Large Intelligent Surfaces - Massive MIMO Evolution or Revolution?

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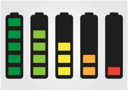
Outline

Digital Communications

- Low error rates
- Higher and higher bit rates
- Spectral efficiency [bps/Hz]

- Power savings

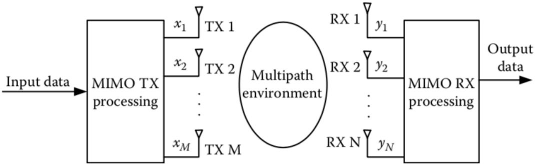


Channel Capacity

$$C = B\log_2(1 + SNR)$$

- Channel coding
  - Turbo codes
  - LDPC codes
  - Polar codes
- Equalization
  - MLSE
  - OFDM
  - SC-FDE
- Synchronization and channel estimation

MIMO Channel



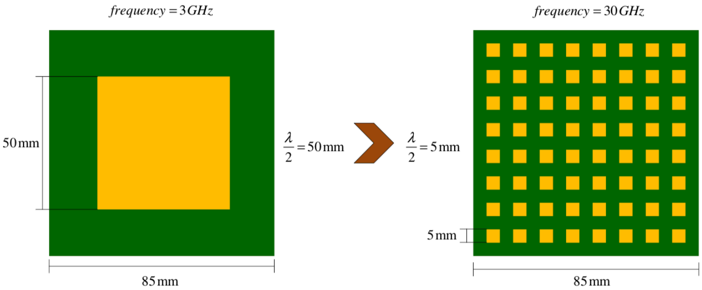
$$C = \log_2 \left(\det \left(\mathbf{I} + \frac{SNR}{N_{Tx}} \mathbf{H}\mathbf{H}^H \right) \right)$$

- Channel capacity grows with the number of antennas
- Gain relatively the SISO case upperbounded by $\min(N_{Tx}, N_{Rx})$
- Suitable for OFDM and SC-FDE schemes
- Optimum receiver too complex
- Practical receivers based on MMSE with excellent performance/complexity trade-offs

Massive MIMO

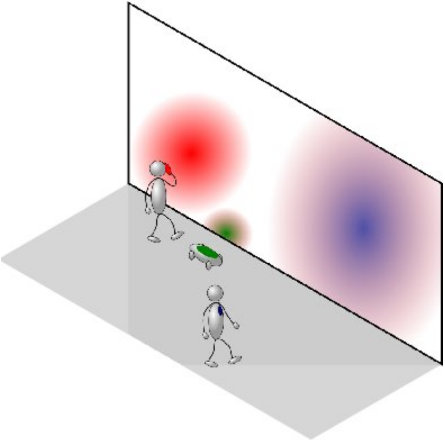
- Conventional MIMO schemes suitable for systems up to about 8×8
- Massive MIMO not a scaled version of MIMO!
- Low complexity implementations (low resolution DACs and ADCs, strongly nonlinear amplifiers, simplified equalization/pre-coding, etc.)
- Common elements (RF chains, mixers, DAC/ADC, etc.)
- Channel estimation challenges (e.g., pilot contamination)

LIS - Large Intelligent Surfaces



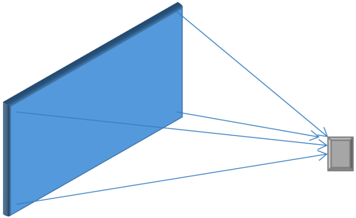
- Evolution of massive MIMO
- Much more antenna elements
- Short range
- Near field communication
- LoS communication

LIS Access



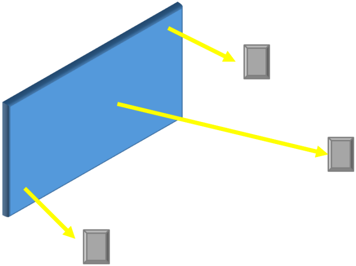
- Antennas switched on and off according to user position and/or user requirements
- Resource allocation at the space domain

LIS for Positioning



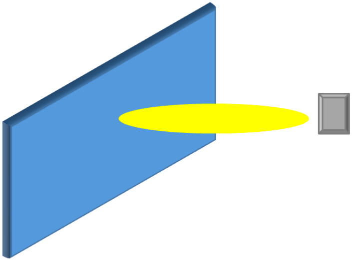
- Antennas with different RSS and/or AoA/AoD
- Accurate positioning

LIS for Communication



- Communication aided by positioning information
- Low complexity transmission and detection schemes
- Huge capacity and coverage gains
- Robustness to interference and imperfections

LIS for Energy Harvesting



- Beamforming to compensate losses in energy harvesting
- Better range and/or energy harvesting efficiency than traditional techniques
- Ranges of 1m or more

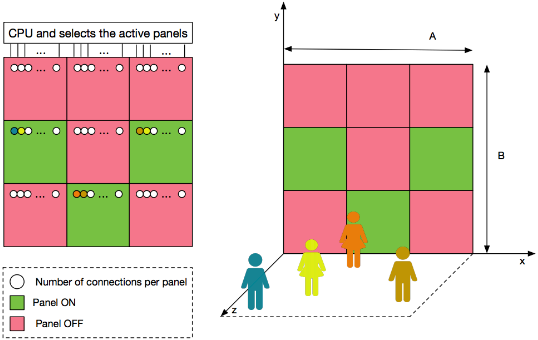
Transceiver Design

- Need for very low complexity transceivers
- On/off approaches
- Beamforming
- Skip equalizers?
- Interference cancellation
- Low resolution DAC/ADC (1 bit quantizers?)
- Low complexity amplifiers (saturated or even switched amplifiers)

Channel Estimation

- Too many channel to estimate
- Parameterized channel models
- Position-aided channel estimation
- Channel tracking

Resource Allocation



- Space-domain resource allocation
- Aided by position information
- LIS split in panels
  - Many antennas per panel
  - Small number of outputs per panel
  - A user can be associated to several panels

Conclusions

- Path from SISO to LIS
- LIS with very high potential
- Challenges
- It is possible!