Algorithms for Radio Networks

Smart Antennas and MIMO
Smart Antennas

- **Alternative terms**
  - Adaptive Array Antennas
  - Multiple Input Multiple Output (MIMO)

- **Prinziple**
  - Multiple antennas are coordinated manner
    - used to improve reception or transmission of behavior
    - to allow additional features

- **Features**
  - Directional receivers
  - Directional senders
    - better path loss exponent
    - spatial multiplexing
    - MIMO communication
With two antennas, one can determine the receive direction (DOA)


Idea:
- The signals arrive at different times to the antennas. By parallel testing of overlays can be candidates for the angle of incidence findenn
Beam forming

- Simulation of receiving or transmitting antenna behavior of any of Smart Antennas

- Active
  - By suitably chosen time shift, receipt of signals at the antennas will transmit the desired direction preference
    - Other directions only increase only background noise
  - Applications: radar, mobile communications, MIMO

- Passive
  - As with the DOA-detection, the signals are delayed and superimposed
  - Applications: Microphones, MIMO
Smart Antennas Combinations

- **SISO (Single Input Single Output)**
  - Classic radio model

- **SIMO (Single Input Multiple Output)**
  - Classical transmitter with an antenna
  - Antenna array at the receiver
  - Different channels can be received in parallel from different angles

- **MISO (Multiple Input Single Output)**
  - Antenna array as a transmitter
  - Individual recipients (groups) can be individually reached

- **MIMO (Multiple Input Multiple Output)**
  - Directed (and parallel) communication between the transmitter and receiver possible
  - Efficient utilization of the medium
MIMO-Klassifikationen

- Single User (since 1996)
  - Only a point to point connection can be made
    - More connections via multiplexing possible
- Multi User (since 2004)
  - Parallel communication between various partners
    - on the same carrier wave, at the same time
    - as long as angles differ
Theoretical Potential of MIMO

- Gerard J. Foschini and Michael. J. Gans

- Shannon's theorem does not apply to antenna arrays
  - Transmission rate can increase arbitrarily for large numbers of antennae
Pros and Cons

- **Pro**
  - Shannon's law repealed
  - SNR is improved
  - more bandwidth, more parallel connections
  - spatial localization possible
  - beam forming

- **Contra**
  - complex structure
  - rotations must be compensated
  - motion tracking necessary