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Institute for the Wireless Internet of Things
at Northeastern University

OpenRAN Gym
Enabling AI and ML in O-RAN

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Joint work with most of the people you see in the room

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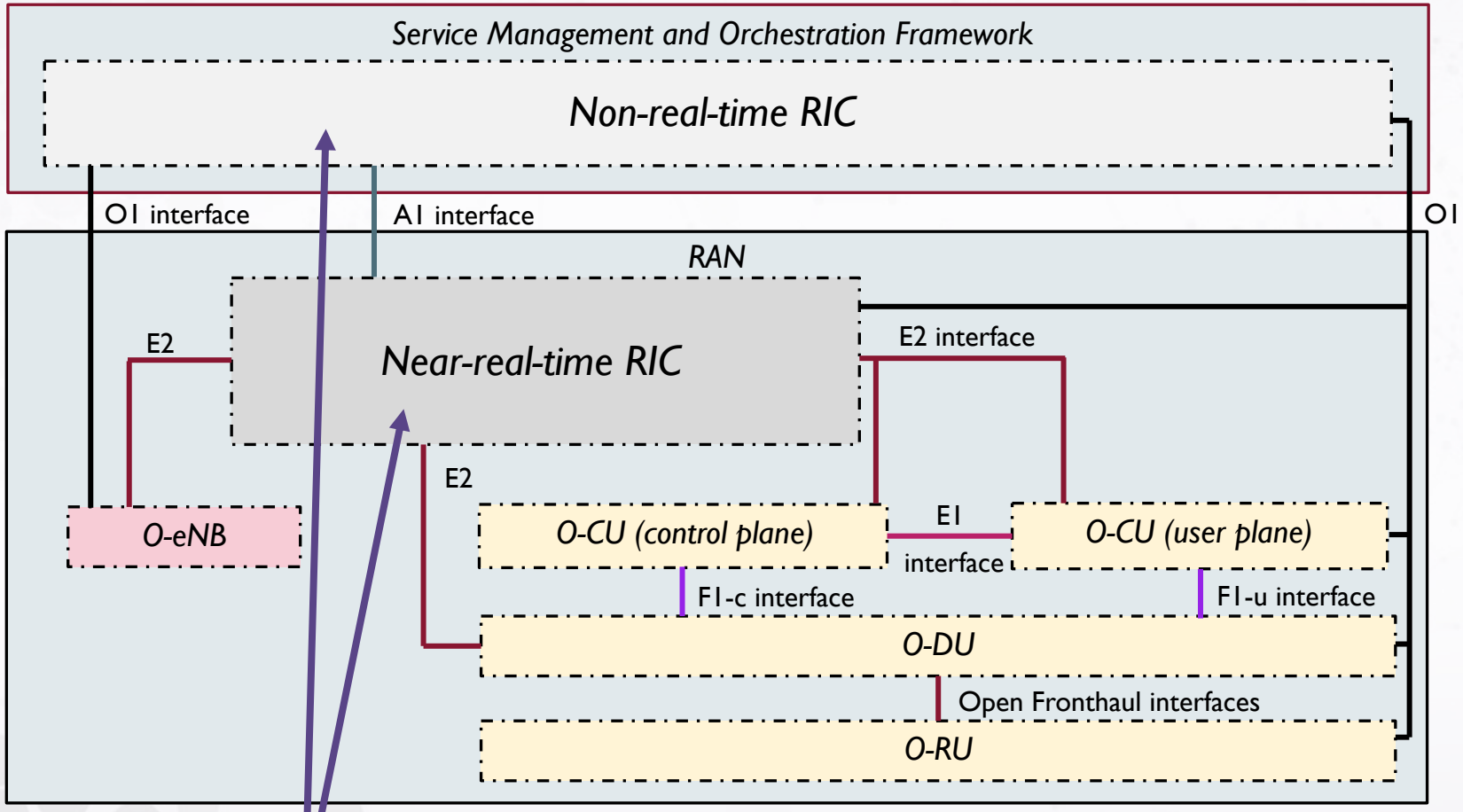
O-RAN - a reference architecture for programmable NextG



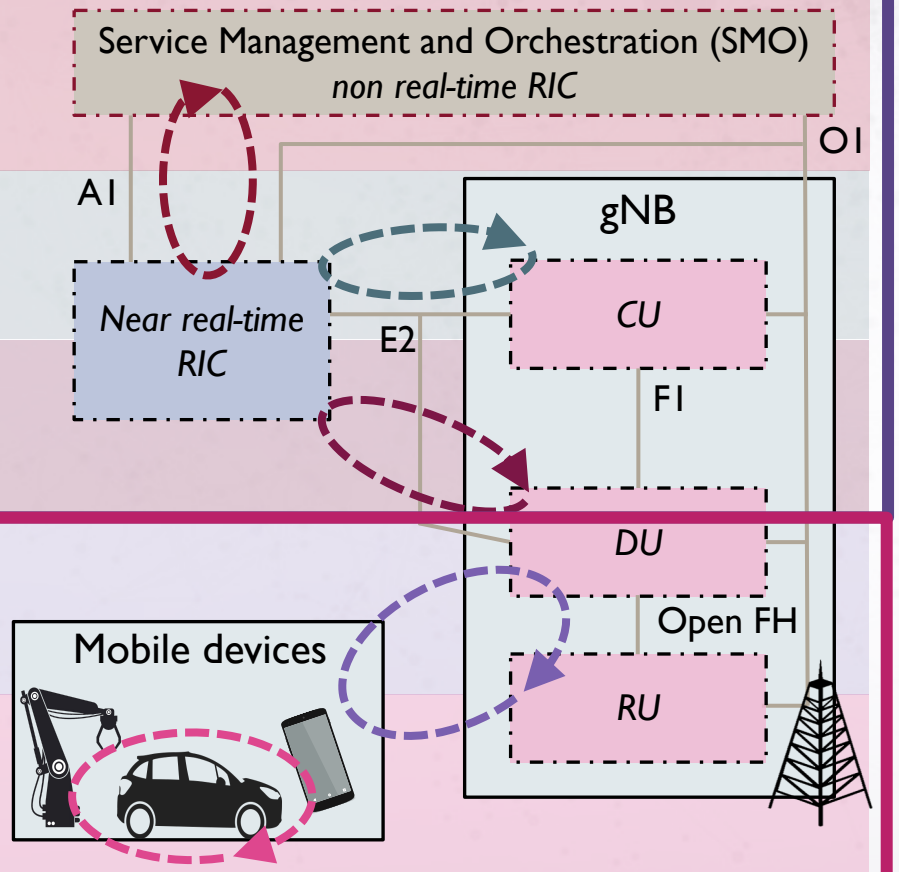
1. Open, standardized interfaces
2. Disaggregated RAN
3. Software
4. RAN Intelligent Controllers

Intelligent Control Loops

Currently supported by O-RAN

Control and learning objective	Scale	Input data	Timescale
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

Architecture



For further study or not supported

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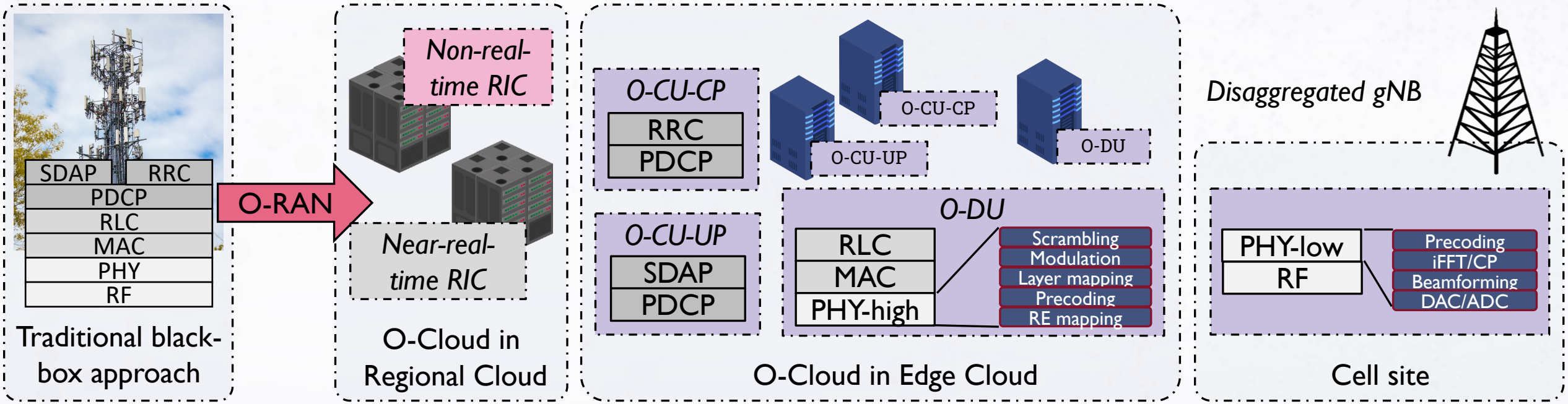
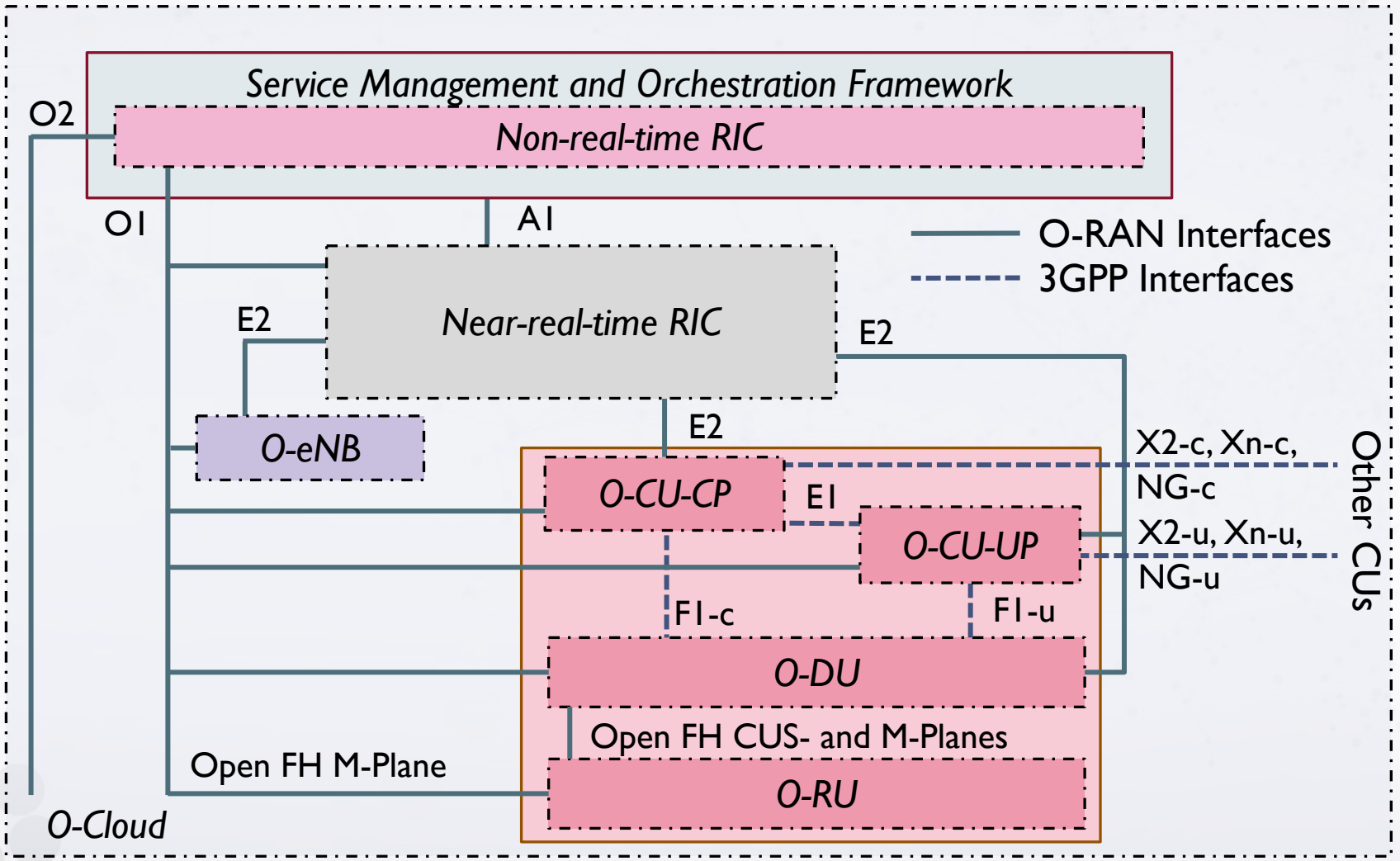
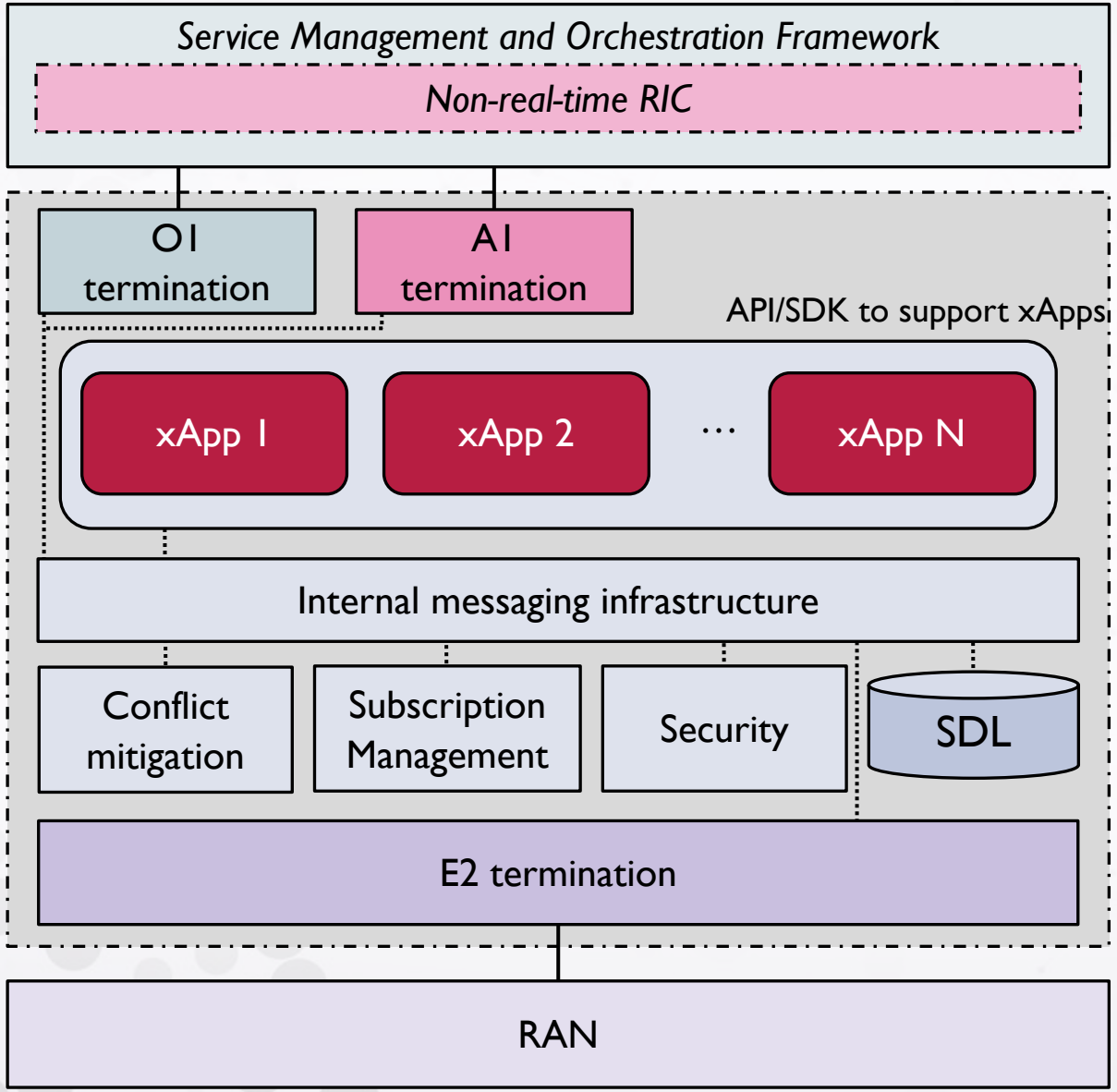
A split architecture



Logical architecture overview

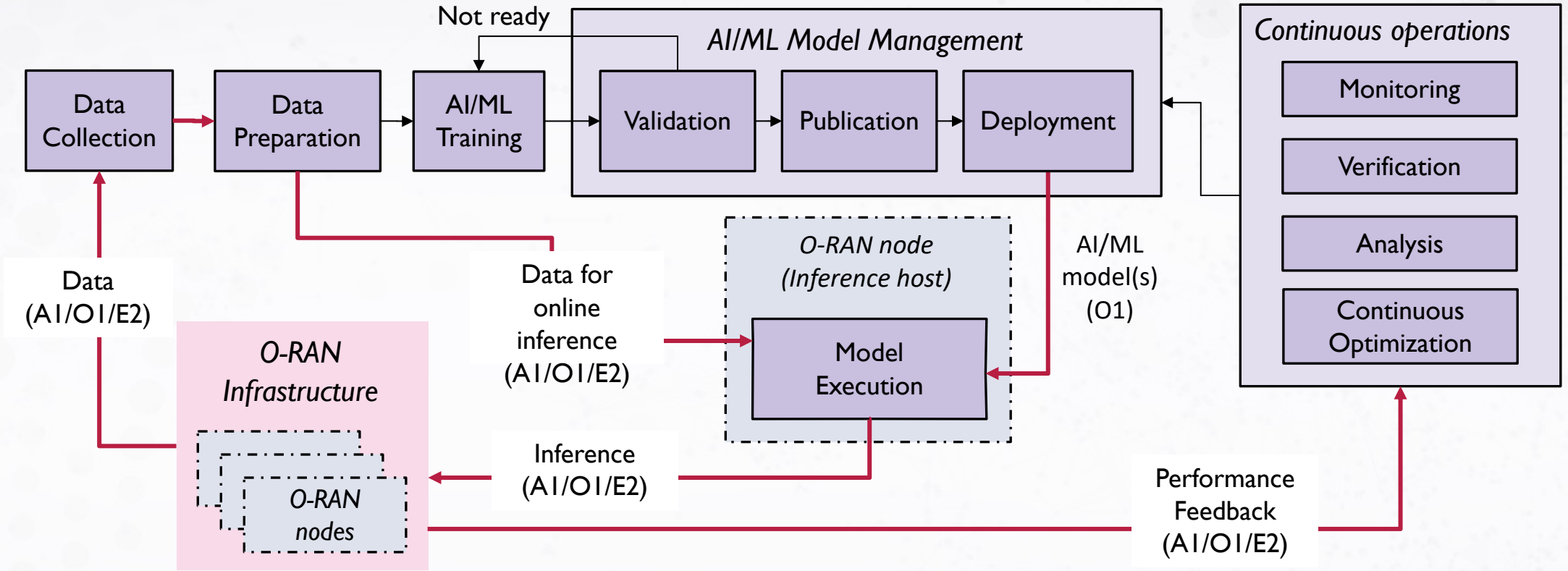


Near-real-time RIC



- Standardized blocks and functionality
- Different implementations

Lifecycle of AI/ML in O-RAN



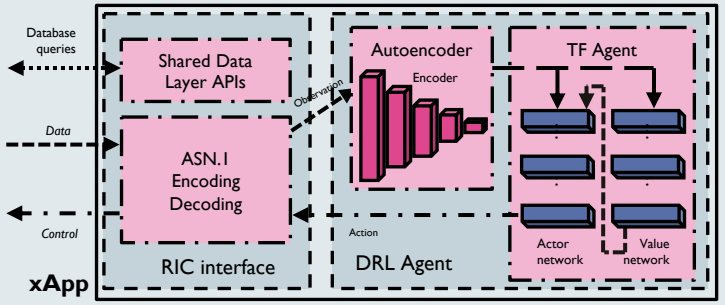
- From **data collection** to **online fine-tuning and inference**
- Covers all aspects of **AIOps:**
  - Monitor
  - Engage
  - Act

The OpenRAN Gym vision

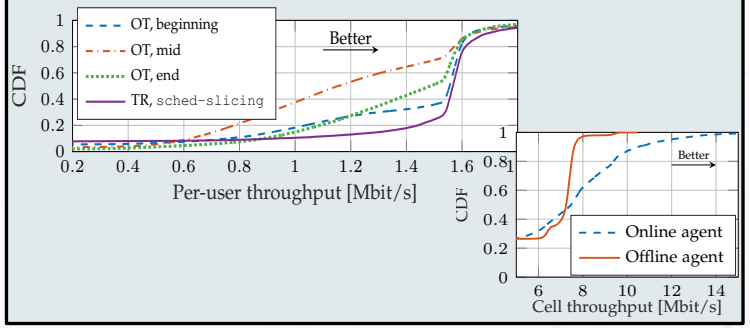
Enable native O-RAN-driven experiments in large-scale experimental testbeds and networks

Collect data at scale on virtual RF scenarios

Design, train, and package AI/ML components as xApps



Test and refine on experimental wireless platforms



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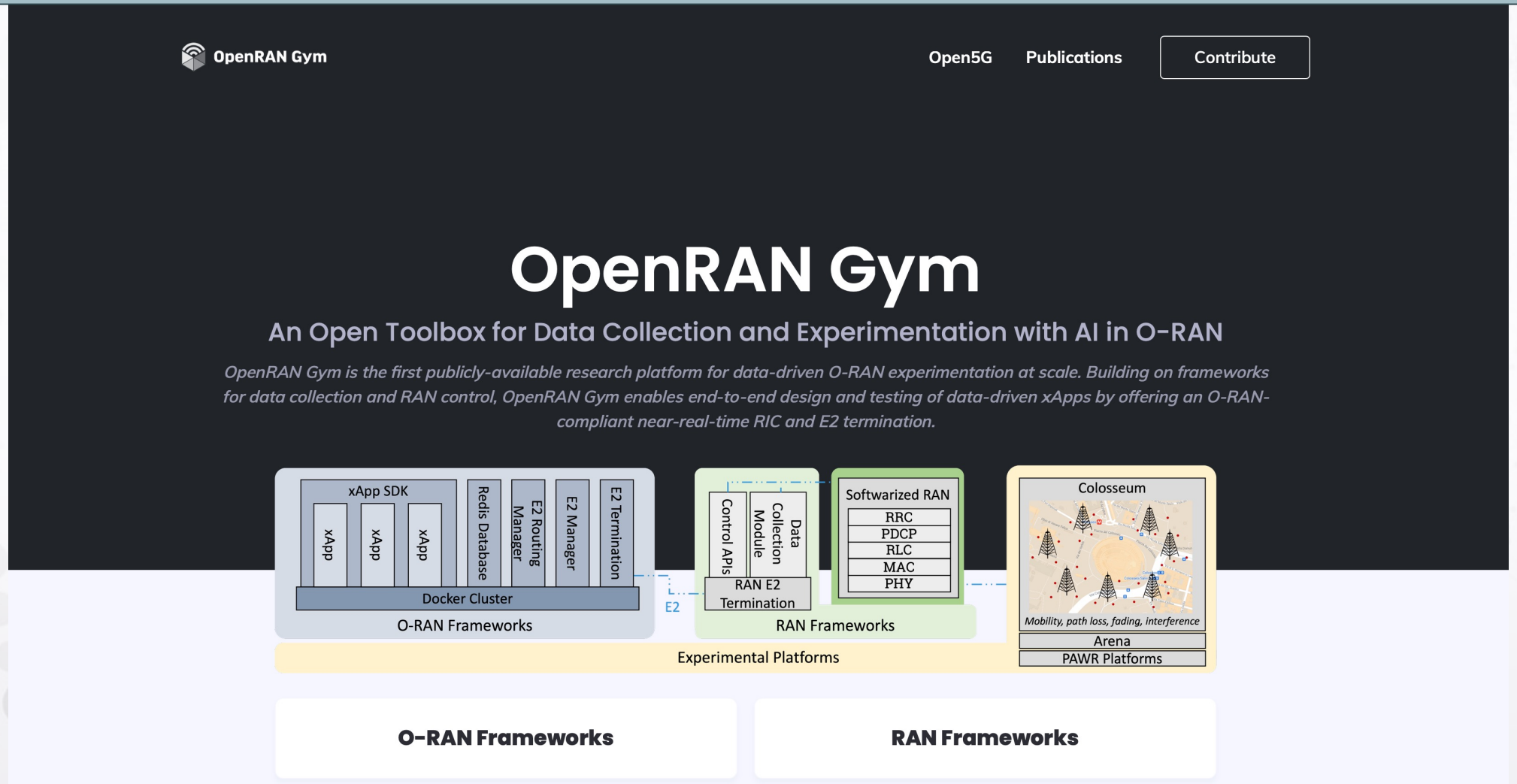
OpenRAN Gym

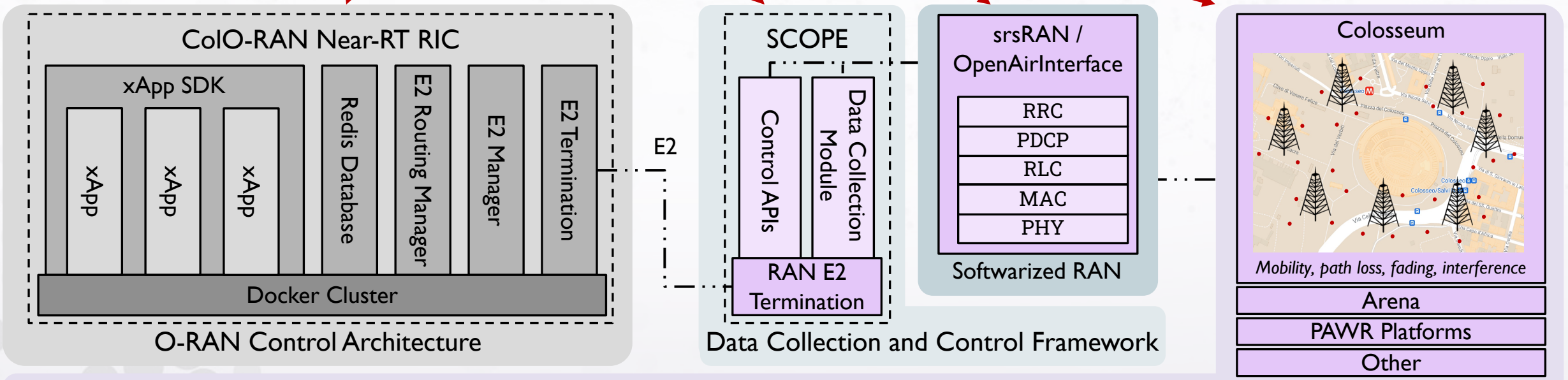
A toolbox for Intelligent O-RAN

www.openrangym.com



OpenRAN Gym – A Toolbox for Intelligent O-RAN

- O-RAN-compliant **near-real-time RIC** running on Colosseum (ColO-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)



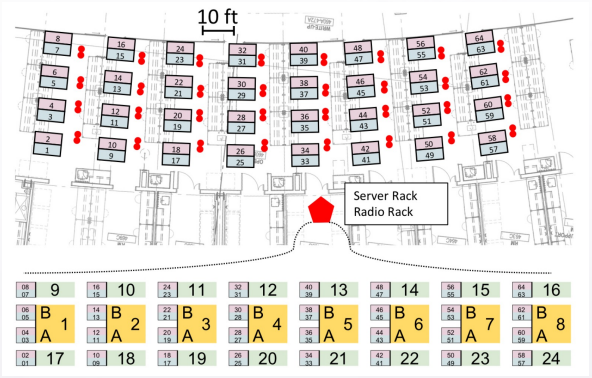
Moving OpenRAN Gym experiments

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

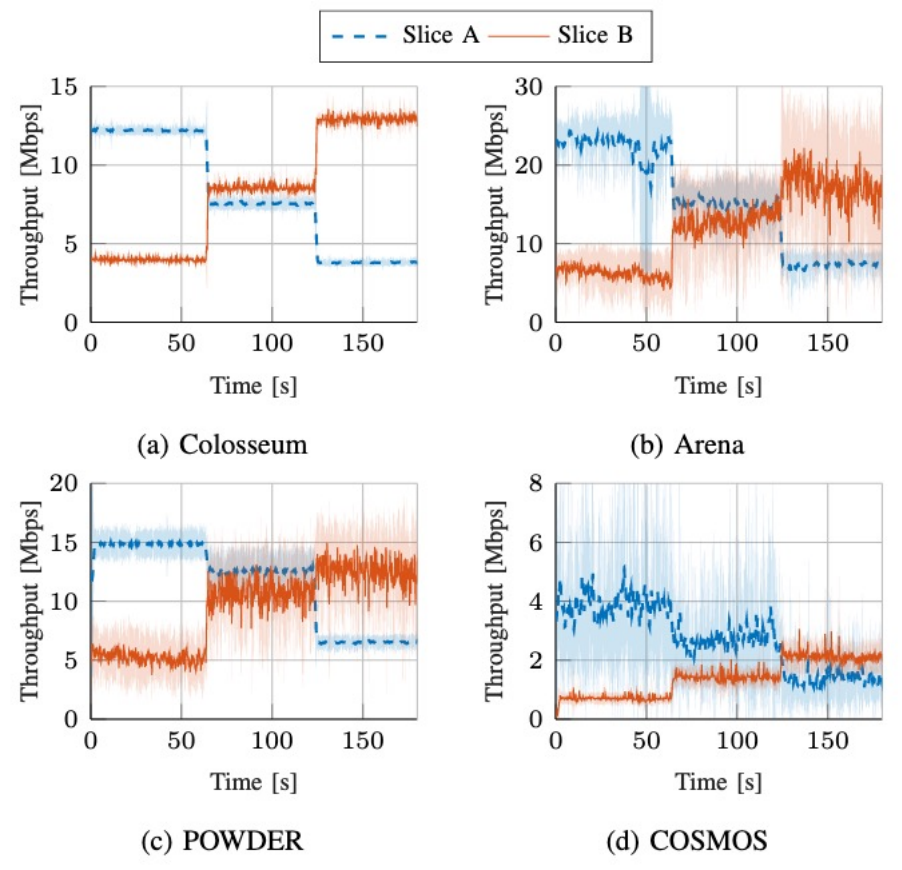
Validate in real wireless environment



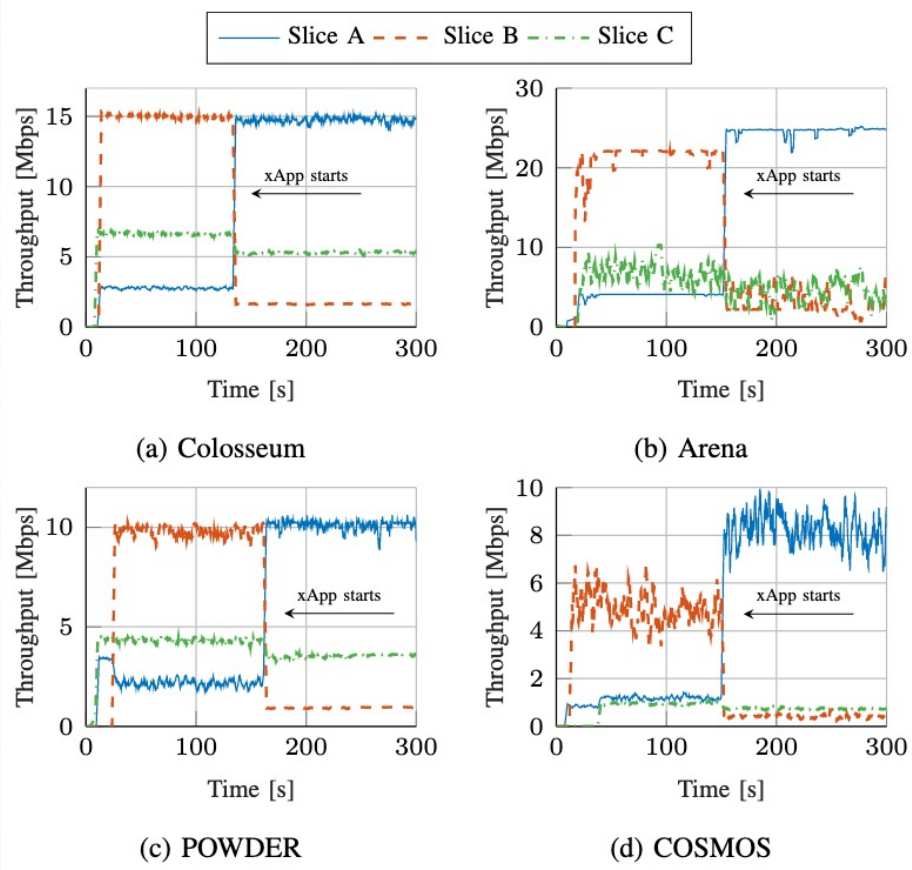
Test large-scale capabilities

Example: Open RAN experiment across different testbeds

Periodic change of slicing resources



xApp closed-control loop

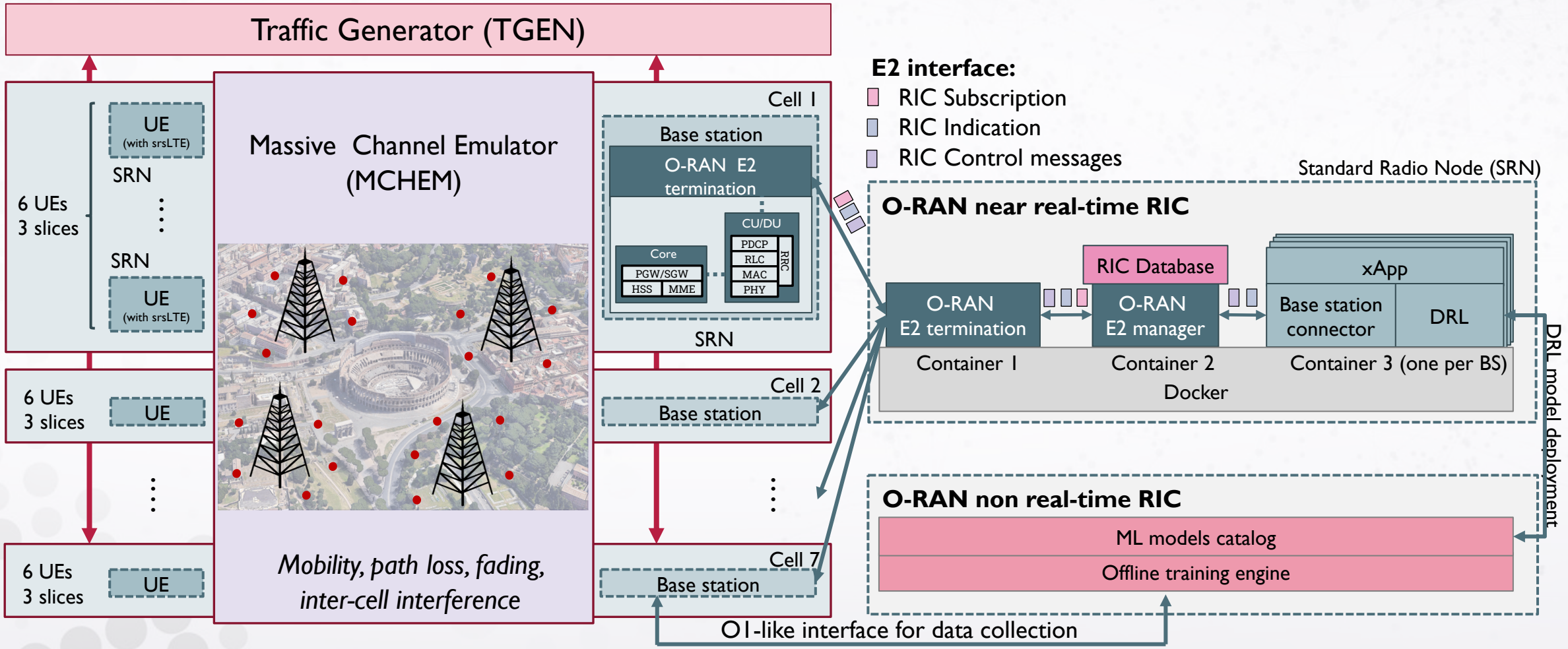


*Results are consistent across **very different platforms** with **heterogeneous environments***

L. Bonati, M. Polese, S. D'Oro, S. Basagni, T. Melodia, "*OpenRAN Gym: AI/ML Development, Data Collection, and Testing for O-RAN on PAWR Platforms*," arXiv:2207.12362 [cs.NI], 2022.

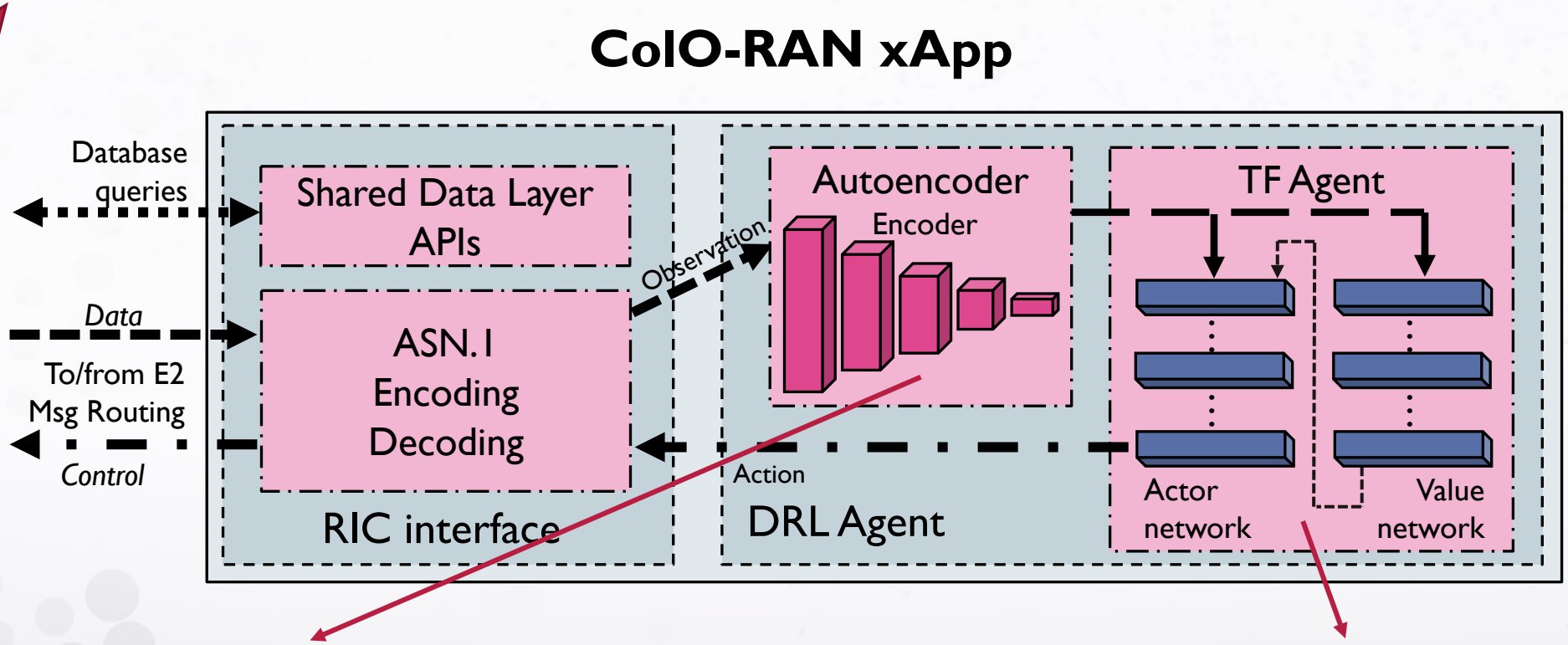
Example OpenRAN Gym deployment – 42 UEs and 7 gNBs

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



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

Need algorithms that generalize to different scenarios and conditions

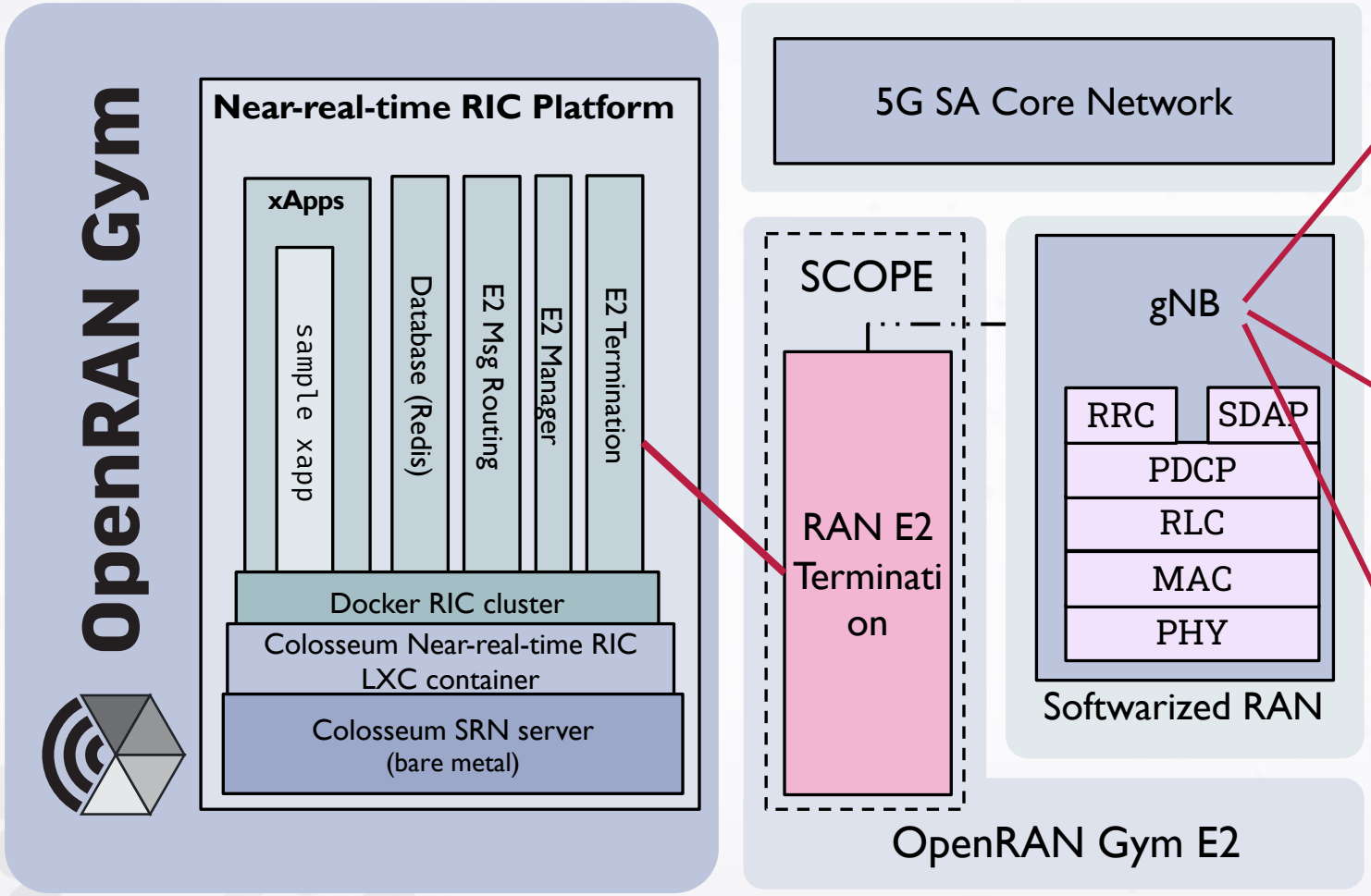


Generate a compressed representation of the RAN

Exploit it to generate control actions in the network

M. Polese, L. Bonati, S. D'Oro, S. Basagni, and T. Melodia, "ColO-RAN: Developing Machine Learning-based xApps for Open RAN Closed-loop Control on Programmable Experimental Platforms", IEEE TMC, to appear

E2 interfaces for OpenRAN Gym



The first release supported srsLTE

New: support for simulated gNBs in ns-3 (ns-O-RAN)

New: support for OAI gNBs

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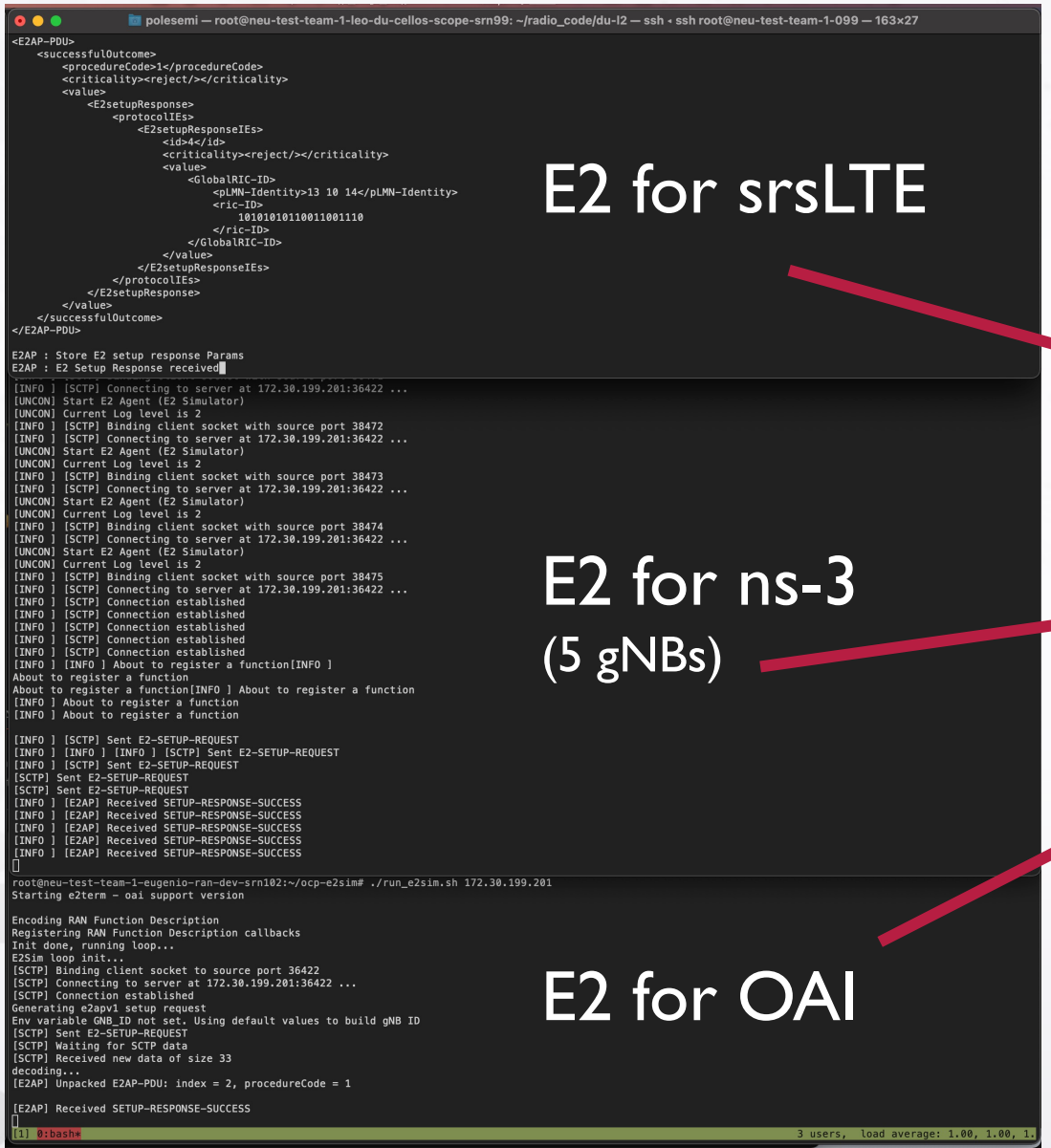
True interoperability!



Same OpenRAN Gym RIC

```
[127.0.0.1:6379> KEYS *
 1) "{e2Manager},GNB:313131:00110011000000000000000000000"
 2) "{e2Manager},RAN:gnb_131_133_31000000"
 3) "{e2Manager},E2TAddresses"
 4) "{e2Manager},GNB:313131:00110001000000000000000000000"
 5) "{e2Manager},GNB:373437:10110101110001100111011111000"
 6) "{e2Manager},RAN:gnb_131_133_32000000"
 7) "{e2Manager},RAN:gnb_131_133_33000000"
 8) "{e2Manager},GNB:313131:00110101000000000000000000000"
 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:13F184:000000010000100100001001000000001"
13) "{e2Manager},RAN:gnb_131_133_35000000"
14) "{e2Manager},RAN:gnb_131_133_34000000"
15) "{e2Manager},GNB:313131:00110100000000000000000000000"
16) "{e2Manager},GNB:313131:00110010000000000000000000000"
17) "{e2Manager},GNB"
127.0.0.1:6379>
```

Based on OSC RIC

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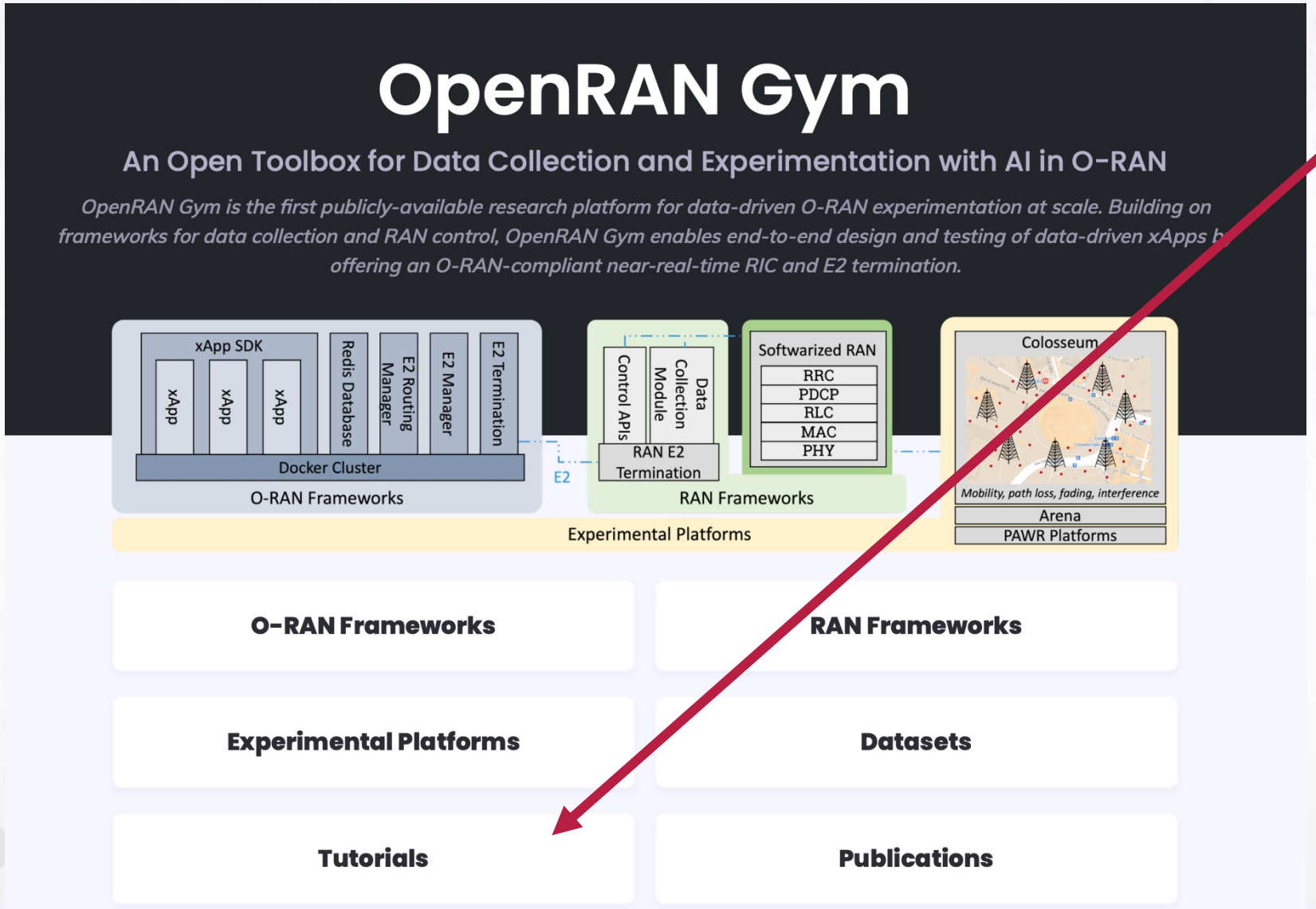
OpenRAN Gym – multiple RAN support

- 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?



New tutorial section on openrangym.com

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

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or wait for the hands-on after lunch ;)

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

Survey paper

Open, Programmable, and Virtualized 5G Networks: State-of-the-Art and the Road Ahead☆

Bonati *, Michele Polese, Salvatore D'Oro, Stefano Basagni, Tommaso Melodia

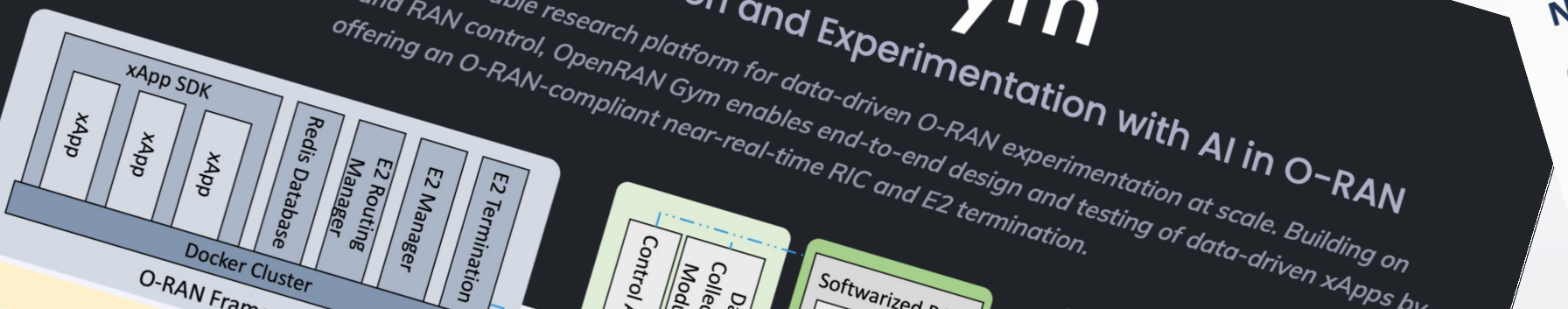
Things, Northeastern University, Boston, MA 02115, USA

Check for updates

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.



Open, Programmable, and Virtualized 5G Networks

Consider contributing to this open list on Github

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Open 5G Forum
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Wireless

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