IEEE

IEEE Future Networks

IEEE Future Networks Webinar - 16 March 2022 - 11:00 am

Open RAN: Challenges and Opportunites for Future Wireless Networks

Register today: **bit.ly/FNIWebinarMar22**

Michele Polese, Northeastern Univ.
Brian Daly, AT&T
Ashutosh Dutta, JHU/APL
Manish Singh, Meta

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Institute for the Wireless Internet of Things
at Northeastern University

Intelligent networks with Open RAN
Challenges and opportunities

Michele Polese

Institute for the Wireless Internet of Things

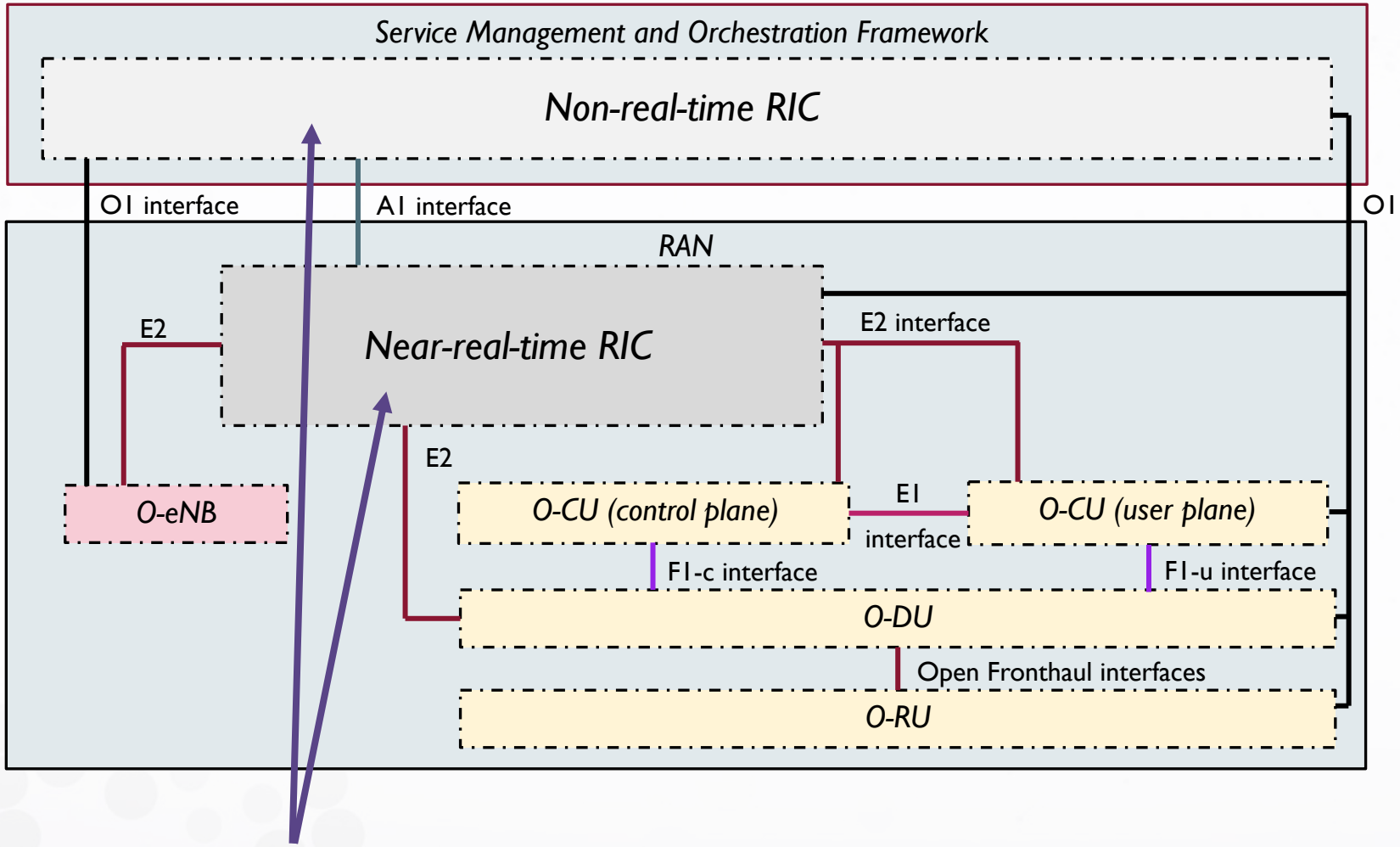
Northeastern University

m.polese@northeastern.edu

with Leonardo Bonati, Salvatore D'Oro, Stefano Basagni, Tommaso Melodia

Partially supported by NSF Grants CNS-1925601, CNS-2120447, and CNS-2112471 and ONR Grant N00014-20-1-2132

O-RAN - a reference architecture for programmable NextG



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

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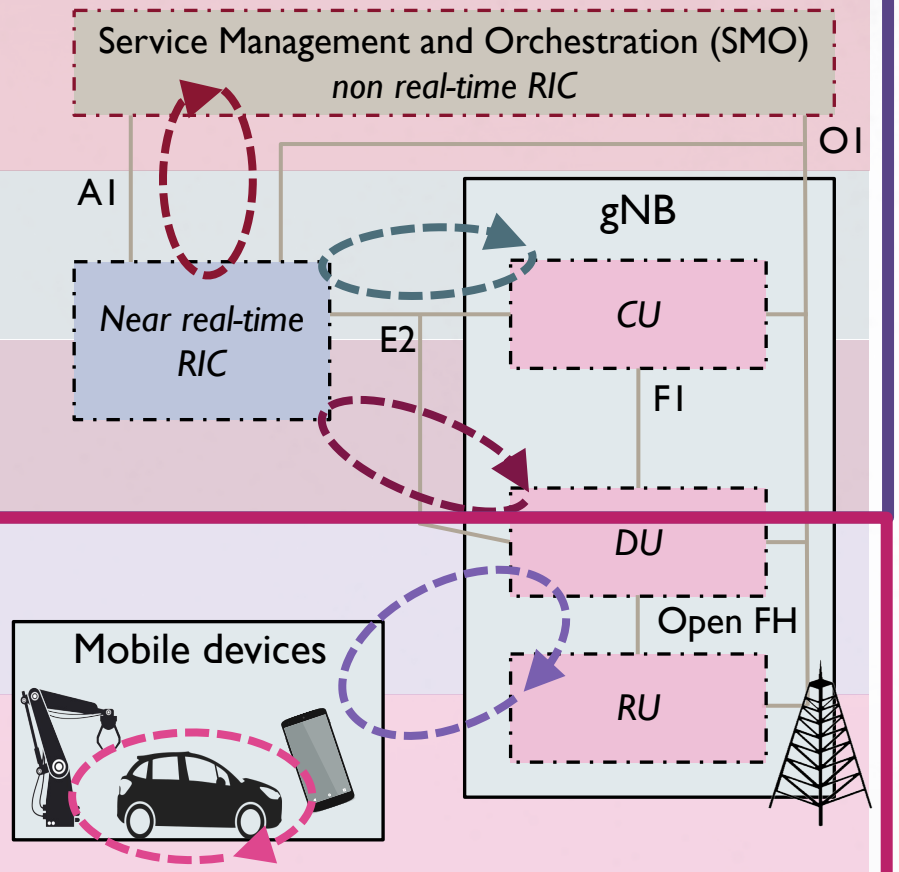
Intelligent Control Loops

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



For further study or not supported

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Open Challenges toward Intelligent Open RAN

Need large-scale heterogeneous datasets

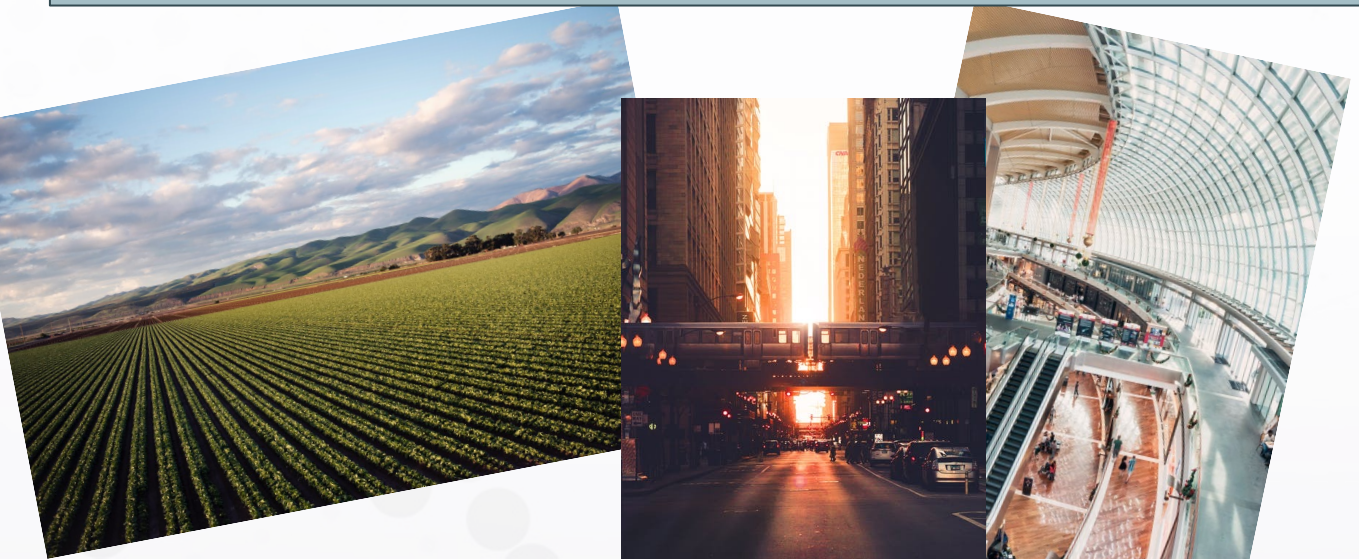
Need testing of closed-loop control without compromising network performance

Need algorithms that generalize to different scenarios and conditions

Experimental platforms for wireless AI

Need large-scale heterogeneous datasets

*PAWR platforms and Colosseum can be used to collect **datasets** at scale*



Tools are available for large-scale data collection in cellular networks: SCOPE platform
https://github.com/wineslab/colosseum-scope

https://advancedwireless.org
https://northeastern.edu/colosseum/

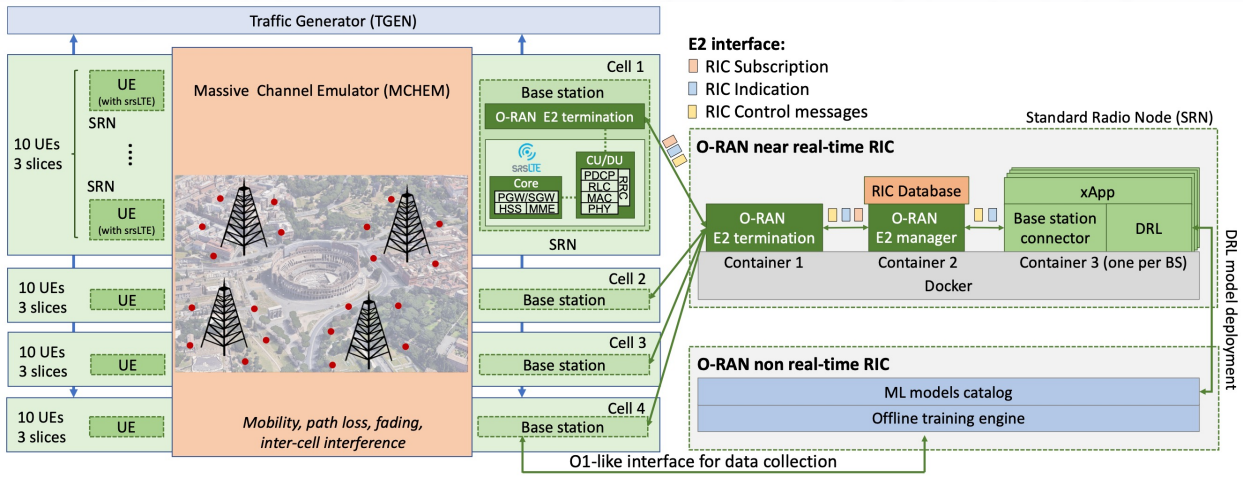
Open Challenges

Need testing of closed-loop control without compromising network performance

Need algorithms that generalize to different scenarios and conditions

OpenRAN Gym

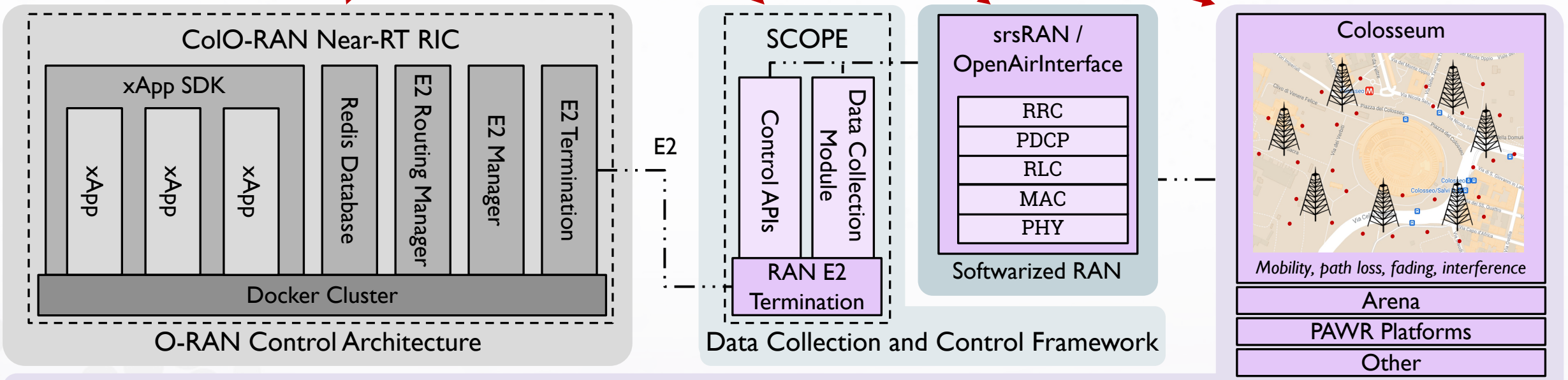
www.openrangym.com



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

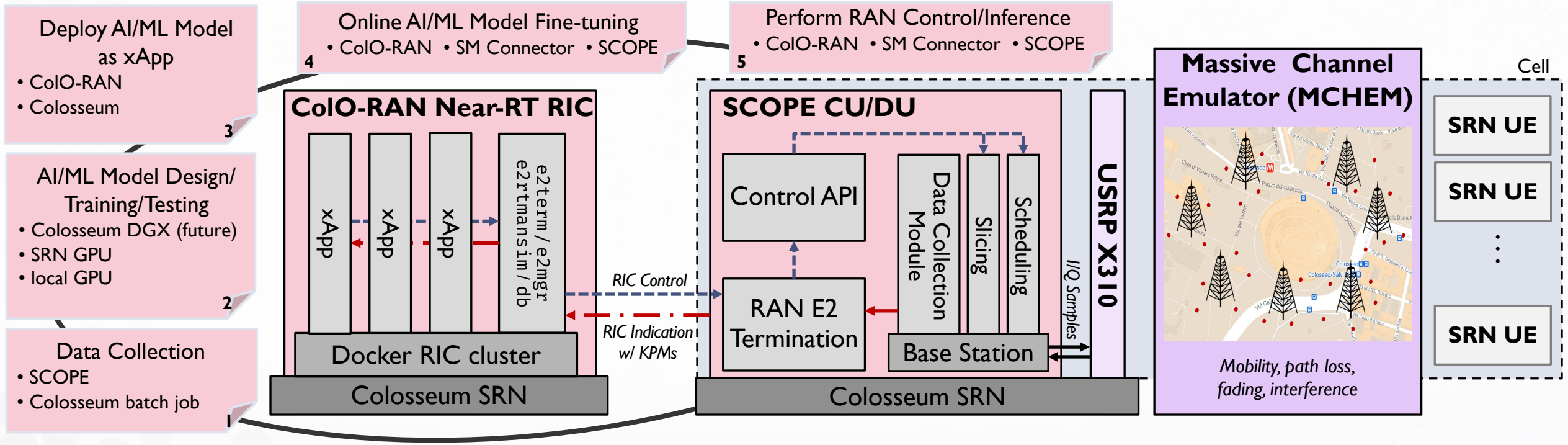
OpenRAN Gym – A Toolbox for Intelligent O-RAN

- 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** protocol stacks (based on srsRAN at this time)
- Publicly-accessible **experimental platforms** (e.g., Colosseum, Arena, PAWR platforms)



OpenRAN Gym workflow

End-to-end flow for Open RAN AI/ML development

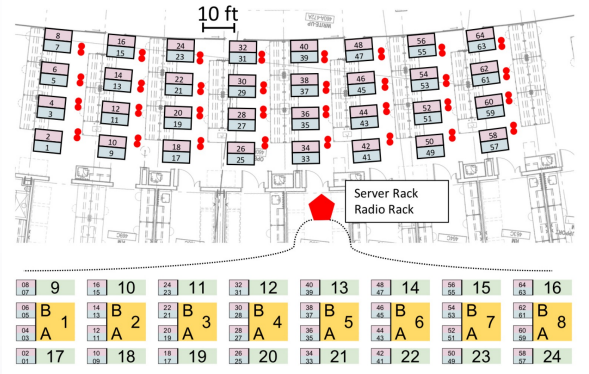


Traveling Container: Prototype At-scale, Test in the Wild

- Develop application once as a container
- Prototype, test and fine-tune safely on Colosseum
- When satisfied, "move" container to different testbed
- Validate in real environment (e.g., Arena)
- Test large-scale capabilities on city-scale platforms (e.g., PAWR platforms)

Test at-a-scale on emulated scenarios

Validate in real wireless environment

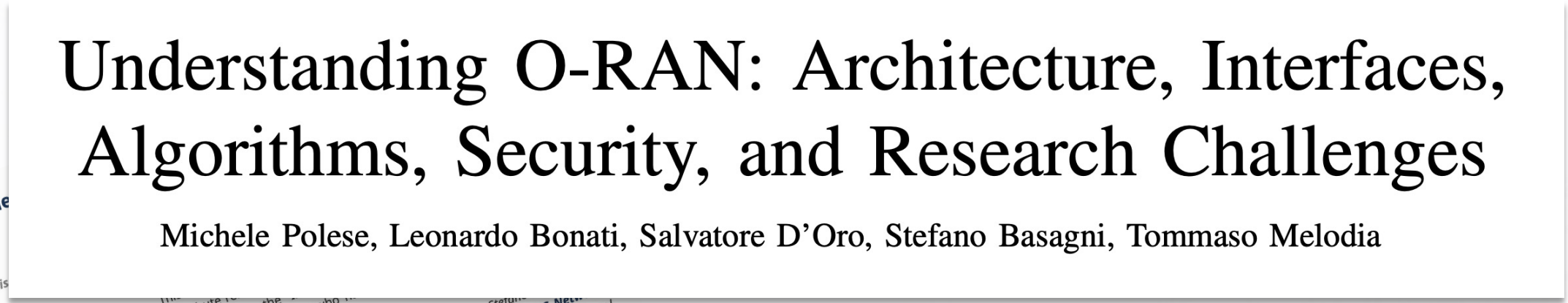


Arena

Test large-scale capabilities

Resources on NextG open source software

Open 5G Forum – slides and videos online: open5g.info/open-5g-forum
(supported by ACM SIGMOBILE)



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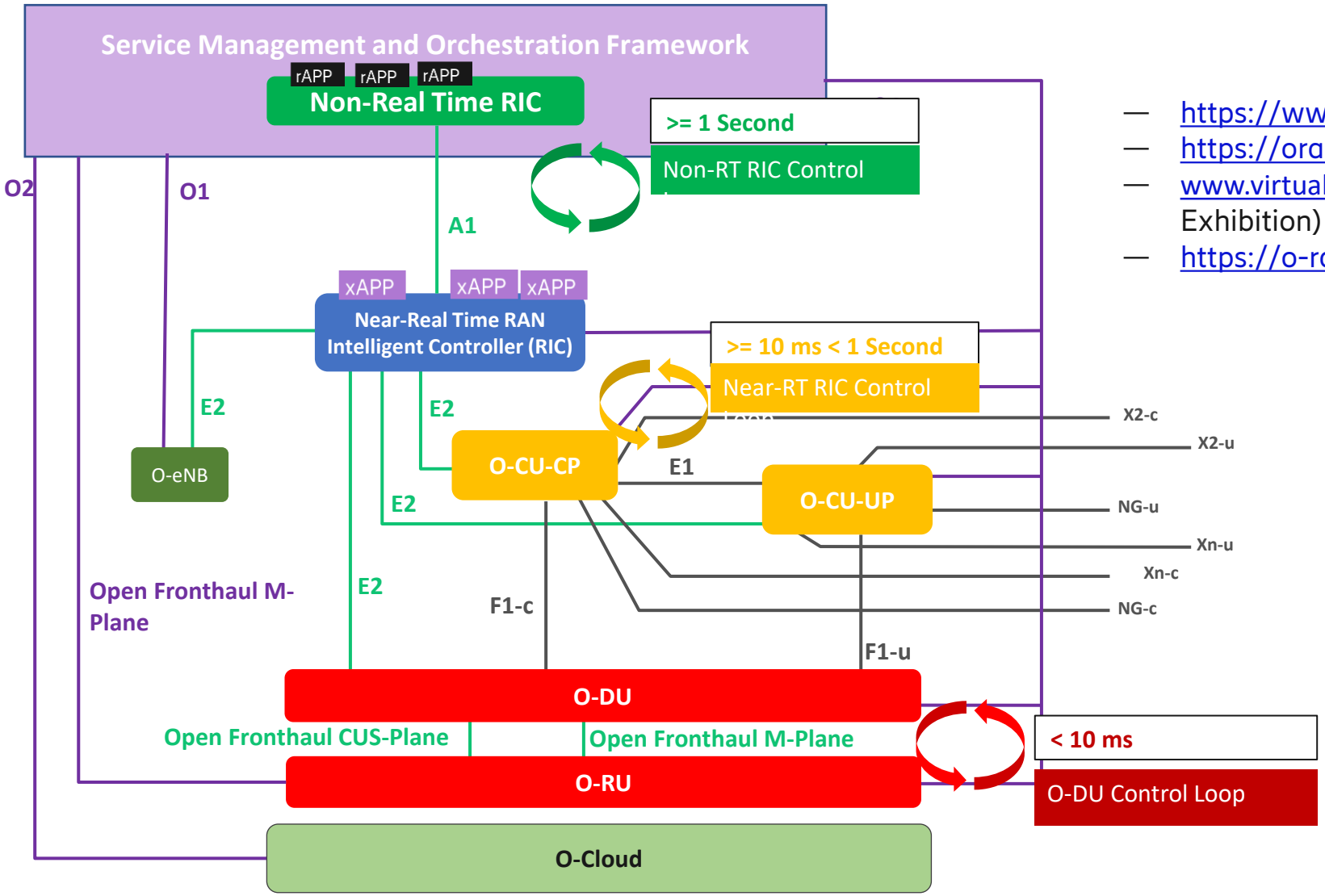
Open RAN Update

Brian K. Daly
AT&T
AT&T Fellow | AVP Standards & Industry Alliances
Network Chief Technology Office

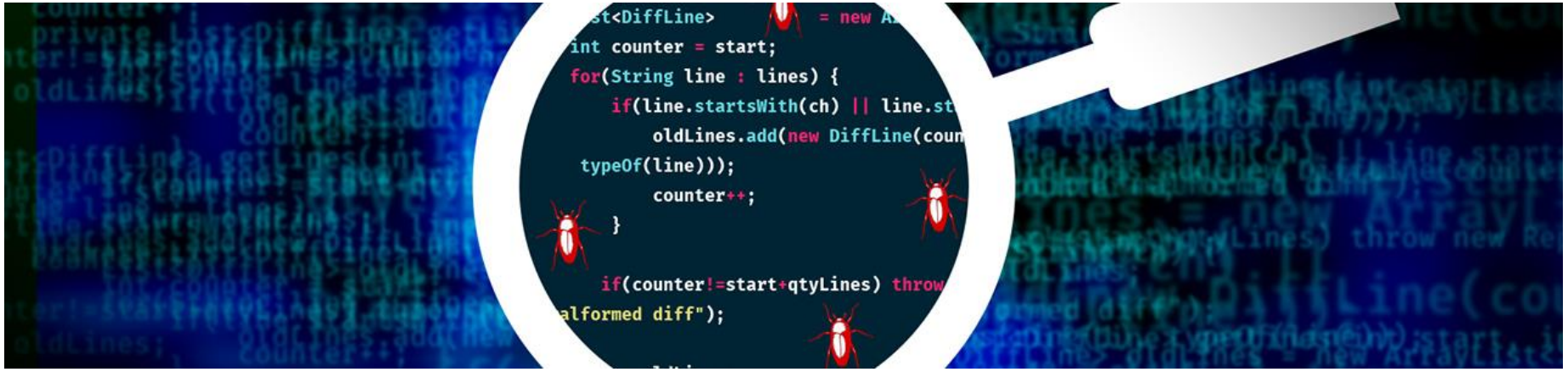
Open RAN Architecture (O-RAN)



- https://www.o-ran.org/ (O-RAN Website)
- https://oranalliance.atlassian.net (O-RAN WIKI)
- www.virtualexhibition.o-ran.org (O-RAN Virtual Exhibition)
- https://o-ran-sc.org/ (O-RAN Software Community)

O-RAN Software Community

- The O-RAN Software Community delivers 5th open-source software release – release E.
- Includes support for:
  - Traffic Steering use case
  - Basic RAN slicing feature
  - Closed-loop slice SLA assurance
  - Improved features and E2E integration of O-RAN architecture components



Plans to Deploy Open RAN

The Radios we are currently buying are software upgradeable to support new Open interfaces

Our vRAN plans include support for Open Interfaces

Currently pursuing Open RAN management options based (based on O-RAN SMO Framework)

Part of our challenge is the interoperability with existing deployments of 4G and 5G macro networks

Expect to see Open Interfaces deployed in enterprise and indoor locations first

Industry Connections (IC)
IEEE SA STANDARDS ASSOCIATION

IEEE Open RAN Industry Connections Activity

Ashutosh Dutta, Ph.D.

Co-Chair, IEEE Future Networks Initiative

Chair of IEEE SA Open RAN Industry Connections Activity

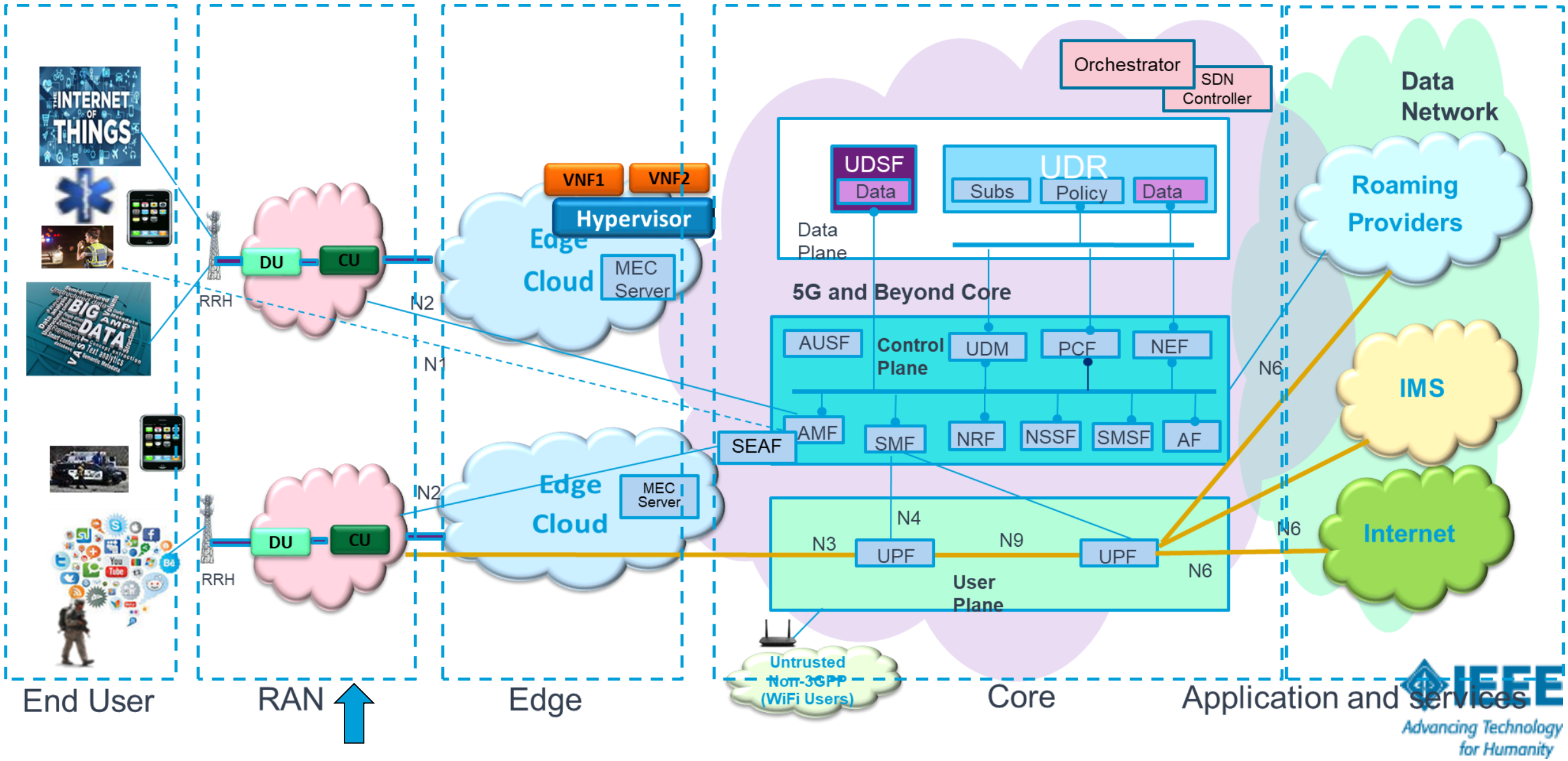
Johns Hopkins University Applied Physics Lab (JHU/APL)

IEEE Fellow

Email: ashutosh.dutta@ieee.org; Ashutosh.Dutta@jhuapl.edu

Tuesday, 30 November 2021 | Virtual

5G End-to-End System Model



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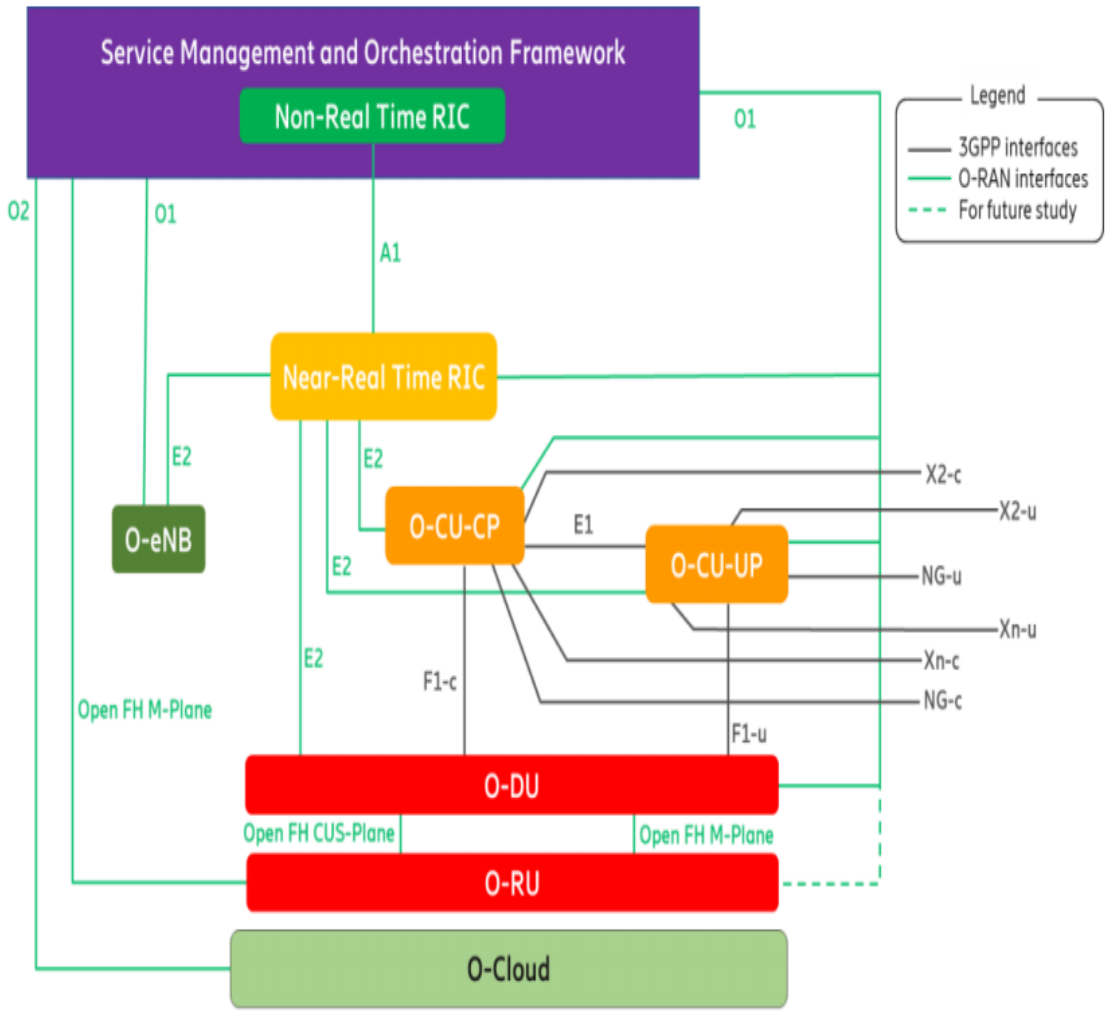
Current Open RAN Related Efforts

- O-RAN Alliance (www.o-ran.org)
- 3GPP (www.3gpp.org)
- IEEE Future Networks Initiative Roadmap Activities
  - futurenetworks.ieee.org/roadmap
- IEEE Standards Association Open RAN Industry Connection
- ATIS Next G Alliance (https://nextgalliance.org/)
- TIP (Telecom Infra Project) by Facebook
- Open RAN Policy Consortium
- Others

ORAN Overview



Reference: 3GPP TS 38.401: NG-RAN; Architecture description

The Open RAN Architecture is designed to enable next generation RAN (Radio Access Network) infrastructures.

It is designed with the principles of intelligence, virtualization, and disaggregation.

In an Open RAN environment, the traditional gNB or eNB (base station) is disaggregated into three main building blocks:

- Radio Unit (RU)
- Distributed Unit (DU)
- Centralized Unit (CU)

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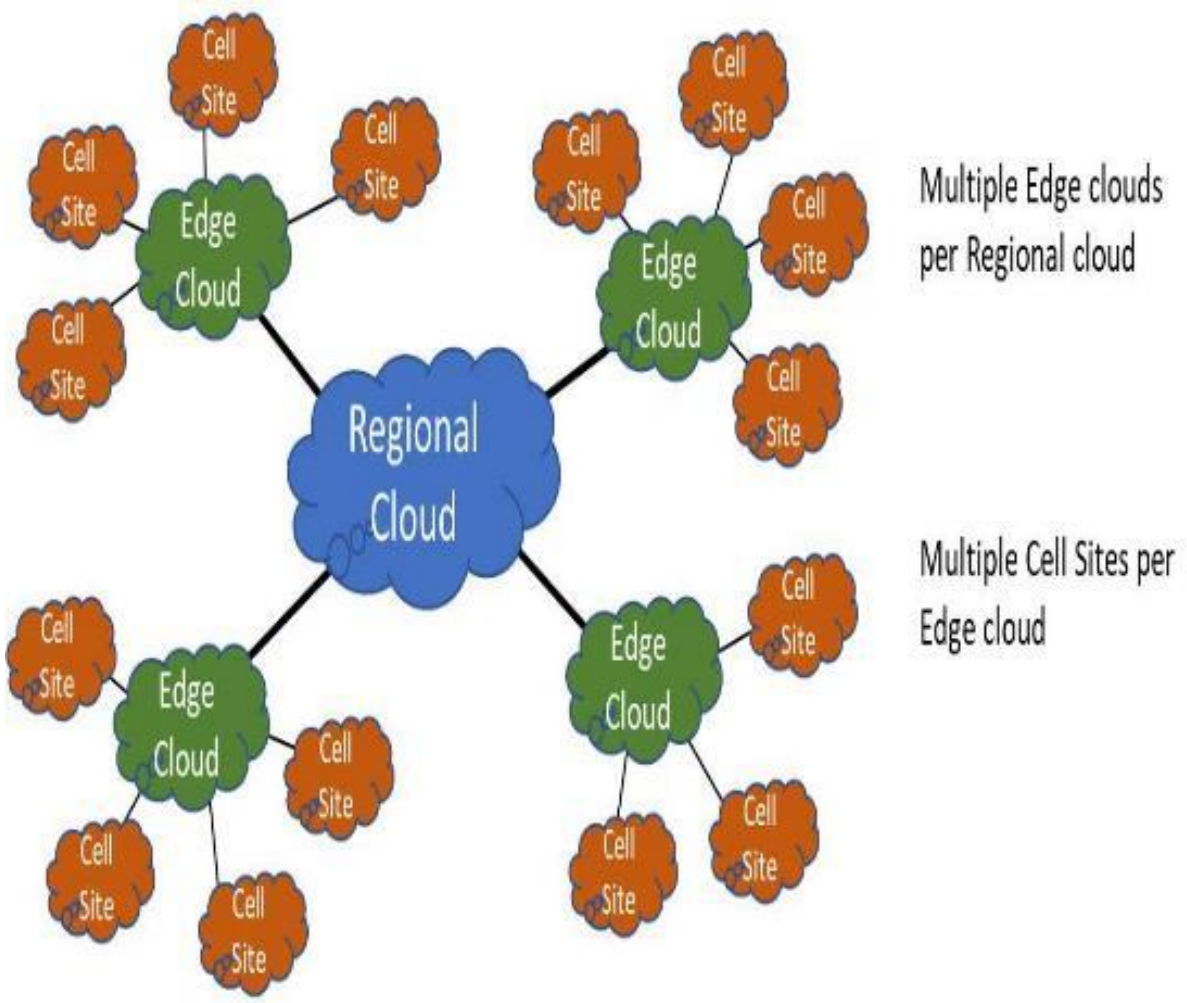
O-RAN – Disaggregated RAN (Ref: O-RAN Alliance)



https://www.o-ran.org/

- WG1: Use Cases and Overall Architecture Workgroup
- WG2: The Non-Real-Time RAN Intelligent Controller and A1 Interface Workgroup
- WG3: The Near-Real-Time RIC and E2 Interface Workgroup
- WG4: The Open Fronthaul Interfaces Workgroup
- WG5: The Open F1/W1/E1/X2/Xn Interface Workgroup
- WG6: The Cloudification and Orchestration Workgroup
- WG7: The White-box Hardware Workgroup
- WG8: Stack Reference Design Workgroup
- WG9: Open X-haul Transport Workgroup
- WG10: OAM Workgroup
- TIFG: Test & Integration Focus Group
- SFG: Security Focus Group

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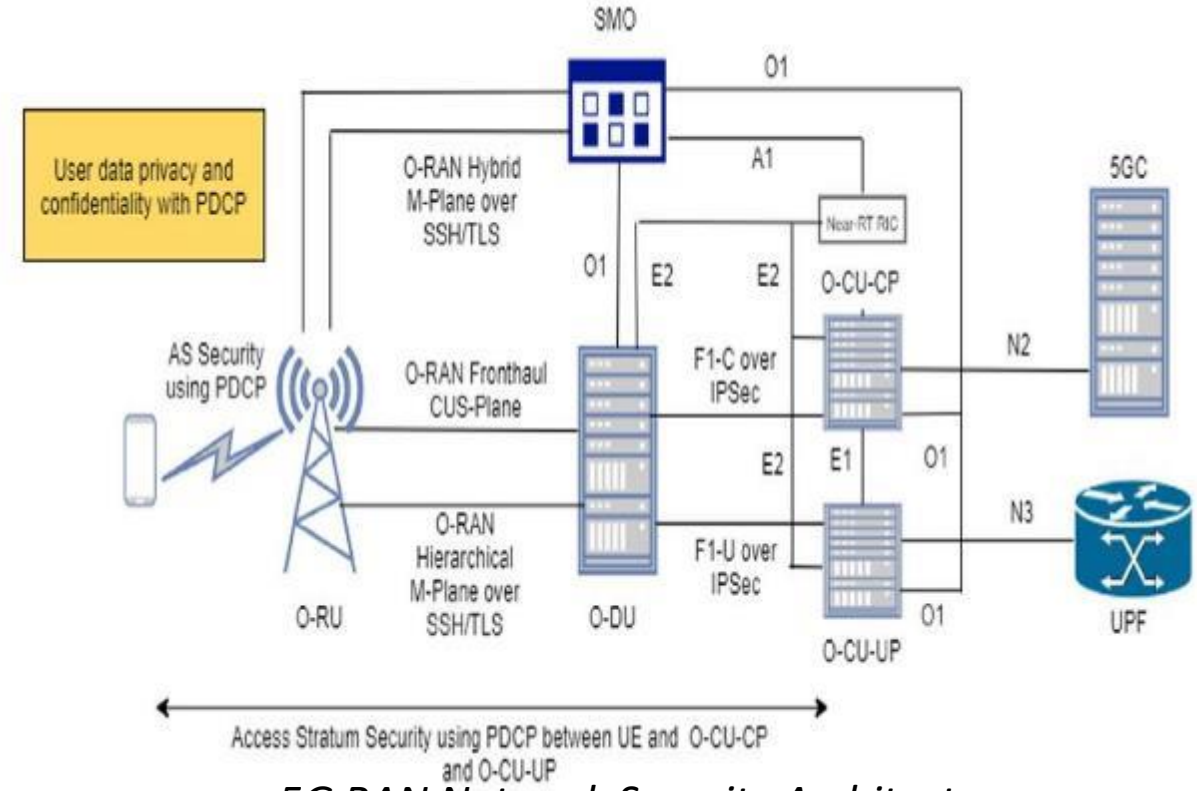
Open RAN Challenges and Opportunities

- The split architecture poses issues for applications that have latency requirements below 1 msec.
- One challenge is to reduce the latency that exists between the three parts of the disaggregated RAN, especially given the growing numbers of high-speed 5G users which will need to access it.
- While O-RAN offers a great deal of security opportunities, however, there are additional security challenges introduced due to orchestration, virtualization, slicing, and resource sharing that need to be investigated and mitigation techniques developed.
- Another challenge has to do with the developing use cases, traffic models, and deployment scenarios that Open RAN makes possible.
- Opening of these interfaces in an Open RAN environment could possibly impact the overall performance of the network and present interoperability issues.
- Interoperability issues with Open RAN with a diversity of suppliers, fault- and configuration-management
- Validation and testing and ensuring compatibility with legacy 4G equipment.

RAN Sub-System Security Analysis

Interface	Peer Nodes	Security Mechanism	Specified by
E1	O-CU-CP, O-CU-UP	NDS IP (IPSEC) or DTLS	3GPP
Xn	Source gNodeB, Target gNodeB	NDS IP (IPSEC) or DTLS	3GPP
Backhaul	O-CU-CP and 5GC (N2) O-CU-UP and 5GC (N3)	NDS IP (IPSEC) or DTLS	3GPP
Midhaul (F1)	O-CU-CP and O-DU (F1-C) O-CU-UP and O-DU (F1-U)	NDS IP (IPSEC) or DTLS	3GPP
Open Front Haul (M-Plane)	O-RU and O-DU/SMO	SSHv2, TLS	O-RAN WG4
Open Front Haul (CUS-Plane)	O-DU and O-RU	Work in Progress	O-RAN WG1 STG
O1	SMO and O-RAN Managed elements	Work in Progress	O-RAN WG1 STG
E2	Near RT RIC (xAPPS) and O-CU-CP	Work in Progress	O-RAN WG1 STG
A1	Near RT RIC and Non RT RIC	Work in Progress	O-RAN WG1 STG
O2	SMO and O-Cloud	Work in Progress	O-RAN WG1 STG



5G RAN Network Security Architecture

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Open RAN - Security Opportunities, Challenges, Mitigation and Risks

Security Opportunities	Security Challenges	Potential Mitigation Techniques	Risk Severity	Threat Likelihood
Programmability and Virtualization of RAN will adapt to dynamic nature of traffic and multi provider access SoftRAN (cRAN) in 5G networks will have **embedded DDoS detection and mitigation** functions **Dynamic Radio Resource Scheduling** significantly reduces the risk of jamming attacks targeting mission critical devices **Correlation of control plane and data plane traffic** will enable security monitoring of traffic via correlation	DDOS (Distributed Denial of Service) attack will result in resource starvation at cRAN Virtual Network Functions due to instantiation of additional vFirewalls	• Intelligent VM resource allocations • Capping of resources • Scale up functionality • Security monitoring at the edge	Medium	Medium
	VM (Virtual Machine) manipulation, Data exfiltration due to virtualization	• Hypervisor Separation • Hypervisor Hardening	High	Medium
	Programmable and Software RAN will increase the chance of Man-In-The-Middle Attack at the base station	• Traffic monitoring and closed loop orchestration will detect the attacks and mitigate these attacks	High	Medium
	Orchestration attack during scaling up and scaling down of VNFs in the cloud RAN	• Deploy detection and mitigation techniques for orchestration and API-based attacks	Medium	Low
	Jamming can be launched against control-plane signaling or user-plane data messages	• Deploy DDOS detection, IDS and vFirewall functions • Dynamic Service Chaining • Access Class Barring	Medium	Low

High Medium Low

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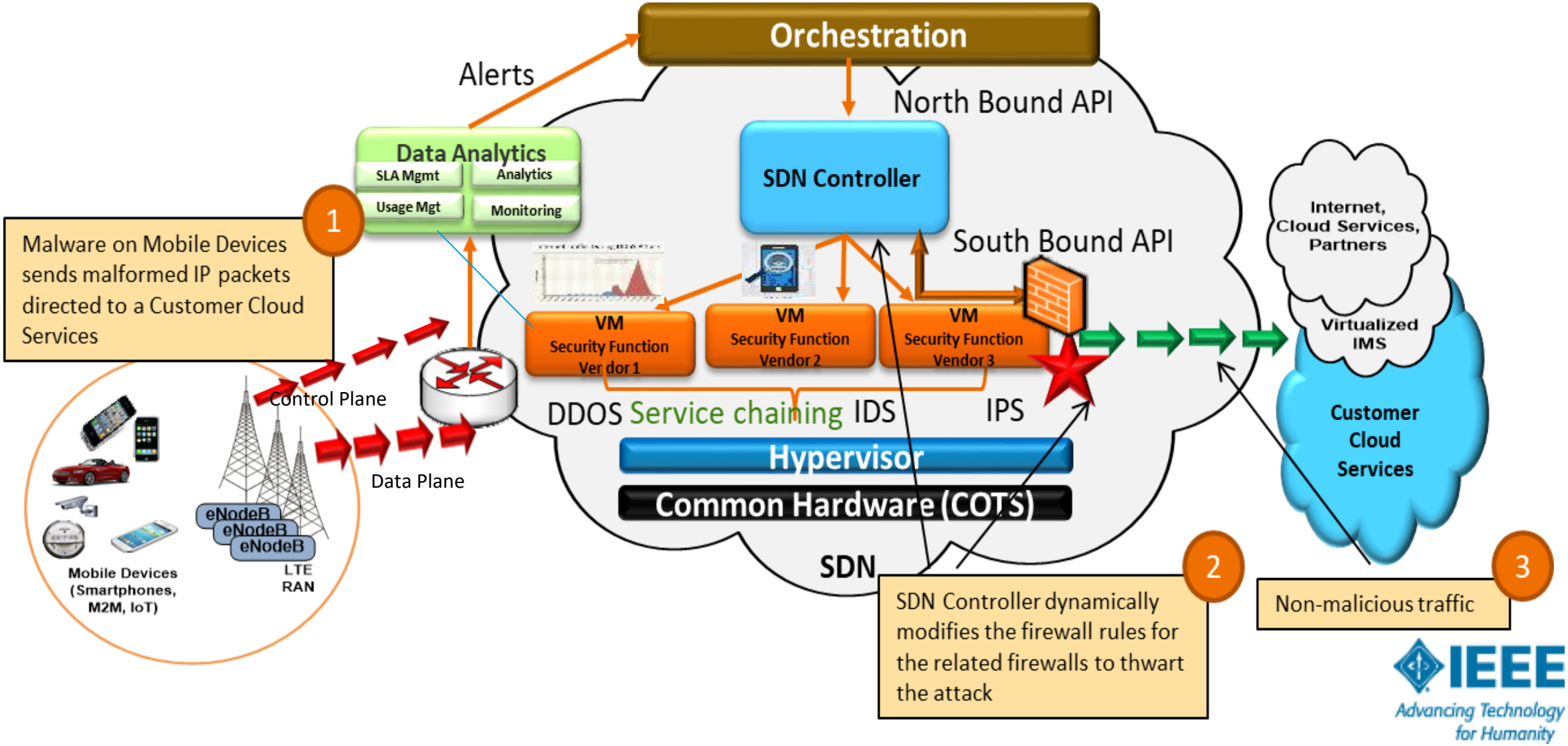
Security-As-a-Service – Closed Loop Automation in ORAN



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Proposed Plan for IEEE ORAN Industry Connection (1/2)

- Contribute to Open RAN ecosystem by filling the gap or complementing other Open RAN related efforts
- Harmonization and Collaboration with other organizations/SDOs (e.g., O-RAN Alliance)
- Collaborate with other ICAIDs within Industry Connection
- Develop and demonstrate Proof-of-concept of use various cases in collaboration with operators, vendors, end users, application service providers in collaboration with other SDOs and OUs
- Provide Open Testbeds for compliance and interoperability verification to augment the efforts of O-RAN alliance
- Initiate White papers, position papers, and peer-reviewed guides
- Publications in magazines and journals around Open RAN
- Conferences, webinars, workshops, and other events in collaboration with the industry, academia, and government

Proposed Plan IEEE ORAN Industry Connection (2/2)

- Practice Guide and Framework for Various Deployment Scenarios
- Use Case Guide for various verticals (e.g., Agriculture, First Responder, Health)
- Guidelines for different implementations
- Guidelines to ensure proper interoperability and compliance
- Guidelines Specifications for Configuration and Fault Management
- Guidelines Specifications for the Management Interface
- Practices and guidelines to help solution deployment across different interfaces, vendors, and frameworks
- Proposals for new standards. When a need is seen for a new standard, a project authorization request (PAR) is created and, if approved, the standard then would be developed by an IEEE SA Working Group.

Advancing Open-RAN: Research, Standards, and Deployment

Industry Connections (IC)
IEEE SA STANDARDS ASSOCIATION

Tuesday, 30 November 2021 | **Virtual Event** |

Opening Remarks - Introduction to IEEE SA Connectivity & Telecom Practice
Purva Rajkotia, IEEE SA | 10:00 - 10:05 AM ET

Overview of IEEE SA Open RAN Industry Connections Activity
Ashutosh Dutta, Chair of IEEE SA Open RAN Industry Connections Activity; Johns Hopkins University Applied Physics Lab | 10:05 - 10:25 AM ET

O-RAN: Open, Virtualized, and Intelligent RAN for 5G-A and 6G
Chih-Lin I, CMCC | 10:25 - 10:45 AM ET

Open RAN: Status and Next Steps
Brian Daly, AT&T | 10:45 - 11:05 AM ET

O-RAN architected end to end intelligence in 5G and beyond 5G networks
Rajarajan Sivaraj, Mavenir | 11:05 - 11:25 AM ET

The Future of O-RAN Fronthaul
Amitabha Ghosh, Nokia | 11:25 - 11:45 AM

Break 11:45 – 11:55 AM

ONAP/ORAN PoC: Multi-Operator/Multi-Vendor Resource Pooling and RAN Slicing
Ivan Seskar, Rutgers University/WINLAB | 11:55 AM - 12:15 PM ET

Unlocking the Full Potential of Open RAN Through an Automation and Intelligence Ecosystem
Vish Ponnampalam, Facebook | 12:15 - 12:35 PM ET

Evolving a Strong O-RAN Security Posture
Scott Poretsky, Ericsson | 12:35 - 12:55 PM ET

O-RAN Test and Integration: Challenges and Solutions
Ian Wong, Viavi Solutions | 12:55 - 01:15 PM ET

Security Opportunities with Open RAN
Bryan Larish, Verizon | 01:15 - 01:35 PM ET

Closing Remarks
Purva Rajkotia, IEEE SA | 01:35 - 01:40 PM ET

https://engagestandards.ieee.org/open-ran-webinar.html

Current Office Bearers

- **Chair**: Ashutosh Dutta, Johns Hopkins University Applied Physics Lab
- **Industry Connections Program Administrator**: Purva Rajkotia, IEEE SA
- **Vice Chair**: Ivan Seskar, Rutgers University WINLAB
- **Secretary**: Mithun Mukherjee, Nanjing University of Information Science and Technology

Ashutosh Dutta
JHU/APL

Purva Rajkotia
IEEE SA

Ivan Seskar
Rutgers University
WINLAB

Mithun Mukherjee NUIST

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Join us in ORAN Industry Connection Initiative

The IEEE SA Open RAN Industry Connection Program welcomes participants from academia, government, and industry such as telecommunications and network service providers, original equipment manufacturers (OEMs), start-ups, technology providers, as well as stakeholders from other industry sectors.

For more information or to join the program, please visit the program webpage

https://standards.ieee.org/industry-connections/open-ran.html?utm_source=light-reading&utm_medium=asset&utm_campaign=ct-2021&utm_content=open-ran

iMeet workspace: https://ieee-sa.imeetcentral.com/oran/home
Email alias: oran@ieee.org

Contact Points:

Ashutosh Dutta – IEEE Industry Initiative Chair **-** ashutosh.dutta@ieee.org
Purva Rajkotia – IEEE Standards Association - p.rajkotia@ieee.org
Industry Connections Program Administrator **-** IndustryConnections@ieee.org

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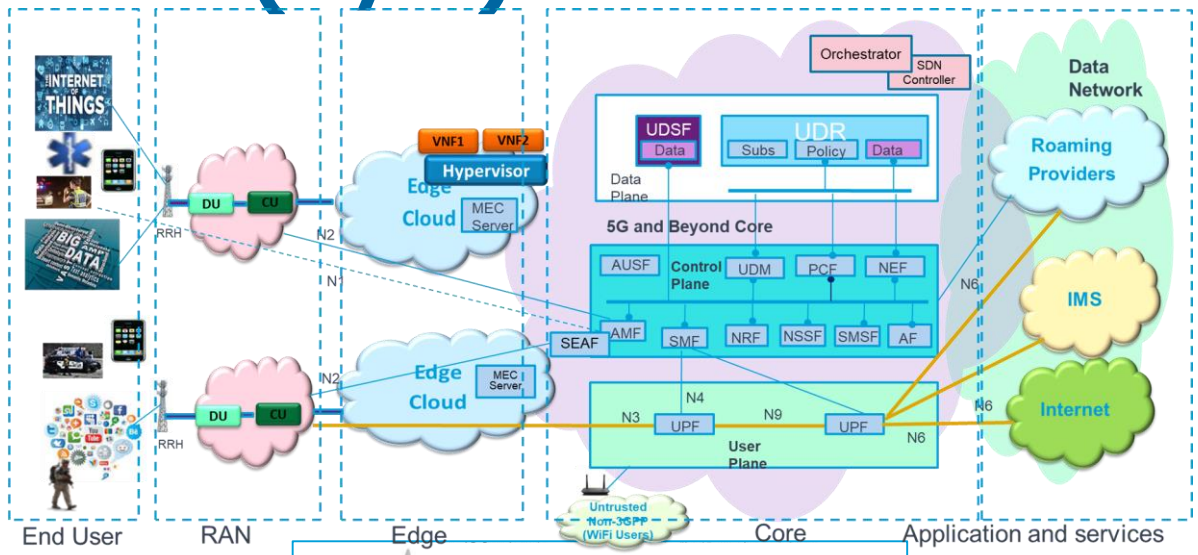
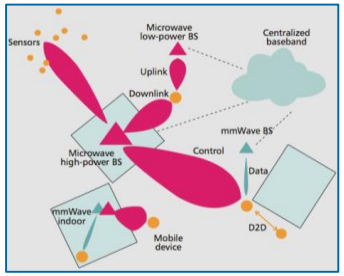
5G and Beyond Characteristics (1/2)

- New Flexible Radio Access Technology (RAT) / Waveform
  - New flexible physical layer – 3GPP 5G New Radio (NR)
  - Ultra-low latency
  - Extremely High Throughput Wireless LAN (802.11be)
- Millimeter-wave (mmWave) Communications
  - New spectrum 6 GHz – 100 GHz
  - mmWave small cells complement sub-6 GHz macrocells
- Massive MIMO
  - 100+ antenna elements on the base station-side
  - LTE FD-MIMO already deployed with 64 transmit & receive
- Densification of Small Cells
- Wireless Backhaul / Access Integration
- Converged Networks





Ref: Introducing 5G: 2017 The Next Wave

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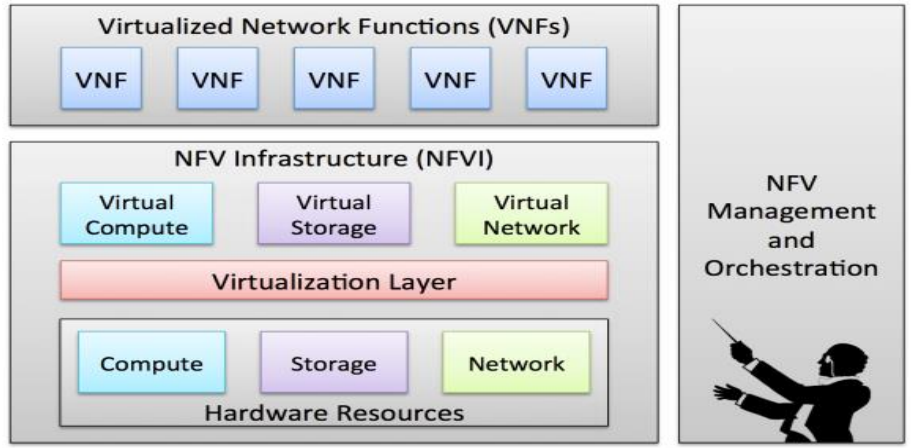
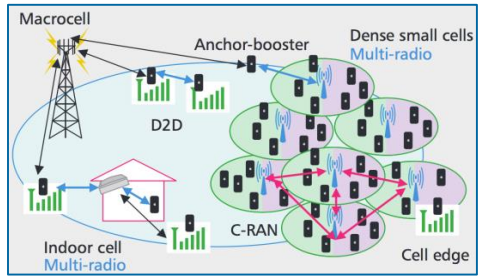
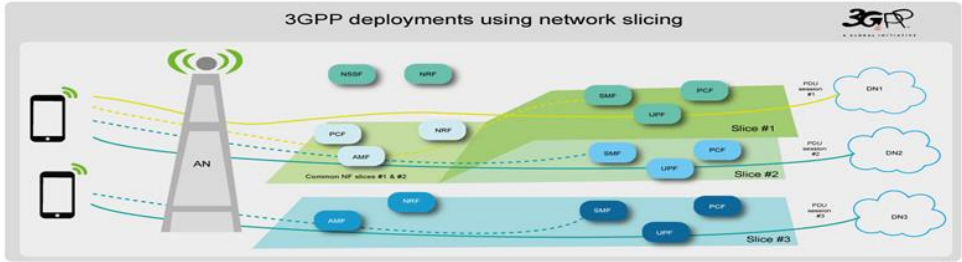
5G and Beyond Characteristics (2/2)

- Software Defined Networking / Network Function Virtualization
- Closed Loop Automation/Orchestration
- Mobile Edge Cloud
- Network Slicing
- Open Radio Access Network (ORAN)
- Service-based architecture
- Heterogeneous Networks
  - Multi-tiered networks: Macrocells, small cells
  - Multiple radio access technologies & WLAN (Wi-Fi)
- Device-Centric Architectures
  - Device-to-Device (D2D)
  - User-plane / Control-plane split
  - Context Aware Networking
- Native Machine-Type-Communications (MTC) Support
  - Internet of Things (IoT)
  - Massive number always-on devices
  - Vehicular communications already defined with LTE Cellular V2X







Ref: Introducing 5G: 2017 The Next Wave

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TELECOM INFRA PROJECT

OpenRAN Project Group

Introduction

Manish Singh,

Head of Wireless Ecosystem Programs
Meta Connectivity

March 16, 2022

TIP OpenRAN Project Group: Focus areas and workstreams

OPENRAN PROJECT GROUP vodafone T-Mobile orange airtel

COMPONENT SUBGROUPS

RU	dish vodafone T-Mobile	Whiteboxes (4G/5G)
DU & CU	intel vodafone T-Mobile	Whiteboxes (4G/5G)
Radio Intelligence & Automation	vodafone T-Mobile BT dish	AI/ML use cases for MaMIMO, RRM and SON
ROMA	Telefónica vodafone T-Mobile	OpenRAN orchestration & lifecycle management automation

SEGMENT SUBGROUPS

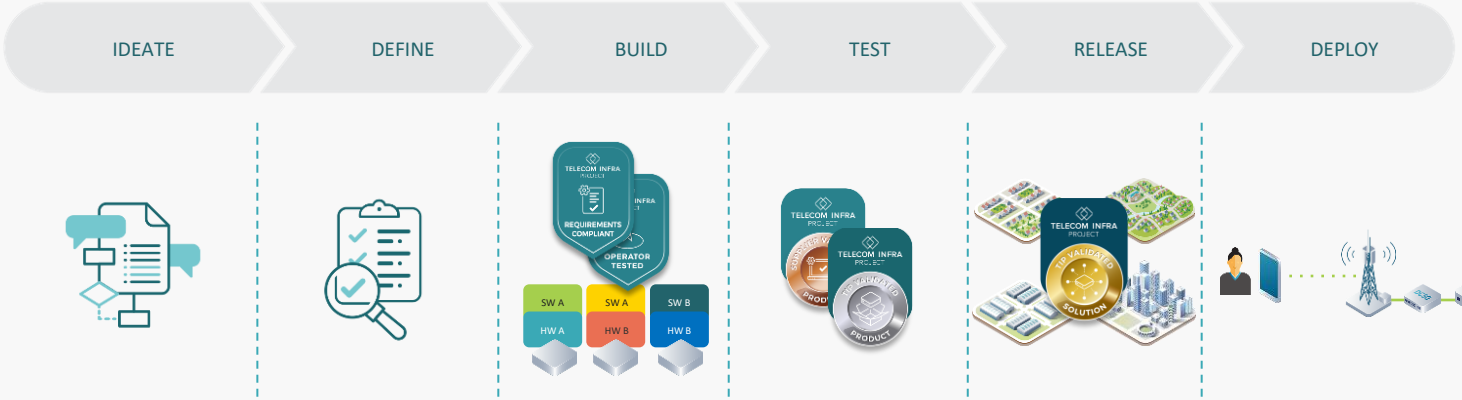
Outdoor

orange vodafone smartfren Indosat Ooredoo TPG

Indoor

orange T-Mobile China unicom中国联通

TIP focuses on accelerating OpenRAN commercialization in collaboration with MNOs, technology partners and SDOs

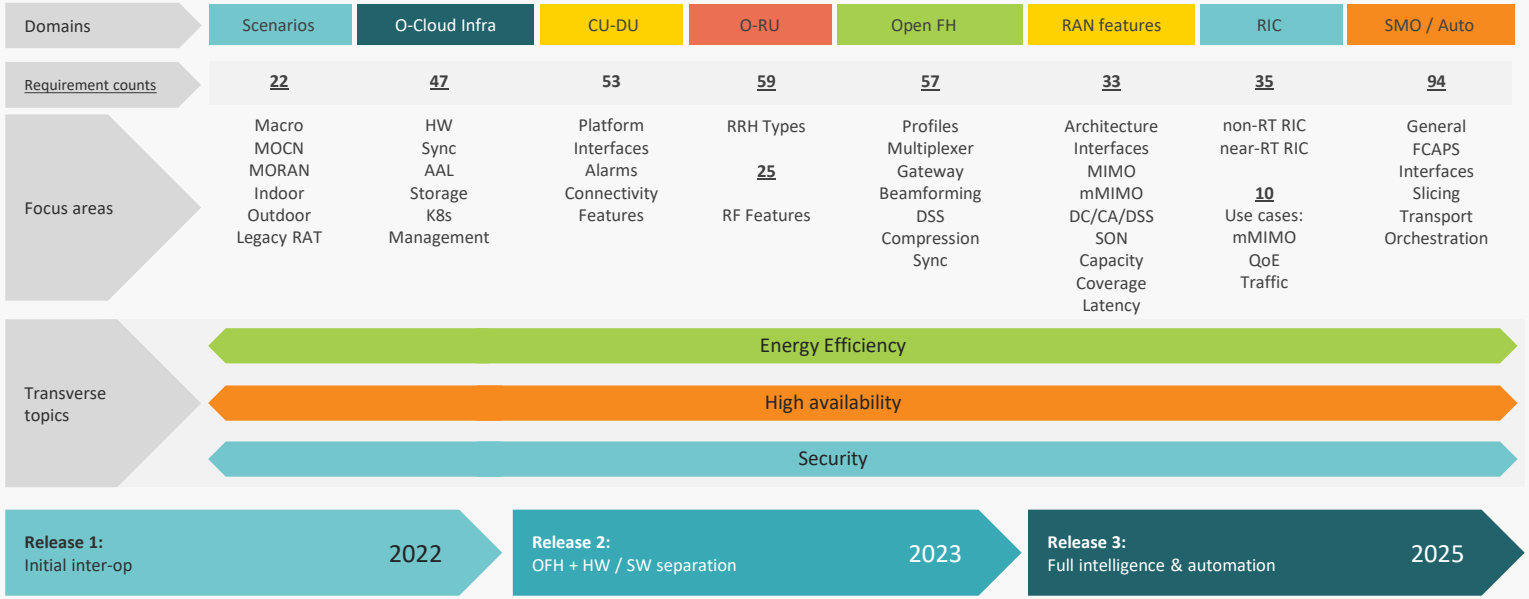


INDUSTRY BODIES

Open-source SW

OTIC

OpenRAN MOU Group (OMG) Technical Priorities requirement alignment



View the TIP OpenRAN Draft Release 2.0 Detailed Technical Requirements Document

Translating OMG Requirements to Blueprints

An Ecosystem Approach

1. **Gather inputs from additional MNOs** to align industry wide requirements and boost demand signal

2. **Assess vendor compliance** and readiness against OMG requirements

3. **Initiate TIP roadmapping process** to define multiple releases over time with the growing mandatory features.
   - Balancing demand and supply readiness

4. **Publish TIP OpenRAN consolidated requirements** document 2.x for each OpenRAN workstream (Subgroup) RU, DU/CU, RIA, ROMA, Outdoor Macro and Indoor Small Cell

5. **Publish TIP OpenRAN roadmap** for release 2.x and Release 3.x
   - Align vendor roadmaps

6. Initiate vendor's **'Compliance to Requirements'** process for each workstream

7. Issue 'Supplier Validated' badges to participating vendors. **A prerequisite to participate in TIP T&V**

8. **Publish blueprint definitions**

9. **Initiate T&V in TIP Community Labs (CL)**

10. **Publish final validated configurations on TIP Exchange**

REPEAT ON A REGULAR BASIS

TIP OpenRAN Project Group - Releases

First Macro Outdoor OpenRAN Release

Based on Vodafone / Telefonica RFI

Ongoing TIP OpenRAN Roadmap

Based on MNO requirements contributed to Component Subgroups (RU, DU/CU, RIA, ROMA) and Segment Subgroups (Outdoor & Indoor)

Upcoming TIP OpenRAN Roadmap based on Open RAN MoU Group (G5) and other operator inputs

Baseline contributed from requirements published in the Open RAN MoU Group Technical Priorities Document

TIP Publishes OpenRAN's Release 2 Roadmap

TIP Exchange | OpenRAN Vendor Participants

Subgroup Badge Allocation

OpenRAN Subgroups	OpenRAN Subgroup Badge Allocation				
	Requirements Compliance Ribbon	Operator Tested Ribbon**	Community Labs Badge	Field Trials Badge	Plugfest Badge
RU	20	1		3	
DU/CU	12				
Outdoor Macro	19	3	2	3	2
Indoor Small Cell	1				

Last updated 26 October 2021.

*Listings can be eligible for multiple badges within OpenRAN. **Outdoor Macro Operator Tested Ribbons listed under OpenRAN Tip Community, Field Trials and Plugfest Badges are no longer awarded, but searchable through TIP Exchange.

ALTIOSTAR Leading Network Transformation
mi
ALTRAN part of Capgemini
NEC
BaiCells
NTS
Comba
Parallel Wireless
DELL Technologies
QCT
FUJITSU
Silicom Ltd. Connectivity Solutions
Hewlett Packard Enterprise
SUPERMICRO
JMA
Tecore networks
kontron
WIND
MAVENIR
zt Systems

Becoming a Global Commercial Reality: Testing and Validating in TIP Community Labs

[Middle East MNOs establish regions first OpenRAN Lab]

OpenRAN Trials and Deployments

Thank you