The DAVINCI Project

Design and Versatile Implementation of Non-Binary Wireless Communications based on Innovative LDPC Codes

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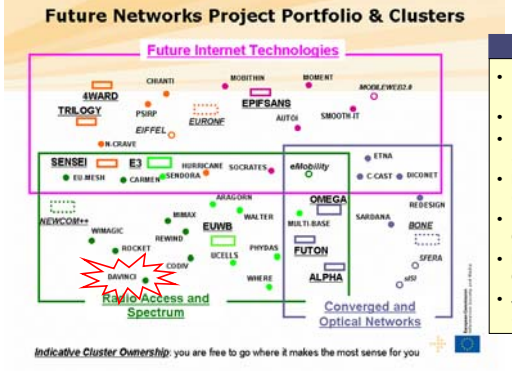
Project Goal and Main Objectives

Goal: To demonstrate the outstanding performance improvements & industrial feasibility of pioneering non-binary LDPC codes and adapted link level technologies for next generation wireless communications.

Main objectives:

- To develop a novel family of non-binary LDPC codes
- To design adapted strategies for link level procedures
- To propose and demonstrate adequate algorithm and architecture design for low complexity implementation on a chip
- To quantify the performance improvements of DAVINCI technologies

DAVINCI in the FP7 Project Portfolio and the Consortium

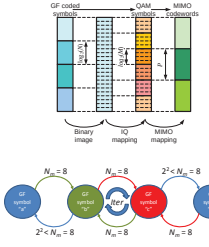


Selected Work Items

- Non-binary LDPC codes show best iterative decoding performance for considered block lengths
- Specific designs for the block-fading channel
- Non-binary link adaptation strategy, including ACM and HARQ
- Evaluation of DaVinci codes in IMT-Advanced candidates – link and system level
- Demonstrate feasibility of ASIC implementation in CMOS 45 nm technology
- Real-time wireless demonstrator with a 2×2 MIMO-OFDM platform with DaVinci decoder on FPGA
- Joint definition of hardware and code structure: build a decoder

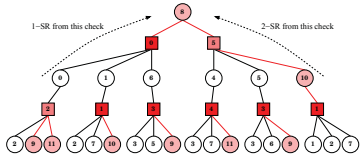
Low-complexity demapping for MIMO

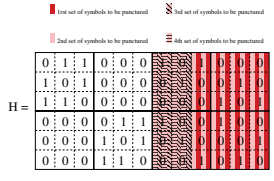
- We consider the combination of NB-LDPC (GF64) with any QAM-constellation, MIMO configuration (e.g. 2x2, 4x2, etc.) and coding scheme (Alamouti, uncoded SM, etc.)
- We focus on the soft demapper
- Strategy for mapping:
  - Limit the number of multiplexed code symbols into same I or Q component of one constellation symbol
  - Limit the number of multiplexed code symbols into the same MIMO codeword
  - Exploit available degree of freedom to achieve the highest diversity inside the code symbol
  - Reduce significantly the complexity of LLR computation when more than one code symbols multiplex into the same MIMO codeword, by exploiting only a number of most likelihood LLRs from a first GF symbol to derive the LLRs of a second GF symbols.



Optimization of Puncturing Patterns

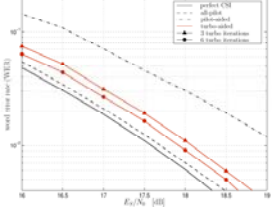
- Fact: Binary-wise puncturing of non-binary LDPC codes leads to the best performance, but on the contrary, complicates the receiver design
- Our approach: From a rate R = 1/2 mother code, we design puncturing patterns up to R = 3/4 at the *symbol level*. The optimized pattern needs to be adapted to the protograph used for code construction !
- Design criterion: we chose to maximize the number of 1-SR (one step recoverable) symbols in the computational tree of the Tanner graph associated to the LDPC code.
- The figure below shows that the punctured nodes see actually only 1-SR symbols through the computational tree



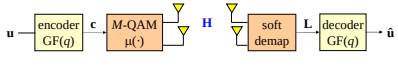
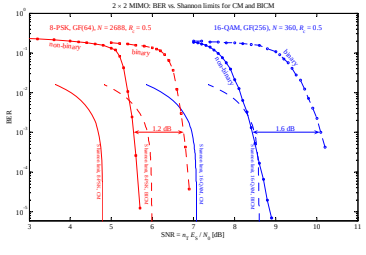


Iterative Channel Estimation

- Specific iterative channel estimation for OFDM signals with non-binary LDPC encoding (including hard and soft information)
- Limited but significant improvement w.r.t. the pilot-aided scenario (about 0.5 – 1 dB), especially for large constellations and with low mobility, at the expense of an increased receiver complexity
- Negligible performance degradation due to i) channel mismatch and/or ii) hard-detected information and/or iii) suboptimal filtering
- Impact of time correlation, in terms of accuracy of the performance evaluation and receiver complexity, currently under investigation



MIMO with non-binary coding



- Demapping is simple if one code symbols corresponds to one channel use, $\log q = n_T \cdot \log M$
- Non-binary ($q \in \{64,256\}$) processing is significantly better than binary processing
- BER with non-binary LDPC code outperforms Shannon limit of BICM (bit-interleaved coded modulation)