Low-Density Parity Check (LDPC) Codes Design for Indonesia Digital Television DVB-T2

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Outlines

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Motivations

DVB-T to DVB-T2 Migration

- Implementation of DVB-T2 for Indonesia terrestrial digital television replace the DVB-T standard [1].
- Absence of the suitable Low-Density Parity Check codes rate profile for Indonesia channel model.

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[1]*Peraturan Menteri Komunikasi dan Informatika NOMOR: 05/PER/M.KOMINFO/2/2012*.

Outlines

- DVB-T2 is a standard for digital terrestrial television broadcasting, offering significant benefits compared to DVB-T both of it used Coded Orthogonal Frequency Division Multiplex (COFDM) [1].
- Main benefit of the DVB-T2 over DVB-T is the possibility to increase the capacity in digital terrestrial television (DTT) [2].

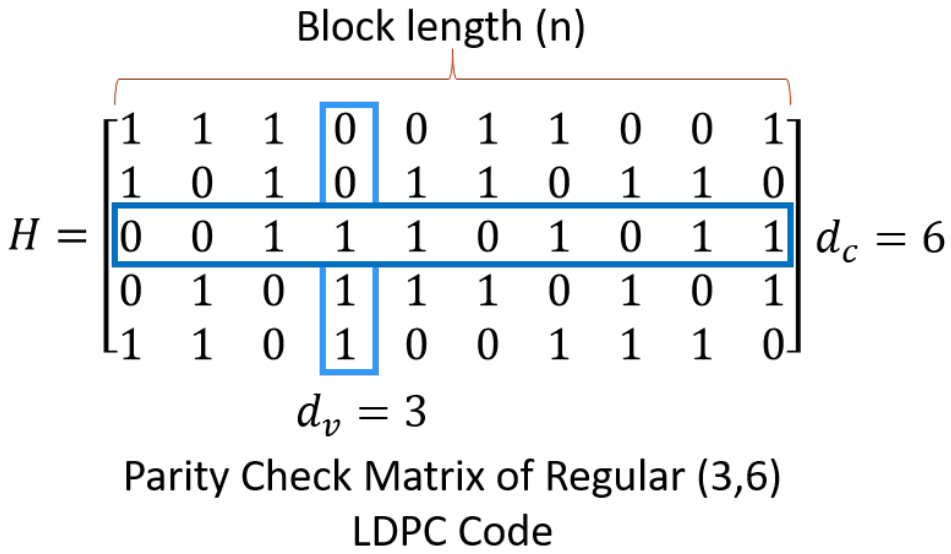
	DVB-T	DVB-T2
Modulation	64-QAM	256-QAM
FFT size	8 K	32 K
Guard Interval	1/4	1/16
FEC	2/3CC + RS	3/5LDPC + BCH
Scattered Pilots	8.3%	4.2%
Continual Pilots	2.0%	0.39%
L1 Overhead	1.0%	0.65%
Carrier mode	Standard	Extended
Capacity	19.9 Mbit/s	33.2 Mbit/s

The comparison between DVB-T2 and DVB-T for a long guard interval (SFN) mode, with the same absolute guard interval in both cases.

[1] *Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)*

[2] *Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)*

- LDPC codes or sometimes called Gallager's code were originally proposed in 1962 by Robert Gallager, One of error correction method have been proved to be capable of closely approaching the channel capacity [1].
- LDPC codes of almost any rate and blocklength can be created simply by specifying the shape of the parity check matrix (H) [1].
- Low-density parity-check codes are codes specified by a matrix containing mostly 0's and only a small number of 1's [2].
- Parity check matrix H
  - ✓ Long block length n
  - ✓ Variable node degree d_v
  - ✓ Check node degree d_c
- ☐ Regular LDPC :
  - ✓ $d_v = fixed$
  - ✓ $d_c = fixed$
- ☐ Irregular LDPC :
  - ✓ $d_v = not fixed$
  - ✓ $d_c = not fixed$



Parity Check Matrix of Regular (3,6) LDPC Code

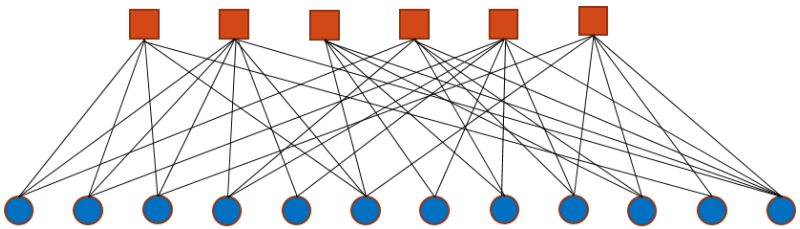
[1] Moon, *Error Correction Coding : Mathematical Methods and Algorithms*

[2] Gallager, "Low-Density Parity-Check Codes"

- LDPC codes in DVB-T2 are irregular LDPC codes and the error-protection level of each code bit is not uniform, but depends on the column weight of the parity-check matrix [1].
- Irregular LDPC codes can substantially outperform similar codes based on regular LDPC codes [2].
- The irregular LDPC codes associated with the column $\lambda(x)$ and row distribution $\rho(x)$:

$$\lambda(x) = \sum_{i=2}^{dv} \lambda_i x^{i-1} \qquad \rho(x) = \sum_{i=2}^{dc} \rho_i x^{i-1} \tag{1}$$

- Example :



Irregular LDPC codes Tanner Graph

So,

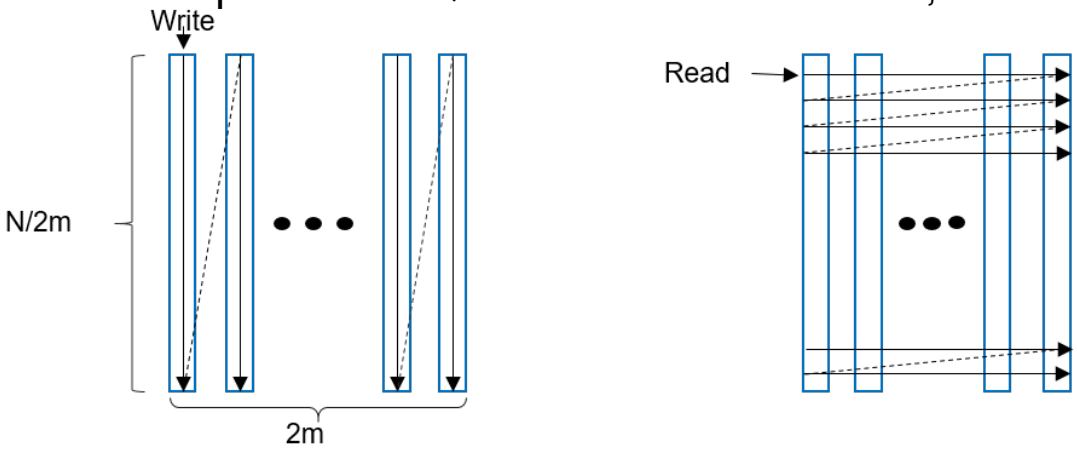
$$\rho(x) = \frac{1}{6}x^4 + \frac{2}{6}x^5 + \frac{1}{6}x^6 + \frac{2}{6}x^7 \tag{2}$$

$$\lambda(x) = \frac{3}{12}x^2 + \frac{7}{12}x^3 + \frac{1}{12}x^4 + \frac{1}{12}x^5 \tag{3}$$

[1] *Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)*

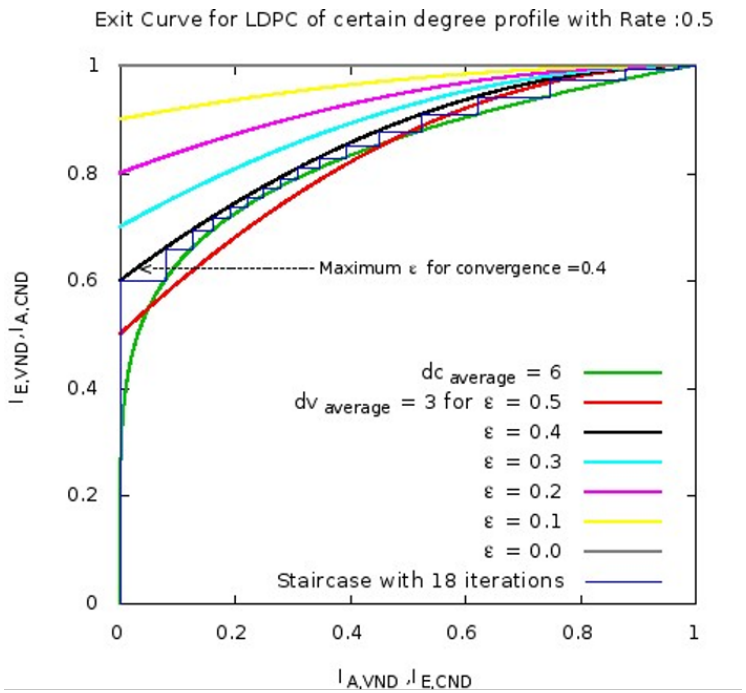
[2] Luby et al., “Improved Low-Density Parity-Check Codes Using Irregular Graphs”

- LDPC codes in DVB-T2 are irregular LDPC codes and the error-protection level of each code bit is not uniform, but depends on the column weight of the parity-check matrix [1].
- The block length for LDPC code in DVB-T2 for normal codes $N_{ldpc} = 64800$ and for the short codes $N_{ldpc} = 16200$ [1].
- Standard code rate for DVB-T2 is $1/2, 3/5, 2/3, 3/4, 4/5$, and $5/6$.
- Cyclic structure used for implementation of encoder and decoder, Staircase structure used for generating parity bits by an accumulator.
- In DVB-T2, a bit interleaver having $Nc = 2m$ columns is used for the $2^m - QAM$ constellation - except for 256-QAM with the short code, which uses $m = 8$ columns.



Basic structure of 2m-columns bit interleaver

[1] *Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)*



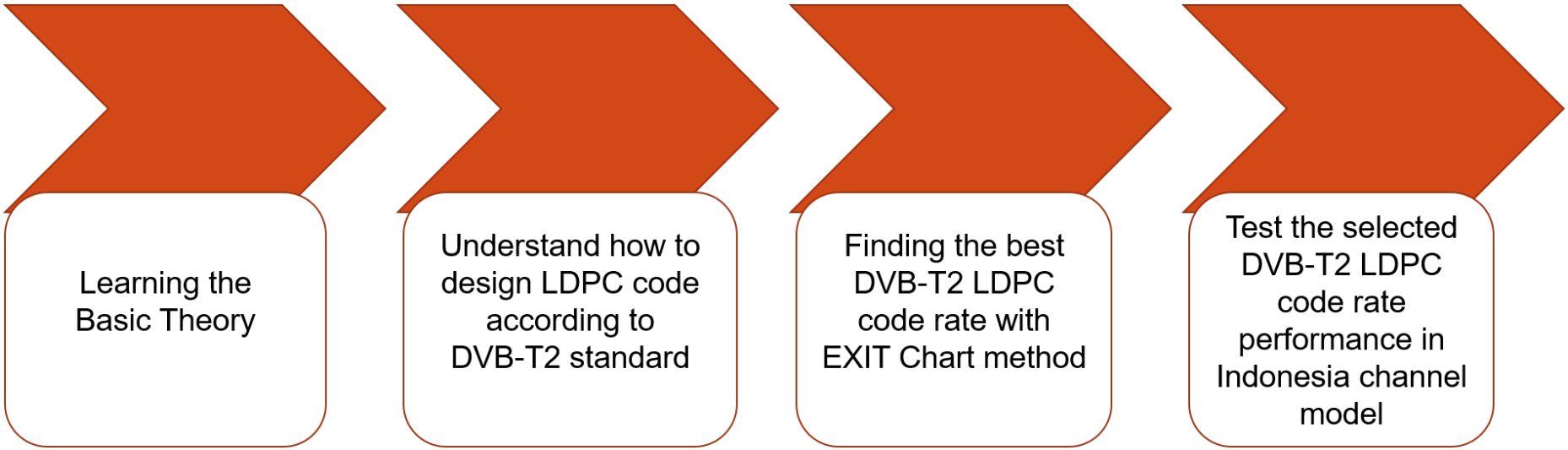
LDPC code (3,6) with BEC channel model

- **EX**trinsic **I**nformation **T**ransfer (EXIT) Chart introduced by Stephan ten Brink, it's a method used to evaluate performance of any iterative decoder and giving a feedback on required number of iterations to reach successful decoding [1].
- The chart is plotted as the a priori mutual information I_A before message is decoded and the extrinsic mutual information I_E after decoding.
- EXIT charts can also be established for LDPC codes, the Variable Node decoder (VND) and the Check Node decoder (CND).
- The output extrinsic mutual information of a variable node and check node denoted as $I_{E,VND}$ and $I_{E,CND}$, for the input a priori mutual information of a variable node and check node denoted as $I_{A,VND}$ and $I_{A,CND}$.

[1] Brink S, "Convergence behaviour of iteratively decoded parallel concatenated codes"

Outlines

Research Trajectory



Research Trajectory

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Conclusion

This research will propose the rate of LDPC code for DVB-T2 in Indonesia channel model with the performance at BER, BLER, and outage probability using EXIT chart method.

Thank you