Figure 3, we report replication consequences for the AWGN channel for the LTE turbo code that was deliberate in the preceding segment. When allegorized to the customary MAP and SOVA decoders [11, 12], the BP algorithm is concerning 1.7 dB not as good as at a BER worth of 10−2. Also, as we accumulated a universal structure for the parity-check matrices of tail-biting helix and turbo codes, then we can augment the recital by probing additional decoding algorithms which are also valid for LDPC codes.

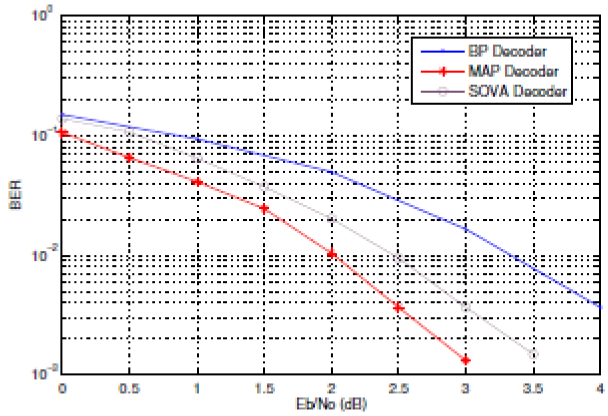

Figure 3. Comparisons of BER for length-40 rate 1/3 turbo code.

For auxiliary research, we recommend exploring determinations to the drenching agenda regularly espoused for LDPC codes to augment the BER concert

VI. CONVOLUTION ASSESSMENT

A unswerving association among the convolution of unusual decoding algorithms is accomplishment reliant. Starting with the conventional decoders for turbo codes, the MAP procedure gauges the log-probability for all paths in the grille. The MAP algorithm calibrations the metric for together conventional binary zero and a customary binary one, then allegorizes them to conclude the best largely approximation. The SOVA procedure only deduces two paths of the grille per step: the best path with a information bit of zero and the finest lane with a information bit of one. In addition, it utilizes the difference of the log-probability occupation for each of these paths. Nevertheless, the SOVA is the smallest amount multifarious of the two algorithms in requisites of quantity of deductions [14]. Lastly, intended for the BP algorithm, the decoding intricacy per reoccurrences grows progressively with the number of boundaries (the numeral of messages conceded per duplications is twice the amount of edges in the graph E).Moreover, one can dispute to facilitate the intricacy of the efforts at the patchy and check nodes regularly scales progressively with

$$E = \sum_{i=1}^{d_{v\,max}} n v_i i = \sum_{i=1}^{d_{c\,max}} n c_j j$$

Subsequent the gesticulations of Luby et al. [13], deem a Tanner graph with n left nodes, where $v_i = \frac{n_i}{n}$ delineates the portion of left nodes of level $i > 0$ and d_v (resp. d_c)is the erratic node degree (res. check node degree). Also, $c_j = \frac{r_j}{r}$ is distinct to be the portion of right nodes of level $j > 1$.The intricacy metaphors of the a variety of decoding algorithms are exposed in Table I wherever k is the figure of methodical bits and v is the memory sort of the encoder. The counter gives the operations per recitations on behalf of MAP, SOVA, in toting up to BP decoding projected in support of the horizontal (H) and vertical (V) step. Note that, for the BP algorithm, the complication per in sequence bit is

$$K = \frac{1}{\sum_i \lambda_i/i - \sum_i \rho_i/i} \int_{p_t}^{p0} \frac{dp}{p \log\left(\frac{p}{\sum_i \lambda_i f_i(p)}\right)},$$

Considering example 3, Figure 4 shows a assessment flanked by these mentioned algorithms in requisites of the number of operations mandatory in the interventions . In comparison with MAP and SOVA decoders, BP illustrates the lowest accomplishment intricacy over all the required operations.

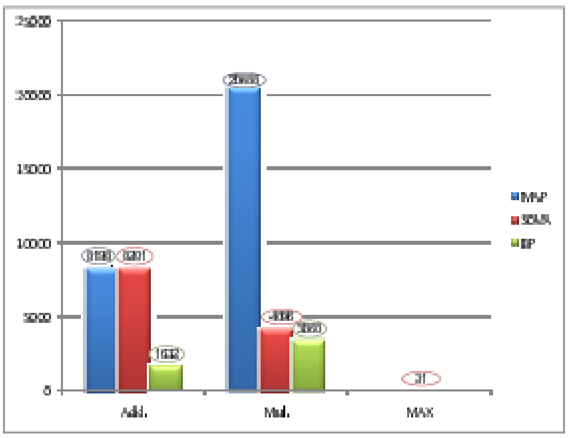

Figure 4. Comparison of MAP, SOVA, and BP decoders in terms of number of operations

VII. CONCLUSION

In this paper, the feasibility of decoding arbitrary tail biting helix and turbo codes using the BP algorithm was inveterate. Using this algorithm to decipher the tail biting helix code in WiMAX systems speeds up the error rectification convergence and reduces the decoding computational intricacy with approbation to the ML-Viterbi-based algorithm. In toting up, the BP algorithm performs a non-trellis based forward-only algorithm and has only an prologue decoding delay, thus avoiding transitional decoding delays that habitually be an appendage to the traditional MAP and SOVA machinery in LTE turbo decoders. However, with deference to the traditional decoders for turbo codes, the BP algorithm is about 1.7 dB shoddier at a BER value of 10^{-2}. This is because the nonzero element allocation in the parity-check matrix is not unsystematic enough. Also, there are a number of short cycles in the analogous Tanner graphs. Finally, as an unadulterated work, we suggest the BP decoder for these codes in a pooled architecture which is advantageous over a elucidation based on two separate decoders due to dexterous reuse of computational hardware and memory possessions for both decoders. In fact, since the conventional turbo decoders (based on MAP and SOVA components) have a elevated intricacy, the pragmatic loss in concert with BP is ore than compensated by a radically lower comprehension intricacy. Moreover, the low decoding intricacy of the BP decoder brings pertaining to end to- end proficiency since both encoding and decoding can be enforced with fairly low hardware intricacy.

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