End-to-End Research Platform for Public Safety Millimeter Wave Communications

PSIAP STAKEHOLDER MEETING, CHICAGO

JULY 10TH 2019
4G LTE & Public Safety

2004: First proposed by NTT DOCOMO
2007: First live demo by Ericsson
2010: Commercialization
2012: Congress created FirstNet
2013: Rel. 12 includes mission critical technology
   - Proximity Service
   - Group call enablers
2017: FirstNet signed a contract with ATT
Beyond conventional cellular...

FAA approves Flying Cow drones to restore Puerto Rico cell network


COW = Cell On Wings

INTRODUCTION
Fully intertwined with 5G!

From E. Kalantari et al., "Backhaul-aware robust 3D drone placement in 5G+ wireless networks".
Why mmWave?

4G spectrum cannot accommodate the increasing mobile broadband demand.

the mmWave spectrum is vast and largely unused!
4G - Omnidirectional
4G - Omnidirectional

WELL BEHAVED RADIO PROPAGATION
passing through obstacles (walls, trees, humans)
5G mmWave - Directional
5G mmWave - Directional

CHALLENGING RADIO PROPAGATION
bouncing off obstacles (walls, trees, humans)
Initial search

😊 SLOW CONNECTION
😊 LOWER BATTERY LIFE

MMWAVE
Reconnection

😊 LONG INTERRUPTION
😊 LOWER BATTERY LIFE
Faster access

10x times faster [1]

More robust

Our mission

- **Thrust 1**: Measure dynamic directional channels in Public Safety (PS) scenarios.

- **Thrust 2**: Prototyping new ultra-low latency MAC and synchronization algorithms likely to be used in the PS links.

- **Thrust 3**: Provide the first scalable real-time emulation of complex mmWave channels in PS settings.

- **Thrust 4**: Development and integration of PS specific scenarios in end-to-end mmWave network simulator.
Human-Body Blockage

Aerial mmWave

Measurements were performed in the NYU WIRELESS office space.

TX was raised to ceiling height using a light stand, RX was kept at ground level.

Maximum separation is approx. 8 meters due to cables running between TX and RX.

Blockers walk close to RX, distances varying from 20 to 100 cm.

Various mechanical rotations done at TX and RX (situation dependent).
Prototyping effort

**Transceiver Board**

- **ANALOG DEVICES**
  - DAC 37J84 (TI)
  - DAC 37J84 (TI)

- **Texas Instruments**
  - Power
  - LO Generation
  - Clocking

- **JESD 204B**

**FMC connector**

- **Patch Antennas with lens retro-fit option**

**VCU118 - Baseband Board**

- **MATLAB & SIMULINK**
  - QSFP+ port

**Host Computer**

- **OPEN AIR INTERFACE**
  - QSFP+ port

- **Linux**
  - GNU Radio
Emulated 3GPP channels
End-to-end mmWave ns-3

- Open source
- 3GPP channel models / scenarios
- Mobility (including vehicular / hi-speed transportation / drones)
- Customizable 3GPP NR frame structures, frequency bands, OFDM numerologies, schedulers
- 3GPP NR beam management
- E2E performance evaluation including:
  - TCP/IP, S2/X1, PDCP, RLC, MAC/PHY metrics
  - RRC signaling, RLC buffers, HARQ procedures
  - Coexistence with other radio technologies (e.g., IEEE 802.11, LTE)
- Dual connectivity, carrier aggregation, IAB, ..

Mezzavilla et al., “End-to-end simulation of 5G mmWave networks”, IEEE COMST 2018
Aerial mmWave control

Robotic mmWave control

Simulated PSC scenarios

Motivation:
- Provide to the community reference scenarios implemented in ns-3

Key contribution:
- Evaluation of the performance of mmWave communications in three realistic PSC scenarios

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Chemical plant explosion scenario with remote wheelbarrow robot operations & HQ video stream

Motivation:

- Need to accurately model directional propagation in realistic deployment scenario

Key contribution:

- Implementation of multiple sectors at the base stations and multiple panels at the UE
- End-to-end performance evaluation

In a nutshell

- We have conducted several mmWave measurements (aerial, blockage, outdoor), and NEXT STEPS: plan to run indoor-office p2p measurements
- We have spun out a fully-digital mmWave transceiver board for prototyping, and NEXT STEPS: plan to integrate a network stack on top of it
- We have integrated 3GPP channel models in the emulator, and NEXT STEPS: plan to connect it to our prototyping board
- We have implemented a number of additional features to our ns-3 mmWave simulator, and NEXT STEPS: plan to improve the channel abstraction and add more PSC-related options
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Come back for the
Next Session
3:30 PM

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