Spatial Multiplexing in mmWave Wireless Networks

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mmWave MIMO vs. Legacy MIMO

- Concurrent transmission of multiple spatial streams
- Key to scale to dense user populations

Path Discovery

(i) Repurposing the initial beam sweeps for PDP estimations
- Zero additional overhead
- Sparse scattering
- GHz sampling rate

(ii) Exploiting the knowledge of radiation patterns to infer direction

- If PDP containing/not containing a path, the path angle is likely/unlikely to lie into the high directivity range
- By weighting each PDP by the known directional gain, we narrow the direction interval that each path may fall into

Analog Configuration, the Key Player!

\[ \begin{align*}
\mathbf{h}^{(1)}_{eff} &= \mathbf{w}^H_{AP} \mathbf{h} \mathbf{w}_{UE,1} \\
\mathbf{h}^{(2)}_{eff} &= \mathbf{w}^H_{AP} \mathbf{h} \mathbf{w}_{UE,2}
\end{align*} \]

- Received SNR
- Interference
- Degrees of freedom (DoF) or multiplexing gain

Key challenges

- Efficiently discovering best analog beams at the AP and Clients to O(N^s) search space for s streams
- Exhaustive search has prohibitively large training overhead
  - Re-training to recover from mobility
  - Training time in orders of 10s of msec
  - 2 ms data transmission time

Multi-Stream Beam Selection

- Over diverse or ideally orthogonal paths
- Maximizing DoF or spatial multiplexing gain
- MUTE (Multi-stream beam-Training for mmwaveE networks)

MUTE Design

Benchmarking

- SNR-based candidate beam selection
- Relying on ZF to cancel residual interference

MUTE Performance

X60 Testbed

- NI mmWave Transceiver System
- Wideband Transmissions (2 GHz)
- Programmable PHY/MAC
- 24-element Phased Array Antenna
- Trace-driven Emulations

Publications: