Downscaled LDPC Codes for Indonesia Digital Video Broadcasting Terrestrial 2nd Generation (DVB-T2)

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Outline

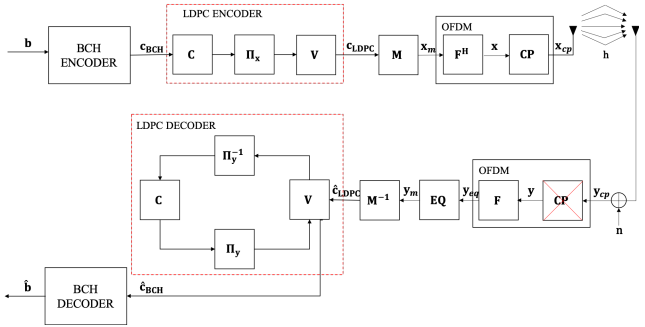
Motivation and Problem

Figure: Indonesia Digital Television Standard Migration.

- DVB-T2 replaces DVB-T standard as the Indonesia terrestrial digital television standard.
- Absence of the suitable LDPC codes for Indonesia channel model leading to an optimal performances.

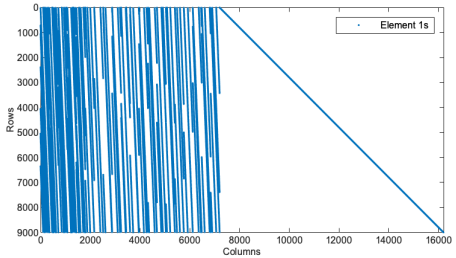
Minisitry of Communications and Informatics Indonesia Regulation Number: 05/PER/M.KOMINFO/2/2012.

System Model of DVB-T2



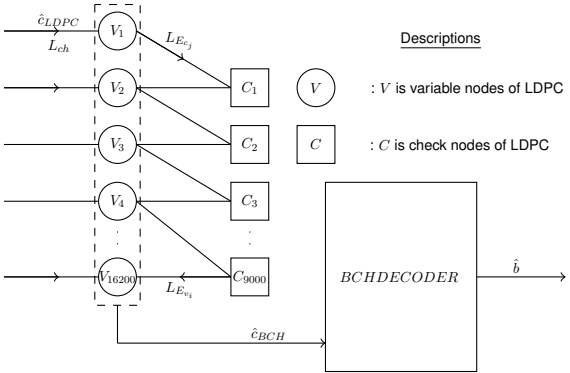
- The structure of LDPC encoder and decoder are adapted from ETSI TS 102 831 V1.2.1.
- The modulation $\mathbf{M}$ is Quadrature Phase Shift Keying (QPSK).
- We consider multipath channel $\mathbf{h}$ using Bandung DVB-T2 channel model.

DVB-T2 LDPC Codes



- DVB-T2 LDPC codes according to ETSI TS 102 831 V1.2.1 have block-length $N_{LDPC} = 16200$ and $N_{LDPC} = 64800$.
- LDPC codes with $N_{LDPC} = 16200$ have code rates $R = \{\frac{4}{9}, \frac{3}{5}, \frac{2}{3}, \frac{11}{15}, \frac{7}{9}, \frac{37}{45}\}$
- We proposed DVB-T2 LDPC codes with $N_{LDPC} = 16200$ having code rates $R = \frac{4}{9}$.

Tanner Graph of The Proposed DVB-T2 LDPC Codes



$L_{E_{v_i}}$ and $L_{E_{c_j}}$ are expressed

$$L_{E_{v_i}}(n) = L_{ch} + \sum_{j=1, j\neq i}^{d_{v_n}} L_{A_{v_j}}, \qquad (1)$$

$$L_{E_{c_j}}(k) = \sum_{i=1, i\neq j}^{d_{c_k}} \boxplus L_{A_{c_i}}. \qquad (2)$$

S. ten Brink, "Convergence Behavior of Iteratively Decoded Parallel Concatenated Codes," IEEE Transactions on Communications, vol. 49, no. 10, pp. 1727–1737, Oct 2001.

The Proposed Parity Check Matrices

Code rate		Column weight					
R_n	R_e	13	12	8	3	2	1
1/2	4/9			1800	5400	8999	1
3/5	3/5		3240		6480	6479	1
2/3	2/3	1080			9720	5399	1
3/4	11/15		360		11520	4319	1
4/5	7/9				12600	3599	1
5/6	37/45	360			12960	2879	1

The parity check matrices of LDPC codes DVB-T2 must have the column weight according to the table with R_n is nominal rate and R_e is effective rate, so the parity check matrix size will formed from the effective rate.

ETSI, Digital Video Broadcasting (DVB); Frame Structure Channel Coding and Modulation for a Second Generation Digital Terrestrial Television Broadcasting System (DVB-T2), 1st ed., ETSI, July 2015.

The Downscaled Technique for DVB-T2 LDPC Codes

20	712	2386	6354	4061	1062	5045	5158
21	2543	5748	4822	2348	3089	6328	5876
22	926	5701	269	3693	2438	3190	3507
23	2802	4520	3577	5324	1091	4667	4449
24	5140	2003	1263	4742	6497	1185	6202
0	4046	6934					
1	2855	66					
2	6694	212					
3	3439	1158					
4	3850	4422					
5	5924	290					
6	1467	4049					
7	7820	2242					
8	4606	3080					
9	4633	7877					
10	3884	6868					
11	8935	4996					
12	3028	764					
13	5988	1057					
14	7411	3450					

- State the scaling factor s_f, where the factor must be divisors of 360. 360 is the number of node indices of DVB-T2 LDPC codes.
- Fill $p_1(j), p_2(j), p_3(j), \ldots, p_q(j), j = 1, 2, 3, \ldots, J$ and $q = 1, 2, 3, \ldots, Q$.
- Calculate $r_1(j), r_2(j), r_3(j), \ldots, r_q(j)$

$$r_q(j) = mod\{[p_q(j) + j_{max}[P/s_f]\},$$

$$1 < k \leq (360/s_f)$$

- The new table of addresses parity bit accumulators r_q are obtained.

F. A. Newagy and S. H. Elramly, "Novel Technique for Scaling Down LDPC Code Lengths in DVB-T2 Standard," in 2012 International Conference on Telecommu-

The Downscaled Technique for DVB-T2 LDPC Codes (2)

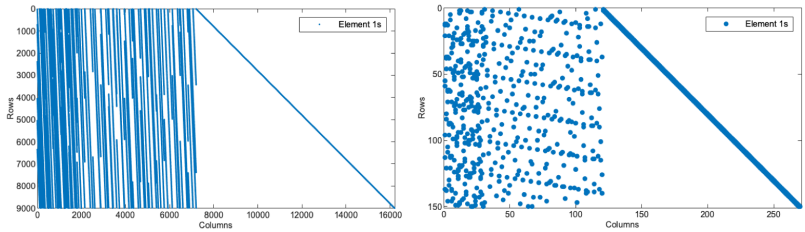


Figure: The comparison between parity check matrix of LDPC codes with a block length $N_{LDPC} = 16200$ and $N_{LDPC} = 270$.

By using $s_f = 60$ the LDPC codes with block length $N_{LDPC} = 16200$, so the size of matrix LDPC codes will be smaller become $N_{LDPC} = 270$.

The Proposed Downscaled DVB-T2 LDPC Codes (1): Degree Distribution

$R = \frac{4}{9}$

$$\lambda(x) = \frac{1}{270}x + \frac{149}{270}x^2 + \frac{90}{270}x^3 + \frac{30}{270}x^8 \quad (5)$$

$$\rho(x) = \frac{25}{150}x^4 + \frac{53}{150}x^5 + \frac{60}{150}x^6 + \frac{12}{150}x^{12}, \quad (6)$$

$R = \frac{2}{3}$

$$\lambda(x) = \frac{1}{270}x + \frac{89}{270}x^2 + \frac{162}{270}x^3 + \frac{18}{270}x^{13}, \quad (7)$$

$$\rho(x) = \frac{1}{90}x^9 + \frac{89}{90}x^{10}, \quad (8)$$

$R = \frac{3}{5}$

$$\lambda(x) = \frac{1}{270}x + \frac{107}{270}x^2 + \frac{132}{270}x^3 + \frac{30}{270}x^{12}, \quad (9)$$

$$\rho(x) = \frac{1}{108}x^8 + \frac{107}{108}x^9, \quad (10)$$

The Proposed Downscaled DVB-T2 LDPC Codes (2): Degree Distribution

$R = \frac{11}{15}$

$$\lambda(x) = \frac{1}{270}x + \frac{71}{270}x^2 + \frac{192}{270}x^3 + \frac{6}{270}x^{12}, \quad (11)$$

$$\rho(x) = \frac{7}{48}x^{15} + \frac{17}{48}x^{16} + \frac{18}{48}x^{17} + \frac{6}{48}x^{18}, \quad (12)$$

$R = \frac{7}{9}$

$$\lambda(x) = \frac{1}{270}x + \frac{71}{270}x^2 + \frac{198}{270}x^3, \quad (13)$$

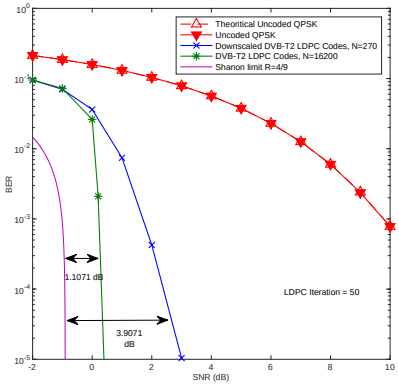
$$\rho(x) = \frac{7}{60}x^{11} + \frac{29}{60}x^{12} + \frac{24}{60}x^{13}, \quad (14)$$

$R = \frac{37}{45}$

$$\lambda(x) = \frac{1}{270}x + \frac{71}{270}x^2 + \frac{192}{270}x^3 + \frac{6}{270}x^{12}, \quad (15)$$

$$\frac{7}{9}, \frac{11}{10}, \frac{36}{11}, \frac{12}{12}$$

Performance Comparison on AWGN Channel



- Gap between the Shannon limits for $R = 4/9$ and DVB-T2 LDPC codes with $N_{LDPC} = 270$ is about $3.9\ dB$ while the gap of DVB-T2 LDPC codes with $N_{LDPC} = 16200$ is obtained about $1.1\ dB$.

Figure: BER performances of DVB-T2 LDPC codes with $R = \frac{4}{9}$ under AWGN channel.

Performance Evaluation on Bandung Channel Models

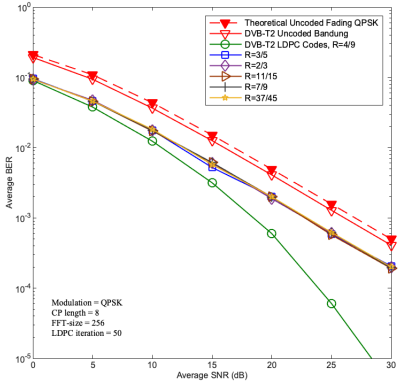


Figure: BER performances Downscaled DVB-T2 LDPC codes codes under Bandung Channel models.

- The BER Performances of DVB-T2 LDPC codes with $R = \left\{\frac{4}{9}, \frac{3}{5}, \frac{2}{3}, \frac{11}{15}, \frac{7}{9}, \frac{37}{45}\right\}$ are evaluate under Bandung Channel models[1].
- The best performances of Downscaled LDPC codes DVB-T2 on is achieved 10^{-4} at $R = \frac{4}{9}$.

D. Fitriyani, K. Anwar, and D. M. Saputri, "Study on Radio Frequency Profile of Indonesia Digital Television DVB-T2 for Urban Areas", in 2019.

Conclusion

- This paper has provided the BER performances comparison between DVB-T2 LDPC codes with block length $N_{LDPC} = 16200$ and downscaled DVB-T2 LDPC codes with $N_{LDPC} = 270$.
- This paper provide the BER performances of downscaled DVB-T2 LDPC codes in all rate at Bandung Channel Model.
- The gap between DVB-T2 LDPC codes $N_{LDPC} = 16200$ and downscaled DVB-T2 LDPC codes $N_{LDPC} = 270$ is about $2.8\ dB$
- The best code rate of downscaled DVB-T2 LDPC codes under Bandung Channel model is $R = \frac{4}{9}$.
- The results are expected to be one of the solutions for implementation of DVB-T2 in Indonesia.