Open AI Cellular (OAIC)

Prototyping AI-Enabled Control and Testing Systems for Cellular Communications

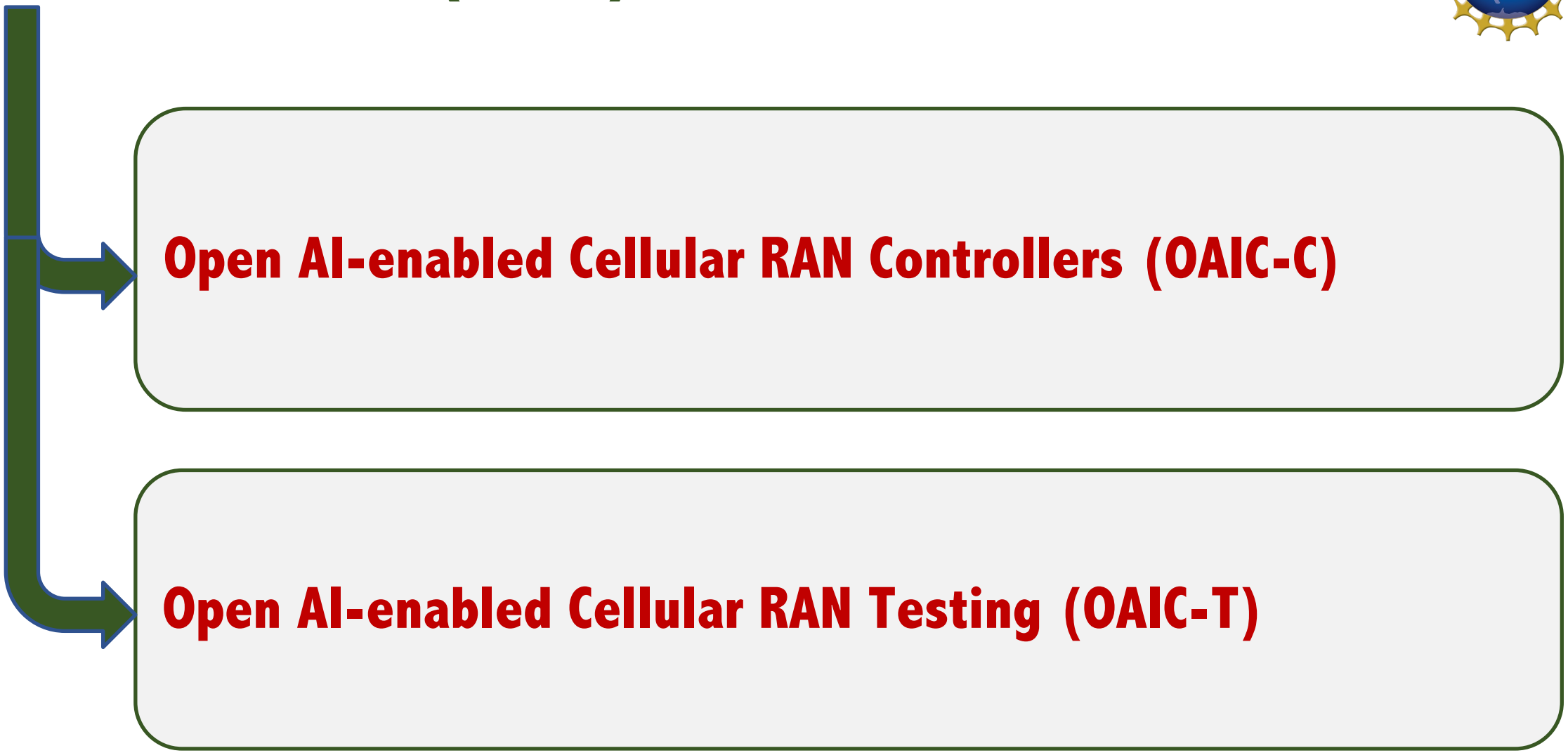
Vijay K. Shah, George Mason University

First IEEE NextG Summit 2022
June 14, 2022

OAIC Mission

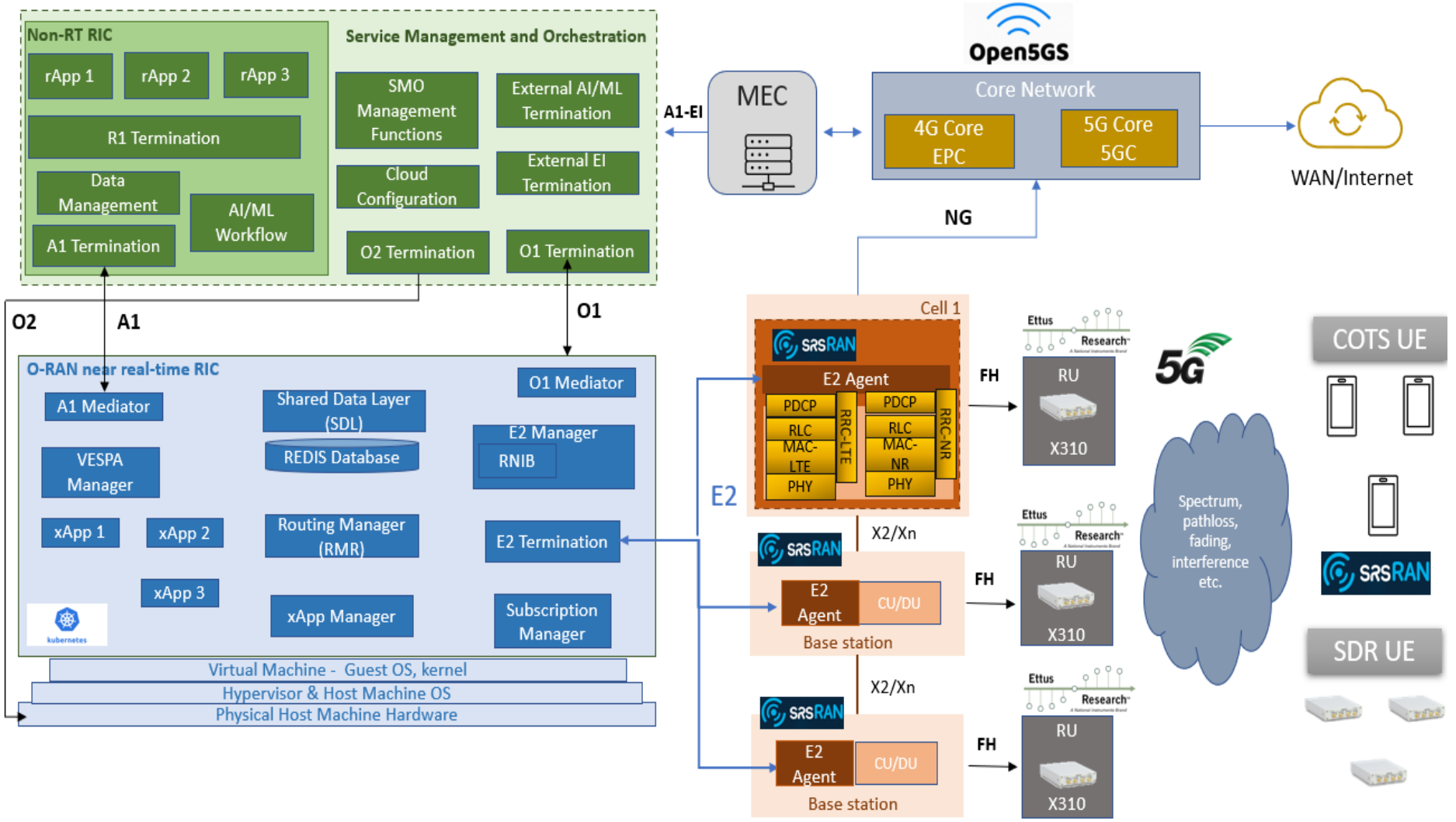
Provide an open platform (including, software architecture, library and toolset) for prototyping and testing artificial intelligence-based radio access network (RAN) controllers enabling Next-G networks.

Open AI Cellular (OAIC)



Open AI Cellular RAN Controllers (OAIC-C)

OAIC-C => O-RAN Architecture[1] + 5G NR Protocol[2] + Software Radios[3]



O-RAN component	OAIC implementation
O-CU, O-DU, O-RU	srsRAN-5G with USRPs, new/ enhanced interfaces
E2 interface	O-RAN Software Community (OSC)
RAN Intelligent Controller (RIC)	OSC + real time RIC extension
xApps	Existing and new
5G Core	Open5GS

[1]O-RAN Alliance + New Extensions

[2]Open-source software

[3]Commercial off-the-shelf hardware

OAIC-C: AI Controllers

Existing xApps

1. Hello World - O-RAN Software Community
2. Bouncer – O-RAN Software Community
3. KPIMON – O-RAN Software Community
4. Traffic Steering – O-RAN Software Community
5. Load Prediction – O-RAN Software Community
6. NexRAN (RAN Slicing) – POWDER

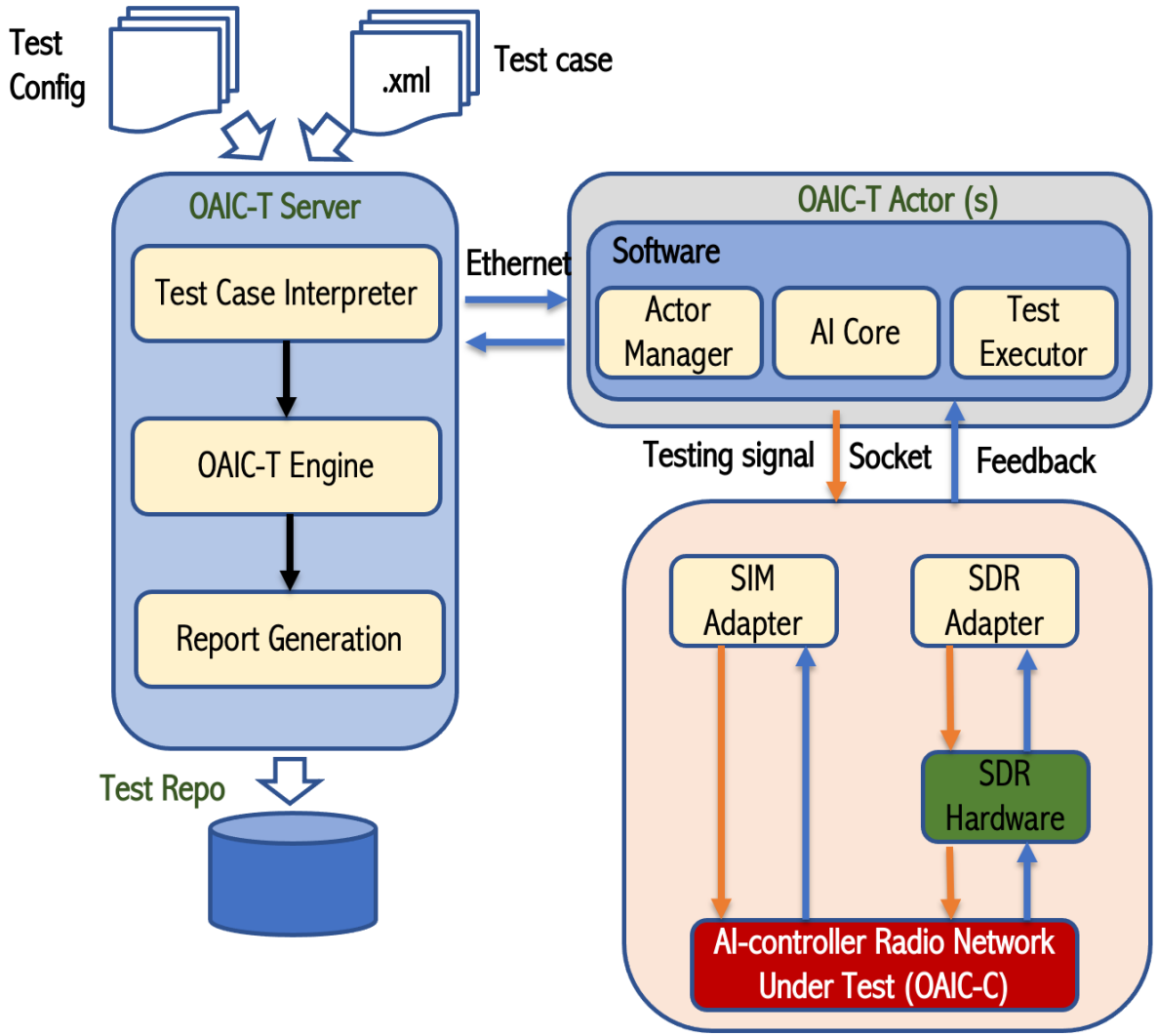
New xApps (To be released soon)

1. Age of Information (AoI) Scheduler
2. AI-enabled Schedulers
3. RAN Slicing v2
4. Several xApps (under initial phase)

Beyond xApps

- **zApps/dApps**: Real-time control loop for AI-enhanced PHY layer control
- **Orchestration & Management (O&M)** and **rApps**

Open AI Cellular RAN Testing (OAIC-T)



Server

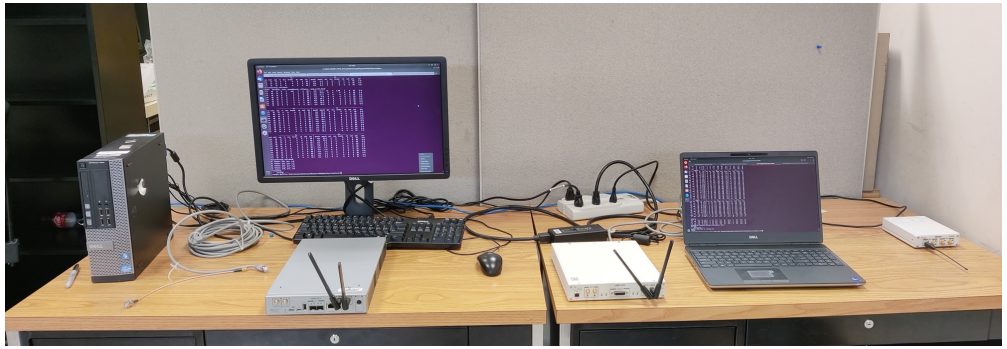
Test Script Interpreter	Read test scripts in .xml, .json, etc.
Server Engine	Manage all actors, set up testing environment, and monitor test status.
Report Generation	Generate testing reports and access test repository.

Actor(s)

Actor Manager	Manage actor resources and running of test scripts.
AI Core	Provide AI capability, i.e., AI learner instances.
Test Executor	Execute individual test actions defined in test script.
SIM/SDR Adapter	Provide interfaces to the unit under test.

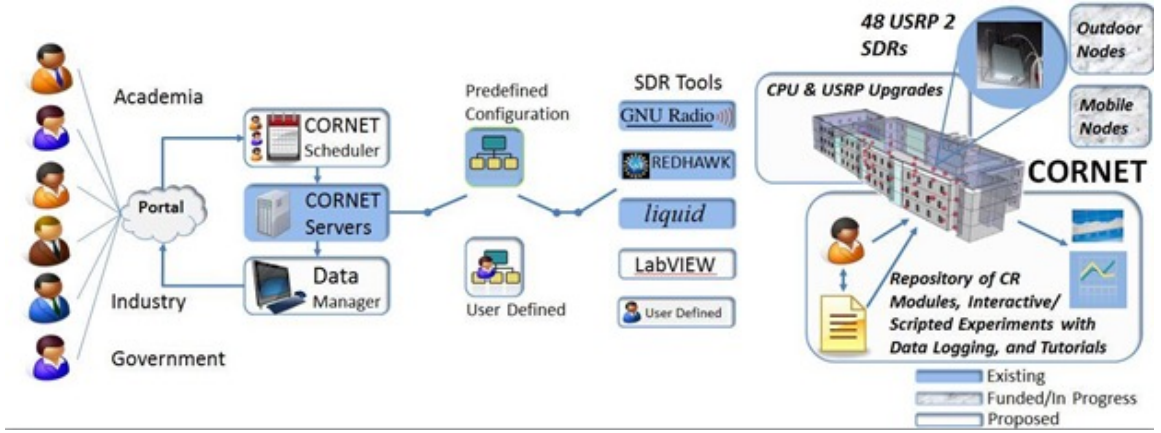
Small/Medium-Scale Testbeds

In-lab Testbed



- Small-scale in-lab 5G O-RAN testbed at VT, MSU and GMU.
- Features near-RT RIC, 5G NSA and SA, developed using srsRAN and O-RAN software, and 2-14 SDRs and ZeroMQ simulator integrated with GNU Radio.

Virginia Tech Cognitive Radio Network (CORNET) Testbed



- Remotely accessible in-building testbed with numerous (nearly 50) USRPs, switches, and virtual machines for development and testing
- Develop source code, automate testing, deploy applications
- Users can run sample OAIC experiments or develop and execute new experiments on CORNET

Large-Scale Testbeds

CCI xG Testbed

- Large-scale 72-node indoor testbed featuring USRPs and MEC capabilities.
- In collaboration with CCI xG Testbed Director, OAIC will be integrated and made available to testbed users

NSF PAWR Platform

- City-scale outdoor testbeds featuring USRPs and other radios, drones (AERPAW), networking and computing resources, FCC licenses
- In collaboration with PAWR PIs, OAIC will be installed and tested on PAWR platforms and made available to their users

How Do I Benefit?

OAIC (both OAIC-C and OAIC-T) will a a fully open-source community research infrastructure.

- Source code will be be made available via Github and/or OAIC website
- OAIC SDR testbed will be remotely accessible via website and/or terminal

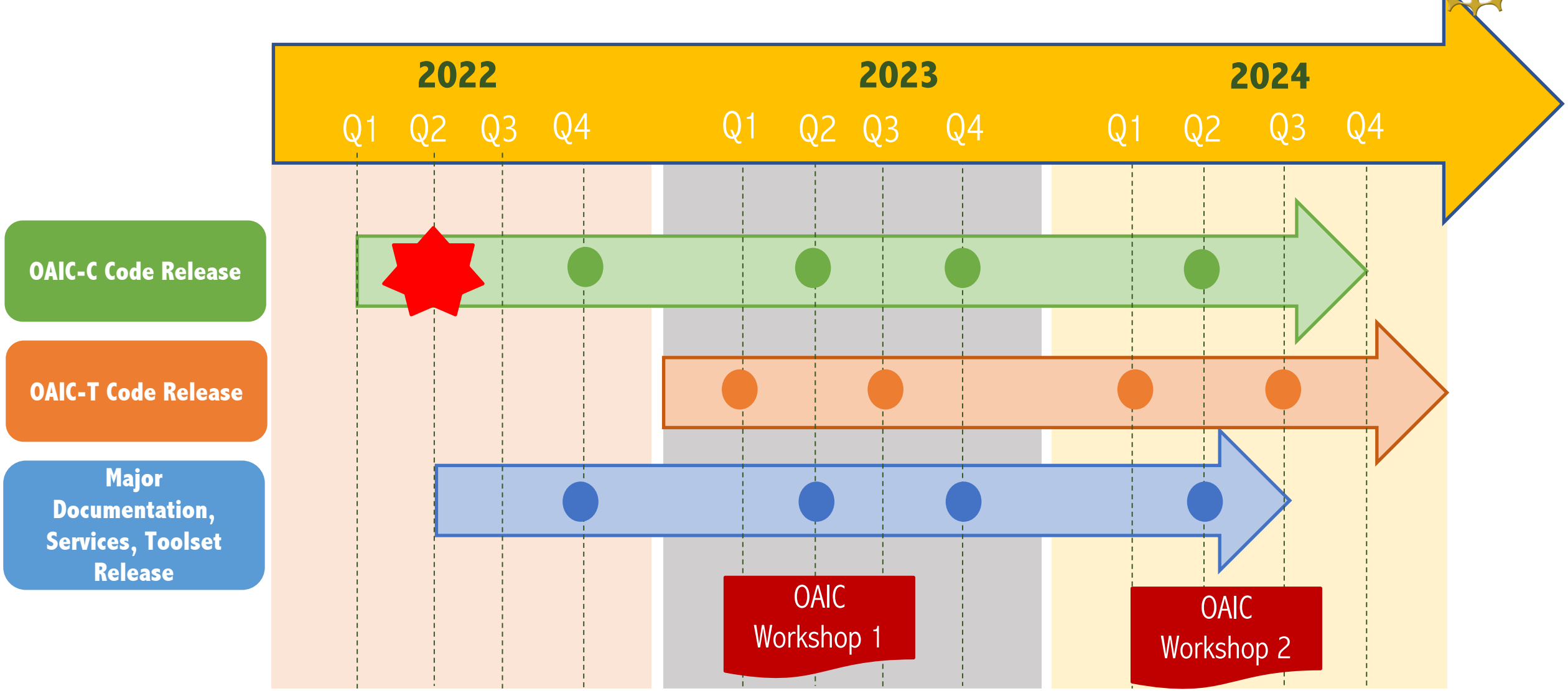
Use OAIC-C to build your own AI controllers (using near-RT RIC and/or RT RIC) for PHY, MAC (and possibly higher layers) RAN functionalities

Use OAIC-T to test your AI-controlled RAN functionalities. (*Source code will be made available as well.*)

All the collected dataset will be made available. You can remotely utilize OAIC platform to collect your own dataset for experimental/verification purposes.

All the documentation, services, tools will be made available. OAIC platform will be also be remotely available.

OAIC Timeline and Roadmap



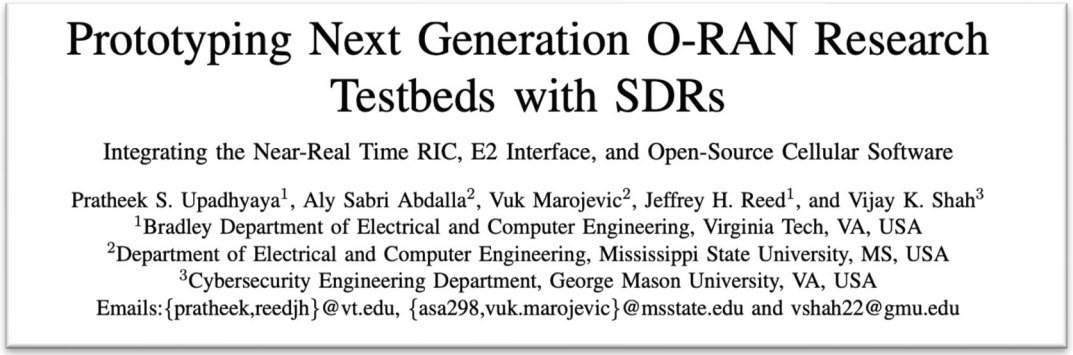
OAIC Release 1.0: Code Repository

OAIC 1.0: Code

Link: https://github.com/openaicellular

Currently supports **O-RAN-based 5G NSA** networks

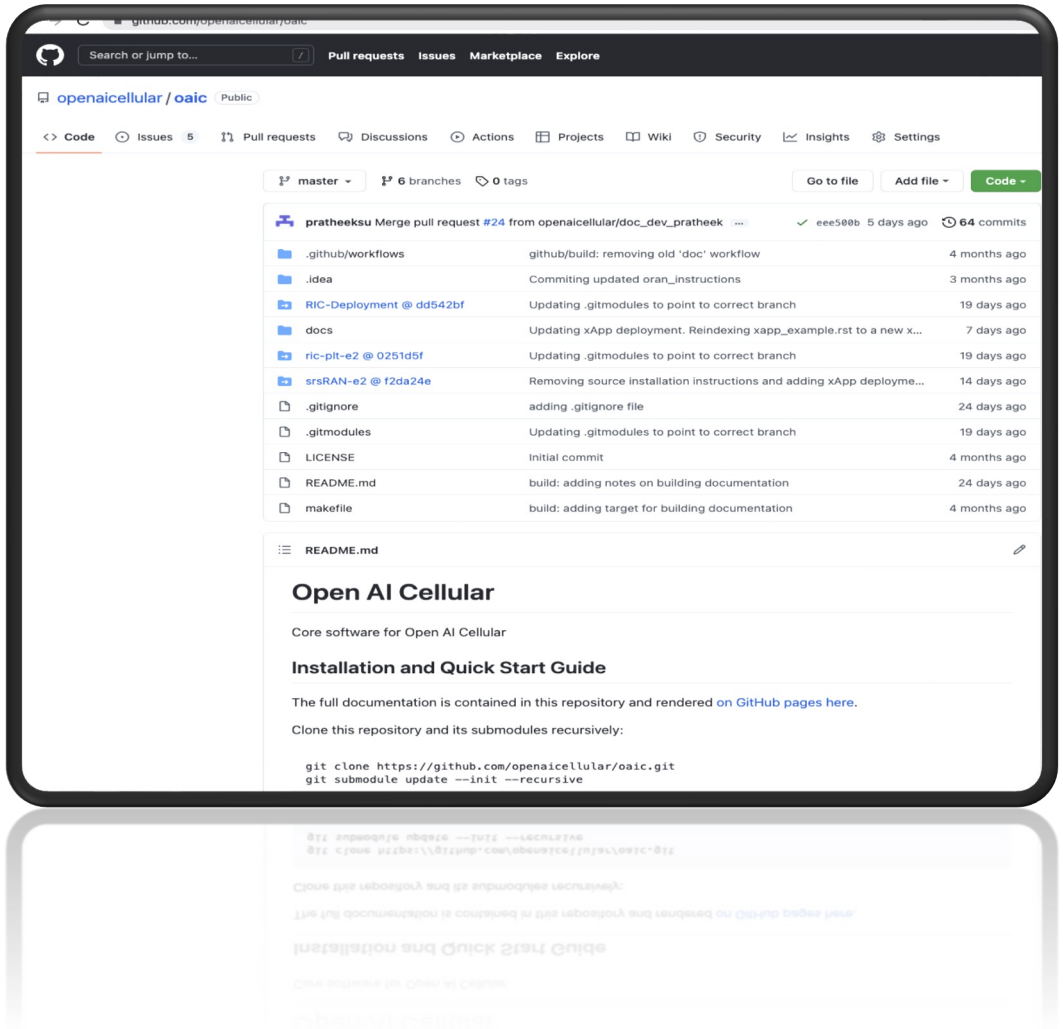
- Based on srsRAN and OSC code
- Both ZeroMQ Simulator and SDRs
- Upgrade to O-RAN based 5G SA networks (Will be integrated shortly).



Prototyping Next Generation O-RAN Research Testbeds with SDRs

Integrating the Near-Real Time RIC, E2 Interface, and Open-Source Cellular Software

Pratheek S. Upadhyaya[1], Aly Sabri Abdalla[2], Vuk Marojevic[2], Jeffrey H. Reed[1], and Vijay K. Shah[3]
[1]Bradley Department of Electrical and Computer Engineering, Virginia Tech, VA, USA
[2]Department of Electrical and Computer Engineering, Mississippi State University, MS, USA
[3]Cybersecurity Engineering Department, George Mason University, VA, USA
Emails:{pratheek,reedjh}@vt.edu, {asa298,vuk.marojevic}@msstate.edu and vshah22@gmu.edu

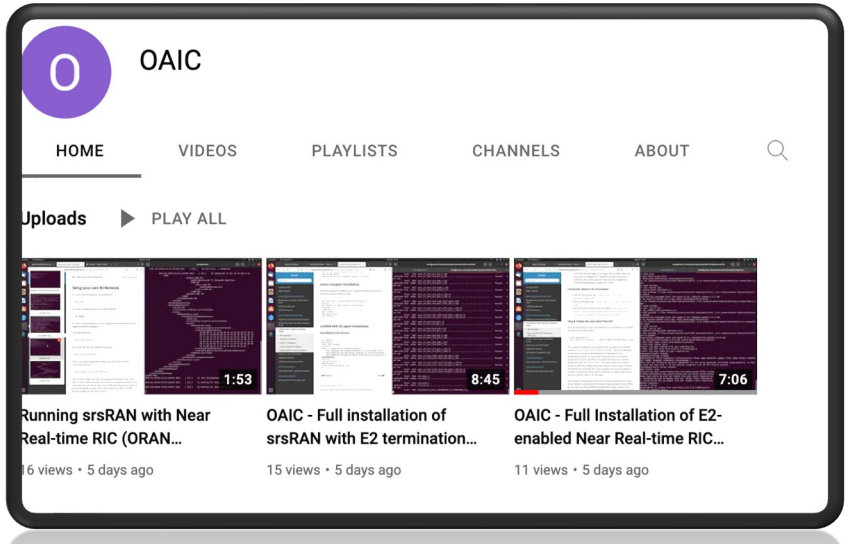


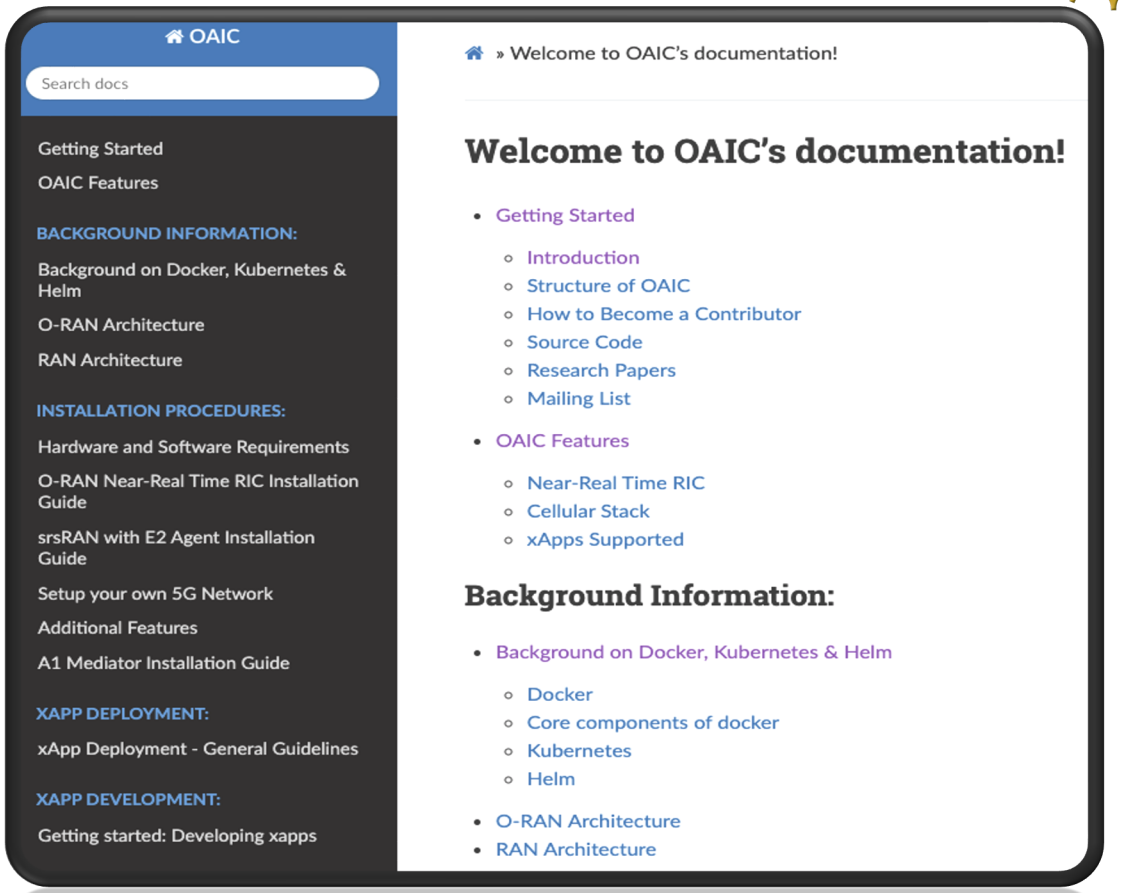
OAIC Release 1.0: Documentation

OAIC 1.0: Documentation

Link: https://openaicellular.github.io/oaic/

YouTube Channel: OAIC
https://www.youtube.com/channel/UCpp9hpRisjMP2gwR5OGEmVQ





OAIC Release 1.0: Additional Resources

Website:

- Existing link: https://sites.google.com/msstate.edu/oaic
- New link: www.openaicellular.org (Will be available shortly)

Mailing list: openaicellular@gmail.com

YouTube channel: OAIC

- Link: https://www.youtube.com/channel/UCpp9hpRisjMP2gwR5OGEmVQ

OAIC Principal Investigators

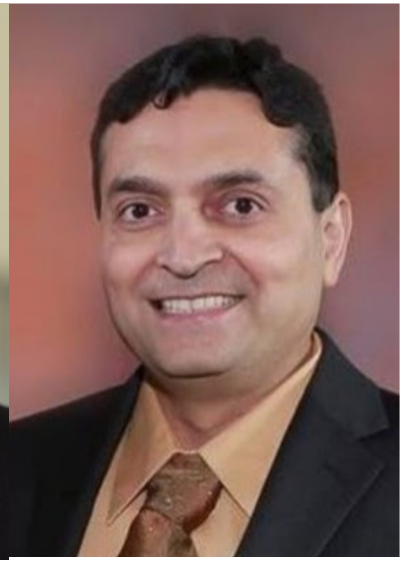
Vuk Marojevic
Testbed Architect

Bo Tang
OAIC-T Architect

Vijay K. Shah
OAIC-C Architect

Joseph Gaeddert
Software Architect

Jeffrey Reed
Outreach



Nishith Tripathi
Broader Impact

OAIC Team

- **Talha Faizur Rahman**, Postdoc
- **Mohammadreza Kouchaki**, PhD Student
- **Ali Sabri Abdalla**, PhD Student
- **Joshua Moore**, Undergrad

- **Vikram Reddy Anapana**, PhD Student
- **Ta-Seen Reaz Niloy**, PhD Student

- **Pratheek Upadhyaya***, PhD Student
- **Kumar Sai Bondada**, MS Student
- **Romil Khimraj Balar**, MS Student

Getting Involved

Use, explore and contribute to OAIC community infrastructure project.

- We seek **industry involvement** with building our OAIC community infrastructure, both OAIC-C and OAIC-T.
- We also want to hear your research interests, discuss collaboration opportunities, define R&D directions and joint projects.

Please reach out to us if you are interested in getting involved with OAIC project

- Email: vshah22@gmu.edu, openaicellular@gmail.com (feel free to get in touch other OAIC PIs/Co-PIs.)
- Follow OAIC website for recent updates

Getting Involved

Use, explore and contribute to OAIC community infrastructure project.

- We seek **industry involvement** with building our OAIC community infrastructure, both OAIC-C and OAIC-T.
- We also want to hear your research interests, discuss collaboration opportunities, define R&D directions and joint projects.

Questions?

Please reach out to us if you are interested in getting involved with OAIC project

- Email: vshah22@gmu.edu, openaicellular@gmail.com (feel free to get in touch other OAIC PIs/Co-PIs.)
- Follow OAIC website for recent updates

Backup: AI Challenges in Next-G

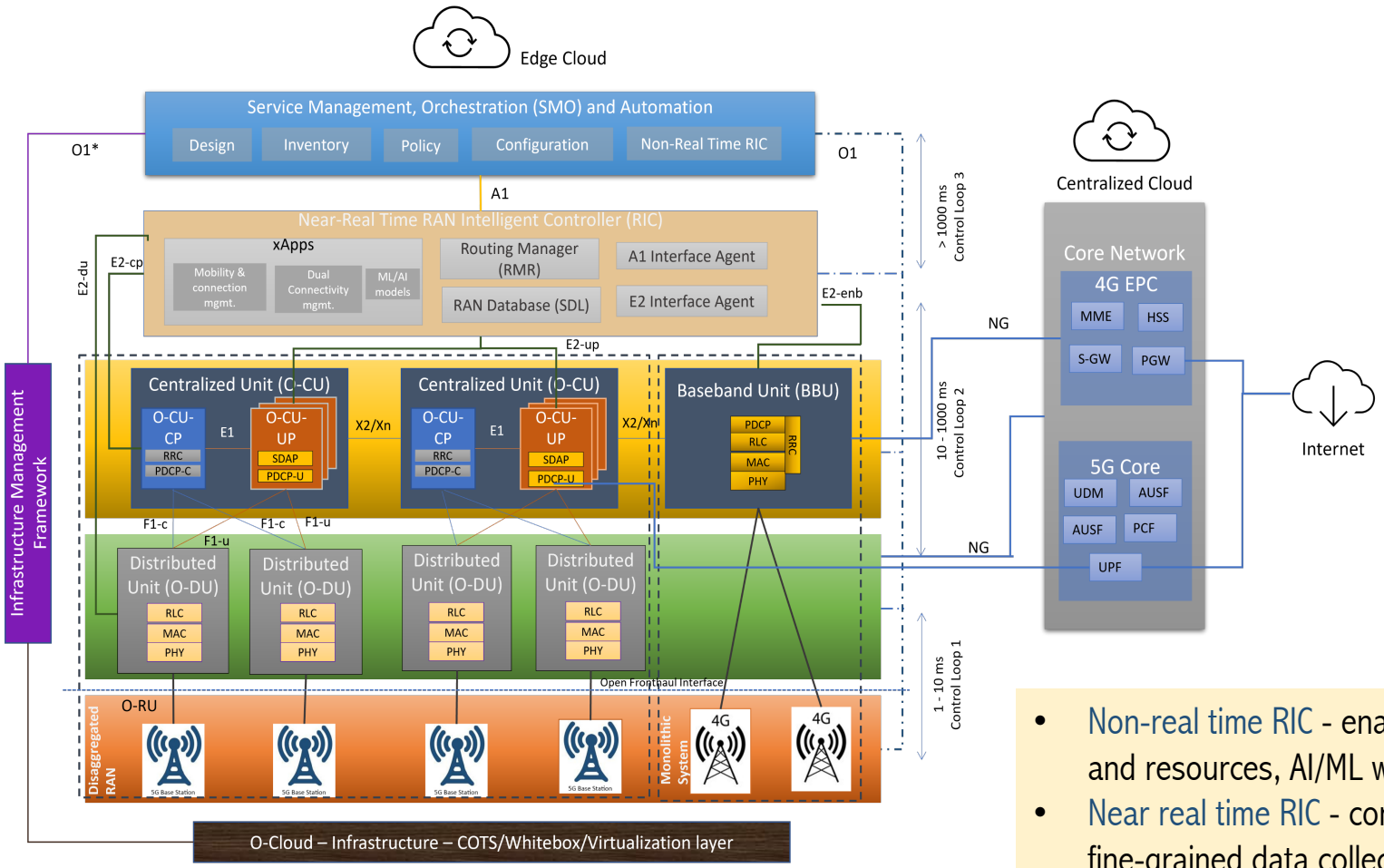
While there is lots of optimism in the wireless research community on AI, the reality is that

- There needs to be **sufficient real-world experience at scale** to prove the added expense of AI is justified in improved performance.
- AI in the network needs to be **extensively tested** with the rigor that other elements of the network are tested today.

Some key research questions

- How do we design cellular networks to be more AI suitable at various locations?
- What methodologies apply to test AI performance at various locations in the network?
- How do we test for cross-layer interactions of AI deployed at various points in the network?
- Can testing of AI be used to find configuration failures as well as to ensure secure configurations?

O-RAN Architecture



Control loop timescales:

- Non-real time : > 100 ms
- Near-real time : 10ms – 1000ms
- Real time : < 1ms

Based on two core principles

- Openness
- Intelligence

Flexibility by design

- Open interfaces and APIs

3GPP Split 7-2x

RAN Intelligent Controllers (RICs)

- Abstract the networks
- Allow telecom operators to implement custom control logic

- Non-real time RIC - enables non-real-time control and optimization of RAN elements and resources, AI/ML workflow over A1 interface.
- Near real time RIC - control and optimization of O-RAN elements and resources via fine-grained data collection and actions over E2 interface.
- O-DU - hosts RLC/MAC/High-PHY layers
- O-CU-CP - hosts the RRC and the control plane part of the PDCP protocol.
- O-CU-UP - hosts the user plane part of the PDCP protocol and the SDAP protocol.
- xApp - Independent software plug-in to the Near-RT RIC platform to provide functional extensibility to the RAN by third parties