Discussion Points for HW-CSP Breakout Session

July 19, 2017

Jeyanandh Paramesh, Subhanshu Gupta, Greg LaCaille, Vishal Saxena, Sarah Yost

Topics for Discussion (Tentative)

- What are the main issues at the HW-CSP interface that drive system design at the physical layer? (e.g., energy consumption, HW-CSP co-design signal processing across RF/analog/digital domains and more broadly to mechanical, acoustic or photonic domains, etc.)
- What are the HW-CSP pros/cons of alternative beamforming approaches (e.g, photonic, lens-based, mechanical)?
- What are the most promising directions to pursue in advanced systems beyond 5G and how do they impact on HW-CSP challenges? (higher frequencies, spatial multiplexing MIMO, point-to-point MIMO, high-order modulation, full-duplex etc.)
- What frequencies and bandwidths to target at millimeter-wave?
- What are the most promising emerging physical/device technologies, circuit or algorithmic concepts?
- Should we intelligently partition the signal processing across RF, analog and digital domains? Or should we strive for an all-digital approach?
- What HW-CSP-NET co-design approaches are necessary to address interference and co-existence issues (with other communication systems, or with radar)?
- What role can machine learning play not only at the HW-CSP level, but also at the network level?
- How important is physical layer and hardware level security? What are some of the key HW-CSP considerations related to this?
- Training/Education: How should we train researchers with sufficient breadth for effective collaboration at the HW-CSP interface? How must university curricula adapt?

System Issues

- Massive MIMO
  - Extremely high hardware complexity → how many elements?
  - Where to use → Backhaul? Uplink? Downlink? Or all?
  - How many elements? At base-station, At mobile?

- MIMO approaches
  - Will digital beamforming be viable? If so, in what scenarios?
  - Is hybrid beamforming the answer? What are the big issues? How to scale?
  - Beamspace MIMO?

- Scalable energy models for massive MIMO radios?
- What role can machine learning play?
- Target frequencies and target bandwidths

Signal Processing & Algorithms

- Lots of current research on new algorithms for mm-wave communication systems
  - Channel estimation, beam acquisition and tracking, precoding and (de)modulation, training, equalization etc.
- Are their underlying assumptions valid?
  - Modeling of hardware structures and imperfections
  - Sparsity of channel models
- What is the energy footprint of these algorithms?
  - Compressive algorithms?
  - Basestation vs mobile
- How should we intelligently partition the signal processing across RF, analog and digital domains?
- Can Cloud-RAN address energy challenges at basestation/network level?
- Energy costs of error-correcting codes?

Chip-level Challenges

- Transmitter (i.e., PA's at back-off)
  - What is transmitter power consumption in hybrid MIMO?
  - All-CMOS vs (III-V + CMOS) transmitter?

- Designing for ultra-wide mm-wave frequency ranges
- Frequency synthesis and LO distribution → phase-noise & spurs
- ADC's and DAC's
- Digital power consumption

- What co-existence and interference issues to consider?
  - Communication with radar?

Packaging & Non-chip Challenges

- Packaging issues
- Antenna design
  - Reconfigurable?
  - Multi-band?
- What about other forms of RF-domain beam-steering?
  - Mechanical beamforming,
  - Lens-based beamforming
  - beamspace MIMO
  - Combining lens arrays and phased arrays (e.g. a phased array on the focal surface of a lens array)
- Testing challenges at various levels?
  - Chip, module, benchtop, on-air

HW/CSP Issues in Future Systems

- What approaches to increase spectral efficiency and network capacity?
  - Spatial multiplexing
  - Cognitive sensing
  - Polarization MIMO
  - Full-duplex
- Physical layer security
  - Using directionality, power control, encryption?
- Combined sensing (radar/imaging) + comms @ mm-wave