Boosting 5G Capacity with VMware RIC and Cohere

Enabling Cohere's MU-MIMO Scheduler with a RIC

SOLUTION AT A GLANCE

Running Cohere's Spectrum Multiplier and Cloud Scheduler as xApps on VMware RIC drastically improves spectrum efficiency using 5G MU-MIMO.

TRIAL AT VODAFONE

Vodafone announced in a press release that Cohere Technologies, VMware, Intel, and other companies have successfully demonstrated how a powerful new Open RAN platform can further boost the capacity of 5G where multiple customers are using the same site.

OPENING UP THE RAN

The telecommunications industry is moving toward open radio access networks (RAN) as communications service providers (CSPs) consider how to future proof and manage their networks for long-term innovation and revenue growth with the goal of unlocking the full potential of 5G, network slicing, and edge computing. At the same time, CSPs must continue to extract value from their 4G investments.

The shift to open RAN

The telecommunications industry is undergoing a big shift as CSPs rethink their core propositions and seek to deliver on the promises of 5G, moving beyond connectivity and exploring new opportunities for revenue growth. With this shift comes significant challenges: As the network becomes more complex, CSPs must consider how they can prepare for innovation while driving cost and operational efficiency.

Against this backdrop, CSPs are looking to open RAN as a way to restructure how the RAN is organized. The vision of the O-RAN Alliance, the industry consortium leading the charge for standardizing a practical open RAN architecture, is to disaggregate the RAN and make it more open, fostering greater choice in a traditionally closed market. These changes will provide CSPs with a strong foundation to secure a return on their investments and monetize their networks by launching new applications and services, especially at the edge.

At a basic level, the O-RAN architecture separates the radio unit by opening up the fronthaul interface and virtualizing the baseband unit (BBU) functions, and the architecture separates the control and management planes containing the RAN intelligence by opening up programmable interfaces to the data plane of the BBU software and moving the RAN intelligence to the cloud.

Virtualization of the RAN: Decoupling hardware and software

Virtualizing the RAN means decoupling the RAN software from the underlying hardware by running it on a virtualization layer. More specifically, it involves virtualizing the BBUs so they can run as software on commodity hardware.

The BBU is split into multiple virtual functions: the virtual Distributed Unit (DU), the virtual Centralized Unit (CU) and optionally the RIC. By logically splitting these functions, CSPs gain flexibility for where they place their workloads and gain economies of scale through centralization. For example, virtualized CUs can be centralized at designated sites, rather than each cellular site requiring its own traditional CU (as part of the BBU). In certain configurations, the virtualized DUs might sit at aggregated local sites rather than at remote cellular towers.

With the software and hardware now independent of each other, services can now scale up and down as needed. In addition, the ability to shift from proprietary to commercial-off-the-shelf (COTS) hardware will help CSPs reduce CapEx and OpEx. CSPs can also pool hardware for hybrid infrastructure.

Decoupling the RAN software and hardware diversifies the vendor ecosystem by enabling the baseband software and hardware to be provided by different vendors. This separation of functions ensures greater competition among different vendor partners and helps foster innovation in the RAN.

SOLUTIONS TO TRANSFORM THE RADIO ACCESS NETWORK

Open RAN (O-RAN) will give CSPs the flexibility, scalability, and agility to offer services beyond connectivity, support innovation, and increase revenue.

• Open RAN represents a shift from closed, proprietary architectures dominated by a few vendors to a disaggregated, multi-vendor environment with open interfaces, programmable infrastructure, and a vibrant ecosystem.

• VMware and Cohere Technologies are committed to enabling and supporting the transformation to open RAN with proven solutions, relevant domain expertise, and key ecosystem partnerships.

• Cohere's Spectrum Multiplier software enables multi-user multiple input, multiple output (MU-MIMO) and massive MIMO for both frequency division duplex (FDD) and time division duplex (TDD) networks in any band, under varying mobility conditions, with any radio and any handset, while operating in the cloud.
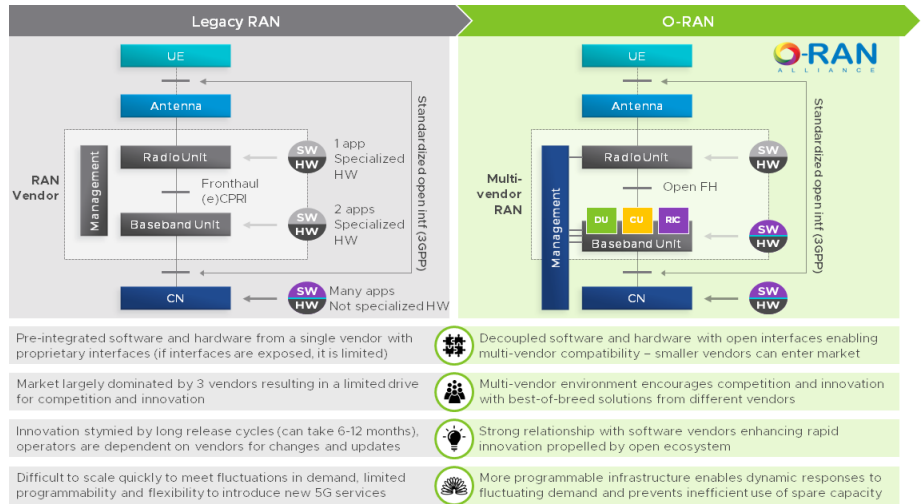

FIGURE 1: O-RAN represents a shift toward a multi-vendor ecosystem with open interfaces.

Software-defining the RAN: Shift to open interfaces

This next dimension involves decoupling the control and management planes of the RAN from its data plane and replacing vendor-proprietary interfaces with open standards-based interfaces to enable the CUs and DUs to interoperate with control and management units from different vendors, thus enabling a fully disaggregated and programmable RAN.

Decoupling the management function from the data plane to create a layer for service management and orchestration (SMO) enables vendor neutrality in the lifecycle management of network functions in the RAN across all types of telco clouds using open interfaces. The result lets CSPs use more automation to manage distributed deployments across the entire RAN topology, which can otherwise become a huge operational challenge. Decoupling the management plane also ensures greater integrity of performance and customer experience testing so that CSPs can accurately triage faults and identify root causes of issues.

Decoupling the Near-Real-Time (Near-RT) control plane is the last step in disaggregating the RAN. It involves decoupling the intelligence of the RAN software so that it can be delivered on top of a controller platform. Introducing a controller platform, the Near-RT RIC, as an abstraction layer unlocks greater innovation across the CSP ecosystem. CSPs can provide APIs to partners to build applications on top of the RIC without the challenges of having to integrate with the underlying data plane. This enables rapid deployment of innovative RAN control-plane functions and xApps to improve spectral efficiency and subscriber experience. It also introduces new monetization capabilities. Cohere's Spectrum Multiplier software, for instance, uses the new set of interfaces that enable disaggregation of the RAN intelligence.

RAN Intelligent Controller platform

The RIC is a key element in the O-RAN architecture

Figure 2 shows the modular components in the O-RAN reference architecture and the open interfaces between them. The key O-RAN defined elements that enable the transformation to a virtual and cloud-native RAN are the O-Cloud (effectively a COTS hardware abstraction layer) along with the O2 and the open fronthaul interfaces. Similarly, the key O-RAN defined elements that enable the transformation to a programmable and software-defined RAN are the Near-RT and the Non-RT RIC
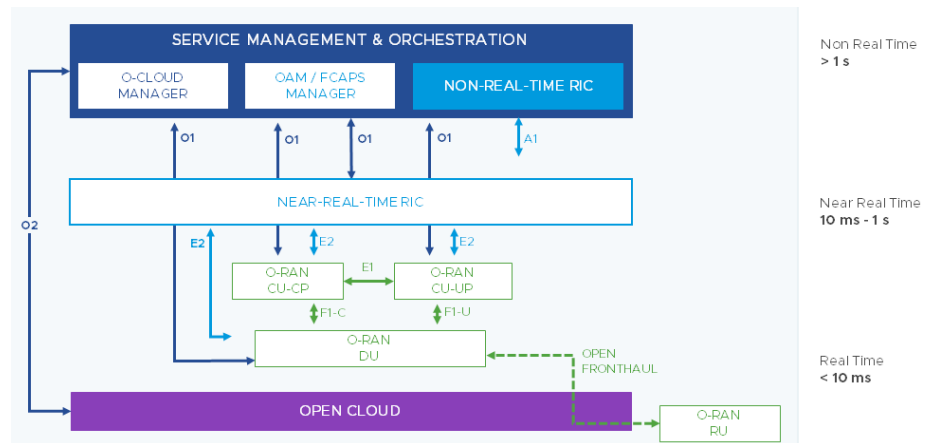
FIGURE 2: The O-RAN Reference Architecture.

(effectively the RAN data-plane abstraction layers for the control and the management planes respectively) along with the E2, O1 and A1 interfaces.

Logically, the RIC is a RAN data-plane abstraction layer. As shown in Figure 2, O-RAN has specified two flavors of the RIC: a Near-RT RIC for the near-real-time[1] control plane and a Non-RT RIC for the management plane.

The Near-RT RIC uses the southbound E2 interface to control the RAN data plane, i.e., the RAN baseband software, e.g., centralized unit control plane (CU-CP), centralized unit user plane (CU-UP), DU, and exposes open northbound APIs for third parties to provide various RAN control-plane applications (referred to as xApps). Similarly, the Non-RT RIC uses the southbound O1 and A1 interfaces to manage the RAN data plane (the RAN baseband software, e.g., CU-CP, CU-UP, DU) and the RAN control plane (Near-RT RIC) respectively, and exposes open northbound APIs for third parties to provide various RAN management-plane applications (referred to as rApps).

The RIC enables an open and multi-vendor RAN

The Near-RT and the Non-RT RICs are the central pieces that glue together the RAN data-plane functions (e.g., CU-CP, CU-UP, DU), the RAN control-plane functions (the xApps) and the RAN management-plane functions (the rApps), each of which could potentially be provided by a different vendor. As for the RAN data plane, the RICs abstract away the complexity of integrating with third-party xApps and rApps, which could range from 10s to 100s in any RAN market; instead, the RICs provide a single end point to the RAN data-plane functions for all external control and management.

Similarly, for xApps and rApps, the RICs abstract away the complexity of integrating with individual RAN nodes, which could range from 10s to 1000s in any RAN market and could also potentially span multiple RAN vendors; the RICs provide a single endpoint for the xApps and rApps to interface with the RAN. In addition, the RICs provide a set of common services, such as network state management, subscription management, conflict management, lifecycle management, to name a few, reducing the processing overhead and simplifying the software design for both xApps and rApps and RAN (CU/DU). This accelerates the time to develop and deploy new xApps and rApps, and also allows multiple xApps and rApps from different vendors to operate simultaneously in a RAN.

1 Decoupling the real-time (i.e., < 10 ms) control algorithms from the data plane is challenging in practice due to the stringent latency/jitter requirements. Hence, as a pragmatic choice, the O-RAN architecture only specifies that near-real-time (i.e., 10 ms – 1 second) control algorithms be decoupled from the data plane and moved to the Near-RT RIC.

In essence, the RIC platforms enable CSPs to build an open and multi-vendor RAN, diversify their supply chain, and increase agility. As such, CSPs can manage their costs more effectively while improving the quality of services and customer experiences. The success of the RIC, driven by O-RAN, is the key for CSPs to realize this open multi-vendor RAN vision.

Benefits of VMware RIC

VMware RIC is an integral part of an open RAN strategy. Here are some of the benefits of VMware RIC:

- Provides flexibility in RAN vendor choice: VMware is committed to remaining RAN vendor neutral. The VMware vision and strategy is to integrate its RIC platforms with CUs and DUs from a wide variety of RAN vendors. This vision aims to maximize CSPs' flexibility and agility in selecting their RAN vendors and give ecosystem partners a wide reach for their xApps and rApps.

- Accelerates innovation: VMware is committed to creating a thriving ecosystem of xApps and rApps focused on delivering value to CSPs across major dimensions: automation to improve operational efficiency, reduce time to resolution for problems, and lower OpEx; optimization to improve customer experience and network KPIs; and the ability to introduce new service capabilities and help add new revenue streams to monetize the RAN. VMware RIC will allow CSPs to access a diverse set of RAN intelligence vendors through the ecosystem, promoting innovation in their networks while driving cost effectiveness and revenue enhancements.

- Simplifies cell site infrastructure: VMware RIC along with the xApps and rApps designed to be cloud native and to run anywhere in CSPs' networks from the core to the edge, depending on their latency requirements. This flexibility allows CSPs to freely move complex intelligence away from the cell sites, making them far more simplified than the traditional RAN. As a result, CSPs can drastically reduce CapEx and OpEx.

- Built for developers: VMware RIC is built with developer experience at the heart of its design. VMware offers a software development kit (SDK) containing a set of valuable resources, tools, and services to help developers jump-start and accelerate their xApp and rApp development. As such, VMware RIC is an attractive option for app developers who are looking to provide intelligent functions for the RAN. More developers in turn mean a more vibrant ecosystem and faster innovation.

- Advances application performance: VMware RIC exposes advanced compute capabilities and processing libraries from partners like Intel, Nvidia and Dell to app developers, thereby allowing app partners like Cohere to use advanced ML, AI, and algorithmic capabilities to build intelligent functions for the RAN.

Cohere xApp for intelligent MU-MIMO scheduling

Cohere Technologies is working with VMware to help CSPs take full advantage of MU-MIMO and Open Cloud Architecture by moving Intelligence to the cloud to drive network performance across well-defined and standard interfaces, thus simplifying RAN complexities and economics. Cohere's Spectrum Multiplier software can be integrated within the RAN DU, the CU, or as an xApp in the RIC in a telco cloud or O-RAN, without any changes to handsets or radios.

Cohere xApp addresses the practical challenges of MU-MIMO

MU-MIMO boosts the capacity or spectrum efficiency of a cell by communicating with multiple users simultaneously in the same time and frequency slots. Wireless is a broadcast medium – signals transmitted by a cell to one user also reach all other users in the coverage area of the cell. Transmissions to multiple users are usually separated in either time or frequency, so each user can receive its own signal without any interference from the transmissions to other users. MU-MIMO allows simultaneous
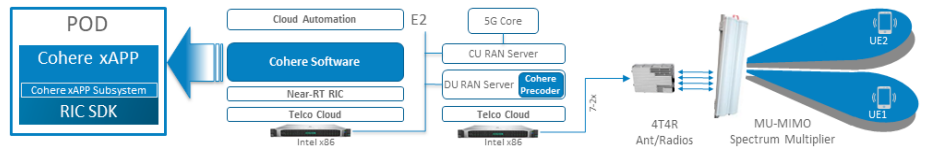
FIGURE 3: The Cohere deployment of a disaggregated RAN cloud scheduler. xApp comes with an xApp-subsystem that can integrate with VMware Distributed RIC SDK.

communication with multiple users in the same time and frequency slots, thereby allowing a cell to push more bits per time and frequency, and thus improve the efficiency of the most valuable resource in the RAN – the spectrum.

However, MU-MIMO is hard to implement in practice because the control plane for MU-MIMO needs to be smart about how users are grouped for simultaneous communication (the problem of user pairing) and how their transmissions are precoded, i.e., shaped, so each user can extract its own transmission without perceiving too much interference from the other transmissions (the problem of user precoding). Without intelligent pairing and precoding, using MU-MIMO can lead to worse performance than not using MU-MIMO at all. To date, these control plane problems generally remain unsolved, at least in satisfactory way, and even though the data plane for MU-MIMO has been standardized by 3GPP for many years, this technology is rarely used in practice.

Cohere xApp delivers intelligent MU-MIMO scheduling

Cohere software improves how MU-MIMO is performed in 4G and 5G wireless systems. Cohere's work in the Delay-Doppler domain creates a robust channel estimation and accurate channel prediction into the future enabling massive MIMO deployments in both FDD and TDD spectrums under varying mobility conditions.

Cohere decouples the RAN intelligence (for MU-MIMO scheduling, especially Dynamic MU-MIMO user pairing and precoding) from the DU and runs it as a service in the cloud on top of VMware RIC, as shown in Figure 3. In the past, the scheduler had always been considered too latency sensitive to move outside the DU and to the cloud. Decoupling the scheduler enables channel estimation and prediction (in both time and frequency) and MU-MIMO to be delivered to existing LTE handsets. The result is an increase in spectral efficiency for existing LTE networks without using more spectrum or requiring handset upgrades. The capacity benefits also translate to 5G deployments.

Features of the Cohere solution running on VMware RIC

• Dynamic orthogonality and MU-MIMO pairing: Cohere software dynamically creates orthogonality between paired user equipment (UEs), eliminating inter-beam interference even with small angular separation.

• Uplink/Downlink Channel Estimation and Prediction: Cohere software takes advantage of existing UE feedback for channel measurement and spatially multiplexes any mix of 4G/5G devices, fully reusing available spectrum, preserving optimal spectral efficiency for any mobile network.

• Massive MU-MIMO in FDD and TDD under all mobility conditions: The opportunity to deploy massive MIMO in FDD is in itself significant given the range and resiliency of low-band spectrums.

• Co-ordinated Multipoint and Intercell Interference Coordination: Due to its location in the cloud, Cohere's disaggregated scheduler can schedule across multiple sites and enable advanced interference mitigation techniques such as Co-ordinated Multipoint (CoMP) and Intercell Interference Coordination (ICIC) that will deliver even higher benefits in dense deployments that are interference limited, especially improving cell edge capacity.

- Reduced computational complexity: Cohere software also significantly reduces computational complexity through concise and accurate channel representation while running on general purpose processors.

- Coexistence/Dynamic Spectrum Sharing: Cohere's cloud scheduler can be used to co-schedule 4G and 5G deployments. The software reuses time and frequency resources to Unicast LTE & 5G new radio (NR) signals via orthogonal beams. As the industry goes through a transition from 4G to 5G, spectrum will need to be intelligently distributed between 4G and 5G access networks. If spectrum is statically allocated to 5G before there are enough 5G enabled handsets to take advantage, it will be wasted and worse at the same time 4G network KPIs get degraded. The decoupled cloud scheduler on the RIC enables dynamic spectrum sharing (DSS) between 4G and 5G since it is architected to work agnostic to the underlying air interface.

- Cohere apps running on VMware RIC can leverage the realtime network telemetry to decide how much spectrum to dynamically allocate between 4G and 5G, and the radio scheduler app can then decide on a per transmission time interval (TTI) basis the exact allocation of the spectrum among the different 4G and 5G UEs. This will enable DSS to be customized by the operator in accordance with their policy and also implement it in a vendor-neutral manner, rather than getting locked into a proprietary implementation.

Trial led by Vodafone

Vodafone announced in a press release that Cohere Technologies, VMware, Intel, and other companies have successfully demonstrated how a powerful new Open RAN platform can further boost the capacity of 5G where multiple customers are using the same site. The successful trial is the latest step in building a cost-effective Open RAN ecosystem that will benefit Vodafone customers. In a test laboratory, the companies increased the capacity of a 5G cell site by two-fold using a programmable, artificial intelligence (AI)-based RIC supporting a mix of Open RAN components from multiple vendors. This collaboration represents a key milestone in demonstrating the potential of VMware RIC sitting at the heart of an Open RAN installation.

The companies showed the first demonstration of 5G MU-MIMO – providing more capacity at a single cell site – running on VMware RIC located at a multi-vendor Open RAN test site. MU-MIMO apportions ample bandwidth to individual users connected to the same mobile site and is considered the pivotal technique to boost cell capacity in future 5G networks. It is a major development in supporting the insatiable demand for faster and more responsive digital connections to deliver high-definition graphics, virtual reality, cloud and IT applications.

Based on the performance of Cohere's Spectrum Multiplier MU-MIMO scheduler in the trial, when the technique is commercially deployed in a low-band (e.g., 700MHz) network, users will benefit from up to 2x the capacity achieved using traditional MIMO.

LEARN MORE

For more information about the VMware Telco Cloud, call 1-877-VMWARE (outside North America, dial +1-650-427-5000) or visit *https://telco.vmware.com/*