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29 March 2017, CTU in Prague, FEE, Czech Republic

Compute-and-Forward in Multi-User Relay Networks — Optimization, Implementation, and Secrecy

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Short Bio

Johannes Richter received in 2011 his Dipl.-Ing. degree in Electrical Engineering from the Dresden University of Technology, Germany. Now, he is with the Communications Laboratory in the Department of Electrical Engineering and Information Technology at the Dresden University of Technology.

Location & Time

Wednesday 29 March 2017 14:30-16:00, room T2:C3-434
The lecture is open for all academics and students.

Lecture abstract

In this presentation, we investigate physical-layer network coding in an L ×M × K relay network, where L source nodes want to transmit messages to K sink nodes via M relay nodes. We focus on the information processing at the relay nodes and the compute-and-forward framework. Nested lattice codes are used, which have the property that every linear combination of codewords is a valid codeword. This property is essential for physical-layer network coding.
Because the actual network coding occurs on the physical layer, the network coding coefficients are determined by the channel realizations. Finding the optimal network coding coefficients for given channel realizations is a nontrivial optimization problem. We provide an algorithm to find network coding coefficients that result in the highest data rate at a chosen relay. The solution of this optimization problem is only locally optimal, i.e., it is optimal for a particular relay. If we consider a multi-hop network, each potential receiver must get enough linear independent combinations to be able to decode the individual messages. If this is not the case, outage occurs, which results in data loss. In this thesis, we propose a new strategy for choosing the network coding coefficients locally at the relays without solving the optimization problem globally. We thereby reduce the solution space for the relays such that linear independence between their decoded linear combinations is guaranteed. Further, we discuss the influence of spatial correlation on the optimization problem.
Having solved the optimization problem, we combine physical-layer network coding with physical-layer secrecy. This allows us to propose a coding scheme to exploit untrusted relays in multi-user relay networks. We show that physical layer network coding, especially compute-and-forward, is a key technology for simultaneous and secure communication of several users over an untrusted relay. First, we derive the achievable secrecy rate for the two-way relay channel. Then, we enhance this scenario to a multi-way relay channel with multiple antennas. We describe our implementation of the compute-and-forward framework with software-defined radio and demonstrate the practical feasibility. We show that it is possible to use the framework in real-life scenarios and demonstrate a transmission from two users to a relay. We gain valuable insights into a real transmission using the compute-and-forward framework. We discuss possible improvements of the current implementation and point out further work.

About DiRaC (Digital Radio Communications) group

DiRaC group is the research group at the department of Radio Engineering K13137 at FEE/CTU. The group is headed by prof. Jan Sykora. General areas of activity are: Digital communication theory - modulation, coding, physical layer signal processing algorithms, Information theory, Parameter estimation and detection theory, Stochastic signal processing.
In our current effort, we concentrate on: Mobile radio communication systems with distributed, cooperative and MIMO coding and processing, Physical Layer Network Coding, Network coded modulation in Multi-node and Multi-source systems, Spatial diversity technique, particularly MIMO systems, Nonlinear Space-time modulation and coding, Iterative Factor Graph based technique in detection, channel state estimation and equalization, Adaptive modulation under specific constraints.

More information at...

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Digital Radio Communications Group