RAN OPTIMIZATION THROUGH CONTROL LOOP AUTOMATION

5G-LOGINNOV joint technical workshop

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RAN optimization through control loop automation (1)

Objectives:

Adopt **open software solutions** and embrace the concept of **Zero-Touch Automation (ZTA)**.

- ***Towards Open-Source Software:*** Adoption of the *open-source software solutions* following O-RAN specs with respect to AI/ML workflow (control loop 2).

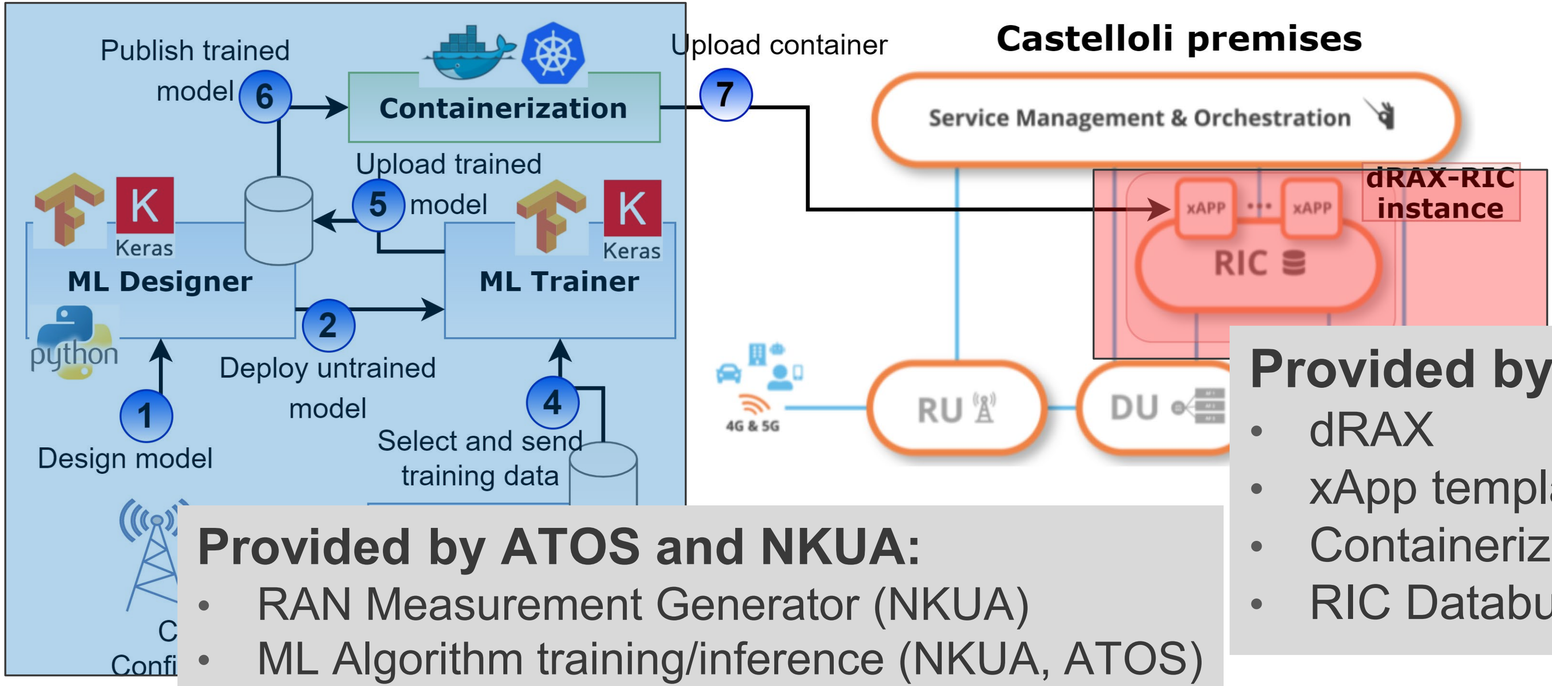
- ***Towards ZTA:*** Designing, Implementing and Testing of an accurate *Deep Reinforcement Learning (DRL)* algorithm, combined with automated *model serving (TensorFlowServing-TFS)* for RAN ZTA and optimization.

RAN optimization through closed-loop automation (2)

Key Features:

- 4G/5G RAN configuration through the **Near-RT RIC (dRAX)**.
- Implementation of a **5G-compliant simulator** for RAN measurement generation (3GPP urban channel models).
- Implementation of an O-RAN compliant **xApp** for network optimization.
- Reconfiguration of O-RU transmit power for **throughput maximization** based on the outcome of a **DRL model**.
- Support and integration of an automated **model serving tool (TFS)** for real-time inference at the dRAX (**control loop 2**).
- Practical implementation of a theoretically-validated DRL model in **commercial product (dRAX)**.
- Real deployment in **Castelloli premises** and network.

Steps in a nutshell

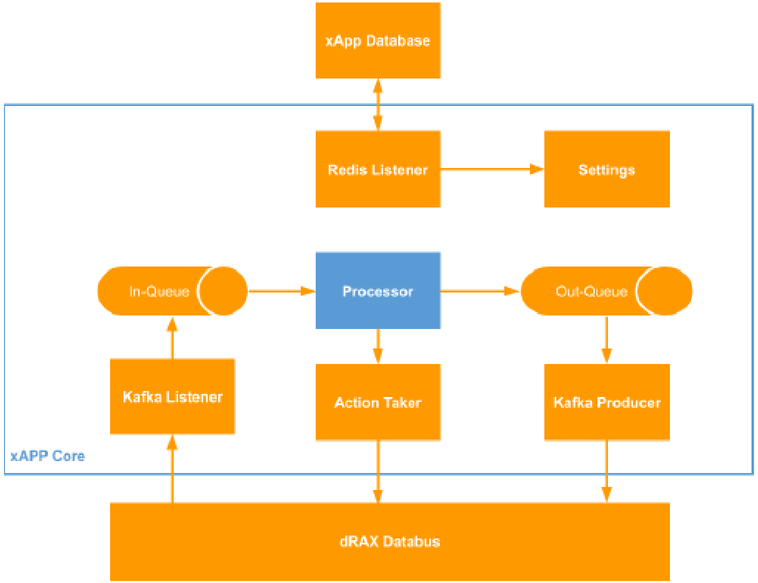


Provided by ACC:
- dRAX
- xApp templates
- Containerization
- RIC Databus

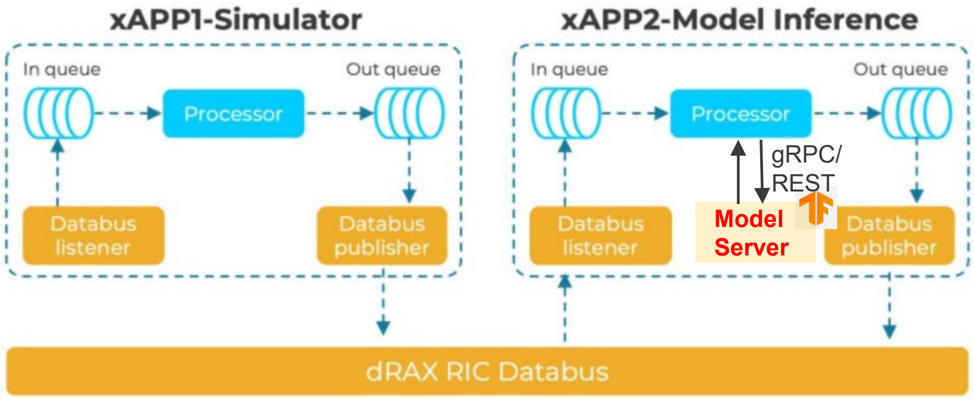
Provided by ATOS and NKUA:
- RAN Measurement Generator (NKUA)
- ML Algorithm training/inference (NKUA, ATOS)
- TensorFlowServing module (ATOS, NKUA)

xApps Outline

(i) xApp Internal Structure



(ii) Data generation and model inference cycle



POSS: a Python Open-Source Simulator for 5G systems

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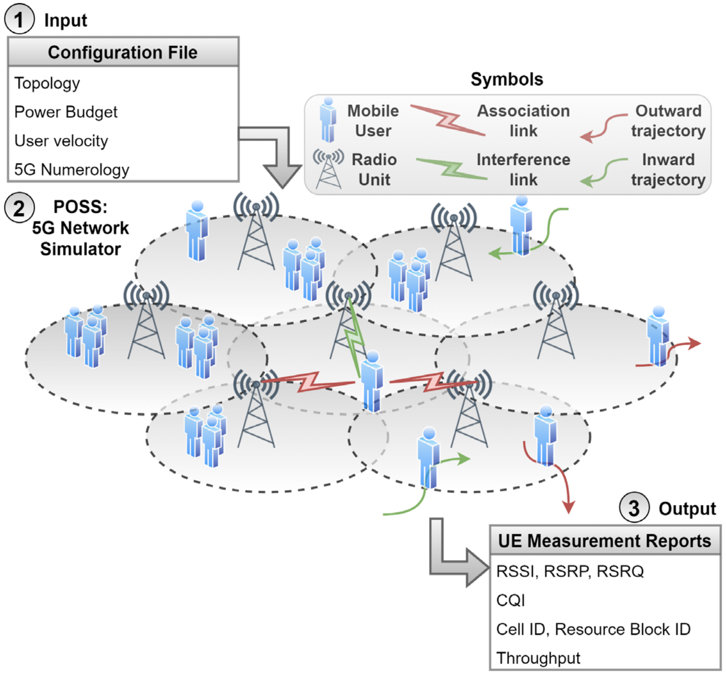
- A general-purpose flexible 5G simulator is built in the form of xApp.
- Flexible topology, power budget, user characteristics, 5G numerology.
- Respects the maximum/minimum power budget limitations.
- Interference, channel and bit-rate calculations based on 3GPP/5G specifications of UMa/UMi.
- Association based on maximum throughput criterion.
- Random Walk and Handover calculations.
- Outputs 7 metrics:
  - Receive Strength Signal Indicator (**RSSI**), Reference Signal Received Power (**RSRP**), Reference Signal Received Quality (**RSRQ**), Channel Quality Indicator (**CQI**), associated **RU ID**, associated **PRB ID** and UE experienced **throughput**



Throughput Optimization algorithm

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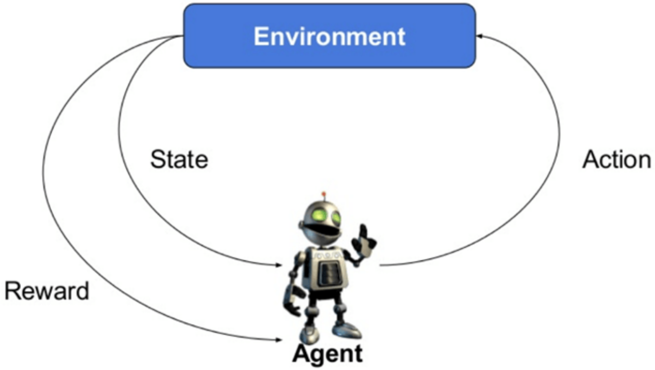
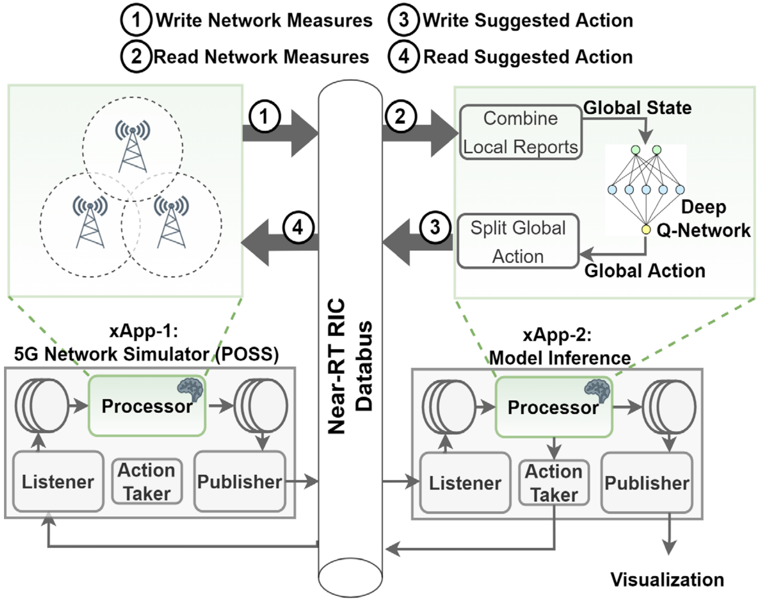
- Network-wide throughput maximization through power regulation.
- Proper adjustment of power levels, while simultaneously mitigating the co-channel interferences.
- DRL terminology: The centralized **agent** (the near-RT RIC) interacting with a telecom **environment** (cellular areas) aims to maximize the **objective function** (the network throughput) by observing the **state space** (the measurement reports) and taking **actions** (power level adjustments).
- Following a trial-and-error approach, the agent gradually converges in power control policy that ensures increased network utility.

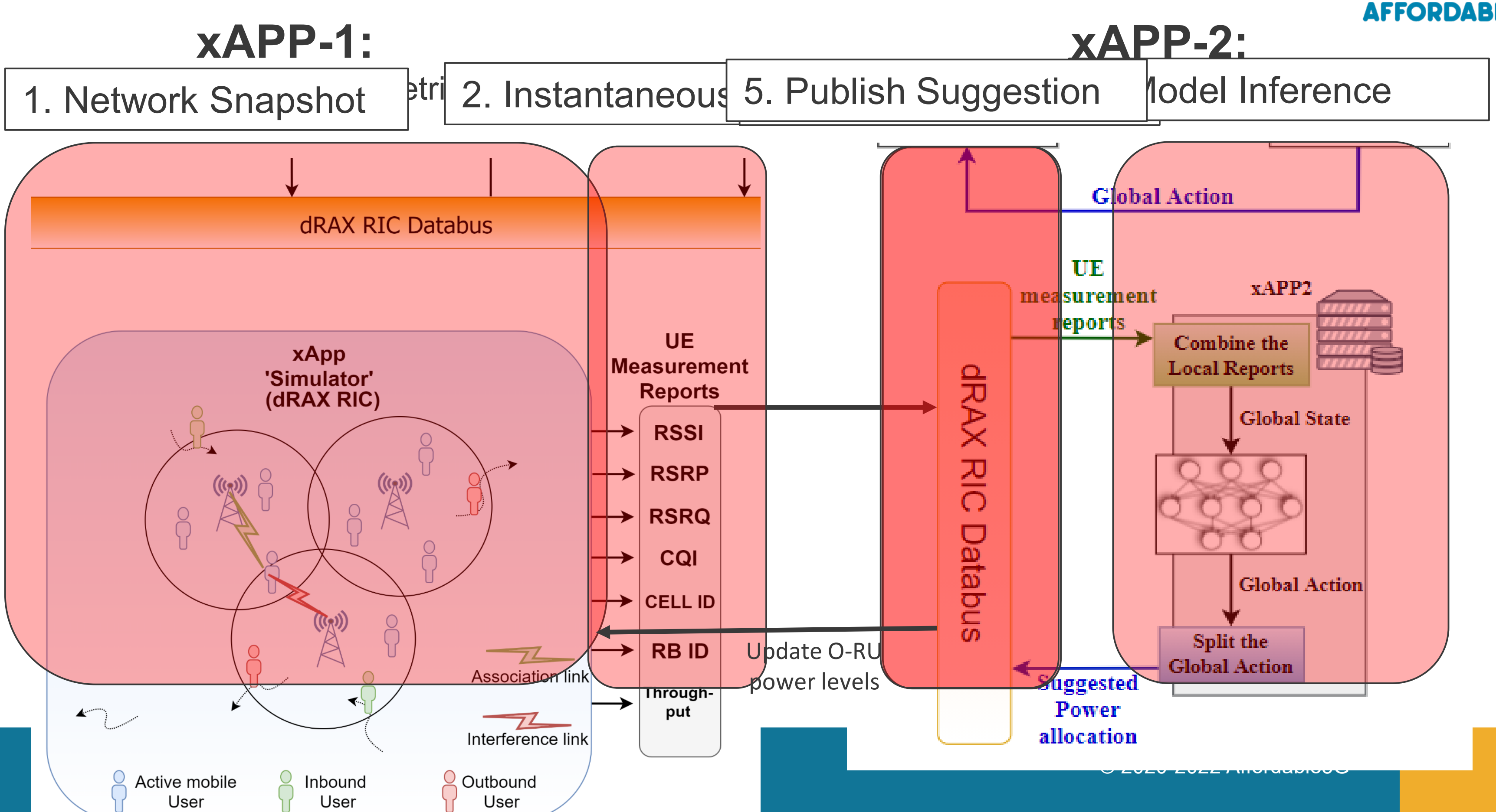


Network Automation through xApps

- Practical implementation and interaction of the POSS and the DRL agent was deployed in the form of xApps in the near-RT RIC.
- **xApp1**: generates **5G-compliant measurement reports** of UEs in a configured network topology.
- **xApp2**: pre-trained DRL agent. It reads the **measurement reports** from the Databus and infers the DRL model to get the **corrective power levels**.
- This process is **continuously repeated** to visualize the time-course of the model inference performance.
- Diverse objective-specific AI/ML models can be deployed, dockerized and stored in a dedicated ML catalogue for potential future inference.

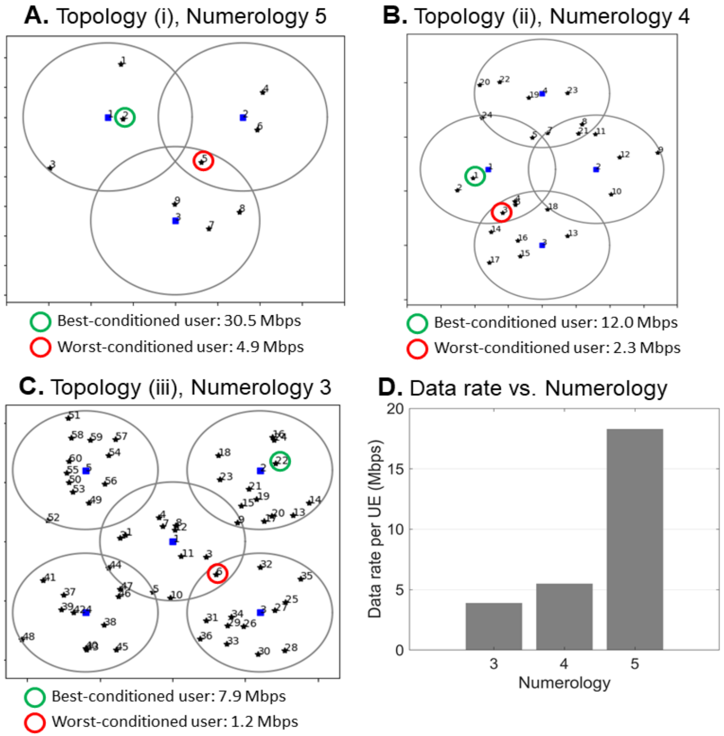


A closer view on xApps



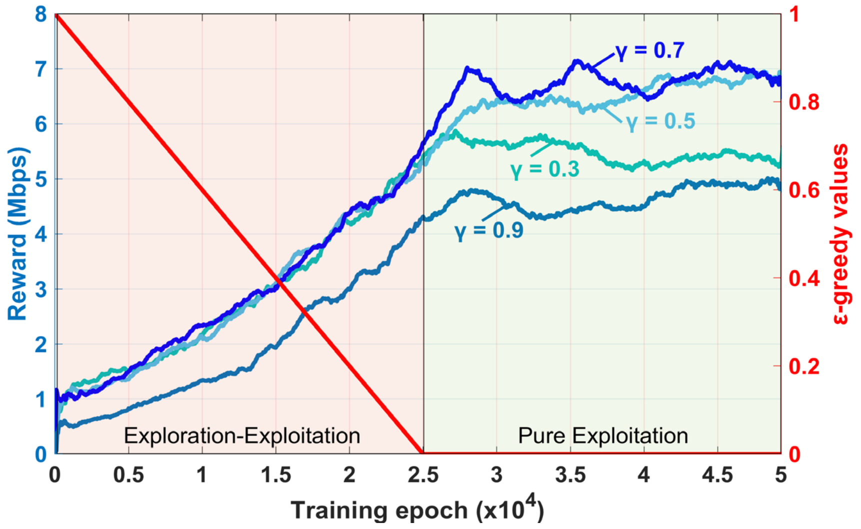
xApp1: Simulator Functionalities

- 3 configuration scenarios of the simulator are considered, parameterized as full-capacity scenarios:
  - with a **3-cell topology** and **numerology 5** (**3 PRBs** per RU, each one with bandwidth **5.76 MHz**)
  - with a **4-cell topology** and **numerology 4** (**6 PRBs** per RU, each one with bandwidth **2.88 MHz**)
  - with a **5-cell topology** and **numerology 3** (**12 PRBs** per RU, each one with bandwidth **1.44 MHz**).
- Heterogeneous demand points: fixed reception points/PCs (0m/s), pedestrians (1m/s) and vehicles (10–20m/s).
- Average UE data rate is positively correlated with the numerology.
- UE capacity decreases with the numerology

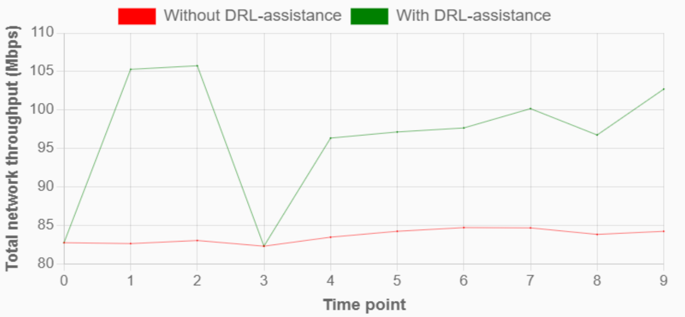


xApp2: Training &Evaluating the DRL agents

- **Offline training** prior deployment as xApp.
- Training process was performed with **simulated measurements** by the POSS simulator.
- In each training episode, the initial power levels are set to the **average power level**.
- Discount factor (γ) is associated with the extent to which the agent prefers **immediate (γ=0) or future (γ=1)** rewards.
- Learning curve of the training **with ε-decaying.**



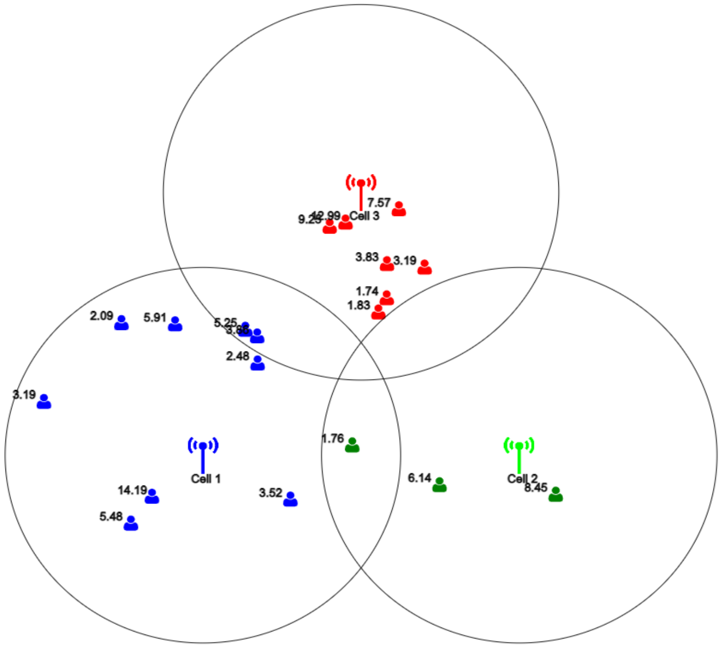
Overall Assessment: Integrating xApp1/xApp2



Instantaneous Power Levels

0 Watt — 25 Watt

	Rb1	Rb2	Rb3	Rb4	Rb5	Rb6	Rb7	Rb8	Rb9	Rb10	Rb11	Rb12
Ru1	1.27	2.34	0.78	2.06	34.33	5.88	5.57	4.32	1.98	4.36	5.87	6.48
Ru2	5.69	6.51	0.10	4.09	0.10	3.86	6.21	3.48	3.14	5.59	0.10	2.60
Ru3	2.38	4.35	2.01	1.53	4.83	5.59	5.43	0.10	35.82	5.73	0.10	0.10



Conclusions & Take-aways

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Main Outcomes:

- Development of a **general-purpose 5G simulator** based on 3GPP specs.
- Coupling between **O-RAN optimization & model serving** capabilities towards reaching ZTA.
- **General development framework** to support multiple xApps.
- **Synergy** between industrial and academic partners (ACC-ATOS-NKUA).
- **Knowledge transfer** from published research papers to commercial software.

Future Extensions:

- Replacement of the xApp-Simulator with real eNB/gNB and measurements.
- Accuracy improvements, addressing also the Energy-Efficiency aspect.
- Extension of the open source toolset, especially for the training phase automation (Model Orchestration Platforms, AirFlow adoption)

Partners

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Atos

ADVA Optical Networking

cellnex

Accelleran Small Cells, Done Right

ATHONET

Think Silicon ultra-low power | vivid graphics

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THANK YOU FOR YOUR ATTENTION