XL Simpozijum o novim tehnologijama u poštanskom i telekomunikacionom saobraćaju – PosTel 2022, Beograd, 29-30. novembar 2022.

https://doi.org/10.37528/FTTE/9788673954165/POSTEL.2022.021

OPEN RAN – POSSIBILITIES AND CHALLENGES

Aleksandar Đurović[1], Anica Plećić[2], Filip Banković[3], Goran Marković[4]
[1]Roaming Networks, aleksandar.djurovic@roamingnetworks.rs
[2]RNC Solutions, a.plecic@rnc-solutions.com
[3]Roaming Networks, filip.bankovic@roamingnetworks.com
[4]University of Belgrade - Faculty of Transport and Traffic Engineering, g.markovic@sf.bg.ac.rs

Abstract: *The entire telecom industry is going through a change that can be only compared to the change that data centers went through in the 2000s, both driven by Moore's Law. Open RAN (O-RAN) is a crucial enabler for this transformation, allowing building networks using a fully programmable software-defined RAN solution based on open interfaces that run on commercial, off-the shelf hardware. This paper aims to present the O-RAN from a theoretical perspective, the possibilities and advantages of the O-RAN compared to legacy RAN, and the challenges mobile network operators might face during the O-RAN deployment.*

Key words: *Open RAN, 5G, virtualization, functional split*

1. Introduction

Though the RAN components are "supposed" to be open as they are 3GPP-standards based, they are monolithic units provided by a limited number of vendors and seen by the operators as black boxes, which leads to limited reconfigurability of the RAN and lack support for diverse deployments and different traffic profiles. Operators can not put vendor B's software on a BBU (Baseband Processing Unit) from Vendor A or connect a radio from Vendor A to a virtualized BBU hardware and software from vendor B, known as vendor lock-in. Furthermore, the complexity of cellular networks is constantly increasing. New developments include mMIMO (massive Multiple Input, Multiple Output), millimeter wave and sub-terahertz communications, network slicing and Machine Learning (ML) based digital signal processing [1]. This will impose increasing capital and operational costs (CapEx and OpEx) for the network operators, which will have to continuously upgrade and maintain their infrastructure to keep up with new market trends and customer requirements.

Recently, researchers have shown that RAN participates with almost 60% in CapEx and OpEx. To overcome these limitations and cut down the costs, in the last decade, several research and standardization efforts have promoted the O-RAN as the new paradigm for the RAN of the future. O-RAN deployments are based on disaggregated, virtualized and software-based components, connected through open and standardized interfaces and interoperability across different vendors. O-RAN helps significantly reduce RAN costs, and reducing RAN costs can significantly help mobile network operators cut down their CapEx. Before we discuss O-RAN in more detail, in the next chapter, we will explain the difference between the Centralized/Cloud RAN (C-RAN), virtualized RAN (vRAN), and O-RAN concepts since they are often used in conjunction with each other and sometimes confusingly.

2. Open RAN evolution

About 12 years ago, virtualization of the RAN functions started with the C-RAN (cloud RAN or centralized RAN) initiative from IBM, Intel and China Mobile. The BBU moves to a centralized location in C-RAN implementation, and the cell site only has the antenna and remote radio unit (RRU). C-RAN required a new fronthaul interface (FH), and various industry standards such as the Common Public Radio Interface (CPRI) [2] and the Next Generation Fronthaul Interface (NGFI) [3] evolved to enable these new interfaces between the radios and BBU. In addition, a second option of the centralized RAN architecture has a further split in BBUs into Distribution Unit (DU) and Central Unit (CU). As shown in Figure 1, CU is further toward the core network resulting in a new interface called midhaul (MH). Since radios were connected to BBU in the data center via a dedicated high-bandwidth connection, this made C-RAN deployments only applicable to areas with access to fiber. Furthermore, C-RAN wasn't necessarily open, but it did begin the movement toward disaggregating the RAN.

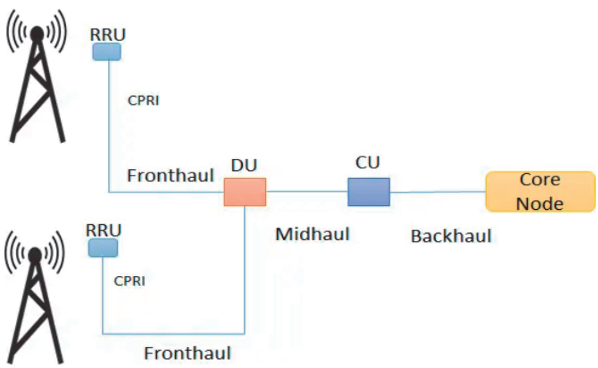

Figure 1. C- RAN with BBU split

Next came Virtual RAN or vRAN, which decouples the software from the hardware by virtualizing network functions. It uses virtualization technologies such as Network Function Virtualization (NFV) or containers to deploy CU and DU over an x86 server. Even if RAN functions are virtualized on a COTS server, the interface between the BBU and RRU is still not an open interface, so vRAN can still create vendor lock-in. In fact, we can consider vRAN as a type of C-RAN since there is no difference between vRAN and C-RAN except that traditionally C-RAN uses proprietary hardware. In contrast, vRAN uses Network Functions on the server platform.

The key with O-RAN is that the interface between the BBU and RRU is an open interface, so, any vendor's software can work on any open RRU. As seen in Figure 2, an MNO can virtualize and disaggregate its RAN, but unless the interfaces between components are open, the RAN is not truly open.

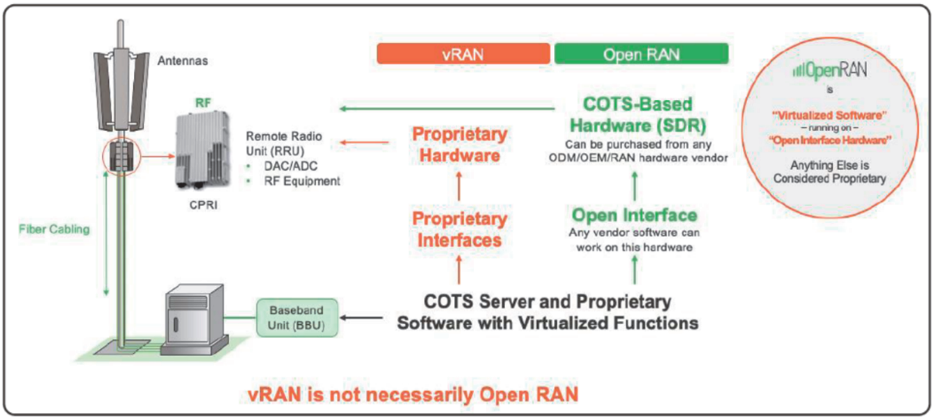

Figure 2. Virtualized RAN versus O-RAN [4]

Two leading organizations are driving O-RAN development today: O-RAN Alliance and OpenRAN group. OpenRAN refers to the project group that is a part of the Telecom Infra Group (TIP), whose main objective is the deployment of fully programmable RAN solutions based on general-purpose processors (GPPs)/COTS and disaggregated software [5]. The O-RAN alliance [6] is the other main driver of the O-RAN concept, focused on efforts to standardize interfaces. The alliance was founded in 2018 by AT&T, China Mobile, Deutsche Telekom, NTT DOCOMO and Orange. While The O-RAN Alliance develops, drives and enforces standards to ensure that equipment from multiple vendors inter-operates with each other, TIP is more deployment and execution focused. TIP encourage Plugfests and live deployments in the field, and it's responsible for productization of use cases, facilitates trials, field testing and deployment. An essential step in developing the O-RAN ecosystem was an alliance agreement between the two organizations. The new deal allows the two groups to share information, reference specifications and conduct joint testing and integration efforts.

3. O-RAN architecture and functional splits

In Release 15, 3GPP, defined a new, flexible architecture for the 5G RAN, where the base station or gNodeB (gNB) is split into three logical nodes: the CU, DU and the RU, each capable of hosting different functions of the 5G NR stack [7]. As shown in Figure 3, 3GPP specifies eight options for distributing the functionality of the 5G NR RAN stack across the fronthaul network — the functional splits. Within the eight main functional split options that 3GPP defines, option 7 further divides into sub-options 7-1, 7-2 and 7-3.

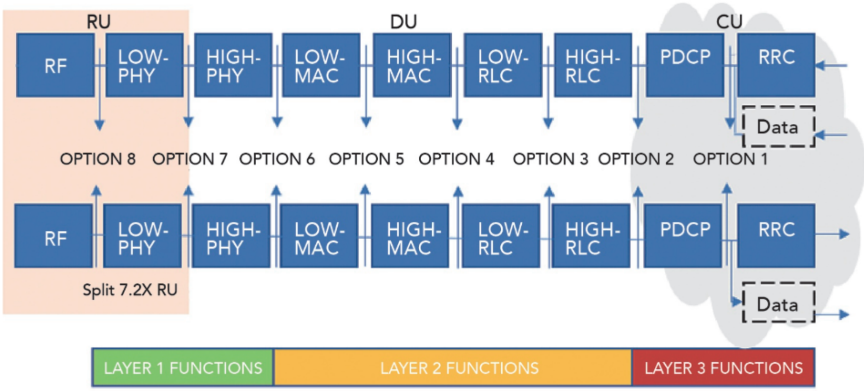

Figure 3. 3GPP functional split options for the 5G [8]

To support increasing FH bandwidth O-RAN fronthaul specifications include a new provision for functional splitting called Split Option 7-2x. An overview of Split Option 7-2x is shown in Figure 4. This split places in radio equipment some Layer 1 functions (named PHY-Low) traditionally located in the BBU. They also prescribe detailed signal formats and equipment operation required for multi-vendor RAN hasn't been prescribed in eCPRI specifications and Management Plane (M-Plane).

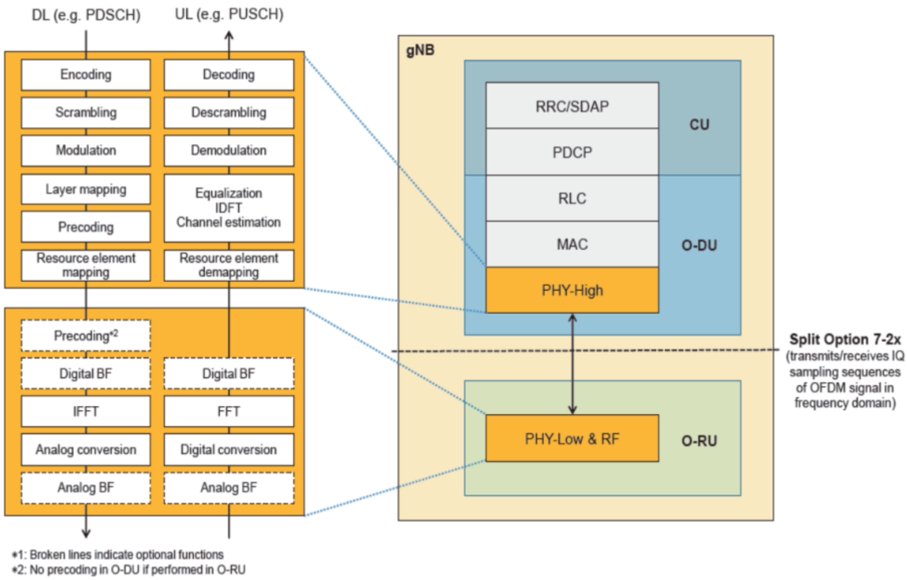

Figure 4. Split option 7-2x adopted in O-RAN [9]

O-RAN architecture is designed flexibly, consisting of different nodes and interfaces along with various options for implementation. The main building blocks in O-RAN architecture are presented in Table 1. Separate vendors can provide them, thus, they can create an ecosystem of players developing only CUs, DUs, or only xApps or RICs.

Table 1. O-RAN architecture building blocks [10]

Name	**Short description**
O-Cloud	Cloud Computing platform comprising physical infrastructure nodes to host O-RAN functions, like near RT-RIC, O-DU, etc.; supporting software components (e.g. operating systems, virtual machine monitoring, container runtime), management, and orchestration functions.
O-RU (O-RAN Remote Unit)	A logical node hosting a low-PHY layer functions
O-DU (O-RAN Distributed Unit)	A logical node hosting RLC (Radio Link Control)/MAC (Medium Access Control) and high-PHY layer functions.
O-CU-CP (O-RAN Central Unit-Control Plane)	A logical node hosting RRC (Radio Resource Control) and CP (Control Plane) part of PDCP (Packet Data Convergence Protocol).
O-CU-UP (O-RAN Central Unit-User Plane)	A logical node hosting SDAP (Service Data Adaption Protocol) and UP (User Plane) part of PDCP.
near-RT RIC (near Real-Time RAN Inteligent Controler or nRT RIC)	A logical node, enabling near-RT control and optimization of RAN elements and resources via fine-grained data collection and actions over E2. Near-RT RIC may include AI/ML workflow.
non-RT RIC (non Real-Time RAN Inteligent Controler or NRT RIC)	A logical node, enabling non-RT control and optimization of RAN elements and resources, capturing AI/ML workflow, and policy-based guidance of application-features in NRT RIC.
xAPP	An application designed to run on near-RT, likely to consist of one or more micro services, that identifies data to consume and provide. xApp is independent of nRT RIC and may be provided by a third party.
SMO (Service and Management Orchestration)	System supporting orchestration of O-RAN components that includes NRT RIC.

Within the logical architecture of O-RAN, as shown in Figure 5 below, the radio side includes nRT RIC,O-CU-CP, O-CU-UP, O-DU, and O-RU functions. Although not shown in this figure, the O-eNB supports O-DU and O-RU functions with an Open Fronthaul interface between them. The solid line is used for interfaces specified by 3GPP, while dashed lines are used for interfaces specified by O-RAN Alliance.

A1 interface is defined between non-RT RIC and near-RT RIC, through which NRT provides nRT RIC with policies, enrichment info, and ML model updates, while on the other hand nRT RIC provides back the policy feedback. E2 interfaces, touch and get into specific entities within the base station, i.e., O-DU and O-CU. It can control what is happening with the base station, using monitor, suspend, override, control messages, and execute actions coming from xAPPs/nRT RIC. O1 and Open-Fronthaul M-Plane interfaces are responsible for FCAPS (Fault, Configuration, Accounting, Performance, Security). O2 interfaces manage the platform resources and workload (like resource scaling and FCAPS for a cloud computing platform).

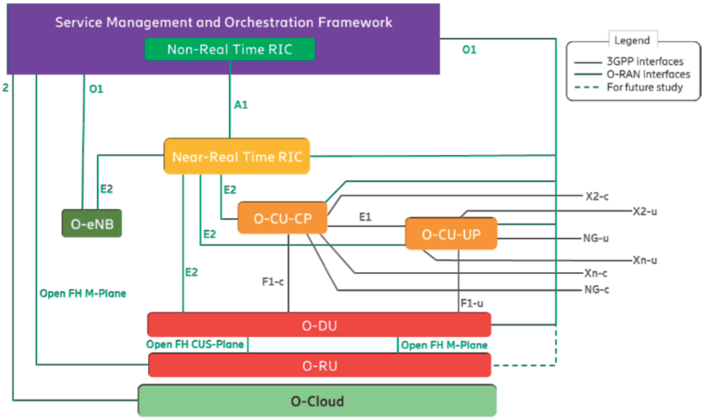

Figure 5. The logical architecture of O-RAN [10]

4. O-RAN possibilities and challenges

The O-RAN concept and movement are not new – MNOs and network and technology vendors have been developing solutions, conducting trials and deploying networks for the last few years. Clearly, O-RAN is no longer a regional solution, nor one that only applies to greenfield operators or MNOs in developing regions of the world. iGR identified 23 publicly announced MNOs worldwide using equipment from multiple vendors, including Altiostar, Mavenir and Parallel Wireless, who had deployed O-RAN in commercial networks. These MNOs collectively have just over 1.308 billion subscribers in their retail networks and operate in countries or regions with a total population of nearly 2.459 billion [11]. These MNOs have realized significant savings in CapEx and OpEx and many have discussed this publicly. The primary benefits of deploying O-RAN are:

- Lower CapEx/OpEx costs compared to legacy RAN since there is a competition among many different layers of the hardware and software supply chain. Operation and maintenance of an O-RAN system are simplified because the hardware is standardized, standardized interoperable interfaces and open APIs are used, DevOps approaches can be utilized, and the software does not rely on purpose-built components.
- Enabling edge centric architecture – multiple mini data centers can be built closer to subscribers, mainly in high-population areas, to serve subscriber needs, support low latency connectivity for 5G applications and provide scalability for both devices and applications.
- Use best-of-breed components and software architecting to build the infrastructure for the network.
- Lower deployment times – Using virtualized RAN, benefits like automation can reduce the average time for deploying a site. Also, a virtualized RAN combined with centralization can be deployed faster than a traditional architecture since the only site installation required is for the radio and power.
- Minimizes vendor lock-in danger. The incoming O-RAN vendor's equipment will work with the incumbent and future vendors' solutions.

- Ability to add massive scale if needed using a web-scale approach.
- In addition, to further support mobile operators as they transition to 5G, O-RAN also supports legacy 2G, 3G and 4G networks.

Nevertheless, MNO might face challenges and limitations during the O-RAN deployment and maintenance. Table 2 lists some of the major arguments against O-RAN and reasons why they are not or shouldn't be relevant anymore in the future.

Table 2. The discussion against Open RAN integration

Argument	Details	Current situation
MNO will need to integrate O-RAN solutions themselves	Since multiple vendors are required for an O-RAN deployment, the solution is not integrated, so MNO will be responsible for the cost of integration, which might lead to higher overall costs and delayed time to market	MNOs that have deployed O-RAN have said integration costs are no higher than with the traditional single-vendor approach
High risk for network reliability	Since network elements are from different vendors, network reliability might be compromised because identifying and troubleshooting network issues will be more complex	Network management tools have been developed for O-RAN, meaning that any issues can be quickly identified and resolved
COTS capability	Some advanced features and RAN deployments require more specialized hardware solution	Major hardware vendors are working to address this issue
Systems integration lacking	The argument is that software solutions are not integrated, and that software is not integrated into hardware	Rich ecosystem of vendors for radios, BBU, hardware and software is already working together to ensure integrated solutions are available to the market
Less secure	Lack of integration argument is that O-RAN deployments are inherently less secure than the traditional single-vendor approach	O-RAN deployments have followed data center, private cloud, and enterprise IT integration and security best practices

5. Conclusion

The legacy RAN vendors have provided proprietary solutions and continue to promote and deliver only closed systems in their best interests. We can even say that some of the legacies of RAN vendors underestimated the potential of O-RAN, but nowdays they are moving slowly in that direction. Some of the major O-RAN benefits for MNO are following: lower costs (both CapEx and OpEx) and deployment times, minimizing the danger of vendor lock-in, more accessible network scale and upgrade, usage of best-of-breed software and less expensive hardware components, etc.

Nevertheless, there are some challenges associated with an O-RAN concept. Because of the multi-vendor environment, MNO can not use the "one neck to choke" approach. Also, O-RAN standards are not currently widely adopted, and O-RAN vendors are slightly behind the legacy vendor regarding network performances and supported features. In theory, MNO can use COTS hardware, but the practice has shown that general-purpose hardware is insufficient to support RAN demands in some cases. Hardware and software vendors, system integrators, ORAN Alliance, TIP, and other organizations are putting great effort into overcoming these challenges. The future of O-RAN should be more transparent in upcoming years. Still, since significant operators worldwide already adopt O-RAN, we think O-RAN is on its way to become a natural and unified alternative to proprietary RAN networks in the middle of this decade.

Literature

[1] M. Polese, L. Bonati, S. D'Oro, S. Basagni, T. Melodia, "*Understanding O-RAN: Architecture, Interfaces, Algorithms, Security, and Research Challenges*", August 2022

[2] Ericsson AB, Huawei Technologies Co. Ltd, NEC Corporation, Alcatel and Nokia Networks, *CPRI Specification V7.0,* 2015, available at http://www.cpri.info/spec.html

[3] Small Cell Forum, "*nFAPI and FAPI specification*", Version 082.09.05, May 2017.

[4] Parallel Wireless, "*Everything you need to know about Open RAN*", 2020.

[5] https://telecominfraproject.com/

[6] https://www.o-ran.org/

[7] https://ieeexplore.ieee.org/document/8479363

[8] 3GPP, "*NR and NG-RAN Overall description; Stage-2,*" 3rd Generation Partnership Project (3GPP), Technical Specification (TS) 38.300, July 2022

[9] A.Umesh, T. Yajima, T. Uchino, S. Okuyama, "*Overview of O-RAN Fronthaul specifications*", *NTT DOCOMO Technical Journal*, vol 21, pp. 46-59, July 2019.

[10] O-RAN Working Group 1, "*O-RAN Architecture Description," ORAN.WG1.O-RAN-Architecture-Description-v06.00*", Technical Specification, November 2021.

[11] iGR, "*Open RAN Integration: Run With it*", White Paper, 2021.

Rezime: *Telekom industrija prolazi kroz promenu koja se po značaju može uporediti sa virtualizacijom hardvera u data centrima početkom XXI veka. Otvorene radio pristupne mreže se nalaze u središtu transformacije, omogućavajući izgradnju mreže instalacijom potpuno programabilnog RAN softvera na komercijalnom hardveru opšte namene koji je baziran na otvorenim interfejsima. U radu se razmatraju otvorene radio pristupne mreže sa teorijskog stanovišta, njihove mogućnosti i prednosti u poređenju sa tradicionalnim bežičnim mrežama, ali i izazovi sa kojima se mobilni operator može suočiti prilikom implementacije otvorenih radio pristupnih mreža.*

Ključne reči: *Otvorene radio pristupne mreže, mobilna mreža pete generacije, virtualizacija, funkcionalna podela*

OPEN RAN – MOGUĆNOSTI I IZAZOVI

Aleksandar Đurović, Anica Plećić, Filip Banković, Goran Marković