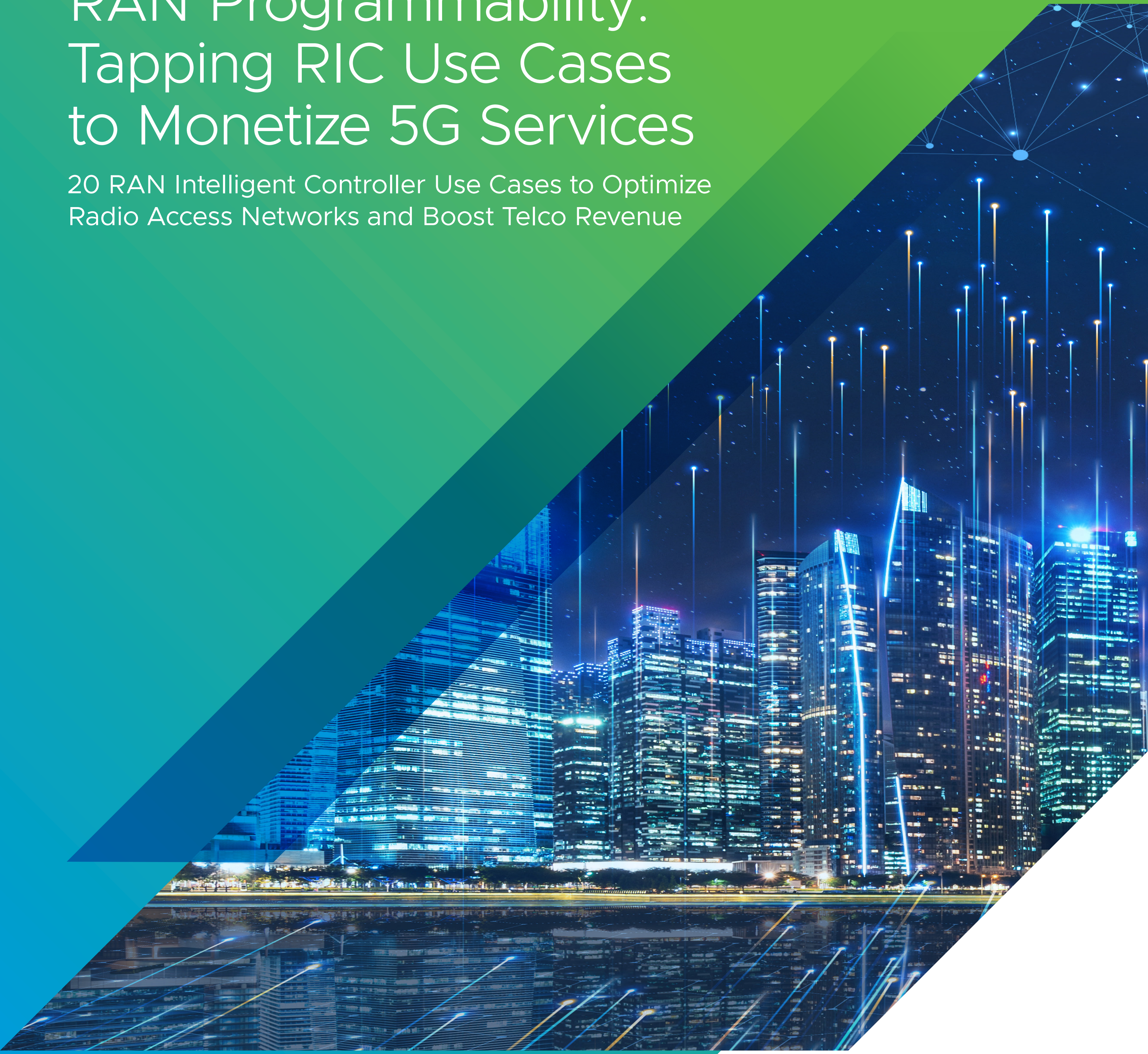
# RAN Programmability: Tapping RIC Use Cases to Monetize 5G Services

## 20 RAN Intelligent Controller Use Cases to Optimize Radio Access Networks and Boost Telco Revenue



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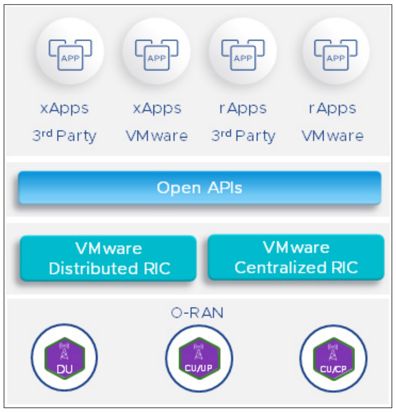



**FIGURE 1:** VMware Distributed RIC and VMware Centralized RIC.

### VIABLE RIC USE CASES

Viable RIC use cases expand network programmability, diversity vendor supply chains, and optimize the RAN.

- Massive MIMO optimization
- Local indoor positioning
- Programmable multi-services hub
- PCI conflict and collision detection
- Subscriber QoS optimization
- Traffic steering
- QoE optimization
- Network slicing
- SLA assurance
- Signaling storm protection
- Energy efficiency

# VMware RAN Intelligent Controller

An open radio access network seeks to adopt the industry trajectory toward virtualization and software-defined networking. The standards for 5G point toward a cloud-native future, and part of that future lies in a vision to disaggregate and open the RAN.

The O-RAN Alliance's architecture extends the 3GPP's open RAN architecture to further disaggregate the radio access network and open it up to multiple vendors. As such, the O-RAN architecture not only splits the distributed unit (DU) of the 3GPP into a DU and a radio unit (RU), it also introduces a new component: the RAN intelligent controller, commonly referred to as the RIC.

The RIC introduces robust network programming into the RAN. Programming the network enables you to improve subscriber experiences and drive topline growth through machine learning, optimization, and real-time decisions. RIC use cases — such as Massive MIMO optimization, precise location positioning, and PCI value optimization— can reduce costs and spark monetization.

There are two logical forms of the RIC, and each performs a different function.

- The near-real-time RIC is a distributed RIC that runs extensible microservices from third-party vendors, called xApps by the O-RAN Alliance, to manage RAN resources for network functions.
- The non-real-time RIC is a centralized RIC that hosts rApps.

Both the near-real-time RIC (near-RT RIC) and the non-real-time RIC (non-RT RIC) are virtualized or containerized logical components that control and optimize RAN elements and resources. Many xApps and rApps will use open interfaces and machine learning to optimize RAN resources.

The RAN Intelligent Controller from VMware, called VMware RIC, brings network programmability, control, and automation to the RAN by hosting xApps and rApps. The near-real-time RIC from VMware is called VMware Distributed RIC, and the non-real-time RIC is called VMware Centralized RIC.


"[The RIC] validates the role that this powerful new platform plays in defining Open RAN as the future of networking. It boosts capacity for customers when they need it most, reduces the need for expensive hardware by a third and cuts down on energy consumption. These time and cost savings will ultimately encourage the introduction of new, innovative services."

FRANCISCO MARTÍN,
HEAD OF OPEN RAN,
VODAFONE

DECONSTRUCTING THE RIC

The O-RAN Alliance's architecture decouples the RIC: Non-real time (Non-RT) control functionality of greater than 1 second typically resides in the non-RT RIC, and the near-real time (near-RT) control functions of between 10 miliseconds and 1 second reside in the near-RT RIC.

Non-RT functions typically include service and policy management, RAN analytics, and training for machine-learning models.

Trained machine-learning models, artificial intelligence-enabled policies, and real-time control functions produced in the non-RT RIC are distributed to the near-RT RIC for runtime execution.

The  O-RAN A1 interface connects the orchestration layer containing the non-RT RIC with the eNB containing the near-RT RIC.

As a result, you can modify the RAN and program your network according to models optimized to meet your network's unique policies and objectives.

## The RIC Opportunity: Boosting Revenue, Lowering Costs, and Improving Quality

The RIC disaggregates the control, management, and data planes to enable applications from different vendors to access control and management plane functions. The result radically improves RAN programmability.

In the short term, the RIC is an opportunity to reduce costs, increase energy efficiency, and improve quality of service. In the longer term, the RIC presents a sizable opportunity to monetize radio access networks by running 5G services.

- Cost savings through automation: RIC applications introduce more automation into the network with software-based control of the RAN that helps reduce manual work, saves on power consumption, and manages ressources more efficiently.
- Quality of service improvements: RIC applications use information from the network to orchestrate, optimize, and assure workloads. By monitoring and analyzing the data of applications using the network, the RIC can ensure a high quality of service (Qos) for users and provide assurance for SLAs.
- New revenue opportunities: As an open platform, the RIC can drive innovation through new applications — xApps and rApps. These applications bring intelligence to the RAN and spark dynamic use cases, such as assurance for network slicing and edge applications.

This paper explores the most viable use cases to take advantage of the opportunity that the RIC presents. These use cases can benefit your CSP by optimizing resources, improving efficiency, generating revenue, or unlocking better customer experiences.

VMware is working with a broad set of ecosystem partners to drive innovation in the RAN and to take advantage of the opportunities that the RIC presents.

Some of the use cases in this paper demonstrate the power of partnership to overcome challenges in the RAN by running rApps and xApps on VMware RIC.

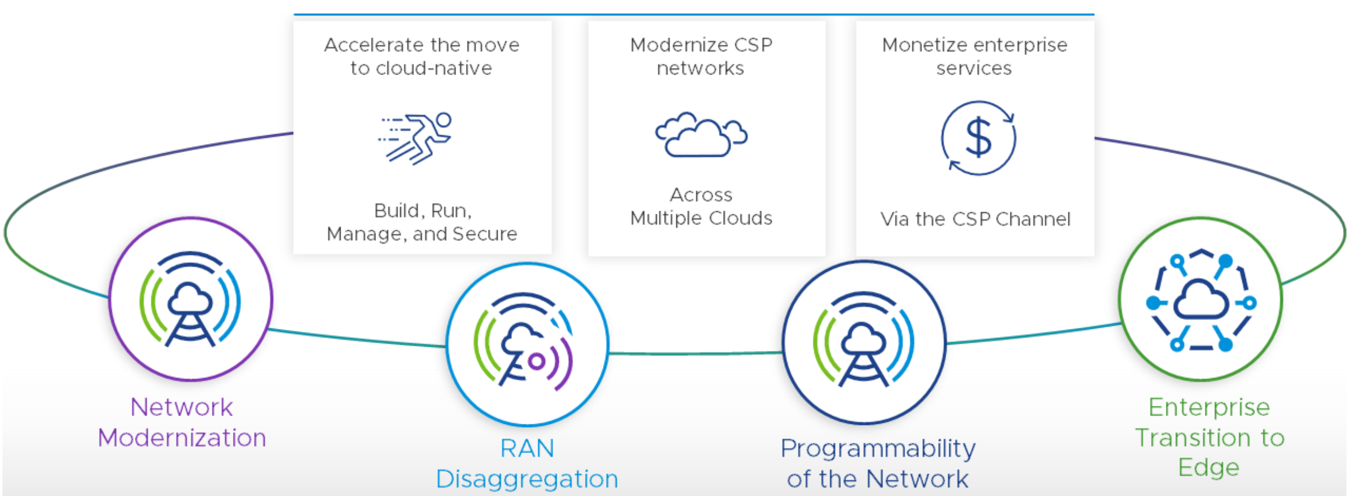



FIGURE 2: The RIC is part of a strategy to disaggregate the RAN, improve network programmability, and monetize services.

**THE RIC POWERS AN OPEN, MULTI-VENDOR RAN**

As open interfaces began to be specified and standardized, the telecommunications industry quickly realized that such interfaces can be used to build and deploy value-added capabilities in the RAN. For example, in scenarios where GPS is unavailable or unreliable, you can now design an xApps that infer the locations of devices using RAN information and expose the devices to location-based services.

Similarly, rApps can gather information from the RAN to produce intelligence, such as RAN-layer throughput predictions, coverage or signal predictions, and real-time network load information. External applications or services can then use this intelligence to enhance capabilities or performance.

In other words, the RIC can become a platform for deploying innovative RAN capabilities that enhance the performance and experience of OTT applications and edge services. In essence, the RIC enables you to build a multi-vendor RAN, diversify your supply chain, and boost agility.

The result: You can manage your costs more effectively while improving the quality of your services and your customers' experiences. The success of the RIC, driven by the O-RAN Alliance, is one key to realize this open multi-vendor RAN vision and take control of programming your networks.

*Demo Video: Activating Network Programmability with VMware RIC*

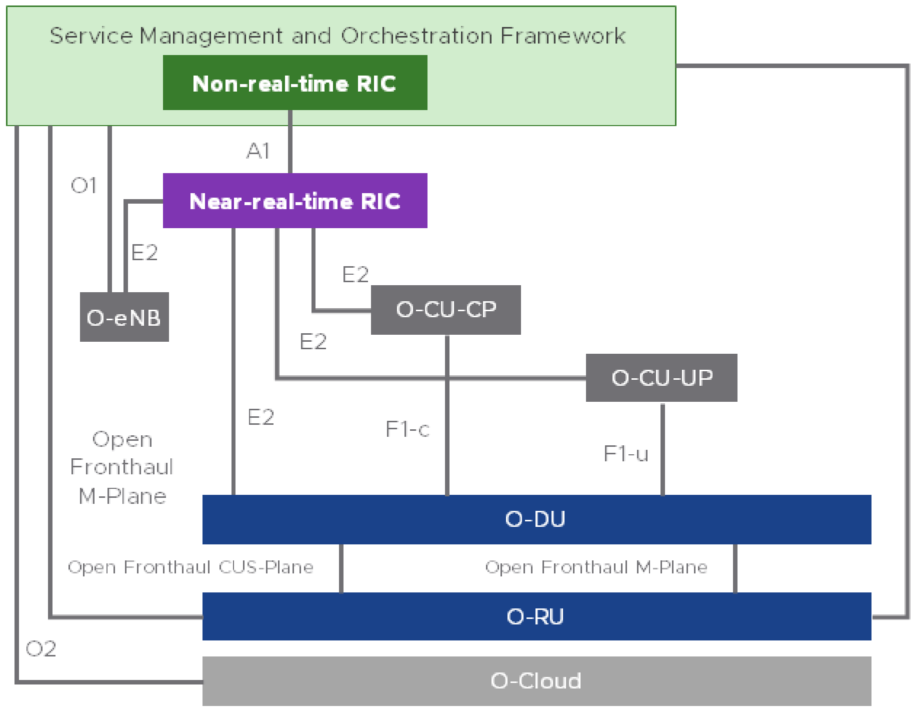



**FIGURE 3:** The O-RAN reference architecture. Source: The O-RAN Alliance.

# Situating the RIC in the RAN

The RIC is a key element of the O-RAN architecture. Figure 3 shows the modular components in the O-RAN reference architecture and the open interfaces between them. The key O-RAN elements that create a virtual and cloud-native RAN are the O-Cloud, which is effectively a COTS hardware abstraction layer, and the O2 and the open fronthaul interfaces. Similarly, the key O-RAN element that facilitates a programmable software-defined RAN is the RAN intelligent controller.

The RIC disaggregates the control and management planes from the data plane. As shown in Figure 3, the O-RAN Alliance specifies two types of RAN intelligent controllers:

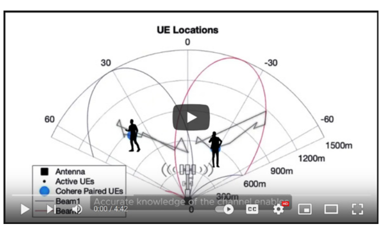
- A Near-RT RIC for the near-real-time control plane
- A Non-RT RIC for the management plane

The Near-RT RIC uses the southbound E2 interface to control the RAN data plane — that is, the RAN baseband software that includes the centralized unit control plane (CU-CP), the centralized unit user plane (CU-UP), and the distributed unit (DU). The near-RT RIC exposes open northbound APIs for third parties to run RAN control-plane applications — xApps.

Similarly, the Non-RT RIC uses the southbound O1 and A1 interfaces to manage the RAN data plane (the RAN baseband software that includes the CU-CP, CU-UP, and DU) and the RAN control plane (the Near-RT RIC). It exposes open northbound APIs for third parties to run RAN management-plane applications —rApps.

"Our ongoing work with Cohere Technologies shows the value of disaggregating hardware functions and moving them to the telco cloud. Our solution is designed to help accelerate RAN automation, optimization, and monetization by enabling CSPs to deploy intelligent, cloud-native RAN applications created by a growing xApp developer community."

STEPHEN SPELLICY, VICE PRESIDENT OF PRODUCT MARKETING AND SOLUTIONS, SERVICE PROVIDER AND EDGE, VMWARE




*Demo Video: Activating Sustainable Broadband with VMware RIC and Cohere Technologies*

# MU-MIMO Capacity Expansion

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 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.

Cohere Technologies' 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.

## Cohere and VMware working together

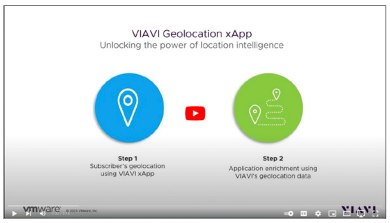
Cohere Technologies is working with VMware to help CSPs take full advantage of MU-MIMO and Open Cloud Architecture by moving Intelligence to the cloud to drive network performance across well-defined and standard interfaces, thus simplifying RAN complexities and economics. Cohere's Spectrum Multiplier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

## Role of the Cohere xApp on VMware RIC

The 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 to enable massive MIMO deployments in FDD and TDD spectrums under varying mobility conditions.

Cohere decouples 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.

VIDEO DEMONSTRATION OF THE USE CASE ON VMWARE RIC




*Harnessing the Power of Location Intelligence with the VIAVI Geolocation xApp on VMware RIC*

BENEFITS OF USING VIAVI'S GEOLOCATION xAPP

The precise geolocation information delivered by the VIAVI Geolocation xApp lets you use a data-driven, automated approach to tailor and optimize the RAN.

- Reduce energy usage in the RAN
- Optimize coverage and capacity
- Perform massive MIMO SSB beam optimization
- Enhance MU MIMO pairing

# RAN-Based Geo Positioning

Current positioning techniques are under the control of device manufacturers and rely on technologies like GPS, WiFi, or BLE, which are plagued with shortcomings like poor indoor coverage, high battery consumption, and varied support on different devices. Consequently, it's difficult to effectively tap this information for services or network optimization.

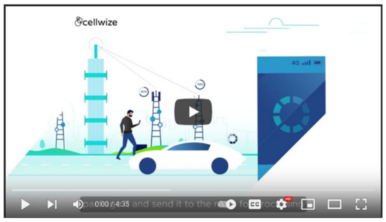
As the most widely used positioning system, GPS can provide accurate information within a skew of only a few meters. To achieve such accuracies, however, the GPS receiver mounted on the tracking device should typically have an unobstructed line of sight to four or more GPS satellites. Obstacles like mountains and buildings block GPS signals; as a result, in dense urban areas, hilly terrain, and common indoor scenarios, GPS-based positioning is often unreliable and sometimes unavailable. Similarly, WiFI and Bluetooth low energy positioning technologies have limited coverage. In such scenarios, RAN-based positioning has emerged as a promising alternative.

## VIAVI's Geolocation xApp on VMware RIC

VIAVI's Geolocation xApp, which runs on VMware Distributed RIC, unlocks the power of location intelligence for the RAN. By using mobile cellular signaling data as the primary input for its location technology and pairing it with network configuration management data, radio site information, and subscriber digital geospatial information, VIAVI's xApp accurately locates subscribers 24/7 and makes this information available for consumption by other apps in the near-real-time domain.

## Role of the VIAVI xApp on VMware RIC

- The VIAVI Geolocation xApp exposes rich subscriber-centric information via the RMR messages or the Subscriber Data Layer (SDL) API. The availablity of geolocation estimates in near real-time allows other applications registered with VMware Distributed RIC or VMware Centralized RIC to use the information.
- The VIAVI Geolocation xApp aggregates location information through time. Aggregating the data centrally has additional potential – the measurements and locations of mobile devices over longer periods reveal effects of subscriber behavior on the RAN. This data unlocks data-driven optimization use cases to tailor the network.




DEMO VIDEO

*Transforming any RAN into a Multi-Services Hub with VMware and Cellwize*

# Programmable Multi-Services Hub

The RIC helps transform any RAN into a programmable multi-services hub. With this adaptability, the RAN — including legacy radio access networks — becomes a multi-services hub that you can use to monetize new services through programmability. VMware's work with Cellwize provides an example.

## Cellwize and VMware working together

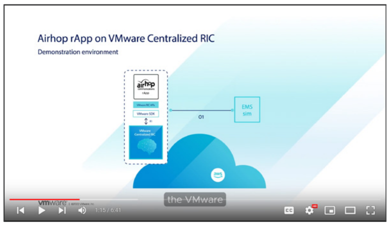
- VMware RIC has integrated Cellwize technology to remove programmability limitations in purpose-built RAN deployments, unlocking monetization of a RAN by transforming it into a multi-service hub.
- By using Cellwize technology, VMware RIC can communicate with proprietary management systems.
- By using the Cellwize CHIME platform for RAN data mediation and AI services, VMware Centralized RIC removes the inherent limitations of purpose-built RAN deployments so you can move operational and business intelligence away from the underlying infrastructure and back into your control.

MODERNIZE THE RAN TO MONETIZE THE EDGE

With an open RAN, virtualization and cloud-native technology bring efficiency, flexibility, and automation. A common platform can turn the RAN into a 5G multi-services hub that lets you deploy non-RAN CNFs alongside vRAN functions. As a result, you can monetize 5G by quickly introducing new services while streamlining operations.

## The role of the Cellwize rApp on VMware RIC

- As a benefit of integregation, the Cellwize EN-DC rApp dynamically manages dual connectivity of 4G and 5G through programmability in 5G non-standalone deployments.
- The Cellwize rApp is onboarded by using the VMware Centralized RIC SDK.
- The Cellwize rApp lets you apply optimization policies and frequency strategies.
- The Cellwize EN-DC rApp maximizes the usage of 5G spectrum by, for example, reducing RAN bottlenecks to improve overall network capacity.




DEMO VIDEO

*Mitigating PCI Collisions with the AirHop rApp on VMware RIC*

"We are thrilled to collaborate with VMware to accelerate the realization of AirHop's commercially hardened 4G and 5G RAN automation and optimization solutions in the O-RAN architecture on the VMware RIC. Combining VMware RIC with AirHop xApps and rApps will enable MNOs to optimize their network performance in real time and reduce operating costs."

JOE THOME,
VICE PRESIDENT OF BUSINESS OPERATIONS AND MARKETING,
AIRHOP

# PCI Conflict and Collision Detection

If frequency planning, conflict mitigation, and optimization are costly and time consuming, it slows down the deployment of new cells, impedes the launching of new services, and impairs the performance of existing cells.

The AirHop PCI rApp, which is powered by VMware Centralized RIC, efficiently detects physical cell identity (PCI) confusion and collisions during critical operator scenarios to speed up new cell deployments, drive faster times to market for new services, and improve performance of existing cells. The AirHop PCI rApp automatically issues resolution commands to drive optimal performance for the RAN.

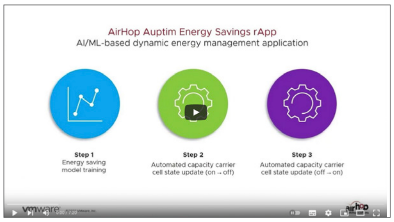
## AirHop and VMware working together

- The AirHop PCI rApp runs on VMware Centralized RIC to automate and program the mitigation of PCI conflicts and collisons.
- AirHop uses a VMware Centralized RIC SDK to onboard the rApp.
- VMware Centralized RIC furnishes the environment in which the AirHop PCI rApp can query the EMS for cell configurations.
- VMware Centralized RIC delivers the resolution commands from the AirHop rApp to the EMS system to optimize the PCI values across the network.

## The role of the AirHop PCI rApp on VMware RIC

- Cells are registered and then queried to obtain their PCI configurations. The PCI algorithm detects and resolves PCI confusion and collisions by using its network view of one-hop and two-hop network cells.
- By using the connectivity furnished by VMware Centralized RIC, AirHop's rApp can retrieve the network relationship of neighboring cells and apply the PCI algorithm to detect confusions and collisions.
- AirHop's PCI rApp demonstrates how the use of automation and programmability can redefine the process of PCI conflict mitigation and PCI value optimization.

VIDEO DEMONSTRATION OF
THE USE CASE ON VMWARE RIC




*Managing RAN energy consumption with AirHop's Energy Savings rApp*

BENEFITS OF USING
AIRHOP'S AUPTIM rAPP

- Reduce energy consumption.
- Ensure user quality of service and fulfill customer SLAs.
- Improve operational sustainability

# RAN Energy Management with the Auptim rApp from AirHop

As you expand your RAN footprint to enhance connectivity and services, a major challenge is finding the right balance between energy consumption and network performance.

In 5G networks, CSPs use carrier aggregation to furnish wide-area coverage and high-capacity throughput for data-heavy applications. You need to strike a balance between resources assigned to coverage and capacity. If insufficient resources are provided for capacity, user experience will suffer, but if full resources are permanently allocated for both coverage and capacity, energy consumption in the RAN will be higher than needed to meet end-user service expectations.

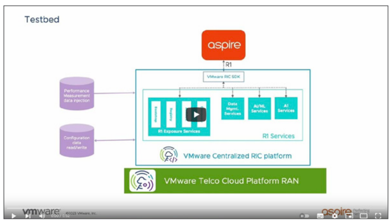
## Role of AirHop's Auptim rApp on VMware RIC

AirHop's Auptim AI/ML-based Energy Savings rApp intelligently manages energy consumption in multi-carrier cellular networks while maintaining high levels of end-user quality of service. The rApp optimizes network-wide energy usage by switching on and off capacity carriers in response to service demand levels. Using the Energy Savings rApp results in a reduction of operating expenses in the form of energy costs, assurance of quality of service, and a more sustainable network.

- Supported by the policy-based guidance, data analytics, and AI/ML model management provided by VMware Centralized RIC, the AirHop Communications Auptim rApp uses machine learning to predict energy savings actions in the network.
- The training process begins by ingesting historical RAN data composed of unique traffic profiles characterizing demand variations due to time windows and by types of customers, network configurations, and performance KPIs.
- Then the application establishes a single trained model deployed as distributed inferences across cells in the network. The deployed model is periodically updated based on various nputs.

Finally, the rApp makes an intelligent decision about the on or off state of the capacity carrier in order to maximize energy savings. As a result, the energy consumption of the RAN fluctuates with traffic demand without affecting user quality of service.

VIDEO DEMONSTRATION OF THE USE CASE ON VMWARE RIC




*Running Aspire's rApp on VMware Centralized RIC to Oversee Configuration Management*

BENEFITS OF USING ASPIRE'S GOVERNANCE rAPP

- Detect and correct conflicting configuration changes before network performance is affected.
- Forge ahead with a range of rApps for different use cases.

# Detecting and Resolving KPI Anomalies with Aspire's rApp

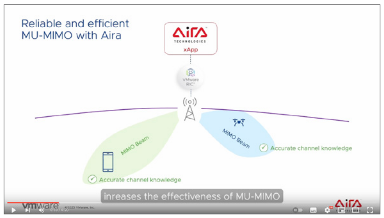
The Open RAN vision of multiple rApps optimizing the network in tandem has many advantages, but it also presents challenges. One is the lack of intelligent coordination between rApps. Concurrent changes might interfere with each other and lead to a degradation in performance. This problem could be compounded if rApps respond to the drop in performance by attempting to make more changes. An intelligent, centralized governance application can ensure that other applications can operate simultaneously without interfering with one another.

To solve this challenge, Aspire Technology has developed a governance rApp. It monitors network performance and uses AI and machine learning to detect KPI anomalies caused by conflicting configuration changes requested by other rApps. When it detects severe performance degradation, it rolls back configuration changes initiated by other rApps, mitigating cross-rApp interference and restoring RAN performance. It also records which changes caused drops in performance to help developers evaluate rApp performance and improve their rApp stack.

## Role of Aspire's rApp on VMware RIC

- Aspire Technology's Governance rApp, powered by VMware Centralized RIC, automates configuration management corrections by monitoring network performance KPIs. The rApp can restore RAN performance to expected levels.
- The automatic detection, reporting, and visualization of anomalies allows operators to better monitor networks, reducing OpEx and improving network quality.
- The AI/ML Detection Model that is the core intelligence of the rApp. It groups KPIs into variable and stable categories. Generalized Extreme Studentized Deviate (GESD) is used to to detect anomalies in the variable KPIs. Thresholds based on percentiles are use to detect anomalies in the stable KPIs.
- To detect anomalies, the rApp periodically requests performance management data from the RIC and applies a detection algorithm to the performance KPIs.

VIDEO DEMONSTRATION OF THE USE CASE ON VMWARE RIC




*Boosting MU-MIMO Performance with Aira's xApp on VMware Distributed RIC*

BENEFITS OF USING AIRA'S HIGH FIDELITY CHANNEL ESTIMATION AND PREDICTION xAPP

- Increase the effectiveness of MU-MIMO compared to simple channel estimation.
- Obtain large SINR gains.
- Expand cell coverage.
- Reduce power consumption.
- Reduce OpEx and CapEx.

# Using Aira's xApp to Boost MU-MIMO Performance

MU-MIMO can improve RAN performance without changes to devices or radios. In order to beamform efficiently, however, MU-MIMO requires accurate knowledge of the channel between the user and the base station. Current channel estimation techniques fail to incorporate user mobility and evolution of the RF environment into their calculations, resulting in inaccurate estimates that eliminate the advantage of MU-MIMO.

Aira's High Fidelity Channel Estimation and Prediction xApp can allow operators with existing networks to achieve more than double the throughput and gain up to 3dB of Signal to Interference Noise Ratio (SINR).

This excess throughput can either service more subscribers or furnish existing ones with higher levels of data rates for high-fidelity applications like VR and gaming, helping operators improve revenue. With these gains in SINR, operators can extend cell ranges and plan new network deployments with fewer base stations, which can reduce TCO, CapEx, and OpEx.

Channel Estimation is a key processing block in the Distributed Unit (DU) of the radio access network (RAN) software stack. In traditional implementations, the algorithm used for channel estimation relies solely on the reference signals (such as SRS and DMRS) defined by 3GPP. Aira's more custom approach taps its machine learning module to use the reference signals to establish and continuously update a network profile and user profile.

## Role of Aira's xApp on VMware RIC

- The characteristics of the serving network and user behavior are finger-printed by Aria using ML algorithms that can predict future changes in the channels between users and their serving networks.
- Aira's Channel Prediction xApp uses L1 reference signals (SRS, DMRS, etc.) to first estimate and classify the user status, including their speed and distance from the base station, and the network environment, including especially the most likely channel model and multipath delays. The xApp then uses this information with the reference signals to predict the evolution of the user channel.

VIDEO DEMONSTRATION OF THE USE CASE ON VMWARE RIC


*Maximizing energy efficiency with HCLSoftware's iDES rApp*

BENEFITS OF USING THE HCLSOFTWARE rAPP

- Save energy beyond the standard dSON energy-saving feature.
- Maximize customer experience.
- Fulfill SLAs while controlling energy costs.

# Saving Energy Dynamically with the HCLSoftware rApp

As you transform your networks to deliver innovative 5G services, it's important to find the right compromise between quality of experience for subscribers and reducing the energy needed to power your networks. Insufficient network resources can lower service quality; excessive network resources wastes energy and increases operating costs. A recent study by McKinsey showed that the RAN consumes around 60 percent of the power consumed by a mobile network.

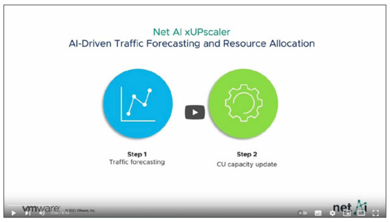
HCL's iDES rApp uses artificial intelligence and machine learning (AI/ML) to predict future traffic load and expected user quality-of-experience. iDES then determines which cells to turn off in order to save energy while meeting key quality indicators (KQIs). An example of such a KQI is the maximum percentage of UEs below an SLA at any given time. It can safely turn off cells to reduce power consumption without compromising on QoE. It can turns cells back on when the quality of experience is expected to degrade.

Field deployments of iDES show that by extending cell off-time (or sleep time) of under-utilized cells, an additional 7% reduction in energy savings can be achieved compared to traditional techniques.

## Role of the HCL iDES rApp on VMware RIC

- The HCLSoftware iDES rApp runs on VMware Centralized RIC and uses resources and services provided by the RIC's R1 interface, including network and UE data.
- The iDES rApp includes several decision-making modules that process input data to make network configuration decisions. iDES works with supporting rApps that use AI/ML to forecast changes in network load and the quality of user experience.
- iDES lets you set a target value for a key quality indicator (KQI) to determine the service quality that the network must delivery. For example, if you set a KQI mandating that up to 20 percent of users might experience throughput below 8Mbps, iDES will turn cells off only when the KQI can be guaranteed and turn cells back on when the algorithms predict the KQI would be breached. Cell on-off decisions are sent to VMWare RIC over R1, which then sends them to the network, and then an iDES rApp module validates that changes deliver the intended result.

VIDEO DEMONSTRATION OF THE USE CASE ON VMWARE RIC




*Forecasting RAN Traffic and Autoscaling Resources with a Net AI xApp on VMware RIC*

BENEFITS OF USING THE NET AI xAPP

- Use near real-time RAN-resource auto-scaling to optimize QoS performance.
- Tap artificial intelligence to improve accuracy in traffic forecasts.
- Enhance quality of service for customers.
- Reduce energy costs and OpEx.

# Autoscaling Resources with the Net AI xUPscaler xApp

Investment in network infrastructure is typically driven by traffic estimates obtained with the aid of deep packet-inspection tools. Provisioning of RAN Centralized Unit (CU) user plane capacity, for example, is largely performed to meet peak traffic demand and does not change in real-time to meet actual demand. Network resources are typically managed reactively, based on offline information that is usually too dated for effective decision making. Such an approach results in poor CapEx efficiency, modest user quality of experience, and high energy and engineering costs.

Real-time predictive information about service-level network usage is critical to the effective management and monetization of 5G networks.

Net AI's xUPscaler xApp, which runs on VMware Distributed RIC, helps tackle the challenges of meeting increasing traffic demands in a cost-effective and energy-efficient way. The xApp embeds Net AI's artificial intelligence models and uses historic and real-time network traffic data to forecast traffic volumes at the level of base stations (or at higher geographic granularity) to furnish actionable analytics to the near-RT RIC through an O-RAN-compliant interface. The xApp sends comprehensive KPIs to a web service, which displays these values on a dashboard.

## The Role of the Net AI xApp on VMware RIC

- Net AI's xApp disentangles metadata that summarizes traffic consumption measured by the volume of uplink and downlink data into the demands of the individual services that make up these aggregates. It predicts future traffic consumption over configurable time horizons.
- Net AI's forecasting engine uses spatiotemporal correlations characteristic of mobile traffic along with AI-driven autoscaling logic to produce relative capacity values for gNB Centralized Unit User Plane (gNB-CU-UP) entities, which are used to load-balance traffic between gNB-CU-UPs.
- Forecasts are generated using traffic volume data from each antenna in the RAN relayed to the xApp by an E2 interface subscription to VMware Distributed RIC. The forecasts are saved to the VMware RIC shared data layer to avail them to other xApps registered with the RIC.

BENEFITS OF USING P.I. WORKS PCI OPTIMIZER rAPP

- Eliminate PCI conflicts, difficulties in attaching to a network, and other issues that result in dropped calls or poor subscriber experiences.
- Protect against the introduction of new errors during 5G network rollouts.
- View reports on PCI conflicts and confusions.

# Detecting Physical Cell ID Collision and Confusion

The physical cell identifier, or PCI, is a key identifier used in 5G networks to allow mobile devices to separate information from different cells. There are 1,008 PCI values permitted in the 5G standards, which is far less than the number of possible cells in a commercial network. As a result, PCI values must be reused across the network, which creates the potential for conflicts: If neighboring cells share the same PCI and frequency, a mobile device cannot distinguish between the cells and this conflict can affect service quality.

There are two distinct types of conflicts: PCI confusions occur when a 5G cell has two different neighbor cells with equal PCIs in the same frequency band. PCI collisions happen when a 5G cell has a neighbor cell with an identical PCI in the same frequency band. These conflicts can lead to dropped calls and difficulties in obtaining service.

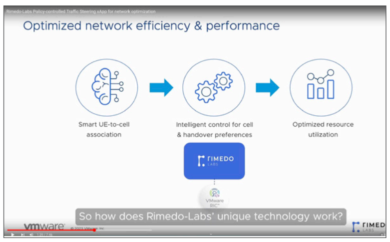
Operators use PCI planning tools to avoid conflicts; however, the dynamic nature of 5G networks, with changing cell ranges and the need for denser networks to improve coverage, conflicts still occur.

P.I. Works PCI Optimizer rApp resolves existing PCI code conflicts in a 5G network and uses intelligent algorithms to proactively detect and resolve potential future clashes.

## Role of PCI Optimizer rApp on VMware RIC

- The PCI Optimizer rApp from P.I. Works works with VMware Centralized RIC through the standard R1 interface, and it uses the services supplied by the RIC to obtain network data and to update configurations.
- The rApp provides reports on PCI conflicts and confusions it finds, and then it can be used to generate a revised PCI plan to eliminate the conflicts.
- The current PCI plan is obtained by fetching connection management data, and the service quality provided by the RAN is obtained by retrieving performance measurement data from the RIC. When the rApp discovers PCI conflicts between cells, it updates the RAN with new PCI values that eliminate the conflicts by using write commands supported by the connection management service of VMware RIC.

VIDEO DEMONSTRATION OF THE USE CASE ON VMWARE RIC




*Steering traffic with the Rimedo Labs xApp for network optimization*

# Rimedo Labs xApp Steers Traffic to Optimize Utilization

Current Traffic steering mechanisms primarily use radio conditions of the cell to determine where to steer traffic and they offer very reduced steering options, mostly limited to cell reselection, modification of handover parameters, and cell priorities. Communication services providers, or CSPs, adopting these traffic steering methods discover their network to be either underutilized in some areas or severely overloaded in others.

Rimedo Labs policy-controlled xApp, powered by VMware Distributed RIC, helps CSPs by providing service-based and load-balancing-focused traffic steering. Using internal intelligence and following the policies specified via the A1 interface, the Rimedo Labs xApp can simultaneously distribute the load between network nodes and offload specific traffic to dedicated cells (e.g., some cells may have caching enabled for video services, or lower latency or larger buffers).

## Role of the Rimedo Labs xApp on VMware RIC

- The combination of VMware Distributed RIC and the Rimedo Labs xApp lets operators specify different objectives for traffic management by optimizing the network and UE performance to achieve a more balanced cell load.
- Operators can flexibly configure desired optimization policies, utilize the right performance criteria, and use machine learning to enable intelligent and proactive traffic steering.
- The xApp receives cell load and RRC A3 events information through the E2 layer of VMare Distributed RIC and determines the 5QI, cell capabilities, and RSRP offset values. Then, if requested, it applies the steering control policies communicated through the A1 interface. As a result, a UE-to-cell association decision is made based on UE metrics, cell capabilities, and current cell load. This association is then communicated to the E2 node through E2SM-RC commands.

With Rimedo Labs' policy-controlled xApp and VMware Distributed RIC, you can optimize resource utilization to build more balanced, resilient, and energy-efficient networks while delivering high-quality customer experiences.

BENEFITS OF THE POLICY-CONTROLLED xAPP FROM RIMEDO LABS ON VMWARE RIC

**The policy-controlled xApp from Rimedo Labs won the *rAppathon* at MWC 2023.**

Here are some of the benefits when the xApp works with VMware Distributed RIC:

- Optimize network efficiency and performance.
- Avoid congestion at cell sites.
- Distribute load and demand evenly across the RAN.
- Gain greater energy efficiency.

BENEFITS OF USING THE RIC FOR QoS OPTIMIZATION

- Tap the flexibility and modularity of the O-RAN model for rApps to improve subscriber quality of service (QoS).
- Optimize subscriber QoS by running VMware's rApps.

# Subscriber QoS Optimization

VMware's subscriber quality-of-service optimization rApps tap subscriber-level trace information to detect subscriber-level anomalies, analyze root causes of the anomalies, predict the subscriber-level impact, identify the signal interference, and optimize the use of underpinning virtualized RAN functions with closed-loop load-balancing.

## Role of VMware's rApps in the Non-RT RIC

The following capabilities of VMware's AI-powered subscriber QoS optimization rApps enable you to automate RAN operations:

- Anomaly detection monitors subscriber-level trace information for every subscriber and uses AI to detect subscribers with anomalous QoS.
- Generate alerts for subscribers with anomalous QoS.
- Root cause analysis automatically finds the root cause in near real time by using AI models.
- Impact prediction hones in on the subscriber-level impact by analyzing the relationship between RAN configuration parameters and subscriber QoS in diverse deployment scenarios.
- Uplink interference localization uses AI models to identify the external interferer and displays the likely location of the issues to eliminate manual, cumbersome, and error-prone processes.
- Closed-loop load balancing uses AI models and automation to determine how the load-balancing thresholds should be changed to resolve the load imbalance and improve the subscriber's experience.

These rApps, developed by VMware, improve subscriber quality of service.

# Traffic Steering

BENEFITS OF USING THE RIC FOR TRAFFIC STEERING

Optimal traffic steering has been a challenge in wireless networks for many years, and RIC applications can help solve this lingering problem by using machine learning to strategically adapt and apply policies based on user and network data.

- Proactively optimize traffic steering by predicting network conditions.
- Specify different objectives for traffic management that vary by scenario.
- Gain flexibility to configure optimization policies tailored for your network.
- Improve network performance for target users or applications.
- Correct performance deterioration in near real time.
- Manage network bandwidth and costs through prioritization policies.
- Dynamically adjust network steering apps to changes in the network's state.
- Tap the modularity and flexibility of O-RAN xApps to improve performance on the fly.

Traffic steering lets you manage traffic according to such objectives as network performance and cell load balancing to help improve access, quality of service, throughput, and performance.

Traffic steering can, for example, radically improve access to and performance of critical low-latency applications running in the RAN.

Rapid mobile traffic growth combined with multiple mobile frequencies make balancing traffic difficult, and RAN traffic often needs to be distributed across multiple access technologies and applications with differing requirements.

In such a context, it is difficult to balance loads among cells, cell groups, and bearers while achieving the low-latency and quality of service requirements required by 5G radio access networks. As a result, spectrum can go underutilized and handover failures rise.

Traffic steering helps solve these problems by routing, balancing, switching, and splitting traffic across diverse, multi-access radio networks.

The RIC plays a key role in implementing traffic steering because it gives you the modularity and flexibility to proactively optimize access with policies, performance criteria, and machine-learning driven predictive management.

## Role of an rApp in the Non-Real Time RIC

- Retrieves configurations and performance data to set policies that manage traffic in the near-RT RIC.
- Build machine learning models based on network and user data to set and modify traffic steering policies.
- Send policies to the near-RT RIC for execution.

## Role of an xApp in the Near-RT RIC

- Implement and enforce the traffic management policies that are received from the Non-RT RIC.

# QoE Optimization

**BENEFITS OF USING THE RIC FOR QoE OPTIMIZATION**

- Optimize QoE by running xApps and rApps on VMware RIC.
- Tap the flexibility and modularity of the O-RAN model for xApps and rApps to tailor QoE optimizations to your network and users.
- Boost efficiency of resource usage in the RAN.
- Improve virtual-reality experiences.
- Enhance connectivity fairness and guarantee quality of experience without sacrificing resource utilization.
- Accelerate the development of QoE applications through VMware RIC SDKs with readily available tools and features.

Cloud-based virtual reality and other highly interactive applications demand high 5G bandwidth and low latency. If RIC applications can use machine learning and AI to fulfill quality-of-experience requirements more effectively than existing QoE applications, especially in the face of fluctuations in transmission capabilities of diverse radio access networks, they can boost the efficiency of resource usage in the RAN and, ultimately, improve virtual-reality user experiences.

By processing such multidimensional data as user and network traffic, a RIC application could train a machine learning model to predict and optimize QoE in near real time.

The rApp in the non-real-time RIC could train the machine learning model and send the policies to an xApp running on the near-real-time RIC. The xApp would then apply and manage the QoE optimization policies.

## Role of an rApp in the Non-RT RIC

- Cull QoE metrics from network measurements to construct and train predictive models that produce policies for optimizing QoE.
- Forward policies to the Near-RT RIC for implementation.

## Role of an xApp in the Near-RT RIC

- Execute the predictive models from the non-RT RIC to classify applications, predict bandwidth requirements at different times and places, and optimize QoE in near real time.
- Collect and send QoE performance data back to the Non-RT RIC to refine the QoE predictive models.

BENEFITS OF USING THE RIC FOR NETWORK SLICING

- Perform policy-driven closed-loop control of RAN slices.
- Monitor network slices in near real time.
- Track slice performance in relation to SLAs.
- Modify and update slice configurations on the fly to meet SLAs.
- Detect unused slice capacity and modify configurations to maximize resource utilization.
- Rectify traffic pattern imbalances across network slices.
- Meet SLA objectives for network slices.

# Network Slicing

5G Network Slicing enables you to create on-demand, isolated, end-to-end logical networks running on shared, common infrastructure. These programmable overlay networks, which are typically associated with business purposes, follow a set of predefined service-level agreements (SLAs) with quality-of-service (QoS) indicators and security requirements for isolation.

VMware's 5G Network Slicing module offers service providers a quick and easy way to create and manage end-to-end network across the network from the core to the RAN. A network slice can span the network across the RAN, transport, and core domains, and that produces a requirement for visualization, monitoring, and assurance of services across network slices.

The root-cause analysis engine of VMware Telco Cloud Operations can help you visualize, monitor, and assure services across network slices. It can also isolate network degradations and proactively pinpoint root causes to resolve issues quickly.

In the context of the RIC, network slicing can take the form of RAN slicing in the O-RAN architecture, and an xApp could, for example, run on VMware RIC to perform and manage RAN slicing in a O-RAN ecosystem.

## Role of an rApp in the Non-RT RIC

- A network slicing rApp could help manage network slicing operations in the RAN.
- The rApp could collect slice performance metrics and work work with an xApp to optimize slicing operations to meet SLAs.
- The rApp could monitor operations to help ensure that SLAs are met.
- The rApp could update slice configurations and pass them to an xApp to apply the changes to the O-RAN centralized units (CUs) and distributed units (DUs).

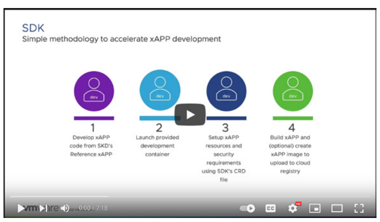
## Role of an xApp in the Near-RT RIC

- The xApp could handle policy-driven closed-loop control of RAN slices by reading the current state of RAN elements and their performance.
- The xApp could be built to control and manage slices by using a custom slicing service model, which could expose RAN controls to the xApp.

### VMWARE RIC SDKs

VMware RIC includes software development kits with resources, tools, and services that speed up xApp and rApp development, improve application portability, and bolster security.

The SDKs for VMware Distributed RIC and VMware Centralized RIC contain a set of libraries and data structure definitions that abstract user applications from the complexities of networking and communicating with VMware RIC, the E2 nodes, and with other apps.




DEMO VIDEO

*Accelerating app development by using the VMware RIC SDK*

# SLA Assurance for RAN Slices

RAN network slices carry performance requirements for throughput, latency, reliability, and energy efficiency. These requirements lead to a service-level agreement for each RAN slice. This RIC use case addresses slice assurance mechanisms for a RAN by dynamically controlling slice configurations in accordance with the performance information and requirements for each slice.

The open interfaces and AI/ML-based architecture of the O-RAN Alliance enable the RIC to help set up SLA assurance for RAN slices.

## Role of an rApp in the Non-RT RIC

- Pull a RAN slice SLA from a source.
- Monitor RAN slice performance.
- Train and refine ML models for RAN slice assurance.
- Deploy slow-loop optimization for a RAN slice.
- Deploy AI/ML models to the near-RT RIC.
- Create policies for assurance.
- Send policies and related information to the near-RT RIC.
- Receive slice SLA assurance xApps from the service management and orchestration (SMO) component.

## Role of an xApp in the Near-RT RIC

- Deploy fast-loop optimization for a RAN slice.
- Monitor slice-specific RAN performance metrics.
- Execute AI/ML models from the non-RT RIC.
- Deploy SLA assurance policies from the non-RT RIC.
- Implement RAN optimization settings to meet RAN slice requirements.
- Receive slice SLA assurance xApps from the SMO.

BENEFITS OF USING THE RIC FOR SIGNALING STORM PROTECTION

- Boost security at the edge to protect the RAN.
- Monitor the network for signaling storms.
- Apply policies in near real-time to mitigate arrant registrations.

# Signaling Storm Protection

If hackers can exploit vulnerabilities in devices, they can trigger a signalling storm that radically escalates the number of repeated device registrations, which have the potential to cause large network outages. Near-RT RIC xApps and non-RT RIC rApps can apply security controls at the edge to help protect the RAN from such attacks.

The VMware RIC software development kits (SDKs) speed up the development and deployment of xApps and rApps, including those that can improve security for open radio access networks.

## Role of an rApp in the Non-RT RIC

- Watches for signaling storms across the network.
- Creates localized attack detection policies for distribution to near-RT RIC in various geographical areas.
- Uses AI/ML models in a signaling storm detection rApp to detect anomalies in the behavior of network-level signals.

## Role of an xApp in the Near-RT RIC

- Monitors the E2 interface for connection establishment messages and identifies abnormal levels of signaling activity using a Signaling Storm Detection xApp.
- A Signaling Storm Mitigation xApp uses policies to mitigate misbehaving or arrant device registrations.
- A Signaling Storm Detection xApp uses AI/ML models monitor cell-level signaling behavior and detect signaling anomalies.
- Applies appropriate detection policy based on policies received from non-RT RIC (for example, false-positive levels, UE thresholds, and throttling ratios).

BENEFITS OF USING THE RIC FOR ENERGY EFFICIENCY

- Reduce carbon emissions.
- Improve energy efficiency.
- Integrate energy and carbon metrics with your workload management system.
- Adjust workloads to minimize emissions through carbon-aware visualization.
- Use machine learning to control when and where workloads are running to maximize the use of renewable energy.
- Track and review energy consumption of RAN components.
- Improve sustainability of your RAN operations.

# Energy Efficiency

Telecommunications and IT together, known as ICT, consume 5-9% percent of the world's electricity supply, and the rapid growth in digitization could increase the information and communications technology industry's power consumption to 20 percent by 2030. This projected increase is driven not by losses in efficiency but by the ever-increasing demand for transmitting and consuming data at maximum speed.

With more telecom network functionality being moved to data centers or the edge, including virtualized RAN sites, the share of network energy consumption is projected to grow nearly five-fold. If the ICT industry can work smarter and manage workloads better, some sources estimate that the ICT industry can prevent emissions at a rate of 10 times its own footprint by 2030. In addition to using massive MIMO, which highly energy efficient, the following strategies could improve RAN energy efficiency:

- Making energy consumption visible and making workloads carbon-aware.
- Using renewable-energy-powered data centers.
- Placing and scheduling workloads with the explicit, measurable intention of minimizing energy consumption and reducing emissions.

If you could manage when and where workloads are running, you could take advantage of renewable energy. A prerequisite to doing so is integrating energy and carbon metrics with your workload management system. The development of carbon-aware software could integrate electricity carbon intensity as an optimization factor into workload management. Intelligent workload placement and optimization could improve the sustainability of 5G, and the RIC could help.

## Role of an rApp in the Non-RT RIC

- Review energy consumption of RAN components when they are not in use.
- Use machine learning models and intelligent workload placement to place workloads so they minimize the consumption of non-renewable energy.

## Role of an xApp in the Near-RT RIC

- Collect data on the carbon intensity of RAN workloads as they run and send it to the non-RT RIC for use in machine learning models that seek to minimize emissions.

BENEFITS OF USING THE RIC TO DEPLOY MASSIVE MIMO OPTIMIZATION

- Spectral Efficiency: Massive MIMO can furnish higher spectral efficiency than previous methods by enabling its antenna array to focus narrow beams toward a user.
- Energy Efficiency: When an antenna array is focused in a small, targeted section, it requires less radiated power and reduces the energy requirement.
- High Data Rate: Array gain and spatial multiplexing increase the data rate and capacity.
- User Tracking: Since massive MIMO uses narrow signal beams, user tracking becomes more reliable and accurate.
- Low Power Consumption: Lower power linear amplifiers eliminate bulky equipment and reduce power consumption.
- Less Fading
- Low Latency
- Reliability: The large number of antennas in massive MIMO provides more diversity gain, which increases link reliability.
- Enhanced Security: Physical security improves with the orthogonal mobile station channels and narrow beams.

# Massive MIMO Optimization

Massive Multiple-Input Multiple-Output (massive MIMO) groups together antennas at both the transmitter and the receiver to furnish high spectral efficiency and energy efficiency for 5G performance. Massive MIMO system configuration can let you, as an operator, optimize network performance and quality of service (QoS) by, for example, Non-RT and Near-RT loop balancing cell loads or reducing inter-cell interference and controlling electromagnetic emissions.

Massive MIMO Beamforming Optimization is one of two massive MIMO use cases cited by the O-RAN Alliance's use cases specification; the other is Massive SU/MU-MIMO Grouping Optimization.

As an example, beamforming can deliver more throughput for a user by improving signal power while decreasing interference. Finding a site's optimal confiruation among all the possible system parameters, however, requires help from machine learning techniques, and that is where the RIC enters the equation.

## Role of an rApp in the Non-Real Time RIC

- Pull configurations, key performance indicators, user activity data, and user location data like GPS coordinates and route them to an ML model.
- Use the ML model to predict user and traffic distribution patterns of cells and derive the optimal configuration of the massive MIMO parameters for each cell or beam.
- Send such things as the optimal beam pattern to SMO configuration components.
- Improve or retrain the ML model by continuing to collect data and using it to refine beam patterns for optimal performance over time.

## Role of an xApp in the Near-Real Time RIC

- Deploy and execute the ML model from the Non-RT RIC.
- Implement and enforce policies from the Non-RT RIC.
- Use the ML model to predict user and traffic distribution patterns of cells and derive the optimal configuration of the massive MIMO parameters for each cell or beam; send the optimal beam configuration policies to E2 nodes.

AT A GLANCE

VMware Telco Cloud Platform RAN™ is powered by field-proven virtualized compute coupled with VMware Telco Cloud Automation™ and VMware Tanzu™ for Telco RAN, a telco-grade Kubernetes distribution.

KEY BENEFITS AND CAPABILITIES

- Run virtualized baseband functions, virtualized distributed units (vDUs), and virtualized central units (vCUs) in accordance with stringent RAN performance and latency requirements
- Optimize the placement of DUs and CUs through programmable resource provisioning
- Use the same common platform to virtualize the RAN and migrate to O-RAN
- Deploy and operate both RAN and non-RAN workloads on a horizontal platform
- Use a security-hardened Linux host called Photon OS that is optimized for running containers on VMware vSphere®
- Isolate containerized network functions (CNFs) on virtual machines and the VMware hypervisor, VMware ESXi™, to establish a strong security boundary
- Automate lifecycle management of infrastructure, Kubernetes clusters, vRAN functions, and 5G services

# Telco Cloud Platform RAN

VMware Telco Cloud Platform RAN is powered by field-proven virtualized compute solution coupled with Tanzu for Telco RAN, a telco-grade Kubernetes distribution, and VMware Telco Cloud Automation. The platform paves a clear RAN modernization path: CSPs can move from their traditional RAN to vRAN now and start to move in the direction of O-RAN.

The RIC helps transform the RAN into a 5G multi-services hub that enables you to develop and deploy custom 5G applications alongside vRAN functions while delivering superior quality 5G services and customer experiences. As a result, you can monetize the RAN.

VMware Telco Cloud Platform RAN helps you virtualize RAN functions on a horizontal platform optimized for the RAN using the Intel FlexRAN software reference design. The same platform becomes the foundation for moving to O-RAN by giving you the flexibility to evolve toward the future without disrupting your operations or overhauling your network design. Furthermore, VMware Telco Cloud Platform RAN simplifies operations with consistency across distributed RAN sites, regardless of the vRAN functions each site hosts. Centralized automation simplifies operations and reduces OpEx.

VMware RIC can run on VMware Telco Cloud Platform RAN or on another platform.

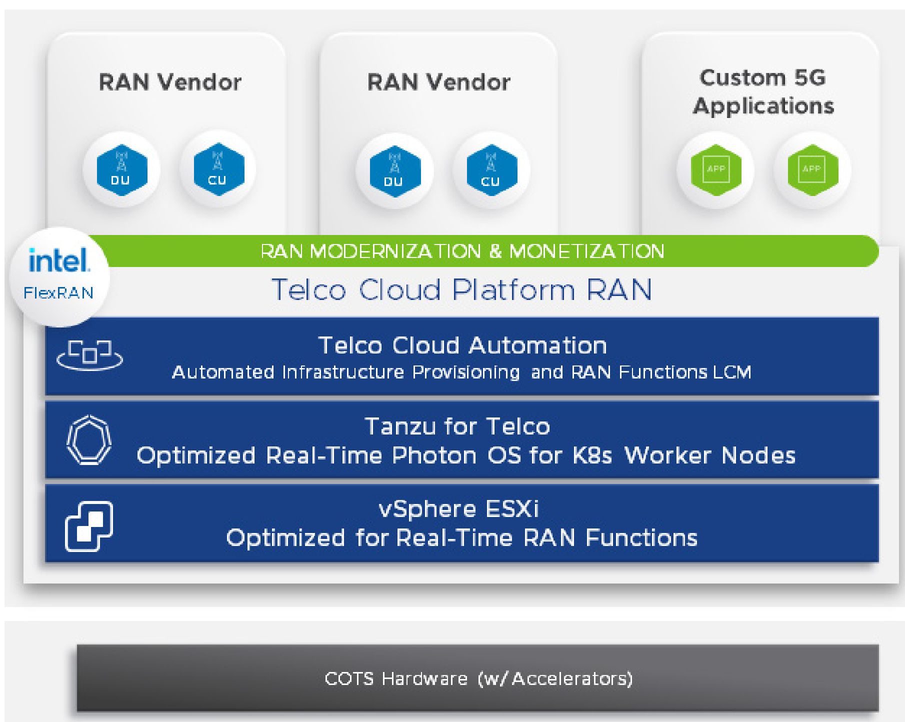



FIGURE 4: The architecture of VMware Telco Cloud Platform RAN enables you to fulfill various 5G use cases with ease and consistency.

RAN PROGRAMMABILITY

The RIC disaggregates the RAN control, management, and data planes to enable applications from different vendors to access control and management plane functions. The result radically improves RAN programmability.

*Demo Video: Activating Network Programmability with VMware RIC*

LEARN MORE

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

# VMware RIC

VMware RIC is a multi-RAN, multi-cloud platform that abstracts the underlying RAN infrastructure to host the xApps and rApps that drive the O-RAN RIC use cases highlighted in this paper. These apps spark innovation by introducing automation, optimization, and service customization.

VMware RIC modernizes the RAN to be programmable so you can build an open RAN with solutions from a vibrant ecosystem of partners. Here are some key capabilities and benefits of VMware RIC and its SDKs:

- Flexibility – VMware RIC can run on VMware Telco Cloud Platform RAN or on other vendors' RAN platforms, including traditional and virtualized RAN environments from third parties, so you can build a future-proof RAN with multi-vendor solutions while protecting your investments.
- Simplicity – Centralized RAN intelligence helps simplify RAN operations and optimizes network utilization.
- Programmability – Reduces operational complexity by running RAN control and management functions with open standards.
- Monetization – The VMware RIC SDKs empower developers and vendors to create innovative services that maximize business growth.
- Ecosystem – The ecosystem partners of VMware spark innovation.

By working with both traditional RAN and virtualized RAN environments, VMware Centralized RIC empowers you to run rApps and xApps without making significant changes to your existing RAN architecture — you can take the first step toward a disaggregated RAN now and set the stage for a smooth transition to open RAN.

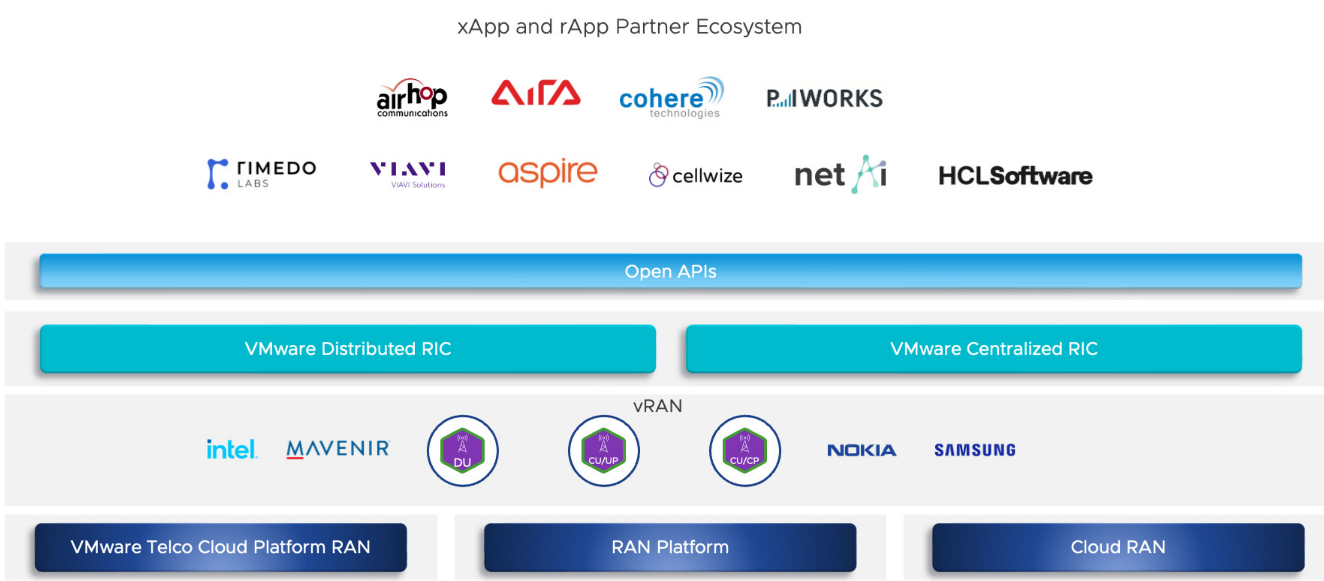



FIGURE 5: Solutions from a vibrant ecosystem of partners put open RAN use cases into action so you can optimize and monetize 5G.

# Propelling 5G Forward

"DISH is building a first-of-its-kind network that will move the entire industry forward. We're excited to be a part of the journey as we continue to work with DISH and its ecosystem partners to launch the first Open RAN-based 5G network in the United States."

SANJAY UPPAL, SENIOR VICE PRESIDENT
AND GENERAL MANAGER,
SERVICE PROVIDER AND EDGE, VMWARE

# Modernize the RAN to Monetize 5G

The use cases covered in this paper demonstrate the potential value that RAN intelligent controllers can drive. By identifying target RIC use cases early, you can work with application developers and independent software vendors to devise a strategy for capitalizing on emerging opportunities.

VMware Telco Cloud Platform RAN modernizes your radio access networks so that you can rapidly develop and deploy innovative 5G services at scale. The use cases, xApps, rApps, and solutions in this paper can be deployed on VMware RIC.

THE VMWARE TELCO CLOUD FOR 5G

VMware helps communications service providers build, operate, protect, and monetize their telco cloud. Our technology empowers you to transform your networks into a 5G force, accelerate the delivery of innovative services, and compete in a multi-cloud world. The VMware telco cloud creates a consistent foundation for operating all generations of cellular and fixed-line technology while leading the way to 5G. Solutions for infrastructure, orchestration, automation, assurance, optimization, and security modernize your network from the core to the RAN.

TELCO CLOUD PORTFOLIO

- VMware Telco Cloud Platform
- VMware Telco Cloud Automation
- VMware Telco Cloud Service Assurance
- VMware Telco Cloud Platform Public Cloud
- VMware Telco Cloud Platform RAN
- VMware RIC

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