Reconfigurable, Efficient, and Scalable Millimeter-Wave Systems

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Motivation and Research Directions

Millimeter-Wave Communications Opportunity

- 28 GHz
- 60 GHz

Cellular and WiFi communications (28GHz and 60GHz)

Challenges and Potential Solutions

1. Power efficiency of mm-wave transmit array is very low.
2. Arrays are large and expensive.
3. Performance delta of mm-wave radio over RF radio is too small.
4. Hardware solutions are specialized and not multifunctional.
   - NCSU investigating ways to increase efficiency by >5X (or reduce area by >5X).
   - NCSU investigating compact, broadband mm-wave arrays.
   - NCSU investigating MIMO receiver for co-located antennas.
   - NCSU investigating universal mm-wave transceiver for arrays.

Towards Efficient Millimeter-Wave Systems

- Efficient Unit and Multi-Unit PAs
- Reconfigurable Dual-Vector Doherty Beamformer (DVDB)
  - Allows independent control of carrier and peaking amp.
  - Embedded phase shifting for phased arrays.
  - Can be configured in high-eff. or reduced linearity mode or high-linearity, reduced efficiency mode.
  - Useful for range of modulations.
  - 60GHz results [3] show increased PAE from 4% to 7% (beamformer).

Conclusions and Future Directions

- Increased back-off efficiency in beamformer is key to enabling lower cost, compact transmitters.
- Transmitter architecture must support high BW at high linearity (challenge for polar architectures).
- Support of multiple modulation schemes suggests reconfigurable architecture desirable (DVDB, left).
- Future: New (heterogeneous) approaches required for bridge devices, circuits, & signal processing.

Towards Scalable Millimeter-Wave Systems

- Hybrid Beamforming (RF+IF+digital)
- Multi-band, multi-beam phased-array solutions enable radio to take advantage of wide spectrum.
- Hybrid beamforming phased-array architectures, (combining aspects of RF, IF, and digital beamforming), may provide new capabilities and/or reducing bandwidth and size constraints.
- Future: Mixer-first architectures which support beamforming and MIMO up through 40 GHz.

Conclusions and Future Directions

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Figure credits: