Optimized Bit Mappings for Spatially Coupled LDPC Codes over Parallel Binary Erasure Channels

CHALMERS

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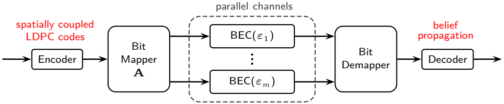
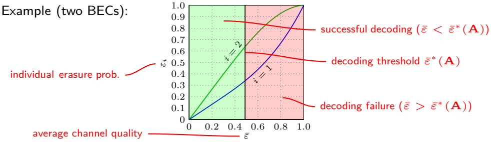
Abstract

In many practical scenarios, one binary encoder/decoder pair is used to communicate over a set of parallel channels. We study spatially coupled low-density parity check (LDPC) codes over parallel binary erasure channels (BECs) and optimize the bit mapper which determines how the coded bits are allocated to the parallel channels.

System Model



Example (two BECs):

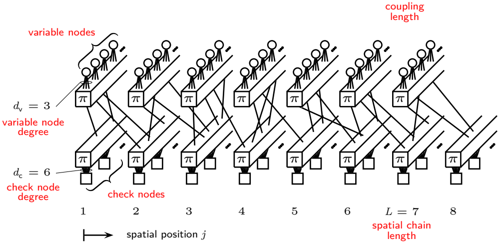


Conclusions

1. Decoding threshold can be improved over a uniform random bit mapper, or, alternatively, the spatial chain length can be reduced.
2. For circular ensembles, different channel qualities can be exploited to obtain wave-like decoding behavior similar to terminated ensembles.

Spatially Coupled LDPC Codes

Example: Tanner graph of the two-sided $(d_\mathsf{v} = 3, d_\mathsf{c} = 6, L = 7, w = 2)$ ensemble



Bit Mapper

- Variable nodes (code bits) at different spatial positions belong to different equivalence classes
- Assignment of classes to channels via matrix $\mathbf{A} = [a_{i,j}] \in \mathbb{R}^{m \times L}$, where $a_{i,j} \triangleq$ fraction of VNs from position j to be sent over ith BEC
- Example: $\mathbf{A} = \begin{pmatrix} 1.0 & 0.0 & 0.5 & 0.75 & 0.25 & 1.0 & 0.0 \\ 0.0 & 1.0 & 0.5 & 0.25 & 0.75 & 0.0 & 1.0 \end{pmatrix}$
- Baseline bit mapper with uniform assignment $a_{i,j} = 1/m, \forall i, j$
- Set of valid assignment matrices $\mathcal{A}^{m \times L}$: columns sum to 1, rows sum to L/m
- Optimized bit mapper $\mathbf{A}_{\mathrm{opt}} = \underset{\mathbf{A} \in \mathcal{A}^{m \times L}}{\operatorname{argmax}} \; \bar{\varepsilon}^*(\mathbf{A})$, via iterative approach

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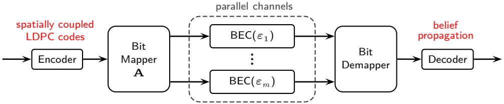

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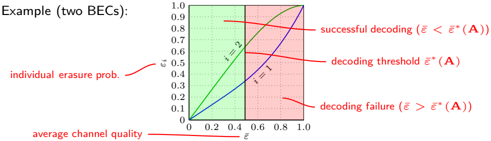

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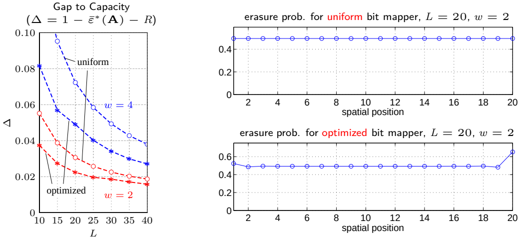
Results: Two-Sided $(4, 8, L, w)$ Ensembles



Results: Circular $(4, 8, L, w)$ Ensembles