Using Automation to Optimize Network Performance in **Open RAN (O-RAN)** Networks

How automation enhances network performance in Open RAN

What is Open RAN? How Radio Access Network is Evolving?

The Open RAN (O-RAN) network concept developed as a natural evolution of a traditional Radio Access Network (RAN) in the context of emerging Software Defined Networking (SDN), cloud computing technologies, and 5G networks. Open RAN is simply a better radio access network architecture.

Traditionally, RAN networks were designed as a monolith and were provided by a single vendor that offered an operator the entire range of equipment and software needed to form and operate the RAN.

The hardware and software were tightly coupled and so the possibility of innovation was left largely to the equipment vendor. The ability to optimize network performance in RAN was initially also tied to vendor-originated network optimization software tools.

The legacy cell towers used in 4G have a large footprint with all the equipment being deployed in a big cell-site cabinet. The Remote Radio Units (RRUs), located at the base of the tower, inside the cabinet, are connected via copper cables to the antennas on the top of the tower. This results in a considerable real-estate footprint and sizeable energy consumption for this type of RAN solution.

Such problems were addressed in next-generation cell towers, where the copper cabling between the Base Transceiver Station (BTS) and the cell antennas were replaced by optical fiber connections, and the RRU was moved to the top of the tower, alongside the antennas. Common Public Radio Interface (CPRI) was used as a communication protocol for the fiber connection between the Remote Radio Head (RRH) and the Base Band Unit (BBU). This evolution provided an improvement in energy consumption and real-estate footprint but did not address the vendor-centric innovation challenge.

How O-RAN Works

RAN advances in 5G networks aim to enhance spectrum efficiency, reduce interference, lower energy consumption, and improve hardware performance with the help of next-level automation. These goals are addressed from two different perspectives:

1.Disaggregation – splitting the baseband functionality from the radio functionality; and

2.Cloudification – separation of the hardware and software and deploying the baseband units onto Common off-the-shelf (COTS) hardware, running a consistent cloud platform.

The Open RAN approach builds on these evolutionary steps by standardizing the interfaces between the disaggregated components, creating a truly open ecosystem that encourages innovation. With Open RAN, Mobile Network Operators (MNOs) can mix-and-match components from different vendors, creating an Open RAN architecture that best fits their strategic network needs, reducing costs, and eliminating vendor lock-in.

The following disaggregated building blocks are proposed in the Open RAN architecture:

- **RU (Radio Unit)** – the hardware unit that converts the radio signals to/from the antenna into a digital signal for transmission over packet networks. It is located near the antenna or integrated within.

- **DU (Distributed Unit)** – the unit responsible for the real-time layer (L1 physical layer) and the lower layer 2 (L2), containing the data link and the scheduling functions. This is a pure software logical node, which might also include a subset of the eNodeB (eNb) / gNodeB (gNb) functions, depending on the functional split. Its operation is controlled by the CU.

- **CU (Centralized Unit)** – the unit responsible for non-real-time, higher L2, and L3 (network layer) functions.

OPEN RAN

What is the O-RAN Alliance?

The O-RAN Alliance (defined with #O-RAN and #oRAN abbreviations) is a consortium of MNOs, equipment and software vendors, system integrators, and other members with the goal of "Transforming the Radio Access Networks industry towards open, intelligent, virtualized and fully interoperable automated RAN." The O-RAN Alliance is seeking to leverage the work done in 3GPP on disaggregating RAN components and building on that by creating open interfaces between those components.

The Alliance announces designated specifications and defines the standards for the interfaces between disaggregated RAN components, supplies open-source software for the RAN, and gives support to the members of the Alliance in processes of the integration and testing of their applications. By standardizing the interfaces between the network components, the O-RAN Alliance is creating an open ecosystem that enables network automation principles to optimize network performance and operations.

The Inherent Automation Components of an O-RAN Network

There are multiple layers of an O-RAN network, as defined by the O-RAN Alliance, each having its role in the automation process. The O-RAN architecture defines the following components:

Service Management and Orchestration (SMO) Framework – a framework responsible for the RAN domain management. SMO key capabilities include the FCAPS (fault, configuration, accounting, performance, security) interface to O-RAN Network Functions (NFs), the Non-RT RIC function, O-Cloud Management, Orchestration, and Workflow Management. Four key interfaces enable these services:

- A1 interface between the non-RT RIC and the near-RT RIC.
- O1 interface between the SMO and the O-RAN NFs for FCAPS support.
- Open Fronthaul M-plane interface between SMO and O-RU for FCAPS support. In the case of a hybrid model, the SMO manages the O-RU, instead of the O-DU managing the O-RU.
- O2 interface between the SMO and the O-Cloud providing platform resources and workload management.

RAN Intelligent Controller (RIC)

Near-Real Time RIC – a logical function that controls and optimizes the RAN NFs using the E2 interface. It handles the near-RT (< 1ms) configuration of the NFs and provides the fine-tuning capability. The volatile character of these configurations means they are non-persistent, and changes are applied continuously. If the near-RT RIC stops working the RAN network would still be functional but not optimized. The E2 interface connects the near-RT RIC to the O-CU and O-DU components.

xApp – specialist software for well-defined functions that run inside the near-RT RIC framework.

Non-Real-Time RIC – a logical function, part of the SMO, that terminates the A1 connection of the near-RT RIC. It handles the non-real-time configuration of the nodes by providing intents and policies to the near-RT RIC through the A1 interface. It supports non-real-time radio resource management, higher layer procedure optimization, and policy optimization in RAN. Non-RT RIC also provides guidance, parameters, policies, and Artificial Intelligence (AI)/Machine Learning (ML) models to support the operation of the near-RT RIC functions in the RAN to drive higher-level non-real-time objectives.

rApp – specialist software for well-defined functions that run inside the non-RT RIC framework.

O-Cloud

O-Cloud – a cloud computing platform containing the physical infrastructure nodes using O-RAN architecture and hosting the Virtual Network Functions (VNFs) present in the architecture.

O-RAN Centralized Unit

(O-CU) – a logical node hosting higher-layer protocols (e.g. Radio Resource Control - RRC, Packet Data Convergence Protocol - PDCP, Service Data Adaption Protocol – SDAP).

O-RAN Centralized Unit – Control Plane (O-CU-CP) – refers to the Control Plane of the O-CU.

O-RAN Centralized Unit – User Plane (O-CU-UP) – refers to the User Plane of the O-CU.

O-RAN Distributed Unit

(O-DU) – a logical node hosting lower-layer protocols (e.g. Radio Link Control – RLC, Medium Access Control – MAC, parts of the physical interface – PHY).

O-RAN Radio Unit

(O-RU) – a physical node processing the radio frequencies that come from or go to the antenna sending them to the O-DU through a Fronthaul interface.

Optimization Through O-RAN Architecture

How is network performance optimized in an Open RAN architecture? What are the key O-RAN metrics/KPI?

An Open RAN architecture provides a variety of opportunities to optimize network performance with open interfaces and an entire ecosystem of software applications that can be deployed to accomplish different functions and goals.

Operation at the Near-RT RIC level

One approach is operating at the near-RT RIC level – defining xApps that work towards network performance optimization. For example – as described in the O-RAN Software Community – defining a xApp that monitors and stores Key Performance Indicators (KPIs), making them available for other xApps to use in making performance optimization decisions. The E2 nodes (i.e., O-CUs and O-DUs – NFs that expose the E2 interface) offer radio and system performance metrics that can be used for closed-loop control. The KPIs include but are not limited to User Equipment (UE) measurements, E2 Node measurements, and E2 Node Load-related measurements. The KPI categories could be even simpler: UE metrics and Cell level metrics.

Some KPIs that were considered in the O-RAN Software Community to help optimize network performance include:

Measurement Reports (signal strength) sent by UE for serving and neighboring cell (E2 Node being the O-CU-CP)

- Reference Signal Received Power (RSRP).
- Reference Signal Received Quality (RSRQ).
- Reference Signal – Signal to Interference plus Noise Ratio (RS-SINR).

Physical Resource Block (PRB) Usage – cell-wide and by UE (E2 Node being the O-DU)

- Total number of PRBs available, cell-wide, on average at sampled times through the measurement period.
- Number of PRBs used, broken down by UE, on average at sampled times through the measurement period.

Packet Data Convergence Protocol (PDCP) Bytes – cell-wide and by UE (E2 Node being the O-CU-UP)

- Number of bytes processed by PDCP layer for the entire cell and broken down by UE, over the measurement period.PDCP Through putwascalculatedbased on this number and the length of the measurement period.

Operation at the SMO level

Another approach is to operate at the SMO level – defining applications inside the SMO Frame work that make use of the A1 and/or O1 interfaces and make decisions about network perfor mance optimization. Mobile/cellular network Performance Monitoring (PM) data can be retrieved through the O1 interface (from O-CUs and O-DUs) and the Open Fronthaul M-plane interface (from O-RUs, but in a hybrid architecture the O-RU is connected directly to the SMO). Data retriev al can be file-based upon receiving an indication that PM data is available, or via notifications, or even via a continuous streaming channel between the SMO and the NF of interest. Based on the metrics, decisions can be made to optimize network performance – either for configuration chang es over the O1 interface or for policy changes through the A1 interface.

Regardless of the approach considered (xApp or application inside the SMO), Artificial Intelligence (AI) algorithms (including Machine Learning – ML) can be leveraged for making the ideal optimization decisions.

Self-Organizing Network (SON) & Open RAN

Self-Organizing Network (SON) is an important part of 4G networks (so-called legacy, in relation to 5G Open RAN networks) and is even more important for 5G networks. SON enables automation to optimize network performance and efficiency, enhance customer experience, and reduce complexity and operational expenses.

SON can be used to address different optimiza tions inside a RAN network. For example, the allocation of Physical Cell Identifiers (PCI) can be automated and optimized or Automated Neighbor Relations (ANR) can be applied in a centralized manner.

O-RAN architecture describes a built-in AI/ML framework with the non-RT and near-RT RAN Intelligent Controller, which enables optimized decision making inside the Open RAN network, through xApps and rApps. Metrics received from different network functions are analyzed by AI/ML models and are then used to act according to the network conditions and configure the NFs for the best customer experience and performance of the network.

The open interfaces defined by the O-RAN Alliance, like the O1 and E2 are important for getting events and metrics from an O-RAN compliant network in a consistent manner for SON use-cases.

Also, the aforementioned interfaces, as well as the A1 interface, are then used to configure the network functions – either concrete configuration done through the O1, or policies defined via A1 and enforced using the E2 interface for fine-tuning. As such, the control loop is closed, and networks have the possibility for both self-learning and self-decision-making, decreasing the complexity and enabling innovation.

A vendor-agnostic SON solution will therefore simplify O-RAN network optimization reducing the need for multiple xApps/rApps and vendor-specific software interworking to optimize network performance.

Legacy Networks and O-RAN Interworking

Challenges and Options to Optimize Network Performance

Two variants of SON, Centralized and Distributed, are used in Legacy networks. The decentralized architecture of Distributed SON is usually vendor-specific and has the advantage of using real-time data. In a (commonly) multi-vendor network architecture there is no SON coordination among equipment from different infrastructure vendors. Centralized SON provides the optimization algorithms via a central SON server that manages all radio nodes across multi-vendor and multi-technology network environments and typically operates with a small data collation lag. Inherent O-RAN real-time capabilities enable a Centralized SON improving module timing (removing data delays) and bringing unified vendor and technology optimization to a single, cross-network platform.

In most cases, O-RAN networks will be deployed in parallel with legacy networks. There will be challenges in this approach because of the different interfaces needed to address network performance optimization issues: on the one hand, open interfaces defined by the O-RAN Alliance for the O-RAN network, and on the other hand, the proprietary interfaces exposed by equipment vendors for legacy networks.

The algorithms needed to optimize network performance need to be implemented in an abstract manner such that the interface for addressing the underlying network should not matter and may be applied to either the open interfaces or any proprietary interface in the RAN network.

Adequate North Bound Interface (NBI) implementations from Open RAN vendors can be used for simple SON implementation in O-RAN. In legacy systems, for some nodes, it is possible to directly connect to make changes, but these changes should be synchronized with the vendor network management system (NMS) so as not to cause any conflict in the management processes. If a change is made without vendor NMS knowledge, it may use incorrect or old parameter values for network functions. To prevent this kind of conflict in Open RAN systems, as is implemented in Legacy systems, each Open RAN vendor should implement NBIs to allow parameter changes in their systems. The concept of Open RAN and the intentions of the O-RAN Alliance will struggle without these interworking and network management basics in play.

Future of O-RAN and Beyond

O-RAN Specifications and Investments

The O-RAN Alliance is continuously improving the standards and the interface specifications. The architecture is well defined and offers a lot of advantages and the open interfaces are evolving to address more use cases and integrate greater innovation to Open RAN networks. The Open RAN ecosystem is beginning to get more and more traction as equipment and software vendors start integrating the new specifications to their products.

There are still issues that need to be addressed in the standardization activities. For example, an alignment between the A1 and O1 configurations needs to be defined. The O-RAN Alliance needs to define a method or procedure to avoid/resolve possible conflicting configurations that come via different interfaces. But this is normal in the life of any Standards Development Organization (SDO) as the standards mature.

Even if all the details are not yet clear, many companies that are interested in the O-RAN ecosystem have already started investigating the different components of the O-RAN architecture (the network functions and the open interfaces between them) to prepare their solutions or products for being compliant with the O-RAN networks.

Benefits of O-RAN for Network Performance

O-RAN has the potential to massively change the way our telecommunication networks evolve and perform. Open standards generally drive innovation and increase competition which can only be good for the quality and price of telecom network architectures of the future. Centralized near-real-time automation to optimize network performance across vendor and technology stacks will further improve return on investment. Stakeholders and customers will reap these benefits.

Recommendations to Optimize Network Performance in Open RAN Networks

Network performance optimization in Open RAN networks can be done at different levels, depending also on the use case being addressed: either at the near-RT RIC level, using the E2 interface as an enabler, or at the Non-RT RIC and SMO levels, using the O1 and A1 interfaces as an enabler.

The use case (or the issue being addressed) needs analysis before an implementation decision is made. Operators should determine if a near-real-time solution with a fine-tuning of the network, or a coarser configuration of the network functions without the need for sub-millisecond reactions is required. In most cases for cross-network and multi-vendor/technology interworking, both near-real-time and less frequent 'coarse' optimization tuning will be necessary.

The specifications released by the O-RAN Alliance need to be monitored; they are continuously evolving and could provide improved implementation and outcomes over time. Operators should ideally position for more efficient implementation and methods to optimize network performance, for example, centralized SON for multi-vendor/technology networks.

The following summarizes the key recommendations in the context of planning O-RAN deployment to optimize network performance using inherent automation and adjunct network optimization software:

Get familiar with the concept and tools of Open RAN

- The RIC technology, standardized by the O-RAN Alliance, will play an important role in network automation and optimization. It is important to be knowledgeable, either directly or via trusted third-party resources, to be able to leverage the evolving Open RAN opportunity.
- There is an opportunity to contribute and drive requirements detail in the vendor community to help ensure that solutions meet or exceed evolutionary needs.

Mix-and-match

- The open interfaces are an enabler for innovation in O-RAN deployments and ensure MNOs can mix and match different solutions to optimize network design and performance at a reasonable cost.
- O-RAN aligned equipment and software vendors create a significant competitive opportunity to drive down the cost of procurement and implementation. Take advantage of the new commercial dynamic in selecing suppliers.

Innovate to optimize

- Utilize AI/ML as a key factor in taking the right optimization decisions on time.
- Use software such as Self Organizing Network (SON) solutions to connect the dots across technologies and vendor platforms. This will not only optimize O-RAN deployments but also ensure legacy (whole) network performance optimization.

Conclusion

The Open RAN concept is gaining momentum and companies who want to be part of this ecosystem need to contribute to its development and adoption. Open RAN comes as a natural next step in the evolution of traditional RAN networks benefiting from widespread cloud computing technologies and the increased interest in Software Defined Networking (SDN) that promotes open interfaces between network functions.

O-RAN network architecture benefits to MNOs:

- The RAN is no longer a monolith and vendor lock-in is eliminated.
- Procurement and implementation costs (CAPEX) decrease as equipment and software competition increase; operators can mix-and-match network functions from different vendors because the interfaces are open and standardized.
- Operational costs (OPEX) will reduce with interoperability enhancements and the opportunity to automatically optimize network performance in Open RAN via centralized solutions such as SON, or specialist code deployed for optimization functions.
- 5G O-RAN (and future mobile evolutions) promises even greater product and service opportunities to satisfy customer demands in quality and price whilst opening new network monetization options.
- Innovation will grow in the O-RAN ecosystem where new players can contribute solutions for different use cases.

The components defined in the O-RAN architecture are important tools for network automation. The Physical Network Functions (pNFs), Virtual Network Functions (vNFs), or Cloudified Network Functions (cNFs), as well as the open interfaces between them, are now key factors for 5G O-RAN network automation.

Self-Organizing Networks, which played an important role in 4G networks, will remain essential in 5G networks enabling automation to optimize network performance and operational efficiency for better user experience and reduced costs. Key Performance Indicators can be retrieved from the network functions through the standard interfaces and be fed to AI/ML algorithms built-in to the O-RAN architecture or specialist solutions such as SON. These models can make optimization decisions and feed them back as configuration to the network functions, either for fine-tuning or broader configurations.

Even if the O-RAN specifications are not fully mature, there is already an advantage in using them and driving innovation through solutions suitable for the Open RAN ecosystem. Existing SON solutions originally built for legacy networks can be seamlessly integrated to O-RAN networks to optimize network performance and provide ongoing automated network configurations across technology and vendor landscapes.

Because 5G networks are increasingly more complex and costly, leveraging an O-RAN architecture, and using automated network performance optimization is essential. With a well-defined approach, MNOs will become more agile, efficient, and innovative, reducing costs, and improving profitability, and enhancing the all-important customer experience.

About Innovile

Innovile has been a trusted network optimization and performance management partner to major mobile networks globally, since its inception in 2005.

Innovile provides Self Organizing Network (SON), Configuration, Performance, and Fault Management vendor-agnostic and multi-technology capable solutions. Open architecture, plug-and-play interfaces, proprietary algorithms, and Artificial Intelligence (AI) tools work in harmony towards a ‘Zero-Touch Network’ vision. Proven results in client network and operational efficiency combined with enhanced customer experience to reduce costs, improve customer loyalty, and enhance profitability.

Innovile team members and knowledge services ensure optimum design and deployment projects bringing rapid results at a reasonable cost. Continuous thought-leadership and innovation keep Innovile as a leading partner in the network and performance optimization space globally.

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