Concatenated LDGM Codes with Reduced Decoder Complexity

Joon-Sung Kim, Hong-Yeop Song

May 8, VTC 2006 Spring, Melbourne

Coding & Information Theory Laboratory
Dept. of Electrical and Electronic Engineering
Yonsei University Seoul, Korea

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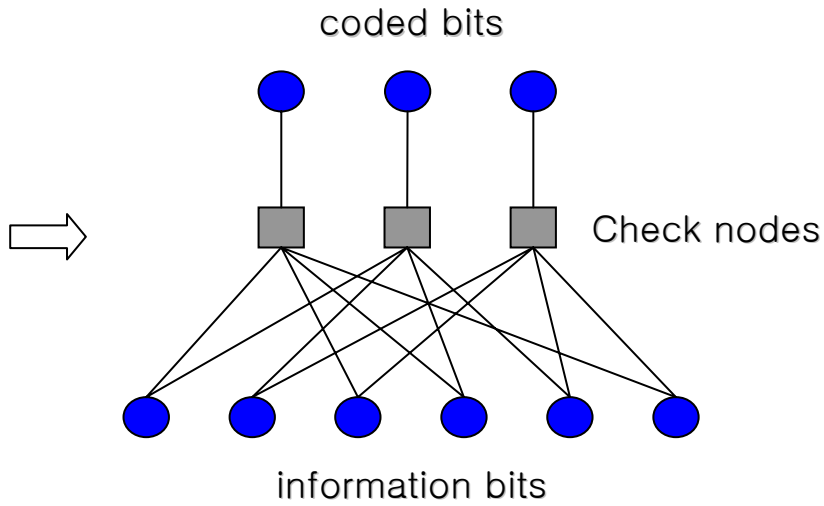
Introduction

- **Low-Denstiy Generator Matrix code**
  - Linear codes with sparse generator matrix
  - The encoder/decoder complexity of LDGM codes is much less than that of LDPC codes.
  - The performance of LDGM codes is known to be asymptotically bad since they have too many degree-1 columns.

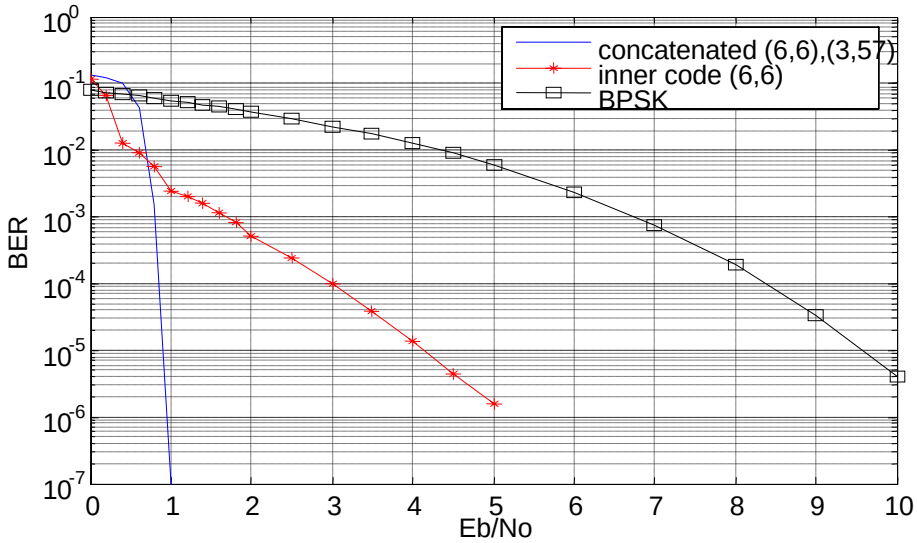
$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$



Introduction

- **Concatenated LDGM Code**
  - The output of the inner LDGM decoder can be regarded as a priori probability to initialize the bit nodes of the outer LDGM decoder.
  - achieve near Shannon limit performance
  - The decoder hardware complexity becomes higher than that of a single LDPC code since these code requires both inner and outer decoders.

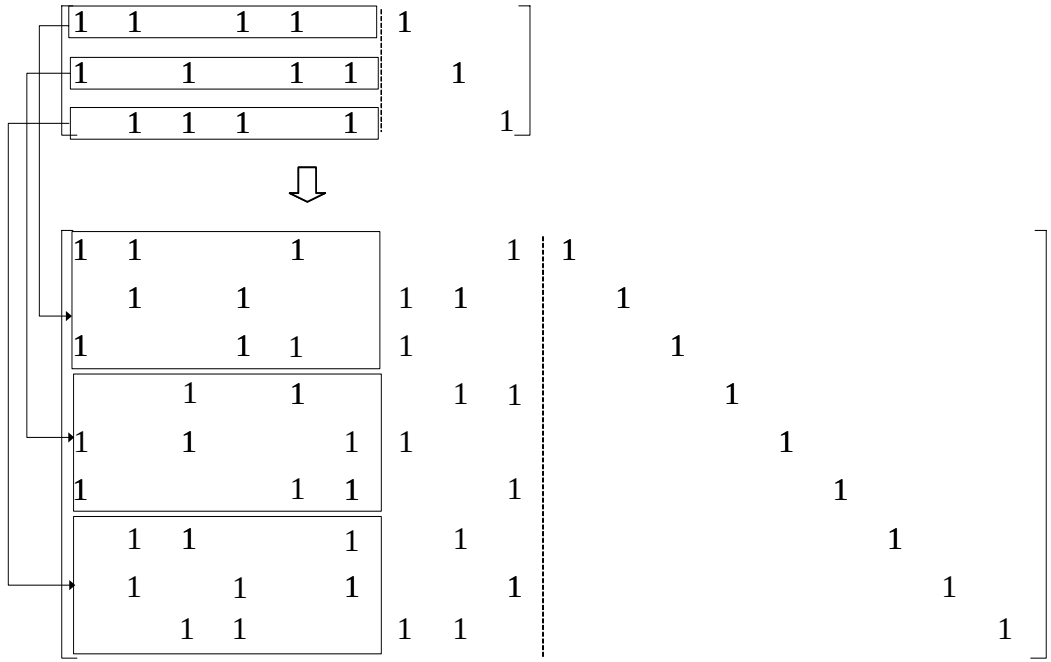


Concatenated LDGM Codes with Reduced Decoder Complexity

- **Proposed Design Criterion**
  - The parity check matrix of the inner LDGM code can be derived from the outer LDGM code by expanding each row of the parity check matrix of the outer LDGM code into several rows.
  - The OR operation of the expanded rows must be the same as the row of the outer LDGM code.
  - This enables us to make the parity check matrices of both codes to have essentially the same decoder structure. So, we can use the inner decoder in the decoding of the outer code.
  - We must use a bitinterleaver between the inner and the outer code since inner and outer code has the same decoder structure.

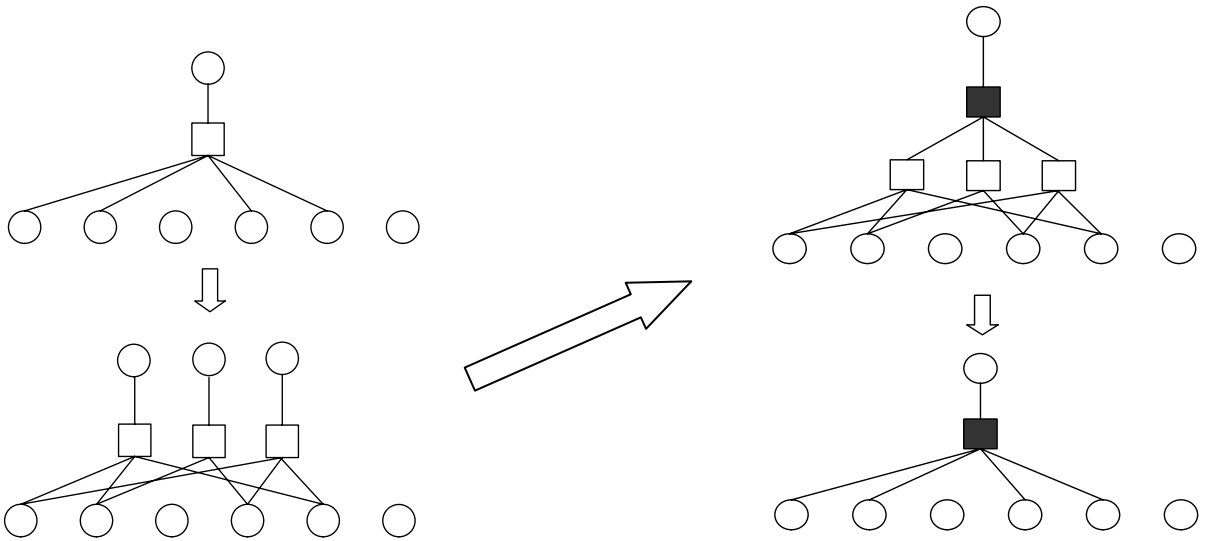
Code Construction Example

- **Construction of inner LDGM code**
  - The inner code can be obtained by expanding each row of the parity check matrix of the outer code into 3 rows, where the number of the edges of each bit node is increased twice.



Code Construction Example

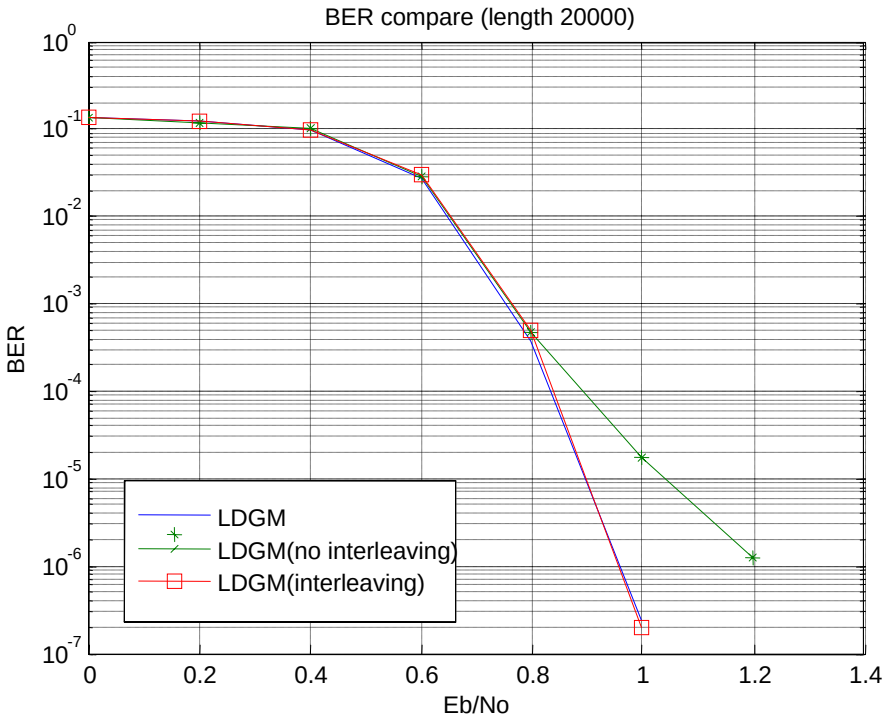
- **Bipartite graph representation**
  - In decoding process, if all the messages from the expanded check nodes of the inner decoder are merged into another new check node, the resulted message passing will be the same as the check node of the outer decoder.

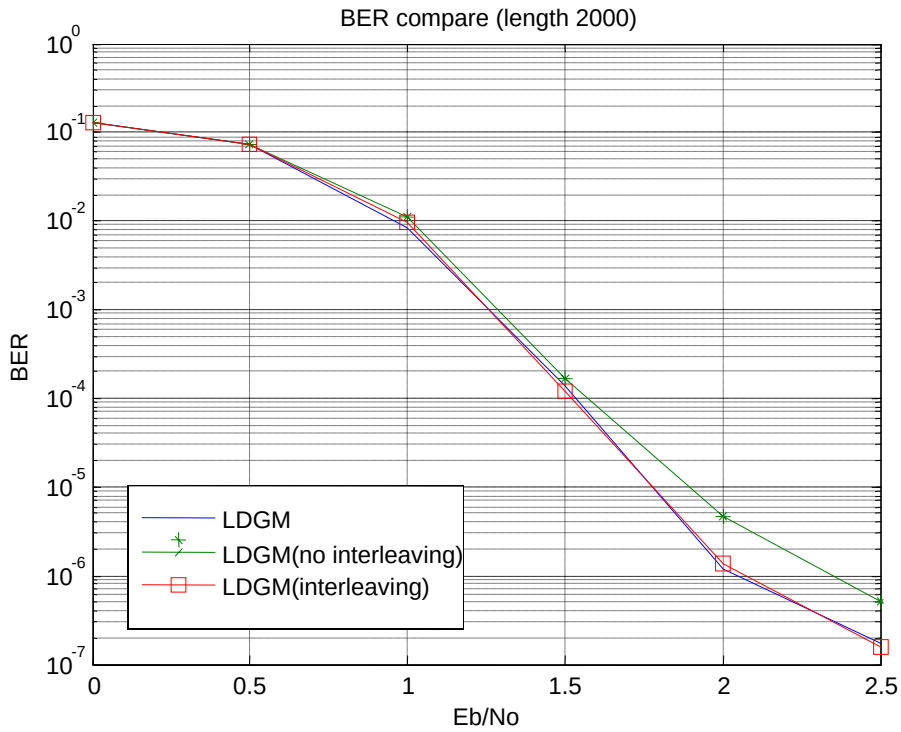


(a) Expansion of a check node (b) Merge of the expanded check nodes

Simulation Results

Simulation Results





Conclusions

- **Summary**
  - We propose a design criterion of concatenated LDGM codes which require a single decoder and a bit-interleaver.
  - The concatenated LDGM codes as presented has no computational savings but can achieve the goal of reducing the decoder hardware complexity.