Institute for the Wireless Internet of Things
at Northeastern University

B5GPC International Conference 2024

Panel Discussion: 6G Research Challenges

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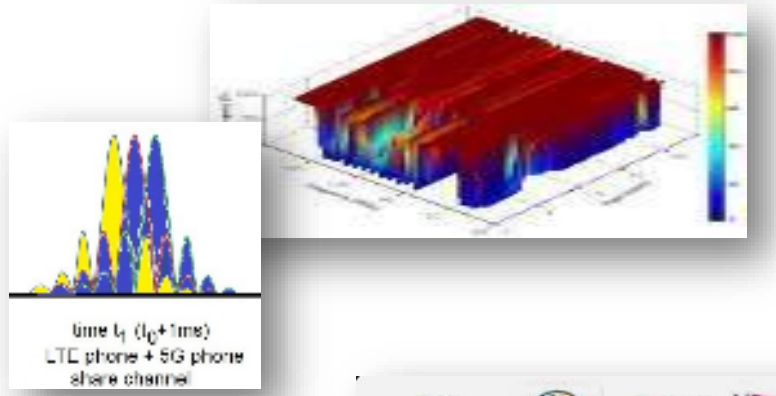
- Co-Founder of 6GSymposium

A Roadmap Toward 6G

1. Conquering the Spectrum
2. Open, Programmable, Virtualized
3. AI-Native Processing and Control
4. Flexible Spectrum Exploitation
5. Connecting the Metaverse

FutureG Technology Focus Areas

- **Dynamic Spectrum Management and Utilization**
  - EMS sensing and deconfliction
  - AI/ML approaches to reduce/eliminate manual spectrum management
- **Hyper-dimensional Software Defined Networks**
  - Improved deployment models for public and private networks
  - Distributed and easy to maintain networks
  - Open-source interfaces to support device mobility
- **Mobile IP and Privacy Enhancing Technologies**
  - Lower power, improved performance; trusted, secure, and privacy-enhancing networks
  - Stealth in cyberspace; EMS and network signature management
- **Microelectronics for FutureG**
  - Core and applied research of hardware approaches that enable FutureG
  - Transitions to Microelectronics Commons
- **Unlimited Software Defined Radio**
  - Tailored access to open-source wireless resources for new commercial markets
  - Spectrum maneuvers to hide, protect, and maintain communications at all levels of DoD activities



Summary of New Spectrum Bands Under Research and Consideration

- Terrestrial Component of 6G: (global perspective): 6-15GHz; 15-24GHz; and >110 GHz
  - 7-15GHz and 15-24GHz:
    - Existing FCC Considerations include:
      1. 10.0-10.5GHz (in WRC-23 Agenda Item 1.2. The FCC has recommended a positive stance); and
      2. The FCC has ruled out 12.2-12.7GHz but has 12.7-13.25GHz for consideration under NPRM (FCC-23-36)
    - Almost universal agreement from industry and academia that regulators must address the increasing demand of IMT by opening more spectrum from 7-15 GHz (the range from 15-24GHz is deemed less favorable due to radio-technology state of the art (cost))
    - Many entities are investing in channel analysis and modeling and advanced radio systems using bandwidths of up to 500MHz to support this
  - >110GHz:
    - Most demanding applications envisioned for 6G imply necessary bandwidths of >10GHz and thus the exploration of frequencies above 110GHz
    - This presents significant pressure on the state of the art for all related wireless technologies
- Non-Terrestrial Component of 6G:
  - Spectrum bands are under consideration today for use by integrated non-terrestrial networks (NTN) for 6G range from 900Mhz to upwards of 80 GHz.
  - Because of propagation characteristics, a variety of different bands will be required to meet the diverse 6G user cases.

Summary of considerations beyond adding spectrum for terrestrial IMT

- Elements which all contribute to arguments for better use of existing spectrum:
  1. challenges of re-allocation or re-farming;
  2. the wide variation in real-time occupation of licensed spectrum over geography and over time (low utilization); and
  3. the state of the art of spatial multiplexing
- Flexible Access to Unused Spectrum
  - require or incentivize licensees to cede use of spectrum when it is not in use or is under-utilized. (This can also be one avenue to address one facet of the rural digital divide.)
- Spectrum Sharing among different services (e.g., federal radiolocation and commercial mobile or satellite communication), and among same services (e.g., terrestrial and non-terrestrial, including satellite)
- Increased Cell Density
  - Consider the advantages and disadvantages of increased cell-density.
- Spatial Multiplexing Technologies
  - Higher-order MIMO and beam-forming have become ubiquitous in C-band 5G systems. This approach to increase bps/Hz/km2 ensures spatial allocation of a user's signal (RF flux density) is constrained to the user's physical location.

COLOSSEUM
at Northeastern University

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Platforms for Advanced Wireless Research

NETWORK DIGITAL TWIN RESOURCE FOR WIRELESS SYSTEMS RESEARCH

- Colosseum, a massive $20M wireless systems testbed developed by DARPA, has already been transferred to Northeastern University and is currently up, operational, and open to the NSF community
- Transfer to Northeastern funded by NSF CCRI grant
  - 256 x 256 100 MHz RF channel emulation, 128 Programmable Radio Nodes
  - Computing resources (CPU, GPU, FPGA)
  - Access control and scheduling infrastructure
- Supports remote shared access
  - Spectrum Sharing
  - AI + Wireless
  - 5G (softwarization, slicing, security)
  - IoT

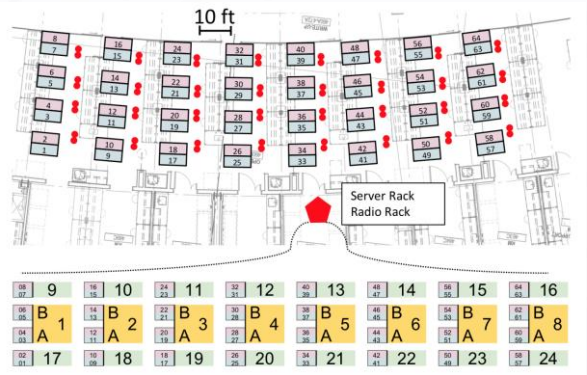
Experiment-as-a-Service Over Multiple Testbeds

One container to rule them all:

- Initial design and testing at-a-scale on Colosseum w/ different scenarios
- Validate on real-world indoor environment on Arena
- Experiment into the wild on PAWR city-scale platforms

Test at-a-scale on emulated scenarios

Validate in real wireless environment



Test large-scale capabilities

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You Need Testbeds, Data, and Cross-platform Validation

Design

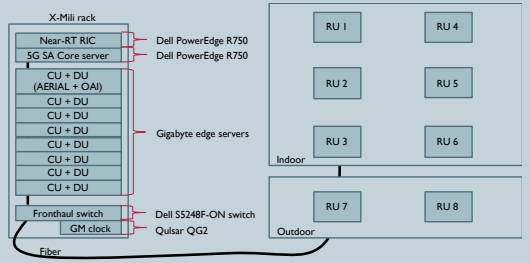
Data

Evaluation and validation

Colosseum

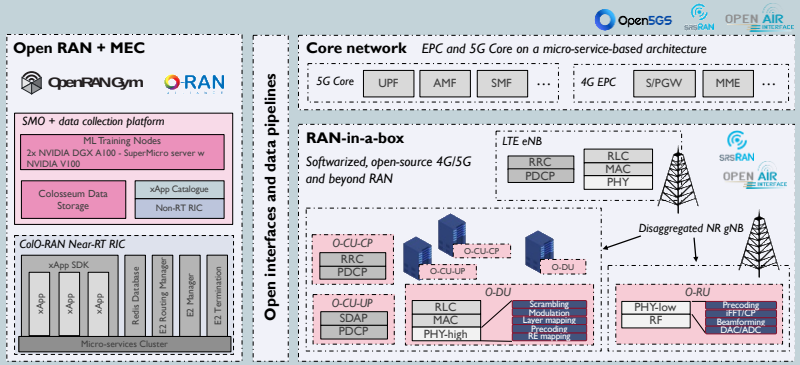
Arena + PAWR

Wide Area Network



OpenRAN Gym

End-to-end programmable cellular



FCC Innovation Zones

Production 5G+AI automation