Commonwealth Cyber Initiative

Building an Open Testbed for the Next Generation of Networks

Luiz DaSilva

Executive Director, Commonwealth Cyber Initiative

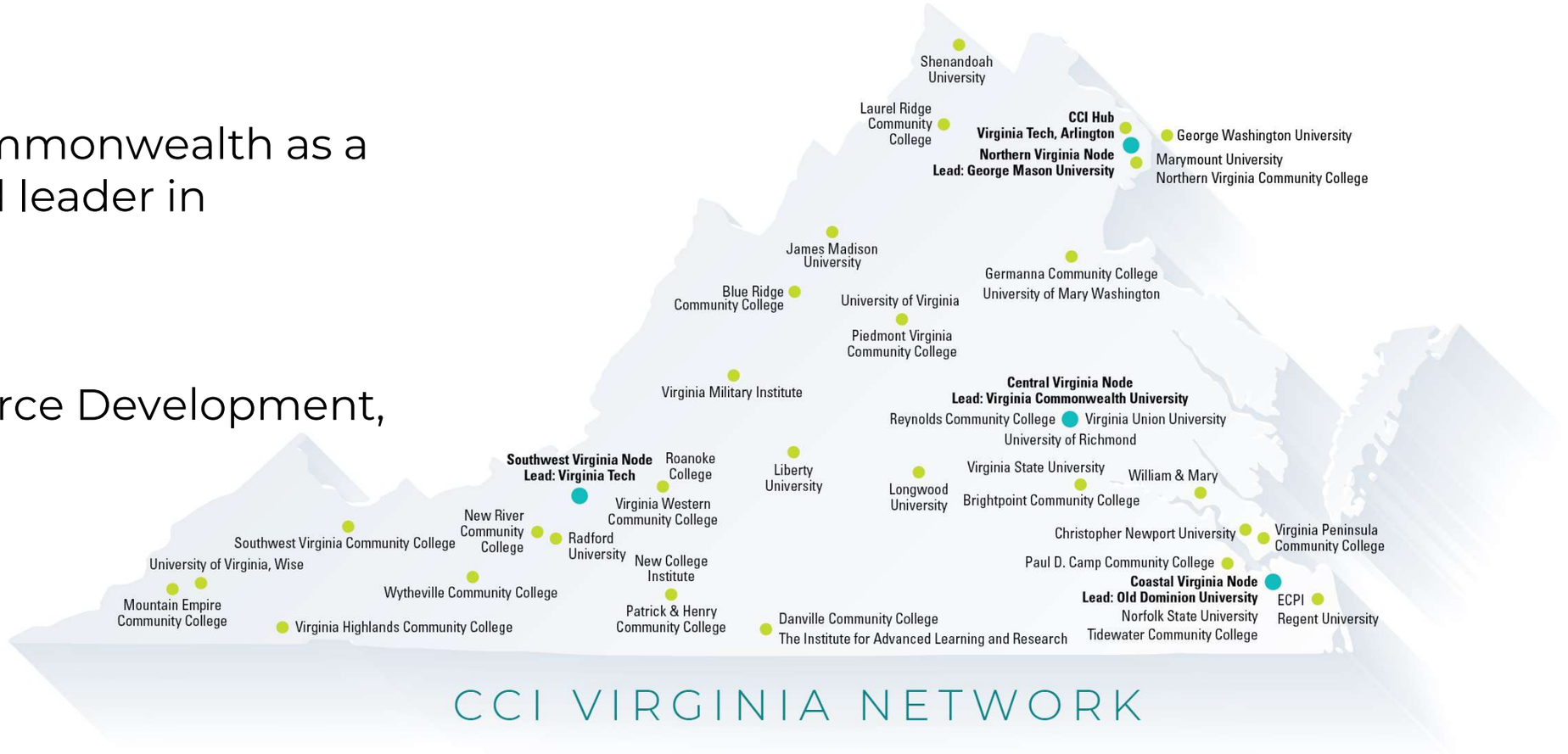
Bradley Professor of Cybersecurity, Virginia Tech

WTESTBEDS 2024 @ CSBC 2024
Brasilia, 24 July 2024

The Commonwealth Cyber Initiative

Vision:
Positioning the commonwealth as a globally recognized leader in cybersecurity

Mission Lines:
Innovation, Workforce Development, and Research



45 Higher Education Institutions
300+ faculty members

Network testbeds…

… provide a network environment where **reproducible tests** can be run

… are used by researchers to **evaluate their innovations** in a controlled setting

… are often built out of a combination of **prototypes and real systems**

Principles

1. **Openness** – relying whenever possible on open source hardware and software

2. **Programmability** – fully configurable, with flexible network management

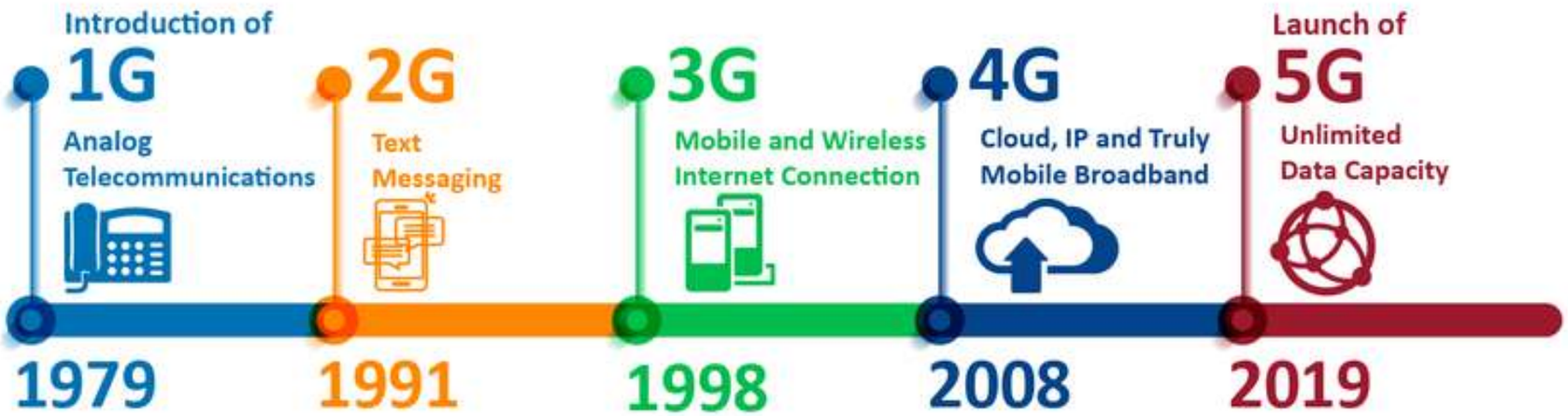
3. **Componentization** – open APIs, containerized, cloud-native

4. **Interoperability** – multi-vendor and interoperable with other testbeds, indoor and outdoor

The xG testbed

1. **Indoor and outdoor** experimentation
2. End-to-end **open-source** hardware and software
3. End-to-end closed-loop **O-RAN** experimentation
   - AI/ML Server, SMO/Non-RT-RIC, Near-RT-RIC, RAN, UE
4. End-to-end **5G NSA and 5G SA**
   - Core, eNB/gNB, UE
5. 28Ghz **mmWave** RU
6. Operates under FCC **Experimental License**
7. Available **CBRS** Priority Access License (3.5Ghz – 3.7GHz)

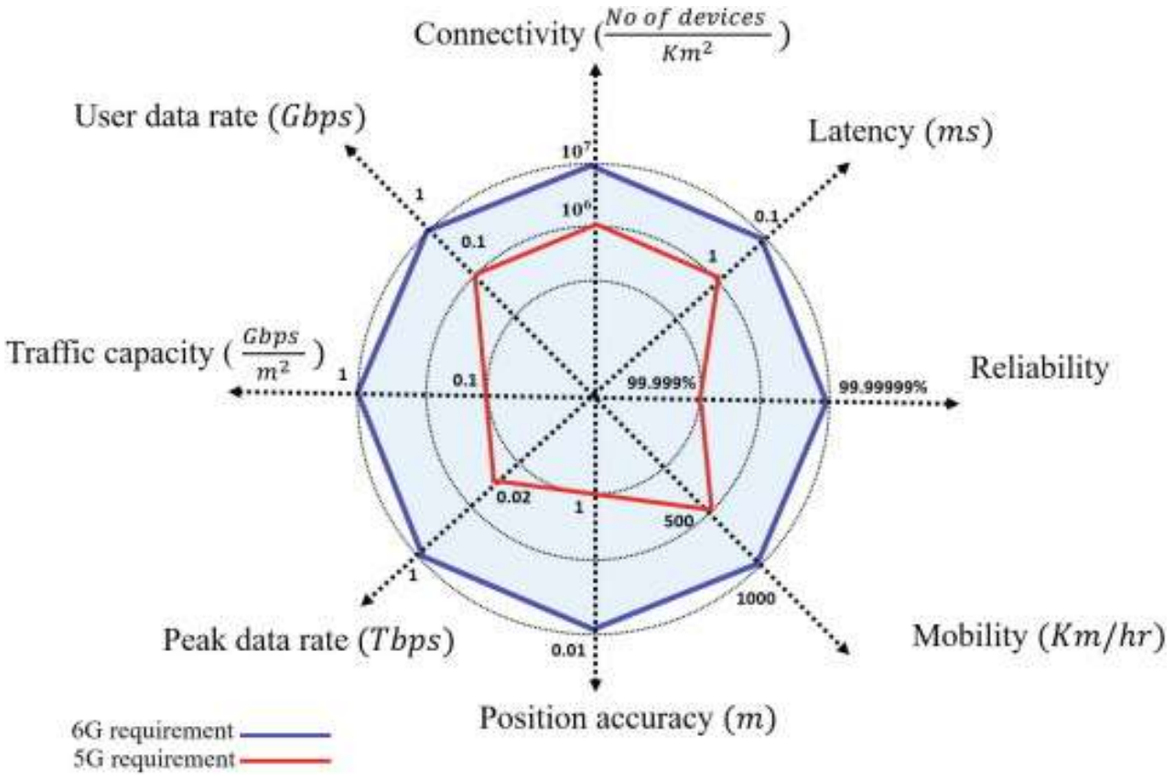
The timing for 6G



6G

- 2020-2022: Vision
- 2023-2025: Requirements
- 2025-2028: Standards
- 2029+: Deployment

What will 6G bring? (still evolving…)



Spectrum sharing

AI-native

Integrated communications and sensing

(…)

xG testbed is 6G-ready

- ✓ VT/CCI joined the NextG Alliance in 2021
- ✓ Transitioning our research into the standardization and commercialization process for 6G

- ✓ Full (open-source) end-to-end system
- ✓ srsRAN 5G stack
- ✓ OAI functionality
- ✓ Integrating commercial systems

Let’s talk about ORAN…

What is the motivation behind ORAN?

What exactly is ”open”?

What are some of the challenges?

What does the US CHIPS and Science Act have to do with it?

xG testbed is one of the first to support ORAN

- ✓ VT/CCI joined the ORAN Alliance in 2021
- ✓ Our researchers participate in the working groups

- ✓ In 2023, we were designated an OTIC
- ✓ Only 7 in the US and 19 around the world

xG testbed OTIC

Vision: to serve as a center of excellence, research and development, and innovation in the Washington, DC area to accelerate end-to-end ORAN deployment and testing

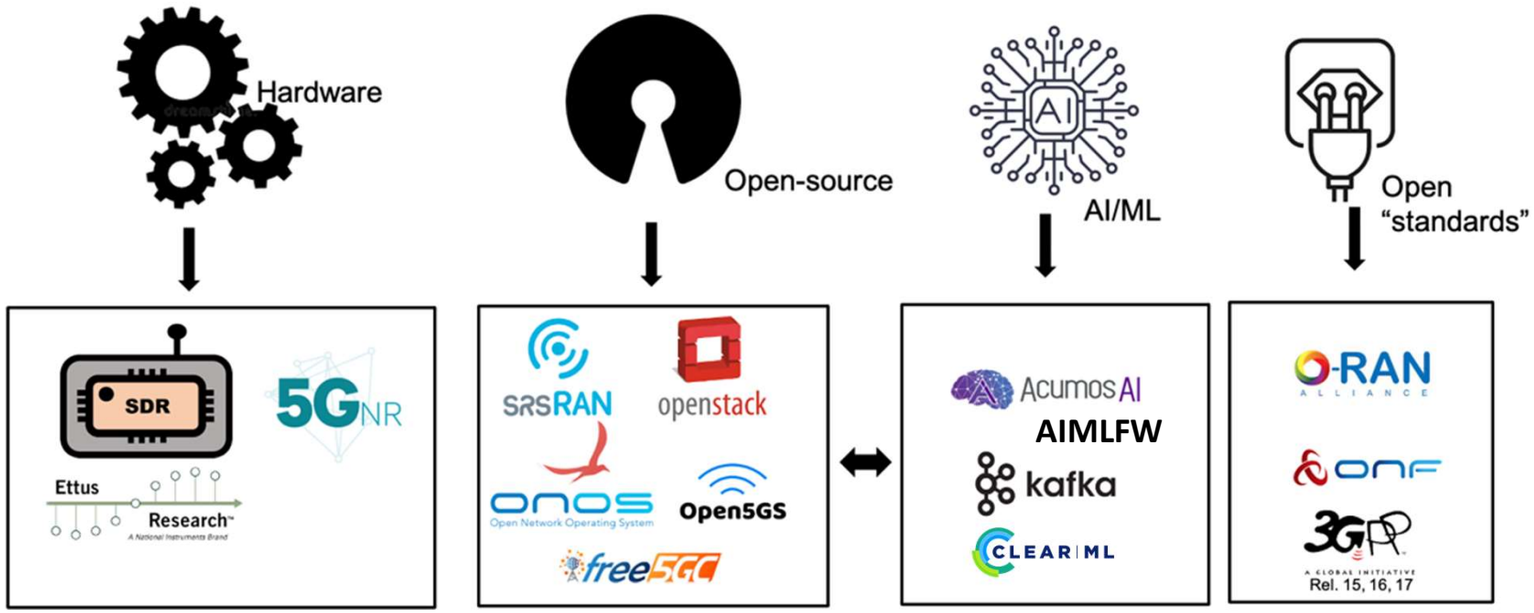
AT&T

verizon

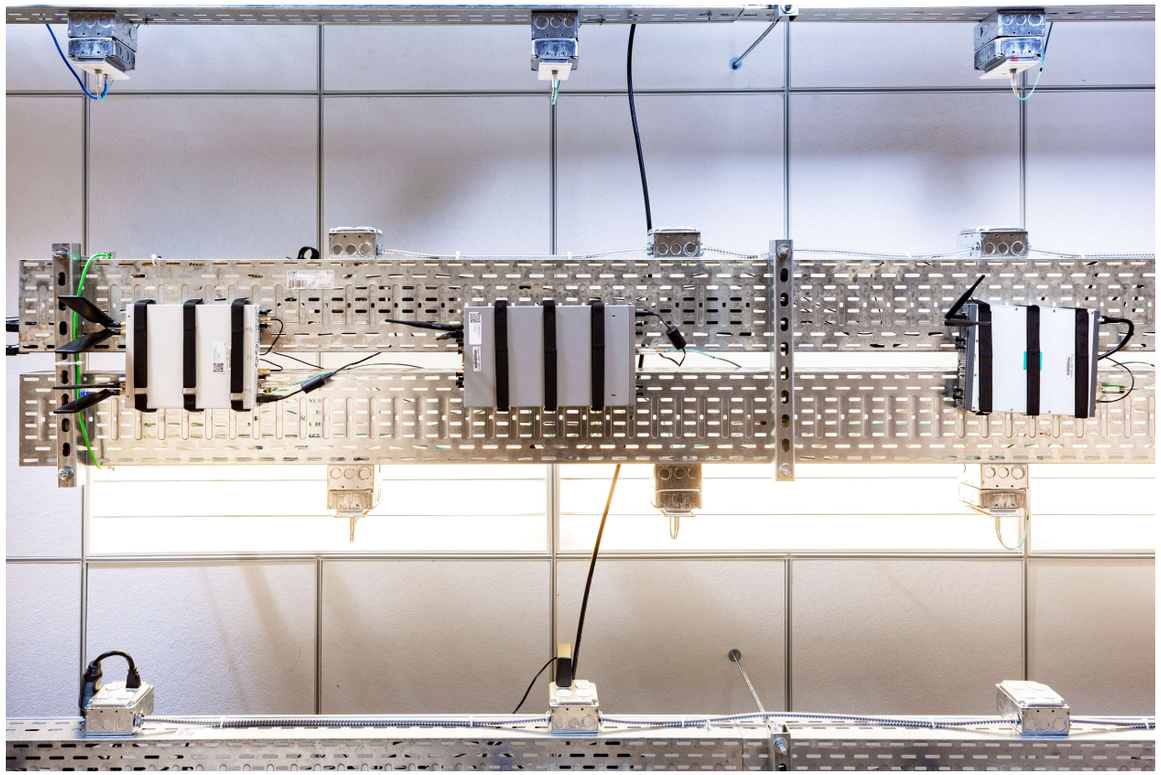
dish NETWORK

Partners: AT&T, Verizon, and dish

Key testbed components

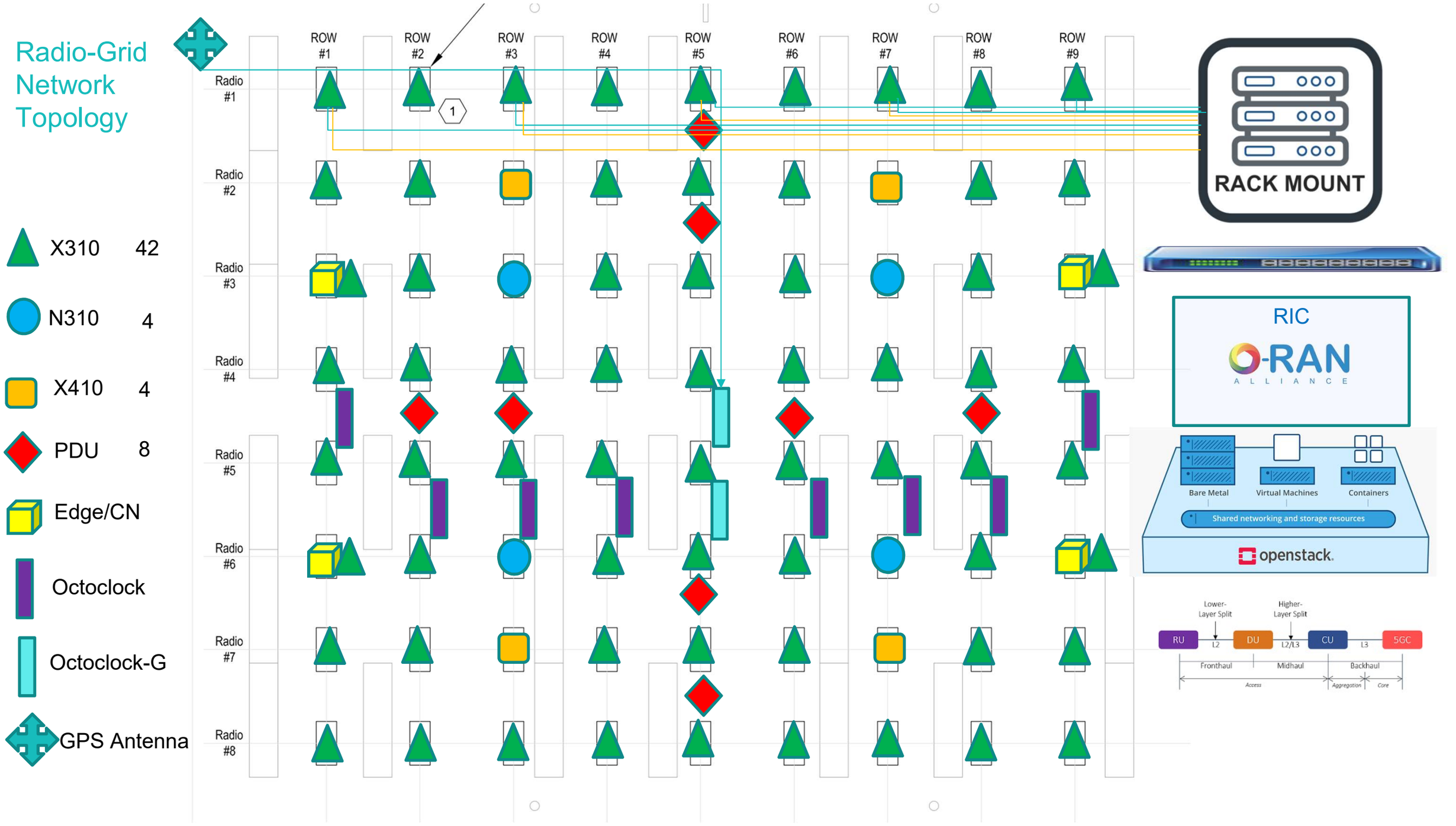


The indoor testbed site



- Indoors
- 32’ x 29’ 2D radio grid
- 72 SDRs
- Over-The-Air
- FCC Experimental License

Radio-Grid Network Topology



Let’s talk about CBRS…

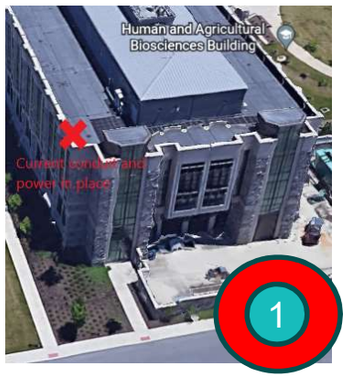
Why share spectrum?

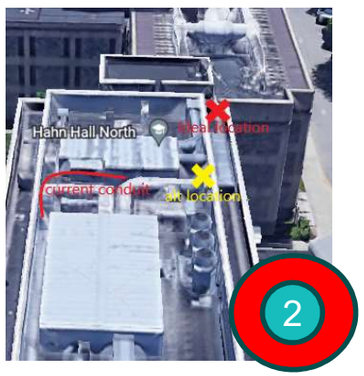
What is a Spectrum Access System (SAS)?

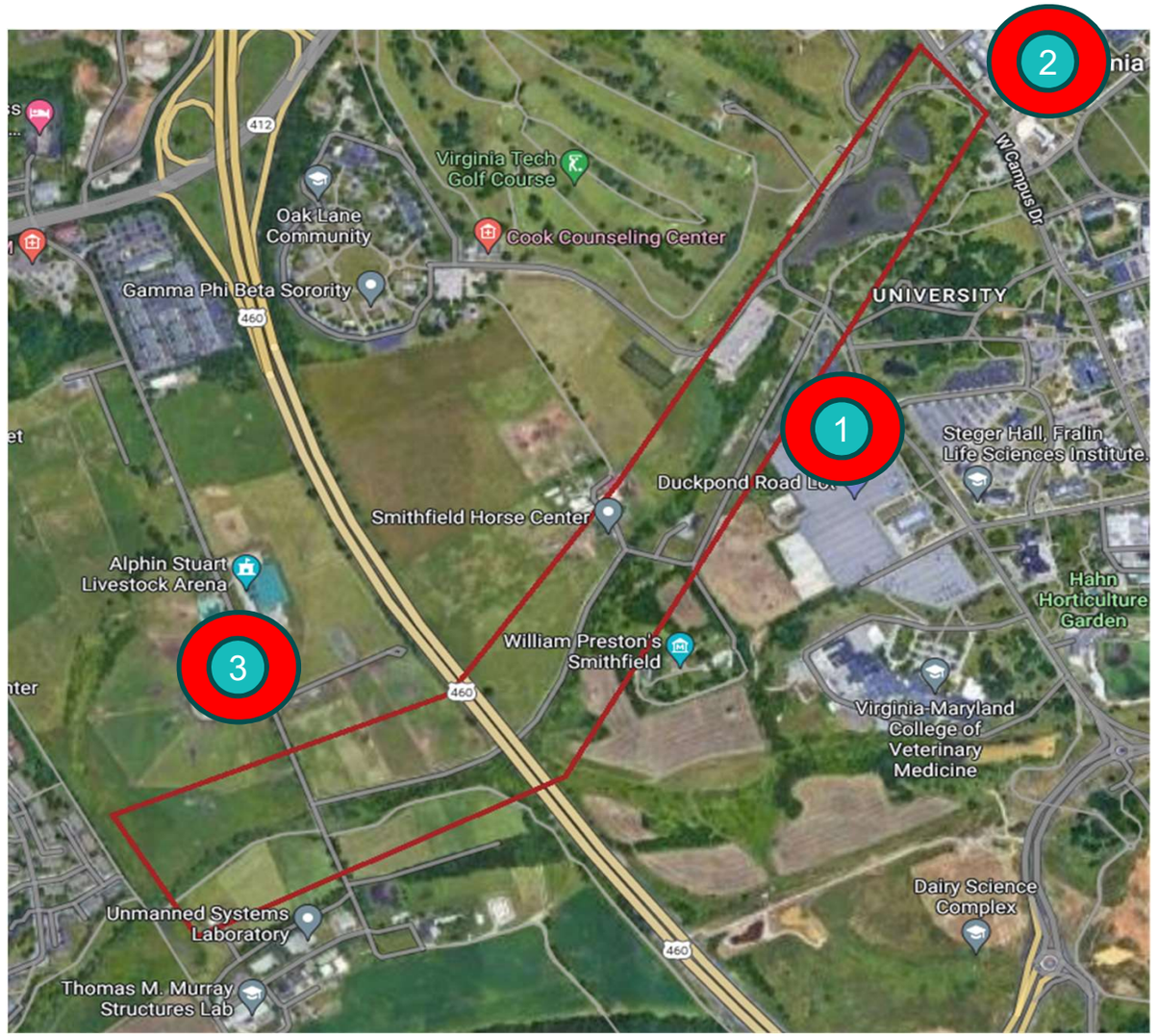
How does sharing work in CBRS?

Why would a university hold a spectrum license?

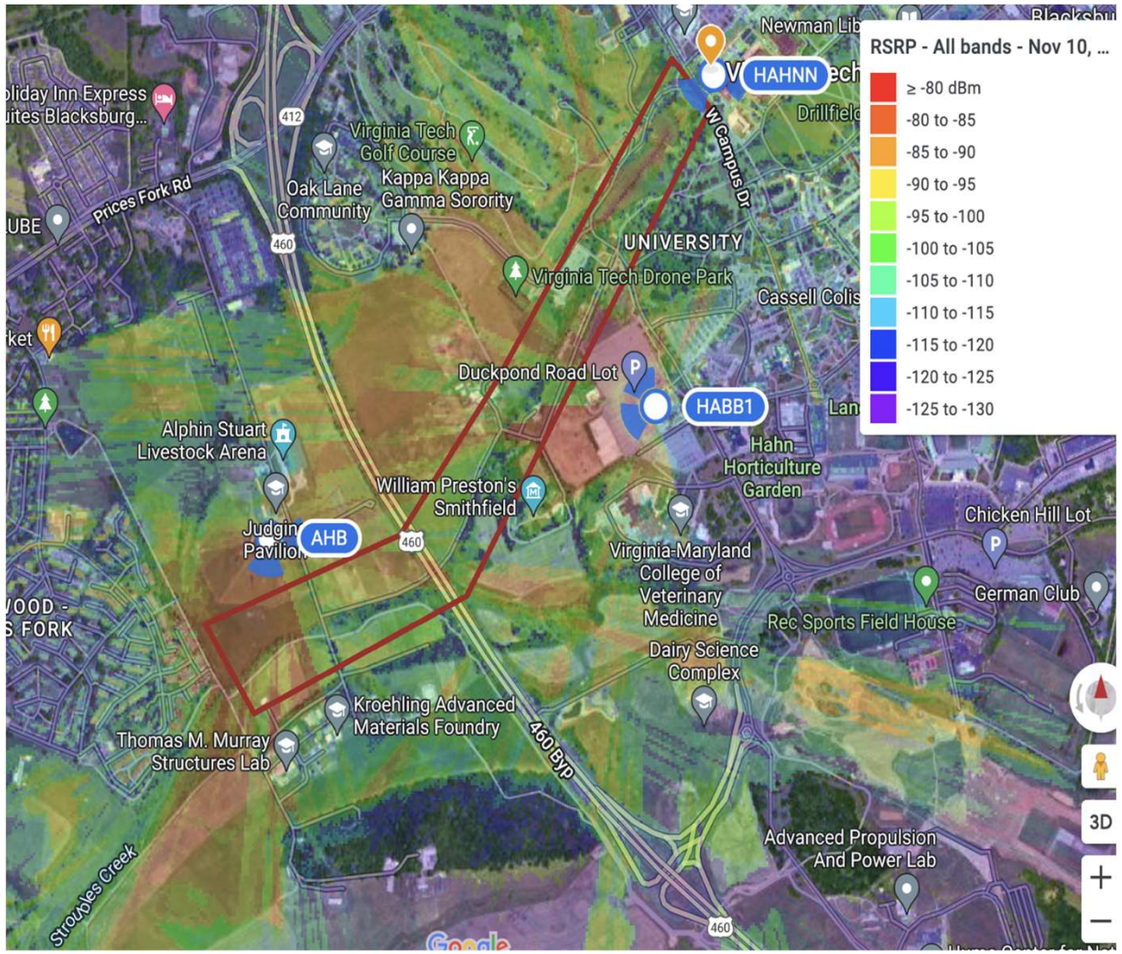
The outdoor testbed site







The outdoor testbed



- Outdoors
- CBRS priority access license (PAL)
- 1.5-mile corridor
- Dual use for research and production
- OpenSAS
- FCC experimental license

Enabling research on…

- **O-RAN security**
- **Spectrum sharing**
- **End-to-end Network slicing**
- **Open-source Spectrum Access System (SAS)**
- **SAS security**
- **WiFi priority access**
- **Autonomy and intelligence in the computing continuum**
- **Distributed Near-RT-RIC**
- **VNF security & multi-site orchestration**
- **O-RAN end-to-end integration and interoperability**
- **rApp and xApp development and orchestration**
- **mmWave intelligent beamforming management**

NTIA Wireless Innovation Fund

Funding Amount	Project Title and Description
$42M	Acceleration of Compatibility and Commercialization for Open RAN Deployments (ACCoRD)
$2M	Enhancing O-RAN Systems Against Sophisticated Attacks
$2M	Learning-Based ORAN Testing
$2M	AI Enabled Efficient Testing and Evaluation for RU, DU, and CU Components of 5G RAN
$2M	A Holistic Cybersecurity Framework for 5G RAN
$2M	Digital Twin to Predict System Failures

U.S. Commerce Secretary Gina Raimondo at T&E award announcement at CCI Hub (2024)

A personal learning journey…

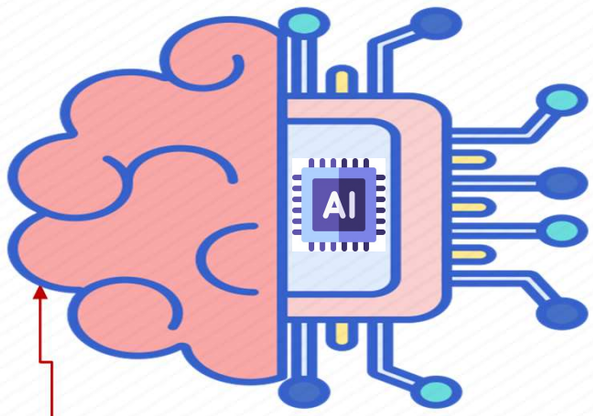
1. Testbeds are a pain in the neck
2. But they add an important level of credibility to R&D ideas
3. They also alert you to research questions that you were not aware of
4. And they are a tremendous workforce development tool (students!)

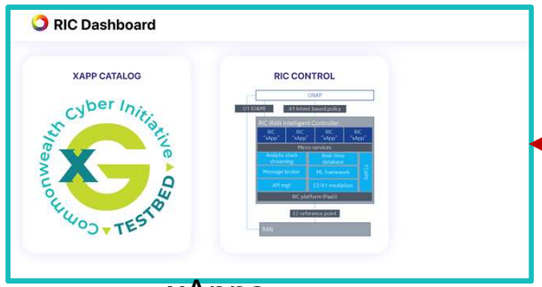
Commonwealth
Cyber Initiative

Control-Loop Software System Design

Closed-Loop Automation with an Open and Extensible AI/ML

Network Intelligence-as-a-Service (NIaaS)

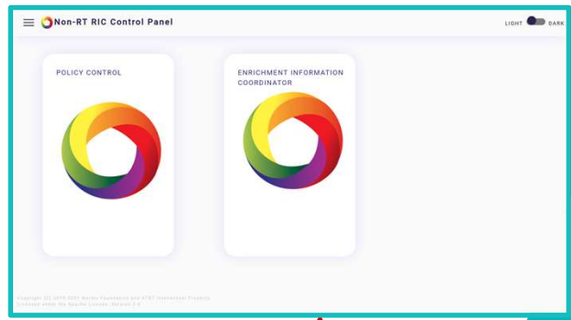




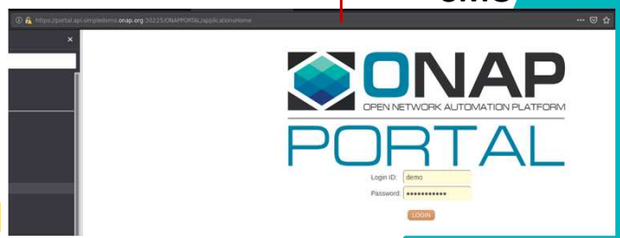
xApps

rApp Eng

rApp Exe



SMO



Load Distribution

Traffic Steering

QoS Optimization

KPI Monitoring

. . .

Load Balance

Energy Saving

KPI Prediction

. . .

VNF Anomaly Detection

VNF UE Monitoring

VNF Placement

. . .

A_1

Near-RT- RIC

Non-RT-RIC

Control Framework

O_1

E_2

O_1

Analytics

redis

mongoDB.

RAN

Core

Metrics, Logs, Triggers

Prometheus

Metrics, Logs, Triggers

Prometheus

AMF

PCF

UPF

Commonwealth Cyber Initiative

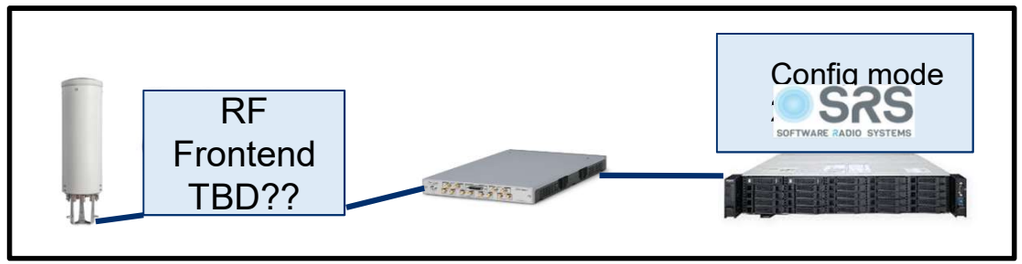
cyberinitiative.org

CBRS Private Network Components

- EPC - Evolved Packet Core (Athonet)
  - Authenticates subscribers (SIM)
  - Core network functionality - gateway, segmentation, QoS, enforces policies
  - User mobility management
- CBSD’s - Citizens Broadband Service Device (Airspan)
    - Category B - outdoors
- SAS - Spectrum Access System (Federated Wireless)
- Client devices
  - Media convertors to replace existing carrier connectivity

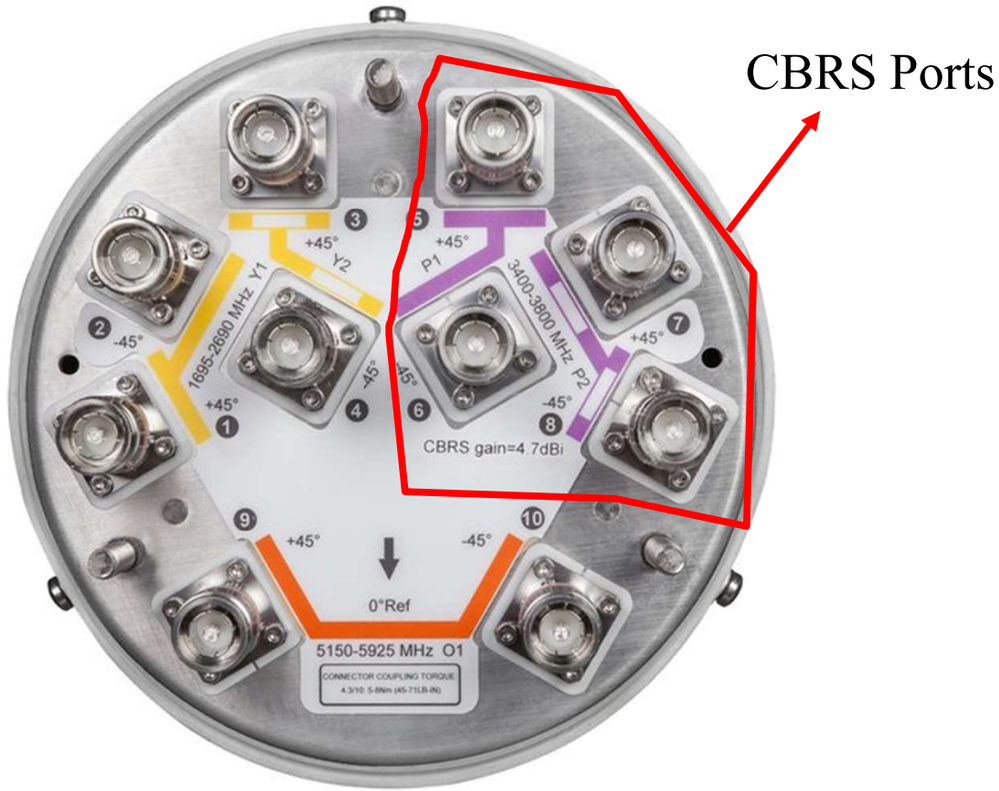
CBRS Experimental Network

- Main Components
  - SDR-based CBSD base station (srsRAN TDD mode)
    - N310
    - Small-factor computer (Intel NUC)
    - RF front-end (filter, LNA, PA)
    - CommScope antenna VVSSP-360S-F
  - OpenSAS
    - open source SAS for outdoor experimentation
    - OpenSAS-to-FDSAS communication via Proxy (To be implemented)
  - Edge Computing
    - Small-factor computer with GPU
  - Others
    - 12 ports SDN-enabled switch
    - OpenStack cloud environment located at CCI Hub Arlington



SDR-Prototype CBRS Antenna : Commscope VVSSP-360S-F

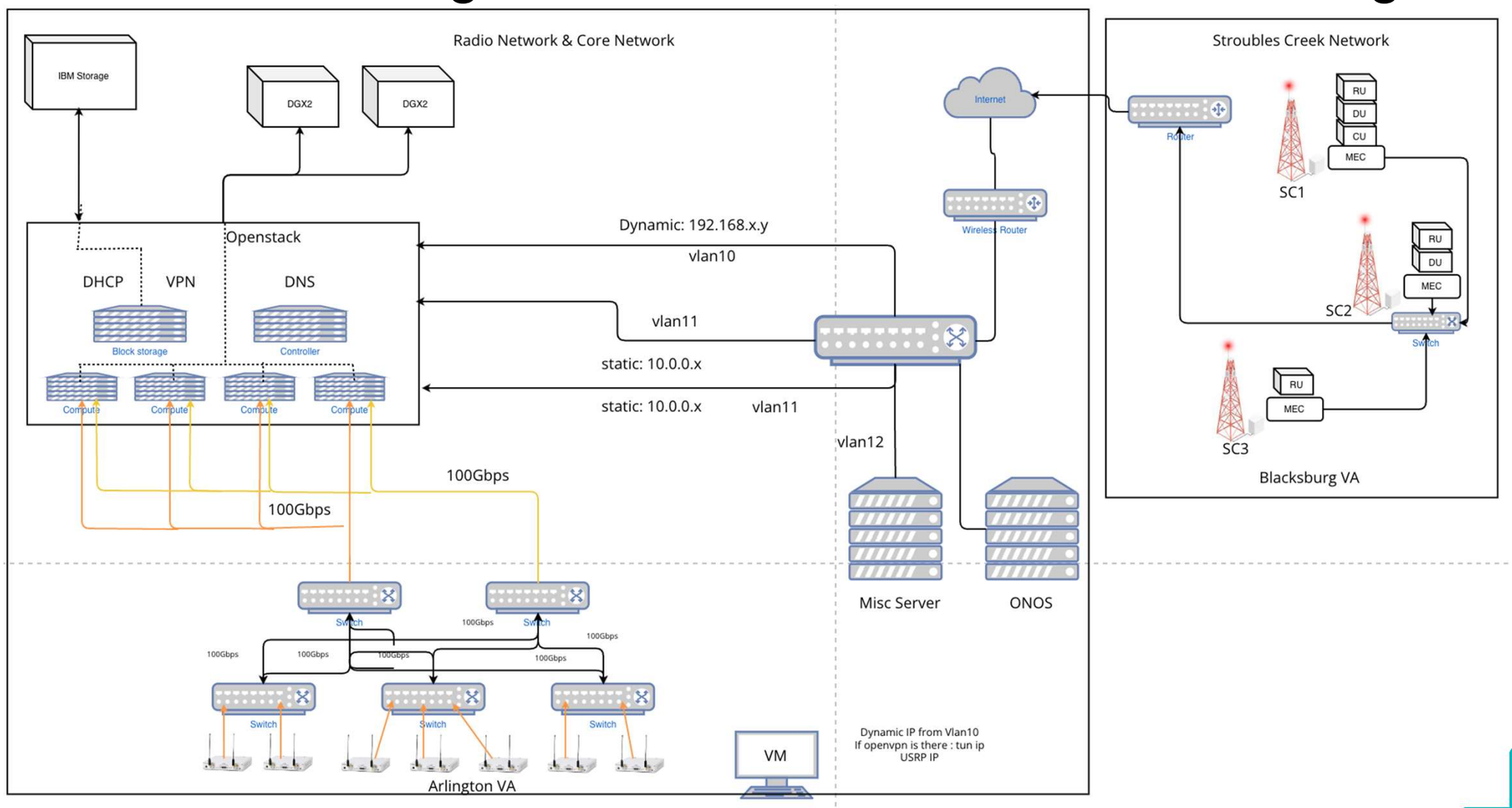
- 1 x 10-port Commscope VVSSP-360S-F multi-band
- 360 horizontal beamwidth, ~20 degree vertical
- 8.2 dBi gain from 2.3 - 2.69 GHz
- 4.9 dBi gain from 3.4 - 3.8 GHz
- 4-port MIMO-capable Cellular elements (1695 - 2690 MHz)
- 4-port MIMO-capable CBRS elements (3400 - 3800 MHz)
- 2-port 5 GHz elements (5150 - 5925 MHz)
- Specifications Website



Commonwealth Cyber Initiative
cyberinitiative.org

Washington DC/Northern Virginia OTIC: Site Connection

Washington DC Site ⟷ 264 miles ⟷ Blacksburg VA Site



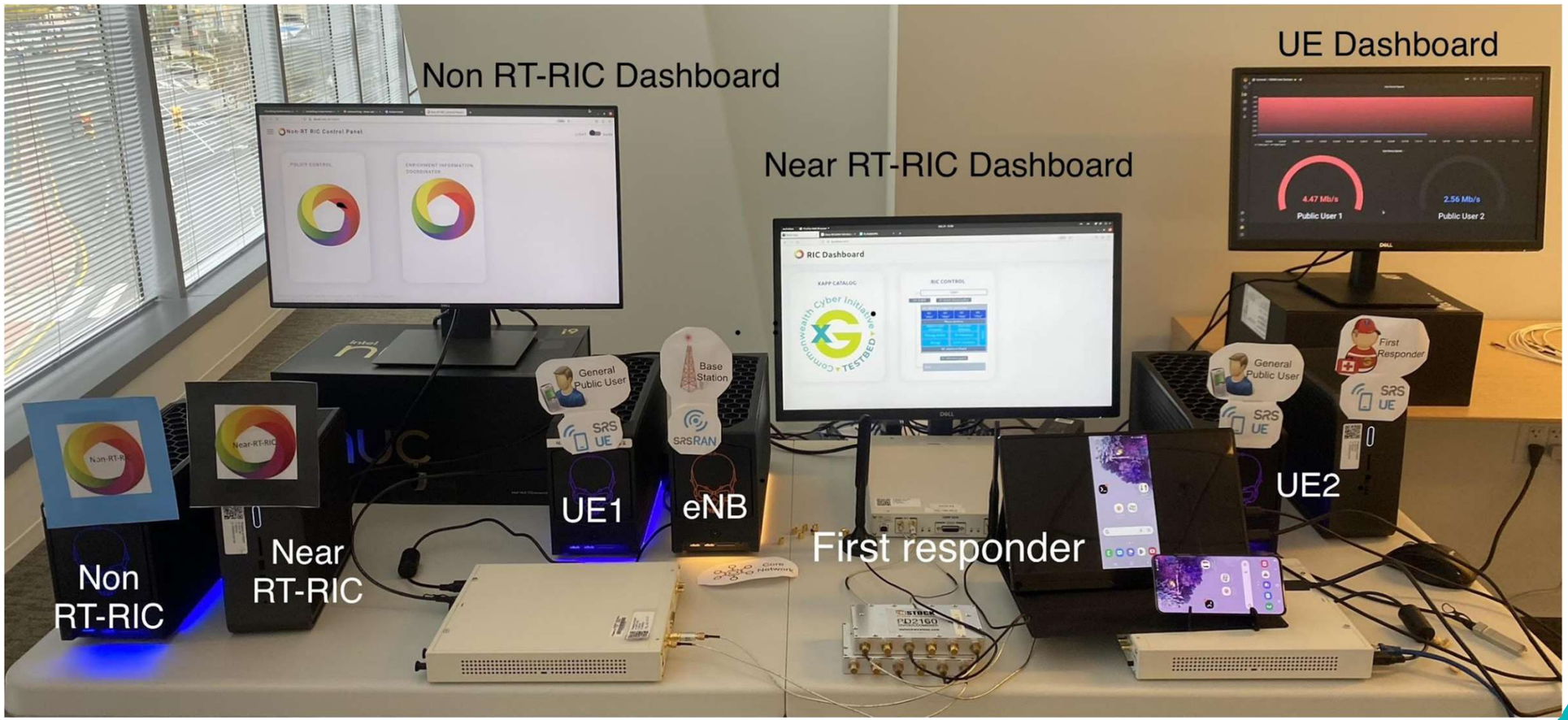
Commonwealth Cyber Initiative

cyberinitiative.org

Commonwealth Cyber Initiative

O-RAN Activities

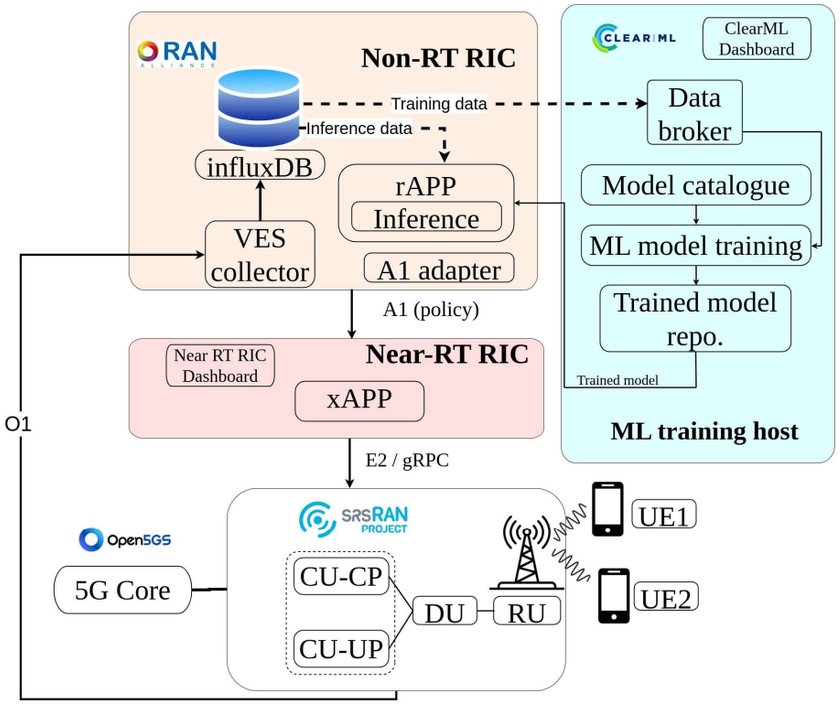
AI/ML driven End-to-End control loop for O-RAN [2]

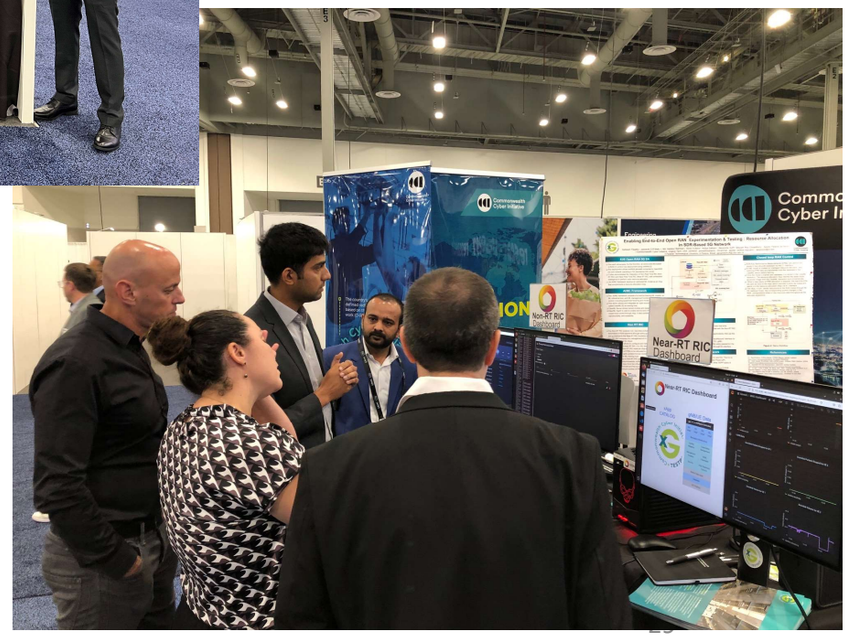


MWC 2022, Las Vegas

[2] Jaswanth S. R. Mallu, Joao F. Santos, Aloizio P. da Silva, Prateek Sethi, Vikas Radhakrishnan, Luiz DaSilva, "*AI/ML Data-driven Control Loop for Managing O-RAN SDR-based RANs*," IEEE INFOCOM Demo, New York, USA, 17 – 20 May 2023.

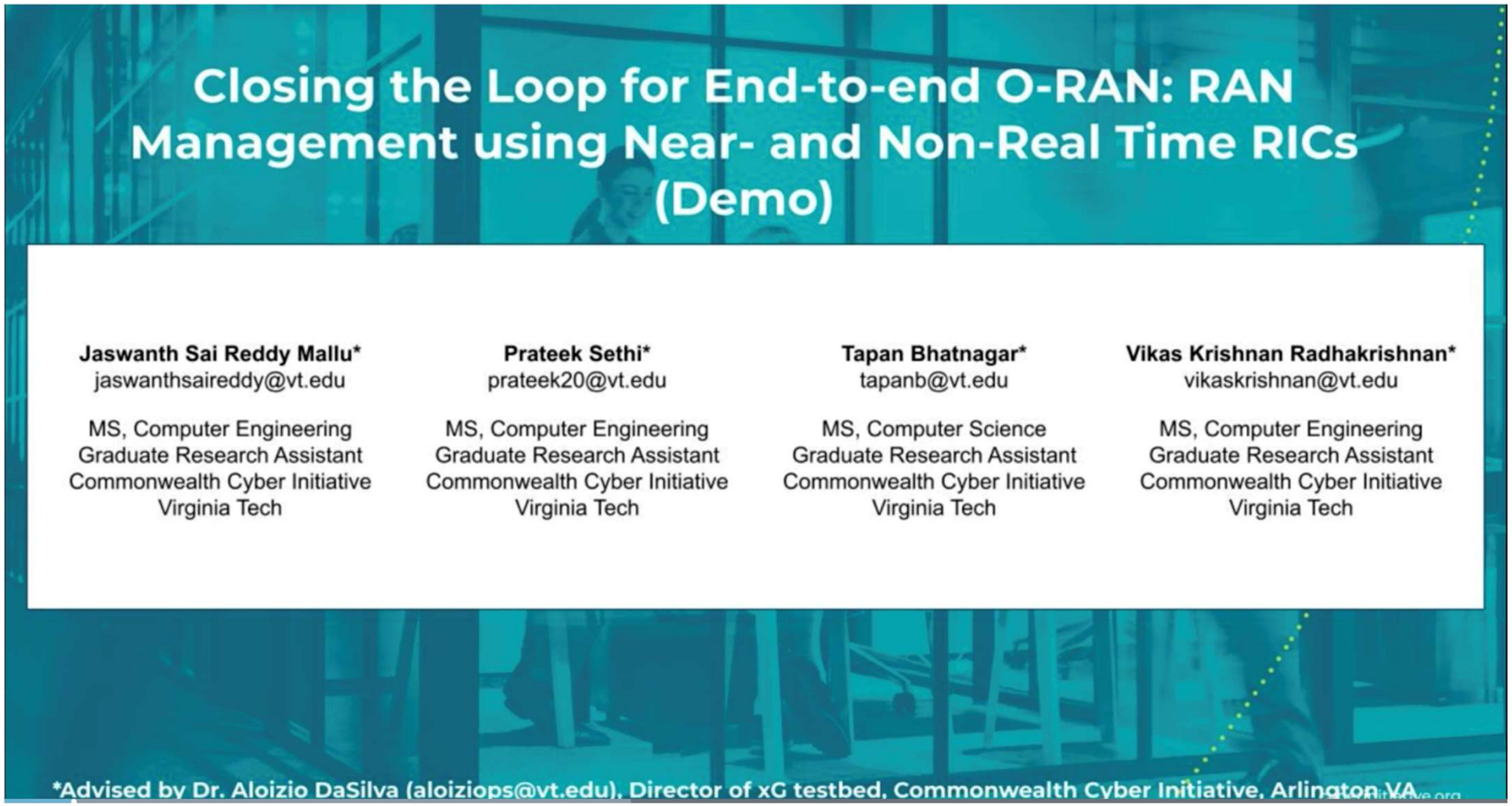
Enabling End-to-End Open RAN Experimentation & Testing: Resource Allocation in SDR-Based 5G Network





MWC 2023, Las Vegas

Commonwealth Cyber Initiative

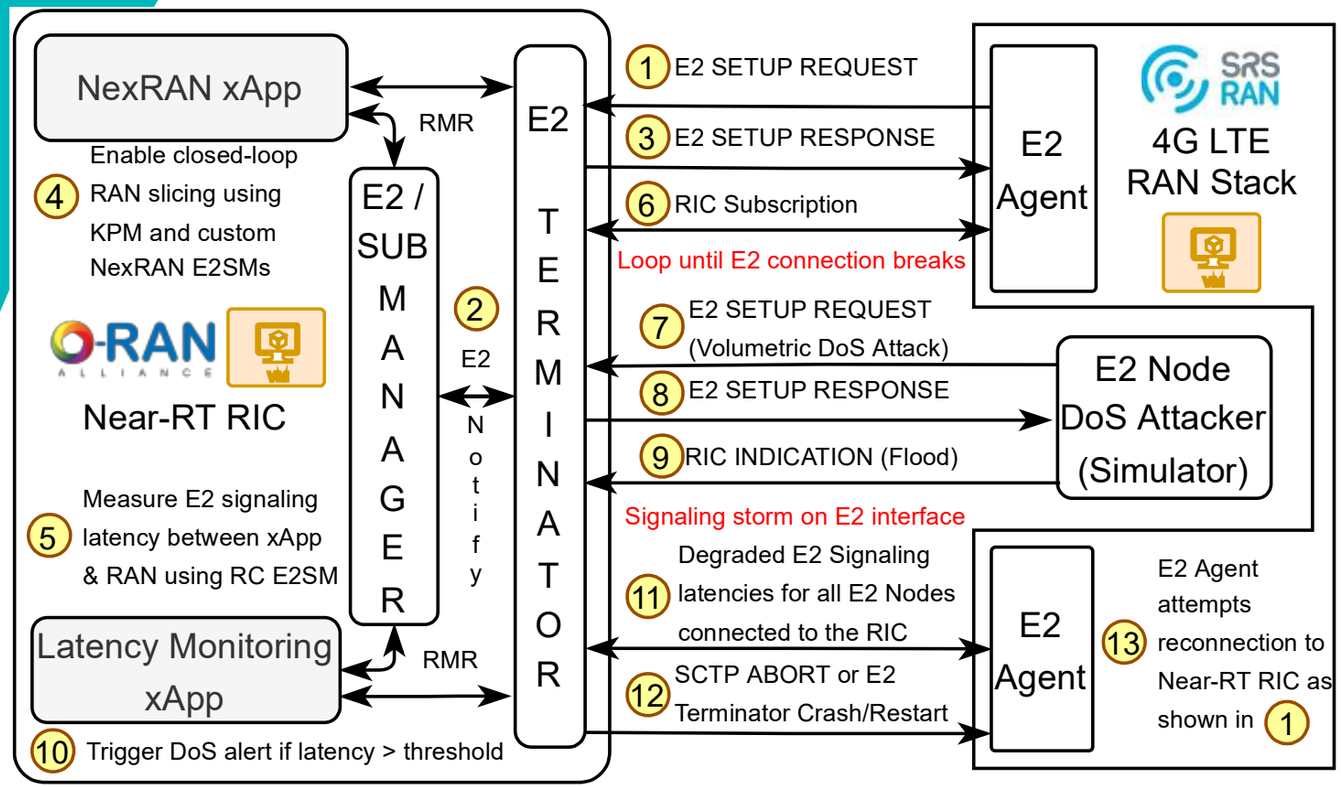


MWC 2023, Shangai

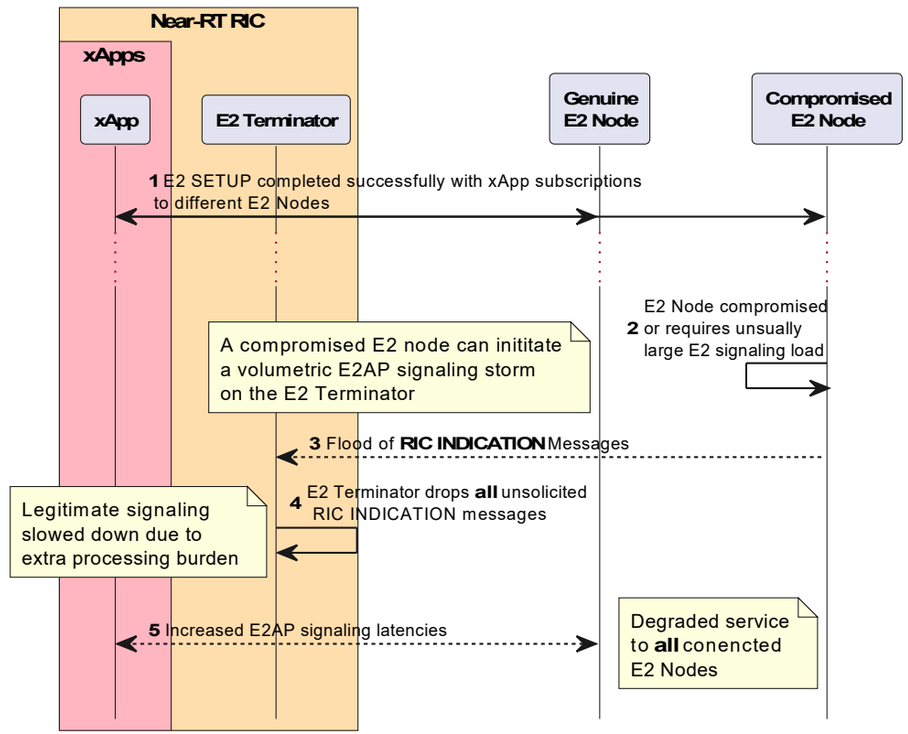
Available at : https://www.virtualexhibition.o-ran.org/classic/generation/2023/category/open-ran-demonstrations/sub/open-source/326

Orchestrating E2 DoS Attack

Work Presented and Results Discussed at WG11 (SFG) plenary call May 17th, 2023



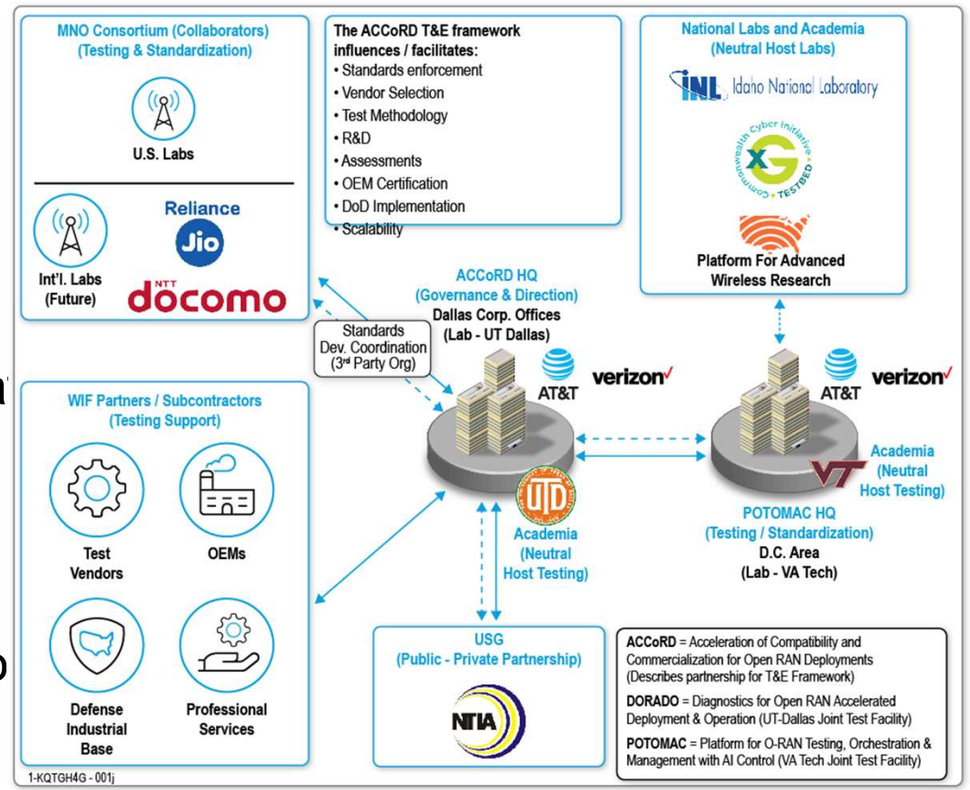
Proof-of-concept DoS attack workflow on the experimental setup



Sequence workflow for a Signaling Storm DoS attack

Acceleration of Compatibility and Commercialization for Open RAN Deployments (ACCoRD)

- NTIA NOFO Award
- Prime: AT&T and Verizon
- Create an Open RAN T&E / R&D Center with a satellite hub in the Washington DC metro area
  - ➢ DORADO (Diagnostics for Open RAN Accelera Deployment and Operation)
  - ➢ **POTOMAC** (**P**latform for **O**-RAN **T**esting, **O**rchestration, and **M**anagement with **AI C**ontro
    - ✓ Located at CCI xG Testbed and OTIC



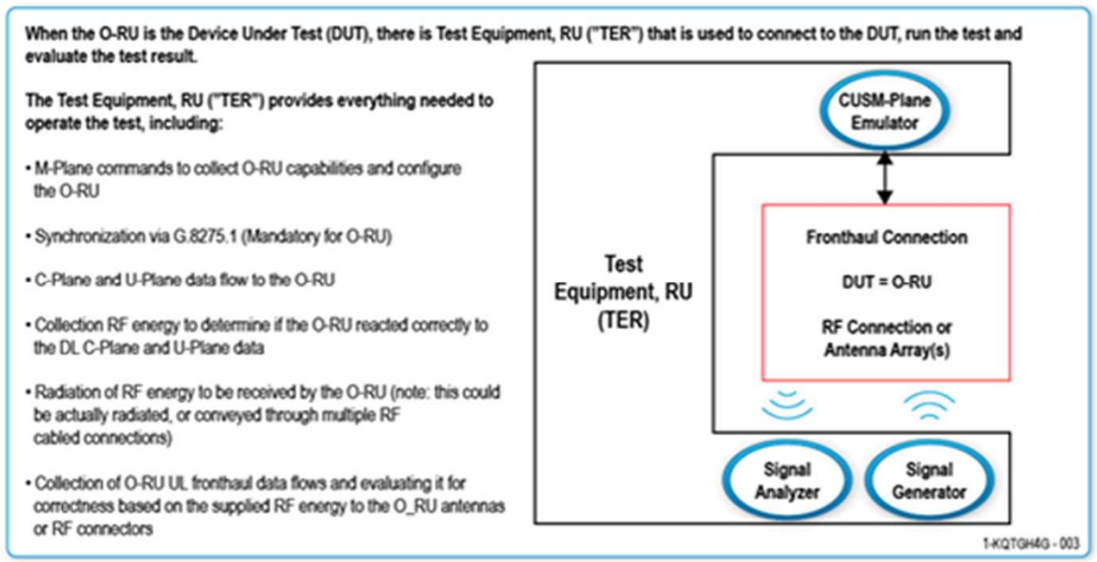
Commonwealth Cyber Initiative

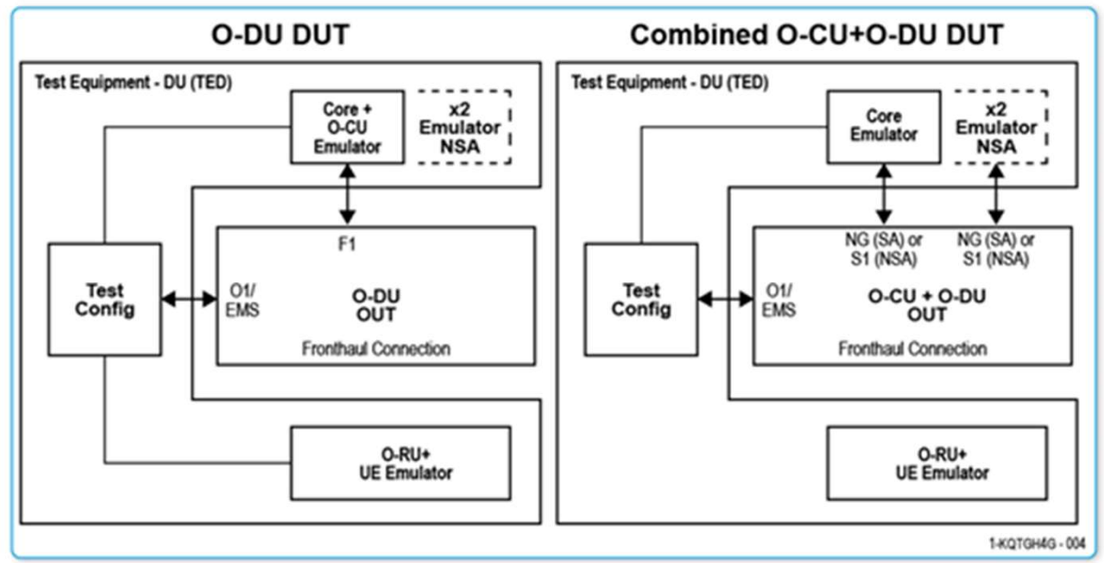
Acceleration of Compatibility and Commercialization for Open RAN Deployments (ACCoRD)

POTOMAC in the **Washington DC metro area** addresses the following objectives:

- **Provide a testbed to support T&E activities** required by NTIA in a manner that is consistent with heightened security requirements;
- **Demonstrate progress towards NTIA T&E** goals in confidence (privately) as well as via exhibitions and workshops open to the public;
- **Serve as the nucleus for the Cloudified Federated Lab as a Service model**;
- **Provide coordination and technical support** for **Neutral Host Facilities**.

Acceleration of Compatibility and Commercialization for Open RAN Deployments (ACCoRD)





Device under Test = O-RU; Device under Test = O-DU or Combined O-CU + O-DU