Massive MIMO Power Consumption Reduction

Prof. Brian L. Evans, Mr. Jinseok Choi, and Mr. Junmo Sung
The University of Texas at Austin

Wireless Networking & Communications Group

TEXAS The University of Texas at Austin

OBJECTIVES

For realization of power-efficient massive MIMO structures, we investigate

a) ADC bit allocation b) Antenna selection c) User scheduling d) Channel estimation

RECEIVER ARCHITECTURE

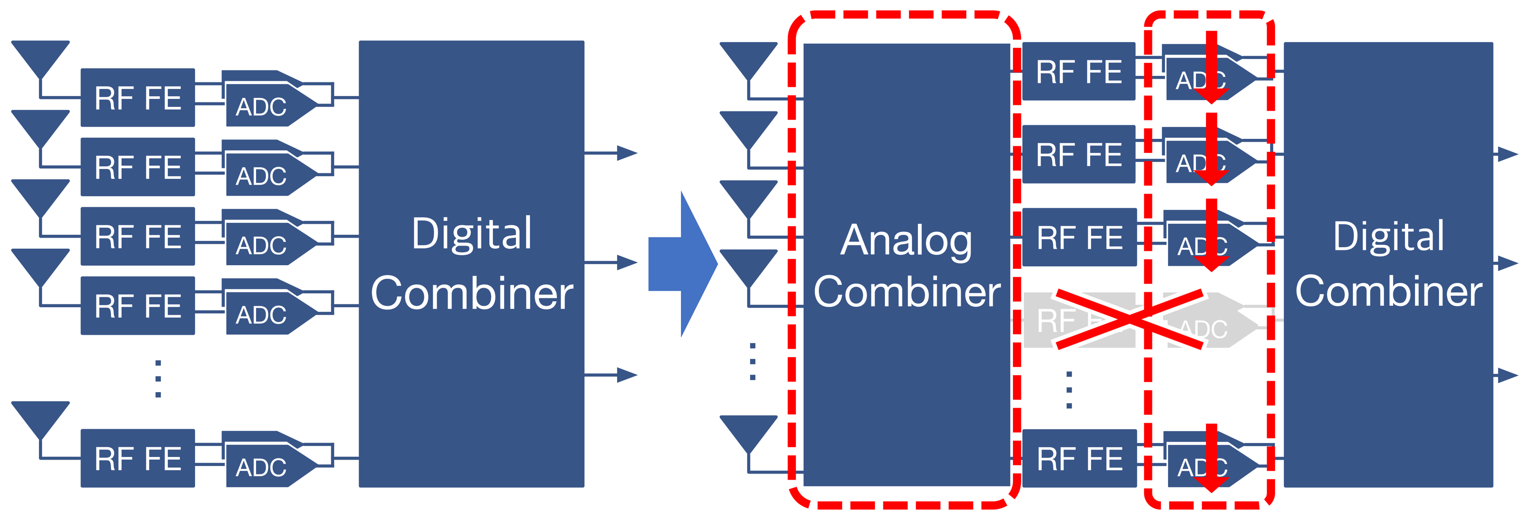

Figure 1: Power-efficient massive MIMO receiver architecture.

ADC BIT ALLOCATION

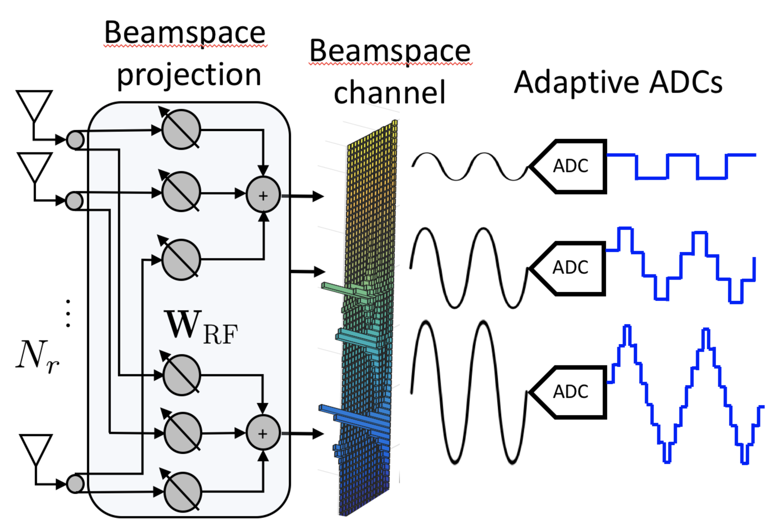

Figure 2: Resolution-adaptive ADC architecture.

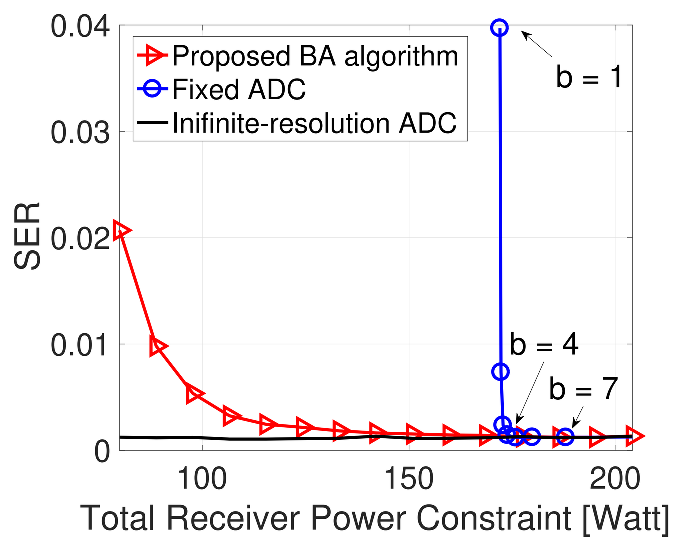

Figure 3: Symbol error rate with ZF equalizer.

- Motivation: Use ADC power consumption more efficiently.
  - Exploit sparsity of mmWave channel in beam domain.
  - Derive **closed-form bit allocation solution** $b_i = f(\mathbf{H})$.
  - Achieve large performance improvement with same power consumption.

ANTENNA SELECTION

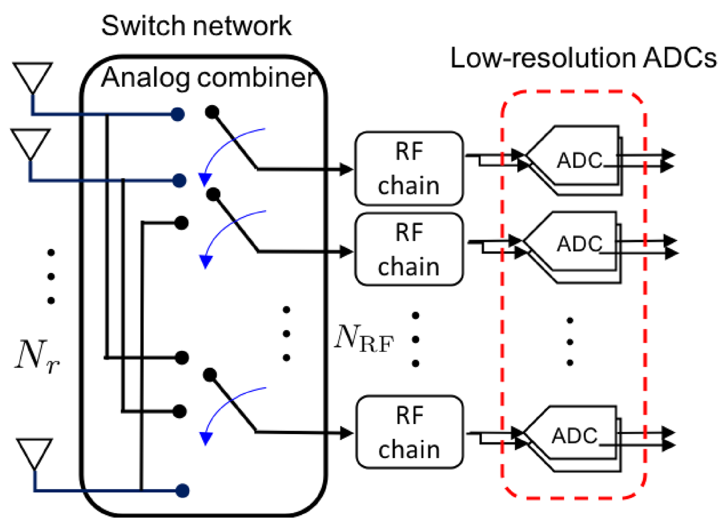

Figure 4: Antenna selection with low-res. ADCs

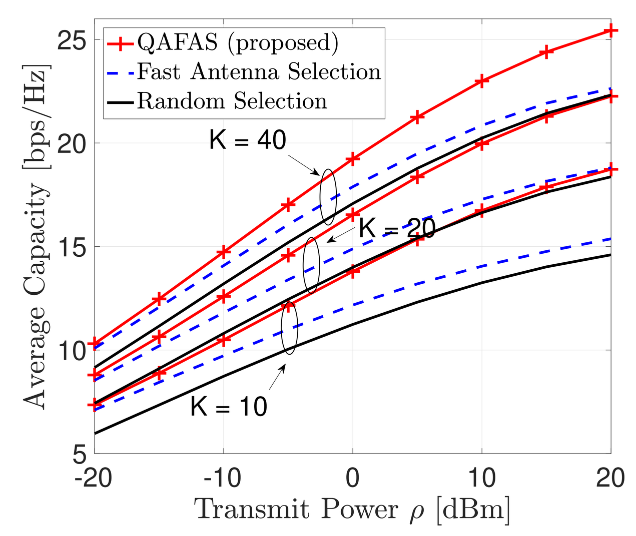

Figure 5: Mutual info. with antenna selection.

- Motivation: Reduce number of RF chains without using phase-shifters.
  - Capture trade-off between **channel gain** vs. **quantization error**.
  - Develop low-complexity quantization-aware antenna selection algorithm.
  - Achieve large performance improvement with same power consumption.

USER SCHEDULING

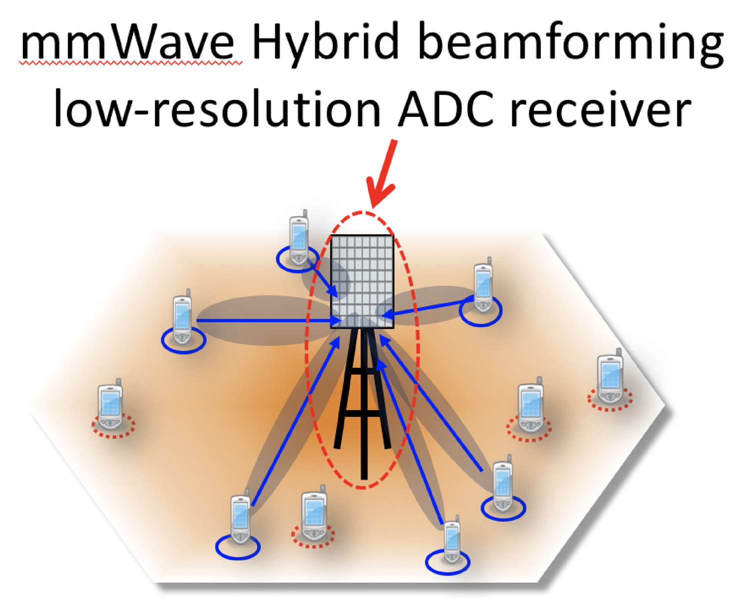

Figure 6: Scheduling criteria with quant. error.

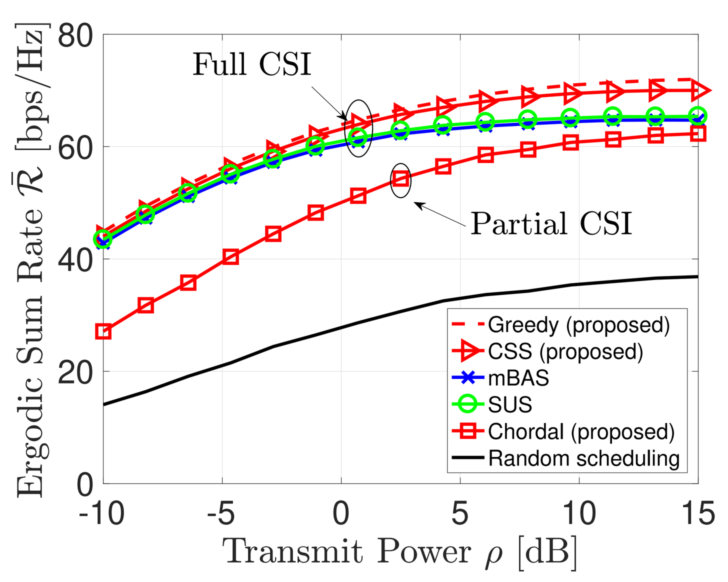

Figure 7: Ergodic rate with ZF equalizer

- Motivation: New user scheduling criteria are necessary for low-res. ADCs.
  - Schedule users with **balanced channel gain** and **quantization error**.
  - Derive **additional scheduling criteria** regarding channel structure.
  - Achieve large performance improvement with full/partial CSI.

CHANNEL ESTIMATION

Motivation

In hybrid low-resolution systems,

- Channel state information is critical for
  - Hybrid beamformer configuration
  - Channel equalization
- Channel estimation is challenging due to
  - Indirect access to channels
  - Significant training overhead
  - Quantization distortion

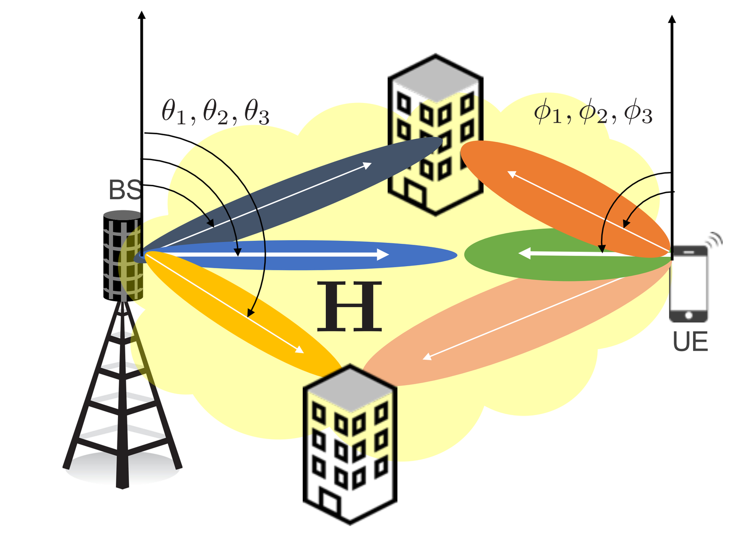

Figure 8: Angles of departure and arrival and associated channel gains

Work 1: Phase-shifting analog beamformer and 1-bit ADC systems

- Compressed sensing algorithms to exploit sparsity of mmWave channels
- Modified 1-bit GAMP to address nonlinearity due to 1-bit ADCs
- The proposed algorithm outperforms variants of GAMP and LS estimator

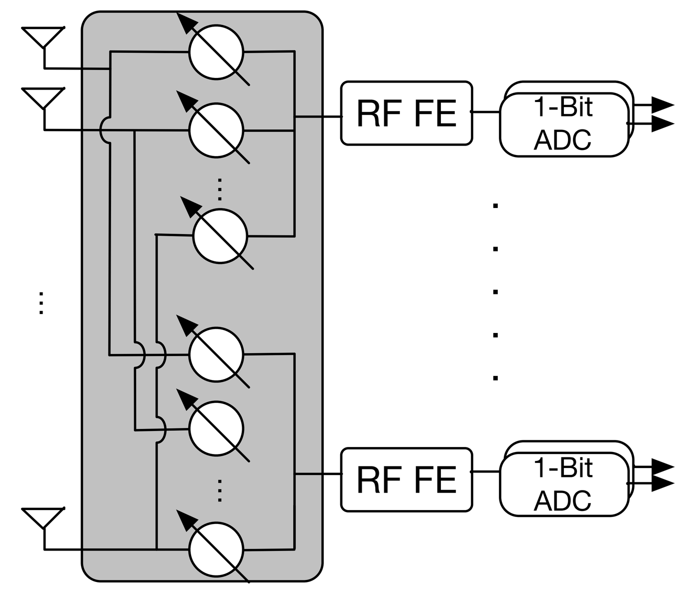

Figure 9: Receiver diagram with PS-based analog combiner and 1-bit ADCs

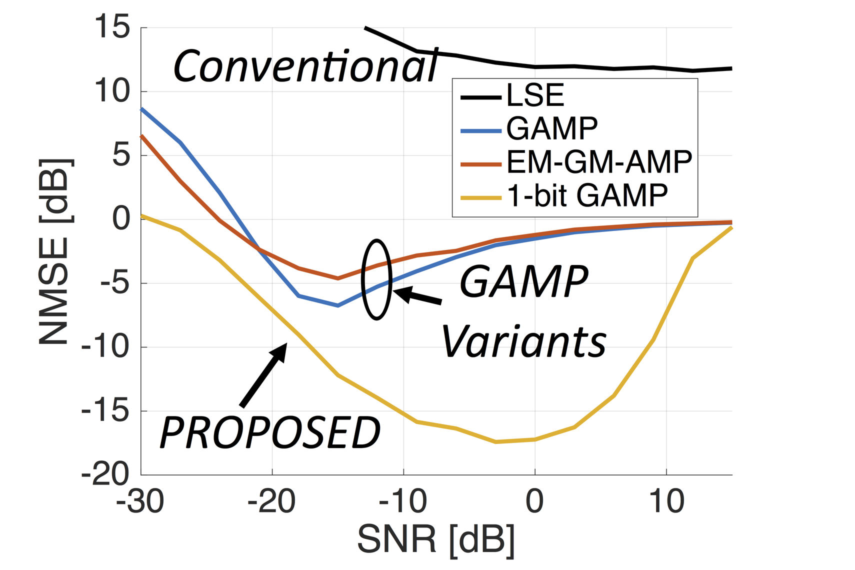

Figure 10: Channel estimation performance comparison

Work 2: Universal and deterministic beamformer design

- Deterministic design for performance enhancement of CS algorithms
- Universal beamformer design applicable to various hybrid architectures

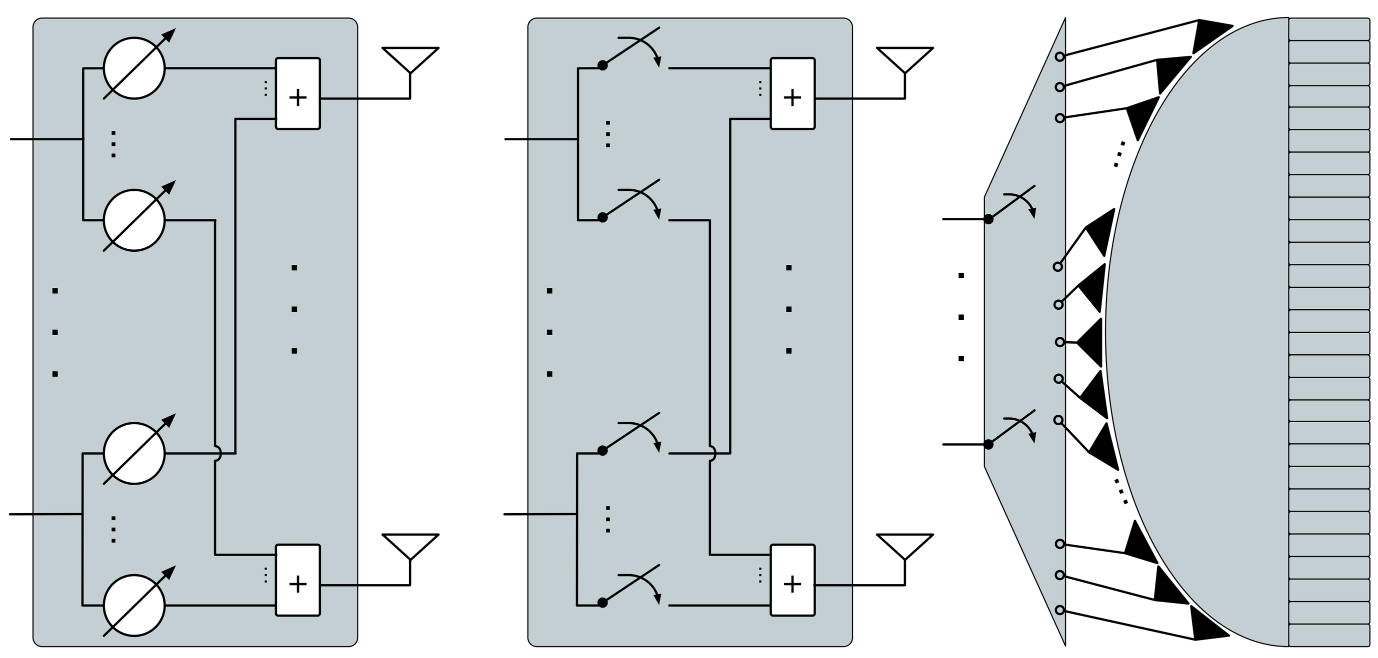

Figure 11: Phase shifter, switch and discrete lens array based architectures

- Channel estimation error comparison with coarse and fine angle grids
  - Deterministic design outperforms random designs
  - Proposed design is robust to fine angle grids

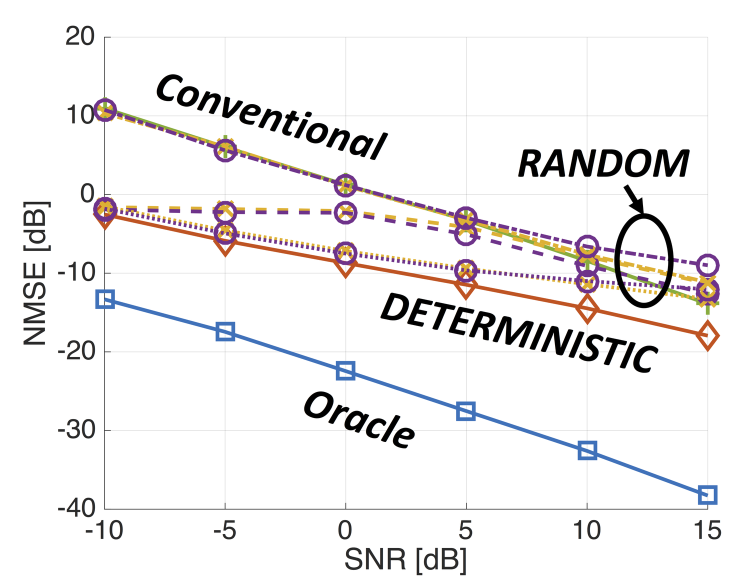

Figure 12: Coarse grids

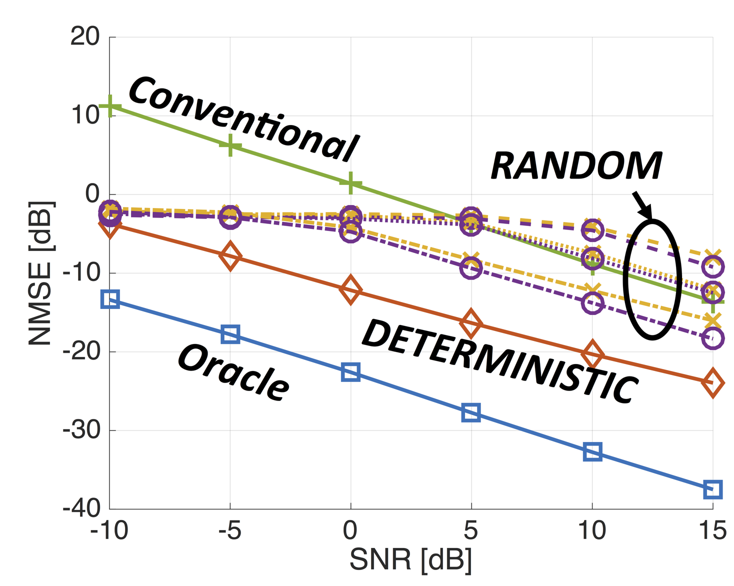

Figure 13: Fine grids

SELECTED REFERENCES

[1] J. Choi, B. L. Evans, and A. Gatherer, "Resolution-adaptive hybrid MIMO architectures for millimeter wave communications," *IEEE TSP*, vol. 65, no. 23, pp. 6201–6216, 2017.

[2] J. Choi, J. Sung, B. L. Evans, and A. Gatherer, "Antenna Selection for Large-Scale MIMO Systems with Low-Resolution ADCs," *IEEE ICASSP*, 2018.

[3] J. Choi, G. Lee, and B. L. Evans, "User Scheduling for Millimeter Wave Hybrid Beamforming Systems with Low-Resolution ADCs," *IEEE TWC*, 2018, submitted.

[4] J. Sung, J. Choi, and B. L. Evans, "Narrowband channel estimation for hybrid beamforming millimeter wave communication systems with one-bit quantization," in *IEEE ICASSP*, 2018.

[5] J. Sung and B. L. Evans, "Universal and deterministic hybrid beamformer design for CS-based mmWave channel estimation," *IEEE TWC*, to be submitted.

http://users.ece.utexas.edu/~bevans/ bevans@ece.utexas.edu