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.


[1] D. McNamara, M. Beach, P. Fletcher, Spatial correlation in indoor MIMO channels
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


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