P8800S UeSIM RAN Testing Toolset

UE emulation solutions for RAN and Open RAN testing

Testing of RAN and Open RAN Networks

The Radio Access Network (RAN) is a vital component of mobile telecommunications systems, connecting individual devices to the broader network through radio connections. In the context of 5G, modern RAN technologies have significantly evolved to support higher speeds, lower latency, and greater capacity. Key features of modern RAN include:

- Massive MIMO (Multiple Input Multiple Output, mMIMO)
- Beamforming
- Network Slicing

Open RAN (O-RAN) is an approach to building RANs using open and interoperable interfaces, allowing components from different vendors to work together providing following flexibility for the network providers and operators.

Artificial Intelligence (AI) and **Machine Learning (ML)** plays a crucial role in modern RAN. AI enhances optimization of the network performance, efficiency and adaptability. AI analyzes real-time data for better resource allocation, reduces latency, and enables predictive maintenance to prevent issues. This results in smarter, more reliable networks ready for future advancements like 6G.

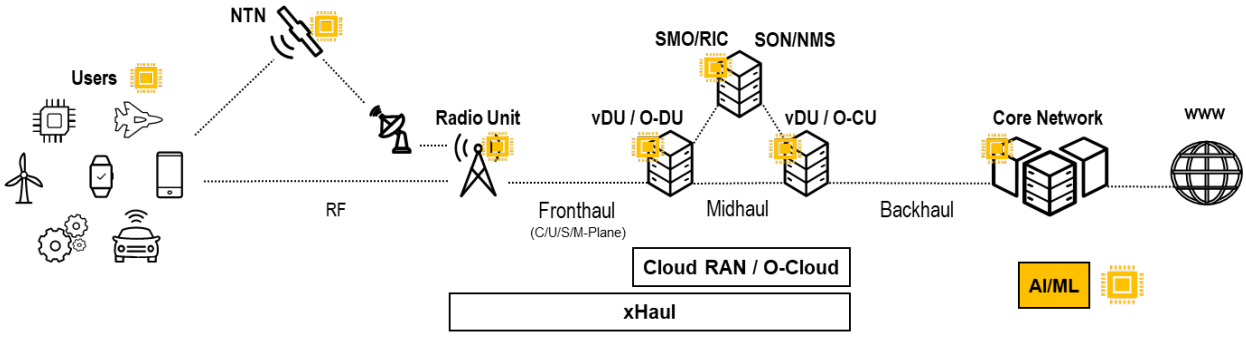

Figure 1. RAN and O-RAN architecture for Terrestrial and Non-Terrestrial networks

KEYSIGHT

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Testing Challenges in RAN Testing Workflow

Testing Radio Access Network (RAN) and Open RAN (O-RAN) components involves several complex challenges. For RAN, ensuring seamless integration and performance across various network elements is critical. O-RAN introduces additional hurdles with its multivendor, disaggregated architecture, requiring rigorous conformance and interoperability testing to ensure different vendors' components work together effectively. The disaggregation of gNB components necessitates testing each part in isolation and in integrated scenarios, adding to the complexity.

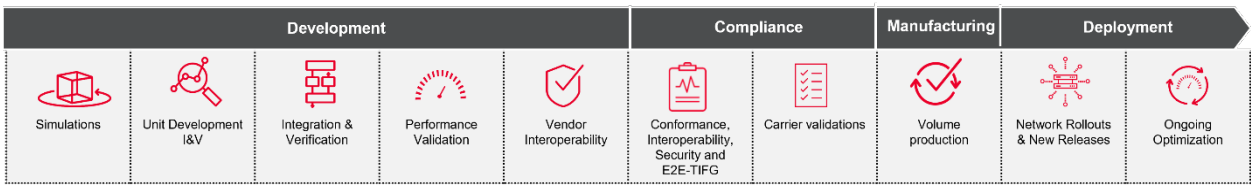

Figure 2. Example of RAN component development workflow

Development phase

Development phase includes various steps where each of them introduces their own challenges. Some of the key challenges which are shared across the steps:

- How to validate the implementation of network elements new features at early stage, before actual UE availability, including forefront technologies like MU-MIMO and NTN.
- How to optimize RAN scheduling algorithms, specifically for MU-MIMO co-scheduled devices.
- How to validate RAN performances in realistic and demanding end to end scenarios, under traffic load of thousands of devices.
- How to generate continuous workloads to develop, train and optimize AI-RAN models.

Compliance phase

In compliance phase components needs to be validated to meet the set specifications. For this type of testing, automation is crucial to be able to run the tests according to set requirements.

- How to ensure interoperability gaps between vendors, specifically within the O-RAN ecosystem.
- How to ensure system meeting set carrier expectations.
- How to characterize and optimize energy efficiency of RAN solutions.
- How to assess and improve RAN response to increasing security threats.

Deployment phase

At deployment phase testing is continuous process where new networks are rolled out, new network releases are being validated, and performance is continuously optimized.

- How to seamlessly integrate into continuous CD/CI/CT workflows for regression.
- How to replicate in the lab complex issues coming from the field.
- How to assess network optimizations before deployment.

P8800S UeSIM RAN Testing Toolset

Figure 3. P8800S UeSIM RAN testing toolset

UeSIM is a UE emulation solution which enables infrastructure vendors, chipset providers and mobile operators to validate end-to-end Radio Access Network (RAN) performance by emulating real network traffic over both radio and O-RAN fronthaul interfaces. Solution is designed to accelerate multi-standard end-to-end network verification by generating IP traffic load, simulating applications running on thousands of concurrent devices operating real voice and data sessions. Both conducted and live testing across the full range of frequencies is supported, with the possibility to cover real-world scenarios spanning protocol and load testing in the lab to field testing, trials and deployments.

Key features

- Support for key 3GPP technologies
  - 4G and 5G in NSA and SA modes, FR1 & FR2 radio frequencies
  - Massive MIMO with beamforming up to 64T64R
  - Non-Terrestrial Networks (NTN)
  - NB-IoT
- Full protocol stack assessment from L1 to L7 covering functional testing – layer by layer

- Scalable up to thousands of UEs and 10+ Component Carriers's with simulation of real application data and generation of network traffic load.
- Support for gNB wrap-around testing with Keysight core emulation option.
- RedCap, Private Networks and Network Slicing.
- Service quality validation with subscriber modeling, and multi-play voice, video, and data traffic generation: eMBMS, VoNR, ViNR.
- Advanced mobility scenarios, fading and cross-cell interference simulation.
- Automation and Integration into CI/CD/CT Workflows.
- Data generation for AI/ML, AI/ML Benchmarking, RAN Workloads for AI and RAN
- Automated O-RAN compliance testing.
- UE / O-RU emulation over the O-RAN Fronthaul with P8822S RuSIM RAN Testing Toolset

Who benefits from this solution?

- Network Equipment Manufacturers (NEM's)
- Mobile Network Operators (MNO's) and Solution Integrators
- Satellite Network Operators (SNO's) and Satellite Manufacturers
- Open Test and Integration Centres (OTIC)
- Open RAN component providers (O-RU, O-DU, O-CU)

Solution components

Figure 4. P8800S UeSIM RAN testing toolset components

AirMosaic UeSIM application

- Main user interface to control UeSIM system.
- Test system configuration and scenario creation.
- Real-Time test execution, results analysis and reporting.

Ethernet Line Server Unit (eLSU)

- eLSU runs the UeSIM full stack protocol signaling and control functions of the solution.
- System can be scaled up by clustering multiple eLSU units.

Software Defined Radio (SDR) RF unit – For MIMO testing

- SDR provides the RF connections to O-RU or gNB up to 16 layers per unit. Number of layers can be scaled up with multiple SDR units.

Massive MIMO testing with Beam MIMO Detect (BMD)

- Designed for comprehensive testing of Massive MIMO (mMIMO) and beamforming technologies up to 16 co-scheduled MU-MIMO UEs in same time and frequency resource.
- Serves as a massive connectivity RF front-end for Keysight's UE emulation solution (UeSIM), allowing for the simulation of a large number of spatially distributed and moving UEs.
- Enables realistic field environment simulation.

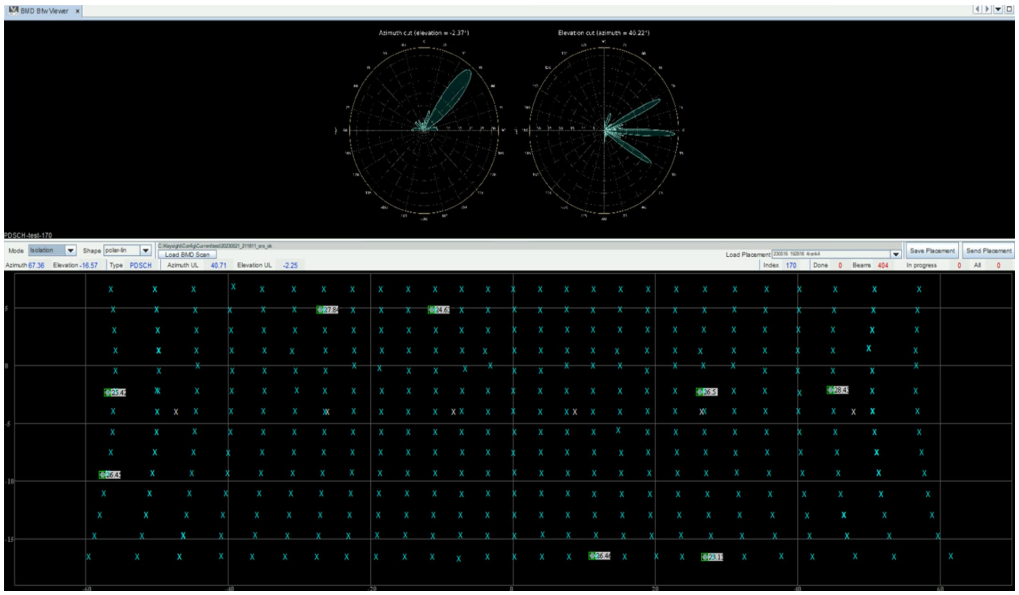

Figure 5. Airmosaic UeSIM Application with mMIMO configuration and beam analytics

Automation, analytics and reporting with Atlas Test Management Center (Atlas-TMC)

- Atlas TMC provides the automation, analytics and reporting interface with pre-defined test case scenarios.
- O-RAN compliance test scenarios enable user to perform test cases according to O-RAN Alliance and 3GPP specifications.

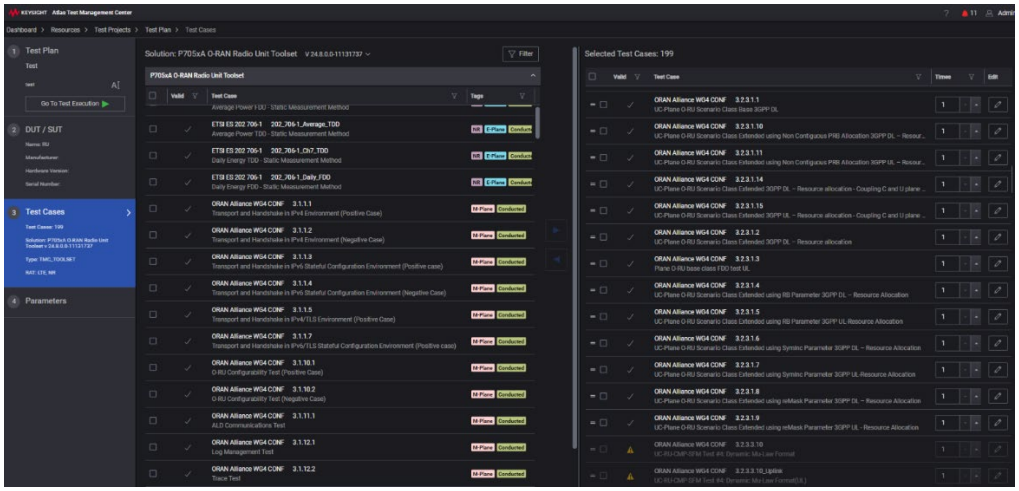

Figure 6. Atlas test management center

Key Use Case Examples

UeSIM provides test solution spanning from early 3GPP feature validation to E2E network performance testing. Below the key use cases highlighted.

- 3GPP Release Validation
- mMIMO DL and ULPI performance validation, including beamforming
- RAN E2E Performance Testing and Optimization
- AI-RAN workload generation, KPI validation and training data generation.
- Non-Terrestrial Networks Testing (NTN)
- O-RAN Compliance Testing covering interoperability, performance and security
- Energy Efficiency Testing

3GPP feature development and verification

3GPP release validation can be split in pre-release validation, when release is not published yet, and frozen release validation. Main challenge for the pre-release validation is that there is no UE's available to test the new 3GPP features and somewhat same challenges stand for the post-release testing.

UeSIM solution provides the latest 3GPP features available to emulate UE's to validate RAN functionality and performance, even before the specification is frozen (pre-release).

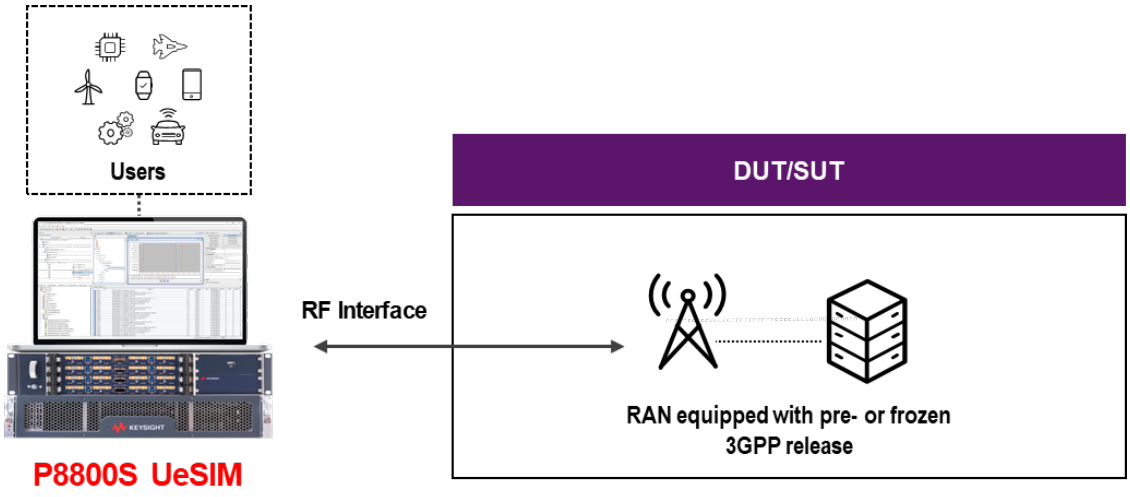

Figure 7. UeSIM solution for 3GPP development and verification

Massive MIMO (mMIMO) Beamforming

UeSIM provides the solution to cover the needs for mMIMO testing, in different phases of the product development worklow. Solution supports massive MIMO beamforming including also ULPI with O-RU up to 64T64R, with the possibility to aggregate more units to test wider O-RU panels and multiple MU-MIMO carriers.

- Test multiple layers
- Load testing
- Mobility testing

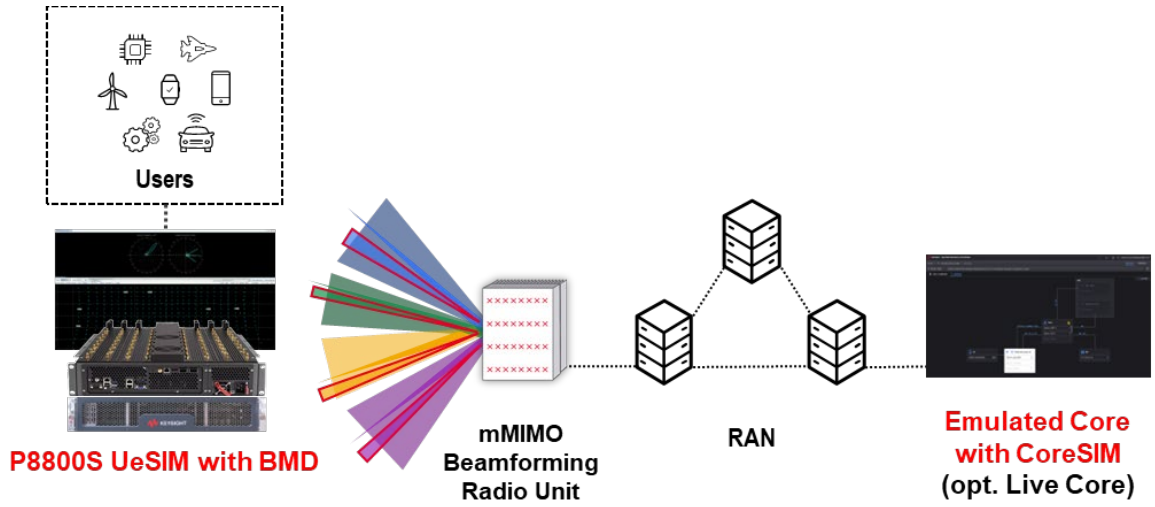

Figure 8. UeSIM solution with BMD advanced multi-port radio for testing RAN with beamforming mMIMO radio unit with ULPI capability.

See use case of How to Emulate Massive MIMO End-to-End**.**

RAN/gNB E2E performance

UeSIM provides the solution for RAN E2E performance validation using real life scenarios:

- Full protocol stack validation including system capacity and user experience characterization.
- Real world traffic simulation to measure data throughput, call drops and advanced mobility scenarios i.e. congestion traffic models service and mixed traffic models.
- Load generation with high number of users per cell.

Wrap-around test solution for RAN/gNB is created when combined with CuSIM and CoreSIM components.

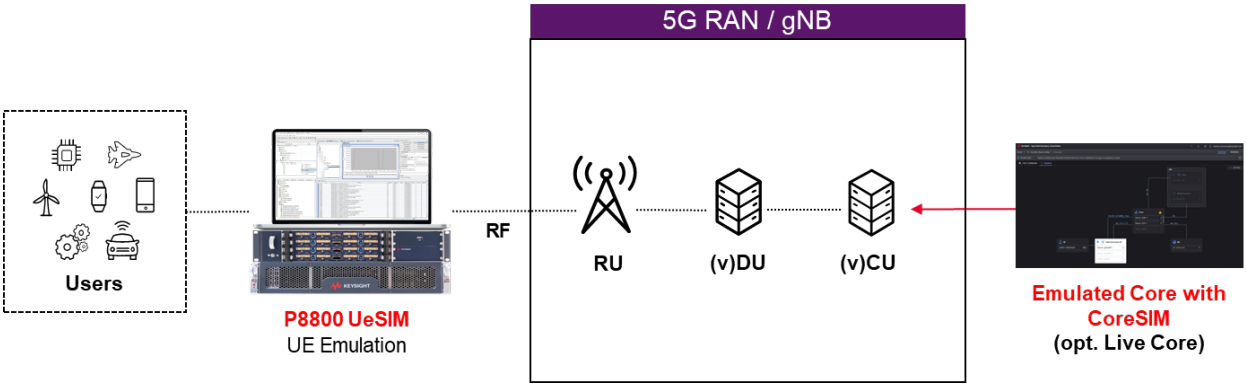

Figure 9. P8800S UeSIM for 5G RAN / gNB wrap-around testing

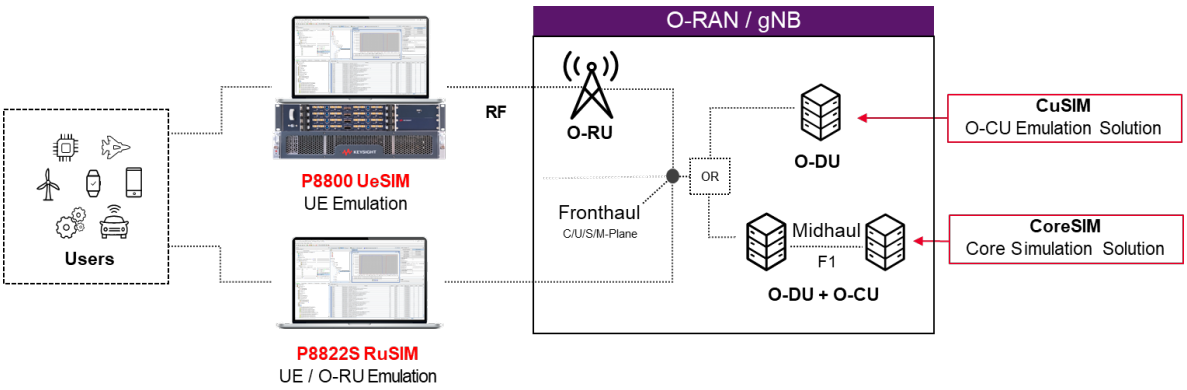

Figure 10. P8800S UeSIM / P8822 RuSIM for Open RAN wrap-around testing

For RAN testing over open fronthaul interface, when O-RU is not available or is wanted to be emulated, Keysight P8822S RuSIM provides solution solution for this use case. Read more about P8822S RuSIM solution.

3GPP Non-Terrestrial Networks (NTN) testing

P8800S UeSIM offers a comprehensive testing solution for NTN, featuring built-in channel emulation to simulate both service and feeder links. This cost-effective solution enables customers to perform functional and load testing for NTN systems utilizing integrated Low Earth Orbit (LEO) and Geostationary Orbit (GSO) satellite emulation, with a small lab footprint.

As a future proof solution, UeSIM covers NR-NTN, NB-NTN and Terrestrial networks testing needs all in one solution. Solution provides test bed for customers requiring wider bandwidths and test environment for 5G advanced and 6G technologies. UeSIM can be paired with PROPSIM Channel Emulator as an option for scenarios requiring advanced channel emulation.

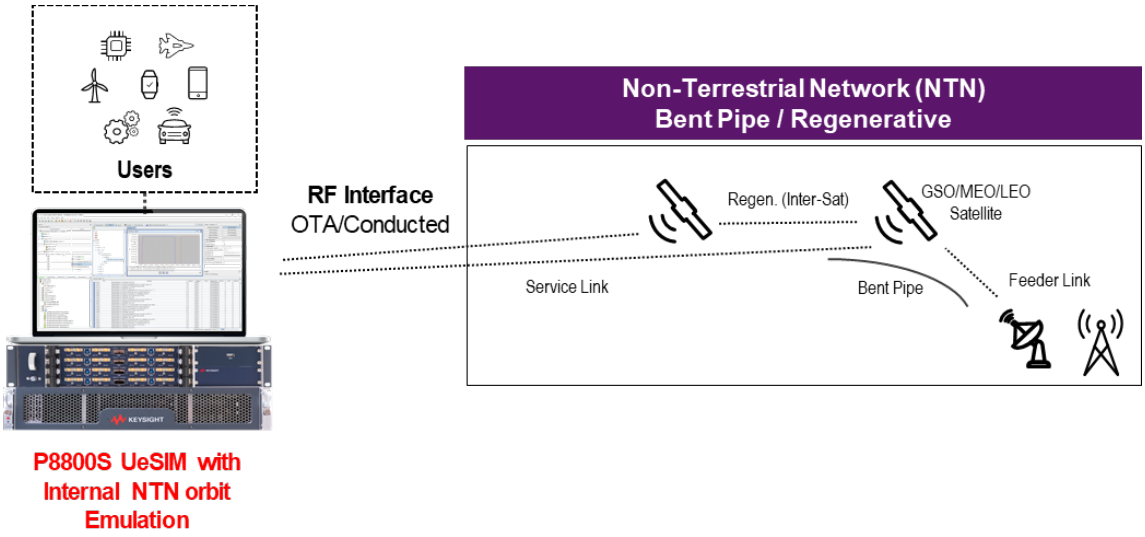

Figure 11. NTN test scenario configuration to emulate

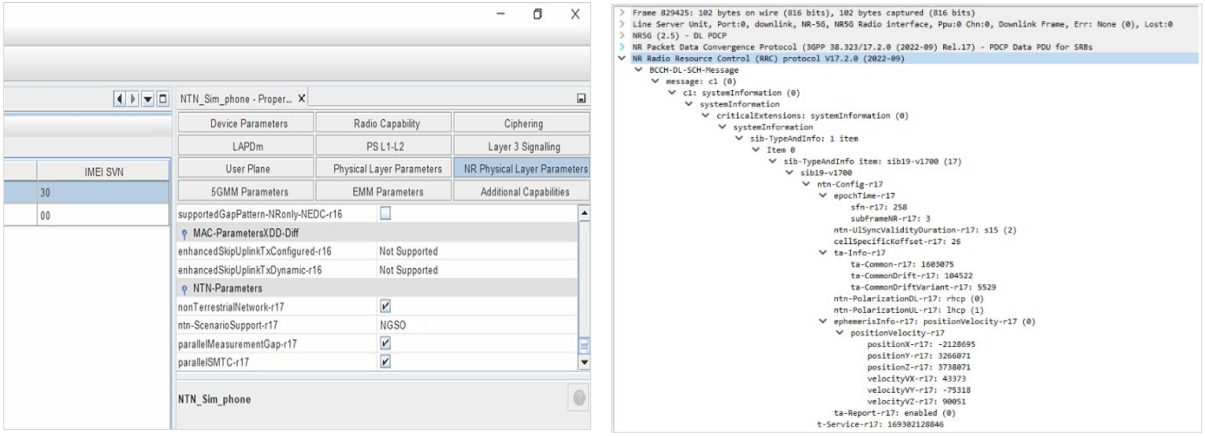

Figure 12. NTN scenario configuration and SIB19 analysis using UeSIM application software (AirMosaic)

Discover use case of How to Emulate Non-Terrestrial Networks in the Lab.

Testing AI empowered RAN (AI-RAN)

Keysight provides wrap-around solution for RAN workload generation, performance evaluation and training data creation for AI-RAN system:

- RAN Workload generation for AI-RAN use cases
- Training data creation.
- KPI Benchmarking of AI/ML models.

Figure 12 illustrates test configuration for AI-and-RAN use case RAN and AI shares the cloud cluster. UeSIM generates RAN workloads, CoreSIM emulates core network and Atlas TMC handles the test automation, results reporting and analytics. RuSIM solution can be alternatively used when Radio Unit emulation is needed.

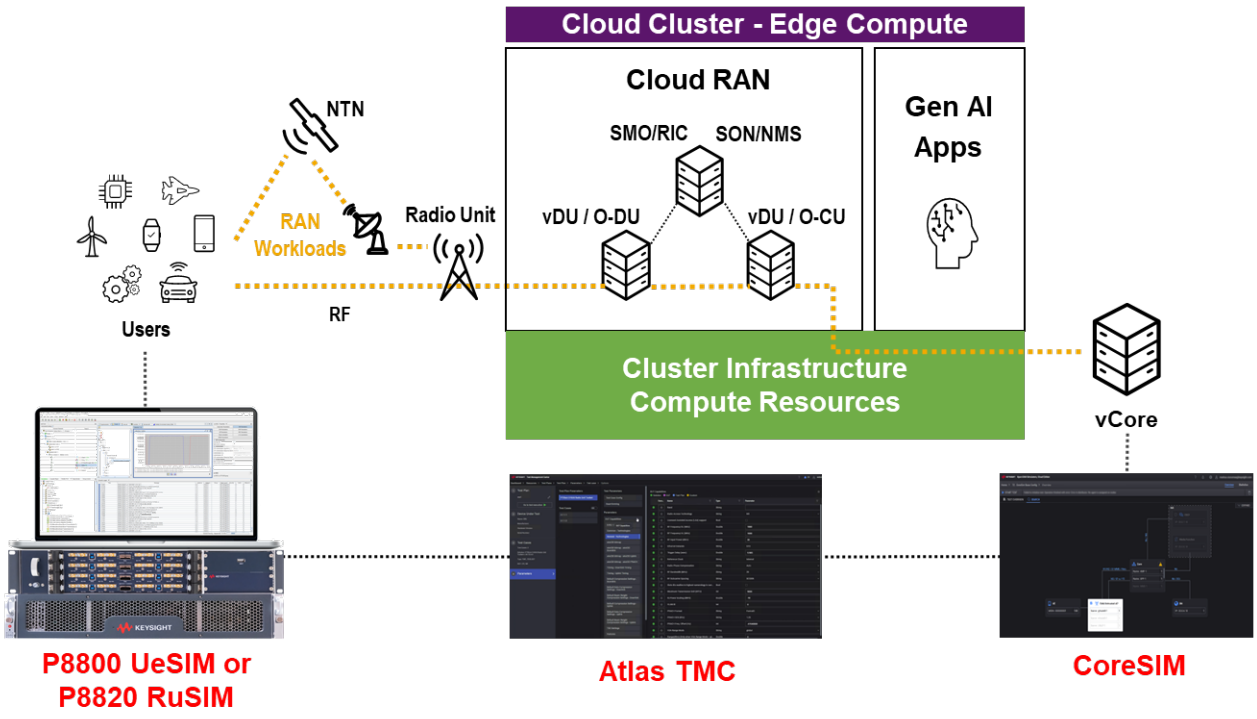

Figure 13. Wrap-around test solution to generate RAN workloads for AI-and-RAN use case

O-RAN compliance testing

Keysight O-RAN Compliance Test Cases Portfolio offers comprehensive test coverage for scenarios defined by the O-RAN Alliance.

Following automated O-RAN Compliance test cases are available with UeSIM:

- O-RAN WG4 Interoperability Test Cases
- O-RAN TIFG E2E Performance Test Cases
- O-RAN WG11 Security Test Cases

O-RAN compliance test case execution, analytics and reporting is centralized to Keysight Atlas Test Management Center (Atlas-TMC).

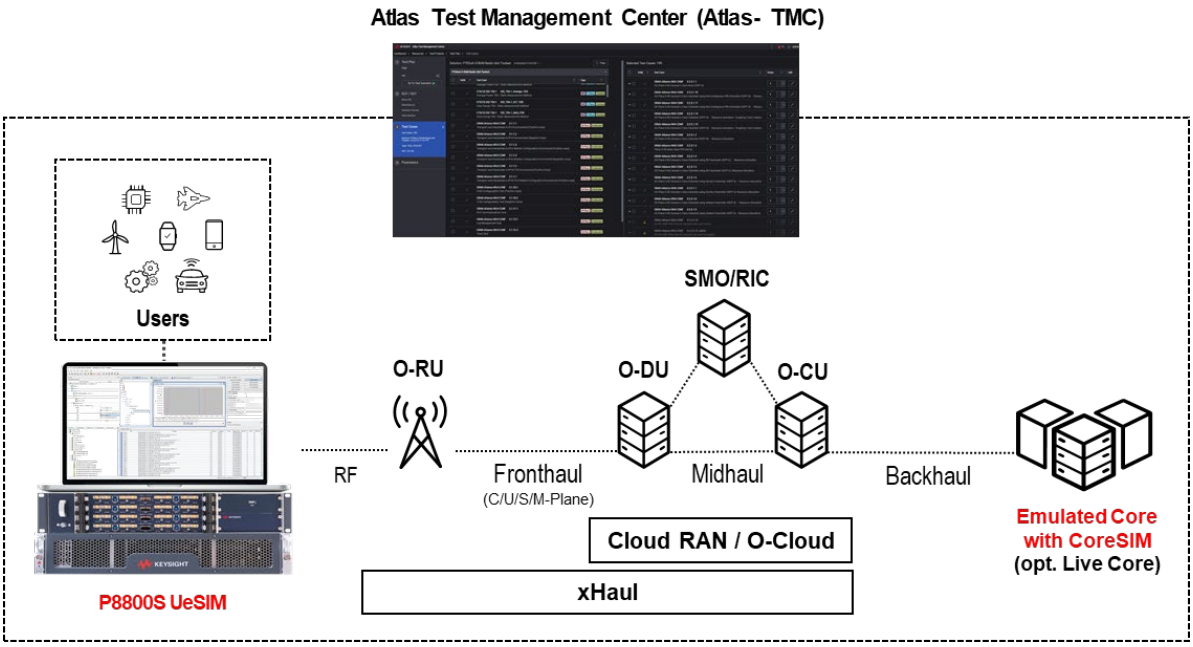

Figure 14. Keysight Atlas Test Management Center (Atlas-TMC) orchestrates the O-RAN compliance tests

Read more about Keysight Open RAN compliance test cases.

Ensuring energy efficency

UeSIM together with Atlas Test Management Center (TMC) forms solution to test energy efficiency of various components:

- Measure power consumption of cloudified O-DU/O-CU.
  - Name space level
  - Pod Level
  - Container Level
- Measure RAN/gNB level energy efficiency.
- Perform tests according to ETSI standards with different traffic profiles.

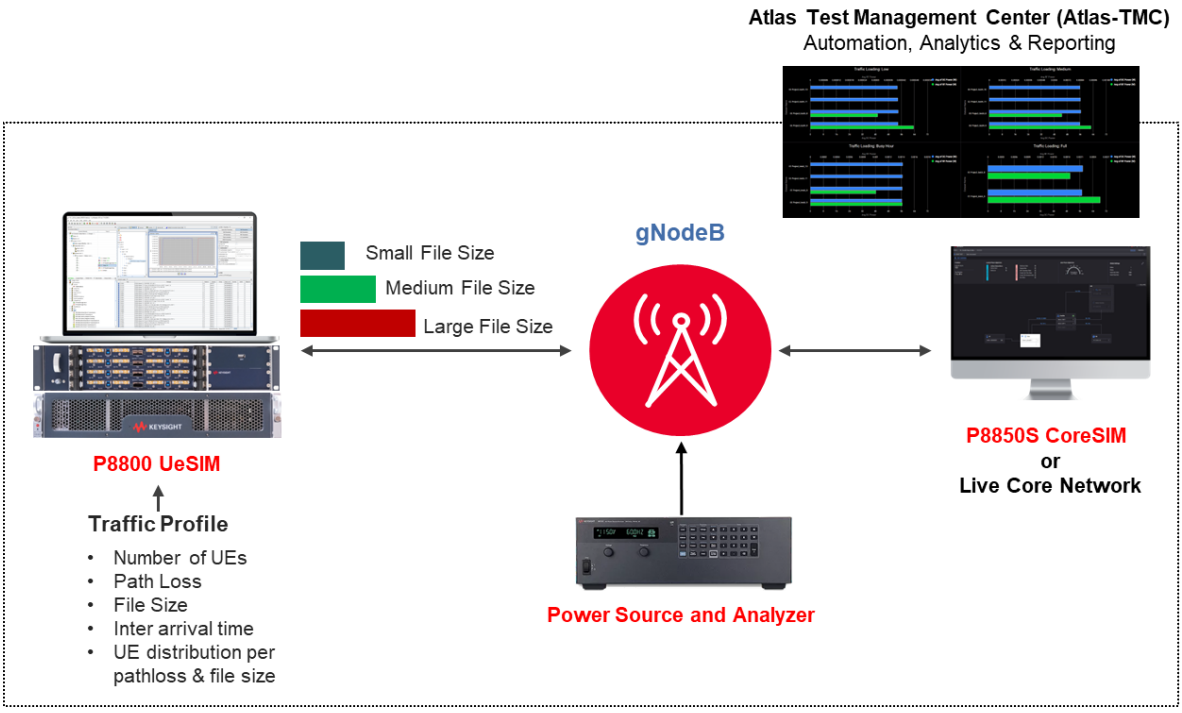

Figure 15. gNodeB Energy Efficiency test configuration

Discover the use case of gNodeB energy efficiency testing according to ETSI specifications.

Flexible licensing options

Keysight offers a wide range of license types and terms for fit into your testing needs, allowing cost effective use of assets.

License type	Description
Node Locked	License may be used on one specific PC/instrument
Floating	Networked instruments/computers can access a license from a server one at a time
Floating single site	License server is based within 1 mile radius from the instrument/computer

License type	Description
Perpetual	Perpetual licenses can be used indefinitely
Subscription based	Temporary licenses can be used for a limited duration of 6, 12, 24, or 36months

Further Resources

- P8800S UeSIM UE Emulation RAN Solutions
- Beam MIMO Detect (BMD) Datasheet
- Radio Access and Core Network Test

Related Solutions

- U5040BSCB Open RAN Studio for O-RU Testing and Validation
- P8822S RuSIM – UE / O-RU Emulation Over the O-RAN Fronthaul
- P8827S CuSIM – O-DU Midhaul Solutions
- P8826S DuSIM – O-CU Midhaul Solutions
- P8828S RICtest — RAN Intelligent Controller Test Solutions
- P8900S LoadCore – Core Network Solutions
- SJ001A WaveJudge Wireless Analyzer Toolset
- PROPSIM Channel Emulator Platforms
- S9160A Massive MIMO and MIMO RF Beamforming Test Accelerator for 5G