VMware RIC: Leading the Way to an Open, Programmable RAN

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Abstract

Telecom service providers (SPs) need a modernized, cloud-based radio access network (RAN) to become competitive in the 5G marketplace. In practical terms, this means a move to the O-RAN Alliance's architecture, which disaggregates the RAN by decoupling the RAN control and management plane from the data plane. The result is much-needed software-defined programmability in the RAN. Opening the RAN itself, however, creates a complex and potentially unsecure environment for the SP to manage. VMware® Centralized RIC™ and VMware Distributed RIC™ offer a solution. These cloud-native implementations of the O-RAN Alliance's Non-real-time RIC and Near-real-time RIC provide a secure RAN independent, vendor-neutral, O-RAN Alliance-compliant solution that supports programmable multi-vendor networks.

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Introduction

Telecom service providers (SPs) today are confronting a continued downward trend in average revenue per user (ARPU), along with increased competition from other SPs, cable multiple system operators (MSOs) and cloud hyperscalers. SPs that want to become more competitive will need to adopt a modernized, cloud-based radio access network (RAN) that is more efficient, economical and flexible than their current purpose-built proprietary RANs.

SPs are taking action, working to virtualize the RAN by disaggregating the RAN software from its underlying hardware. However, more is needed. The industry is moving toward the O-RAN Alliance's architecture, which further disaggregates the software layers, decoupling the RAN control and management plane from the data plane. This design brings software-defined programmability to the RAN.

While the O-RAN Alliance's specifications enable open interfaces and interoperability between network elements, it is left to the vendors to determine the degree of openness and interoperability they will support. This leads to complexity and potential vendor lock-in, despite the O-RAN Alliance's open standards. VMware® Centralized RIC™ and VMware Distributed RIC™ offer a solution. They are cloud native implementations of the O-RAN Alliance's Non-real-time RAN Intelligent Controller (RIC) and Near-real-time RIC.

VMware RIC™ allows for the implementation of an intelligent and programmable RAN network that is vendor neutral and compliant with O-RAN Alliance reference architecture. Working together with other VMware Telco Cloud products, VMware Centralized RIC and VMware Distributed RIC allow for the creation of a secure RAN that is independent, vendor-neutral and O-RAN Alliance–compliant—one that supports programmable multi-vendor networks.

VMware Centralized RIC supports both

traditional and virtual RAN environments.

Understanding the need for RAN modernization

RAN modernization is a non-negotiable need at this point, given the pressures the marketplace exerts on SPs. Traditional RAN, however, is not suited to modernization. It has historically been built using closed, proprietary technologies with tightly vertically integrated hardware and software. The infrastructure is neither flexible nor easily scalable enough to meet the demands of the fast-paced 5G marketplace. In addition, the closed non-transparent nature of traditional RAN makes it extremely difficult for SPs to understand the extent of their large infrastructure's exposure to malicious actors.

What's needed, therefore, is a far more modern, software-centric, cloud-native programmable RAN that provides a much higher degree of agility and flexibility. A cloud-native RAN based on a microservices architecture

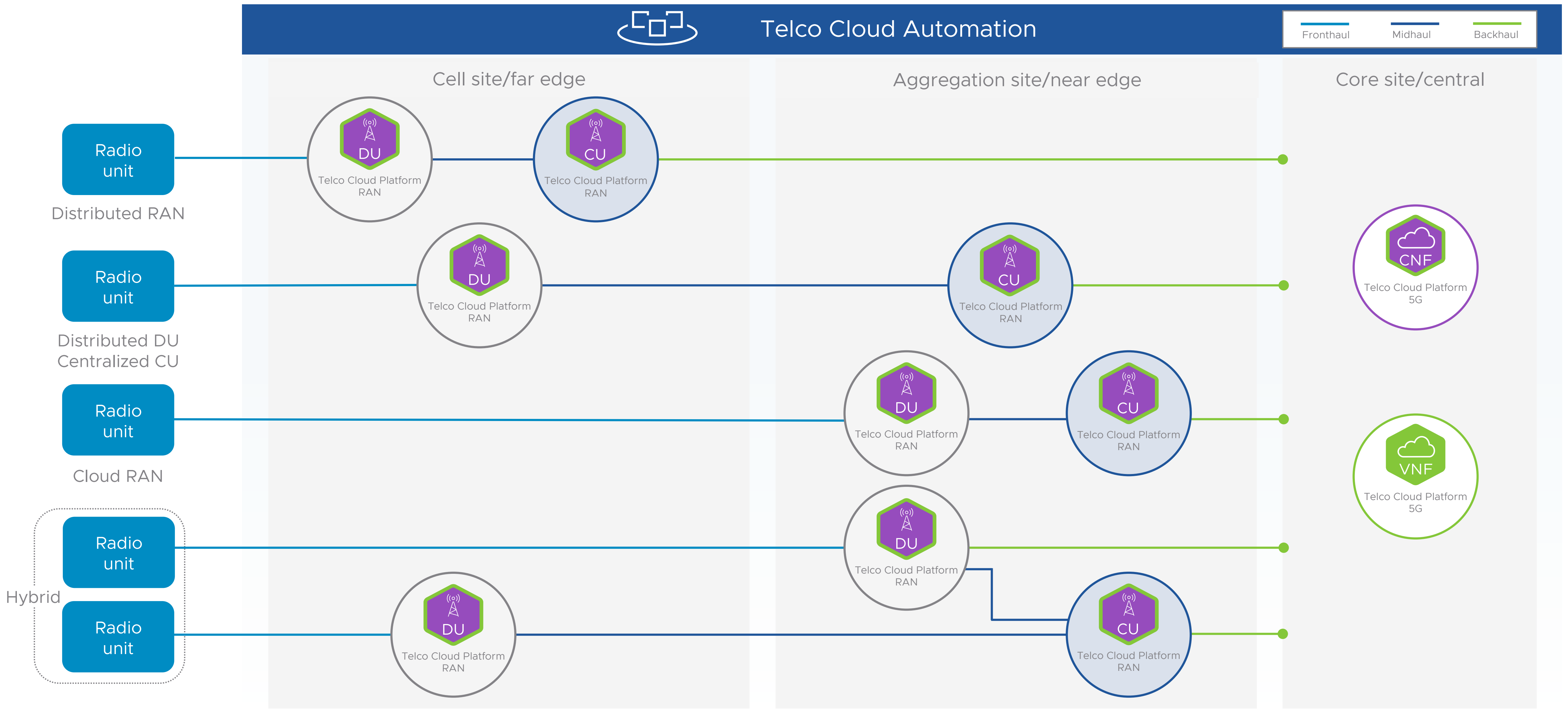

Figure 1: Enabling flexible 5G RAN deployment with a consistent horizontal platform

enables SPs to deploy containerized network functions and services in select locations to best serve their operational purposes based on factors such as cost, processing capacity and performance. Having a RAN based on modern cloud principles enables SPs to deploy and provision network services at scale through advanced cloud infrastructure orchestrators.

The new generation of modern RAN is also programmatically managed and controlled through third-party applications from a broad ecosystem of vendors. The larger number of vendors available to SPs will dramatically increase the velocity of innovation introduction and allow more flexibility in selecting solutions based on the priorities and preferences unique to each SP.

Incorporating artificial intelligence (AI) and machine learning (ML)-based automation and optimization algorithms helps to further increase operational efficiency, which is critical for the ever-increasing complexity of 5G radio technologies. The results of this open ecosystem approach will include reduced capital expense (CapEx) and operating expense (OpEx). Together with increased agility, the new, modern and programmable RAN will drive better overall competitiveness.

SPs today: Virtualization, heading toward open RAN

SPs are making progress toward this vision. Many are beginning to embrace the RAN virtualization process. However, given RAN's long refresh cycles, which can stretch to seven or eight years, SPs want to make sure they get it right. As a result, SPs are embracing open RAN, which promises the kind of agile, open ecosystems SPs need to compete.

RAN virtualization has begun

Virtualization of the RAN shifts RAN operations from purpose-built hardware and software to a virtualized environment that decouples RAN software from hardware. In theory, with vRAN, different vRAN functions are provided by the same network equipment providers (NEPs) but are able to operate on either virtual machines (VMs) or containers that run on inexpensive, commercially available "open hardware." This approach enables SPs to speed up and automate the deployment of the RAN services. vRAN is more flexible than traditional RAN, leading to greater agility and faster time to market.

vRAN may not be enough, however. While it improves flexibility and economics, vRAN is not usually adequate to bring about the degree of change SPs need to compete. For some, vRAN means homogeneous solutions from a limited number of NEPs. Despite a higher level of openness, as opposed to the traditional RAN, the solutions are still relatively rigid. And if vertically stacked solutions are used, it is difficult, if not impossible, to run multiple vRAN functions from different vendors.

The goal: An open, programmable RAN

SPs want the benefits of vRAN without its limitations. They want open, programmable RAN infrastructure that enables agile, fast-paced development of services that draw on multiple vendor technologies. The realization of these objectives has come to life in the form of the O-RAN Alliance initiative.

Open, programmable RAN has taken shape through international standards bodies, primarily the O-RAN Alliance and Telecom Infra Project (TIP), which are supported by complementary standards from the 3rd Generation Partnership Project (3GPP). O-RAN Alliance offers SPs a set of interoperability standards for RAN elements. These elements include commercial-off-the-shelf (COTS) hardware and software from multiple vendors. As the O-RAN Alliance puts it, they are “Transforming the RAN industry toward open, intelligent, virtualized and fully interoperable RAN.”

Open RAN takes vRAN principles further in the direction of openness, breaking down the old RAN silos. The result is a malleable network. By using the O-RAN Alliance’s standard interfaces and architecture, SPs avoid getting stuck with a single vendor’s proprietary hardware and software.

How the O-RAN Alliance’s architecture enables an open, programmable RAN

The O-RAN Alliance’s architecture enables an open, programmable RAN primarily through three primary elements: the O-RAN Alliance’s standards and specifications; the disaggregation of management, control and data planes; and open interfaces, e.g., open application programming interfaces (APIs). These elements come to life in the form of a new RAN architecture, which introduces a new RAN entity. The RIC, depicted in Figure 2, facilitates the programmability of the RAN through decoupling of the management and control planes from the data plane. The RIC is decomposed into two sub-entities, the Non-real-time RIC and the Near-real-time RIC.

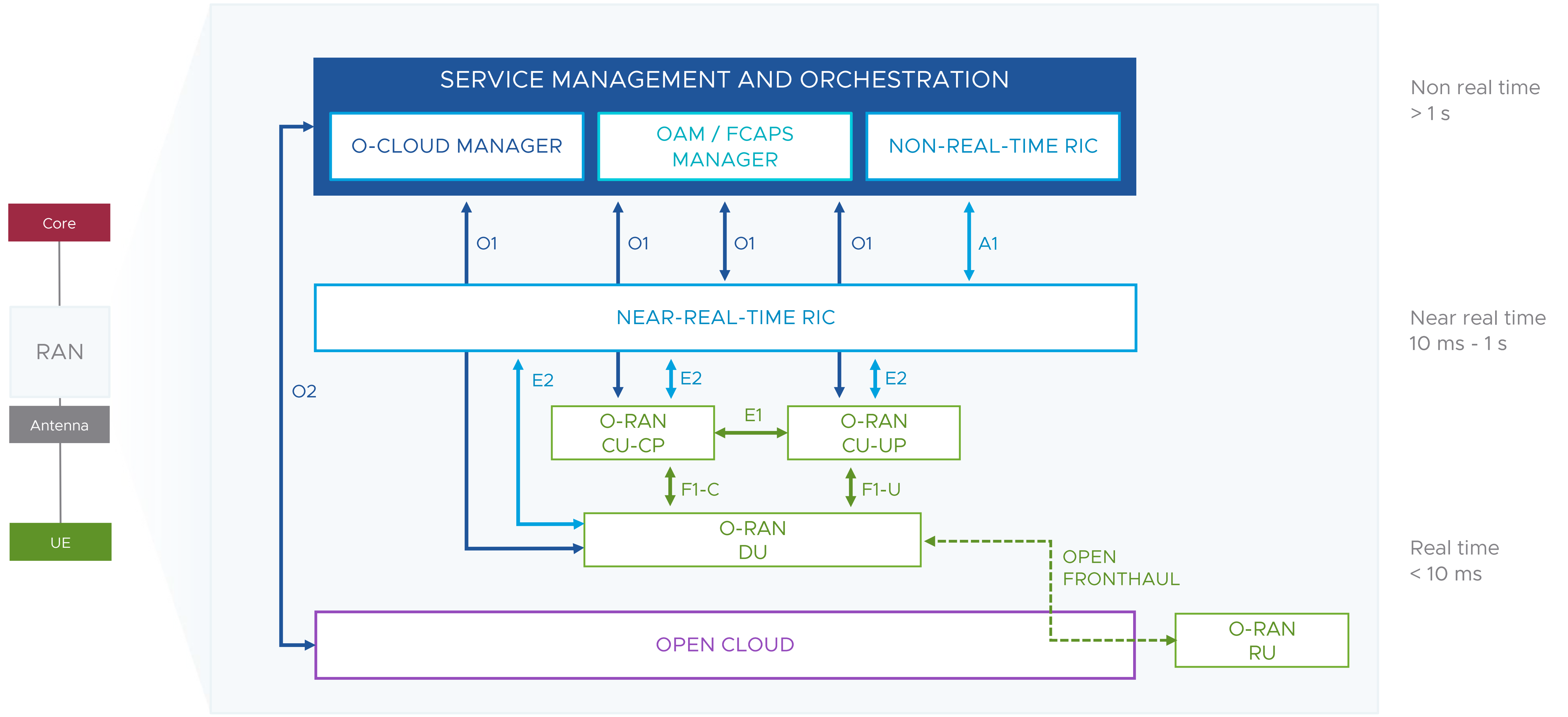

Figure 2: O-RAN Reference Architecture for Open RANs

It is worth taking a moment to explore this architecture, as it represents the blueprint for the future of 5G and its potential for SP business success. Orienting it properly, the architecture sits at the junction between the user equipment (UE) and core. At the right side of the figure are the time scale of the control loop response times associated with the elements comprising this new RAN. At the bottom is “real time,” associated with the data plane elements which have control loop response times on the order of milliseconds. In the middle, the control plane elements of the RAN are functioning with response times at near-real-time of between 10 milliseconds and 1 second. At the top level service management and application layer, control loop response times may be greater than 1 second.

Tracking user access from the lower layers to the upper layers, devices attach to the O-RAN network through open radio units (RUs), which are connected to the O-RAN distributed unit (O-RAN DU) and O-RAN centralized units (O-RAN CU) via the open fronthaul interface. The O-RAN DU and O-RAN CU, as well as the other O-RAN network elements, are containerized network functions instantiated on the open cloud infrastructure composed of standard commercial off-the-shelf hardware.

The next level in the architecture is the Near-real-time RIC which functions as the decoupled RAN control plane in the O-RAN Alliance's architecture. The Near-real-time RIC abstracts the underlying RAN and presents a standard interface to its hosted applications which implement advanced radio resource management (RRM) functions with control loop response times of less than a second, typically on the order of 10 milliseconds.

At the highest level of the O-RAN Alliance's architecture, one finds the service management and orchestration (SMO) layer, which is responsible for RAN domain management. The three main functions of the SMO are:

- O-cloud management and orchestration
- FCAPS management
- Non-real-time RIC

The O-cloud management and orchestration includes functions such as discovery and administration of open cloud resources as well as instantiation and management of containerized network functions. FCAPS management refers to traditional operations, administration, and maintenance (OA&M) functions such as fault management, configuration management, accounting, performance management and security (FCAPS).

The Non-real-time RIC functions as the decoupled management plane entity in the O-RAN Alliance's architecture. Together with its hosted applications, the Non-real-time RIC implements RRM functions with control loop response times greater than 1 second. The Non-real-time RIC also provides policy-based guidance, AI/ML model management and enrichment information to the Near-real-time RIC in support of advanced RRM optimization.

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Management and security challenges in an open, programmable RAN

The O-RAN Alliance's architecture and standards have immense potential, but in their raw form, they still present some practical challenges to SPs. As is the case with many standards-based technology stacks, opening the RAN is complex to implement as-is. It is difficult to manage its various RAN infrastructure elements from multiple RAN vendors.

Friction may arise when trying to implement a multi-vendor ecosystem, for instance. Vendor lock-in can become an issue, standards notwithstanding. Security can also be a problem. Multiple, loosely connected open RAN components represent a large, diverse attack surface area.

The O-RAN Alliance's architecture and standards **have immense potential.**

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VMware RIC solution

VMware RIC solution addresses the shortcomings inherent in the organic O-RAN Alliance–based stack. As shown in Figure 3, VMware RIC is part of the broader VMware Telco Cloud™ ecosystem. VMware RIC actually comprises two products: VMware Centralized RIC, which is non-real-time, and VMware Distributed RIC, which is near-real-time.

In Figure 3, VMware components overlay the O-RAN Alliance's architecture from Figure 2. At the SMO layer, there are VMware Telco Cloud Automation™, VMware Telco Cloud Operations™, and VMware Centralized RIC. This layer is able to connect with a sizable, diverse set of applications through the use of its software development kits (SDKs) and open APIs.

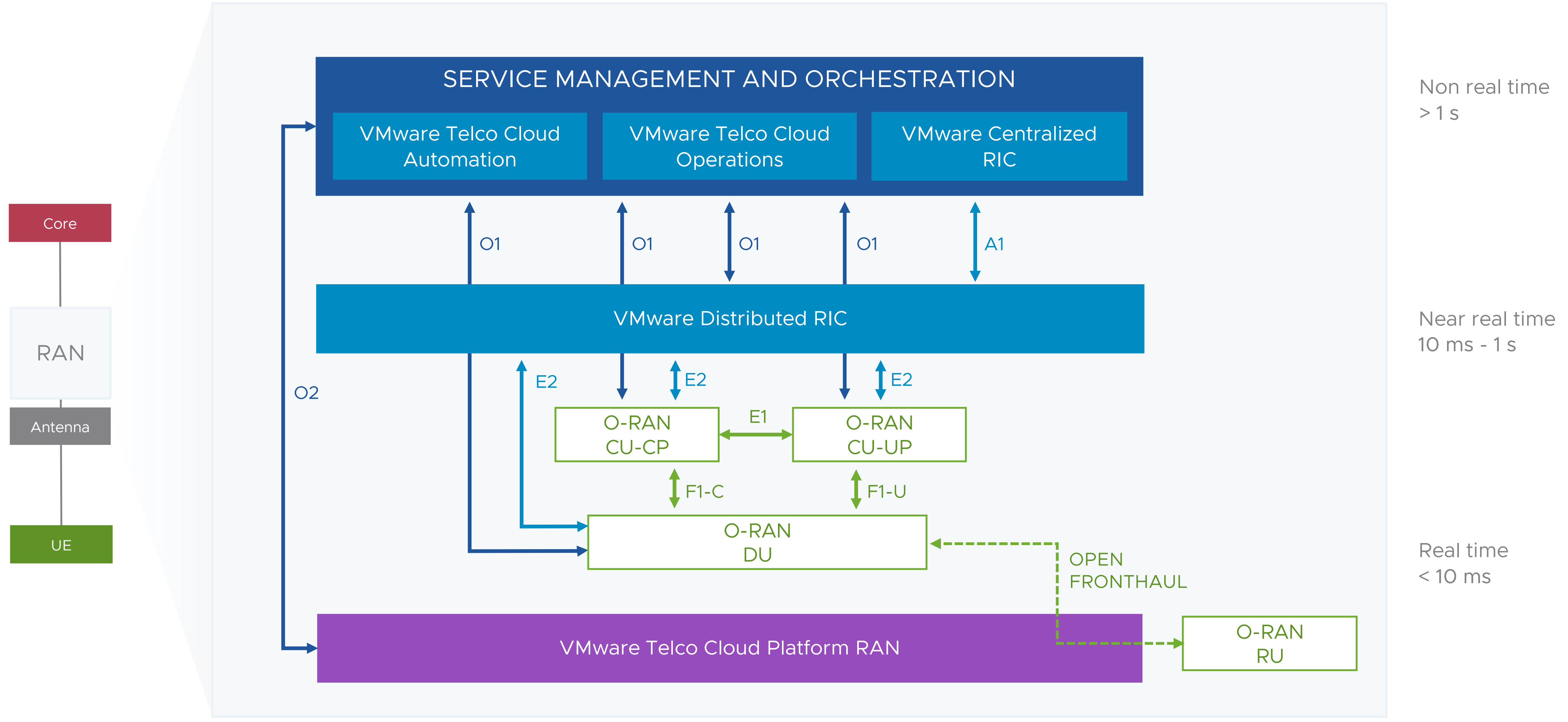

Figure 3: O-RAN architecture, now featuring VMware Centralized RIC, Distributed RIC and other VMware Telco Cloud offerings.

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VMware Telco Cloud Automation, also present at the SMO layer, provides open cloud infrastructure management and orchestration. The SP can use this solution to manage the underpinning infrastructure that supports the O-RAN Alliance's architecture, while also orchestrating workflows, application elements and the platform itself. VMware Telco Cloud Operations on the SMO layer deals with FCAPS.

VMware enables the SMO to be delivered as a complete solution for SPs who want an optimized and integrated SMO solution. At the same time, SPs can choose specific SMO components to fit unique needs. The VMware SMO framework facilitates the SP's path to open, modernized RAN with a range of solutions that take care of managing the RAN domain from a multi-vendor ecosystem. This way, the SMO framework enables SPs to unlock themselves from their existing legacy RAN designs.

Overall, the VMware approach to the SMO allows for programmability while providing architectural flexibility to the SPs. The RAN can dynamically support new applications and services. Its design abstracts the complexities of RAN administration away from the applications and services the SP wants to run on the RAN.

At the base of the architecture sits VMware Telco Cloud Platform RAN. This serves in the role of "open cloud" specified on the O-RAN Alliance's reference architecture.

A RAN-optimized platform, VMware Telco Cloud Platform RAN consists of VMware vSphere®, VMware Tanzu™ and VMware Telco Cloud Automation. It is engineered to reduce latency and eliminate jitter. With this structure and composition, the entire stack can meet and exceed stringent RAN performance requirements.

VMware Telco Cloud Platform RAN abstracts the underlying infrastructure from hardware vendors. It thus enables the RAN to operate latency-sensitive workloads in an ecosystem consisting of RAN software vendors. With its automation capabilities, the platform further facilitates easy provisioning of thousands of distributed RAN instances, along with whatever programmatic configuration is required for onboarding RAN workloads.

VMWare Centralized RIC and VMware Distributed RIC

VMware RICs work differently, but together they are responsible for the control and management functions of the disaggregated open RAN. Both represent true cloud-native software platforms that run on Kubernetes infrastructure. VMware Distributed RIC is an implementation of O-RAN Alliance's Near-real-time RIC. It operates as a control plane entity, hosting external RAN-focused applications known as xApps. It has control functions with response timing of less than 1 second.

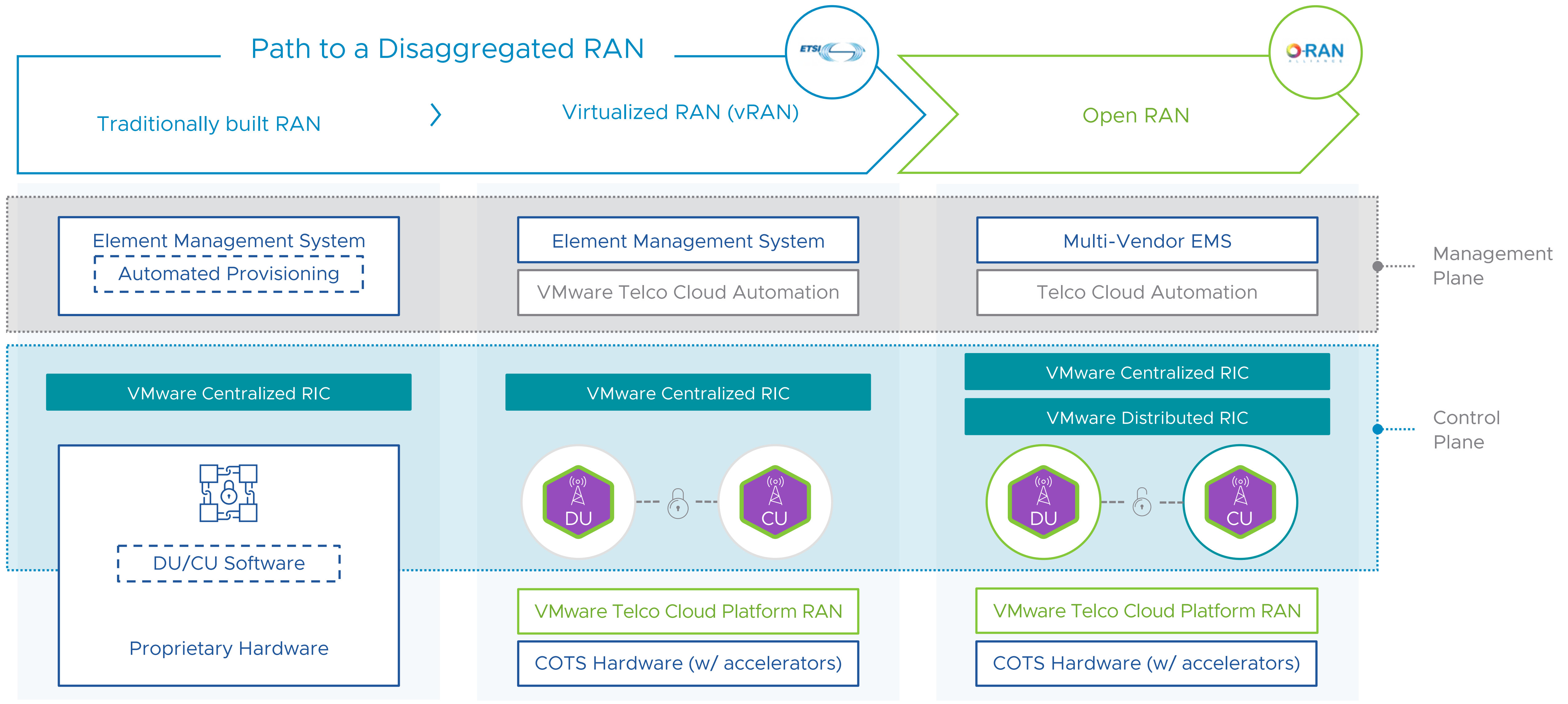

Figure 4: VMware Centralized RIC and VMware Distributed RIC

VMware Centralized RIC is the equivalent of the O-RAN Alliance's Non-real-time RIC. It performs non real time (e.g., greater than 1 second) intelligent RRM. It manages rApps, which are designed to realize a variety of RAN automation and management use cases. These include network optimization, network healing and more. In some cases, VMware Centralized RIC will leverage AI and ML to optimize the RAN infrastructure. VMware Centralized RIC thus supports intelligent RAN optimization through policy-based guidance and data analytics.

VMware Centralized RIC supports traditional RAN and virtualized RAN environments. This allows SPs to take advantage of newly introduced RAN innovation in the form of rApps now, without making significant changes to their existing RAN architecture. The ability of VMware Centralized RIC to support the traditional RAN also enables SPs to take the first step toward the disaggregated RAN and ultimately to the open RAN, making the RAN journey as smooth a transition as possible.

The application ecosystem

VMware's vendor-neutral approach, combined with VMware RIC's programmability, promote the best of breed RAN architecture, creating a rich and vibrant xApp and rApp ecosystem through VMware RIC's SDKs. While the SDKs elevate the activities of application developers, they also empower SPs to develop their own xApps and rApps, meeting their specific business and technology requirements and priorities. Furthermore, this rich and vibrant application ecosystem accelerates the innovation in the RAN because solutions are brought to market at a much faster pace.

USE CASES (rApp/xApp)	APP PROVIDER
PCI, RACH, mobility load balancing	Airhop Communications
Traffic steering, QoS admission control	Capgemini Engineering
4G and 5G dual connectivity	Cellwize Wireless Technologies
MU-MIMO optimization	Cohere Technologies
Geolocation	Polte
Energy savings	VMware
KPI monitoring, QoS scheduling control	VMware
Subscriber QoS optimization	VMware
VoNR traffic steering	VMware

Figure 5: VMware RIC application ecosystem partners and use cases

The ecosystem and VMware RIC's programmability also provide a higher degree of agility and flexibility in the modernized RAN to support a broad range of use cases, from the automation of repetitive, highly manual tasks to the reduction of time to resolution for network problems, resulting in higher efficiency and lower OpEx. In addition, the programmability of the RAN enables SPs to monetize use cases, supported by various xApps and rApps, such as supporting service-level agreements (SLAs) for slices of the RAN that are optimized for specific applications such as the Internet of Things (IoT), autonomous vehicles and SD-WAN.

Network Slicing

One of the more highly anticipated and distinguishing features of 5G is network slicing, which enables agile end-to-end network deployment connectivity for various services with specific requirements, such as quality of service (QoS), low latency, service availability and throughput. Although network slicing involves the end-to-end network programmability that encompasses the core, transport, and RAN domains, the RICs play a critical role in the RAN aspects of slicing. Slicing related policies for the RAN are managed through VMware Centralized RIC and then implemented and enforced in the RAN elements through VMware Distributed RIC. These policies cover the preferences and rules for a variety of aspects of the slices such as location, throughput, latency and priority.

VMware RIC plays critical roles in maintaining the slices once they are instantiated and operational. VMware RIC ingests and monitor telemetry data flows for each slice. AI/ML techniques provide closed-loop automation for SLA assurance. This level of automation powered by VMware RIC enables SPs to offer unique products and services to their customers with minimal human intervention.

Capability examples:

- VMware Centralized RIC collects key performance indicators (KPIs) related to the slice and the parameters required to configure it.
- VMware Centralized RIC and VMware Distributed RIC fine-tune RAN behavior aligned with O-RAN Alliance's architectural roles to assure RAN slice SLAs.
- VMware Centralized RIC monitors long-term trends and patterns for RAN slice subnets' performance and employs AI/ML methods to perform corrective actions through SMO.

Flexibility

VMware RIC enables a flexible open RAN environment. By simplifying the setup of a common platform for multi-vendor RAN, VMware allows for either greenfield or brownfield sites. Interoperability with other elements in the system is also possible. For example, VMware RIC can be used as a common platform across RAN infrastructure from different vendors within the same network. Or, VMware Centralized RIC can ingest data from external sources like mobility management entities (MMEs) and network management systems.

VMware RIC provides flexibility while

securing open RAN.

Security

VMware RIC gives SPs security capabilities to mitigate the threats facing RAN infrastructure. For example, VMware RIC restricts xApps and rApps from having administrative privileges. With the Kubernetes' Pod Security Standards control, xApps and rApps are also prevented from unilaterally accessing and allocating additional resources. The applications are isolated at the Kubernetes namespaces level, which stops unauthorized access. The solution aims to comply with industry security standards from O-RAN Alliance, 3GPP, ETSI and VMware's software development guidelines and processes. VMware further subjects VMware RIC to security testing and vulnerability scanning based on industry best practices.

Conclusion

vRAN is not enough for SPs. Open RAN has much greater potential for the kind of open, programmable RAN infrastructure SPs need to compete. Even so, open RAN in its pure form is a complex, challenging set of technologies to manage and secure. VMware Centralized RIC and VMware Distributed RIC provide the basis for an effective solution. Together with other VMware Telco Cloud products, VMware RIC facilitates a genuine cloud-native implementation of the O-RAN Alliance–based architecture—serving as a foundation for a secure RAN independent, vendor-neutral, O-RAN compliant solution that supports heterogeneous multi-vendor networks.

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