OPEN RAN TECHNICAL PRIORITIES

Focus on Energy Efficiency

UNDER THE OPEN RAN MOU

by Deutsche Telekom, Orange, Telefónica, TIM and Vodafone

This document provides a high-level description of the MoU signatories' technical requirements on Energy Efficiency ("EE").

For the avoidance of doubt, the technical requirements set out in this document are those that the signatories of the Open RAN MoU consider priorities for Open RAN solutions. They serve as guidance to the RAN supplier industry on where to focus to accelerate market deployments in Europe.

1. Overall objectives

Energy Efficiency is an end-to-end requirement involving all domains of Open RAN, which is recommended to be addressed upfront in the design of Open RAN solutions.

The overall objective is for Open RAN networks to gradually become more energy efficient than traditional RAN without sacrificing Open RAN concepts such as cloudification and disaggregation.

EE for Open RAN networks should therefore rely on the following pillars:

- Choice of power efficient hardware
- KPIs at different Hardware and Software levels to report EE
- Open RAN features to improve EE on functional level comparable to SRAN
- Intelligence and orchestration to automate EE features

For each of the network components, suggested EE targets have been defined.

EE priorities have been treated in a transverse manner across the Technical Priority Document, encompassing all the streams (O-RU, O-CU/O-DU SW & HW, O-Cloud SW platform, RIC, RAN features and SMO), with alignment of requirements between streams to ensure the overall consistency.

2. Energy Efficient Hardware

Energy efficient hardware is key to minimise the energy consumption of the network.

While O-RUs represent the major part of the overall power consumption in RAN, hardware infrastructure supporting other functions such as O-DU and O-CU also needs to be considered.

To start with, it is recommended that PAs are not only designed with energy efficient power amplifiers and transceivers, but also with the ability to switch off most of the transmitter elements and digital front end when the network is unloaded.

Commercial-Off-The-Shelf (COTS) servers relying on General Purpose Processors (GPP) to support CU/DU functions should also ideally be designed with power efficient hardware, including low voltage modules.

The choice of accelerator technology (FPGA, GPU or eASIC), due to the compute-intense requirements to support advanced radio functions such as Massive MIMO, will need to be made with careful consideration of their power efficiency.

Globally, to ensure optimal performance in terms of EE, suggested targets have been defined for each of the HW elements of the network.

3. Energy Efficiency KPIs

Measuring and reporting energy consumption is a baseline requirement for the management of EE across the network. Each network element will therefore require dedicated KPIs.

The following counters and KPIs have been prioritised:

- Availability of counters/KPIs to be able to monitor in any time period the power consumption per RAT and frequency band/cell in Multi-band O-RUs.

- O-RU KPIs:
  - EE and power consumption KPIs provided by real-time metering

- O-CU/O-DU HW & SW / O-Cloud SW platform KPIs – it is recommended that:
  - O-CU/O-DU hardware (e.g. CPU, accelerators, NIC cards, fans and power supply, etc.) shall have the capability to measure and report power consumption values to the O-Cloud.
  - The O-Cloud SW shall be able to collect measurement data at the hardware component level (e.g., CPU, NIC, accelerator card, fans and power supply, etc.) and provide power, energy and environmental (PEE) parameters / KPIs. O-Cloud shall be able to report EE through O2 interface to the SMO or through NBI to external tooling.
  - The O-Cloud SW shall be able to provide PEE parameters/KPIs at the workload level (e.g. pod, O-CU/O-DU CNF, etc.), as well as for the O-Cloud platform software components themselves. O-Cloud shall be able to report energy efficiency through O2 interface to the SMO or through NBI to external tooling.
  - O-CU and O-DU provide CNF level energy efficiency counters / KPIs (e.g. power consumption / Traffic load / data volume / throughput), which shall be reported through O1 interface to the SMO or through NBI to external tooling

All KPIs will likely require adapted collection and reporting mechanisms:

- KPI reporting to be supported across Open RAN interfaces
- Data collection and dashboard generation at SMO level, with various levels of aggregation (cluster, CNF, PNF levels)
- Hierarchical or hybrid management model for the O-RU should lead to equivalent KPI results.

Besides, for measurement of power consumption of RAN network elements (e.g. O-RU, O-CU/O-DU SW & HW, O-Cloud SW platform) in realistic load scenarios, RF load generators will be required to be able to artificially load the network by activating pre-defined numbers of Physical Resource Blocks.

4. Features to improve Energy Efficiency

Optimising EE requires a range of features to be supported in order to deactivate network elements at low load in a dynamic manner.

As a general principle, any RAN/O-RAN cell site power consumption shall tend to “zero Watt at zero traffic”, with zero traffic corresponding to the idle state for the RAN node with no “connected users”.

The main types of features for Radio, O-CU/O-DU HW & SW, and O-Cloud SW platform are as follows:

Radio features:

- Symbol shutdown allowing O-RUs to be moved to sleep mode, by switching off power amplifiers and other transceiver components with OFDM symbol granularity.
- Cell switch-off allowing an entire cell (i.e. a frequency layer) to be switched off, leading to most of the RF and Digital Front End components to be set to sleep mode with a few seconds granularity (a couple of minutes maximum).
- RF transceiver switch-off, leading to the reduction of the number of MIMO layers and/or the number of MU-MIMO scheduled users under QoS constraints.

Power management at O-CU/O-DU HW and O-Cloud SW platform level:

- O-CU / O-DU hardware sleep mode to give the ability to switch off part of the processors to adapt dynamically to the workload (e.g. CPU, accelerators) and to minimise the power consumption of fans in case of low load.
- Support of CPU C-state for power reduction and P-state to run processors at different voltage and/or frequency levels.
- Capability to free up and control sleep mode/C-state/P-state of specific hardware resources (e.g. server, CPU) with dynamic reallocation of active workload to specific accelerators and/or CPUs.

Specific features involving O-RU elements to be switched off (OFDM symbol shutdown, cell and MIMO switch-off) need to be also supported by the O-RUs themselves.

5. Intelligence to optimise and automate Energy Efficiency

To make the most of the EE features, a specific automation and optimization framework is expected to be required, leveraging on collected KPIs and data analytics with AI/ML algorithms, with both the SMO and the RIC playing an essential role in orchestrating power saving mechanisms across the RAN infrastructure.

In particular, the operator shall be able to control the activation of each feature at SMO level, with the option to tune various parameters (e.g. scheduling the activation / deactivation over pre-defined time periods).

Intelligent management and orchestration of O-CU/O-DU HW and O-Cloud SW platform resources, coordinated by SMO, are required for the sake of EE. As an example, optimised workload placement and automated scale-in / scale-out processes help to dynamically adapt the pool of active hardware resources to the actual workload needs and allow to free up HW resources which could be shut down in idle times.

RIC-based functions dedicated to EE with support from AI/ML algorithms should improve the EE of the network from different perspectives, e.g.

- Direct power saving through the activation / deactivation of advanced sleep mode functions, allowing network elements to be switched off in an intelligent manner using predictive approaches
- Indirect power reduction by means of energy aware traffic steering, allowing particular cells to be switched off by offloading the traffic to specific bands

6. Energy Efficiency targets

Each network element requires specific EE targets, which may vary depending on network architecture, configuration and load.

Specific targets have been defined in the Technical Priority Document.

For O-RUs:

- O-RU energy efficiency at 100% user traffic load, defined as the ratio of transmitted power over power consumption
- O-RU power consumption at 0% user traffic load, with basic power saving features activated (i.e., symbol shutdown meaning the feature to switch-off/switch-on at OFDM symbol granularity is taken into account)

The initial objective for O-CU/O-DU hardware is to be at least as energy efficient as traditional Base Band Units, with equivalent network configurations.

For O-CU/O-DU, maximum allowed power consumption targets are defined for distributed RAN (O-CU/O-DU on site) with specific network configurations depending on capacity:

- Low capacity scenario: 3 sectors with 2 Layers LTE (each with 20 MHz, 4T4R) + NR (20 MHz, 4T4R)
- High capacity scenario: 3 sectors with 4 Layers LTE (each with 20 MHz, 4T4R) + NR Massive MIMO (64T/64R), 100 MHz and 16 layers DL / 8 layers UL.