



Demonstration of SMaRT-5G™  
Open Source Energy Savings Initiative Using O-RAN Architecture

Phase 1: Integrated cell on/off and proactive traffic steering to save RAN energy consumption without compromising service quality

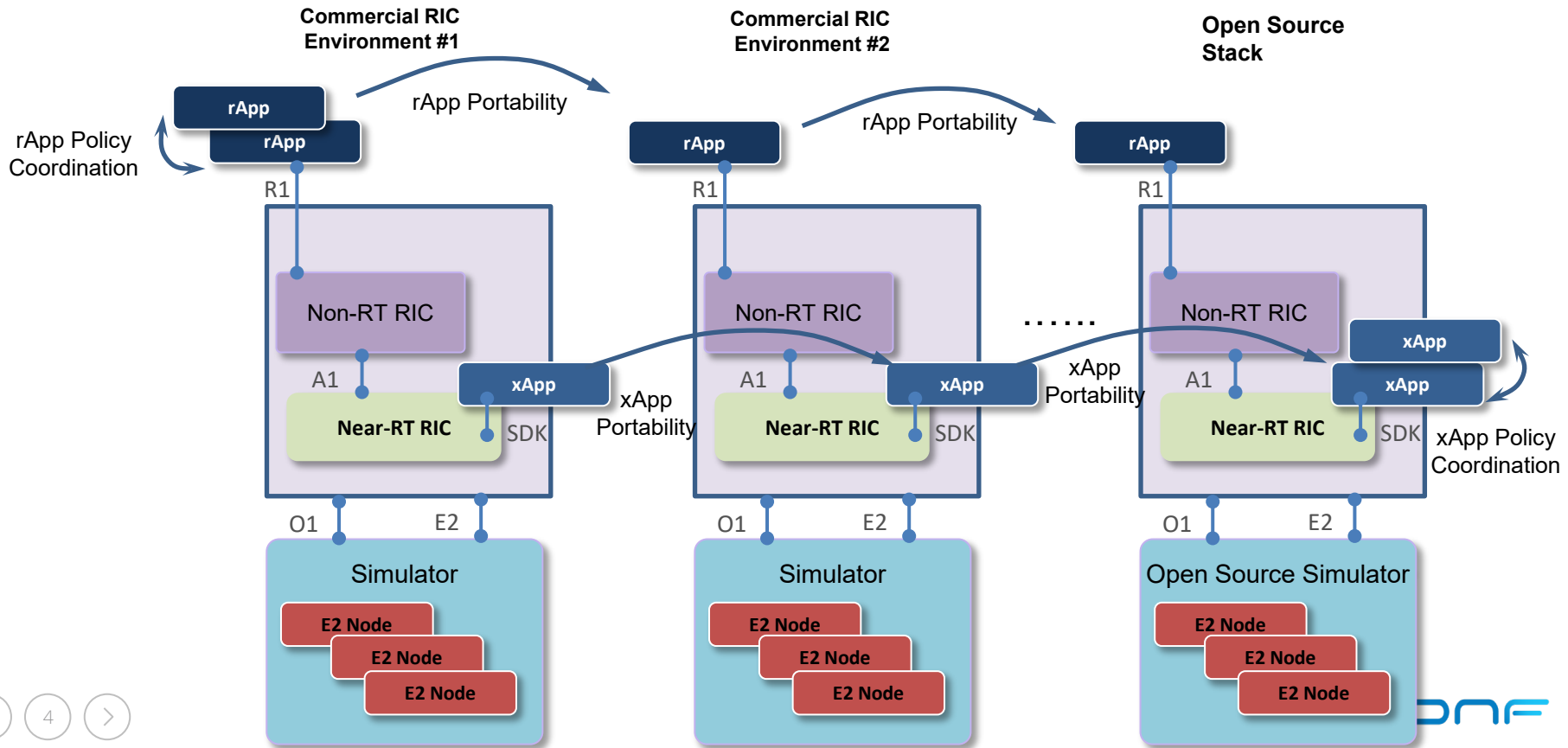
# Introduction

Sarat Puthenpura, ONF

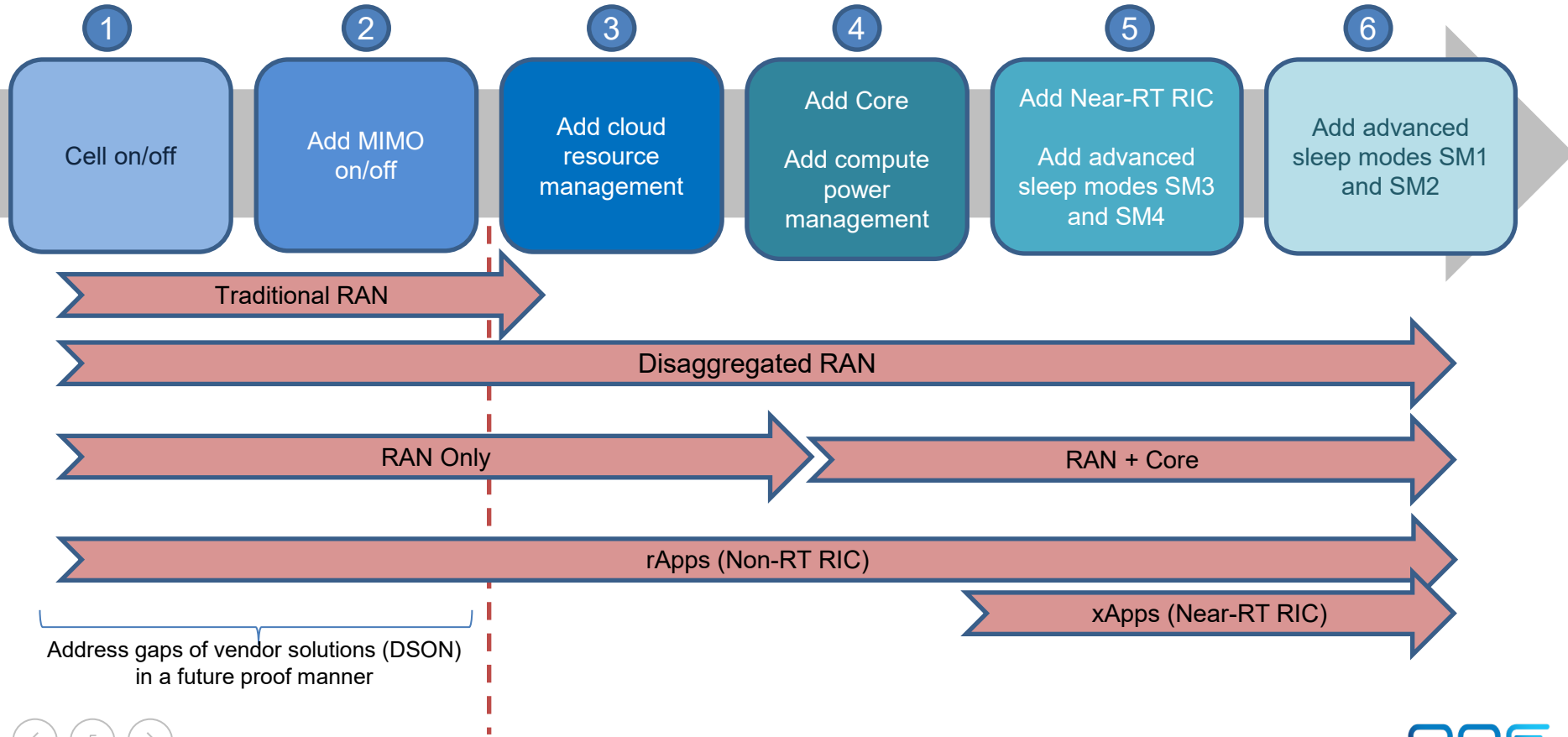
# ONF's New Open RAN Initiatives

- RRAIL (RAN RIC & App Integration Lab): Building a collaborative open environment to test and evaluate x/rApp portability to different RIC/RAN platforms and their interworking
  - Vendor stacks (Interoperability, portability and vendor collaboration)
  - Open source stack (for research and experimentation)
  - Mix of commercial and open source stacks
- SMaRT-5G: Series of PoCs (both commercial and open source options)
  - The SMaRT-5G use case leverages RRAIL
  - Both commercial vendors and ONF to implement x/rApps

# RRAIL: Key Enabler of SMaRT-5G



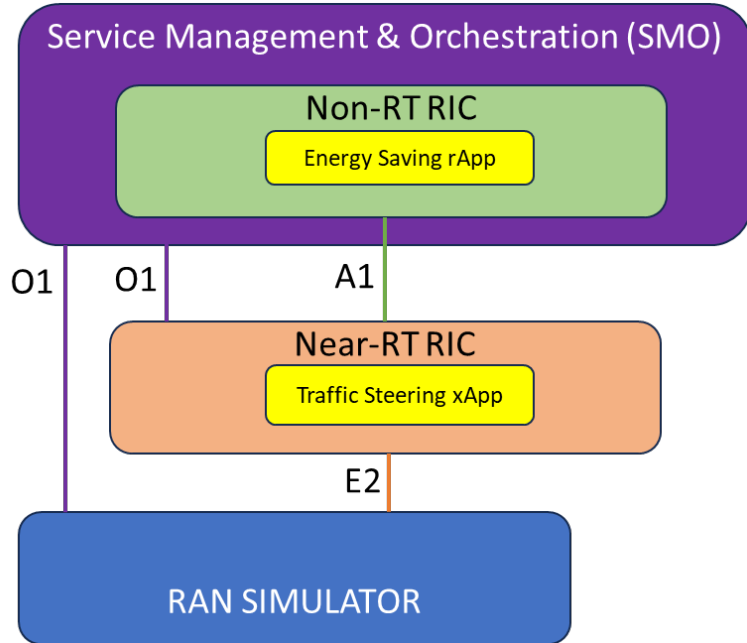
# SMaRT 5G - ONF 5G Energy Savings Use Case



# The Fyuz 2023 Demo Scope

- Demonstration of achieving the first milestone in the SMaRT-5G project
- Intelligent cell on/off RAN energy savings application (rApp) that works hand-in-hand with a traffic steering application (xApp)
  - Ensuring quality of service while optimizing RAN energy consumption
- Energy Saving and Traffic Steering are two of the most important use cases for the mobile industry.
- The first time the ONF community has collaborated to create a single demonstration that combines these use cases in a unified O-RAN compliant open source solution.

# Demo Components



- Rimedo Labs has developed the rApp and xApp
- Near-RT RIC and the RAN Simulator (RANSim) are both integral elements of ONF's SD-RAN platform
- Service Management Orchestration (SMO) and the Non-RT RIC are from the O-RAN Software Community
- Tietoevry has provided system integration and test services enabling this cohesive demonstration

Note: SMO is based on ONAP components

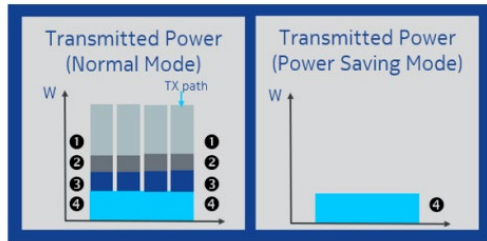
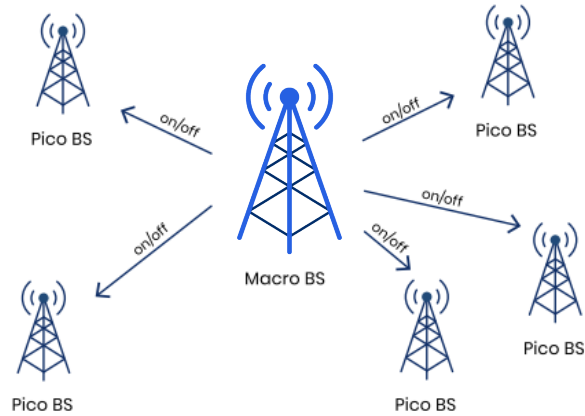
# Application Technology

Marcin Dryjanski, Rimedo Labs

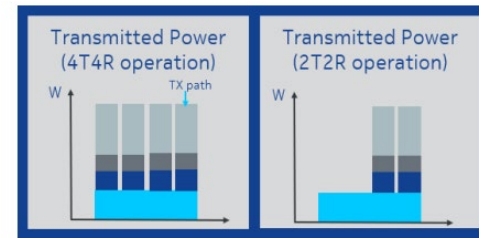
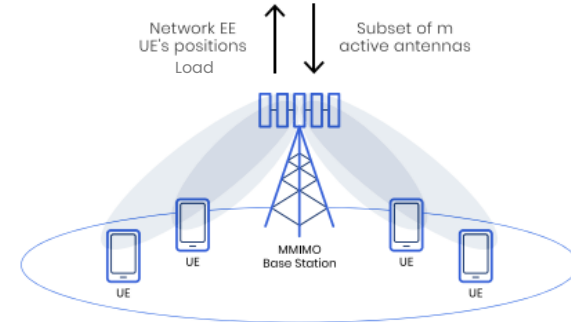


# Energy Efficiency in O-RAN

## Cell On/Off Switching



## RF Channel Reconfiguration

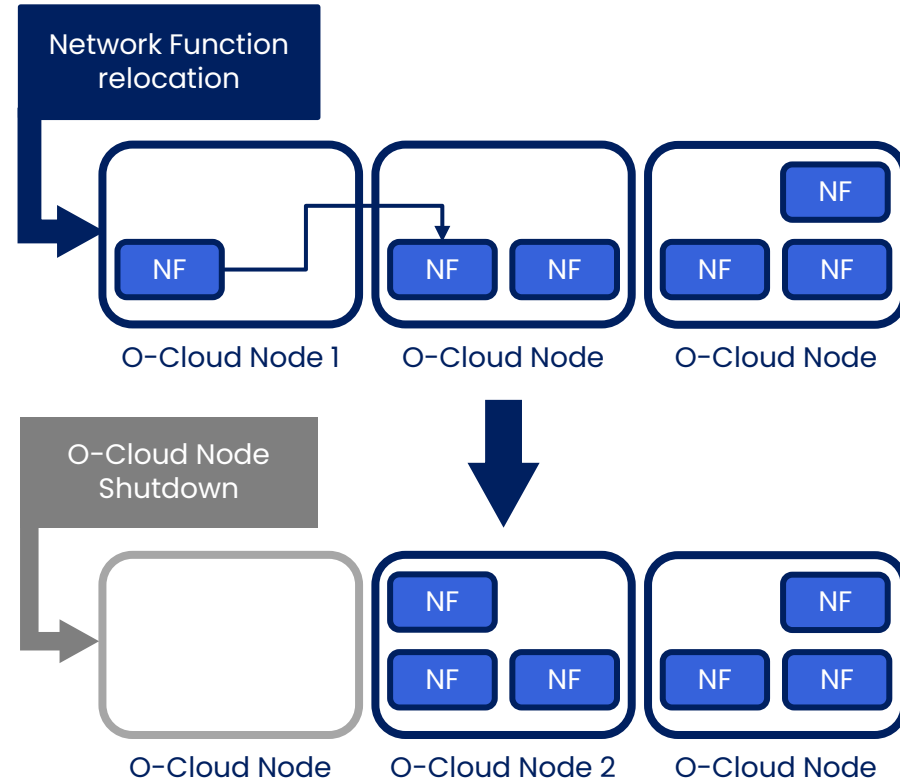


# Energy Efficiency in O-RAN

## Advanced Sleep Mode Selection

Power state	Characteristic	Relative Power $P$	Additional transition energy $E$	Total transition time $T$
Deep sleep	There is neither DL transmission nor UL reception. Time interval for the sleep should be larger than the total transition time entering and leaving this state.	$P1$	$E1$	$T1$
Light sleep	There is neither DL transmission nor UL reception. Time interval for the sleep should be larger than the total transition time entering and leaving this state.	$P2$	$E2$	$T2$
Micro sleep	There is neither DL transmission nor UL reception. Immediate transition is assumed for network energy saving study purpose from or to a non-sleep state.	$P3$	0	0
Active DL	There is only DL transmission.	$P4$	N.A.	
Active UL	There is only UL reception.	$P5$		

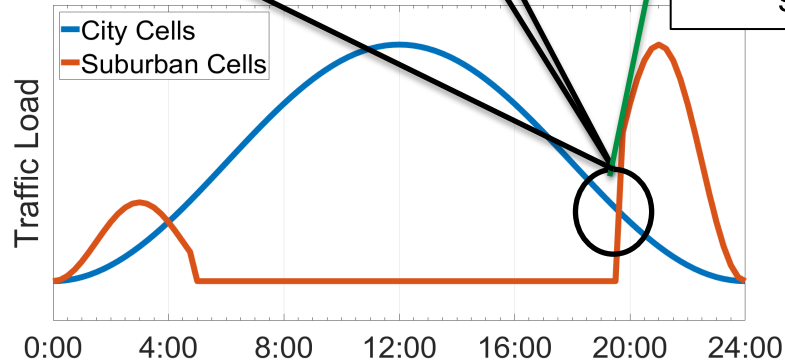
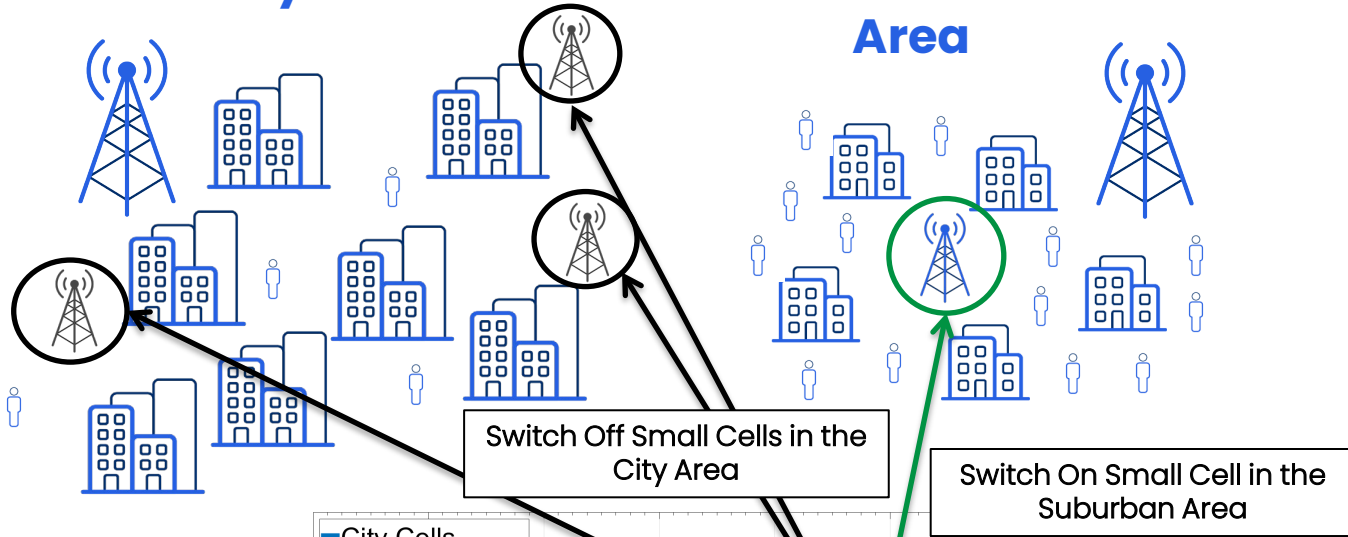
## O-Cloud Resource Energy Saving Mode



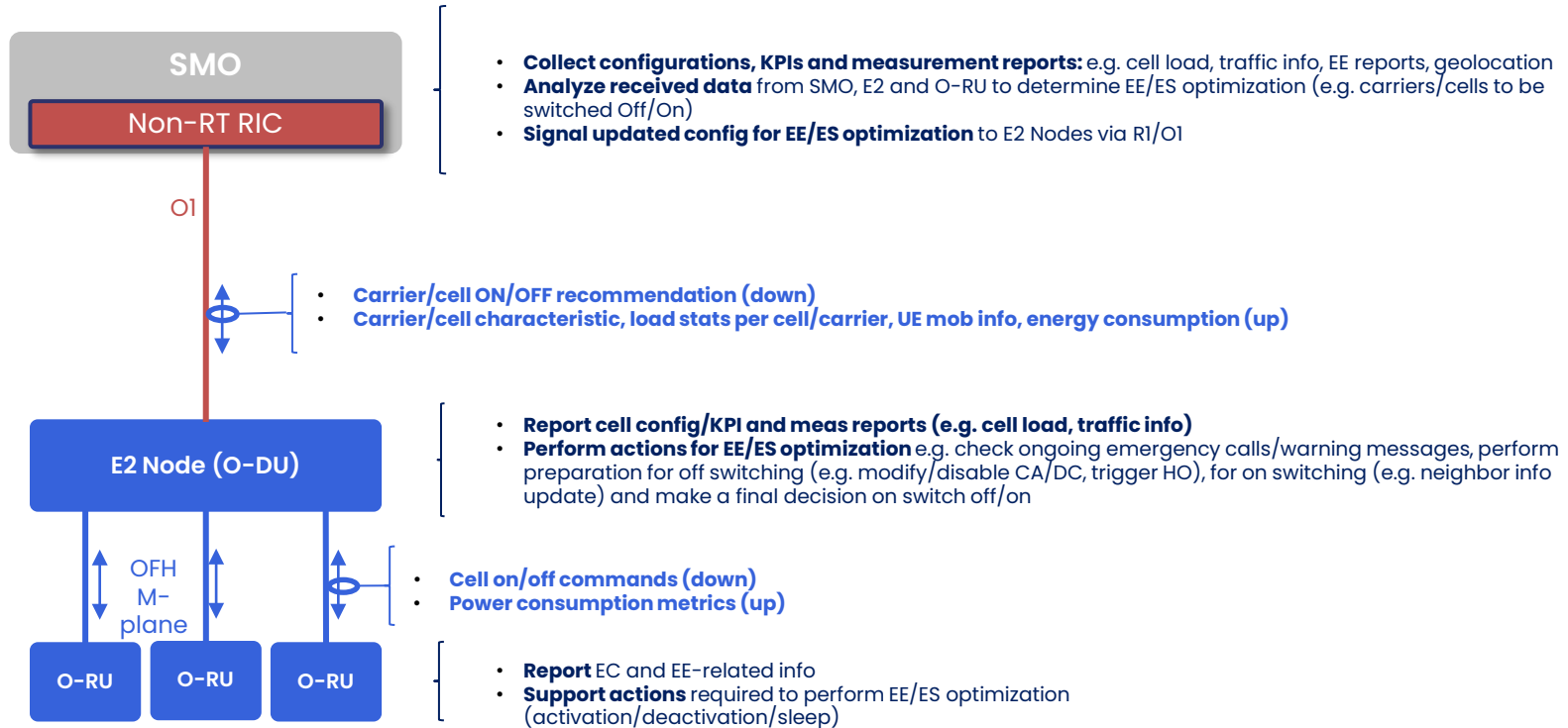
# Cell On/Off Use Case

City Area

Suburban Area

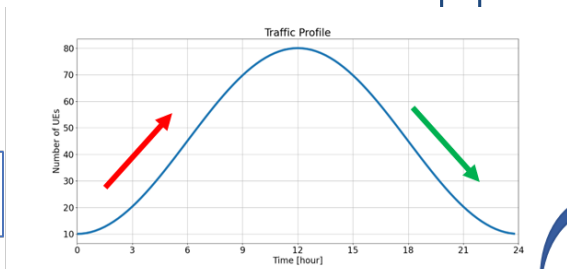


# Cell Switch On/Off – O-RAN Entities Roles





# Coordination of Apps: Flow



**Increasing** traffic load  
(**high** load)

## ES-rApp:

- Capacity Cells – **ON**
- TS Policy – **balance load**

## O-RU:

- Capacity cells – **ON**

## TS-xApp:

- Handover commands:
  - **Distribute users to coverage and capacity cells**

**Decreasing** traffic load  
(**low** load)

## ES-rApp:

- TS Policy – **move all users to the coverage cell**
- Capacity cells – **OFF**

## TS-xApp:

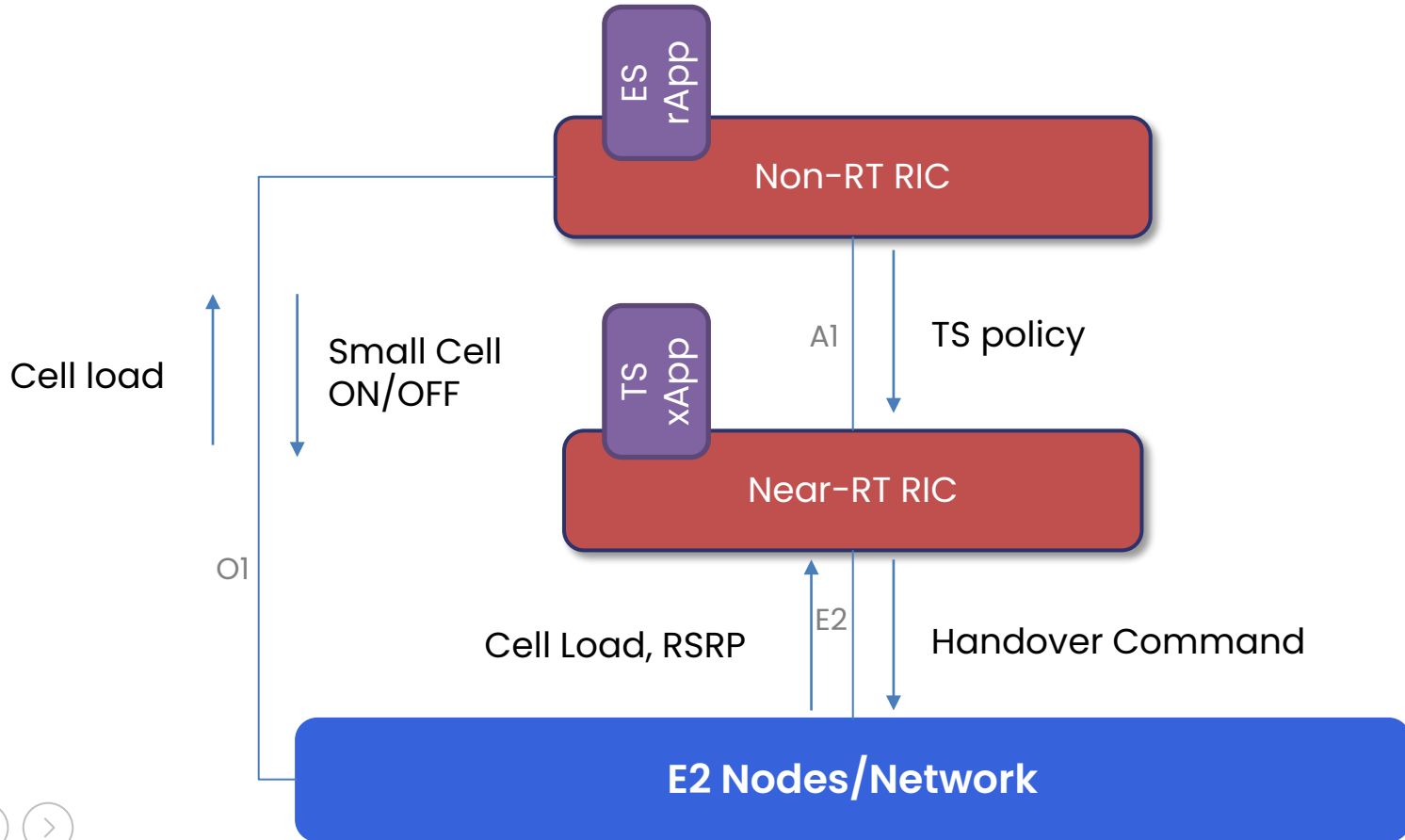
- Handover commands:
  - **ALL Users to coverage cell**

## O-RU:

- Capacity cells – **OFF**



# Coordination of Apps: Design



# Energy Saving rApp

**ES-rApp** enables the cell off/on switching to maximize energy efficiency. The rApp monitors the traffic load per cell and current power consumption over the O1 interface. It generates appropriate traffic control policies and sends them to TS-xApp via the A1 and orders capacity cells off/on over the O1 interface.

## Key features:

- Switches off/on cells to maximize energy efficiency
- Controls Traffic Steering policies
- Suitable for heterogeneous network scenarios

```

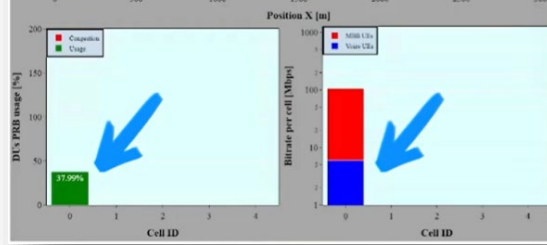
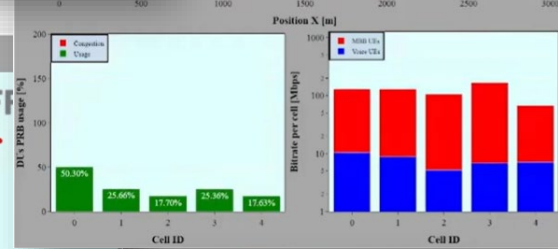
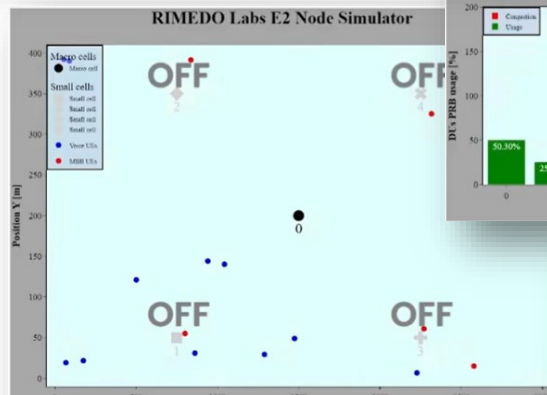
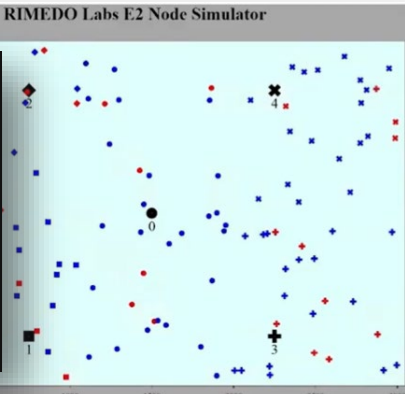
2023-06-22 11:11:21,767 - INFO - PRB usage: 0.159 (spectral efficiency: 3.792 bps/Hz)
(energy consumption: 0.90/0.90 W; per day: 21.60 Wh; per day savings: 0.00 Wh)

2023-06-22 11:11:22,269 - INFO - PRB usage: 0.151 (spectral efficiency: 3.776 bps/Hz)
(energy consumption: 0.90/0.90 W; per day: 21.60 Wh; per day savings: 0.00 Wh)

2023-06-22 11:11:22,770 - INFO - PRB usage: 0.144 (spectral efficiency: 3.760 bps/Hz)
(energy consumption: 0.90/0.90 W; per day: 21.60 Wh; per day savings: 0.00 Wh)

2023-06-22 11:11:22,770 - INFO - Disabling cell with id 2
2023-06-22 11:11:22,801 - INFO - Disabling cell with id 4
2023-06-22 11:11:22,832 - INFO - Disabling cell with id 3
2023-06-22 11:11:22,865 - INFO - Disabling cell with id 1
2023-06-22 11:11:23,392 - INFO - PRB usage: 0.696 (spectral efficiency: 17.720 bps/Hz)
(energy consumption: 0.30/0.90 W; per day: 7.20 Wh; per day savings: 14.40 Wh)

2023-06-22 11:11:23,893 - INFO - PRB usage: 0.693 (spectral efficiency: 15.680 bps/Hz)
(energy consumption: 0.30/0.90 W; per day: 7.20 Wh; per day savings: 14.40 Wh)
    
```

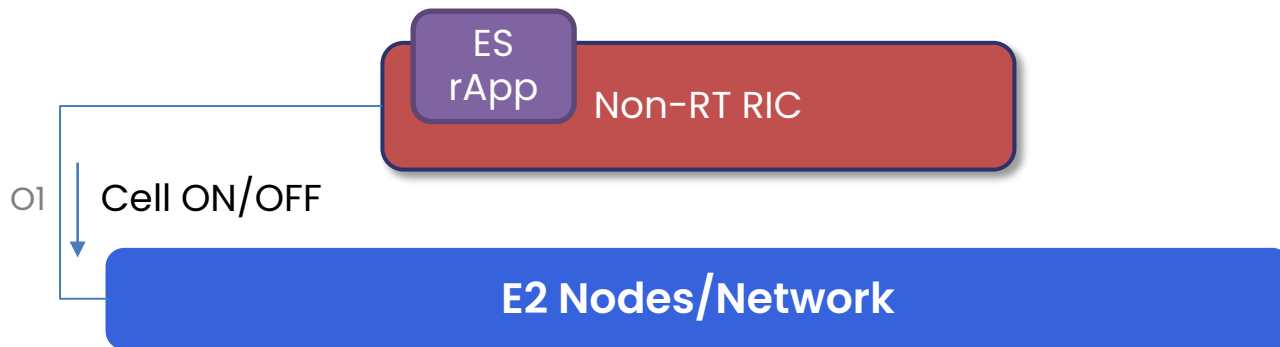


UEs with **FIVE\_QI** = [0, 1]  
**FORBID**  
 Cells with **CELL\_ID** = [1, 2, 3, 4]

UEs with **FIVE\_QI** = [0, 1]  
**SHALL**  
 Cells with **CELL\_ID** = [0]



# ES-rApp: Key Advantages



## Cell On/Off: load based approach:

- Load thresholds can be set based on PRB utilization, #RRC connections, or #QoS flows
- Separate thresholds/hysteresis to avoid ping-pongs:
  - **Switch-off:**  $\text{load} < \text{threshold\_es\_on}$
  - **Switch-on:**  $\text{load} > \text{threshold\_es\_off}$

## ES-rApp intelligently turns appropriate cells on/off to save energy while ensuring

- No Degradation of Service Quality
- No Coverage Loss

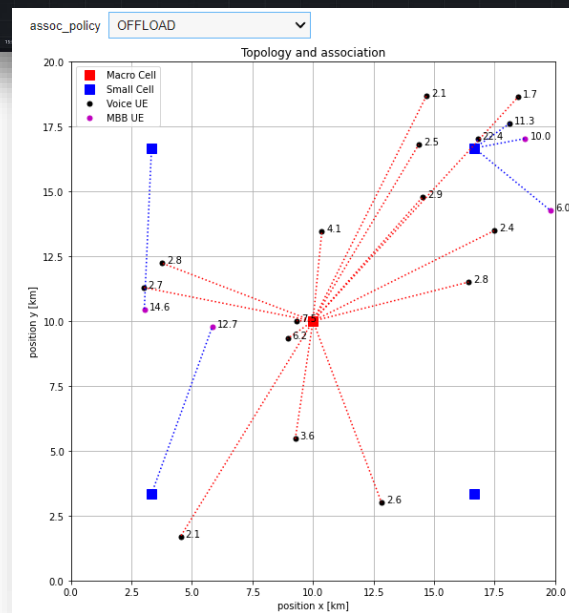
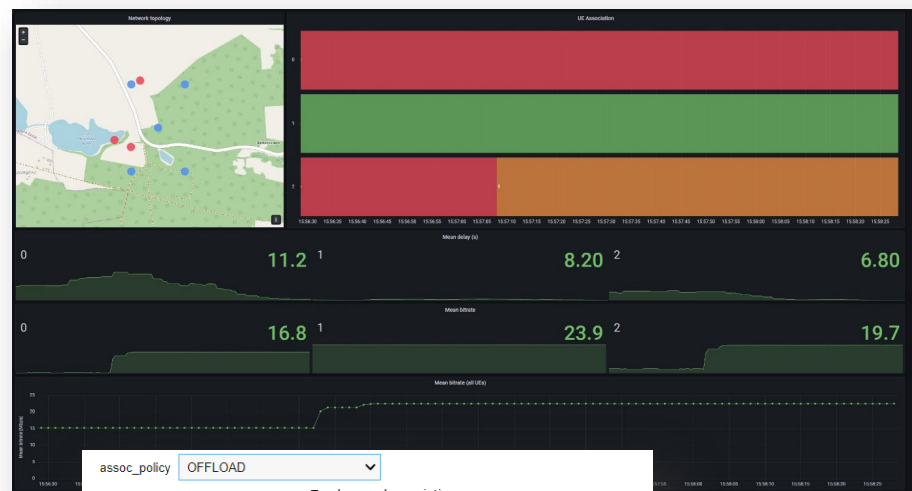


# Traffic Steering xApp

**TS-xApp** associates the users with the eNB/gNB taking into account multiple factors: user radio conditions, cell types, service types, and QoS profiles. It optimizes user throughput and cell outage and is built in a modular manner with two key functions, load balancing and service-based steering.

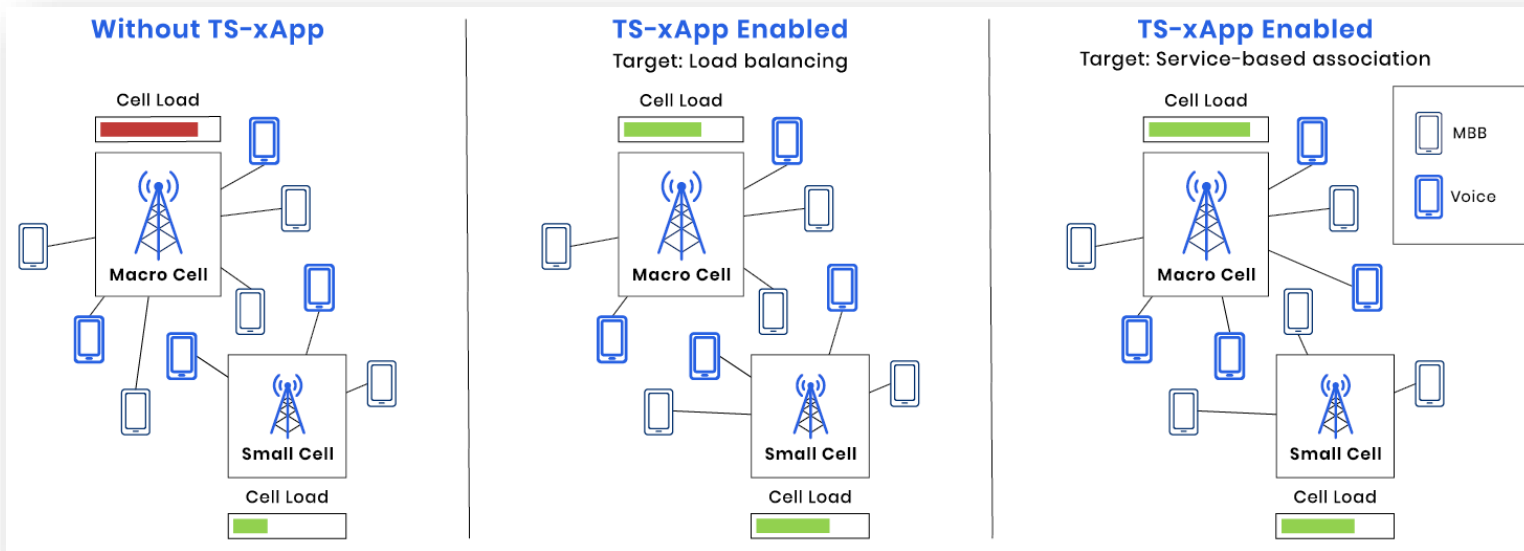
## The xApp supports:

- AI and can be controlled by policies from Non-RT RIC.
- Wide range of scenarios and use cases, e.g. Macro-only, HetNet, V2X, Energy Saving, Mixed Reality, etc.





# TS-xApp: Key Advantages



Joint per-UE cell association, service-based steering, and load balancing

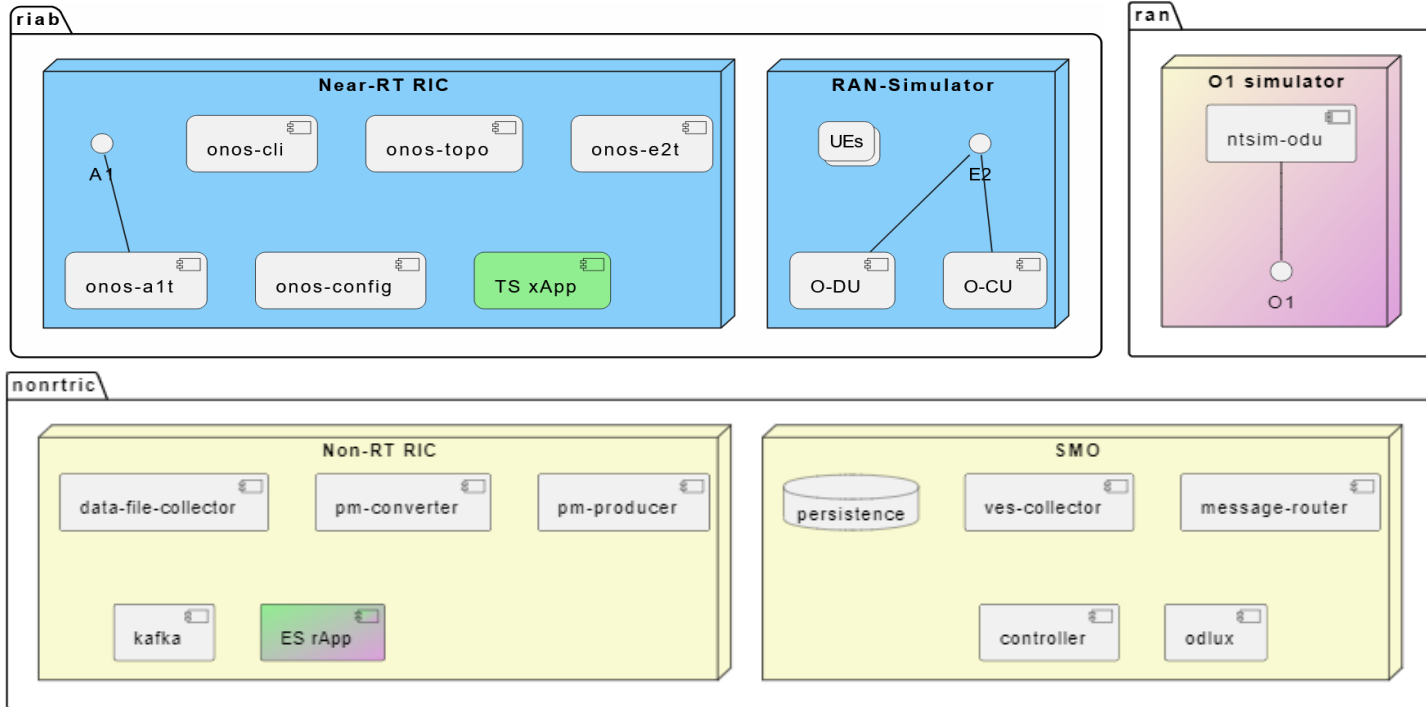


Controllable behavior – e.g. aggressive or smoother load balancing or offload

Demo

Arne Lundbäck, Tietoenvry

# Component View



Contributors:

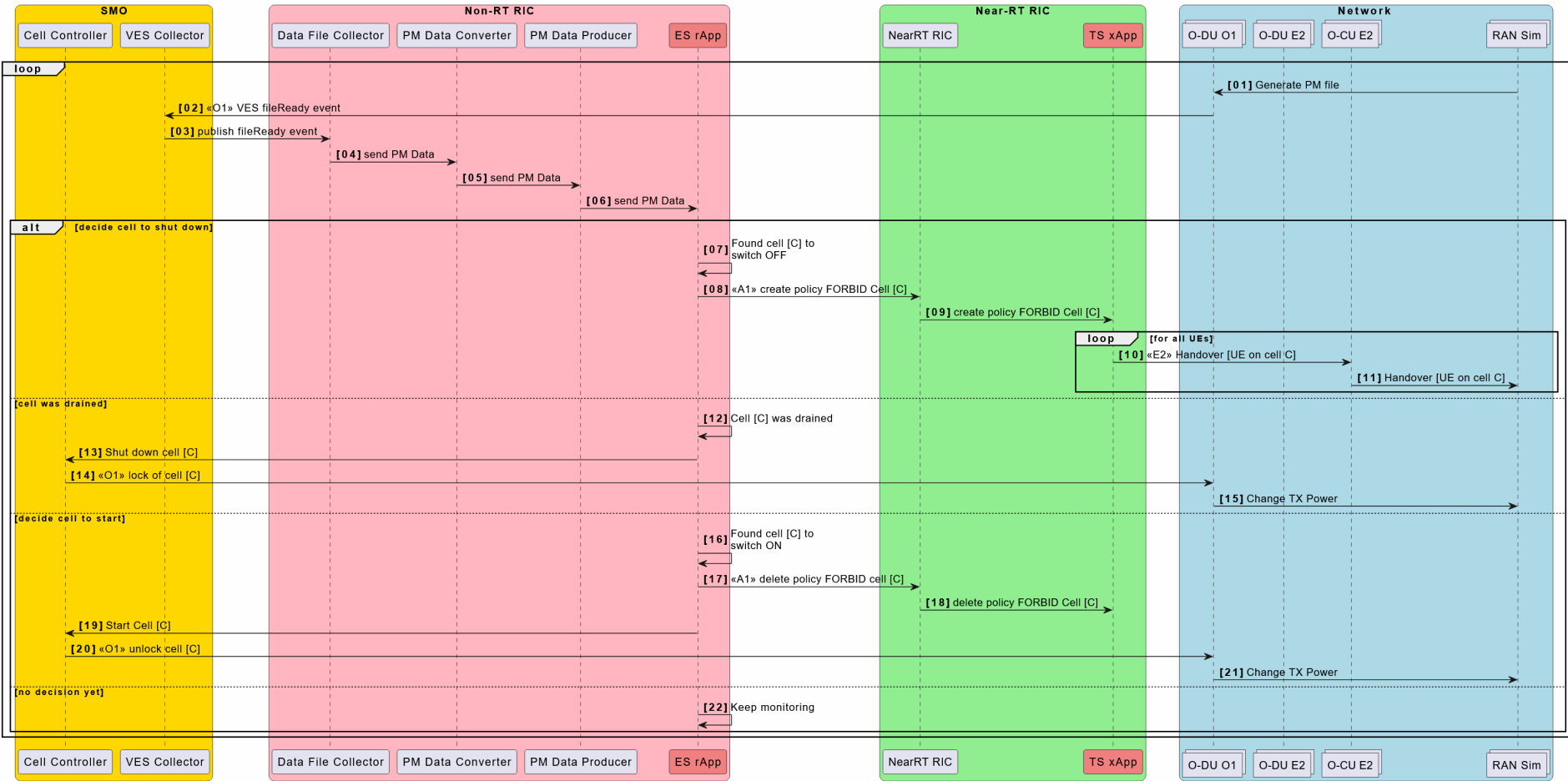
O-RAN SC

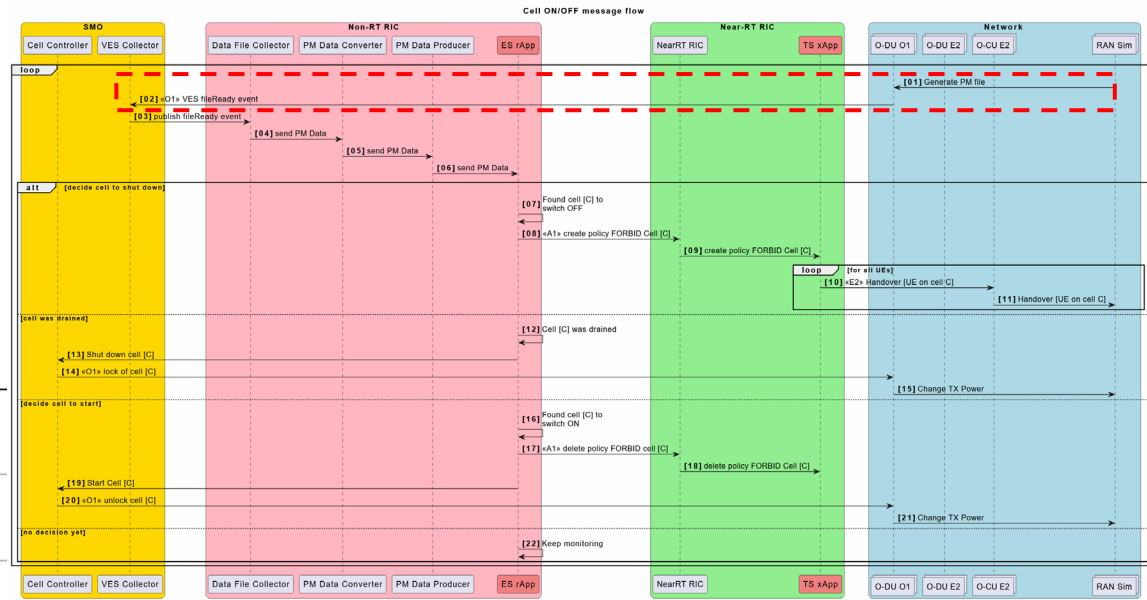
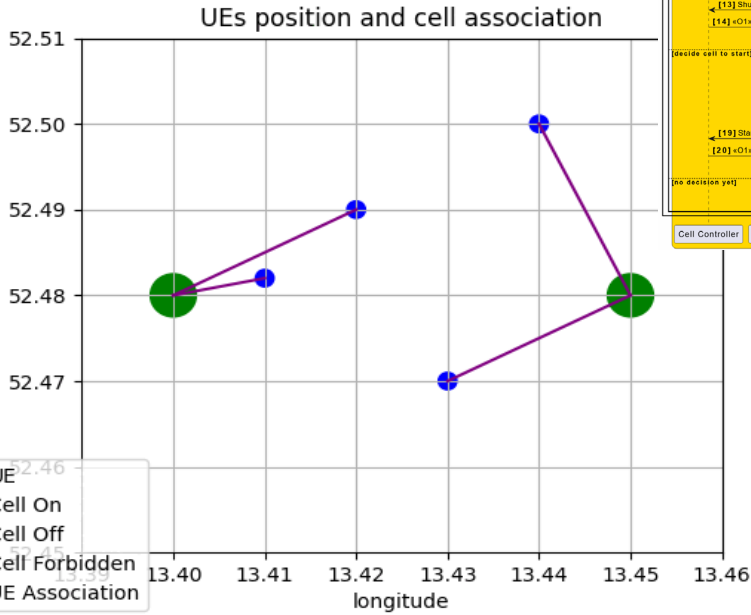
ONF

Rimedo Labs

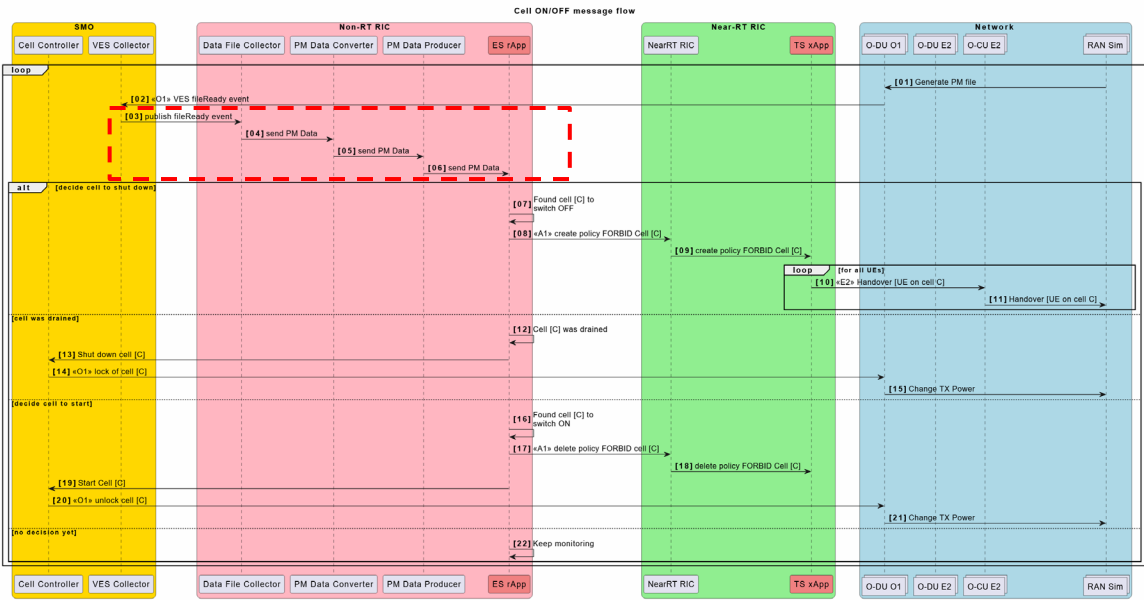
Tietoenvy

Cell ON/OFF message flow

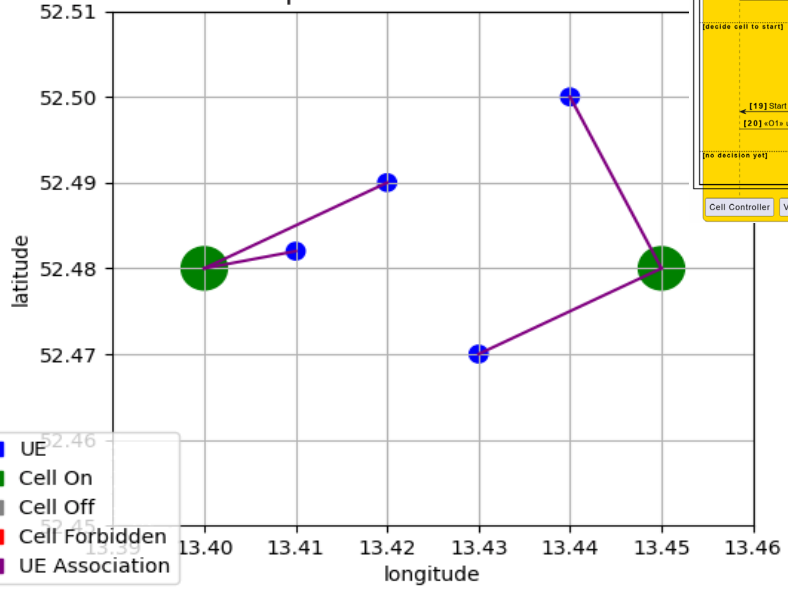




PRB usage data not available yet

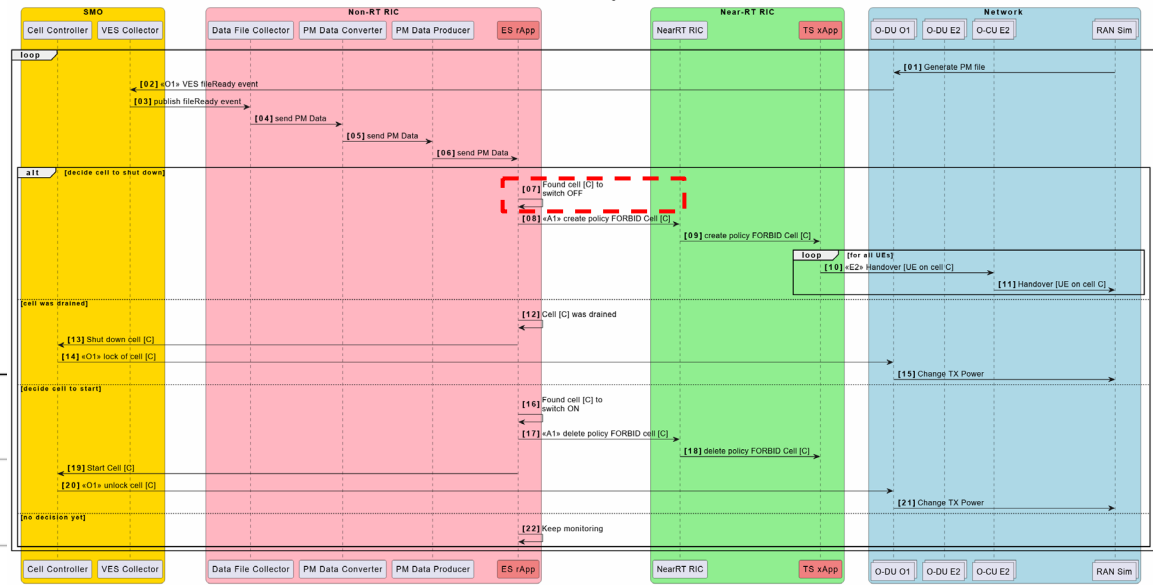


UEs position and cell association

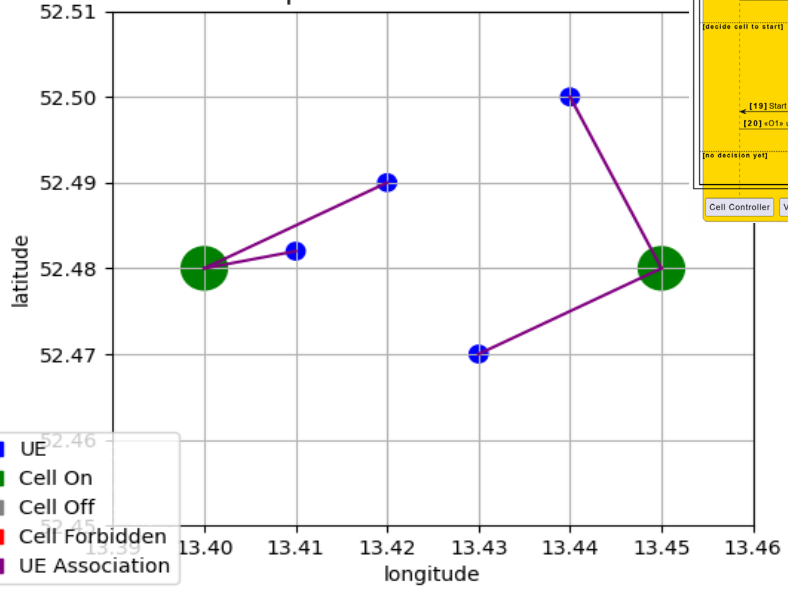


PRB data available  
No action - balance achieved

- UE
- Cell On
- Cell Off
- Cell Forbidden
- UE Association



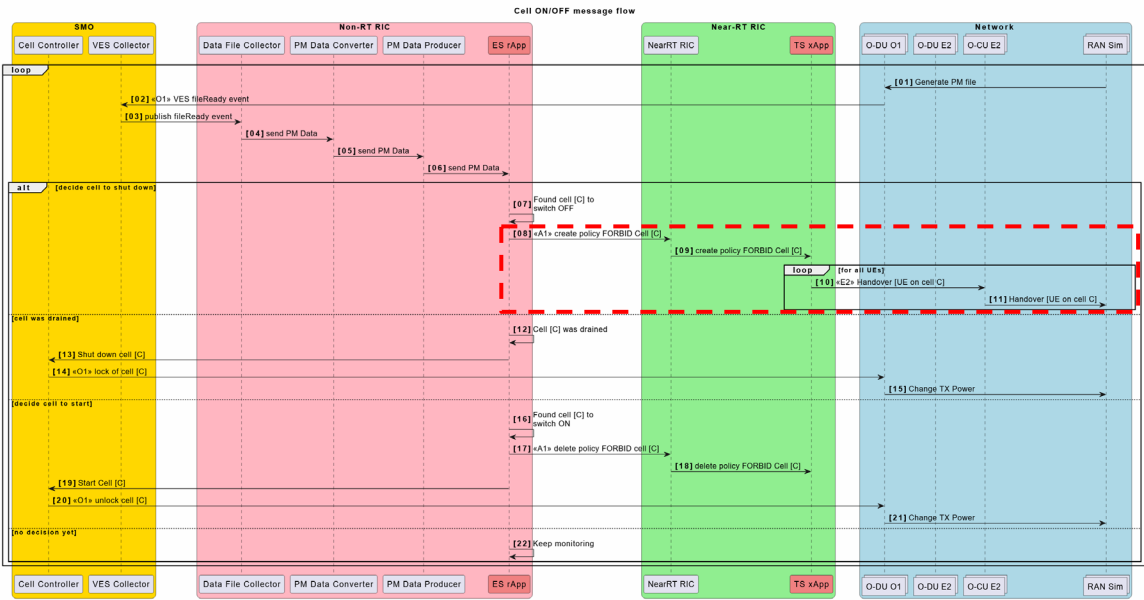
UEs position and cell association



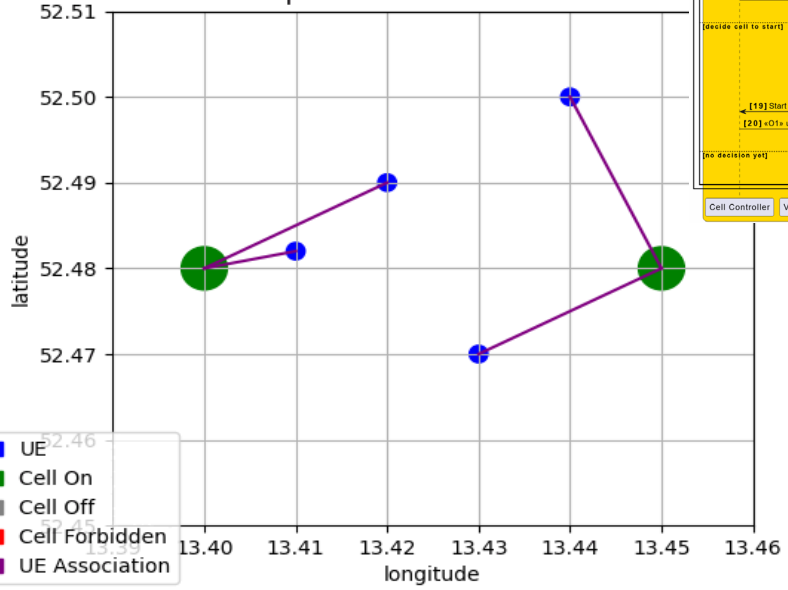
Average PRB usage < threshold\_es\_on  
Trying to disable one cell.

- UE
- Cell On
- Cell Off
- Cell Forbidden
- UE Association



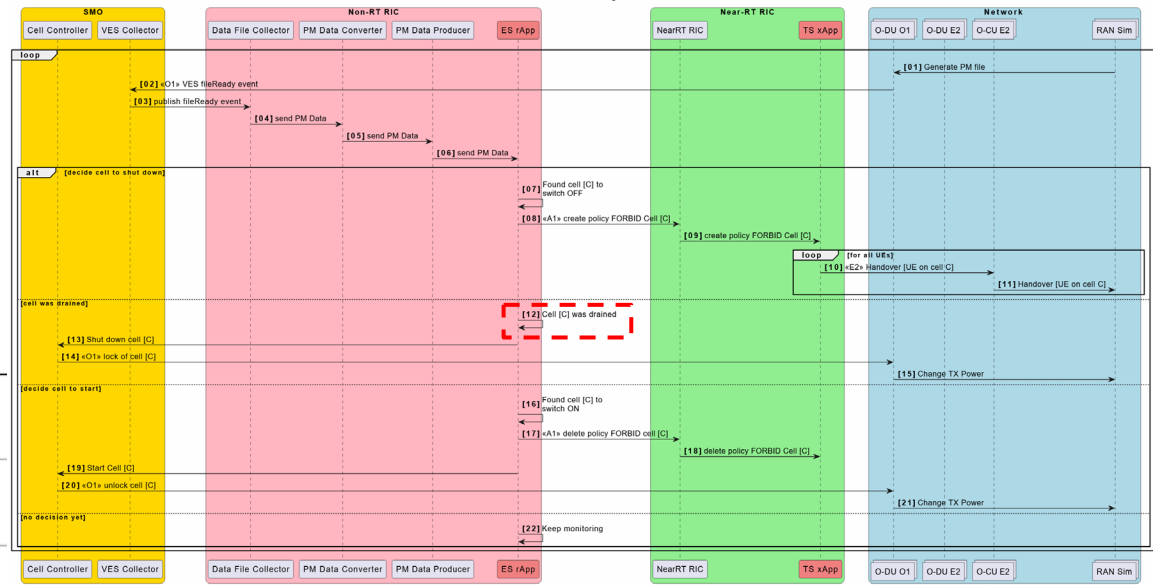


UEs position and cell association

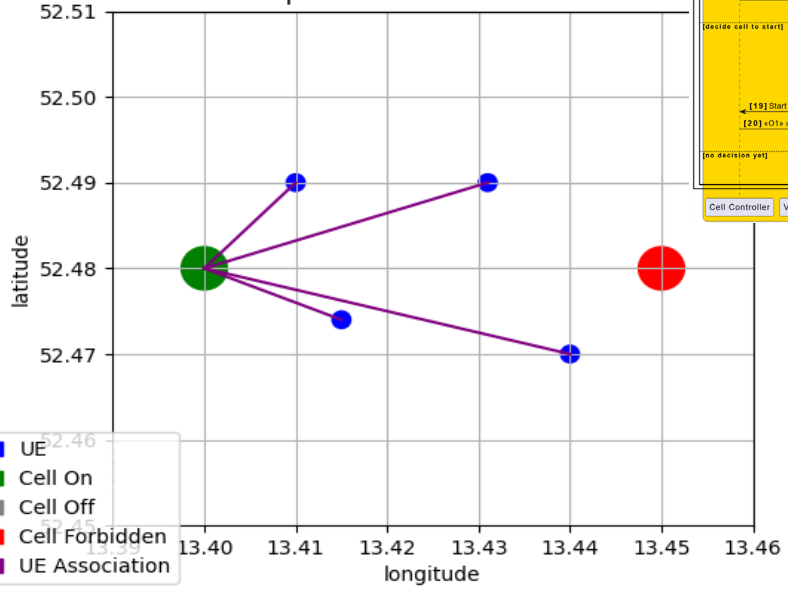


Sending policy (FORBID) for right cell

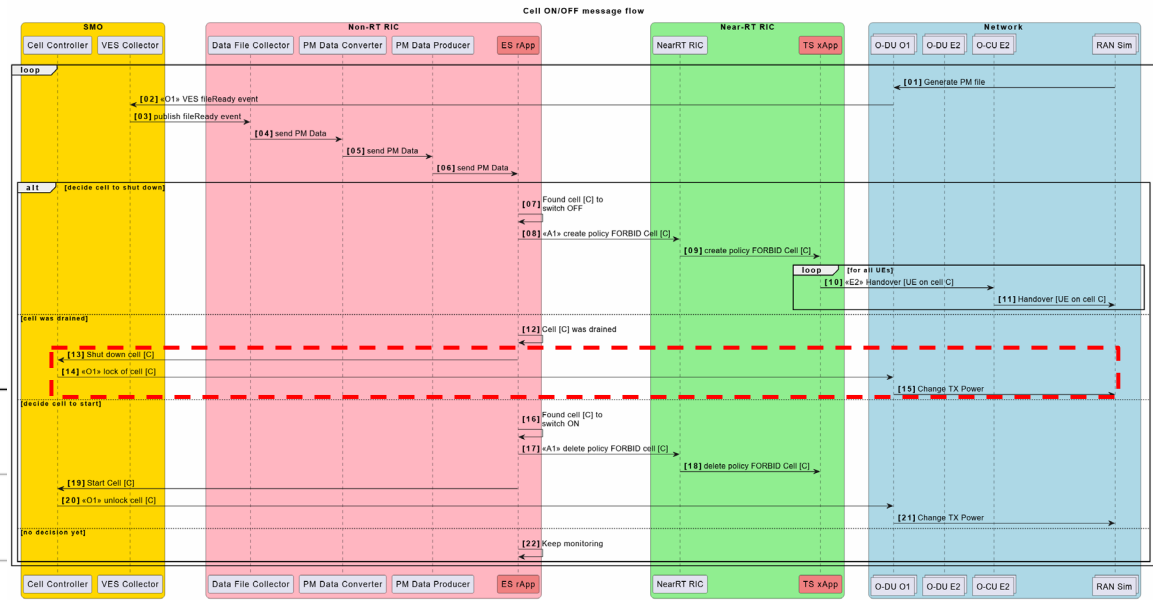
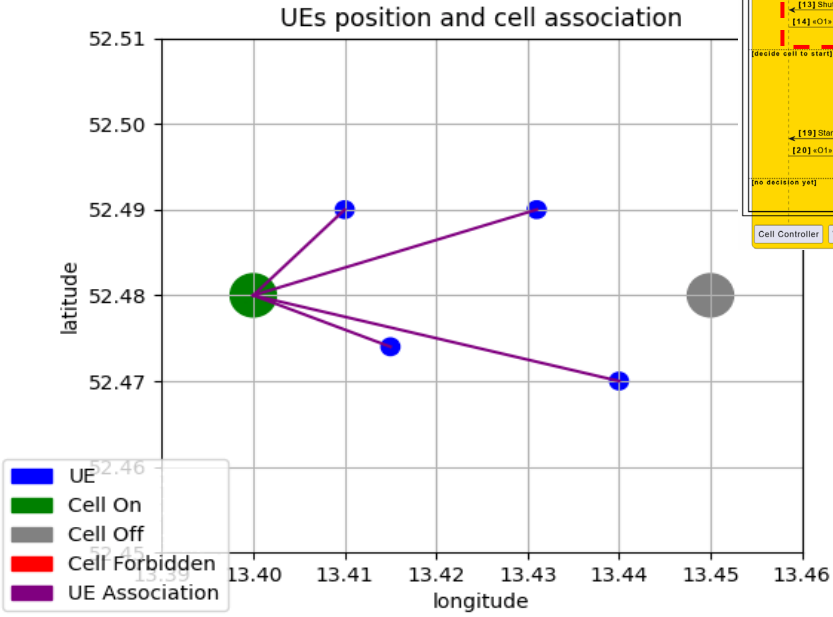
- UE
- Cell On
- Cell Off
- Cell Forbidden
- UE Association



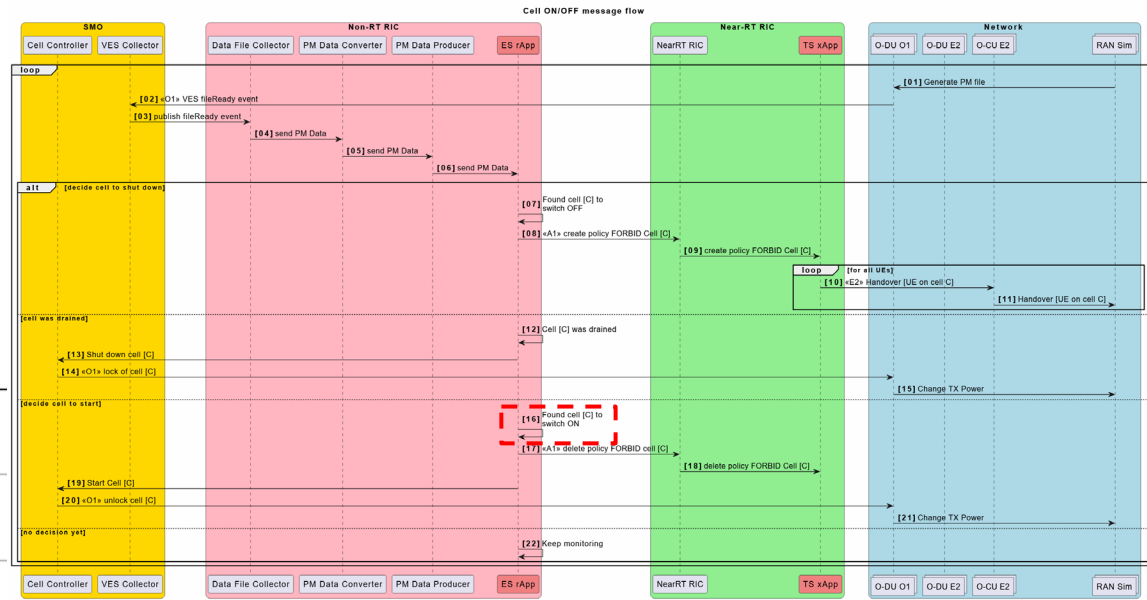
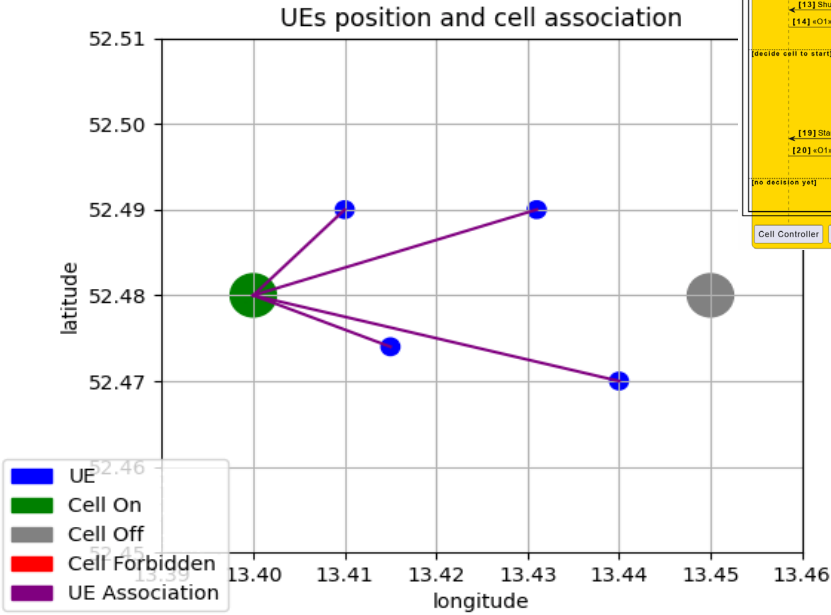
UEs position and cell association



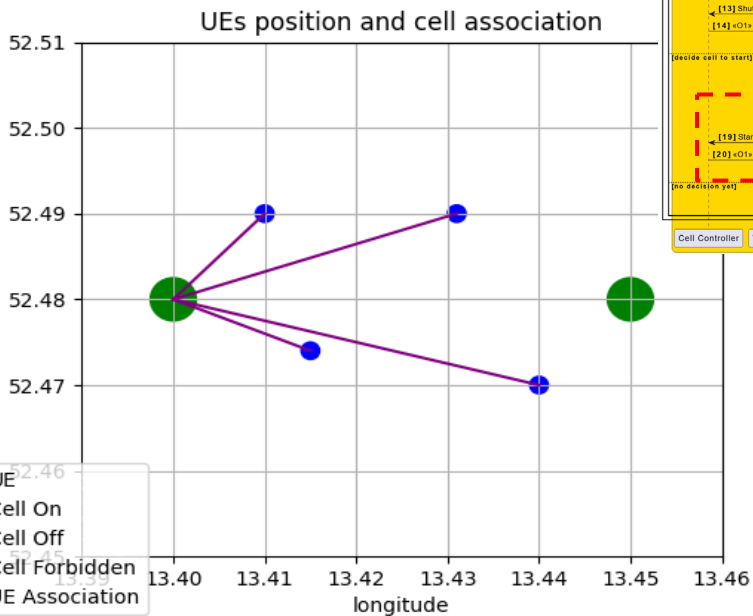
All users moved to left cell



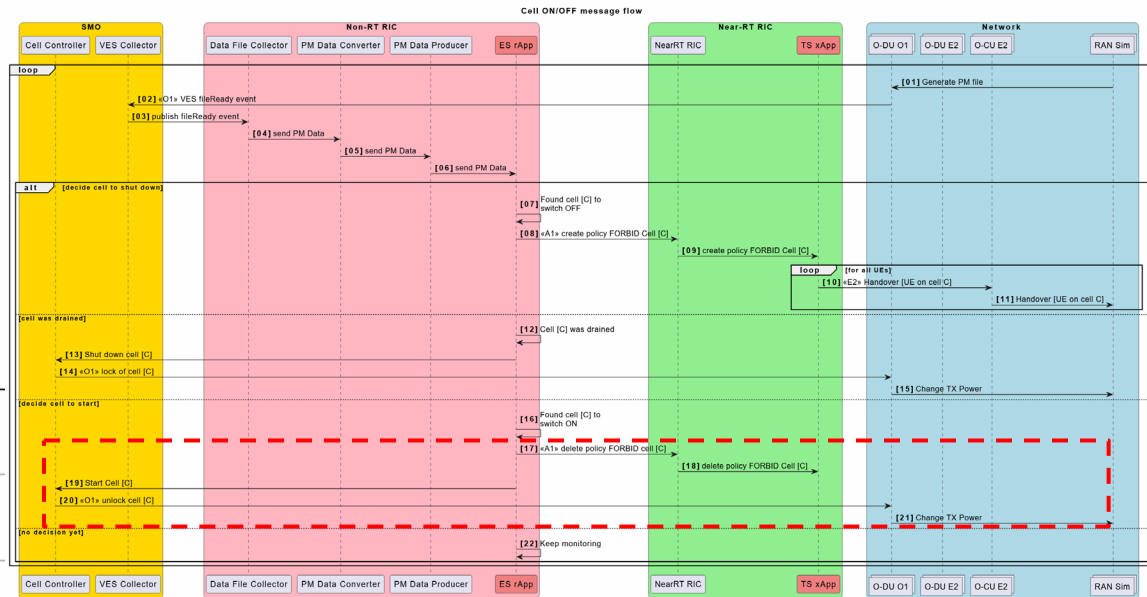
Switching off right cell

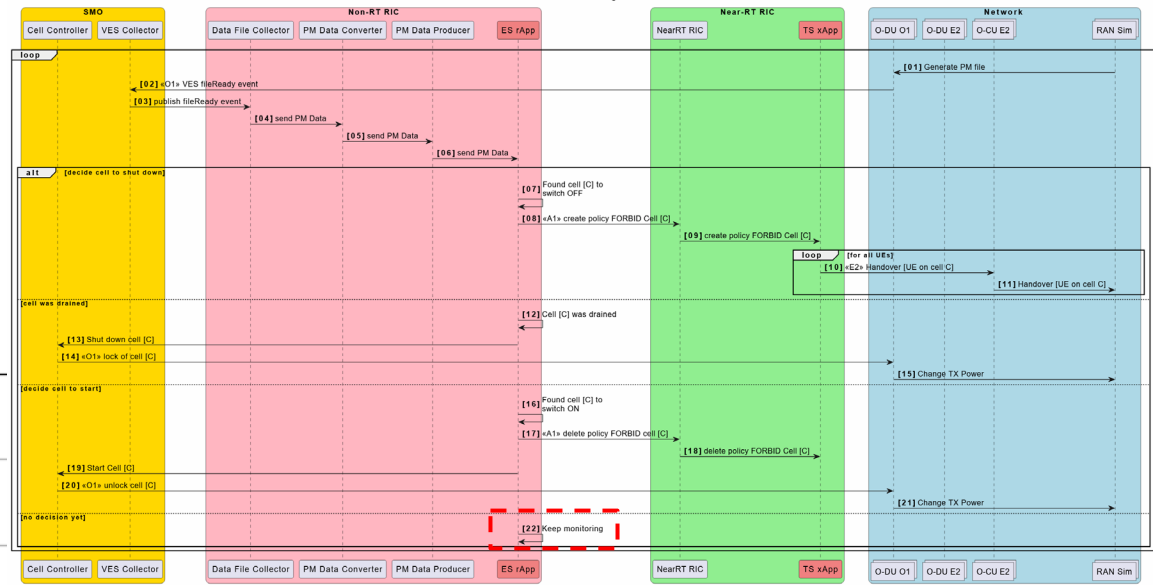


Average PRB usage  $\geq$  threshold\_es\_off  
Trying to enable one cell.

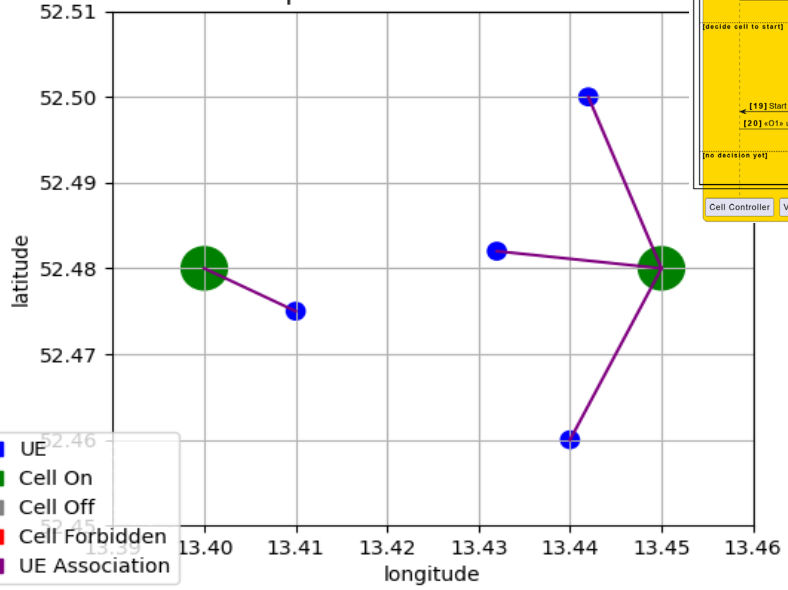


Switching on right cell





UEs position and cell association



Both cells are available for users

# Summary and Next Steps

- Energy Saving and Traffic Steering are two of the most important use cases for the mobile industry
  - This is the first time the ONF community has collaborated to create a single demonstration that combines these use cases in a unified open source solution
  - In this setup, we focus on an rApp-xApp tandem and coordination between them to ensure the system is stable while enabling energy savings, as opposed to a single application doing both functions (conventional approach)
- Next steps
  - The demo to be made available in various labs
  - Multi-vendor xApp/rApp tandem : demonstrating vendor interoperability
  - AI/ML based model for rApp, trained on real network data
  - Integration of commercial simulator to the open source RIC/SMO stack (replacing the current open source simulator)
  - Moving to the next phases of SMaRT-5G



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Thank You