Real-Time Measurements with a 128-Antenna Massive MIMO Testbed

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http://www.bristol.ac.uk/engineering/research/csn/
Summary

• BIO Testbed Description
• First Experimental Trials
• Initial Results
• Future Work
The Massive MIMO Concept

- Increased spectral efficiency and network capacity
- Accurate spatial multiplexing
Importance of Real-World Tests

• A promising theoretical technology, but needs extensive validation

• Successful MIMO performance is inherently environment dependent (i.i.d. assumptions)

• Implementation challenges need to be discovered and tackled
NI Based ‘BIO’ Massive MIMO test-bed

- 128 Programmable Radio Heads (4 racks of 32 radios)
- ‘TD-LTE’ like PHY (20 MHz)
- 1.2 – 6.0GHz Carrier (3.51GHz used)
- MMSE, ZF and MRC/MRT
- Channel processing currently supports up to 24 Clients
- Full FPGA data streams currently supported for up to 12 clients
Hardware Tree

Centralized MIMO Processing

Antennas 0 - 31
Antennas 32 - 63
Antennas 64 - 95
Antennas 96 - 127

13th July 2016, BBC, Salford
Massive MIMO subsystem architecture
MIMO Processor

- Wide Data Path 128 x 12 Linear Detector
- Computes 128 x 12 by 128 x 1 matrix vector multiply in 160 ns
- 24 Million times per second

\[
W_{MMSE} \times y = \sum W_{MMSE_i} y_i = \hat{u}
\]
Frame Schedule

10ms Frame (140 OFDM Symbols)

5ms Coherence Interval

1ms Subframe

Default schedule usually applied to every slot for TDD operation (0.5ms coherence interval)
Initial System Deployment

• Indoor atrium of University of Bristol’s Merchant Venturers Engineering Building
• 5.4m Linear Array with half-wavelength spacing
• LOS Conditions
Initial System Deployment

- Client Separation 2.5 - 6 Wavelengths
- Equal Tx Power
Real-Time Channel Information

- Eigen Structure
- Individual Spatial Stream Rx Magnitude
- Fading over the array caused by stairwell
- Power Delay profiles
- Frequency Domain profiles
for 12 users with scaled N

Scenario 2 (12.5m Straight Line)

32 Antennas

64 Antennas

112 Antennas

dB (Relative to max)
CDF Plots of SVS

Exploitation of azimuth spread

Scenario 1-3 in ascending order of LOS distance

LOS worst scenario for 32 elements
12 Streams of 256-QAM

Paper accepted for presentation at Globecom 2016 in Washington DC

http://www.bristol.ac.uk/news/2016/march/massive-mimo.html

13th July 2016, BBC, Salford
2nd Phase Deployment (11th May 2016)

24.8m 3.51 GHz Patch Array

24 UEs
22 Streams of 256-QAM

• 22 users running 256 QAM in 20MHz Channel

• Using the same frame structure as before this equates to 145.6 bits/s/Hz and an uncoded sum rate of 2.915 Gbps

http://spectrum.ieee.org/tech-talk/telecom/wireless/5g-researchers-achieve-new-spectrum-efficiency-record
http://www.bris.ac.uk/news/2016/may/5g-wireless-spectrum-efficiency.html
Uplink Power Control

• Why?
  • Mitigate ‘Near-far’ effects
  • Combat Intra/Inter cell Interference

• Approaches
  • Open-loop
  • Closed-loop
PC Techniques for M-MIMO

Investigating ways to increase:

- Average SINR
- Power Efficiency

Whilst decreasing:

- Transmission Overheads
- UE Complexity
- Latency
M-MIMO Applications

- Investigating M-MIMO for program making and delivering mobile user content (BBC)
  - Major sporting or cultural events require a large number of wireless cameras
  - Move towards the all wireless studio
Future Work

- Mobility Measurements
- Array configurations and polarisations
- Power Control Techniques
- Performance Optimisation
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Testbed Demonstration Video: https://youtu.be/pucUF9IsL1M