



Institute for the Wireless Internet of Things

at Northeastern University

| OpenRAN Gym: Enabling AI
and ML in O-RAN

Leonardo Bonati



OpenRAN Gym

openrangym.com



Platforms for Advanced
Wireless Research



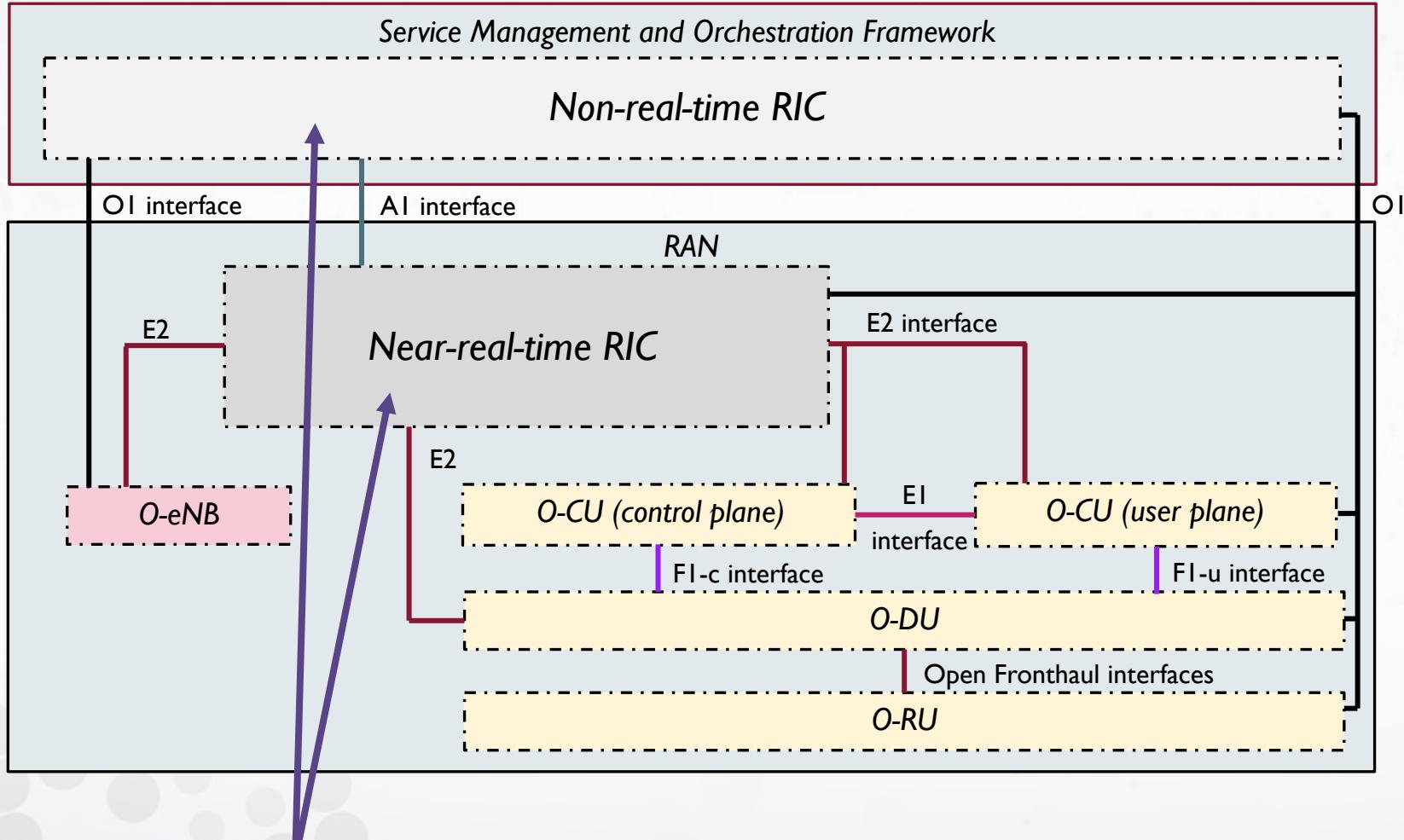
MITRE



MASSACHUSETTS
TECHNOLOGY
COLLABORATIVE



N COLOSSEUM
at Northeastern University



1. Open, standardized interfaces
2. Disaggregated RAN
3. Software

4. RAN Intelligent Controllers

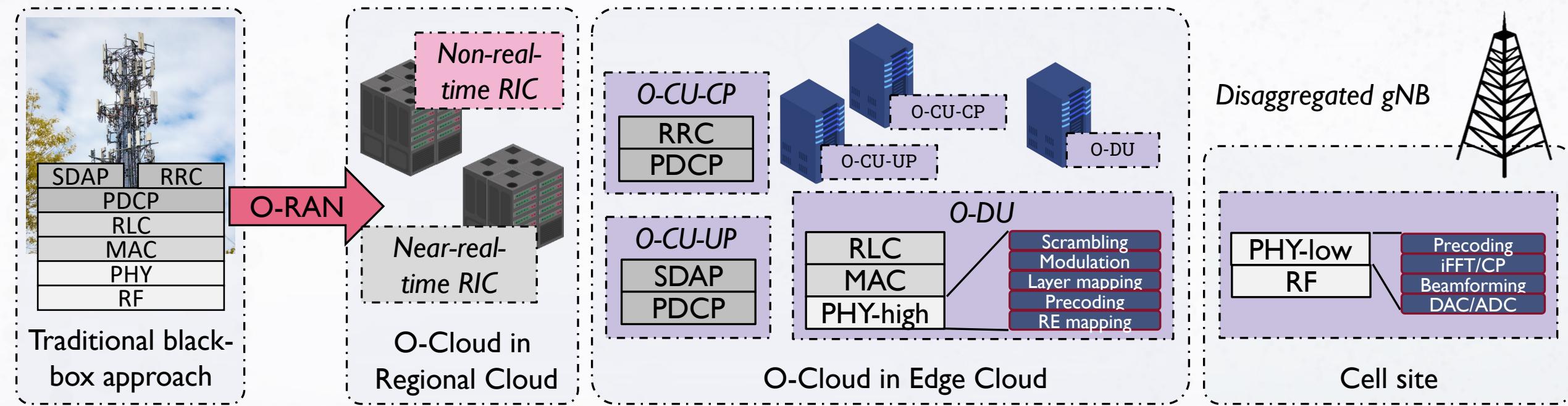
Intelligent Control Loops

Currently supported by O-RAN

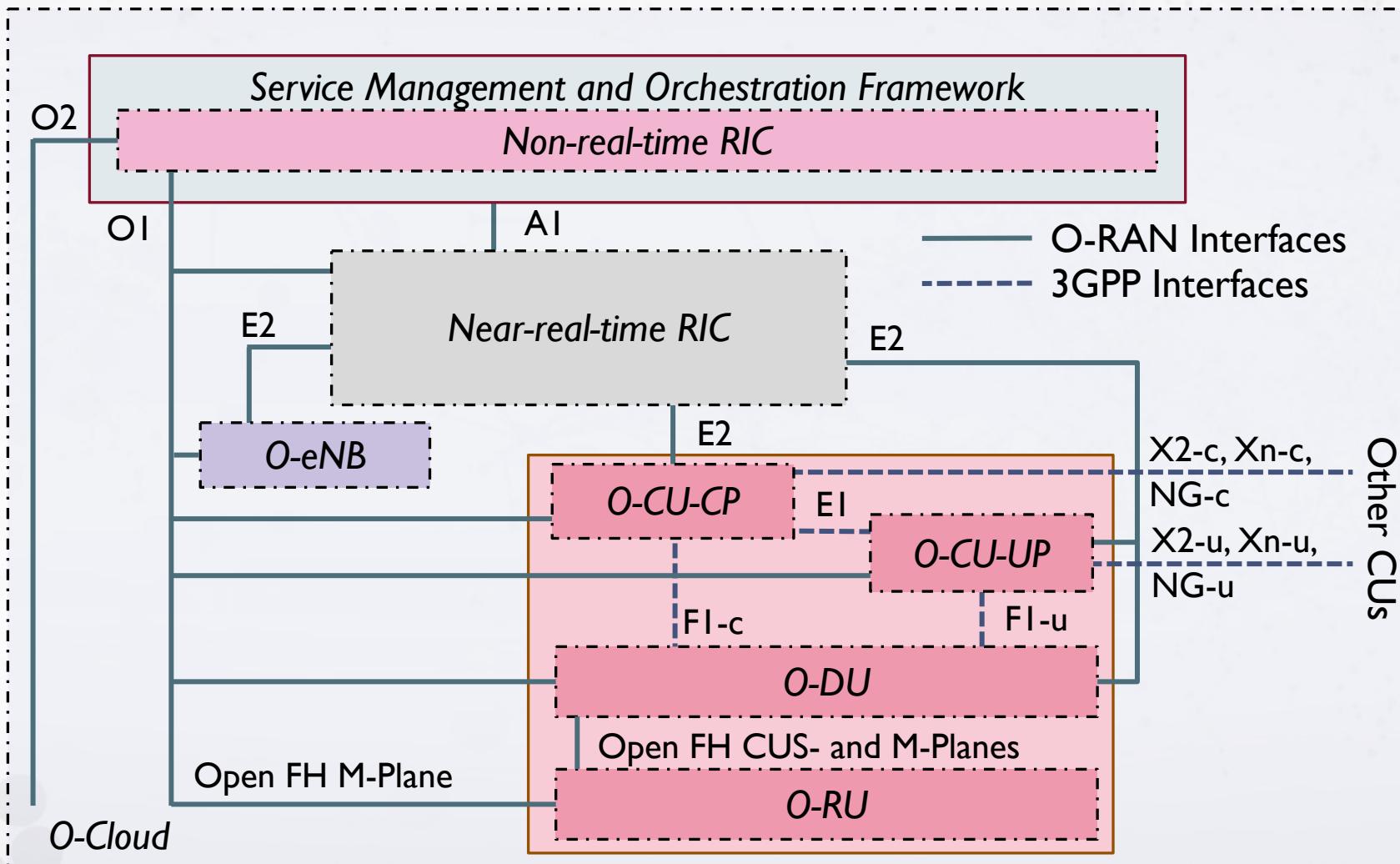
Control and learning objective	Scale	Input data	Timescale	Architecture
Policies, models, slicing	> 1000 devices	Infrastructure-level KPIs	Non real-time > 1 s	
User Session Management e.g., load balancing, handover	> 100 devices	CU-level KPIs e.g., number of sessions, PDCP traffic	Near real-time 10-1000 ms	
Medium Access Management e.g., scheduling policy, RAN slicing	> 100 devices	MAC-level KPIs e.g., PRB utilization, buffering	Near real-time 10-1000 ms	
Radio Management e.g., resource scheduling, beamforming	~10 devices	MAC/PHY-level KPIs e.g., PRB utilization, channel estimation	Real-time < 10 ms	
Device DL/UL Management e.g., modulation, interference, blockage detection	1 device	I/Q samples	Real-time < 1 ms	

Being standardized as dApps

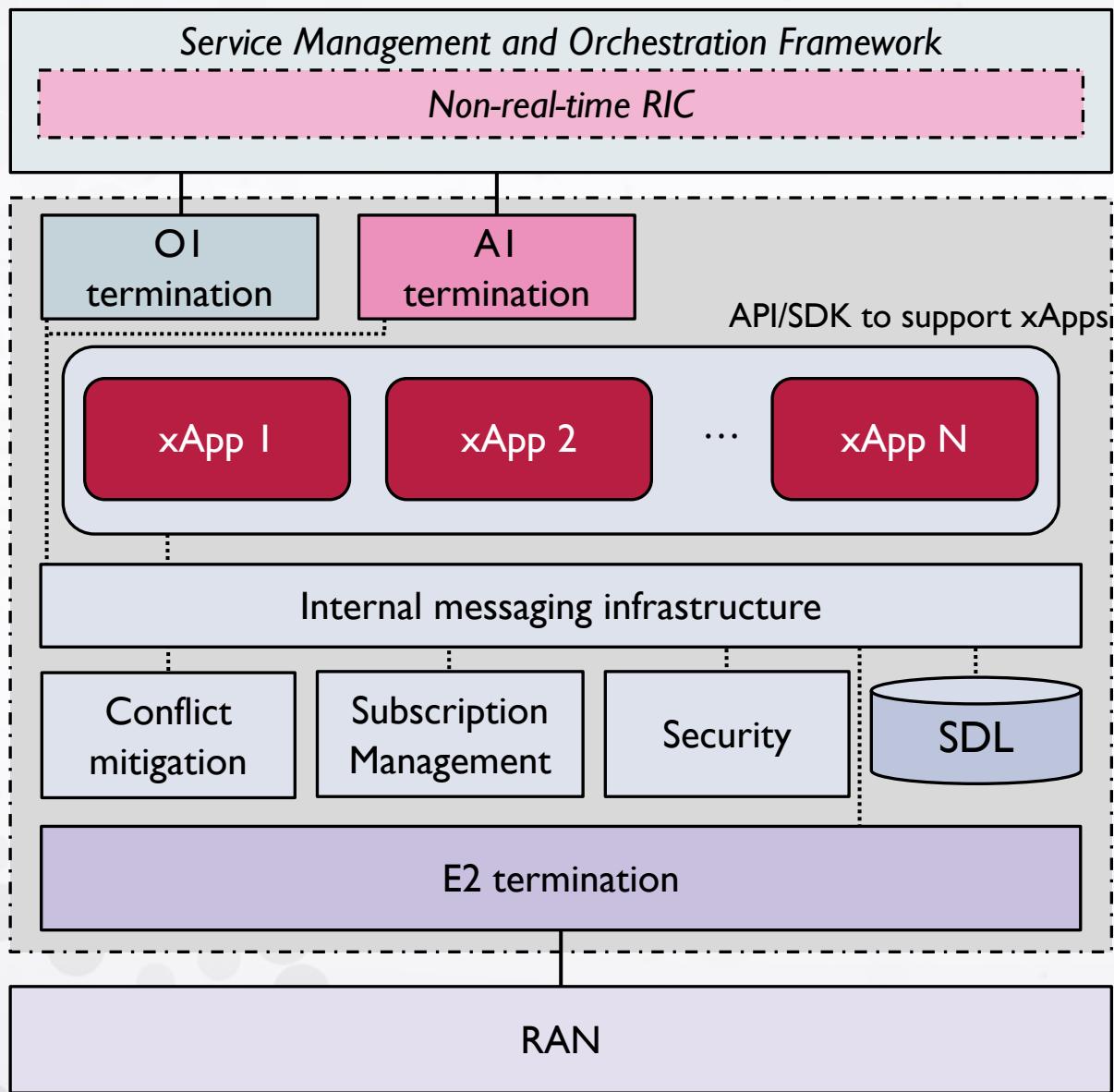
A split architecture



Logical architecture overview

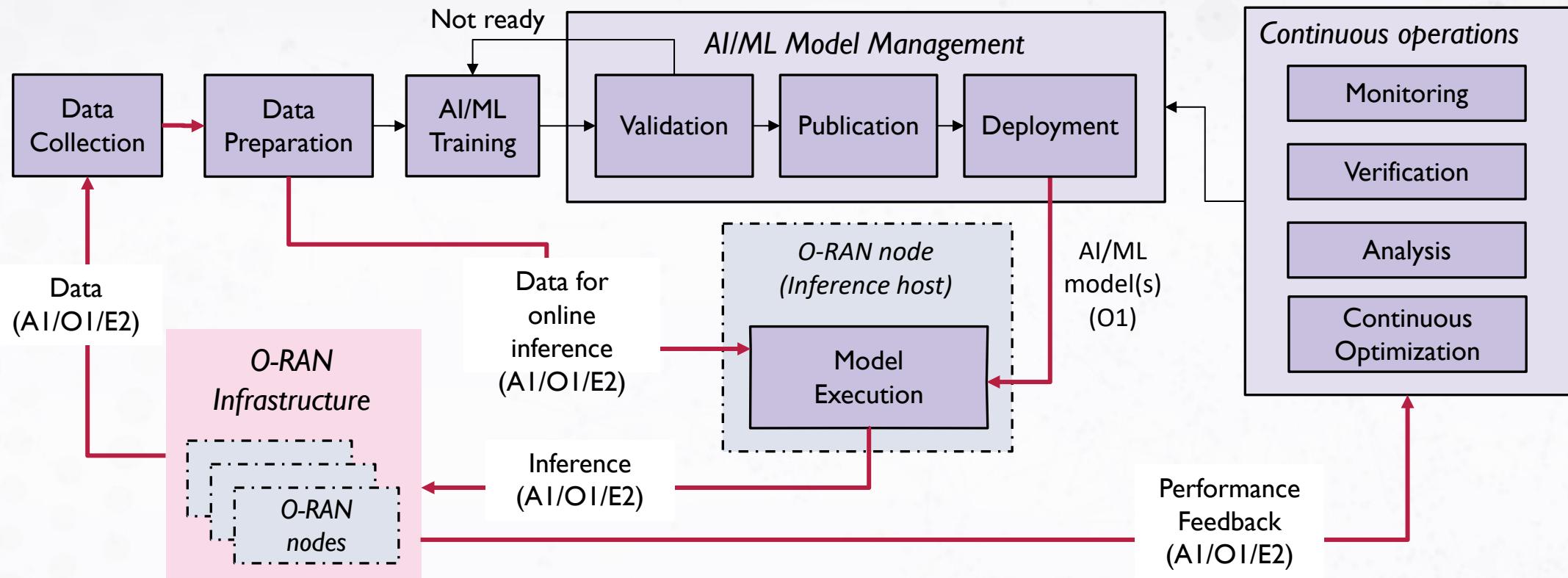


Near-real-time RIC



- Standardized blocks and functionality
- Different implementations

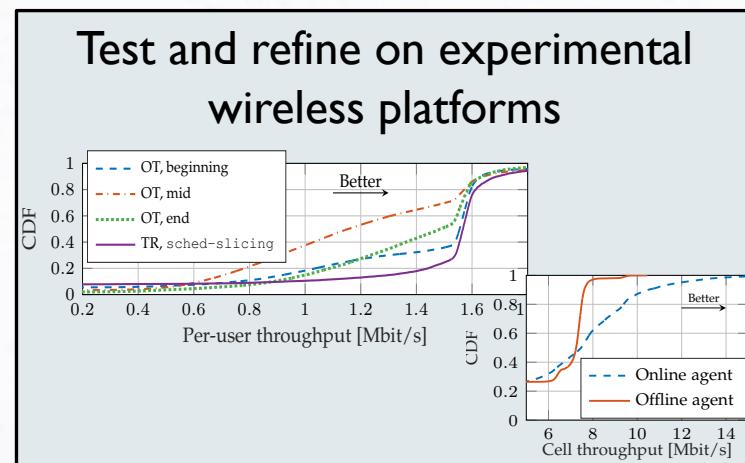
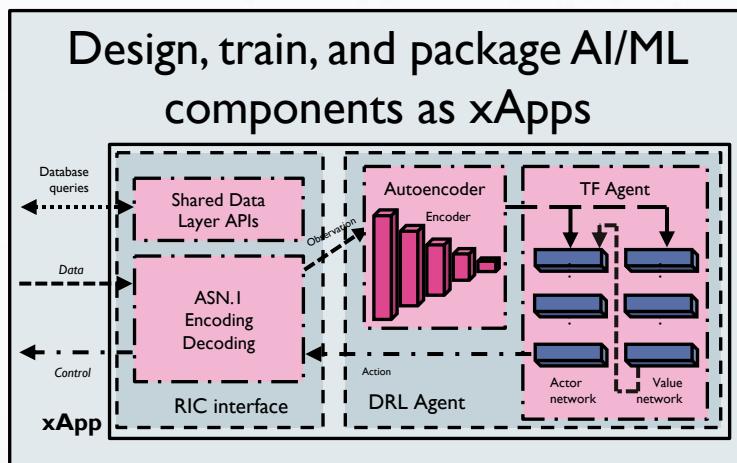
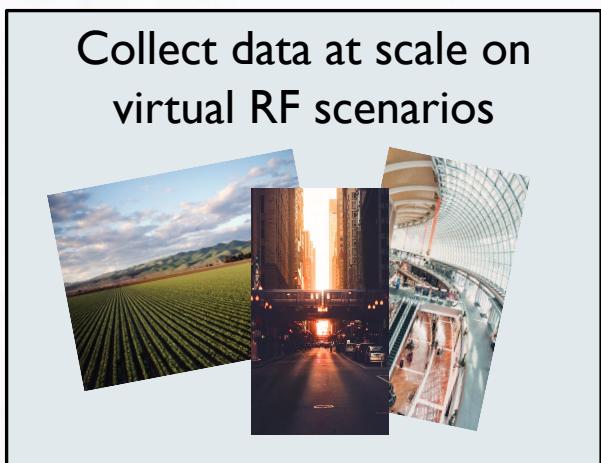
Lifecycle of AI/ML in O-RAN



- From **data collection** to **online fine-tuning and inference**
- Covers all aspects of **AIOps**:
 - Monitor
 - Engage
 - Act

The OpenRAN Gym Vision

Enable native O-RAN-driven experiments in large-scale experimental testbeds and networks



OpenRAN Gym

A toolbox for Intelligent O-RAN
www.openrangym.com



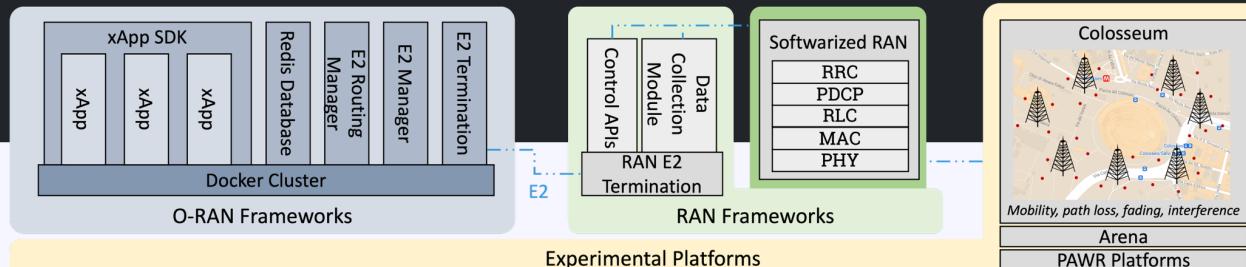
Open5G Publications

Contribute

OpenRAN Gym

An Open Toolbox for Data Collection and Experimentation with AI in O-RAN

OpenRAN Gym is the first publicly-available research platform for data-driven O-RAN experimentation at scale. Building on frameworks for data collection and RAN control, OpenRAN Gym enables end-to-end design and testing of data-driven xApps by offering an O-RAN-compliant near-real-time RIC and E2 termination.



O-RAN Frameworks

RAN Frameworks

the Wireless
Things
n

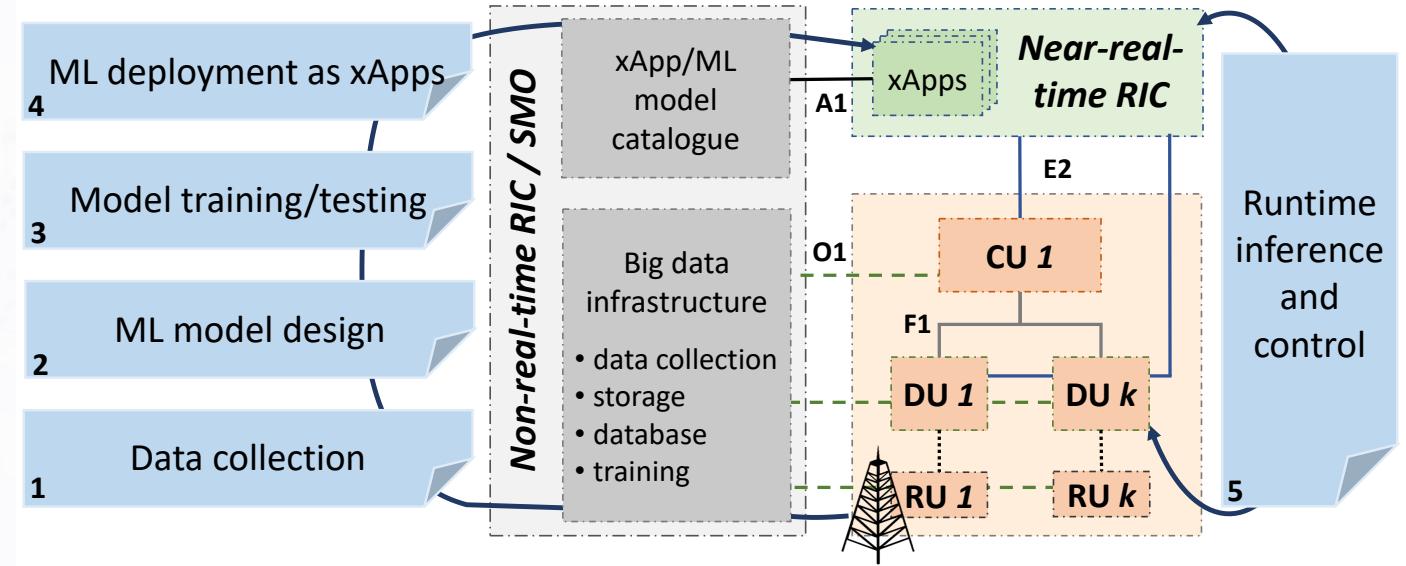
OpenRAN Gym

More info: L. Bonati, M. Polese, S. D'Oro, S. Basagni, T. Melodia, "OpenRAN Gym: An Open Toolbox for Data Collection and Experimentation with AI in O-RAN," Proc. of IEEE WCNC Workshop on Open RAN Architecture for 5G Evolution and 6G, Austin, TX, USA, April 2022.

An **open-source** toolbox for **xApp development** and **Open RAN experimentation**

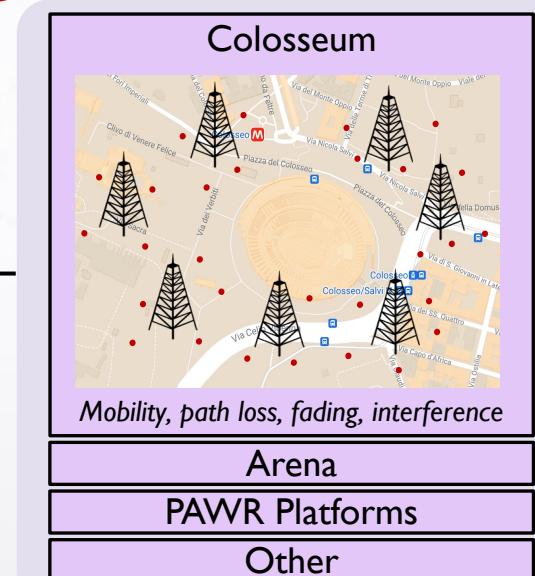
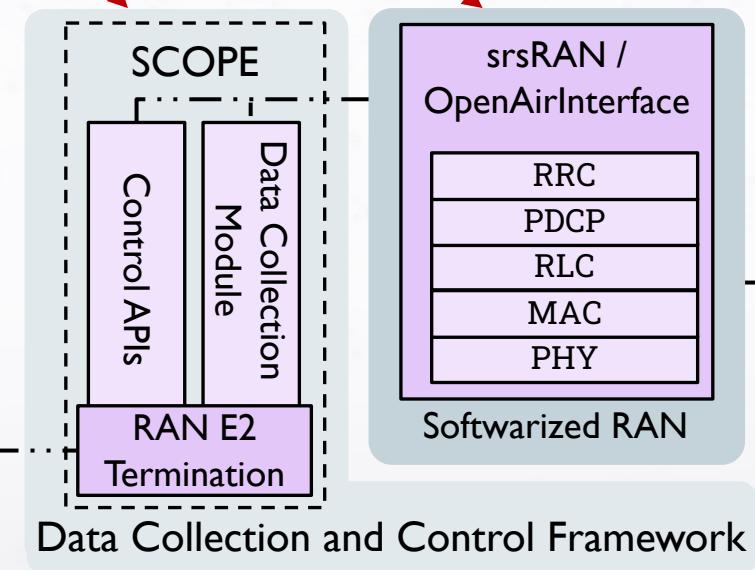
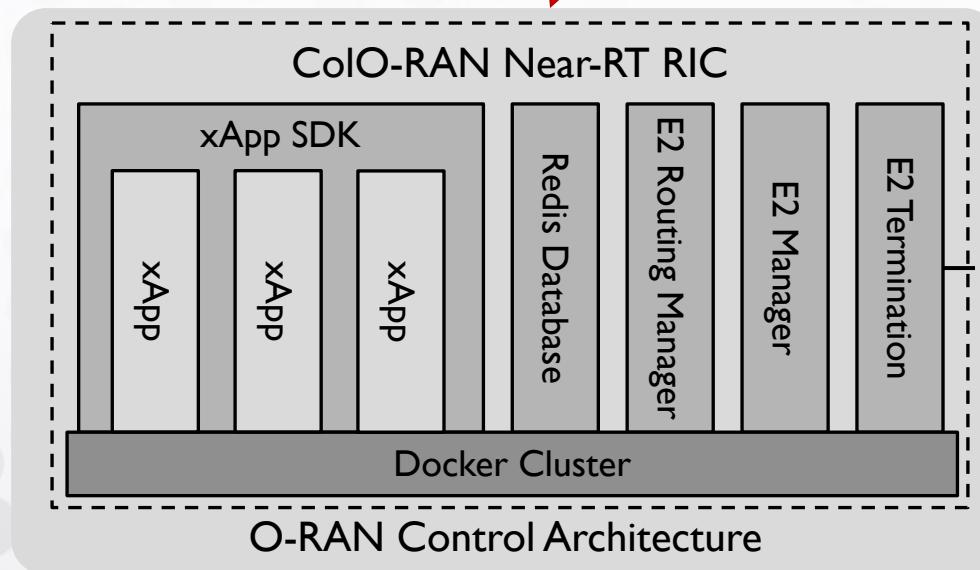
Enables:

1. Data collection
2. AI/ML model design
3. Model training and testing
4. Model deployment on near-RT RIC as xApp
5. Runtime inference and control of a softwarized RAN



OpenRAN Gym – A Toolbox for Intelligent O-RAN

- O-RAN-compliant **near-real-time RIC** running on Colosseum (CoO-RAN)
- RAN framework for **data-collection and control** of the base stations (SCOPE)
- **Programmable** software-defined protocol stacks
- Publicly-accessible **experimental platforms** (e.g., Colosseum, Arena, PAWR platforms)



Moving OpenRAN Gym Experiments

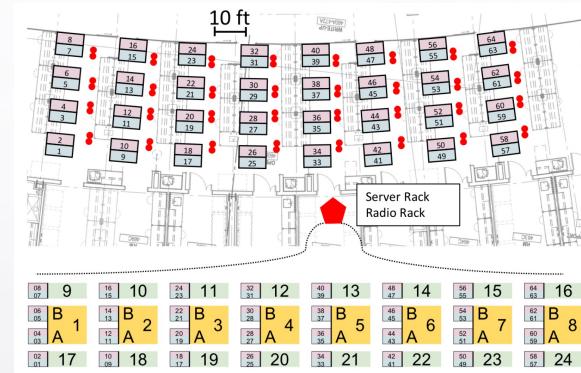
The same experiment (and software) can be seamlessly deployed in different testbeds

- Initial design and testing at-a-scale on Colosseum w/ different scenarios
- Validate on real-world indoor environment on Arena (Northeastern over-the-air SDR testbed)
- Experiment into the wild on PAWR city-scale platforms

Test at-a-scale
on emulated
scenarios



Validate in
real wireless
environment

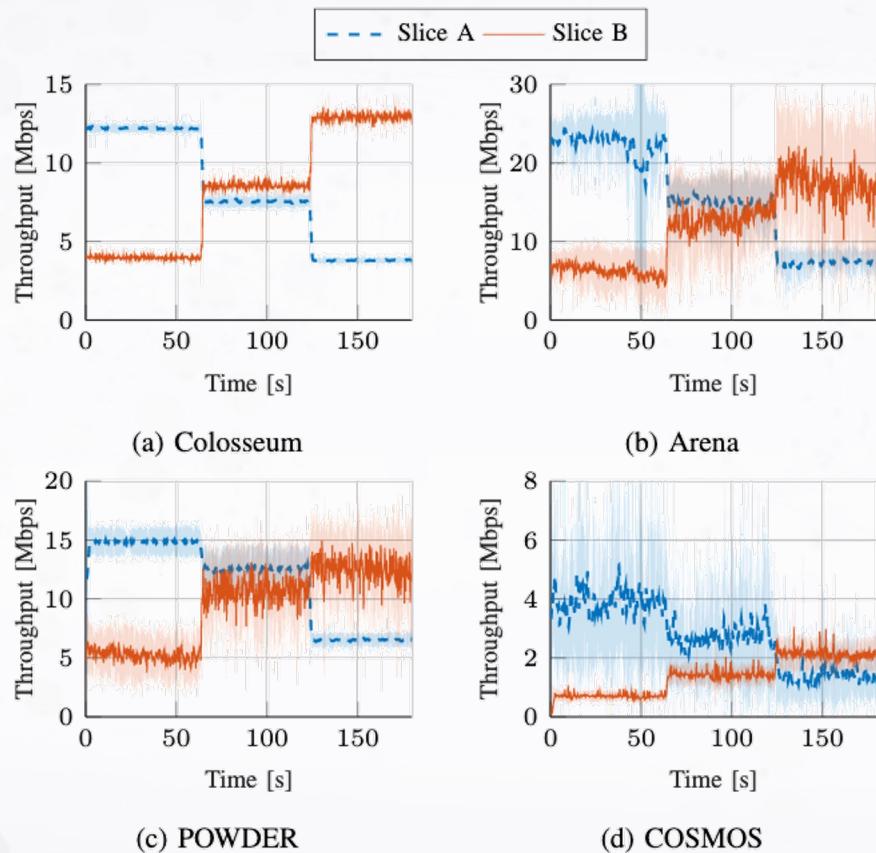


Test large-
scale
capabilities

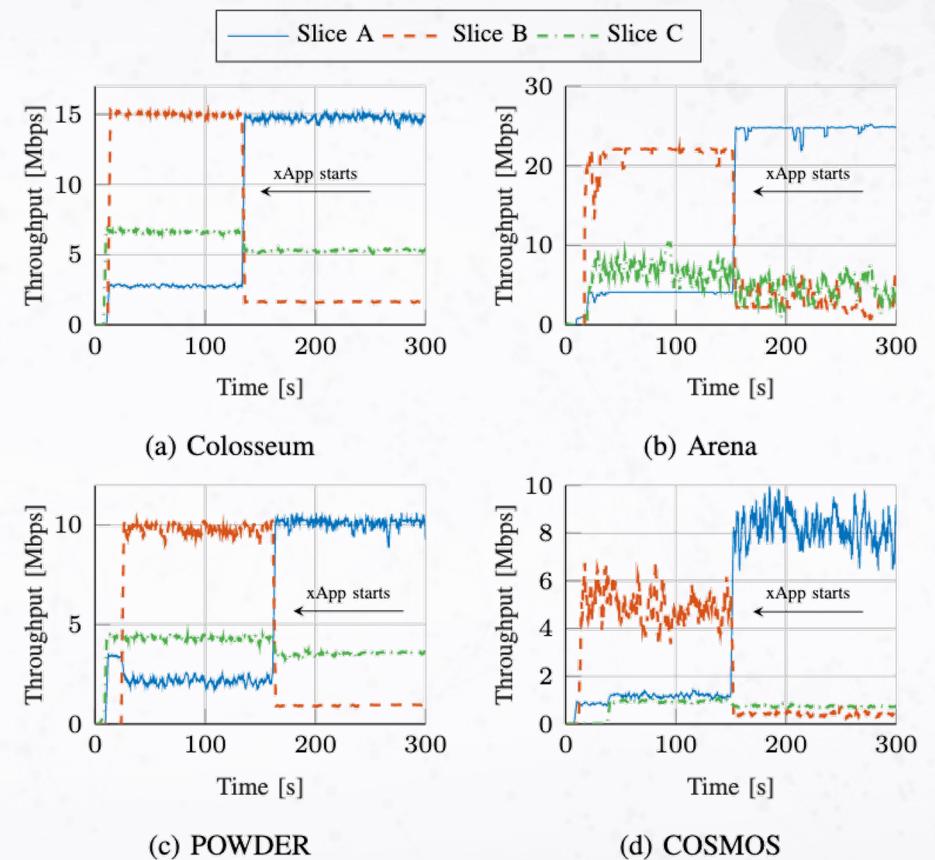


Example: Open RAN Experiment Across Different Testbeds

Periodic change of slicing resources



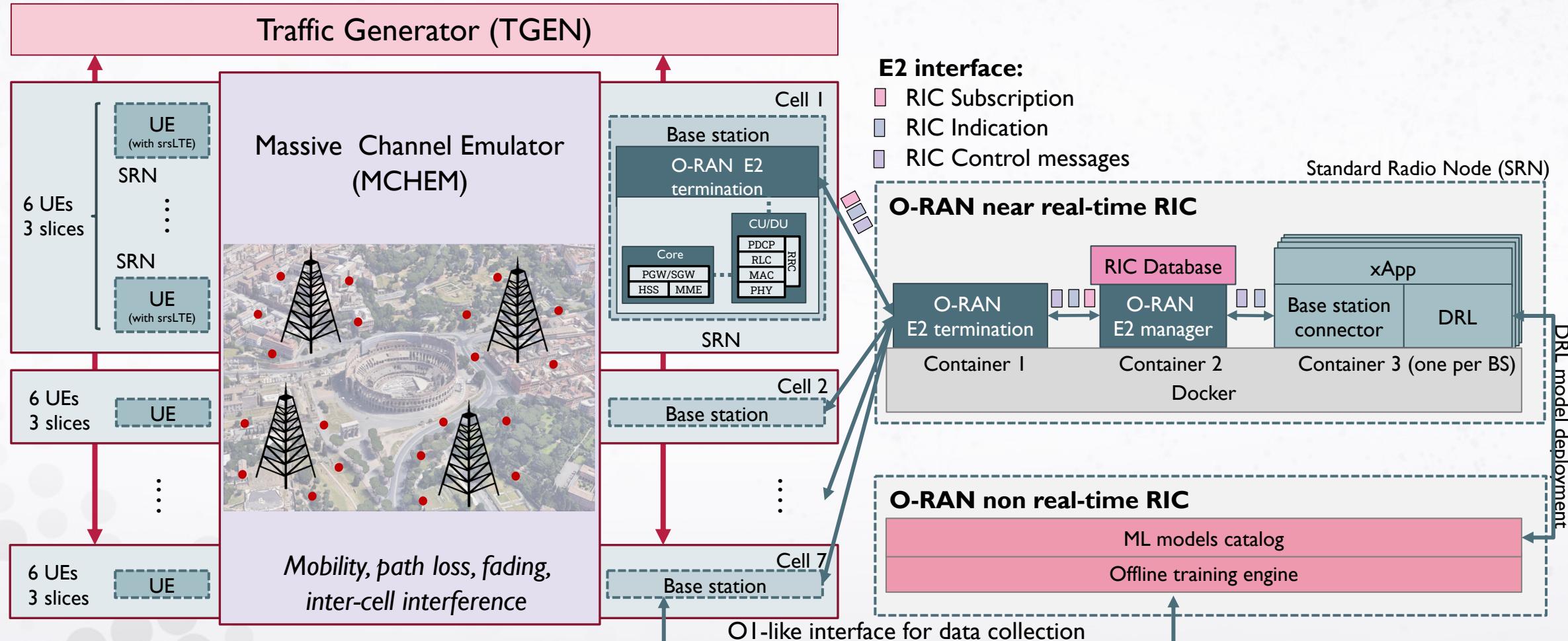
xApp closed-control loop



Results are consistent across **very different platforms** with **heterogeneous environments**

Example OpenRAN Gym deployment – 42 UEs and 7 gNBs

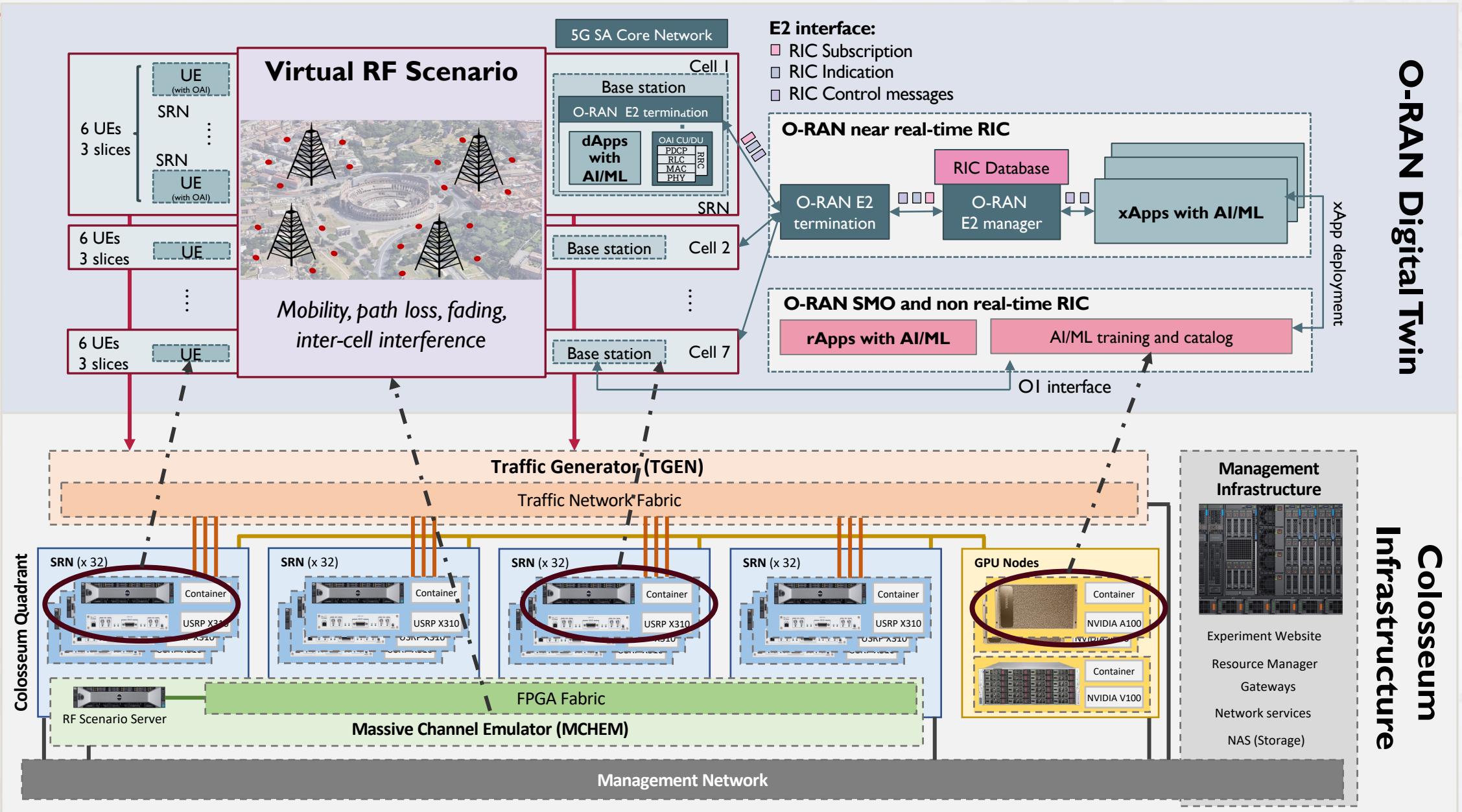
OpenRAN Gym on a large-scale Colosseum deployment – 7 base stations, 42 UEs, 3 slices



Colosseum: The Open RAN Digital Twin

O-RAN Digital Twin

Colosseum Infrastructure



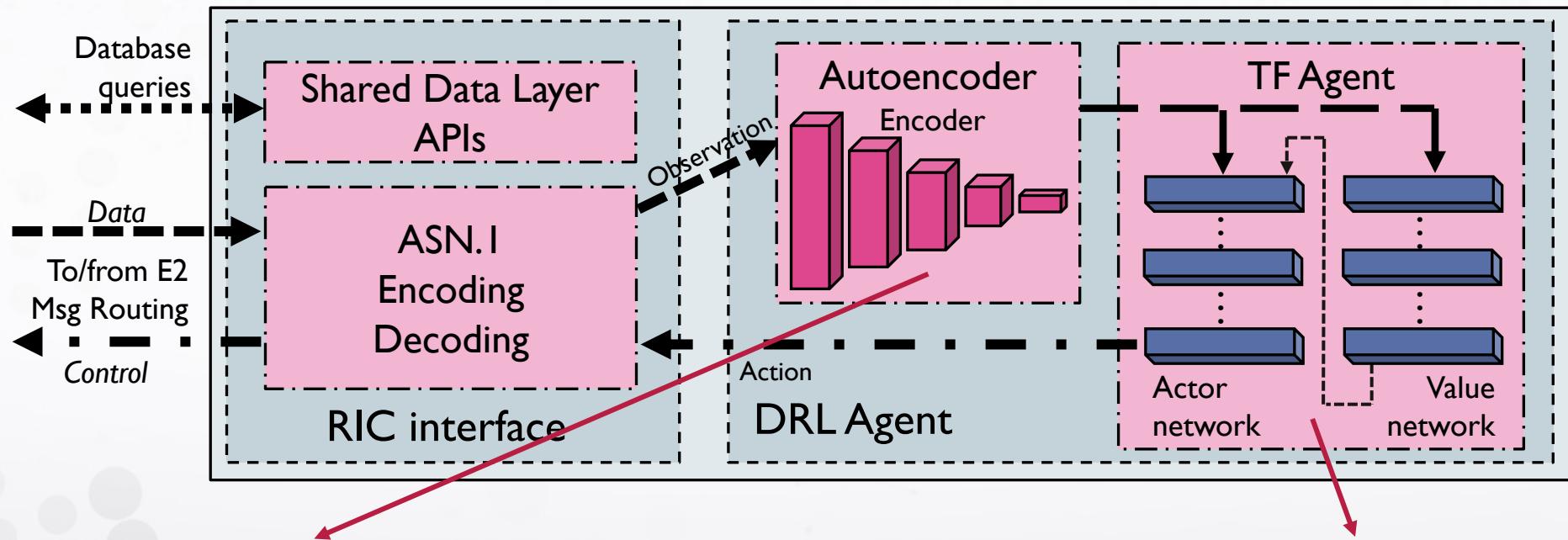
CoO-RAN – ML development and testing for O-RAN



Need algorithms that generalize to different scenarios and conditions



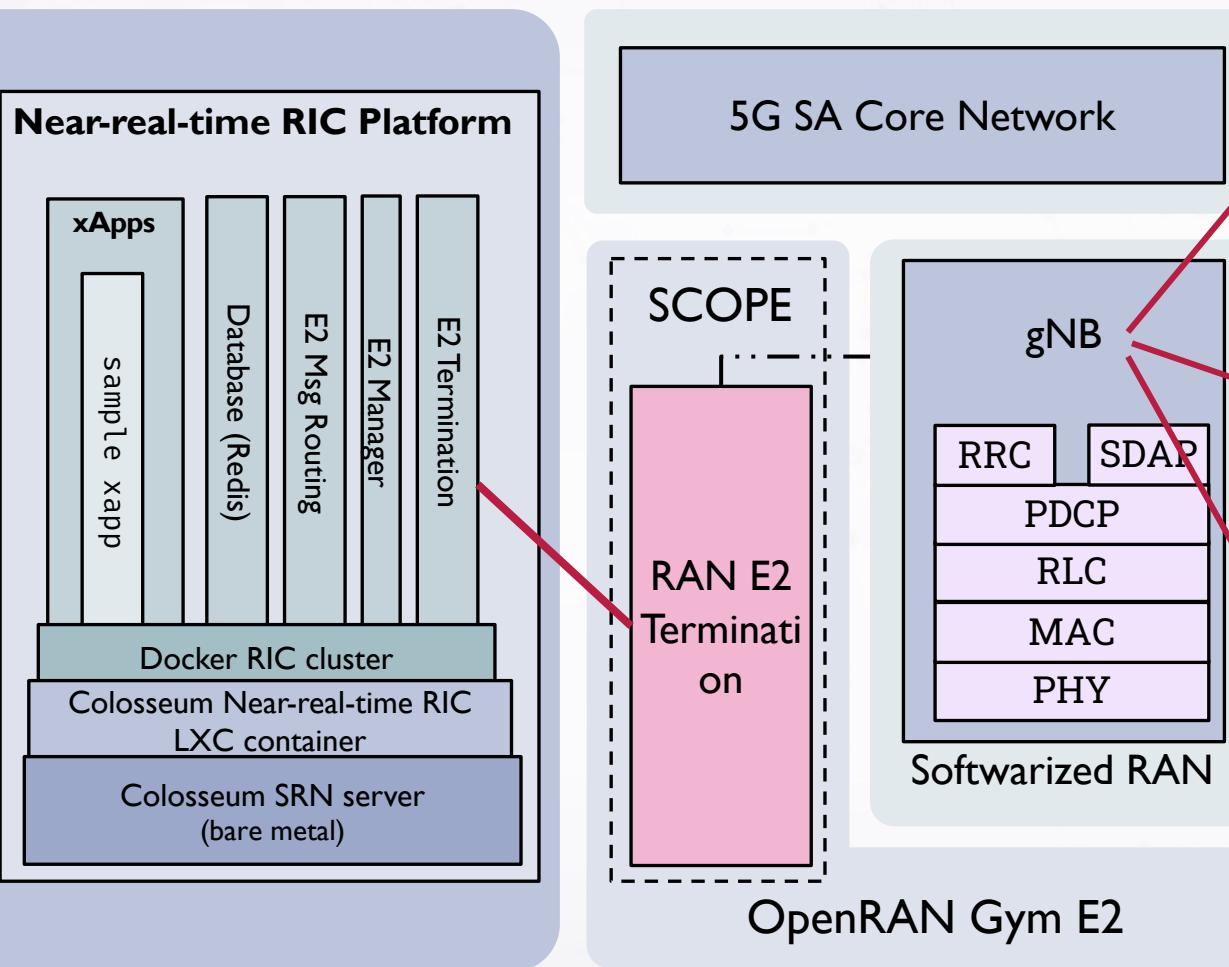
CoO-RAN xApp



Generate a compressed representation of the RAN

Exploit it to generate control actions in the network

E2 interfaces for OpenRAN Gym



The first release supported srsLTE

Support for simulated gNBs in ns-3 (ns-O-RAN)

Support for OAI gNBs

True interoperability!

E2 for srsLTE

E2 for ns-3 (5 gNBs)

E2 for OAI

Same OpenRAN Gym RIC

```
"/> {ezManager},GNB"
[127.0.0.1:6379> KEYS *
 1) "{e2Manager},GNB:313131:00110011000000000000000000000000"
 2) "{e2Manager},RAN:gnb_131_133_31000000"
 3) "{e2Manager},E2TAddresses"
 4) "{e2Manager},GNB:313131:00110010000000000000000000000000"
 5) "{e2Manager},GNB:373437:1011010111000110011101111000"
 6) "{e2Manager},RAN:gnb_131_133_32000000"
 7) "{e2Manager},RAN:gnb_131_133_33000000"
 8) "{e2Manager},GNB:313131:00110101000000000000000000000000"
 9) "{e2Manager},RAN:gnb_311_048_01090901"
10) "{e2Manager},RAN:gnb_734_733_b5c67780"
11) "{e2Manager},E2TInstance:10.0.2.10:38000"
12) "{e2Manager},GNB:13F184:00000001000010010000100100000001"
13) "{e2Manager},RAN:gnb_131_133_35000000"
14) "{e2Manager},RAN:gnb_131_133_34000000"
15) "{e2Manager},GNB:313131:00110100000000000000000000000000"
16) "{e2Manager},GNB:313131:00110010000000000000000000000000"
17) "{e2Manager},GNB"
127.0.0.1:6379> █
```

Based on OSC RIC

OpenRAN Gym – multiple RAN support



Ease of use – provide basic building blocks and end-to-end control connectivity



Support different RANs with the same RIC infrastructure



Adapt a RIC widely adopted by industrial/academic communities (O-RAN Software Community RIC)

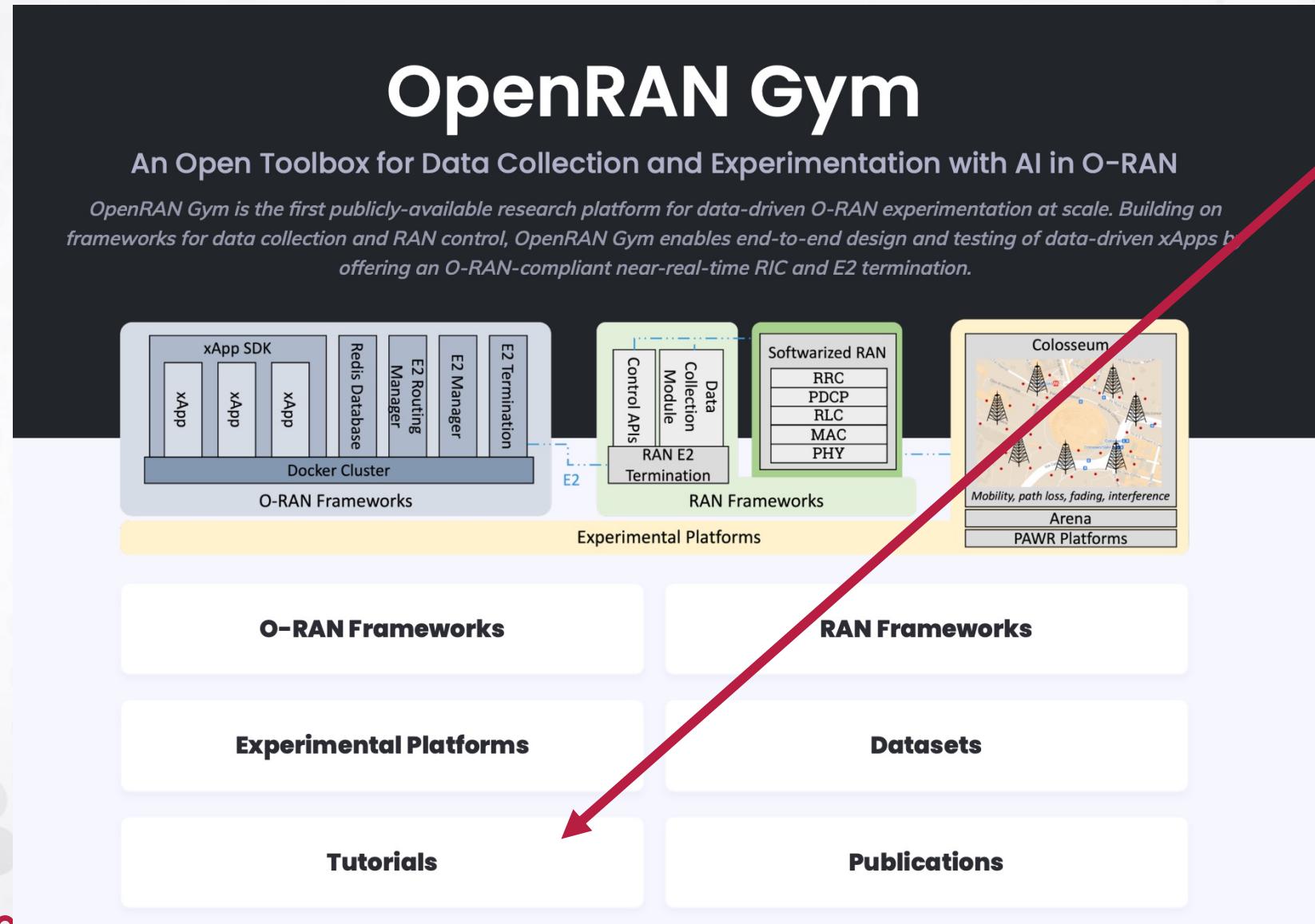


Easily extend for fast prototyping and testing



Pre-packaged for Colosseum (and PAWR platforms)

How to?



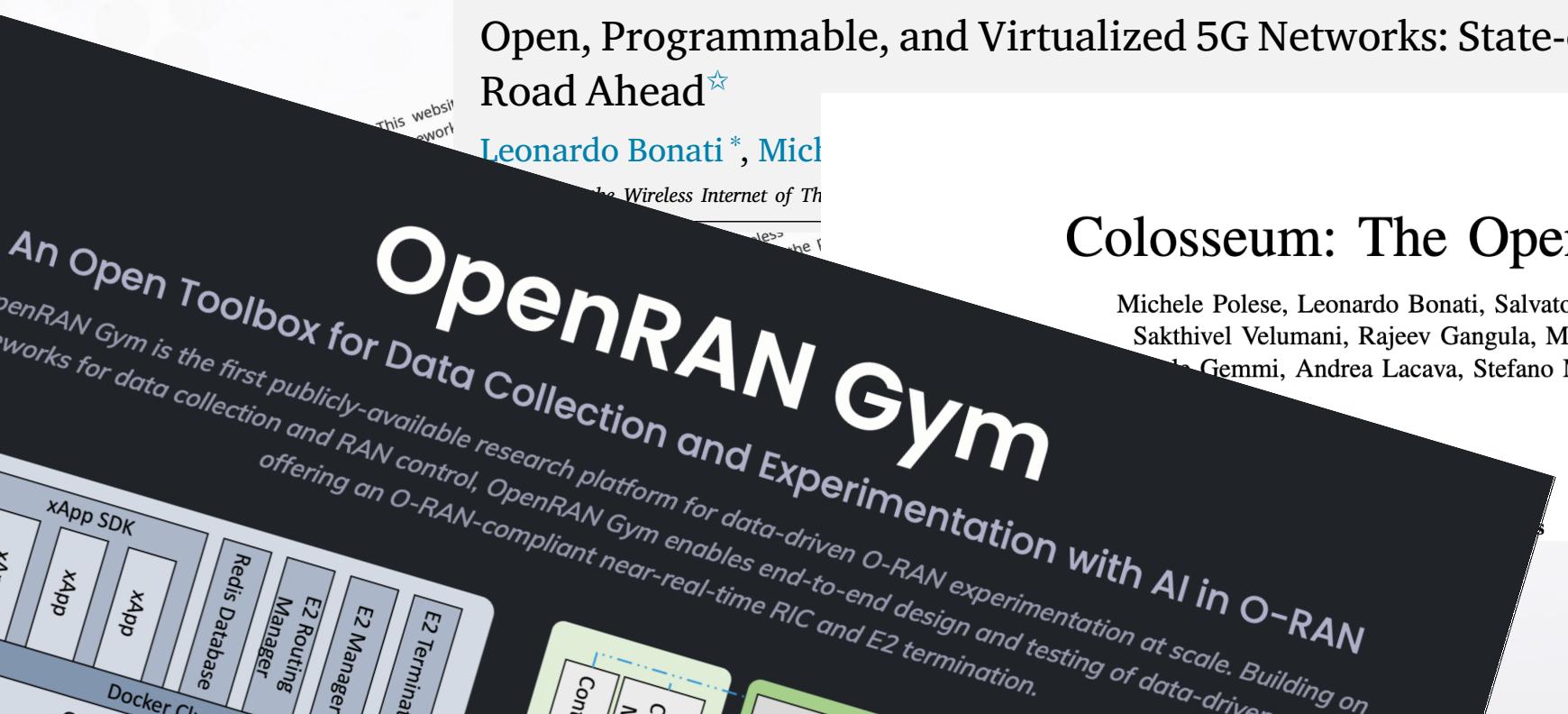
Tutorial section on
openrangym.com

- step-by-step instructions on how to clone, build, execute the different OpenRAN Gym components

Resources on NextG Open-source software

Understanding O-RAN: Architecture, Interfaces, Algorithms, Security, and Research Challenges

Michele Polese, Leonardo Bonati, Salvatore D’Oro, Stefano Basagni, Tommaso Melodia



Colosseum: The Open RAN Digital Twin

Michele Polese, Leonardo Bonati, Salvatore D’Oro, Pedram Johari, Davide Villani, Sakthivel Velumani, Rajeev Gangula, Maria Tsampazi, Clifton Paul P., Gemmi, Andrea Lacava, Stefano Maxenti, Hai Cheng, egram

that can be dynar.
different verticals
paradigm its emb.

Open, Programmable, and Virtualized 5G Networks

A collage of text snippets related to 5G and OpenRAN, including "Consider contrib on Github", "OpenRAN Gym", "Open 5G Forum", and "Architectural Enablers of 5G Cellular".



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Thank You!



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