Evaluation of Spatial Modulation using Urban Channel Data

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Aims

Spatial Modulation Performance :

- Part One
  - Over urban 4x4 MIMO channels
  - Comparison to simulated channels and analytical analysis
- Part Two
    - Over massive MIMO arrays created by virtual MIMO

Division of Tasks

- University of Bristol
  - Collection and characterisation of urban MIMO channel data
  - Selection of channel data for PHY layer simulations

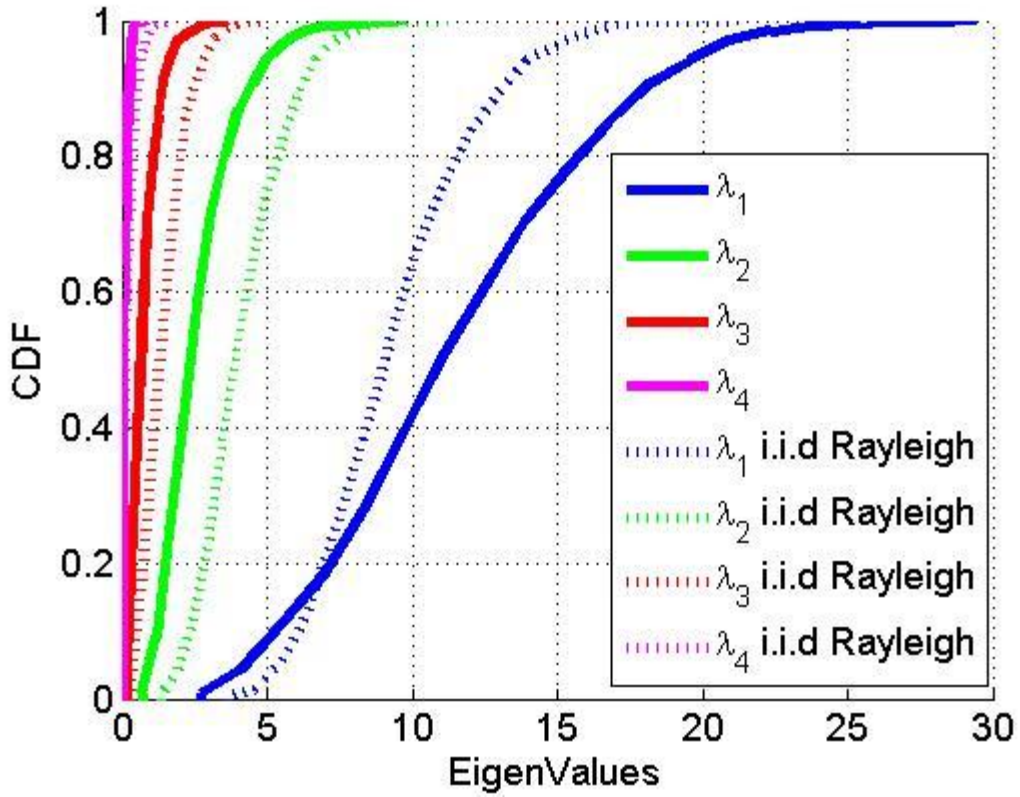
- University of Edinburgh
  - Creation of PHY layer simulator
  - Performance Analysis for Spatial Modulation (SM)

Outdoor MIMO (2GHz Carrier)

Channel Selection

- Real life rarely conforms to nice and simple channel modelling, i.e. i.i.d. Rayleigh fading.
  - Many factors can complicate the channel
    - LOS
    - Element correlation
    - Element shadowing
    - Fading not well modelled by common distributions

Channel Properties Example



Channel Selection

- Initial investigations look at ‘simple’ channels with easily modelled correlation properties
  - Simplifies moving from analytical and channel models to real channel data
  - Selected channels need to fit a Rayleigh fading Kronecker MIMO channel model
  - Four channels selected, two with high and two with low spatial correlation properties

Kronecker MIMO Channel Model

- Models the correlation between elements at the transmitter and receiver using two simple correlation matrices R_{TX} and R_{RX}.

$$H = R_{Rx}^{1/2} G R_{Tx}^{1/2}$$

- Channel correlation modelled using an exponential decay model
- Poor performance for large arrays [1] – sufficient for initial investigations

[1] D. McNamara, M. Beach, P. Fletcher, Spatial correlation in indoor MIMO channels *Personal, Indoor and Mobile Radio Communications, 2002. The 13th IEEE International Symposium on*, 2002, *1*, 290 - 294 vol.1

Channel Selection

- Total of 463 walking measurements were taken
  - 25 fit Rayleigh fading – using Chi-square test
- Uncorrelated channels
  - Two channels with low spatial correlation were selected
- Correlated channels
  - Two channels that best fitted an exponential decay model were selected

Results

Un-Correlated Channels

Correlated Channels

Un-Correlated Channels

Correlated Channels

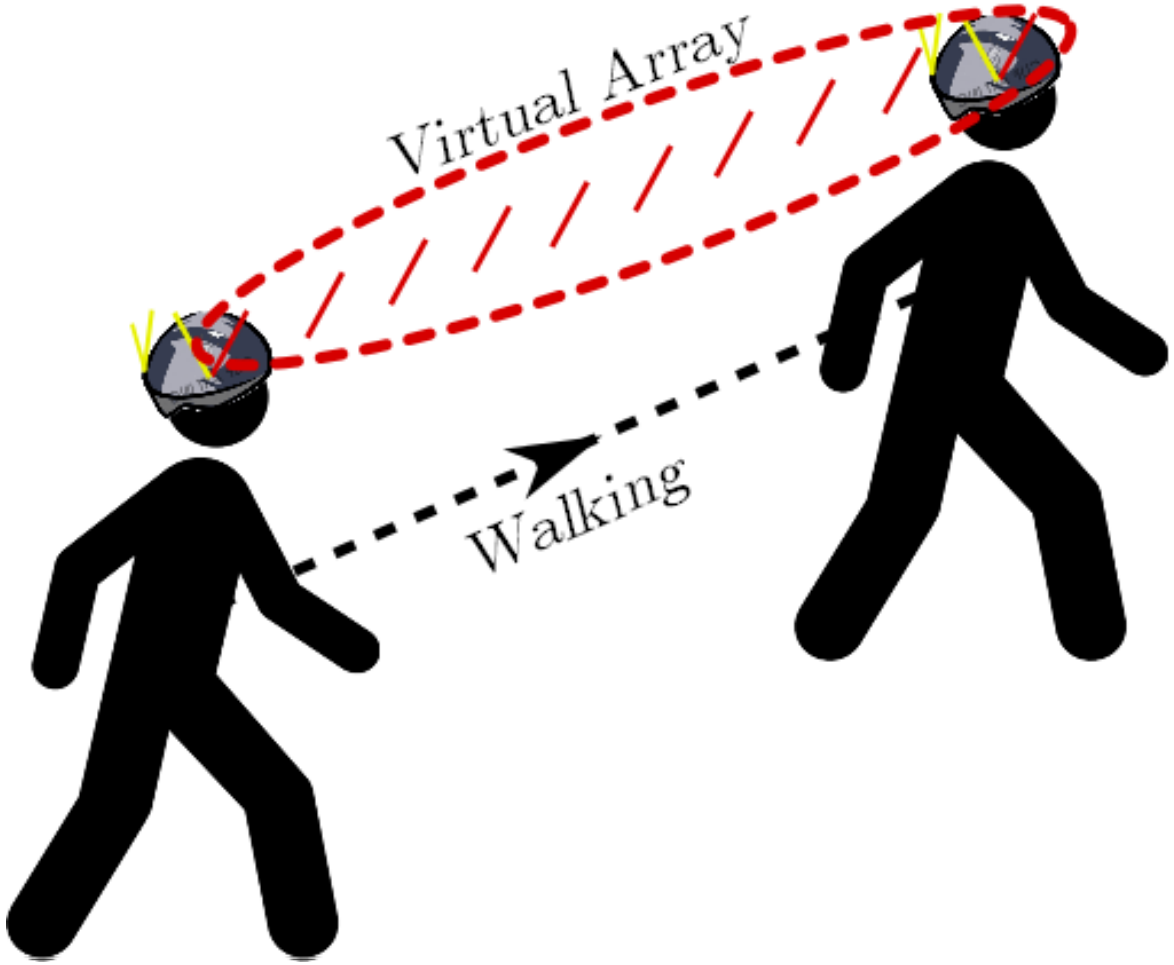
Massive MIMO

- Spatial Modulation on massive MIMO systems [1]
  Highly energy efficient transmission
- Original channel measurements are 4x4
  - Channel manipulation can approximate large virtual MIMO arrays [2]
    - Walking measurements
    - Channels reversed. i.e. Mobile end becomes the transmitter

[1] M. Di Renzo and H. Haas, "Bit Error Probability of Spatial Modulation (SM-) MIMO over Generalized Fading Channels", *IEEE Transactions on Vehicular Technology*, Vol. 61, No. 3, pp. 1124-1144, March 2012.

[2] M. Webb, M. Yu, and M Beach, Propagation Characteristics, Metrics, and Statistics for Virtual MIMO Performance in a Measured Outdoor Cell, IEEE Transactions on Antennas and Propagation, Vol. 59 No. 1, Jan 2011, pp236-244

Virtual Array Creation



Channel Selection

- Selected Channels:
  - Fitted Rayleigh fading
  - All channels experienced similar Rayleigh fading
  - Maximum channel size
    - 256 transmitters, 4 receivers

Results

Conclusion

- The performance of SM was analysed over real channel measurements
- The results validate our analytical and simulation expectations
- For a small number of transmit antennas, SM offers the same or slightly better performance when compared to SMX
- For a large number of transmit antennas, SM offers a much better performance

Further Work

- Performance over more complex channels
  - NLOS/LOS
- Movements influence on performance
  - Walking/standing/driving
- Analysis of HW testbed using measured channels emulated on Electrobit C8