Universität Rostock Traditio et Innovatio

FAKULTÄT FÜR INFORMATIK UND ELEKTROTECHNIK

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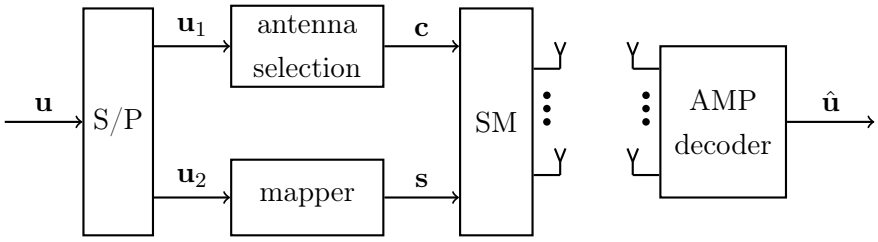
**Master Thesis**

# Spatial Modulation with AMP Variants

## Task Description

Multiple antennas at transmitter and receiver have boosted the performance of mobile radio communications. Since their introduction in 3G systems, they became a well-established component in many state-of-the-art mobile communication systems like 4G, 5G and WIFI systems. Multiple antennas can be used in different ways. They can improve diversity and robustness against fading, they can increase the SNR by beamforming, and they can enhance data rates by spatial multiplexing. Current research focuses on massive Multiple-Input Multiple-Output (MIMO) systems with hundred or even more antennas at a base station.

A relatively new approach is Spatial Modulation (SM). SM uses only $N_\mathrm{a}$ out of $N_\mathrm{t}$ transmit antennas and delivers information by the choice of active antennas. Additionally, conventional data symbols can be transmitted over the activated antennas. Particularly in massive MIMO systems, spatial modulation can achieve very large spectral efficiencies. The principal structure of the communication system is illustrated in the figure below. There is an interesting relationship of spatial modulation and Sparse Regression Codes (SPARCs). Both have the same mathematical structure and decoding can be performed with the same class of algorithms. SPARCs and Approximate Message Passing (AMP) decoding are proven to asymptotically achieve capacity.




This master thesis shall focus on the implementation of AMP algorithms. In particular, sliding-window AMP shall be investigated in terms of computational complexity and performance. Moreover, the VAMP algorithm shall be adapted to the case of frequency-selective channels (equivalent to spatially-coupled SPARCs). It is usually more robust for ill-conditioned matrices than other AMP variants, but does not perform well for block Toeplitz matrices.

For the master thesis, the following tasks have to be performed:

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- A literature study shall make familiar with the basics of spatial modulation and AMP decoding.
- An existing SM simulation environment in Python has to be extended by more sophisticated channel models including angular spreads at transmitter and receiver leading to spatial correlation.
- Implementation of a sliding-window AMP algorithm and analysis of its performance.
- Adapation of VAMP algorithm to block Toeplitz structure of channel matrix.
- The performance analysis of algorithms.

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