Sparse Graph Codes for the Two-Way Relay Network with Correlated Sources

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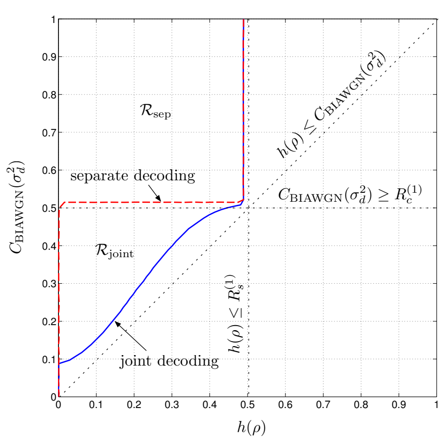
We consider the two-way relay network where two nodes communicate via a relay. We assume that the data at the nodes are correlated (e.g., measurements in a sensor network) and that there is no direct communication between the nodes. The nodes communicate via the relay using a two-phase protocol consisting of an uplink part over an orthogonal multiple access channel and a downlink part over a broadcast channel.

The individual codes as well as the overall system can be represented by a joint factor graph consisting of a source code at each node, a channel code for the each uplink and a channel code for the downlink. The optimality of separation of source and channel coding [1] implies that it is optimal to individually design these codes. We focus on low-density parity-check codes where code design corresponds to the optimisation of their degree distributions [2].

We assume correlated, memoryless binary messages represented by the vectors $\mathbf{W}^{(1)}$, $\mathbf{W}^{(2)}$ of length N_s where the elements are taken iid from a joint distribution $q(w^{(1)}, w^{(2)})$. In the uplink phase, the nodes encode their respective messages to binary codewords $\mathbf{X}^{(1)}$, $\mathbf{X}^{(2)}$ of length N_c. The *bandwidth expansion factor* is defined as $\kappa \triangleq N_c/N_s$, i.e., as the number of channel uses per source symbol. Necessary and sufficient conditions for the achievability of κ are given [1].



While the channel decoder at the relay is a stand-alone decoder, there are two options at the nodes: i) separate decoding or ii) joint decoding of the relay message and the other node's message.

As an example we assume uniform sources correlated via a BSC with cross-over probability ρ and reliable communication on the uplink channels. The broadcast channel is a Gaussian channel with variance σ_d^2. Furthermore, the rate of the source and channel codes is $1/2$ and $\kappa = 1$. We are now interested in the pairs (ρ, σ_d^2) which define the achievable region $\mathcal{R}$ where the iterative decoder converges.

When non capacity-achieving codes are applied (or the sources have a stronger correlation than designed for) then a joint decoder can exploit the remaining redundancy in the source and outperforms a separate decoding scheme.

[1] R. Timo, L. Ong, and G. Lechner, "The two-way relay network with arbitrary correlated sources and an orthogonal MAC," in *Proc. Data Compression Conference (DCC)*, 2010.

[2] T. J. Richardson and R. Urbanke, *Modern Coding Theory*. Cambridge University Press, 2008.

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