Leveraging Machine Learning To Enable Mobility and Enhance Reliability in mmWave Systems

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Mobility & Reliability are Key Challenges

- Mobility Challenges
  - Large training overhead to find best beams
  - Frequent hand-off between BSs

- Reliability Challenges
  - mmWave signals are sensitive to blockages
  - Large difference between LoS & NLoS SNR
  - Reliability is a main challenge with mobility

Proposed Solution: Leverage ML/DL

- Intuition: mmWave channels are functions of
  - Environment geometry, materials
  - TX/RX locations

  \[ h = f(\text{environment geometry, TX/RX locations,...}) \]

- Use cases
  - Learning this mapping \( \rightarrow \) Predict best beam or set of beams
  - Learning mobility pattern \( \rightarrow \) Predict blockages

ML for Highly-Mobile mmWave Systems: Beam Prediction and Low-Complexity Coordination

- Learning to map RF signatures to beams
- Negligible training overhead
- Works indoor and outdoor, LoS & NLoS

ML for Reliable mmWave Systems: Blockage Prediction and Proactive Hand-off

- Beam sequences have diff. lengths depending on user speed, trajectory, time served by this BS
- Adopted a gated recurrent neural network to handle variable-length sequences
- Ray-tracing based simulations
- 95% success probability in predicting hand-off

Conclusion and Future Work

- Conclusion
  - ML enables prediction the beams with negligible training overhead
  - Proposed solutions is general for LOS/NLOS, indoor/outdoor scenarios
  - Novel solution for reliability & latency problems in mmWave

- Future work
  - Extensions to multi-user scenarios
  - Extensions to multi-antenna users
  - Developing analytical guarantees for the performance

REFERENCES