White Paper

VIAVI Solutions

O-RAN: An Open Ecosystem to Power 5G Applications

Open Radio Access Network (O-RAN) is being adopted by operators and equipment manufacturers worldwide to reduce infrastructure deployment cost and lower the barrier to entry for new product innovation. This white paper provides an overview of this technology, industry initiatives to standardize and validate it, and the ecosystem developing around it. A companion Test Suite for O-RAN Specifications presents a comprehensive test suite with modules for lab validation, field deployment and service assurance.

O-RAN Overview

The expectations of 5G will place enormous demands on the network infrastructure to deliver massive volumes of data over swathes of spectrum to multitudes of users at challenging latencies. To meet this challenge necessitates the possibility for the different logical functions of the network to be flexibly placed at different physical locations and for them to be coordinated by a new RAN Intelligent Controller function.

Traditionally, as shown in Figure 1, RAN components such as radio and digital base band have been built on proprietary hardware, and these components typically use vendor-specific protocols for communications. Software functions and interfaces between the different RAN components are designed for optimal performance for that proprietary hardware. For example, Common Public Radio Interface (CPRI) is commonly used for LTE fronthaul (link between radio unit and baseband unit), however, vendor specific implementation often restricts multi-vendor operability.

For the introduction of RAN functions disaggregation and open interfaces in 5G, 3GPP has in Release 15 specified a Higher Layer Split (HLS) option of the gNB, which is also known as the Option 2 NR-PDCP split option. In this option, the gNB may consist of a Central Unit (gNB-CU) and one or more gNB Distributed Unit (gNB-DU) connected through the F1 interface. 3GPP has delivered a set of specifications for the F1 interface, however realizing multi-vendor interoperability over the F1 interface can be very challenging as these specifications have been defined with options which can be used in different manners depending on vendors' implementations.

3GPP started a study on Lower Layer Split (LLS) in Release 15 during which multiple lower layer split options were identified. But it has proven to be difficult for the 3GPP community to converge on specifying a single split option in 3GPP and that study item has completed with no further actions planned. Many vendor specific implementations of lower layer splits exist in the market today which even though they have been optimized to take advantage of the benefits of lower layer split such as improved radio performance due to coordination gains, these closed systems do not support multi-vendor interoperability.

O-RAN is delivering well-defined specifications to the industry to enable deployments of O-RAN-based programmable networks consisting of fully-disaggregated modular O-RAN network functions. These are designed to be multi-vendor interoperable over open interfaces running on cloud-based virtual systems. This empowers operators to design and deploy mixed-vendor network along with network slices which are key to delivering mixes of use cases in the same O-RAN infrastructure.

What is O-RAN?

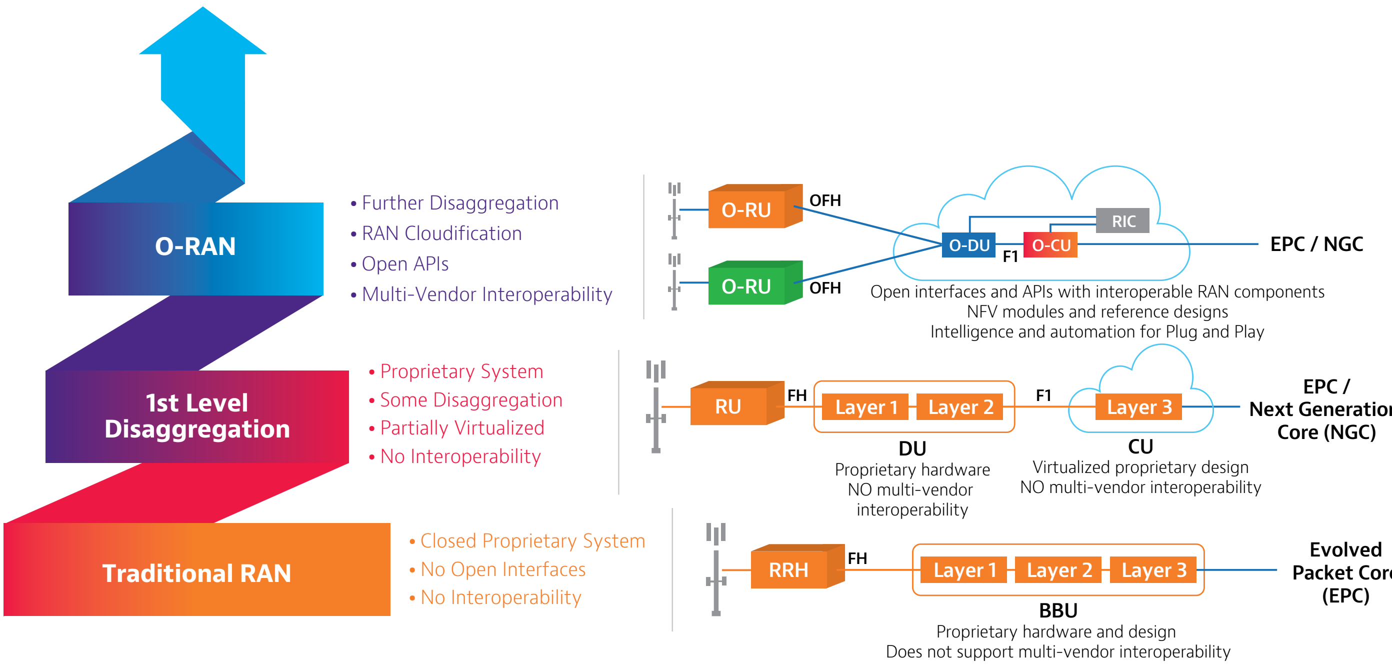

Figure 1. RAN evolution

A key challenge for the more complex and flexible 5G network that results from this is the scale and flexibility of deployment, optimization, management and orchestration of the network. Delivering new services and managing RAN capacity will no longer be practical if managed manually. Intelligence and automation must be integrated into all aspects of the network lifecycle to reduce both CAPEX and OPEX. As RAN disaggregation facilitates managing the complexity required to address the 5G challenge, intelligence in every layer of the RAN architecture is at the core of open RAN technology. This will allow operators to deploy a truly self-managed, zero-touch automated network. Consider the example where baseband capacity can become a bottleneck during an unplanned network event. Artificial intelligence and machine learning agents can detect and characterize this event in a short amount of time leading to automated optimization, such as small cell infill capacity. Such an innovative solution can be deployed quickly and efficiently on a white-box platform.

To achieve the above-mentioned goals of an open radio access network, operators founded the O-RAN ALLIANCE to clearly define requirements and help build a supply chain eco-system that can foster an environment for existing and new vendors to drive innovation. As per the charter of O-RAN ALLIANCE, *O-RAN ALLIANCE members and contributors have committed to evolving radio access networks around the world. Future RANs will be built on a foundation of virtualized network elements, white-box hardware and standardized interfaces that fully embrace O-RAN's core principles of* ***intelligence and openness***.

The key principles of the O-RAN ALLIANCE, as embodied in Figure 2, include:

- Lead the industry towards open, interoperable interfaces, RAN virtualization, and big data enabled RAN intelligence
- Specify APIs and interfaces, driving standards to adopt them as appropriate
- Maximize the use of common off-the-shelf hardware and merchant silicon, thus minimizing proprietary hardware.

Although there are several operator-led industry initiatives that aim to generically create an open RAN ecosystem, the O-RAN ALLIANCE has received the greatest amount of support. In this document we use "O-RAN" to refer to the open RAN ecosystem target of the O-RAN ALLIANCE.

Benefits of O-RAN

5G's diverse use cases and scale have further challenged operators to evolve their infrastructure quickly to monetize the new business opportunities offered by 5G, and simultaneously reduce their CAPEX while managing their OPEX.

As we know, deployment and management of RAN is the most expensive part of a wireless network, which means current approaches to network evolution, growth and maintenance will not scale to meet the 5G challenges and opportunities. Therefore, operators are now seeing O-RAN as the most viable option to help them meet those goals:

1. Enable an open, multi-vendor interoperable ecosystem driving healthier competition, lowering costs for RAN equipment, and delivering a much larger pool of vendors.
2. Enable automation, which can reduce deployment and management cost.
3. Deliver scale and agility, where network components implemented as software functions can be scaled to meet network capability and capacity demands.

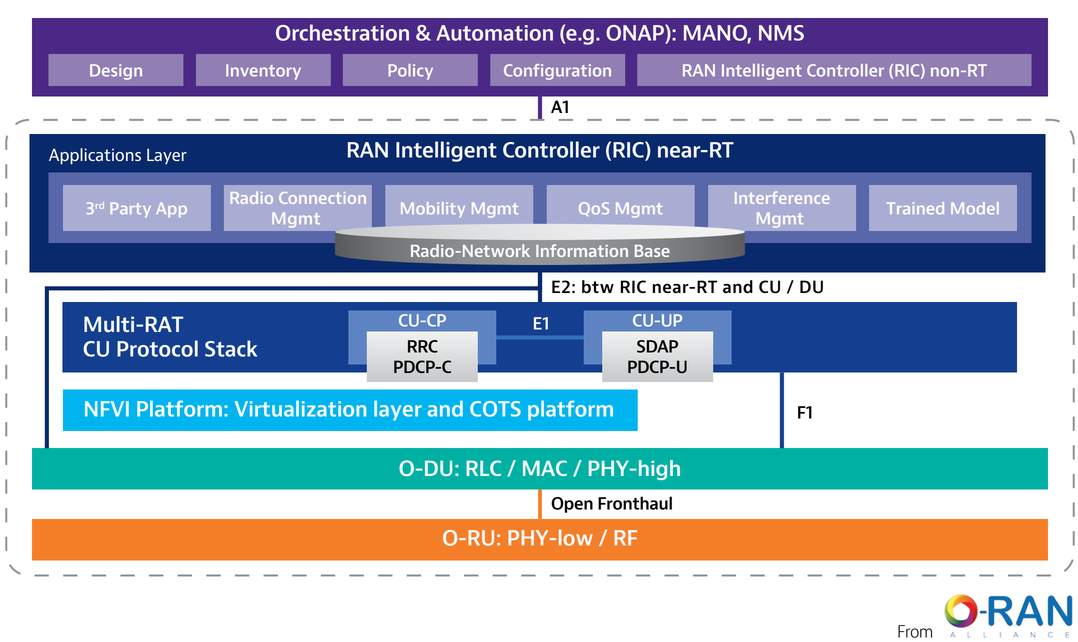

Figure 2. O-RAN Architecture

Challenges of Deploying and Managing O-RAN based networks

Interoperability and end-to-end performance will be by far the biggest concerns on the minds of vendors and operators in an O-RAN environment. Imagine all the advanced coordination features, power control algorithms and intra-technology interactions in a multi-vendor RAN. Today, having one vendor simplifies all that. And, when product related network performance issues arise, which is inevitable, service providers work with only one vendor to resolve them. Now imagine a network where RAN components such as central unit, distributed unit, and radio unit are supplied and supported by multiple vendors – operators and vendors will face greater challenges in both identifying and isolating issues as well as ensuring that performance/cost compares favorably to that of an optimized single vendor solution. Another key challenge of an O-RAN based multi-vendor network will be network management and resource management. Management of multi-vendor spares and training resources to maintain a multi-vendor network will be a learning curve for service providers' operations teams. Not to forget, integrating new functions and orchestration of new services from various vendors in an O-RAN based network will be another key challenge.

To overcome the above challenges, O-RAN ALLIANCE has been working with its members and contributors, including VIAVI, to deliver a **Reference Architecture** designed to enable next generation RAN infrastructures. This reference architecture will be based on well-defined, standardized interfaces to enable an open, interoperable supply chain ecosystem in full support of and complementary to standards promoted by 3GPP and other industry standards organizations. Further details of the structure and working groups are included in Appendix 1.

Key Test Areas for Vendors and Operators

Success of O-RAN will depend on the capability of operators to integrate and meet network KPIs in a true multi-vendor environment. To achieve this goal, operators need to have the confidence that all components in an O-RAN network have been tested in a trusted and controlled environment and all open interfaces and components are working correctly such that a multi-vendor O-RAN network cost to performance ratio is better than that of a traditional a single-vendor network. Operators will only deploy a network with an O-RU from one vendor, fronthaul from another, and baseband from a third one only if the performance and cost meet their targets and network integration is robust.

VIAVI plays an active role in contributing to the development of O-RAN specifications and how O-RAN compliant products can be tested to ensure interoperability, commercial robustness and high performance. In fact, VIAVI is the only T&M vendor holding co-chair positions in multiple O-RAN groups (Test Integration Focus Group and WG9) and editorships of several interoperability specifications (WG4 and WG5). In addition, VIAVI is a key contributor to O-RAN ALLIANCE plugfests, events conducted to foster adoption of open and interoperable 5G and 4G Radio Access Networks. In September and October 2020, VIAVI successfully participated in the global plugfest across five countries, providing industry-leading 4G and 5G test and validation platforms. The O-RAN architecture references multiple standards bodies to deliver a robust open RAN ecosystem. VIAVI participates in those bodies and their workgroups including ITU-T, 3GPP, ONAP, IEEE (specifications for network transport, timing and sync workgroup) to name a few. VIAVI thus facilitates the delivery of test solutions so operators can be confident that their networks, once tested with VIAVI, are compliant with multiple required standards and specifications.

VIAVI has identified various use cases which can help identify, isolate and resolve network performance issues before an O-RAN multi-vendor network is launched.

The following are some key areas of our focus in lab validation, field deployment and network assurance.

- Multi-vendor interoperability test (MV-IOT) for functionality, performance, reliability, robustness, and resilience
- Subsystem (wrap-around) test of O-RU, O-DU, and O-CU
- System level test
- Vendors-pairing evaluation
- Protocol compliance for open interfaces and protocols
- Continuous Integration and Continuous Delivery test automation
- Continuous test process throughout the entire lifecycle
- Holistic evaluation of multiple RAN deployment options (RAN disaggregation, spectrum bands, delay management, features, vendors, etc.)
- Performance monitoring of open interfaces and protocols to ensure optimum operation

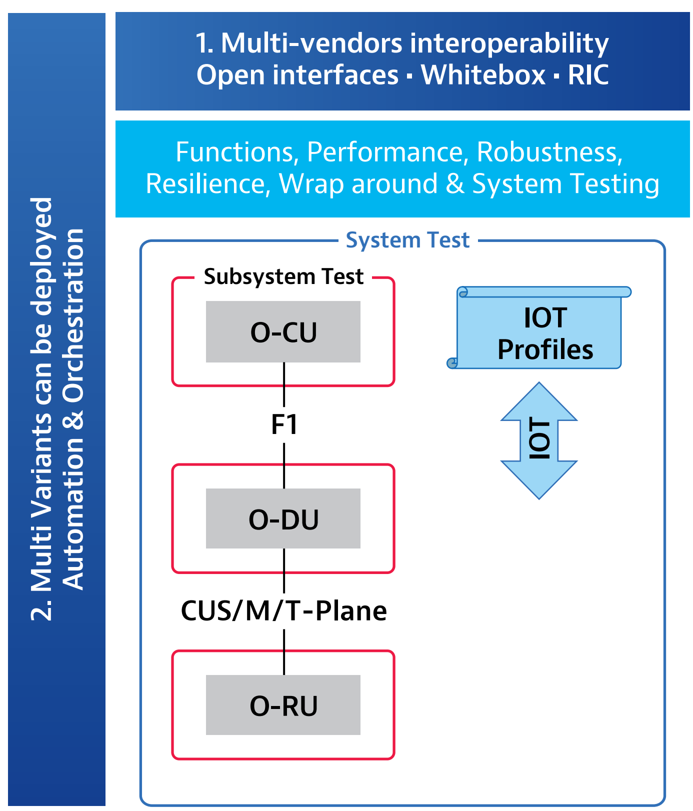

Figure 3. O-RAN Subsystem and System Testing using O-CU, O-DU, and O-RU

Figure 3 shows the scope of system and subsystem testing methodology using O-CU and O-DU. The companion white paper Test Suite for O-RAN Specifications sets out several test challenges and associated use cases, resources and recommendations for how to overcome these challenges. The presented test cases are a subset of the potential use cases rather than an exhaustive list of every required test case and are intended to provide an insight into test requirements and act as a starting point for more detailed discussion. Emphasis is given to multi-vendor testing aspects.

There are many options for deploying multi-vendor networks and the choices made will drive test priorities. One potential scenario is that the operator sources the O-DU and O-CU from one vendor and uses them with O-RUs from different vendors. In this scenario, separating the testing of the single-vendor O-DU and O-CU will enable the single vendor part of the network to be tested and optimized separately from any variability introduced by different O-RUs. Once that is complete, end-to-end testing involving the complete O-RU, O-DU, O-CU chain should be performed as well.

In another scenario, attention is focused on the interworking between the O-DU and the O-CU. In the same way, testing upwards from the F1 interface into the O-CU for the single-vendor part can be separated from the variability introduced by the different O-RU and O-DU suppliers.

Irrespective of decisions about the mix of different vendors and network architectures, certain critical performance aspects will remain. Included among these are:

- End-to-end network performance including during handover and with mobility and fading test scenarios
- Robustness of the X-haul transport and synchronization networks.
- Multi-vendor interoperability testing

To help operators manage testing, VIAVI has worked closely with the O-RAN ALLIANCE in the development of interoperability and conformance test scenarios. Along those lines different operators are launching O-RAN Test and Integration Centers (OTIC) around the globe. The core charter for OTIC is to ensure O-RAN components from multiple vendors support standard and open interfaces and can interoperate in accordance with O-RAN test specifications. Some of the key goals are to:

1. Verify, integrate and test disaggregated RAN components.
2. Ensure O-RAN solutions functionally comply to the specifications of the O-RAN ALLIANCE.
3. Deliver the desired architecture that supports a plug-and-play model for O-RAN network components and solutions.

Appendix 1:

The O-RAN ALLIANCE management structure consists of a board made of operators and a Technical Steering Committee (TSC). Nine technical workgroups have been set up under the supervision of the TSC with specific focus areas as shown in Figure 12.

O-RAN Working Groups
WG1 – Use Cases and Overall Architecture
WG2 – The Non-real-time RAN Intelligent Controller and A1 Interface
WG3 – The Near-real-time RIC and E2 Interface Workgroup
WG4 – The Open Fronthaul Interfaces
WG5 – The Open F1/W1/E1/X2/Xn Interface
WG6 – The Cloudification and Orchestration
WG7 – The White-box Hardware
WG8 – Stack Reference Design
WG9 – Open X-haul Transport

Figure 12. O-RAN working groups

References

[1] O-RAN: Towards an Open and Smart RAN; October 2018

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