January 7, 2015

Efficient Maximum a Posteriori Erasure Decoding of LDPC Codes

Balázs Matuz
Institute for Communications and Navigation
German Aerospace Center (DLR)

In collaboration with:
Gianluigi Liva (DLR)
Enrico Paolini (UniBo)
Marco Chiani (UniBo)

Motivation
Why Maximum a Posteriori Decoding?

- Low-density parity-check (LDPC) codes under iterative (IT) decoding approach capacity for large blocks
- For short/medium blocks ($n < 10000$) notable performance loss w.r.t. theoretical limits
- LDPC codes under maximum a posteriori (MAP) decoding can recover this loss
- Challenge: how to design codes/MAP decoders with low complexity and good performance on the erasure channel?

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Maximum a Posteriori Decoding
Smart Gaussian Elimination and Pivoting

- Straightforward implementation by solving the linear system

$$\mathbf{H}_{\bar{K}}\mathbf{x}_{\bar{K}}^T = \mathbf{H}_K\mathbf{x}_K^T$$

  where $\mathbf{x}_{\bar{K}}$ ($\mathbf{x}_K$) denote the e erased ($n-e$ correctly received) symbols and $\mathbf{H}_{\bar{K}}$ ($\mathbf{H}_K$) the corresponding columns of the $m \times n$ parity-check matrix $\mathbf{H}$.
- Smart Gaussian elimination (GE) to solve the system:
  - Resolve a small set of unknowns (pivots) by complex GE
  - Resolve the rest by fast IT decoding
- Problems faced:
  - How to adjust the code design in order to keep pivots low?
  - How to choose pivots?

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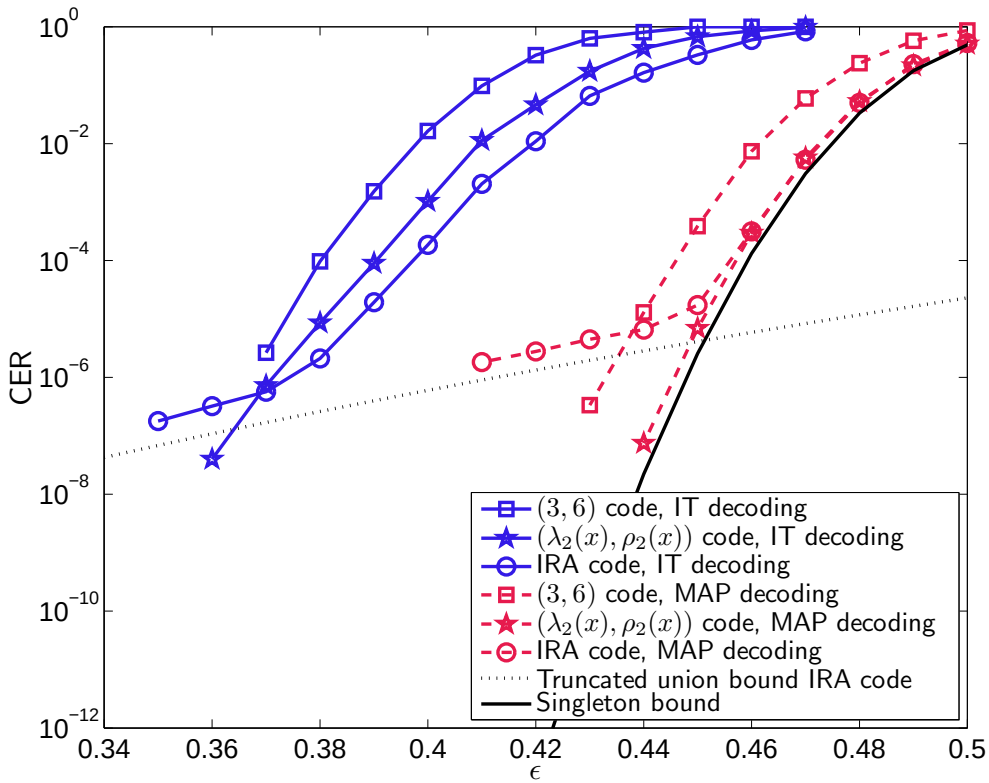
Numerical Results

Codeword Error Rate on the Erasure Channel



Codeword error rate (CER) of different $(2048, 1024)$ LDPC codes under both IT and MAP decoding. For symbol size of 1000 bytes decoding speed of at least 1.5 Gbps has been measured for the code with degree distribution pair $(\lambda_2(x), \rho_2(x))$.