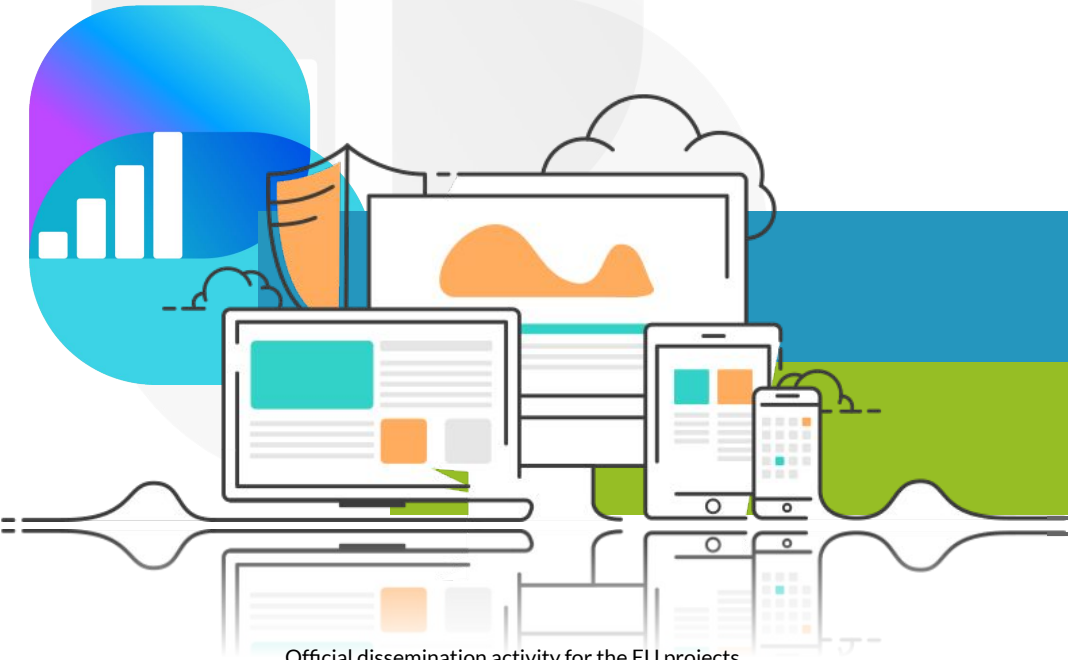
Open RAN Studio Mini-Series - 3rd Europe-USA Edition

Event by BubbleRAN

Tue, Jul 16, 2024, 5:00 PM - 7:00 PM (your local time) Add to calendar

Online



ORS Mini-Series

Episode 03: O-RAN and 6G Innovations

Provided by BubbleRAN

Tuesday, 16 July 2024

Official dissemination activity for the EU projects

6G Cloud

5G TACTIC

6G SNSES

Co-funded by the European Union

6GSNS

Zoom Interaction Rules

1. Please add your affiliation to your zoom name, e.g. Navid Nikaein (BubbleRAN/Eurecom/OSA)
2. **Please use Zoom Chat for any questions or comments** outside of the Q&A session. This is highly recommended to be able to answer all the questions. The team will reply to you.
3. **Please always mute the microphone and disable Video all the time** to minimize background noise.
4. Please enable your video and audio when asking a question during the Q&A.
5. The recorded video will be published on the BubbleRAN Youtube channel. We will send a separate email with all the materials.

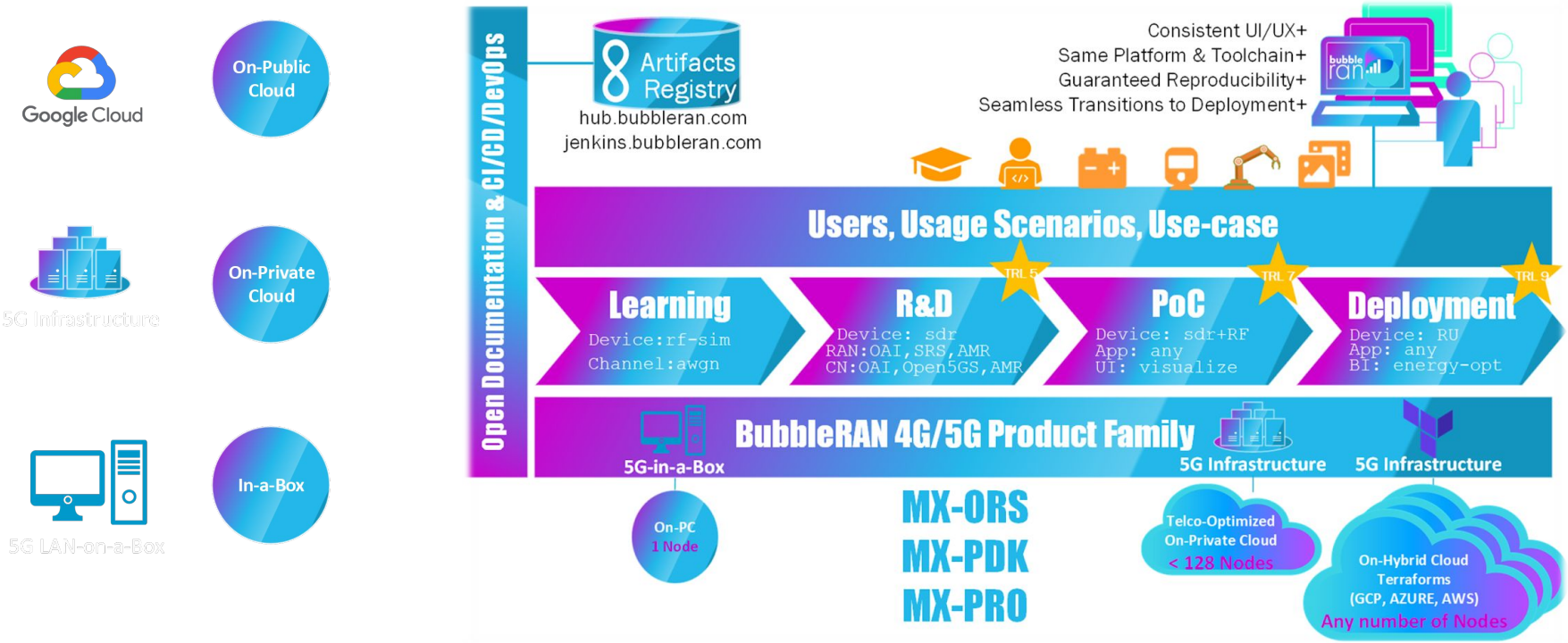
GDPR Notice: By joining this webinar, you are agreeing that your name and voice could appear in the recorded materials and published online without future consent.

ORS Mini-Series

Importance, organization, and goals

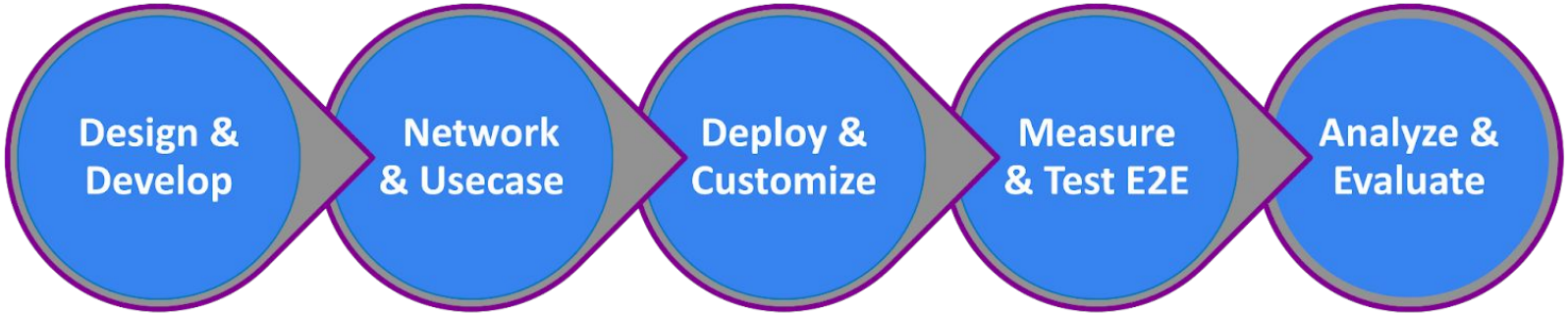
Why Open RAN Studio Mini-Series?

1. Share Knowledge
2. Identify New Challenges/Features toward 6G
3. Accelerate the R&D lifecycle from Idea to PoC/Demo
4. Showcase Ideas and Validate use-cases
5. Foster Academia and Industry Collaboration

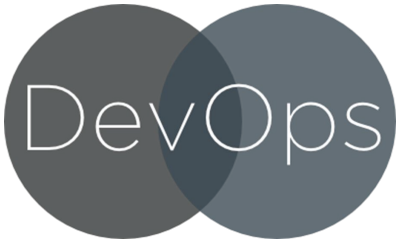


What is Open RAN Studio?

ORS in Nutshell



Open RAN Studio is world-first production-grade cloud-native platform to seamlessly design, operate, experiment an emulated end-to-end 3GPP & O-RAN standard-compliant network with edge services, at scale.

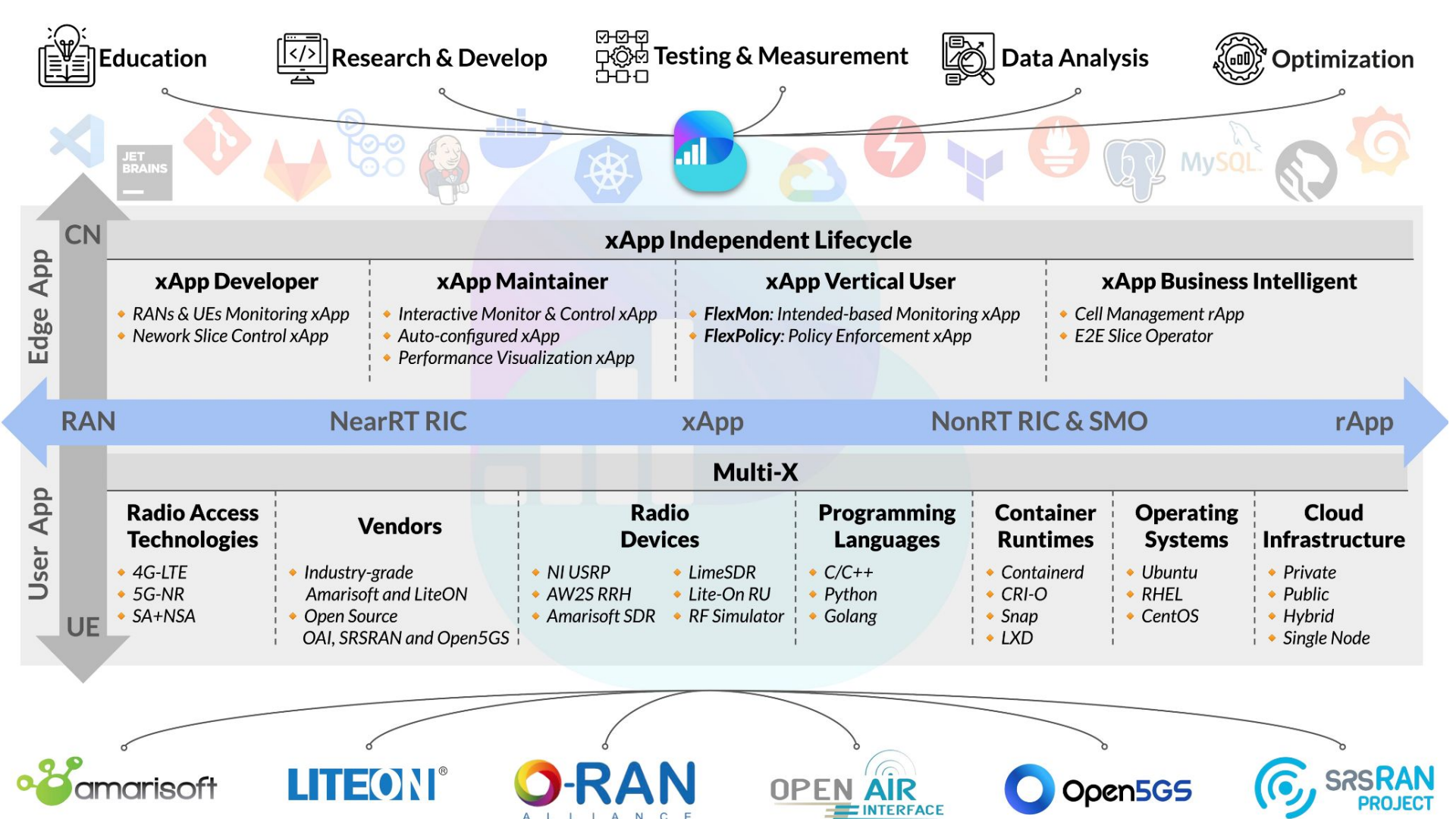


ORS features

- ★ Multi-infrastructure support: Bare-metal, On-premise, Public (GKE), Single-node (Microk8s)
- ★ O-RAN compliant SMO and RIC stack including Non-RT RIC, Near-RT RIC, and OAM
- ★ Network design, protocol tracing, log extraction, integrated UE testing
- ★ rApps and xApps for monitoring and control
- ★ End-to-end agile and scalable declarative deployment including UE
- ★ Day-2 features, including network reconfiguration, upgrade, and fault management
- ★ Difference between declarative and imperative deployments
- ★ Multi-vendor support: OAI, SRS, Open5GS (both LTE and NR), LiteON and Amarisoft
- ★ Programmable cloud-native observability with Grafana dashboard
- ★ Multi-source data lake, including RAN, Energy, and Infrastructure metrics

ORS use cases

- Education and training
- Data collection and model training
- rApp or xApp design and analysis
- Interoperability testing
- Test and measurements with UE in the loop
- Research validation
- Network simulation and emulation


Education
Research & Develop
Testing & Measurement
Data Analysis
Optimization
JET BRAINS
MySQL
Edge App
CN
xApp Independent Lifecycle
xApp Developer
RANs & UEs Monitoring xApp
Nework Slice Control xApp
xApp Maintainer
Interactive Monitor & Control xApp
Auto-configured xApp
Performance Visualization xApp
xApp Vertical User
FlexMon: Intended-based Monitoring xApp
FlexPolicy: Policy Enforcement xApp
xApp Business Intelligent
Cell Management rApp
E2E Slice Operator
RAN
NearRT RIC
xApp
NonRT RIC & SMO
rApp
User App
UE
Multi-X
Radio Access Technologies
4G-LTE
5G-NR
SA+NSA
Vendors
Industry-grade Amarisoft and LiteON
Open Source OAI, SRSRAN and Open5GS
Radio Devices
NI USRP
AW2S RRH
Amarisoft SDR
LimeSDR
Lite-On RU
RF Simulator
Programming Languages
C/C++
Python
Golang
Container Runtimes
Containerd
CRI-O
Snap
LXD
Operating Systems
Ubuntu
RHEL
CentOS
Cloud Infrastructure
Private
Public
Hybrid
Single Node
amarisoft
LITEON
O-RAN ALLIANCE
OPEN AIR INTERFACE
Open5GS
SRSRAN PROJECT

Today's Agenda and Speakers

Part 1

1. BubbleRAN's MX-RIC
2. O-RAN's 3 pillars towards 6G (KPM, RC and CCC)

Break (5 minutes)

Part 2

3. O-RAN and GenAI
4. Beyond O-RAN. On the road to 6G

Mikel
BubbleRAN
Principle Engineer

Alireza
BubbleRAN
Product Manager

Chieh-Chun
PhD. Eurecom
O-RAN expert

Khai
BubbleRAN
RIC developper

Ilias
PhD. Eurecom
SMO/GenAI expert

MX-RIC

BubbleRAN's RIC ecosystem

Open RAN and Heterogeneous Network Symbiosis

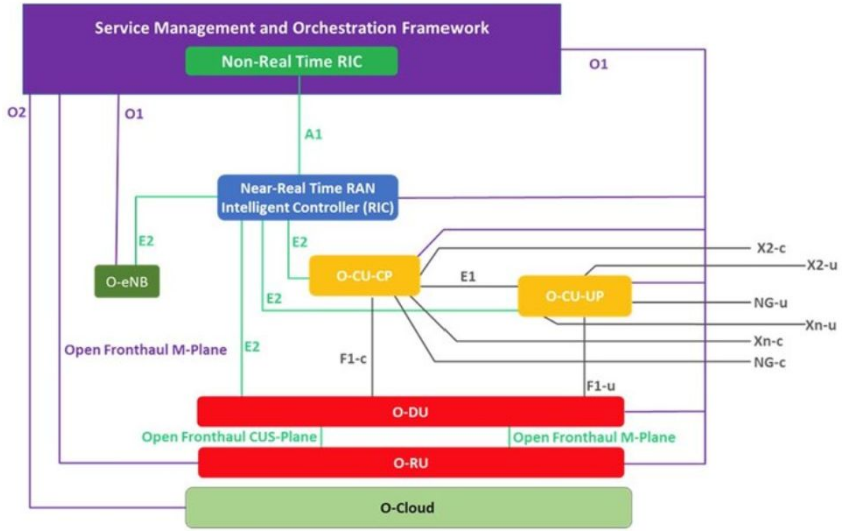
Open RAN

- ★ Open standardized interfaces to interoperate different parts of the network seamlessly and securely regardless of its originating vendor.

Multi-x (MX) network architecture

- ★ Multi-vendors
- ★ Femto to macro cells
- ★ Diverse architectures (e.g., ARM, x86, FPGA)
- ★ Different splits (O-RAN 7.2, E1AP, F1AP)

[Open RAN and Beyond by Multi-x]



BubbleRAN's MX-RIC (FlexRIC Kernel)

- Most **complete** NearRT-RIC and E2 Agent open source O-RAN specification.
- ***Multi-x*** design and implementation:
  - Multi-**RAT** (4G and 5G)
  - Diverse **HW architectures** (ARM, x86 develop using C11 with no intrinsics)
  - Multi-version i.e., static polymorphism (e.g., **E2AP** v1, v2, v3 or **KPM** v2, v3).
  - Multi-**language** (C/C++, Python, Golang). Thanks to SWIG also easily extendable.
  - Multi-**vendor** (OAI, srsRAN, Amarisoft, LiteON).
- SM complete (**KPM**, **RC** and **CCC**)
- Zero **overhead** principle; Small **footprint**; Blazingly **fast**; Minimal **external dependencies**
- **SDKs** to facilitate xApp development with **simple** and **intuitive** APIs
- Best practice **maintenance** e.g., ASan, TSan; **Static analyzers** e.g., cppcheck, scan-build; **Code coverage** and testing i.e., gcov
- Diverse **compiler** i.e., gcc/clang; Diverser **linkers** i.e., ld, ldd, gold, mold
- **Preconditions** and **postconditions** in every function
- **SOLID** principles

NearRT-RIC O-RAN Alliance Solution

- ★ **Microservice-based architecture (Kubernetes)**
- ★ **Disadvantages**
  - **Resource** hungry (VM, 20 GBytes/8 GB RAM)
  - Higher **Latency**
  - Higher **Complexity**
  - Lower **Reliability**
  - No Zero **Overhead** principle
  - Not thoroughly **tested**
  - **Non-intuitive** APIs
  - Non-following **SOLID** principles.
  - Difficult to run it as a **Docker** container
- ★ **Advantages**
  - Greater **flexibility**

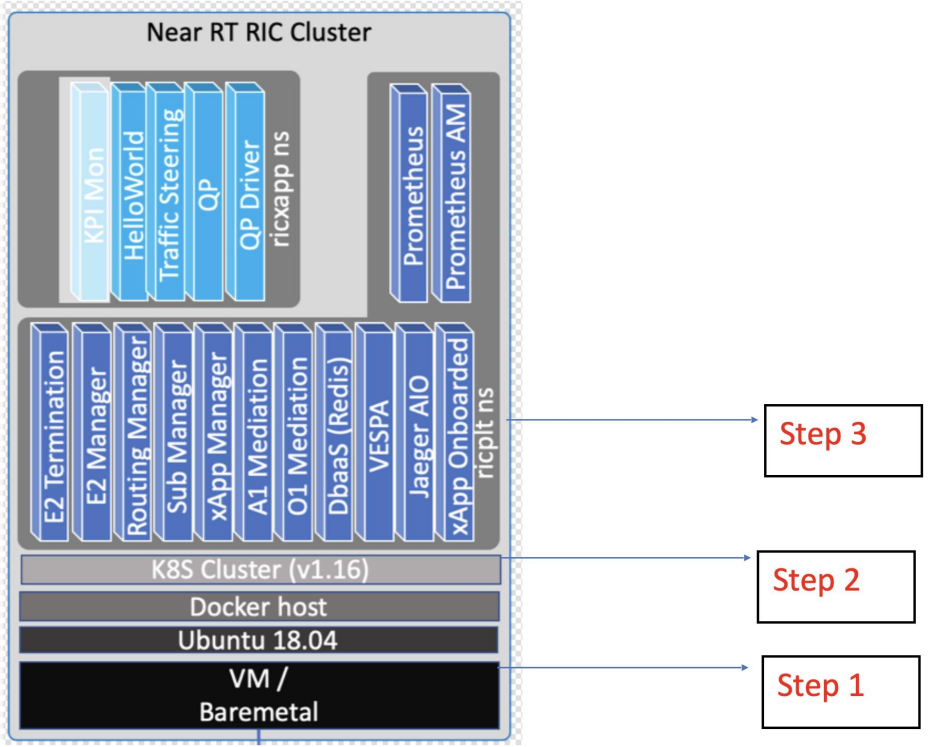


Figure credits: https://openaicellular.github.io/oaic/oran_installation.html

Criteria	O-RAN RIC Release I	MX-RIC
Zero Overhead	No	Yes
Enc/Dec	ASN1.c	ASN1.c, FB, Plain
E2AP version	v1/v2	v1/v2/v3
E2AP Messages / IEs	7/26 (v2, 26%)	20/26 (v2, 76%), 12/28 (v3, 42%)
Multi-language	Yes	Yes
E2 Nodes	Radisys/srsRAN	OAI, SRS, AMR, LiteON
Memory footprint	1	0.17
E2 Agent-xApp latency	>10 ms	< 1 ms
Service Models	Embedded	Pluggable, Extendable

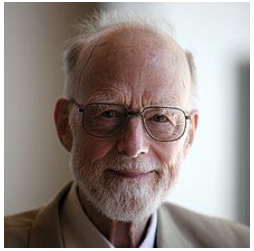
A Comparison

On the way of simplicity/reliability

"Increasingly, people seem to misinterpret complexity as sophistication, which is baffling– the incomprehensible should cause suspicion rather than admiration."

Niklas Wirth (1984 Turing award. Pascal inventor)

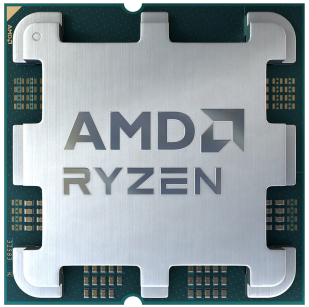
"There are two ways of constructing software design: One way is to make is so simple that there are obviously no deficiencies, and the other way is to make it so complicated that there are no obvious deficiencies. The first method is far more difficult."



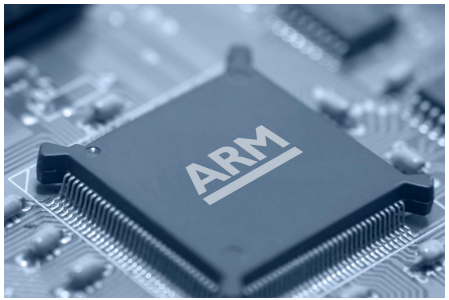
C.A.R. Hoare (1980 Turing award. Hoare Logic)

🔴 LIVE DEMO: Latency on BubbleRAN's MX-RIC

★ AMD Ryzen 7 7840HS (x64): Standard deployment



★ Cortex-A76 (ARM): Small Cell/FemtoCell



★ Snapdragon X Elite Oryon CPU (WSL, Windows on ARM)

Takeaway

- **Complexity is not sophistication.**
- **Better architecture**
  - Lower latency
  - Lower complexity
  - SOLID; Easier to extend/Open close principle (SM, multi-language, DB)
  - Variety of deployment option (femto to macrocell)
  - Variety of hardware (ARM, x86)
- **Better maintenance**
  - PoC != Production ready solution
  - Number of Vendors
  - More use scenarios
  - Security/Memory safety: regularly run with ASan/TSan
- **Use cases**
  - More use cases towards 6G

Pillars of O-RAN RIC

Demos on O-RAN main SMs

Pillars of O-RAN RIC (KPM, RC, CCC)

Outline

Key Performance Measurement (KPM): Gather statistics from the E2 Node.

Demo: Multi-source and multi-vendor (i.e., **OAI, srsRAN as well as Amarisoft**) data lake with KPM.

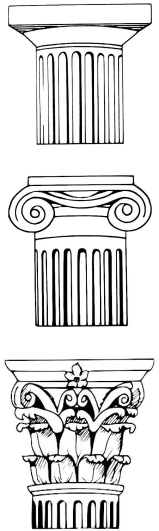
RAN Control (RC): Fetch data and Control the RAN e.g., slicing, handover.

Demo: Multi-vendor (i.e., **OAI, srsRAN**) RAN slicing with RC.

Demo: Handover (i.e. Amarisoft).

Cell Configuration and Control (CCC): Configuration of the Cell e.g., arfcn frequency.

Demo: Dynamic Bandwidth Part reconfiguration using CCC (i.e., **Amarisoft**).

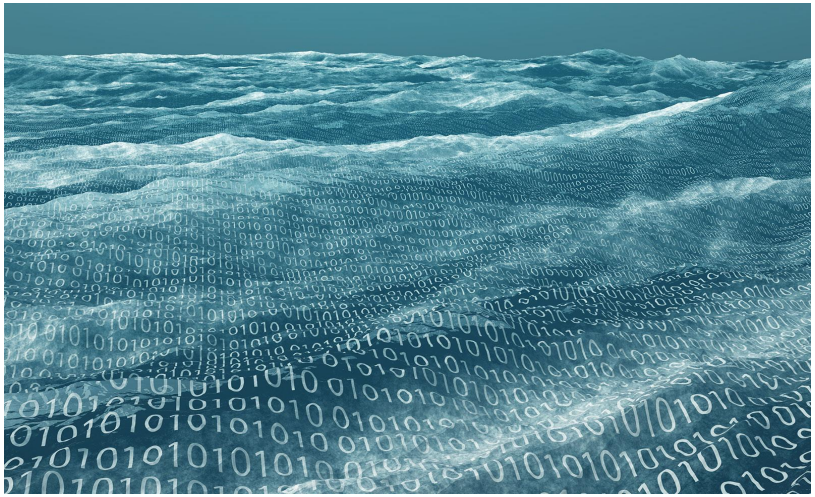


O-RAN Key Performance Measurements

- KPM is the basic, yet essential Service Model.
- More than **900** measurements defined between O-RAN and 3gpp.
- It permits data gathering from heterogeneous networks to form data lakes for ML/AI.
- BubbleRAN currently supports multi-vendor multi-RAT KPM: OAI, srsRAN, Amarisoft and LiteON.
- BubbleRAN offers Sqlite, Mysql, and Timescale DB to store the data for further processing.
- Multivendor
  - *Write Once, Run Anywhere* (WORA)
- xApp: Subscribe to gather information from the E2

  Nodes with periodicity of 1, 2, 5, 10, 20, 50, 100 ms
- From the E2 Node until the xApp < 1 ms on average

  Even in a not-optimized network in the lab.



KPM demo machines configuration (Presenter: Khai)

Sonic: Monitor xApp + Grafana

MX-DATA

Sonic: nearRT-RIC

Sonic: Amarisoft CN

Ayo: srsRAN gNB

Roland: Amarisoft gNB

Mante: OAI gNB

Quectel module

Pixel 5

Quectel module

Machine1

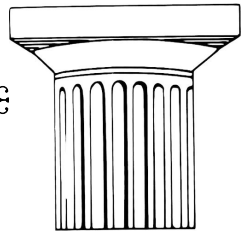
Machine2

Machine3

Machine4

VIDEO DEMO (Presenter: Khai)

Takeaway



[Message] :

- ★ KPM is essential for data gathering e.g., data lakes, and thus, 6G, training, data collection, multi-E2 data source
- ★ Single xApp operating over multi-vendor deployment

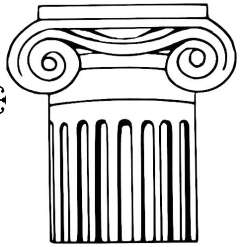
[KPIs] :

- ★ MX-RIC permits a wide range of use cases with different periodicity
- ★ Low-latency (< 1ms)
- ★ MX-RIC goes beyond KPM and permits easily customizable SMs
- ★ MX-RIC permits processing the data in the gNB or in the xApp i.e, BW (raw data) vs CPU processing

[O-RAN and 6G] :

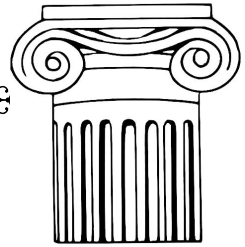
- ★ BubbleRAN MX-RIC evolves KPM towards layer-based, fine-grained, programmable measurements e.g., Sensing and PHY
- ★ Multi-source data lake (MX-DATA): Infrastructure, O-RAN, Energy

O-RAN RAN CONTROL (Presenter: Chieh)



- ★ RC is the Service Model for controlling the RAN.
- ★ It enables remotely controlling the RAN for 6G use cases.
  - Radio Bearer Control
  - Radio Resource Allocation Control
  - Connected Mode Mobility
  - Radio Access Control
  - Dual Connectivity Control
  - Idle Mode Mobility Control
  - Beamforming Configuration Control
- ★ **MX-RIC** currently supports radio resource allocation a.k.a. slicing, in OAI and srsRAN, while connected mode mobility control a.k.a., handover in Amarisoft RAN.
  - **Demo 1: xApp Slicing:** Send the slice RC control message to create network slices within gNBs.
  - **Demo 2: xApp Handover:** Subscribe to the cell information using RC on-demand. Once we know which gNB has UEs and which one does not, we send the handover RC control message.

Slicing Demo Machines Configuration (Presenter: Chieh)



Machine1
Machine2
Machine3

RC slice xApp

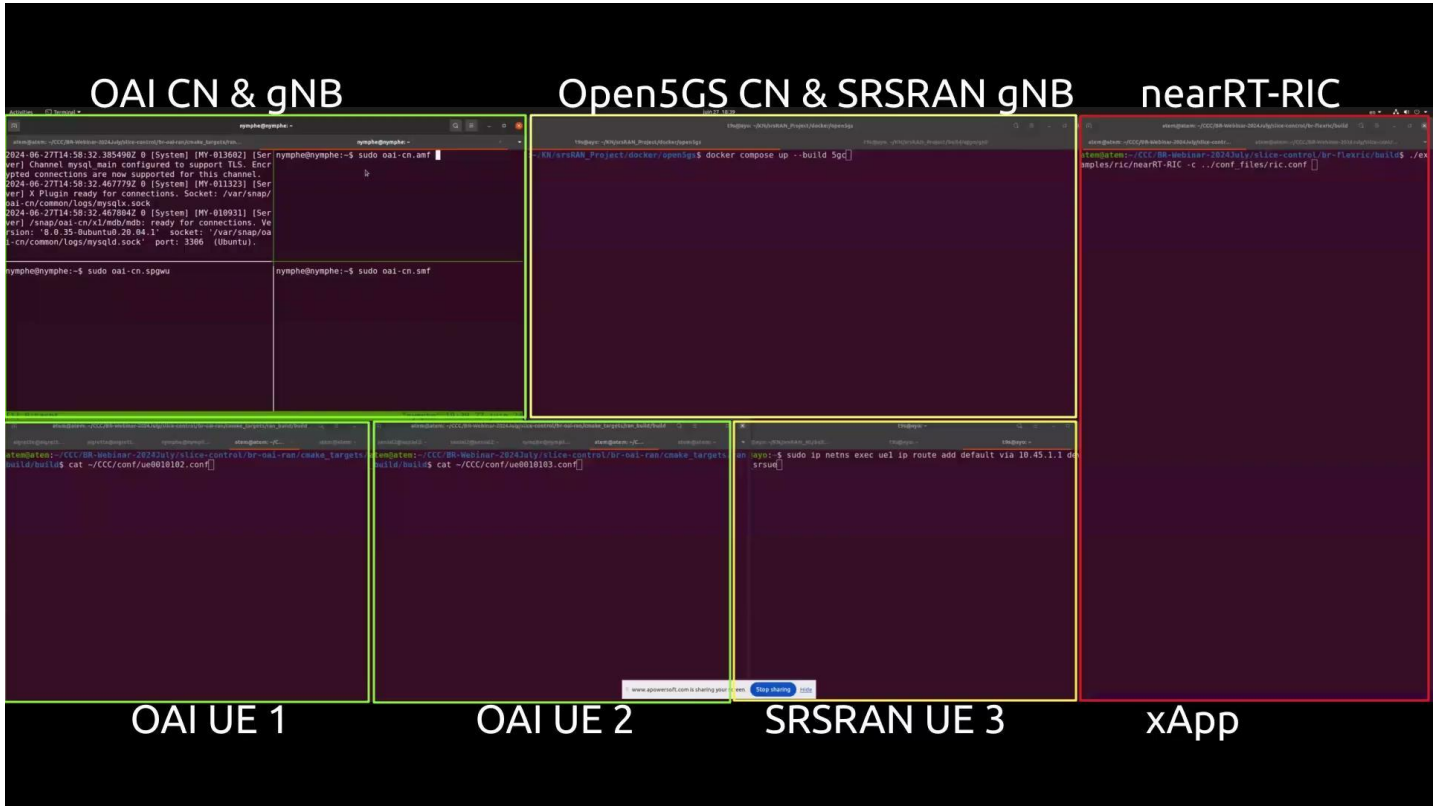
Slice 1 (OAI - SST 1 SD 0): **min 30, max 30**
Slice 2 (OAI - SST 1 SD 5): **min 70, max 100**
Slice 3 (SRSRAN - SST 1 SD 0): **min 5, max 10**

NearRT-RIC

OAI CN	**OAI** gNB	**srsRAN** gNB	**Open5GS** CN (Docker)
iPerf3 Client 1			iPerf3 Client 3
iPerf3 Client 2			

OAI UE 1 SST 1, SD 0	**OAI** UE 2 SST 1, SD 5	**srsRAN** UE SST 1, SD 0
iPerf3 Server1	iPerf3 Server 2	iPerf3 Server3

VIDEO DEMO (Presenter: Chieh)



Handover Demo Machines Configuration

Ayo: xApp + nearRT-RIC

Vinci: Proxy E2 Agent

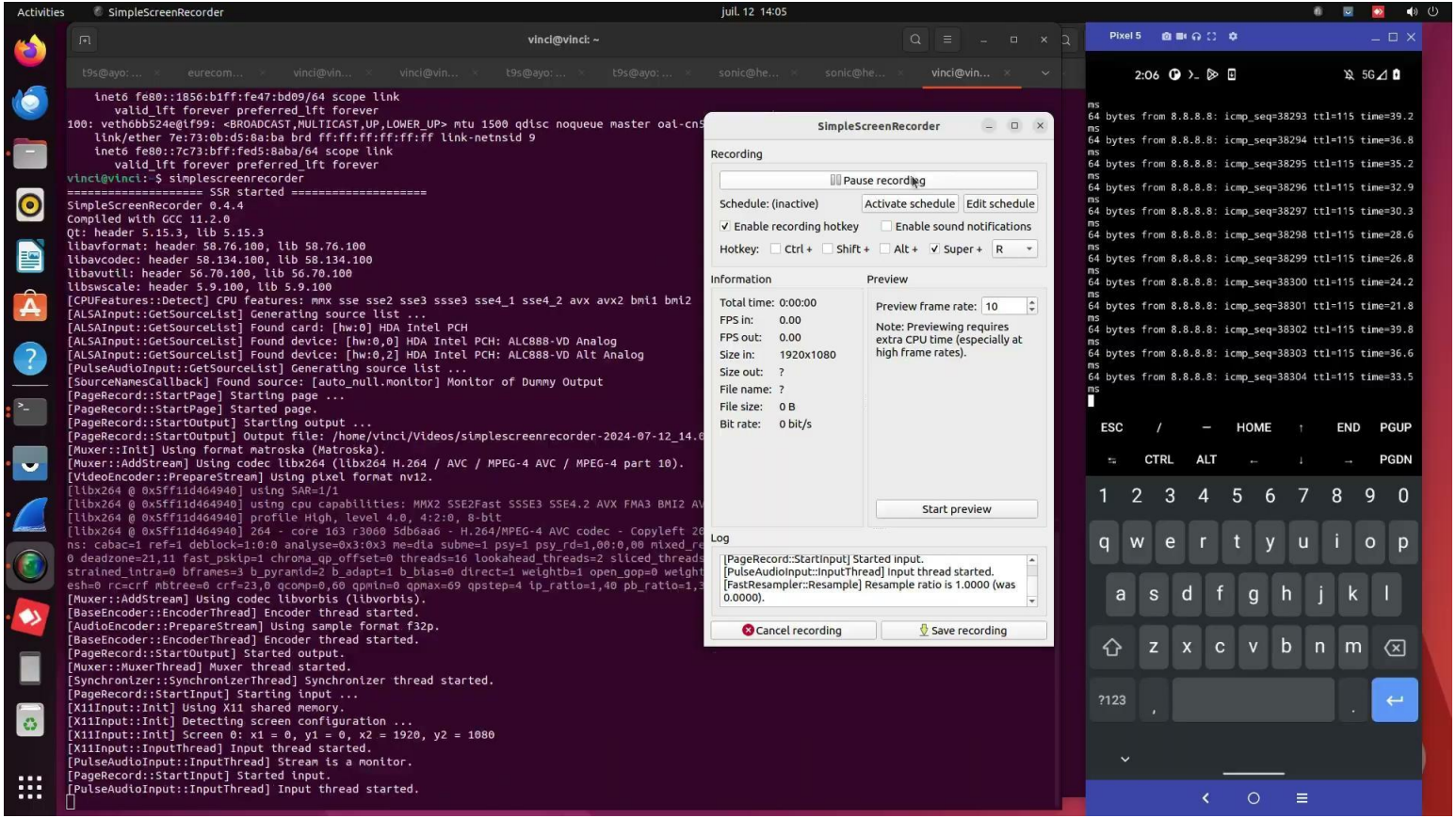
Roland: Amarisoft RAN

Vinci: Proxy E2 Agent

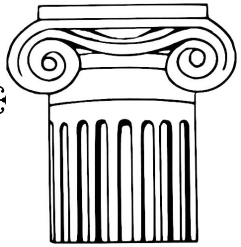
Ayo: Amarisoft RAN

Google Pixel

VIDEO/LIVE DEMO: HO



Takeaways



[Message] :

- ★ RC permits controlling the RAN, as well as monitoring it.
- ★ Single xApp operating over multi-vendor deployment.
- ★ MX-RIC supports Slicing/Handover

[KPI] :

- ★ Real-time control message **< 2 ms**
- ★ RAN control across multi-vendor RANs
- ★ Load balancing/energy efficiency through handover beyond mobility

[O-RAN and 6G] :

- ★ MX-RIC also supports Custom Slice Control Service Model (RC+SC)
  - Asymmetric Uplink and Downlink slicing
  - Multiple slicing algorithms (e.g., NVS, EDF, eEDF, Policy-based)
  - Slice Operator (from application to network and radio)

O-RAN Cell Configuration and Control

- ★ Latest SM addition within the BubleRAN's MX-RIC (missing in Open Source FlexRIC)

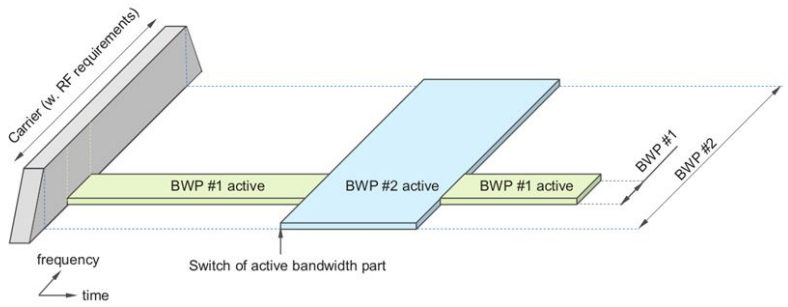
- ★ Key 3rd pillar to reconfigure a cell/node
  - ○ Offline reconfiguration
    - ■ Configuration e.g., ARFCN
  - ○ Online reconfiguration
    - ■ Control e.g., Bandwidth Parts

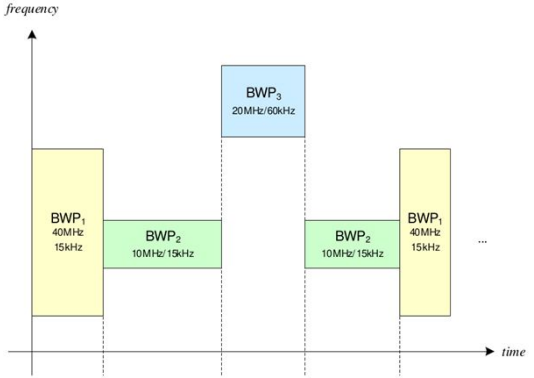
Bandwidth Part (BWP)

- ★ BWP is a procedure to configure a channel into multiple smaller segments.
- ★ Up to 4 different BWP can be defined in 5G.
- ★ Only one can be active at a time.
- ★ It saves energy for devices where full bandwidth is not required, but energy consumption matters.
- ★ It can avoid interference in the UE.

What is BWP?

Chunk of spectrum (numerology + RBs) For handling device capabilities or Lower energy consumption





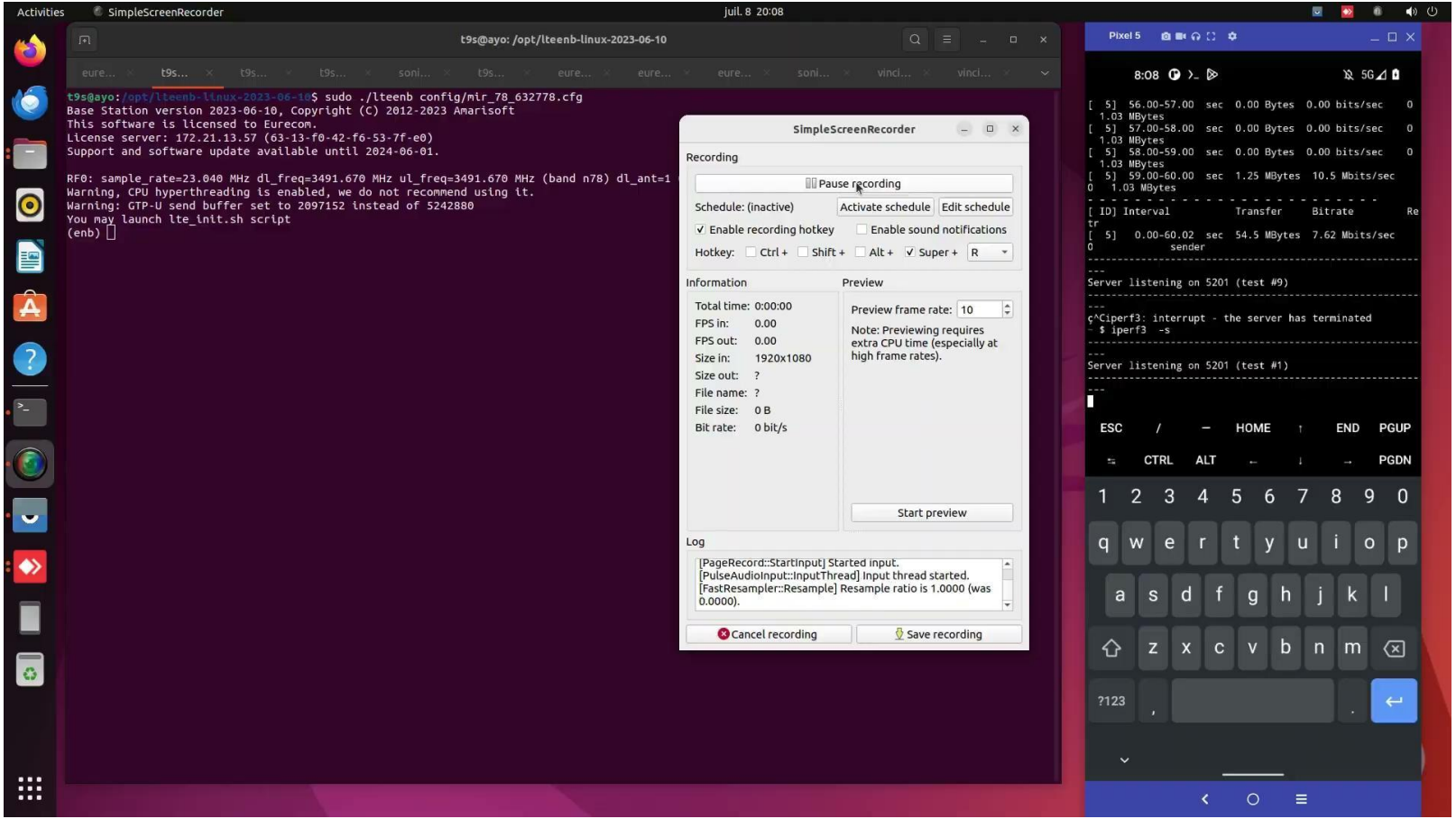
Dynamic BWP Demo Machines Configuration

Sonic: iperf generated traffic + Amarisoft CN

Ayo: xApp + NearRT-RIC + Proxy Agent + Amarisoft RAN

Google Pixel

🔴 LIVE DEMO: BWP



Takeaway

[Message] :

- ★ CCC supports runtime BWP and offline ARFCN configuration. More configuration and control are possible.

[KPI] :

- ★ Latency for the BWP configuration < 50 ms.
- ★ Seamless connection and service continuity

[O-RAN and 6G] :

- ★ Management and Control Convergence: Make Management Plane aware of the CCC actions
- ★ Merged techniques of BWP (CCC) and Slicing (RC) for fine-grained resource control

Overall Takeaway

[Message]:

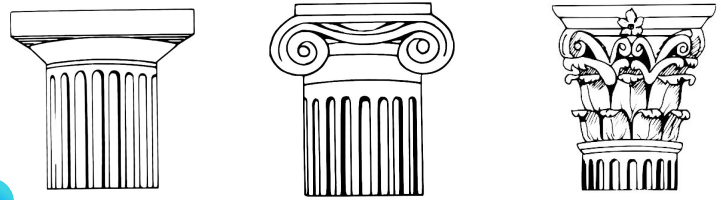
- ★ KPM, RC and CCC are the 3 necessary pillars to monitor and manage the RAN.
- ★ MX-RIC has the most feature complete ecosystem leveraging FlexRIC open source kernel.

[KPI]:

- ★ MX-RIC support low latency control loops to enable 6G use cases well below O-RAN limits e.g., 10 ms
- ★ MX-RIC support for multi-vendor deployments.

[O-RAN and 6G]:

- ★ O-RAN 3 SMs are necessary yet may not be sufficient for 6G use cases.



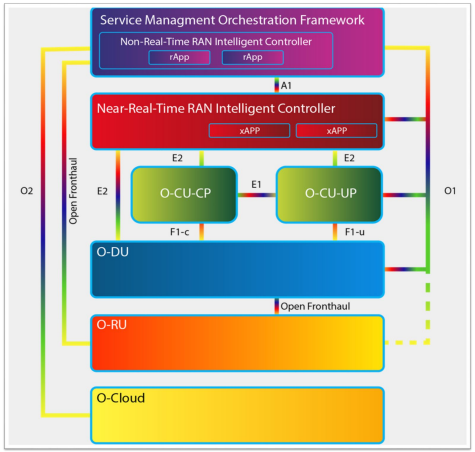
MX-RIC Features

Service Models	O-RAN SMs				Customized SMs					
	KPM		RC	CCC	MAC	RLC	PDCP	NGAP	SLICE CTRL	Traffic CTRL
	v2	v3	v1	V3						
OAI	v	v	v	TBD	v	v	v	v	v	v
srsRAN	NA	v	v	TBD	NA	NA	NA	NA	TBD	TBD
Amarisoft	NA	v	v	v	NA	NA	NA	NA	TBD	TBD
LiteON	NA	v	TBD	TBD	NA	NA	NA	NA	NA	NA

O-RAN and GenAI

O-RAN ecosystem enhanced with LAMs and LLMs

Full O-RAN Ecosystem



O1: SMO to all

O2: SMO to O-Cloud

A1: Non-RT RIC to Neal-RT RIC

E1: O-CU UP and CP

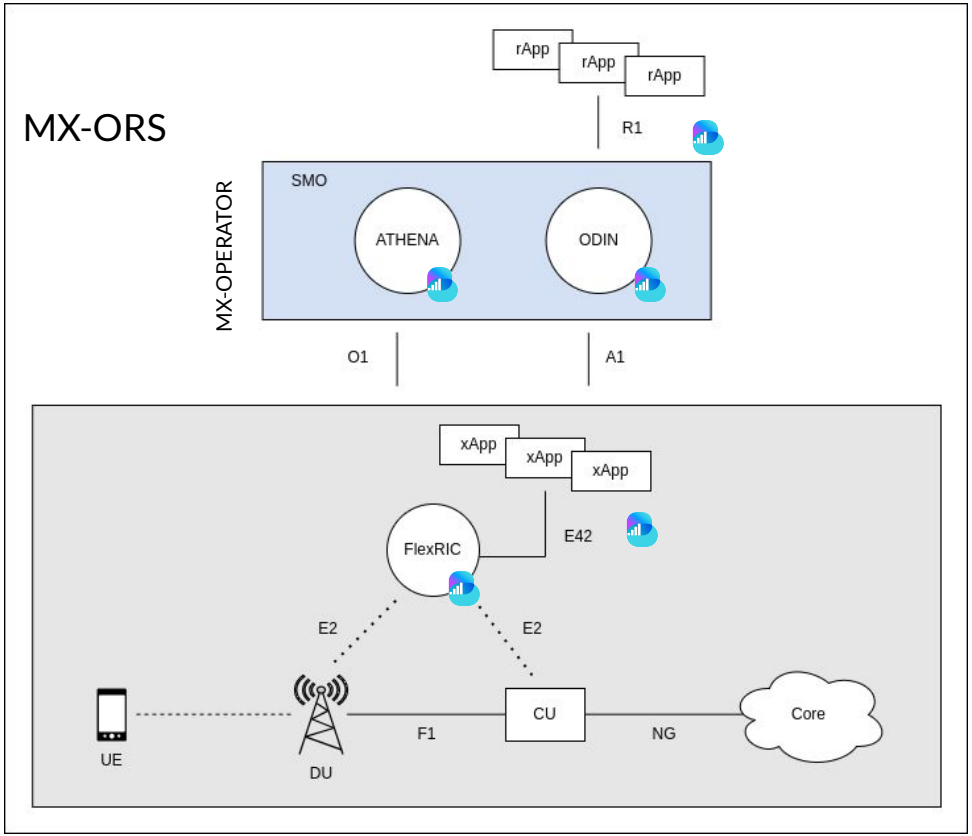
E2: Neal-RT RIC to E2 Nodes

F1-C: O-CU CP to O-DU CP

F1-U: O-CU UP to O-DU UP

Open Fronthaul(7.2): O-DU to O-RU

ODIN = Observable Distributed Intelligent Networking

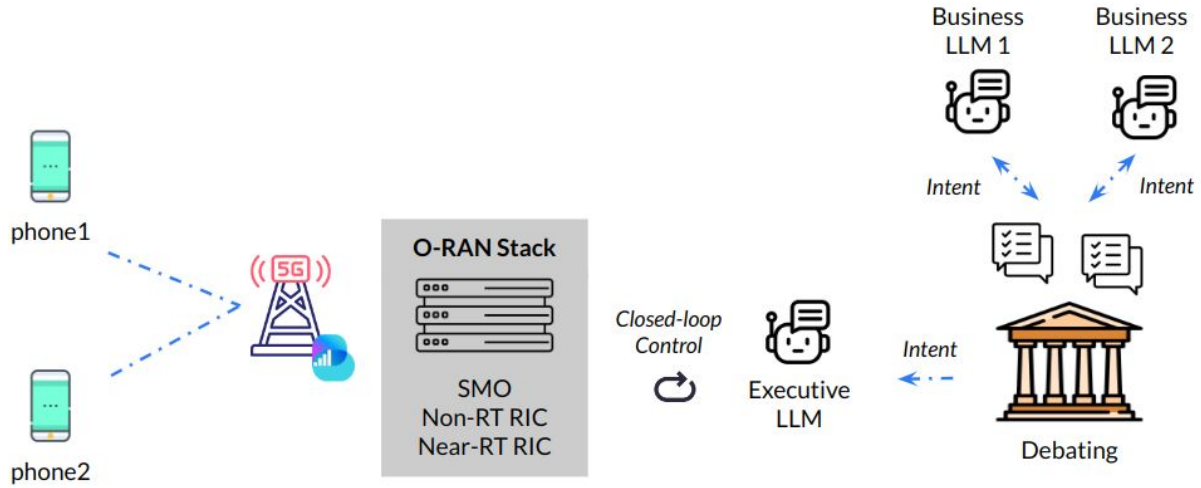


6G Use cases: GenAI LAMs/LLMs

- **Demo 1 :** Throughput SLA Negotiation and Optimization with RC (Slicing)

- **Demo 2:** Mobility and Spectrum Management with RC (Handover) and CCC (Cell Reconfiguration)

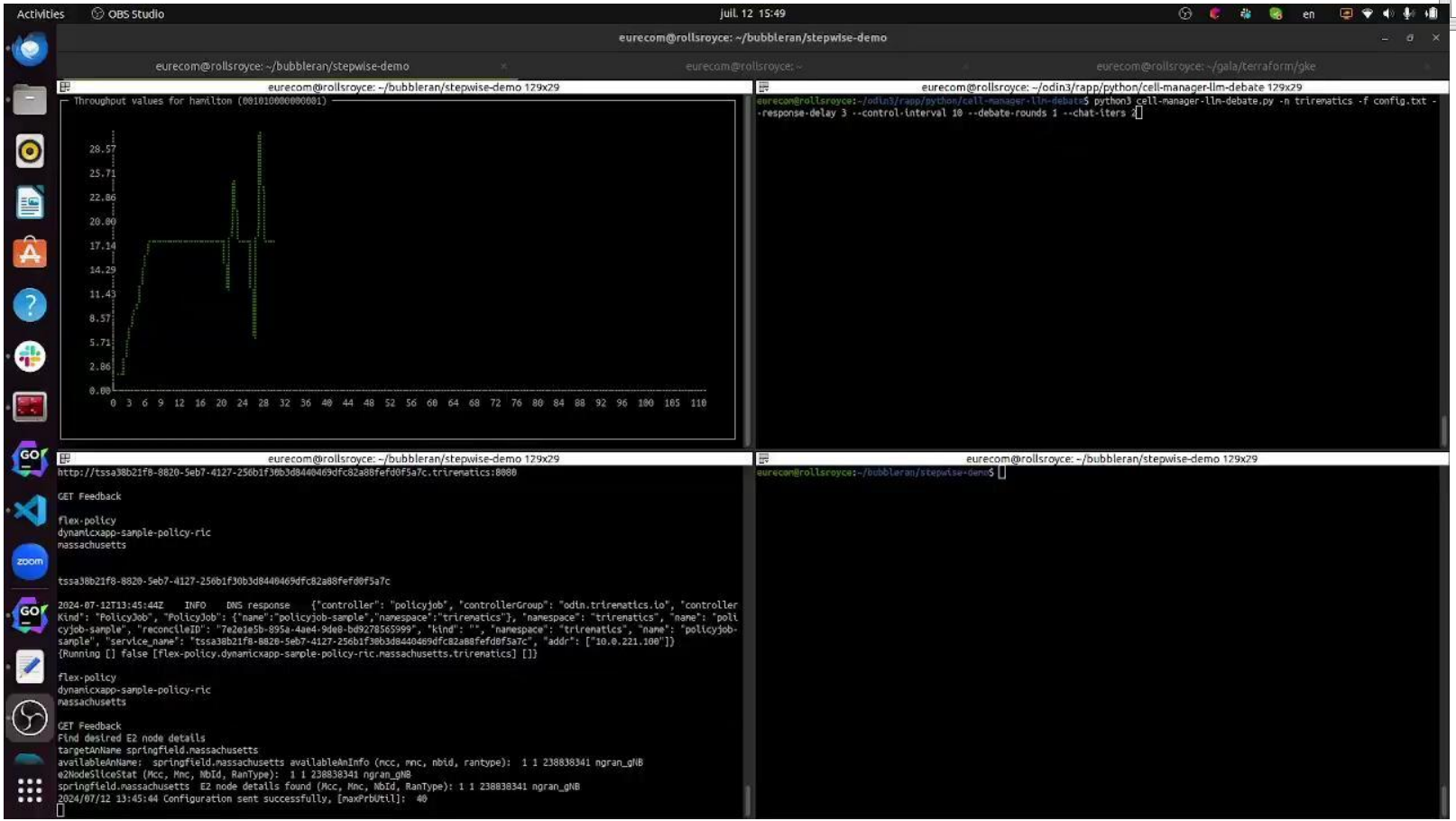
Collaborative LLMs: SLA Negotiation & Optimization



- ★ Intent-Based Networking (IBN)
- ★ Multi-level O-RAN APIs
- ★ Shared Network across many Business Parties

- ★ Resource Negotiation - Debating
- ★ Conflict Resolution (Consensus)
- ★ Closed-loop Operation
- ★ End-to-end Automation

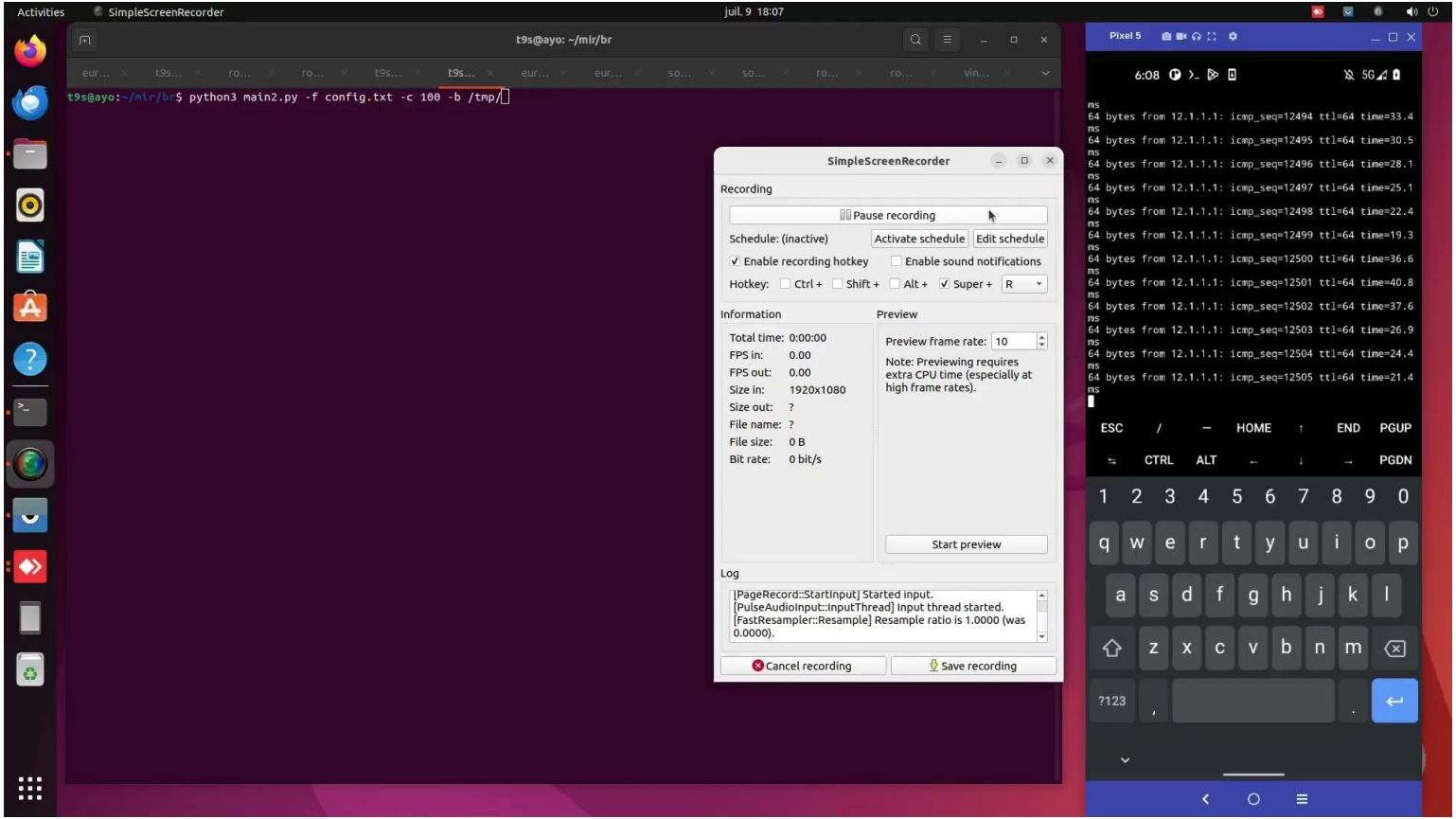
Collaborative LLMs: SLA Negotiation & Optimization



LLM Mobility and Spectrum Management Demo

1. LLM Negotiation on Spectrum Sharing and Cost
2. LLM receives available Spectrum Offers
3. LLM choses to configure a gNB to another Band
4. All UEs are moved to a neighboring gNB through a HO based on RC
5. The gNB is reconfigured with a new band accordingly based on CCC
6. LLMs reconnect the previous UEs to the newly reconfigured cells

LLM Mobility and Spectrum Management Demo



Takeaways

[Message] :

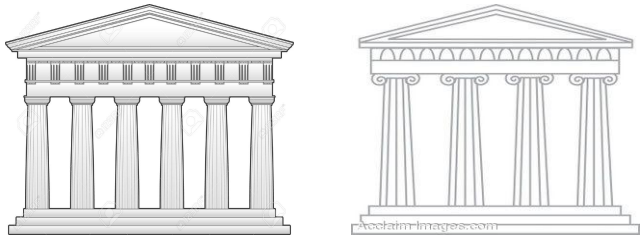
- ★ Through basic building blocks i.e., KPM, RC and CCC, RIC, SMO Realistic 6G Use Cases can be realized

[KPIs] :

- ★ Spectrum agility can be in the order of score of seconds
- ★ LLM inference speed < 1s
- ★ LLM convergence around 2-3 iterations

[O-RAN and 6G] :

- ★ FR3 spectrum management use cases
- ★ Citizens Broadband Radio Service (CBRS) use cases
- ★ LLM assisted 6G RAN Slicing



O-RAN and 6G

O-RAN ecosystem for 6G

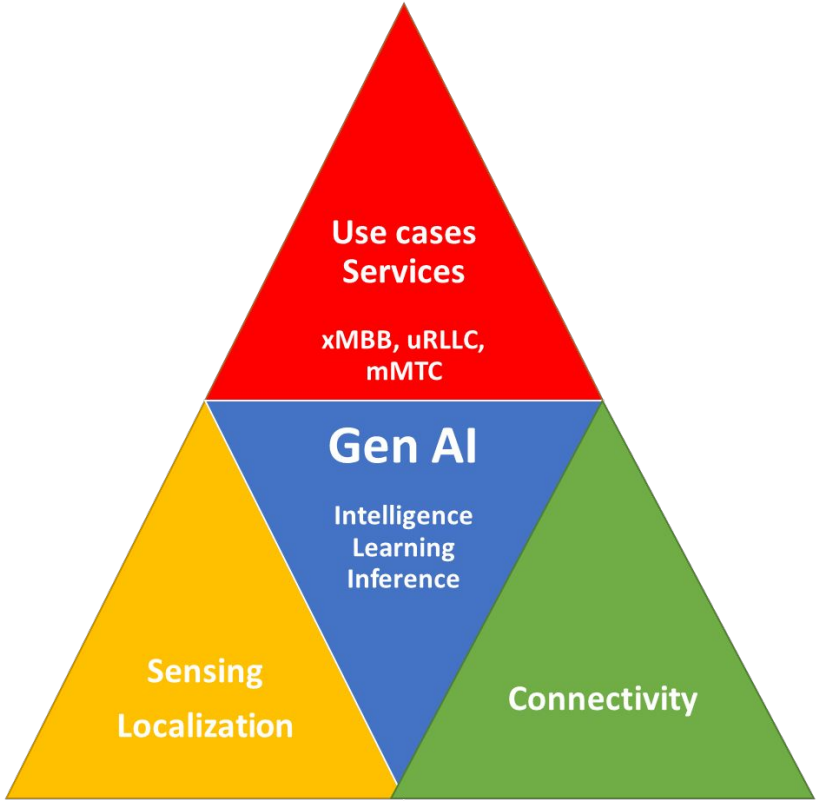
Toward 6G

6G is beyond just connectivity

- ★ Fusion of physical and digital → DT
- ★ Emerging Applications & Services
  - ○ Collaborative Communication and Computing
  - ○ Intelligent Digital twinning
  - ○ Metaverse
  - ○ Extended reality (XR)

GenAI at the center of 6G

- ★ Intelligent Optimization
- ★ Simplification of Control & Management
- ★ Abstraction of Objectives



Thinking outside the box, on the road to 6G

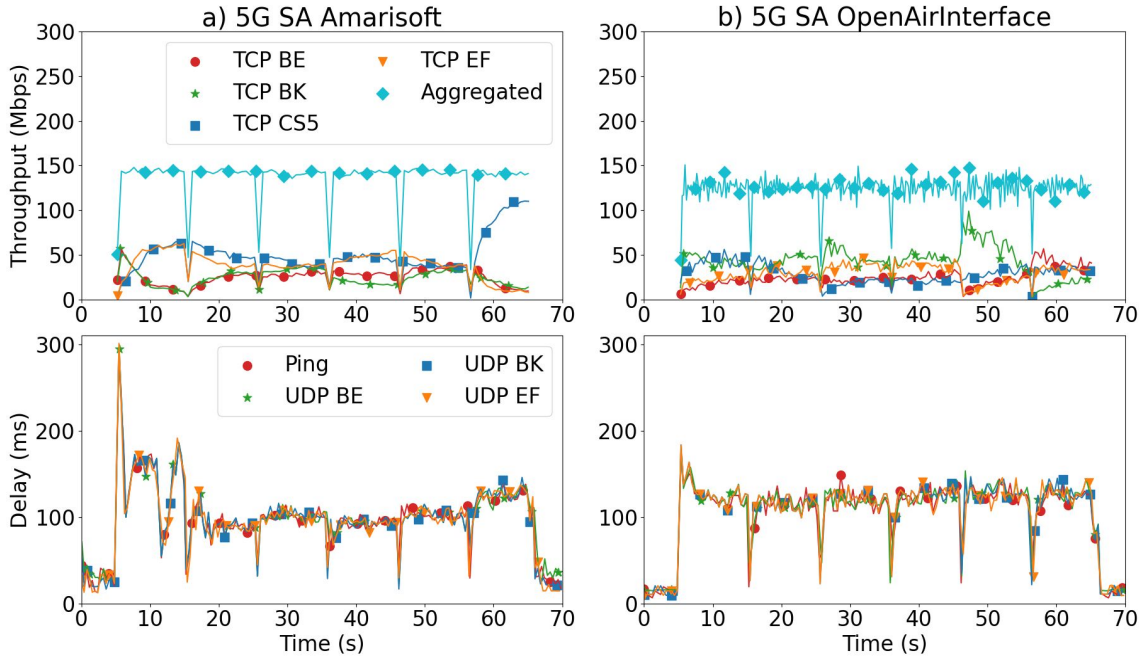
Two directions:

- **QoS:** Bufferbloat in 5G, TC SM and application level QoS
  - Demo: YouTube video behaviour using TC

- **ISAC:** 3D mapping with Sensing, Localization and Positioning

Bufferbloat in 5G

- ★ **Latency is perceived at the application!**
- ★ Contemporary gNBs are the slowest data link in the flow path, and thus are likely to suffer from the bufferbloat phenomenon.



Low Latency, Low Loss and Scalable Throughput (L4S)

- ★ To handle it, in 5G 3gpp Release 18, Low Latency Low Loss and Scalable Throughput (L4S) has been proposed.
- ★ L4S marks the IP packets at PDCP once it detects that bufferbloat is happening at the RLC buffer.

5.37.3.2 Support of ECN marking for L4S in NG-RAN

"To enable ECN marking for L4S in NG-RAN, dedicated QoS Flow(s) are used for carrying L4S enabled IP traffic. [....] The criteria based on which NG-RAN decides to mark ECN bits for L4S is NG-RAN implementation specific"

3gpp V18.5.0 (2024-05)

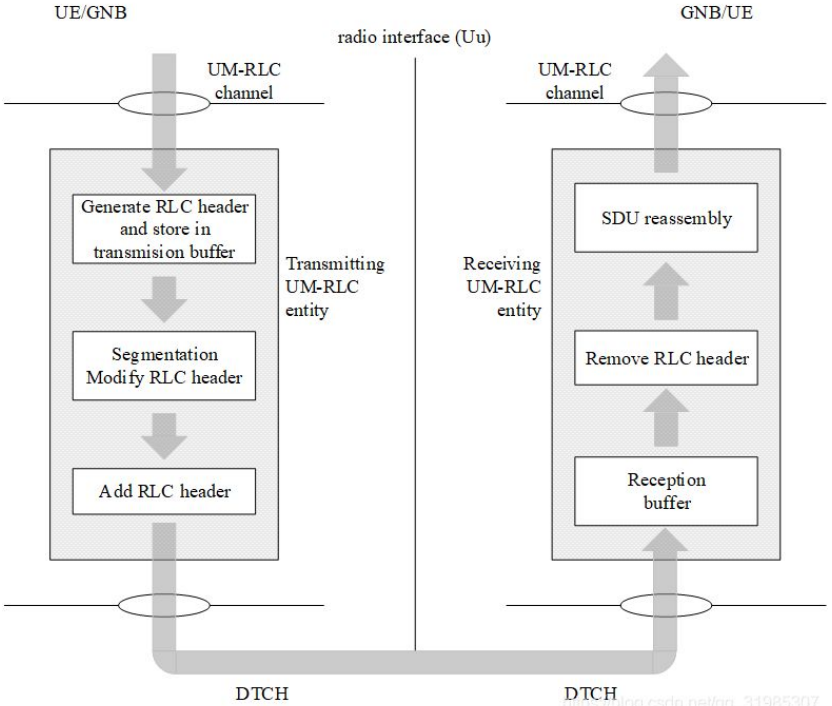


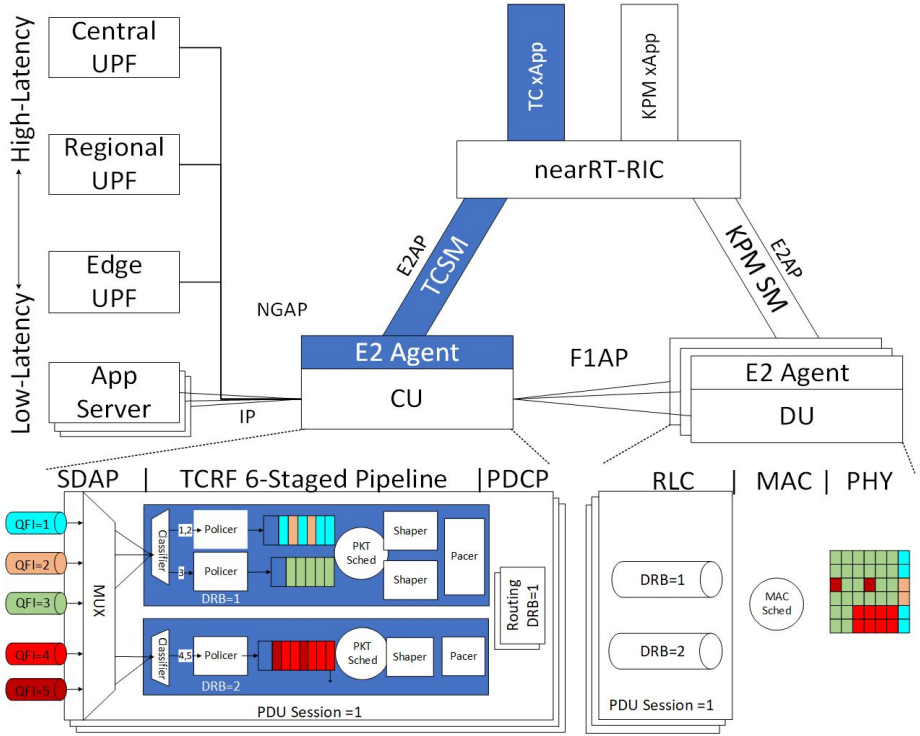
Figure credits: 3GPP

BubbleRAN's approach to the bufferbloat

We developed a Traffic Control SM with 6 stages i.e., policer, classifier, queue, scheduler, pacer and shaper as *.so.

- ★ Classifier: Type of the packet
- ★ Policer: Let it pass/drop/redirect
- ★ Queue: CoDel, FIFO, ECN
- ★ Scheduler: Priority, RR
- ★ Shaper: Shape the BW per queue
- ★ Pacer: Avoid bloating the RLC buffer

- **TC is a superset of L4S**



[TC-RAN: A programmable traffic control service model for 5G/6G SD-RAN]

[Programmable Traffic Control Service in Open RAN for Reducing Latency]

Additional BubbleRAN's TC SM Features

★ **Classifier:** Has been enhanced with a deep packet inspector (nDPI), capable of segregating among more than 100 flows e.g., YouTube, Twitch, Spotify, Zoom, ads/analytics…

★ **Challenge is to model applications behaviour and provide control loops that optimize the traffic.**

- E.g., Youtube > 30 flows e.g., TCP, UDP, QUIC, DNS, and data packets arrive in batches according to the data path bandwidth and latency, which can be monitored (KPM/RC) and dynamically controlled (RC/CCC).
- Additionally, applications adapt to the network status dynamically.

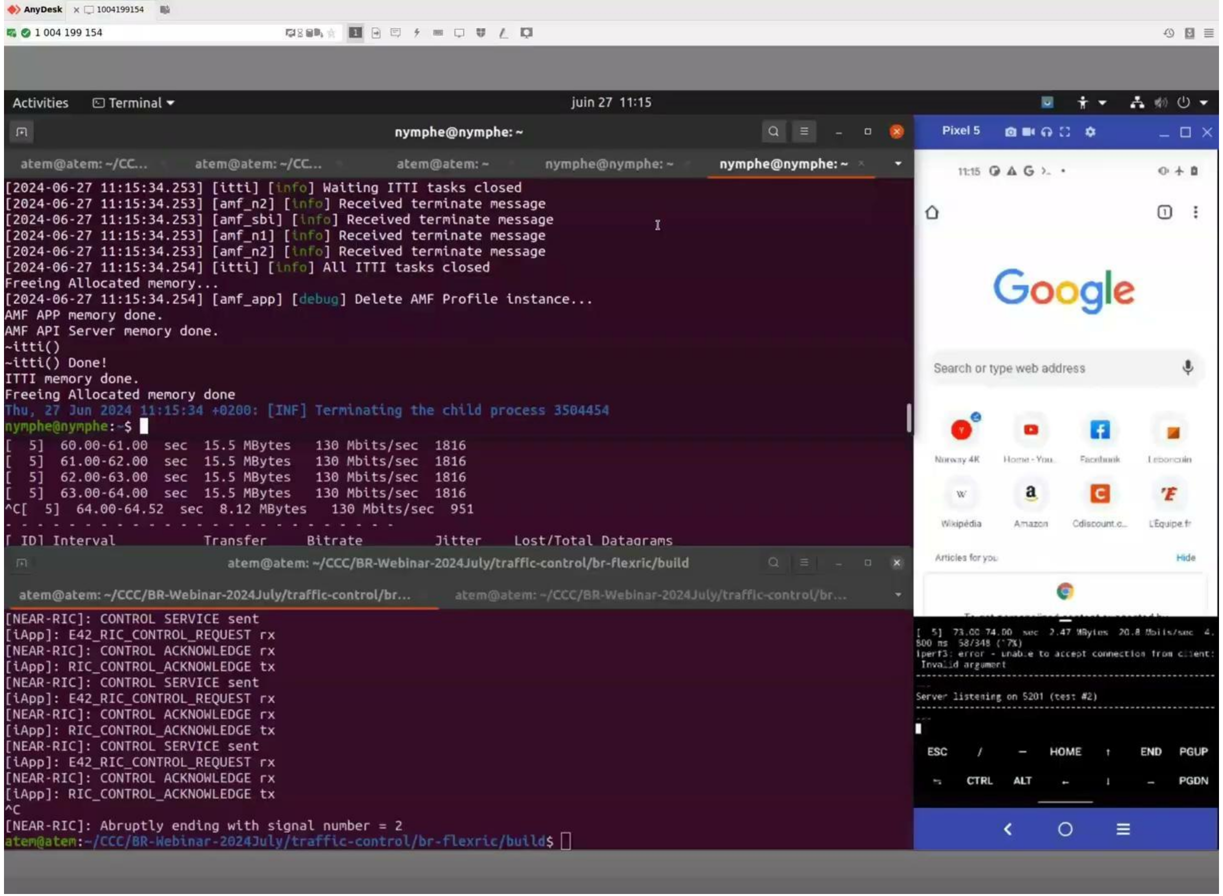
TC Demo Machines Configuration

Nymphe: CN

Atem: gNB + nearRT-RIC + tc xApp

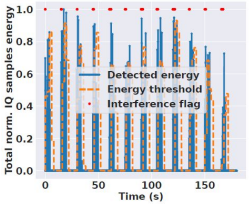
Pixel 5

🎬 VIDEO/LIVE DEMO: TC



3D mapping with Sensing, Localization and Positioning (SLP)

- ★ BubbleRAN is introducing a new custom service model in support of 6G ISAC use case
- ★ **SM data model:** I/Q samples (+SRS) to passively sense and construct the physical environment
  - Multi-cell, Multi-Antenna, Multi-RAT/Frequency (WiFi, 5G sub 6, 5G mWave)
- ★ **Example xApps and their outputs:**
  - RSSI, BLER, Relative position, Observed spectrum energy
  - Interference detection (Background Spikes)
  - Heatmap, 3D Maps
  - Object Classes/Action Recognition, Trajectory Tracking/Collision Avoidance



Note:

- ★ Demand for low-latency and huge amount of data (e.g., 5MHz 15 KHz gNB with a slot of 1 ms generates 25 Resource Blocks x 12 subcarriers x 14 resource elements x 1000 ms x 4 bytes I/Q sample = 16.8 MBytes/s)

Example Use-cases:

- ★ Goal-Oriented Intelligent Connectivity
- ★ Digital Twining
- ★ 3D network/crowd maps

Promotion and Close Session

- Open RAN Mini-Series are a forum to share knowledge and foster academia-industry collaboration
  - We value your feedback to improve the quality, format and the content of upcoming series
- To this end, Open RAN Studio platform is designed with the following objectives
  - Empower communities and organizations to accelerate the adoption of modern technologies
  - Solid ground for tutoring the next generation researchers and engineers
  - Reproducible/verifiable and consistent outcomes for teaching and research
  - Affordable and accessible means for education and research
  - Opening new possibilities and dimensions via multi-disciplinary research
- BubbleRAN's Release in **autumn** would contain all these features available
  - Access to the source code for SDKs would packaged separately
  - Checkout the br-flexric branch on open source FlexRIC for more details
- Official early support for 7.2 via LiteON and OAI
- Official support for O1 for LiteON AIO and O-RU products

Linkedin: https://www.linkedin.com/company/bubbleran

Youtube: https://www.youtube.com/@bubbleran

Email: contact@bubbleran.com

https://bubbleran.com/products/mx-ors/

Q & A

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