Open Networking Foundation

RAN Energy Saving with Traffic Steering

Intel Labs/i14y Labs/ONF/Rimedo Labs/Tietoevry/Viavi Solutions

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Introduction

ONF's Initiatives Around Open RAN - Aether

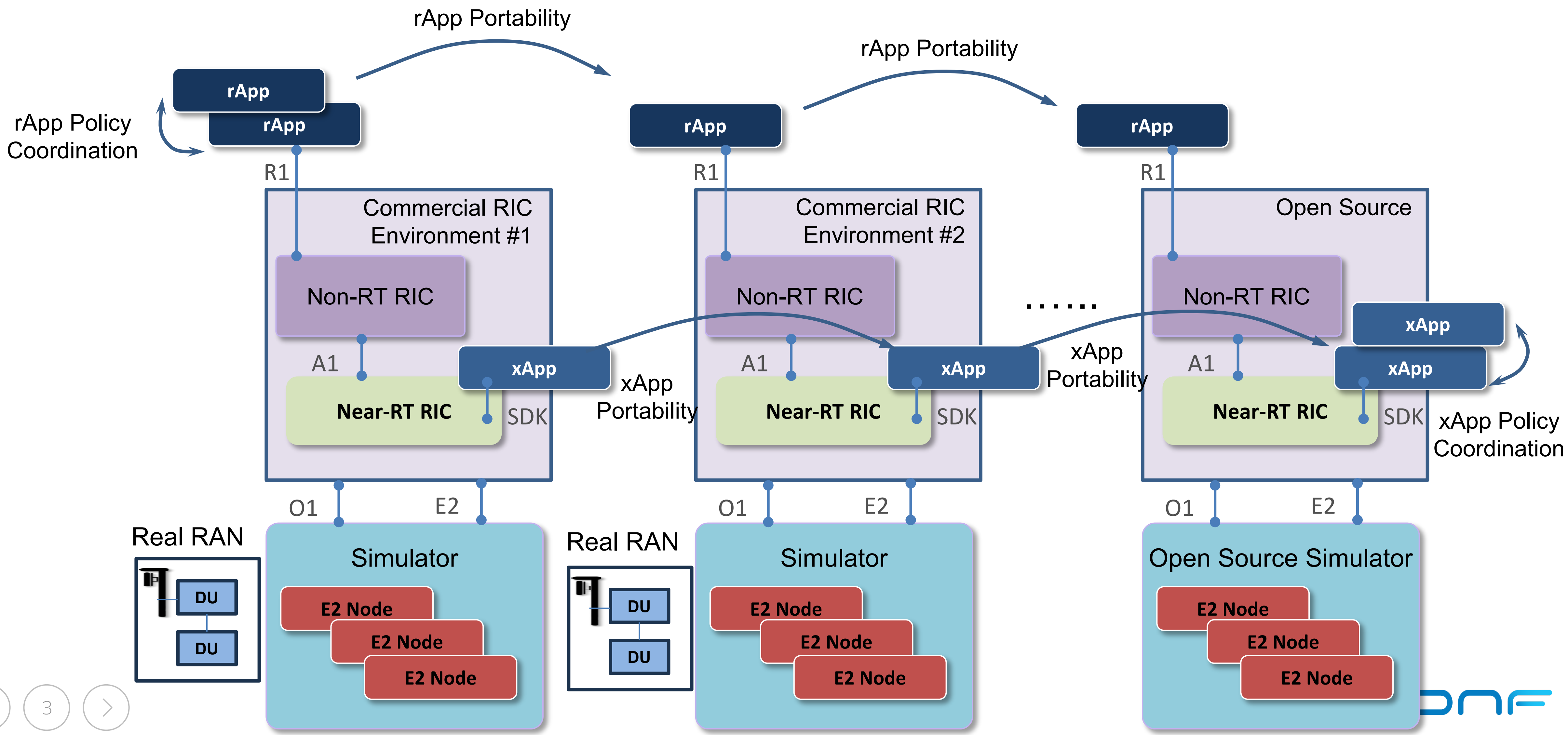
- SD-Core → A cloud native 5G Mobile Core
- SD-RAN → Near-RT RIC, several exemplar xApps/rApps, and a RAN Simulator
- AMP → A cloud-based management plane integrating all the Aether components

OPEN SOURCE PROJECTS

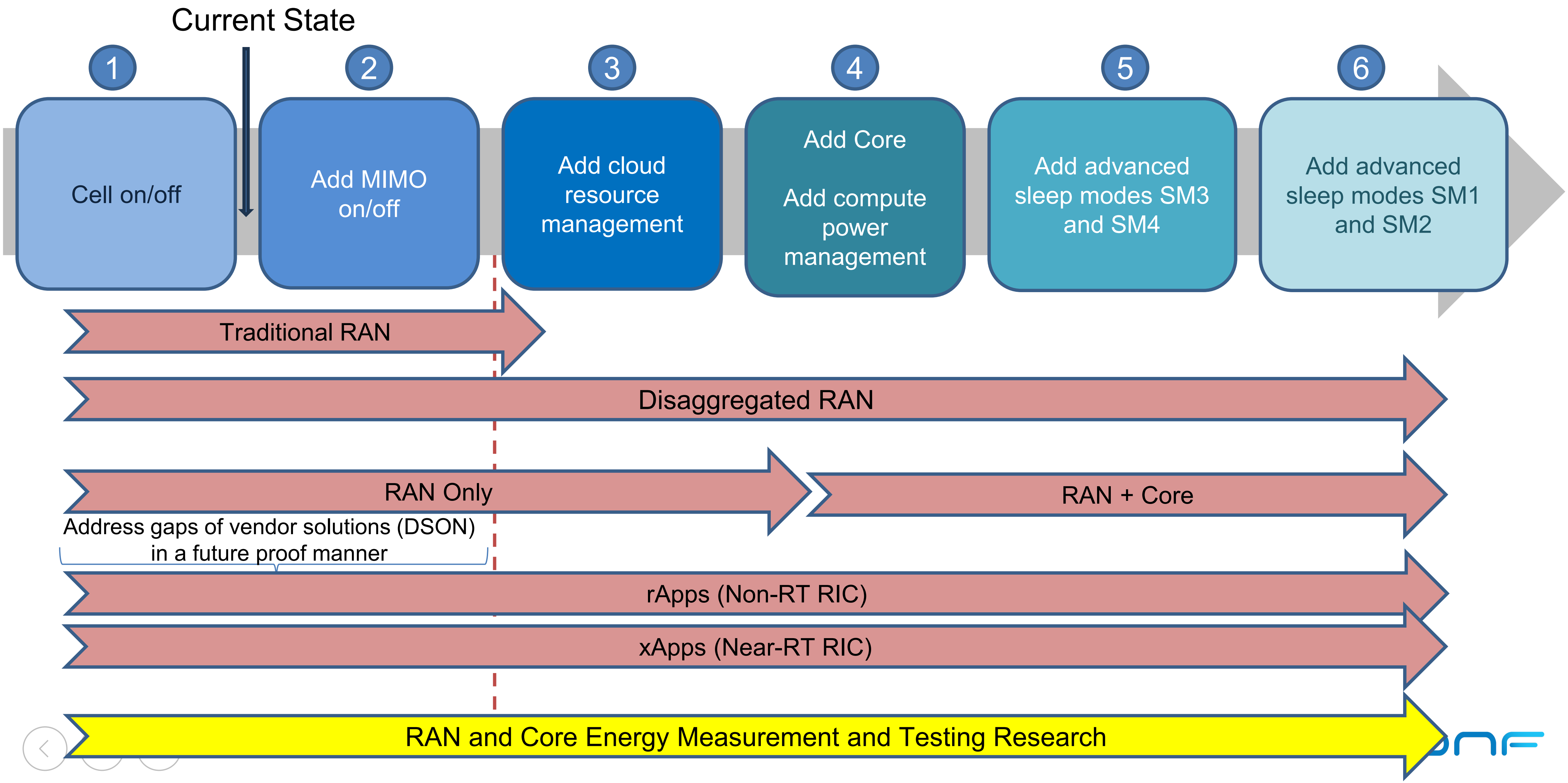
- **SMaRT-5G → A series of PoCs around RAN/Core Sustainability**
- **RRAIL→ Collaborative physical/virtual lab environments to evaluate interoperability and application portability – a key enabler of SMaRT-5G**

OPEN SOURCE AND COMMERCIAL SOLUTIONS

RRAIL: Key Enabler of SMaRT-5G and Other Open RAN Use Cases



SMaRT 5G - ONF 5G Energy Savings Use Case



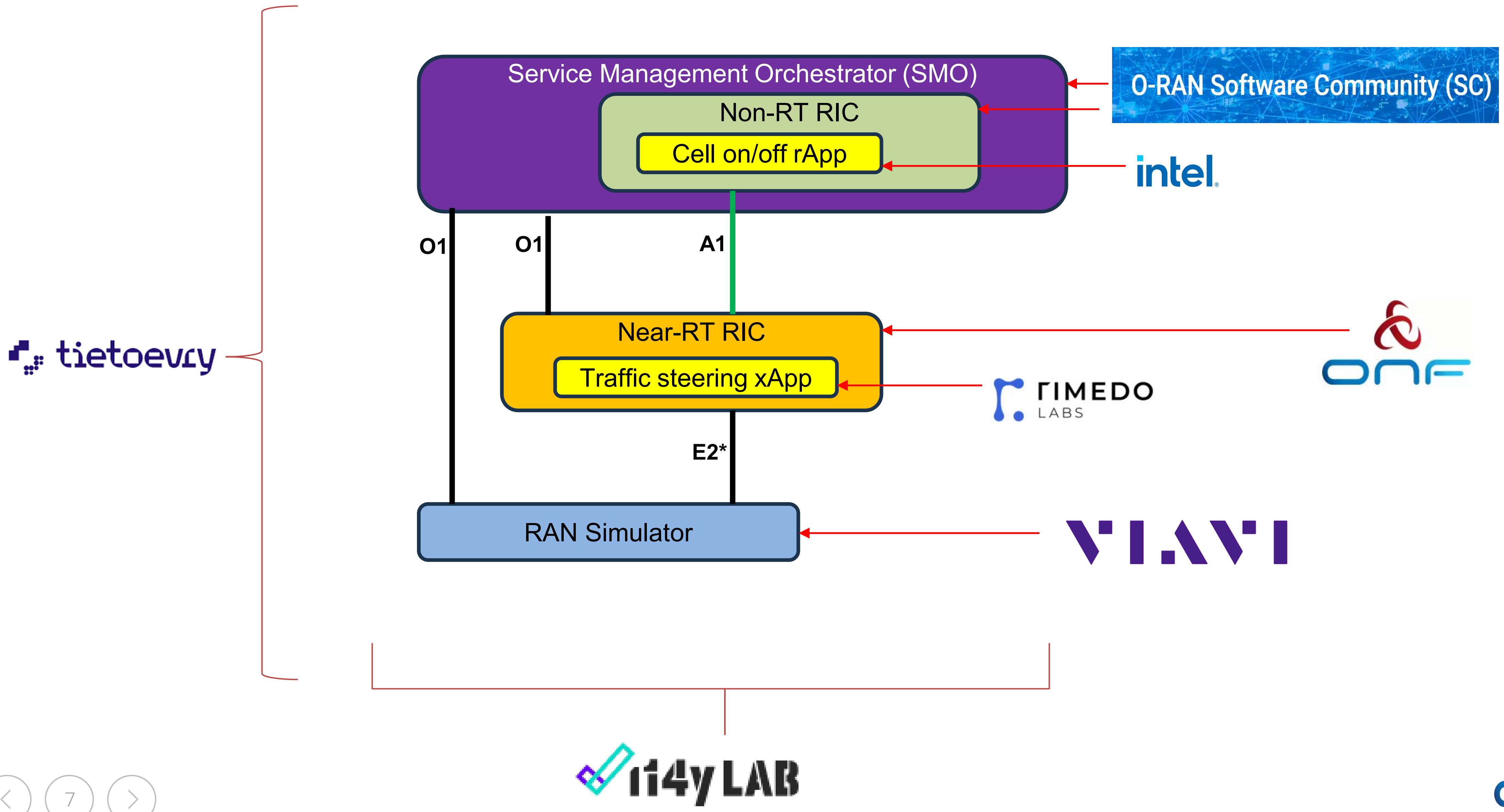
Demo - Highlights

- RAN energy saving and traffic steering coordinated under one demo
    - Cell on-off rApp
    - Traffic steering xApp
- All key O-RAN compliant elements are interfaces included
    - Near-RT RIC, Non-RT RIC, SMO
    - A1, O1, and E2* interfaces
- rApp and xApp are from different vendors
    - Demonstrating interoperability
- Open source Near-RT RIC, Non-RT RIC and SMO
    - Integrated under the ONF RRAIL umbrella
- Commercial RAN Simulator
    - A realistic representation of O-RAN compliant RAN
- Energy saving AI/ML models for rApp trained on real network data

With a commercial simulator and using real network data to train AI/ML models, and then using simulated network data to fine tune the models for the specific scenario, results are expected to be very close to real network scenarios.

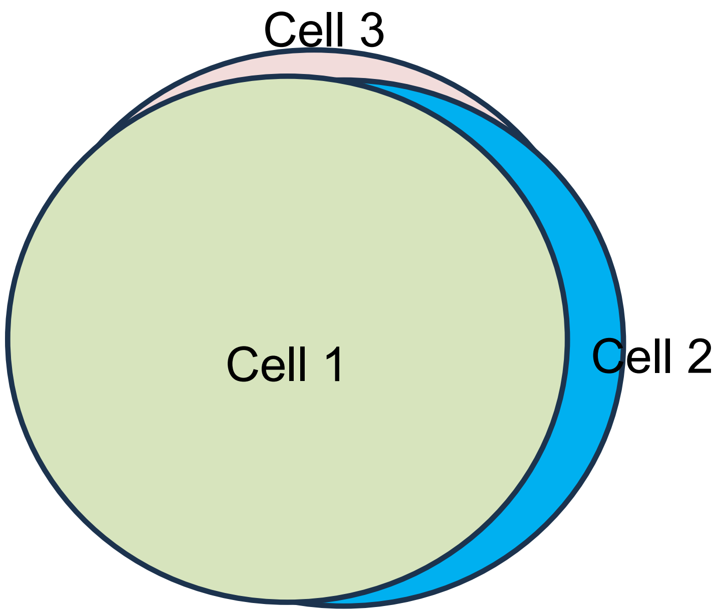
* Handover operations on the E2 interface were bypassed because of a mismatch of encodings between E2 endpoints

Today's Demo and Contributors



Demo – RAN Configuration

- 3 one cell base stations with significant overlapping coverage

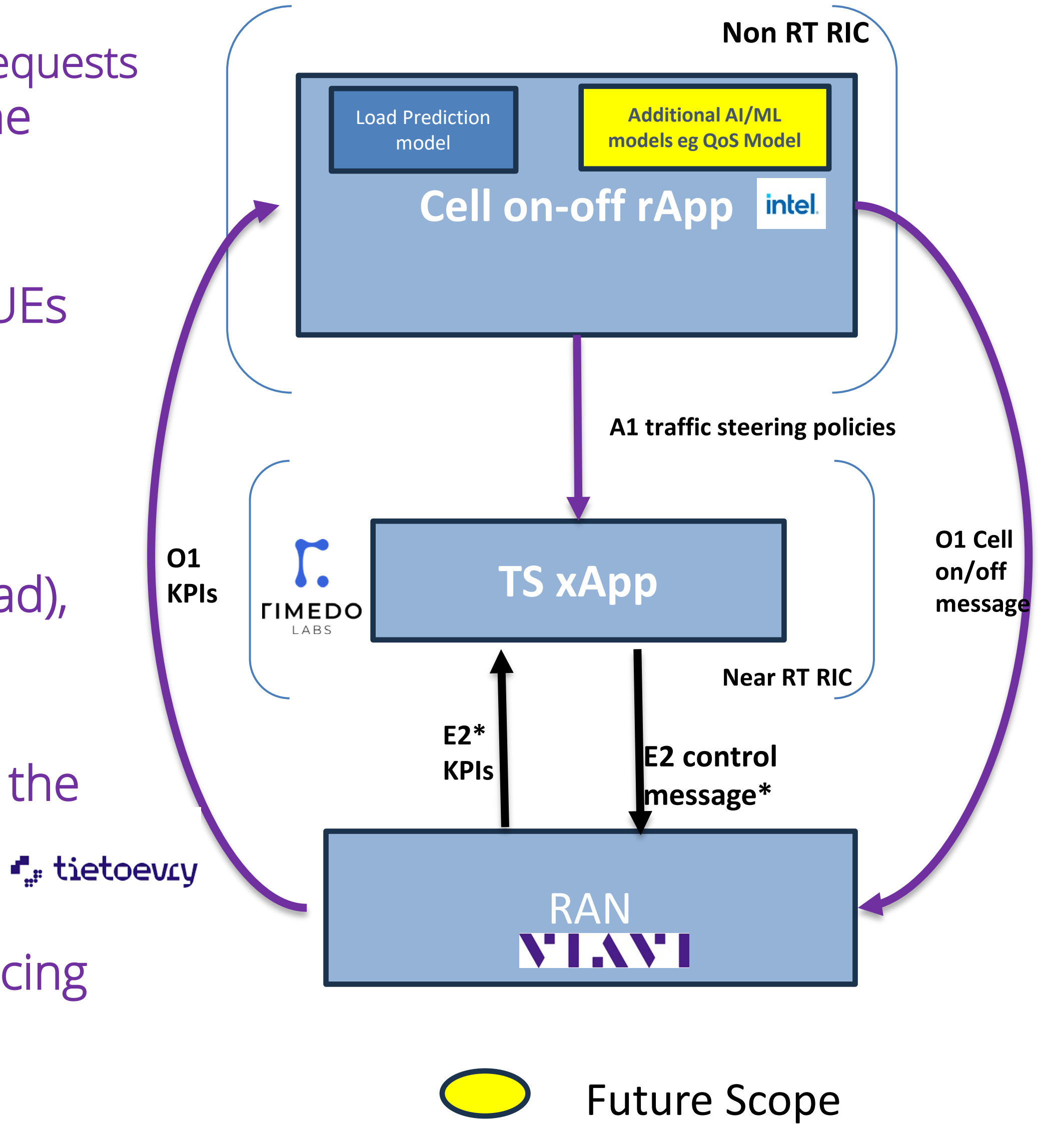


- Cell 1 is the candidate cell for on/off (capacity cell)
- Cell 2 and 3 are alive all the time (coverage cells)
- The cell load is changed in a time-varying manner

- Normal operation, load is balanced among 3 cells
  - 120 UEs
    - 30 served by Cell 1
    - 30 served by Cell 2
    - 30 served by Cell 3
    - 30 moving between the cells

Control Loops

- Cell on-off rApp consumes RAN KPIs over O1 interface and periodically requests information from the AI/ML models, e.g. load prediction; determines the candidate cell to be put to sleep
- Through A1, the Cell on-off rApp instructs the TS xApp to move UEs from the candidate shut down cell to other live cells
  - The TS xApp moves UEs to other live cells and does load balancing among them
- Once UEs are vacated from the candidate cell (detected by no load), the Cell on-off rApp puts the cell to sleep via O1
- If the load among the live cells goes up, Cell on-off rApp turns on the sleeping cell with the help of AI/ML models, via O1
- Cell on-off rApp instructs the TS xApp via A1 to do the load balancing among the cells which are operational
  - The TS xApp does the load balancing and resumes normal operating condition



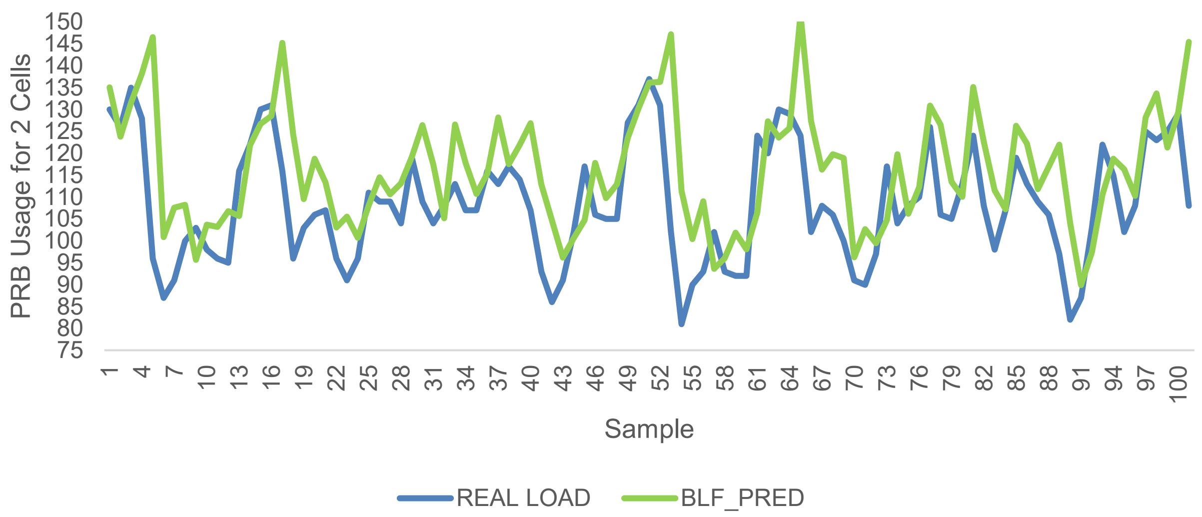
Balancing Loss Function powered Load Prediction (Intel rApp)

Why is Load Prediction on Telecom resource utilization data non-trivial?

1. Imbalance between cost of a wrong decision to switch off vs switch on. An incorrect switch off could be much more costly than an incorrect switch on – Standard loss functions don't capture this insight.
2. Energy saving and throughput guarantee are conflicting objectives and operator may prefer one over the other in certain scenarios – This preference needs to be built-in to the load prediction.

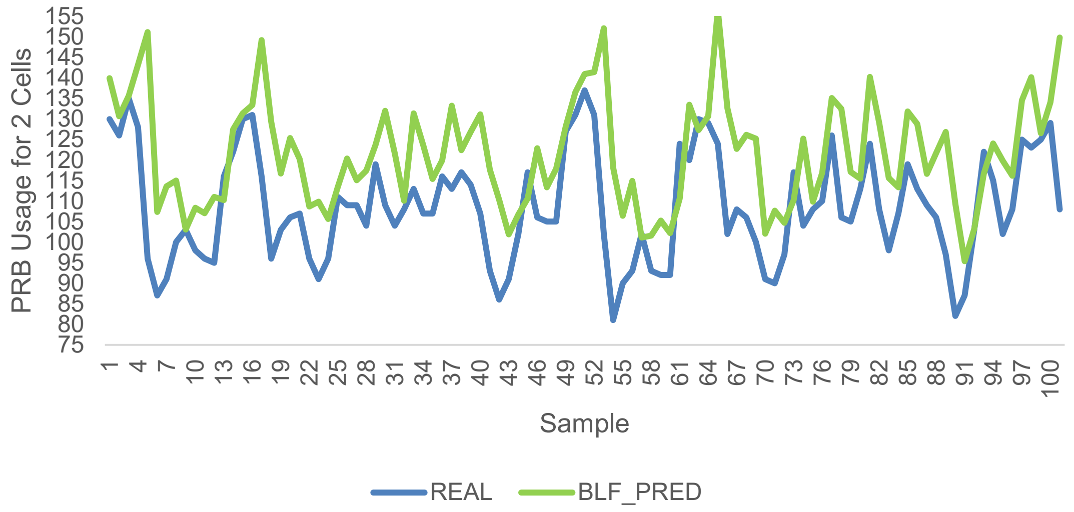
Balancing Loss Function tries to balance the innate imbalance in telecom resource usage data and incorporates operator's preference into decision making. (https://ieeexplore.ieee.org/document/9930603)

Energy Saving Preference Mode

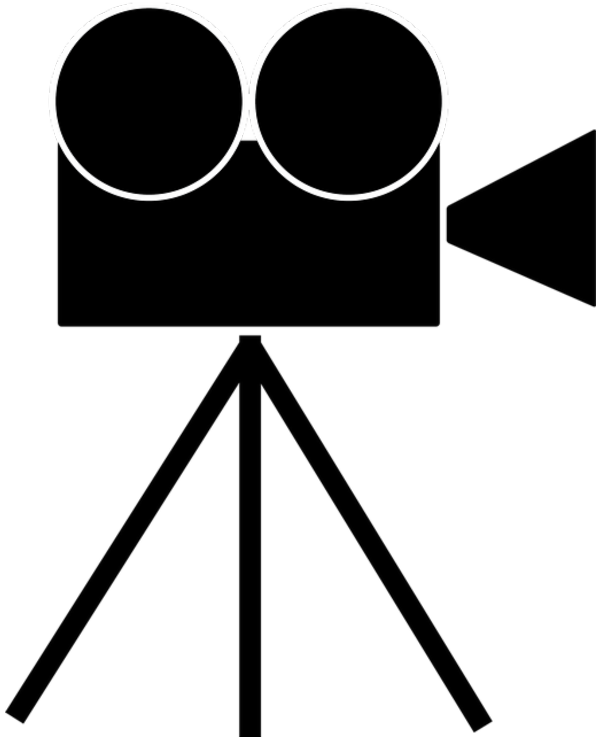


Load overprediction is penalized more, leading to more aggressively saving power

SLA Adherence Preference Mode

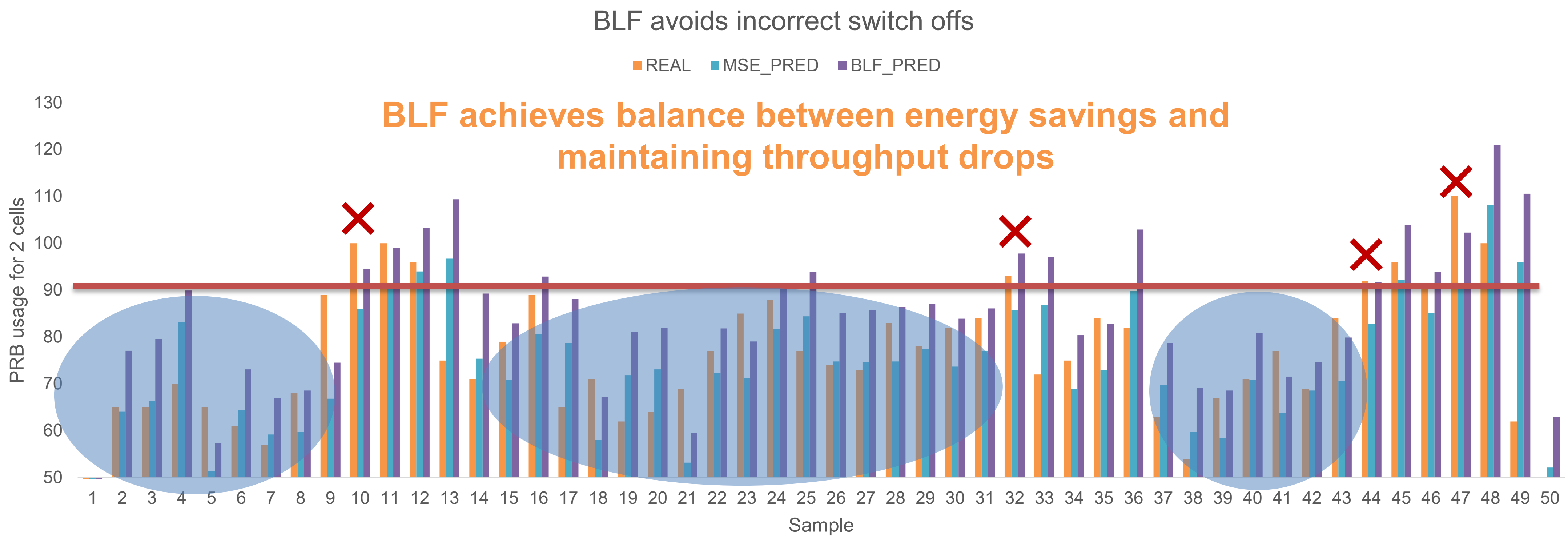


Load underprediction is penalized more, leading to conservative power savings and maintains throughput aggressively



DEMO VIDEO

Balancing Loss Function powered Load Prediction (Intel rApp)



BLF backed predictor is able to **reduce the incorrect switch off instances by >2x** w.r.t. standard loss functions. (36 instances of wrong switch offs vs 15 instances, if BLF is used across ~400 samples. **Threshold chosen is 90**)

Using a BLF backed predictor, **Energy Savings of up to ~20%** is achieved compared to when no power saving mechanism is employed.

Incorrect switch offs by standard loss function

Power saving instances

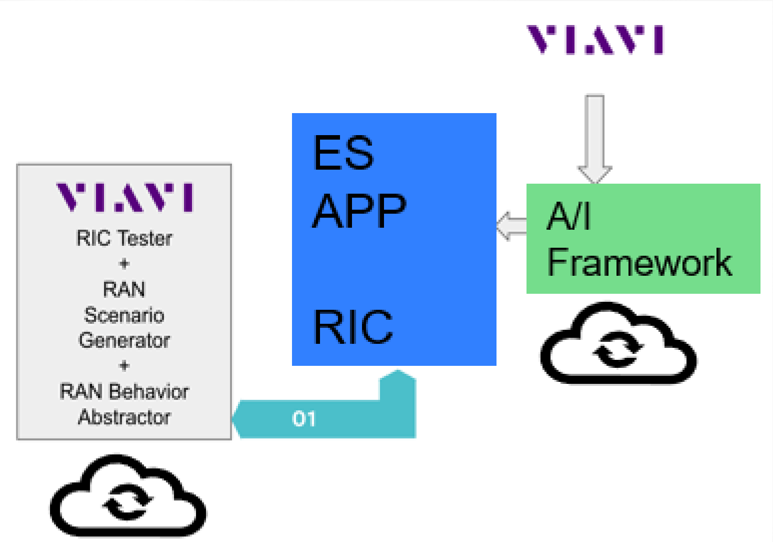
Rimedo Labs Traffic Steering xApp

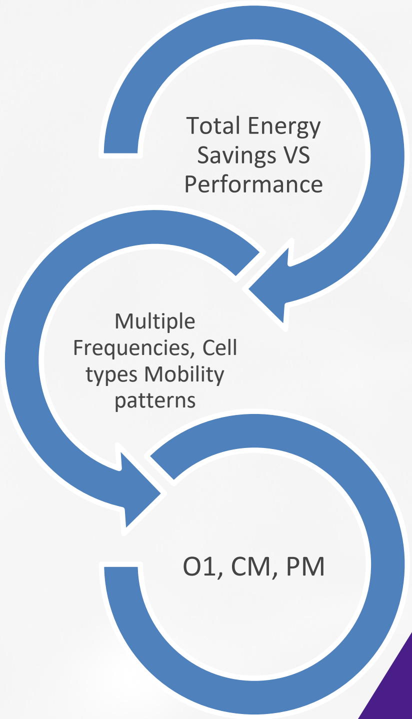
Built in a modular manner with two key functions, load balancing and service based steering.

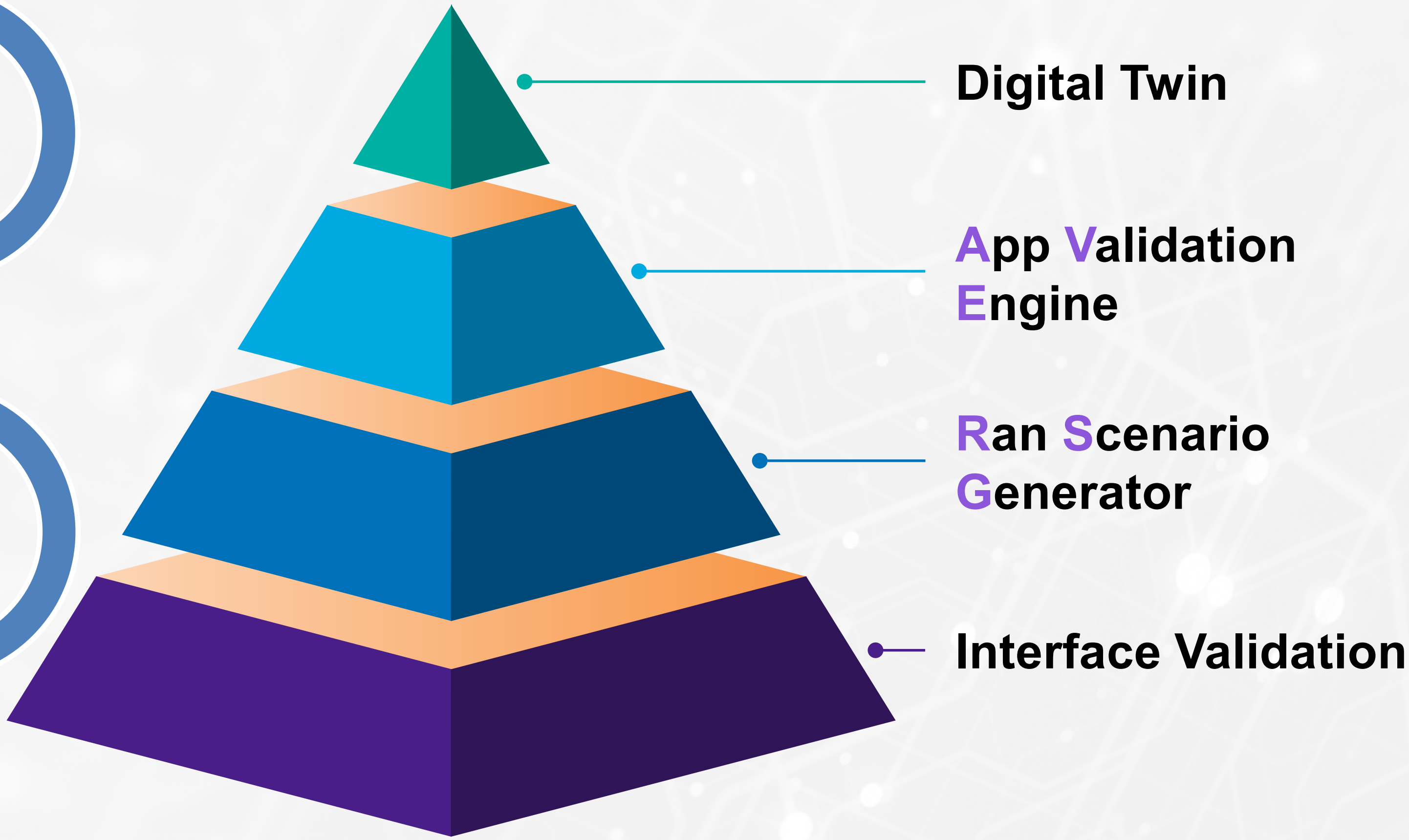
Key features:

- Supports a wide range of scenarios and use cases
  - E.g. Macro-only, HetNet, V2X, Energy Saving, Mixed Reality, etc.
- Takes into account multiple factors
  - User radio conditions, cell types, cell load, service types, and QoS profiles.
- Supports Energy Saving rApp and other similar rApps
- Controllable behavior
  - E.g. aggressive or smoother load balancing or offload
- Supports O-RAN compliant E2 and A1 interfaces
- Supports Mixed Reality (MR) traffic type (taking into account packet delay; MR-focused load balancing)
- Optimizes user throughput and under cell-outages
- Integrates with ONF’s RRAIL platform

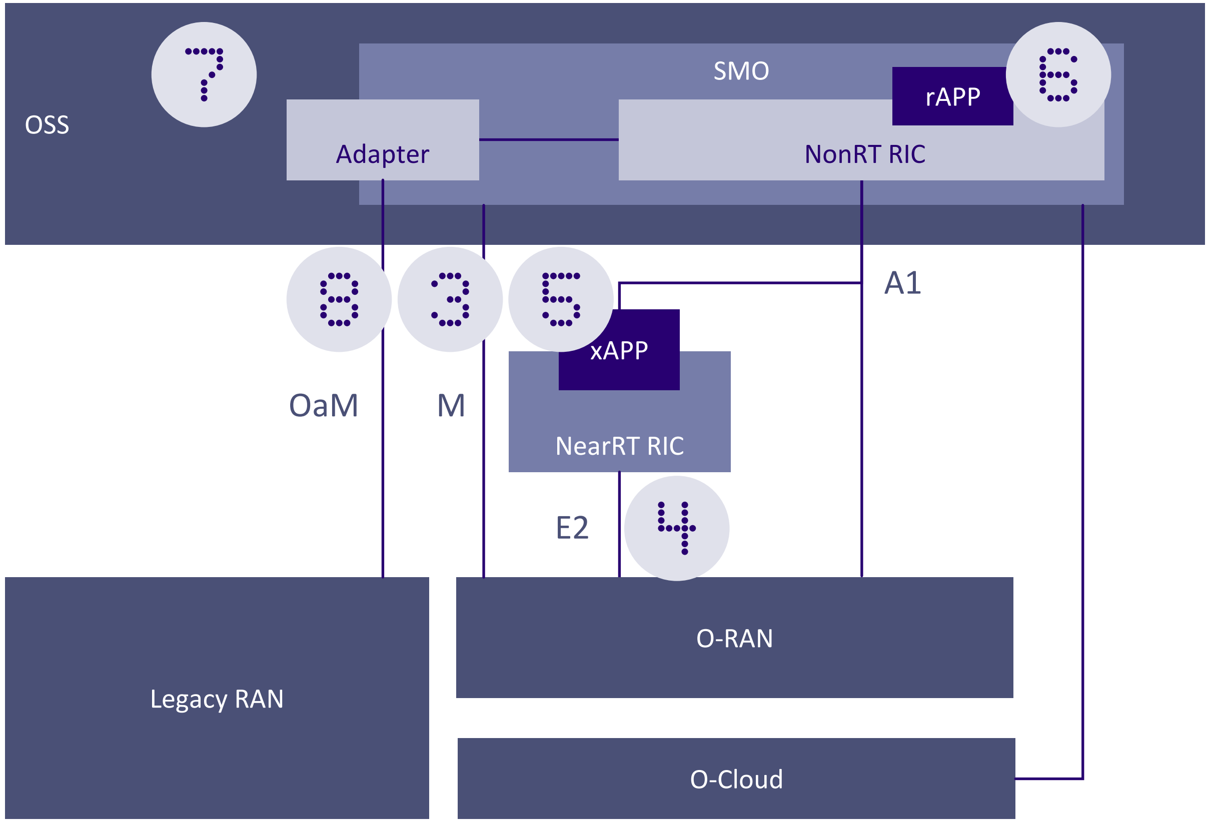
Viavi RIC Test Energy Savings AI Training Solution







Tietoevry integration capabilities for Network Automation



3 M-plane integration
Verify functionality. Provide M-plane test tools. Modify SW in RU, DU, CU or OSS layer

4 E2 integration
Verify functionality. Simulate DU&CU functionality for NRT RIC. Develop SW in DU, CU or NearRT RIC

5 xAPP integration
Simulate & verify functionality and performance. Modify xAPP SW or SMO

6 rAPP integration
Simulate & verify functionality and performance. Modify rAPP SW

7 OSS integration
Develop FCAPS integrations into OSS platforms

8 Legacy RAN integration
Develop Legacy RAN FCAPS adapters and integrations into SMO platforms

Read white paper:

THANK YOU

Backup

Intel Cell on-off rApp

- Cell on-off logic based on AI/ML based predictive models along with closed loop monitoring to guarantee Quality of Service (QoS)
- AI/ML models trained on real data from Telecom Italia
- Takes into account the tradeoff between energy saving and QoS. Operator can tune the AI/ML model for more power saving or alternatively guaranteeing better QoS, based on the requirements
- Prediction performance comparison among two AI/ML models:
  - Cell on/off using MSE (Mean Square Error) model
  - Cell on/off using BLF (Balancing Loss Function) model
- Works in conjunction with a Traffic Steering xApp from Rimedo Labs
  - UEs are handed over to neighbor cells before a cell is switched off to maintain QoS
- Evaluation results of the rApp (load prediction, power saving) on different topologies, cell configurations and UE counts as well as power models.

Telecommunications - SMS, Call, Internet - MI - A multi-source dataset of urban life in the city of Milan and the Province of Trentino Dataverse (harvard.edu)