



# IEEE Future NETWORKS

Enabling 5G and Beyond



International Network  
Generations Roadmap (INGR)

Virtual Workshop

**Massive MIMO WG**

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# 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 Top Needs

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

# Challenges and Solutions to Meet Needs

- Ecosystem drivers (P2):
  - **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 (P2):
  - 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, AI/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
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# Cross Team Meeting Schedule for June 17 and 18

Please contact working group co-chairs for Webex link if you are interested to attend cross team meetings

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June 17

Start Time	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM
Apps & Svcs AI ML					Apps & Svcs Deployment		EE Hardware	Apps & Svcs EE		EE Deployment	
			EAP Massive MIMO	EAP Security		EAP Standards	EAP Testbed				
	Satellite Standards	Satellite Testbed		Massive MIMO Hardware		Massive MIMO Deployment	Massive MIMO Standards				Deployment CTU
				Standards CTU	Sys Opt CTU			Security Sys Opt		CTU Testbed	Sys Opt Testbed
					Satellite Security	Satellite AI ML					
			Security AI ML								

June 18

Start Time	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM
	Apps & Svcs Satellite				AI ML EAP	Apps & Svcs EAP			Apps & Svcs Security		Apps & Svcs Sys Opt
	AI ML Massive MIMO					AI ML CTU		EAP EE	EAP Deployment		
						Security Testbed	Standards Testbed	Standards Security		EE Sys Opt	
									AI ML Testbed		



# Get involved!

## Working Group Members

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**QUESTIONS?**