Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Optional B-LDPC coding for OFDMA PHY**
Date Submitted	**2004-05-10**
Source(s)	Panyuh Joo, Seho Myung, Jaeyeol Kim, Gyubum Kyung, Hongsil Jeong, Kyungcheol Yang, DS Park, Jeho Jeon Samsung Electronics Voice: +82-31-279-5096 Fax: +82-31-279-5130 mailto:panyuh@samsung.com
Re:	802.16e D2
Abstract	Enhanced LDPC coding scheme
Purpose	Discuss B-LDPC in TGe, and adopt proposed text as optional feature.
Notice	
Release	
Patent Policy and Procedures	

Proposed Text

8.4.9.2.4 Low Density Parity Check Code (optional)

8.4.9.2.4.1 Code Description

The fundamental LDPC code is a systematic linear block code with (N_c , N_k), rate = N_k / N_c where N_c is length of code and N_k is information bit size. There is some code definition for the system and variety code rates may be constructed for good code performance for each code rate. Changing the consistent matrix size accommodates v arying data field lengths. Explanation about consistent matrix is in Packet Encoding section.

8.4.9.2.4.2 LDPC encoding

In a general analysis, an (N_c, N_k) LDPC code has N_k information bits and N_c coded bits with code rate r = N_k /N_c. The parity-check matrix $\boldsymbol{H}$ is of dimension (N_c - N_k)×N_c, and it defines a set of equations. For simplicity, let us put N_c - N_k = N_p , where N_p denotes the number of parity bits.

We can get relation parity check matrix $\boldsymbol{H}$ between codewords $\boldsymbol{v}$ as belows

$$\boldsymbol{H} \cdot \boldsymbol{v}^t = \boldsymbol{0} \qquad (1)$$

for all codewords $\boldsymbol{v}$.

An example parity-check matrix is shown below for an LDPC code (8, 4) as well as the expanded parity-check equations

$$\boldsymbol{H} = \begin{bmatrix} 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix} \Leftrightarrow \begin{cases} v_1 + v_3 + v_5 + v_7 = 0 \\ v_1 + v_4 + v_6 + v_8 = 0 \\ v_2 + v_3 + v_6 + v_7 = 0 \\ v_2 + v_4 + v_5 + v_8 = 0 \end{cases}$$

For efficient encoding of LDPC, $\boldsymbol{H}$ are divided into the form

$$\boldsymbol{H} = \begin{pmatrix} \boldsymbol{A} & \boldsymbol{B} & \boldsymbol{T} \\ \boldsymbol{C} & \boldsymbol{D} & \boldsymbol{E} \end{pmatrix} \qquad (2)$$

where $\boldsymbol{A}$ is $\left(N_p - g\right) \times N_k$, $\boldsymbol{B}$ is $\left(N_p - g\right) \times g$, $\boldsymbol{T}$ is $\left(N_p - g\right) \times \left(N_p - g\right)$, $\boldsymbol{C}$ is $g \times N_k$, $\boldsymbol{D}$ is $g \times g$, and finally , $\boldsymbol{E}$ is $g \times \left(N_p - g\right)$. Further, all these matrices are sparse and $\boldsymbol{T}$ is lower triangular with ones along the diagon al.

Let $\boldsymbol{v}$=($\boldsymbol{u}$, $\boldsymbol{p}_1$, $\boldsymbol{p}_2$) that $\boldsymbol{u}$ denotes the systematic part, $\boldsymbol{p}_1$ and $\boldsymbol{p}_2$ combined denote the parity part, $\boldsymbol{p}_1$ has length g, a nd $\boldsymbol{p}_2$ has length (N_p- g). The definition equation $\boldsymbol{H} \cdot \boldsymbol{v}^t = 0$ splits into two equations, as in equation 3 and 4 namely

$$\boldsymbol{A}\boldsymbol{u}^T + \boldsymbol{B}\boldsymbol{p}_1^T + \boldsymbol{T}\boldsymbol{p}_2^T = \boldsymbol{0} \qquad (3)$$

and

$$\left(-\boldsymbol{E}\boldsymbol{T}^{-1}\boldsymbol{A} + \boldsymbol{C}\right)\boldsymbol{u}^T + \left(-\boldsymbol{E}\boldsymbol{T}^{-1}\boldsymbol{B} + \boldsymbol{D}\right)\boldsymbol{p}_1^T = \boldsymbol{0} \qquad (4)$$

Define $\phi := -\boldsymbol{E}\boldsymbol{T}^{-1}\boldsymbol{B} + \boldsymbol{D}$ and when we use the parity check matrix as indicated appendix we can get $\boldsymbol{\phi} = \boldsymbol{I}$. Then from (4) we conclude that

$$\boldsymbol{p}_1^T = \left(-\boldsymbol{E}\boldsymbol{T}^{-1}\boldsymbol{A} + \boldsymbol{C}\right)\boldsymbol{u}^T \qquad (5)$$

and

$$\boldsymbol{p}_2^T = \boldsymbol{T}^{-1}\left(\boldsymbol{A}\boldsymbol{u}^T + \boldsymbol{B}\boldsymbol{p}_1^T\right). \qquad (6)$$

As a result, the encoding procedures and the corresponding operations can be summarized below and illustrated in Fig. 1.

Encoding procedure
Step 1) Compute $\boldsymbol{A}\boldsymbol{u}^T$ and $\boldsymbol{C}\boldsymbol{u}^T$.
Step 2) Compute $\boldsymbol{E}\boldsymbol{T}^{-1}\left(\boldsymbol{A}\boldsymbol{u}^T\right)$.
Step 3) Compute $\boldsymbol{p}_1^T$ by $\boldsymbol{p}_1^T = \boldsymbol{E}\boldsymbol{T}^{-1}\left(\boldsymbol{A}\boldsymbol{u}^T\right) + \boldsymbol{C}\boldsymbol{u}^T$.
Step 4) Compute $\boldsymbol{p}_2^T$ by $\boldsymbol{T}\boldsymbol{p}_2^T = \boldsymbol{A}\boldsymbol{u}^T + \boldsymbol{B}\boldsymbol{p}_1^T$.

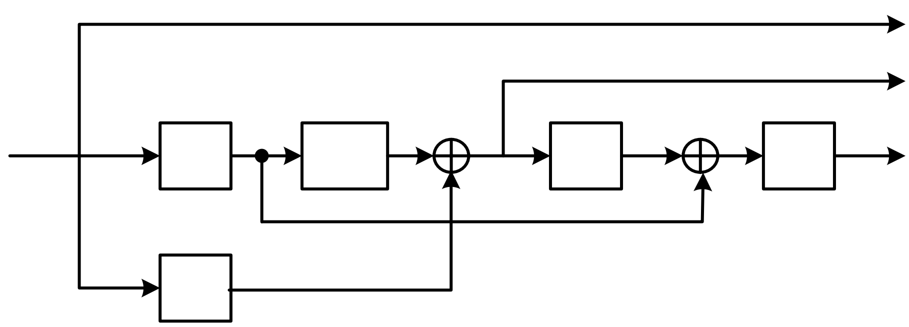

Fig. 1 Block diagram of the encoder architecture for the block LDPC code.

A detailed description of the ***A, B, T, C, D*** and ***E*** matrices of the code is contained in the Appendix LDPC Code Definition. The code is fully described by the definition of the H matrix as indicated in the appendix.

8.4.9.2.4.3 Rate Adjustment

As the code is rate flexible we can easily construct ***H*** matrix for various code rates (e.g. 1/2, 2/3, 3/4 and 5/6). F or each code rate, we design fundamental LDPC codes that achieve good performance whose ***H*** matrix describe d in appendix.

8.4.9.2.4.4 Packet Encoding

In this section, we describe construction of parity check matrix of block LDPC codes to obtain packet data lengt h flexibility. A block LDPC code is an almost structured LDPC codes whose parity-check matrix consists of small square blocks which are the zero matrix or a circulant permutation matrix. Let ***P*** be the $N_s \times N_s$ permutation matrix given by

$$\boldsymbol{P}=\begin{bmatrix} 0 & 1 & 0 & & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & 1 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Note that $\boldsymbol{P}^i$ is just the circulant matrix of the identity matrix $\boldsymbol{I}$ to the right by ($i \mod N_s$) times for any integer i. For simple notation, $\boldsymbol{P}^\infty$ denotes the zero matrix.

Let $\boldsymbol{H}$ be the $mN_s \times nN_s$ matrix defined by

$$\boldsymbol{H}=\begin{bmatrix} \boldsymbol{P}^{a_{11}} & \boldsymbol{P}^{a_{12}} & \boldsymbol{P}^{a_{13}} & \cdots & \boldsymbol{P}^{a_{1(n-1)}} & \boldsymbol{P}^{a_{1n}} \\ \boldsymbol{P}^{a_{21}} & \boldsymbol{P}^{a_{22}} & \boldsymbol{P}^{a_{23}} & \cdots & \boldsymbol{P}^{a_{2(n-1)}} & \boldsymbol{P}^{a_{2n}} \\ \boldsymbol{P}^{a_{31}} & \boldsymbol{P}^{a_{32}} & \boldsymbol{P}^{a_{33}} & \cdots & \boldsymbol{P}^{a_{3(n-1)}} & \boldsymbol{P}^{a_{3n}} \\ \vdots & \vdots & \vdots & \cdots & \vdots & \vdots \\ \boldsymbol{P}^{a_{m1}} & \boldsymbol{P}^{a_{m2}} & \boldsymbol{P}^{a_{m3}} & \cdots & \boldsymbol{P}^{a_{m(n-1)}} & \boldsymbol{P}^{a_{mn}} \end{bmatrix}$$

where $a_{ij} \in \{0,1,\cdots,N_s-1,\infty\}$. When $\boldsymbol{H}$ has full rank, then its codeword size N_c is nN_s and information bit size N_k is $(n-m)N_s$. Therefore, its code rate is given by

$$R=\frac{N_s n - N_s m}{N_s n}=\frac{n-m}{n}=1-\frac{m}{n}$$

regardless of its block length nN_s.

Therefore, we can obtain larger size block LDPC codes by increasing the size of circulant permutation matrices $\boldsymbol{P}$ which is an element matrix of $\boldsymbol{H}$ matrix. Also, we can straightforwardly get small size block LDPC codes by decreasing the size of $\boldsymbol{P}$.

For example, when we use $N_s = 1$ with code rate 1/2 case in appendix, we can construct (24, 12) block LDPC c odes and for the same case. If we set $N_s = 10$, then we can obtain (240, 120) block LDPC codes.

Appendix (normative); LDPC Code Definition

A full definition of an LDPC code can be accomplished through identification of the locations of the “edges” be tween the variable nodes (codeword bits) and check nodes (parity relationships). Figure 2 shows a Tanner graph of an example LDPC code, depicting the arrangement of the check nodes, variable nodes, and the “edges” conn ecting them.

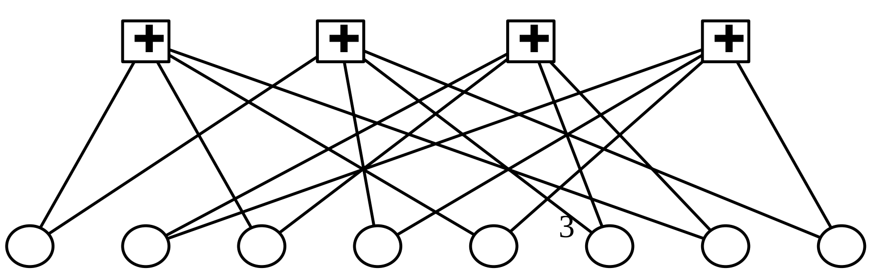

Fig. 2 This is an example Tanner graph of an LDPC code, showing the check nodes, variable nodes, and edges. The codeword is made up of the bits represented by the variable nodes. In this case the codeword has eight bits.

Each check node represents a parity relationship between the codeword bits represented by the variable nodes c onnected to it by the edges. The number of edges connected to a check node is the “degree” of the check node, a nd the number of edges connected to a variable node is the “degree” of the variable node. For the specified code all check nodes are of degree eighteen, all variable nodes related to the systematic information bits are of degre e four, and all variable nodes corresponding to parity bits are of degree two except for the last, which is of degre e one.

This LDPC code list file contains six parts to describe the parity check matrix $\boldsymbol{H}$. When matrix H split into the f orm

$$\boldsymbol{H} = \begin{pmatrix} \boldsymbol{A} & \boldsymbol{B} & \boldsymbol{T} \\ \boldsymbol{C} & \boldsymbol{D} & \boldsymbol{E} \end{pmatrix}$$

we describe the matrices $\boldsymbol{A}$, $\boldsymbol{B}$, $\boldsymbol{T}$, $\boldsymbol{C}$, $\boldsymbol{D}$ and $\boldsymbol{E}$.

An example for a $(8\times N_s, 4\times N_s)$ code with n=8, m=4, we design the parity check matrix

$$H = \begin{bmatrix} P^0 & 0 & 0 & P^0 & P^1 & P^0 & 0 & 0 \\ 0 & P^1 & P^4 & 0 & 0 & P^0 & P^0 & 0 \\ 0 & P^2 & 0 & P^6 & P^2 & 0 & P^0 & P^0 \\ P^3 & 0 & P^5 & 0 & P^3 & 0 & 0 & P^0 \end{bmatrix}$$

where $\boldsymbol{0}$ is $N_s \times N_s$ zero matrix.

Then we describe matrices A, B, T, C, D and E as below

$$\boldsymbol{A} = \begin{bmatrix} 0 & \infty & \infty & 0 \\ \infty & 1 & 4 & \infty \\ \infty & 2 & \infty & 6 \end{bmatrix}, \ \boldsymbol{B} = \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix}, \ \boldsymbol{T} = \begin{bmatrix} 0 & \infty & \infty \\ 0 & 0 & \infty \\ \infty & 0 & 0 \end{bmatrix}$$

$$\boldsymbol{C} = \begin{bmatrix} \boldsymbol{3} & \infty & \boldsymbol{5} & \infty \end{bmatrix}, \ \boldsymbol{D} = \begin{bmatrix} 3 \end{bmatrix}, \ \boldsymbol{E} = \begin{bmatrix} \infty & \infty & 0 \end{bmatrix}$$

Code rate = 1/2

$$
A = \begin{bmatrix}
0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty \\
\infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 \\
\infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty & 26 & \infty & 9 \\
\infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & 13 & 39 & \infty \\
\infty & \infty & 5 & \infty & \infty & 18 & \infty & \infty & 35 & \infty & 16 & \infty \\
30 & \infty & \infty & \infty & \infty & \infty & \infty & 29 & 28 & 17 & \infty & \infty \\
\infty & \infty & \infty & 33 & \infty & \infty & 19 & \infty & 34 & \infty & \infty & \infty \\
\infty & 25 & 26 & \infty & \infty & \infty & \infty & \infty & \infty & 15 & \infty & 4 \\
\infty & \infty & \infty & \infty & 36 & \infty & \infty & 1 & 38 & \infty & 9 & 7 \\
\infty & 23 & \infty & \infty & \infty & \infty & 2 & \infty & \infty & \infty & 30 & 21 \\
\infty & \infty & \infty & 29 & \infty & 27 & \infty & \infty & \infty & 12 & 20 & \infty
\end{bmatrix}
$$

$$
B = \begin{bmatrix}
0 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ Ns-1 \\ \infty \\ \infty \\ \infty \\ \infty
\end{bmatrix}
$$

$$
T = \begin{bmatrix}
0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0
\end{bmatrix}
$$

$$
C = \begin{bmatrix} 39 & \infty & \infty & \infty & 18 & \infty & \infty & \infty & 22 & \infty & \infty & 16 \end{bmatrix}
$$

$$
D = \begin{bmatrix} 1 \end{bmatrix}
$$

$$
E = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 1 \end{bmatrix}
$$

Code Rate = 2/3

$$
A = \begin{bmatrix}
0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & 7 & \infty & \infty & \infty & \infty & \infty & 0 & 0 \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & \infty & 3 & 5 & \infty & 1 & \infty & \infty & 15 \\
\infty & \infty & \infty & 1 & 5 & 11 & \infty & \infty & 4 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 4 & 13 & \infty & 10 & \infty & \infty & 7 & \infty \\
\infty & 6 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 6 & \infty & \infty & 2 & \infty & 15 & \infty & \infty & \infty & \infty & 14 & 8 & \infty & 3 \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & 6 & \infty & 7 & \infty & 5 & \infty & \infty & 9 & \infty & 11 & \infty & \infty & 3 & \infty & 15 & \infty & \infty \\
4 & \infty & 6 & \infty & 1 & \infty & 2 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 8 & \infty & \infty & 12 & \infty & 9 & \infty \\
\infty & \infty & 3 & \infty & \infty & \infty & \infty & \infty & 12 & \infty & \infty & \infty & \infty & 3 & \infty & 14 & \infty & \infty & 2 & 14 & \infty & 11 & \infty & 1 \\
13 & \infty & \infty & \infty & \infty & 6 & \infty & \infty & \infty & \infty & 8 & \infty & 15 & \infty & \infty & \infty & \infty & \infty & 9 & \infty & \infty & 4 & 13 & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & 9 & \infty & \infty & 7 & \infty & 10 & \infty & \infty & 5 & \infty & \infty & 6 & \infty & \infty & 13 & \infty & \infty & 14
\end{bmatrix}
$$

$$
B = \begin{bmatrix} 0 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ Ns-1 \\ \infty \\ \infty \\ \infty \\ \infty \end{bmatrix}
$$

$$
T = \begin{bmatrix}
0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & \infty \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0
\end{bmatrix}
$$

$$
C = \begin{bmatrix} \infty & 4 & \infty & 2 & \infty & \infty & \infty & 5 & \infty & \infty & \infty & \infty & 7 & \infty & \infty & \infty & 3 & \infty & 13 & 15 & \infty & \infty & 10 & \infty \end{bmatrix}
$$

$$
D = \begin{bmatrix} 1 \end{bmatrix}
$$

$$
E = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 1 \end{bmatrix}
$$

Code Rate = 3/4

A =

0	0	0	0	0	0	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	0	0	0	0	∞	∞
∞	∞	∞	∞	∞	∞	0	0	0	0	0	0	∞	∞	∞	∞	∞	2	∞	∞	∞	0	0
∞	5	∞	9	∞	∞	∞	∞	∞	∞	∞	∞	0	0	0	0	0	∞	1	∞	∞	8	∞
2	∞	∞	∞	3	∞	∞	13	∞	∞	15	∞	2	∞	∞	10	∞	0	∞	7	5	∞	4
∞	∞	∞	∞	∞	4	∞	∞	12	11	∞	10	7	∞	17	∞	∞	∞	13	∞	15	14	∞
∞	∞	1	6	∞	∞	3	4	∞	∞	2	∞	∞	∞	13	∞	11	2	∞	5	∞	7	∞
∞	8	∞	∞	10	3	∞	∞	∞	12	∞	7	∞	5	∞	∞	∞	∞	∞	∞	13	15	14

B =

∞
0
10
∞
∞
∞
11

T =

0	0	∞	∞	∞	∞	∞	∞
∞	0	0	∞	∞	∞	∞	∞
∞	∞	0	0	∞	∞	∞	∞
∞	∞	∞	0	0	∞	∞	∞
Ns-1	∞	∞	∞	0	0	∞	∞
∞	∞	∞	∞	∞	0	0	∞
∞	∞	∞	∞	∞	∞	0	0

C =

11	∞	6	∞	∞	∞	9	∞	16	∞	∞	∞	∞	1	∞	5	6	∞	14	7	∞	∞	∞

D =

2

E =

0	∞	∞	∞	∞	∞	∞	0

Code rate = 5/6

$$A = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & \infty \\ \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \infty & 1 & \infty & 0 \\ 1 & 6 & \infty & 4 & \infty & 10 & \infty & 5 & \infty & 11 & \infty & 8 & 7 & \infty & \infty & 15 & \infty & \infty & \infty & \infty & 3 & 12 & \infty & 9 & 2 & 14 & 3 & \infty & \infty & 13 \\ \infty & \infty & 6 & 3 & 2 & 12 & \infty & \infty & \infty & \infty & 9 & \infty & 0 & 9 & \infty & \infty & \infty & 8 & \infty & 12 & \infty & 2 & 3 & \infty & 5 & \infty & \infty & 11 & 5 & \infty \\ \infty & \infty & \infty & \infty & 11 & \infty & 15 & 1 & 10 & 6 & 4 & \infty & \infty & 5 & 4 & \infty & 1 & 7 & 2 & 6 & \infty & \infty & 8 & \infty & \infty & \infty & 13 & \infty & 12 & 10 \end{bmatrix}$$

$$B = \begin{bmatrix} 0 \\ \infty \\ \infty \\ Ns-1 \\ \infty \end{bmatrix}$$

$$T = \begin{bmatrix} 0 & \infty & \infty & \infty & \infty \\ 0 & 0 & \infty & \infty & \infty \\ \infty & 0 & 0 & \infty & \infty \\ \infty & \infty & 0 & 0 & \infty \\ \infty & \infty & \infty & 0 & 0 \end{bmatrix}$$

$$C = \begin{bmatrix} 6 & 13 & 15 & \infty & \infty & \infty & 2 & \infty & \infty & \infty & \infty & 12 & \infty & \infty & 4 & 13 & 11 & \infty & 15 & \infty & 14 & \infty & \infty & 10 & \infty & 8 & 3 & 8 & 0 & 5 \end{bmatrix}$$

$$D = \begin{bmatrix} 1 \end{bmatrix}$$

$$E = \begin{bmatrix} \infty & \infty & \infty & \infty & 1 \end{bmatrix}$$

<u>Supplementary information on the proposed text:</u> Simulation results of convolutional coding vs. Samsung's proposed B-LDPC coding.

The following two graphs in Figure 1 and 2 highlights the performance comparison of convolutional code and L DPC code, i.e., Samsung B-LDPC (proposed in this contribution).

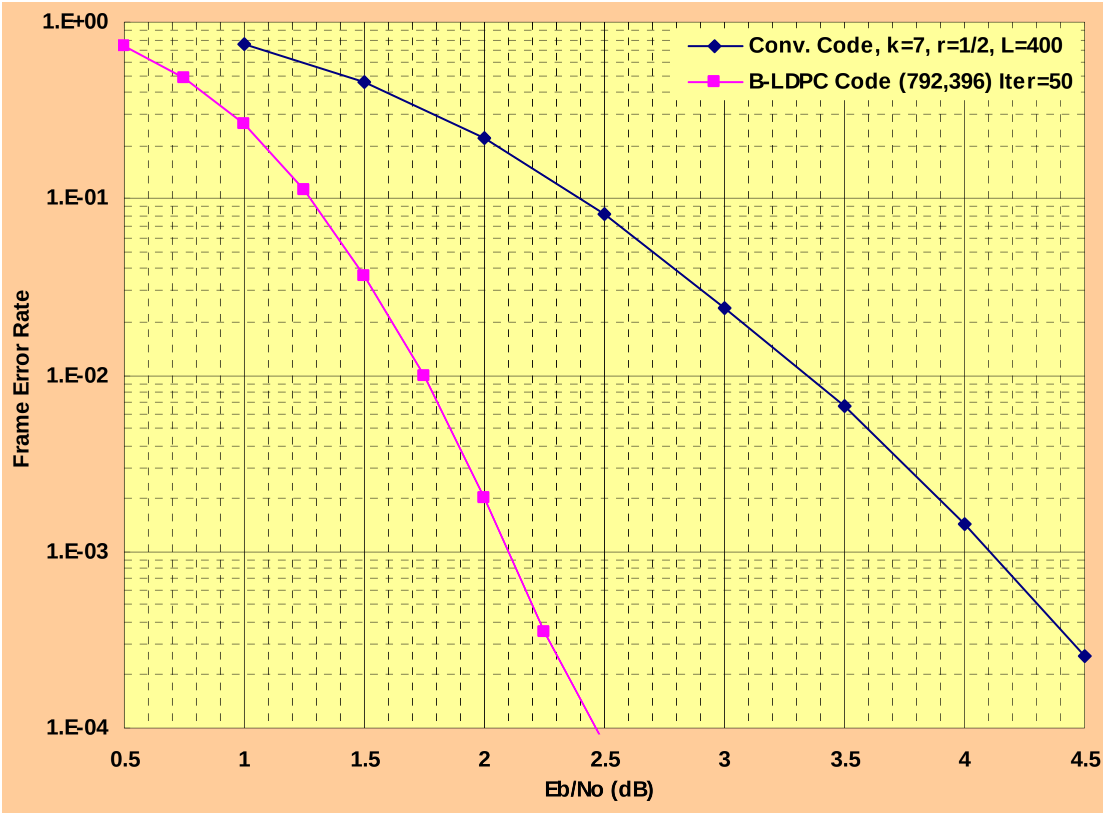

Fig. 1. Performance comparison between a (792,396) B-LDPC code and Convolutional code(K=7, (171, 133), 1/2 code rate, block length = 400)

The performance of a B-LDPCcode with column is compared with that of Convolutional code with frame length 800 and r = 2/3 in Fig. 1, in terms of FER (frame error rate). The parity check matrix of B-LDPC code has the length of the B-LDPC code is 792 and the code rate 1/2.

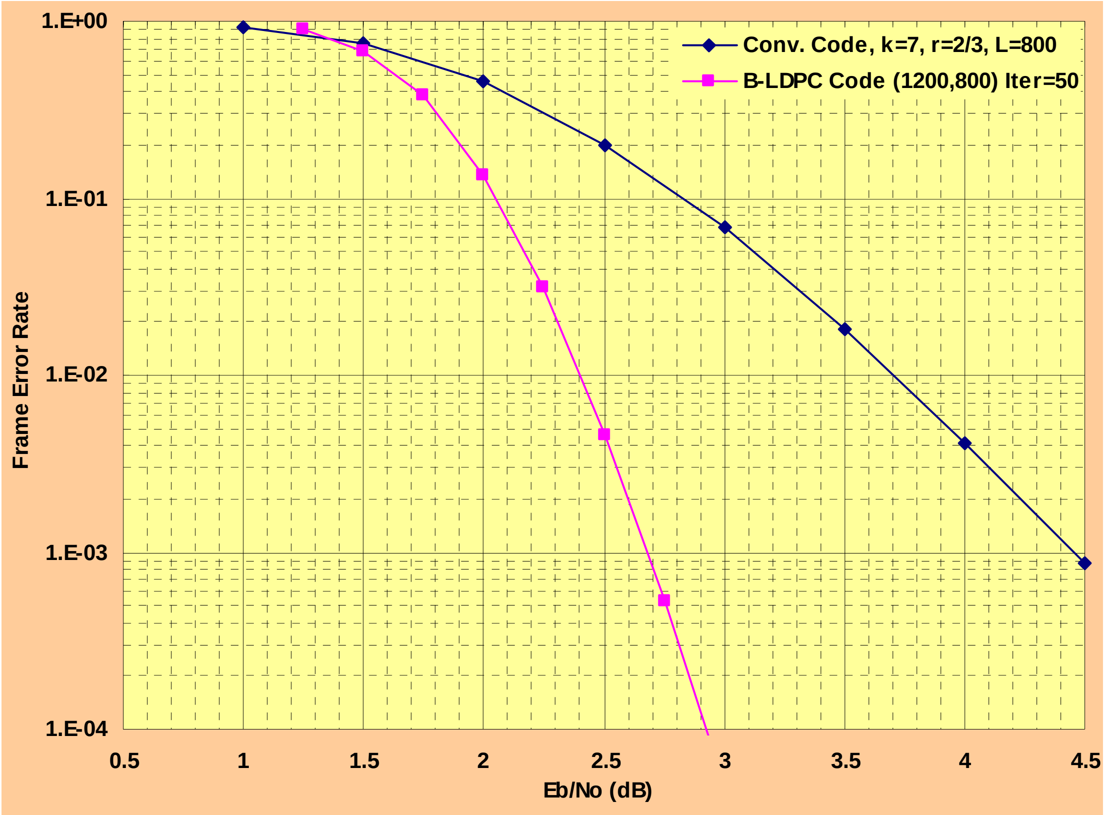

Fig. 2 Performance comparison between a (1200,800) B-LDPC code and Convolutional code(K=7, 2/3 code rate, block length = 800)

The performance of a B-LDPC code with column is compared with that of Convolutional code frame length 800 in Fig. 2, in terms of FER (frame error rate). The pa rity check matrix of B-LDPC code has the length of the B-LDPC code is 1200 and the code rate 2/3.