IEEE Future NETWORKS

Enabling 5G and Beyond

International Network Generations Roadmap (INGR) Industry Forum

Massive MIMO WG

Chris Ng, Webert Montlouis

22 October 2020

IEEE

10-year Vision

- **100-1000** controllable antenna elements per person in the next 10-20 years
  - Enables **intelligent control** of the wireless physical layer
  - Evolves wireless from an interference-limited medium to a **multiuser** communication fabric
- Transforming ubiquitous person-to-person communications to pervasive **device-to-device** communications
  - Emphasis on **networking-like** scheduling, routing and optimization techniques
  - Enables the next-generation of **distributed** signal processing and machine learning algorithms

Scope

- Massive MIMO
  - Use of a large number of antenna elements
  - A key enabling technology in the 5G and Beyond wireless ecosystem
- Intelligent use of the multitude of antenna elements
  - Unleashes unprecedented flexibility and control of the physical channel of the wireless medium.
- Massive MIMO in Future Networks will support:
  - High throughput, high reliability, low error rate, high energy efficiency
  - Low latency
  - Internet-scale number of connected devices
- Edition 2 to expand on Edition 1 to present a 10-20 years long-term vision
  - Orders of magnitude increase in number of antennas
  - Requirements, implications, and enablement to other technology areas through collaborations with other WGs

Today's Landscape

- Rudimentary control in leveraging multitudes of antenna elements:
  - LTE: 2-32 controllable antenna elements
  - 5G: 2-128 controllable antenna elements
  - WiFi: 2-16 controllable antenna elements
- Currently, exploitation of multiple antennas is confined to the wireless physical layer
  - Not exposed as a controllable interface
  - Applications are not aware of Massive MIMO-enabled opportunities (e.g., application requests to steer an RF beam to a certain user at a given time)

Large-Scale Massive MIMO

- Internet-of-Things
- Scalability
- Energy Efficiency
- Signal Efficiency
- Mobility
- Intelligent Edge Network

New Areas of Consideration in Edition 2:

- Regulation & Compliance
- Massive MIMO Radar
- Cell-free Massive MIMO
- Intelligent Reflecting Surface

Challenges and Solutions to Meet Needs

- Ecosystem drivers:
  - **Hardware**: hardware-constrained base stations, low-cost efficient transceivers, new adaptive array transceiver technology
  - **AI**: Deep Learning network architectures to enable Machine-Type Communication
  - **Edge Processing**: Greater compute power and intelligent processing at the edge with an increase in antenna elements (Parallel processing at the edge)
  - Others
- Technology Gaps:
  - Efficient receiver architecture to support 1000 antenna elements: low power, smaller footprint
  - Greater improvement in power efficiency as the number of antenna elements grow
  - CMOS technology improvement

Challenges and Solutions to Meet Needs

- Beamforming algorithms
- Resource management
  - An increase in antenna elements creates smaller beamwidth
  - Beam pointing accuracy is a challenge
- Computationally efficient channel estimation approaches
- Simultaneous multiple transmit/receive beams
- New Deep learning techniques for 5G and beyond

Stakeholders

IEEE Future Networks WGs: Hardware, Testbed, AL/ML, Standards, Security

Academic & Research Institutions

Industry: Equipment vendors, application developers

Businesses: New business models/start-ups based on Future Networks

Contributing Working Group Members

- Haijian Sun
- Chris Ng
- Yiming Huo
- Rose Qiangyang Hu
- Ning Wang
- Chi-Ming Chen
- Kasturi Vasudevan
- Jin Yang
- Webert Montlouis
- Dauda Ayanda
- Kumar Vijay Mishra
- Nasir Hussain

QUESTIONS?