OAI Summer Workshop 2022

OAI as a Catalyst for Building a B5G/6G Research Roadmap for North America
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- US FCC Technology Advisory Council 6G WG Co-Chair
- Board Appointments
  - OpenAirInterface Software Alliance Board Member
  - O-RAN Alliance Academic Research Council
  - Open Networking Foundation (ONF) Member
  - ATIS NextG Alliance
  - Magma Foundation Founding Member
- Organizer of 6G Symposium
Why Open Testbeds

For many in the ecosystem, from academics, federal labs to midsized operators, end-to-end 5G is an expensive and difficult proposition

- Avoid Technology Lock-in, Impact Interoperability and Re-Aggregation

**Academia**
Works on existing radio/FPGA testbeds
Workforce Development
Innovation on lower layers: Scheduler, MAC, PHY
Access to a full 5G stack s/w implementation

**Vendor Ecosystem**
Shorten Design Cycles
Impact interoperability challenge: DU-RU,RAN-Core
Work on multiple platforms: CPU/GPU/FPGA
# Why Open Testbeds

<table>
<thead>
<tr>
<th>Technology to test</th>
<th>Living lab</th>
<th>Current communication test bed</th>
<th>GAFA test in own PF</th>
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</thead>
<tbody>
<tr>
<td>Application (Service)</td>
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<td>Platform (OS)</td>
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<td>Infrastructure (Network)</td>
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<td>Individual technology</td>
<td>Test in individual laboratory and company</td>
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<td>Stage for implementation</td>
<td>Idea</td>
<td>Basic research</td>
<td>Develop</td>
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- Need a test bed for marketing?
- Shift to application development. Need to get diverse participants?

**Institute for the Wireless Internet of Things at Northeastern University**
PAWR program seeks to maintain U.S. leadership in advanced wireless networking innovation

PAWR is funded by the National Science Foundation and a wireless Industry consortium of 35 wireless companies and associations. The PAWR Project Office (PPO) manages the program and is co-led by US Ignite and Northeastern University.
PAWR platforms were chosen to be geographically diverse and research focus independent

POWDER
Salt Lake City, UT
Software defined networks and massive MIMO
AVAILABLE TODAY !!

COSMOS
West Harlem, NY
Millimeter wave and backhaul research
AVAILABLE TODAY !!

AERPAW
Raleigh, NC
Unmanned aerial vehicles and mobility
AVAILABLE TODAY !!

Rural Broadband Platform
Ames, IA

Colosseum – World’s largest RF emulator, located at Northeastern University in Boston
AVAILABLE TODAY !!
Researchers use PAWR testbeds to prove out concepts in an array of disciplines

- Cybersecurity Testing
- Internet of Things
- Millimeter Wave Performance Optimization
- Open Source Hardware & Software Development
- AI-Enabled Network Functions
- Accelerated Virtualization of Network Architectures
- Dynamic Spectrum Management
- Highly Mobile Unmanned Aerial Vehicles
Status of Platforms
Partners
A collaboration of the University of Utah, Rice University, the Utah Education and Telehealth Network, and Salt Lake City

Location
Designed to cover 2.3 square miles of the Utah campus, 1.2 square miles of downtown Salt Lake City, and a 2-mile corridor in between, reaching a population of 40,000

Platform Resources
Includes software defined rooftop and base station radios; access to compute, storage, and cloud resources; a control framework for remote access and control

Research Focus
End-to-end programmable networking, spectrum management, massive MIMO, O-RAN Test and Integration Center
COSMOS

Partners
Partnership of Rutgers University, Columbia University, NYU, and New York City, with support from The City College of New York, the University of Arizona, Silicon Harlem, and IBM

Location
1 square mile in West Harlem

Platform Resources
Includes large and medium-sized software defined base station radios; fiber connections to and from radio sites and to local data centers; interaction with other smart community and innovation initiatives

Research Focus
Millimeter wave radio communications and dynamic optical switching technologies; O-RAN Test and Integration Center
AERPAW

Partners
North Carolina State University and the city of Raleigh and town of Cary, with support from Wireless Research Center of North Carolina, Mississippi State University, and Renaissance Computing Institute (RENCI) at the University of North Carolina at Chapel Hill

Location
Town of Cary, Lake Wheeler Field Laboratory, Centennial Campus in Raleigh

Platform Resources
Fixed software defined radio nodes; unmanned aerial and ground vehicles carrying AERPAW nodes; rural and urban environments; remote access control framework

Research Focus
Advanced wireless services to support unmanned aerial systems and advanced UAS to enable new wireless services
Colosseum

Colosseum is the world’s largest wireless network emulator with granularity at the RF signal level

- 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
- Colosseum supports a containerized software environment with full-stack, end-to-end experiments

northeastern.edu/colosseum
ARA: Rural Broadband Platform

**Partners** Iowa State University, the city of Ames, and surrounding farms and rural communities in Central Iowa.

**Features**

- A deeply programmable infrastructure, featuring a wide range of wireless technologies as well as an application focus on precision agriculture in both crop and livestock farms.
- Wireless backhaul, edge and cloud computing supporting fundamental communication services such as ultra-reliable, low-latency communications.
Timeline

**2018**
- April: POWDER and COSMOS platforms selected

**2019**
- April: POWDER open to beta users
- September: RFP release for final PAWR platform
- September: PAWR sites designated FCC Innovation Zones
- AERPAW platform selected

**2020**
- October: NU inherits Colosseum from DARPA
- POWDER general availability
- COSMOS open to beta users
- July: Colosseum general availability

**2021-2022**
- December: Final platform selected
- AERPAW open to beta users
What we have realized

Global Co-operation is a Need

Public-Private Partnership Models are the norm

Research Infrastructure is on critical path to solving technical challenges
Strategic Action for Beyond 5G

- Creation of National **Entity** to lead Beyond 5G Open Source Activities
- Key Constituents: Academia, Federal labs, SME
- **Software** First Mandate
  - Leverage other consortia for Testing/Integration/Use Cases
- Partner with and Feed inputs from
  - 3GPP
  - ORAN
  - TIP
  - ONF
Strategic Action for National Entity

- Use of OAI as anchor to lead 5G and Beyond Open Activities
  - US Industry Support committed
  - Use of US Engineers to develop code, integrate and test
  - Integration w/ Commercial devices and stacks
  - Heterogeneity of implementation across O-RAN/TIP

- Key Constituents: US Academia and Industry

- **Software** First Mandate implement 3GPP Features
An Innovation Lab Approach

NSF PAWR

DoD Trusted Agency/Federal Labs

Public-Private National Center of Excellence

Federal

Industry/Acad.

Open Source Ecosystem

Open Access Ecosystem

Traditional Non-Traditional Partner(s)

Validation, Interoperability, Use Cases
End-to-End Open Programmable, Virtualized 5G Stack

Interoperable/Interchangeable Modules Per Use Case

- **OAI**
  - Standard Interfaces
  - Spectrum Sharing
  - mmWave Antenna Array Integration

- **OAI + IDCC**
  - Standard Interfaces
  - Network Slicing

- **NI**
  - Standard Interfaces
  - Security
Network Intelligence in 5G + O-RAN

Non-Real-time RIC | Near Real-time RIC | Centralized Unit (CU) | Distributed Unit (DU) | Radio Unit (RU)

Jamming Attack

Recovery Loop 1 (<10ms)

Non-Real-time RIC | Near Real-time RIC | Centralized Unit (CU) | Distributed Unit (DU) | Radio Unit (RU)

Infrastructure Failure Mode

Recovery Loop 1 (<10ms)

Recovery Loop 2 (10-500ms)

IAB Failure

Recovery Loop 3 (> 500ms)

Recovery Loop 2 (10-500ms)

Recovery Loop 1 (<10ms)
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
6G Emerging Technology Trends and Enablers

Technology Enablers to Enhance the Radio Network
- RAN slicing
- Resilient and soft networks for guaranteed QoS
  - “Soft” = User-centric, service oriented, flexible, and powerful in capabilities, guaranteed in QoS, and consistent in user experience
- New RAN architecture
- Technologies to support a digital twin network
- Interconnection with NTN
- Ultra-dense radio network deployments
- RAN infrastructure sharing

Technologies to Enhance the Radio Interface
- Advanced modulation, coding, and multiple access schemes
- Advanced antenna technologies
- In-band full duplex communications
- Multiple physical dimension transmission
- Reconfigurable intelligent surfaces
- THz communications
- Ultra-high accuracy positioning

Looking Ahead

Invest in Next G Technologies developing 6G with timeline towards IMT-2030

Invest in B5G System Fundamentals (model & simulation, design for scale & resilience)
  • Lead B5G System Integration with
    • 5G+ components
    • (distributed MIMO, DSA, terrestrial-NTN integration)
  • Exploit Software-Defined Networking (autonomy, agility)

Time is Now during pre-competitive fundamental and applied research to develop joint roadmaps for digital infrastructure to support future wireless, networking and cloud research.

Anticipated IMT-2030/6G Timeline
Key Takeaways

- Open 5G Reference Architecture is the Need of the Hour
  - OSA is positioned to take a leadership role in this ecosystem

- Consortia and Alliances (TIP, O-RAN, ONF) exist with CodeBase(s)
  - Fragmentation is a risk
  - Interface Compliance becomes a Necessity

- Openness at All Levels of the Stack is desired

- OpenAirInterface is the most viable option for end-to-end B5G/6G
Learn More...
http://advancedwireless.org
http://colosseum.net