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The Essential Role of OSS in Open vRAN

A Heavy Reading white paper produced for Netcracker

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INTRODUCTION

The radio access network (RAN) is increasingly complex. The evolution of mobile technology from one generation to the next has resulted in a host of advances, including greater spectrum efficiency, better power utilization, higher speeds, and wider coverage. However, as operators have moved through the generations, from the 1G of 30 years ago to the 5G of today, they have carried with them vestiges of each previous technology.

Today, as the industry implements both 4G and 5G solutions, mobile operators are embracing four parallel trends in the RAN and preparing for a fifth:

- **The separation of RAN functions,** with some functions residing at the cell tower and some functions consolidated into upstream data centers for better resource utilization and software control.
- **The adoption of open, industry standards-based networking** to enable vendor interoperability, avoid vendor lock-in, and simplify overall network management.
- **The virtualization of network functions**, such as the RAN, to improve and simplify the speed and agility of deployment.
- **The migration to 5G:** With the deployment of 5G technology, the base transceiver station (BTS) of 2G, the NodeB in 3G, and the eNB in 4G, evolve into the gNB of 5G.
- **The move to cloud native** with the adoption of agile continuous integration (CI)/continuous delivery (CD) development processes, and the breakdown of individual virtual network functions (VNFs) into multiple microservices deployed in containers, resulting in a highly flexible and horizontally scalable network.

These trends come together in Open vRAN, which combines full distributed unit (DU) and centralized unit (CU) RAN virtualization with an open fronthaul interface to allow the mixing of radio and baseband vendors.

Several factors drive interest in Open vRAN, including lowering capex, increased vendor choice, and removal of vendor lock-in. Today, Open vRAN is a small, but growing, part of the overall RAN market, and most deployments are at the trial and proof-of-concept stage. Several challenges, including enhancing the flexibility and expanding the scope of existing operations support systems (OSSs), must be addressed for Open vRAN to claim a large proportion of total operator RAN spending.

All of these trends represent the breaking down of barriers: the physical barriers of application-specific hardware appliances, the functional barriers of combined user and data plane solutions, the logical barriers of individual network functions, and the proprietary barriers of vendor-specific solutions. The fall of these barriers presents a vast, complex, and intimidating network landscape with the OSS designed for discrete corrals of network and vendor solutions. This report takes a closer look at what has changed, what is about to change further, and how OSS solutions must adapt in order to manage the new network resulting from Open vRAN.

DEFINITIONS AND DISAMBIGUATIONS

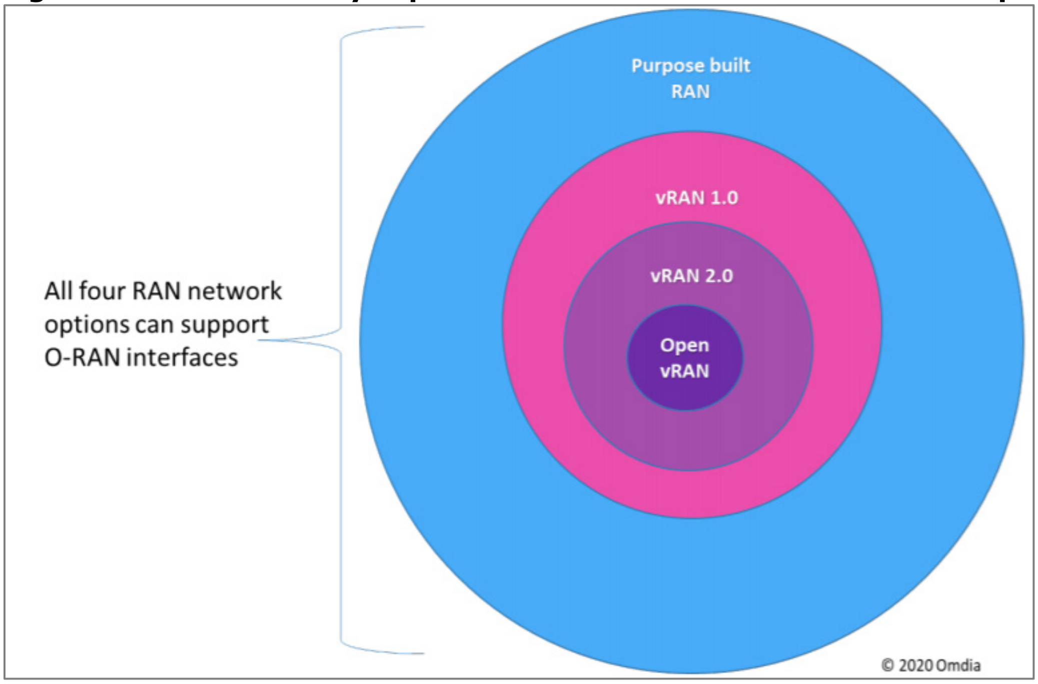
Open vRAN is part of an accelerating trend, driven by the operators and changing market dynamics, to expand options beyond purpose-built RAN solutions. With this trend, new terms have developed to describe those options, such as O-RAN, virtual RAN, cloud RAN, and Open RAN. This has led to some confusion, as each of these terms has its own definition, market, and position in the RAN evolution timeline. They are, however, all part of the continuum that ultimately combines the virtualization of the RAN with the adoption of open, industry-standard RAN interfaces.

- **Purpose-built RAN:** These solutions are how most mobile access networks have been built since the first generation of mobile technology emerged in the 1980s. A single vendor provides the radio, baseband unit (BBU), and software, and the RAN interfaces are specific to the vendor and not easily made interoperable. The BBU software runs on vendor-supplied hardware built specifically for the RAN. A purpose-built RAN is a fully integrated single vendor solution.
- **Cloud RAN (C-RAN):** Jump forward about 30 years. The virtualization of the RAN started with the C-RAN initiative from IBM, Intel, and China Mobile, in which the BBU was separated from the remote radio head (RRH) unit. The solution was not open and it initially relied on dedicated high bandwidth fiber connectivity. C-RAN was, however, the first step toward disaggregation of the RAN, and was the precursor to vRAN.
- **O-RAN Alliance:** In February 2018, the C-RAN Alliance combined with the xRAN Forum (formed in 2016 by AT&T, Deutsche Telekom, SK Telecom and Sachin Katti, a Stanford University professor) to form the O-RAN Alliance. O-RAN creates specifications for open fronthaul interfaces, along with seven other RAN interfaces and two radio intelligent controllers (RICs). O-RAN, with a hyphen, always refers to the O-RAN Alliance. O-RAN interfaces can be applied to both purpose-built and vRAN networks. The mobile network does not need to support all O-RAN interfaces; an operator can deploy a fully virtualized RAN that supports some O-RAN interfaces, but not the fronthaul interface. This also means a network can be open without being virtual and can be virtual without being open.
- **Virtualized RAN or vRAN:** The BBU software and hardware are separate in a vRAN, and the software can be run on commercial of-the-shelf (COTS) servers. The operator can even source the software separately from the servers. We currently have two different types of virtualization: vRAN 1.0 only virtualizes the CU, which resides at an upstream data center and controls higher layer functions of the RAN. In vRAN 2.0, the DU, residing closed to the cell tower, is also virtualized.
- **Open vRAN:** A more specific version of vRAN 2.0. Along with full baseband virtualization, the fronthaul interface between the radio and BBU is open, and an operator has the option to use different radio and BBU vendors.

This list of industry signposts on the road to Open vRAN is not exhaustive. (For example, Heavy Reading skips over the Telecom Infrastructure Project's (TIP) OpenRAN Group formed in November 2017). **However, only Open vRAN combines a fully virtualized RAN with an open fronthaul interface.** The advantages of Open vRAN to the mobile operators are abundant. Open vRAN combines the flexibility and agility of a software-based, virtualized architecture with the open, vendor-agnostic attributes of an open solution.

Figure 1 shows how the four different options defined here relate to each other in terms of level of virtualization, fronthaul openness, and market value. The timeframe for market value as represented in **Figure 1** is through the mid-2020s.

Figure 1: The RAN today: Open standards and virtualization are expanding



Source: Omdia

The next phase: Cloud-native Open vRAN

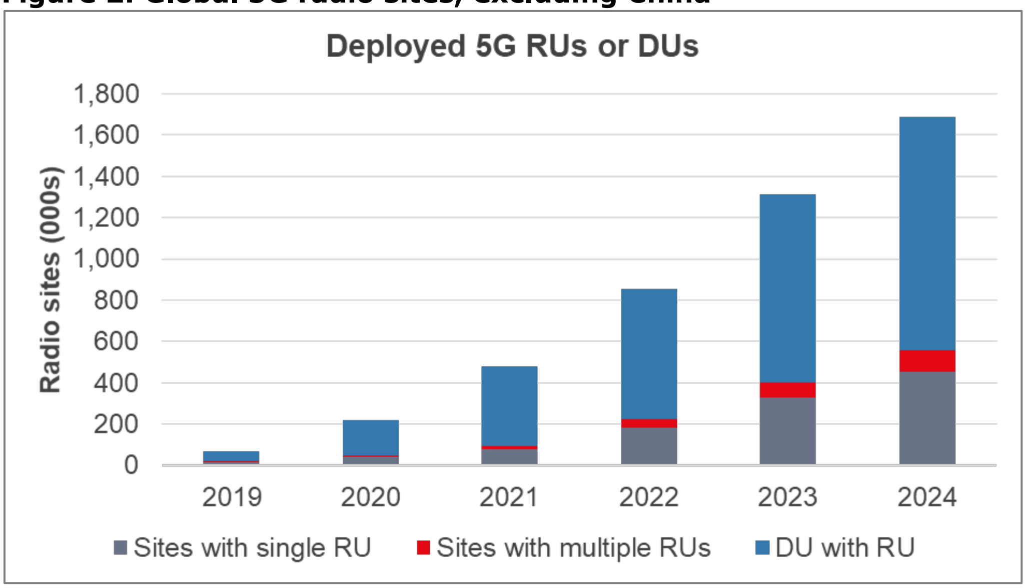
Early in the implementation of VNFs, carriers realized that they were often trading an appliance-based version of a product (e.g., a RAN) for a software-based version with the same features and functionality—and sometimes not even that. Virtualized versions of the network function often lacked the performance and vertical scalability of their hardware counterparts. These VNFs were not written for the cloud and did not take advantage of a DevOps style of development. VNF implementations also had, and still have, challenges with integration, particularly when building service chains of multiple VNFs from different vendors. Cloud native brings with it a move to containers, the implementation of Kubernetes to manage those containers, the ability to scale up and out quickly, faster and better innovation through CI/CD of software, and lower costs with applications realized in microservices. However, carriers have complained that early cloud-native network functions (CNFs) are too frequently VNFs dropped into a cloud-native container. Carriers are having to challenge their vendor partners to ensure that a move to CNFs resolves the challenges carriers have had with network functions virtualization (NFV) and VNFs, and does not perpetuate them.

OSS: THE CHALLENGES OF MANAGING THE EVOLVING OPEN VRAN

The adoption of Open vRAN brings with it several challenges from a management and OSS perspective. First and foremost is the need to manage physical network functions (PNFs), VNFs, and now CNFs simultaneously. There will be a mix of physical, virtual, and cloud functions in all parts of the network, depending on the functional split of the RAN (i.e., which RAN functions are centralized and which are distributed) and the management of these functions must be dynamic as a quick examination of key network growth factors reveals.

Second is the need to manage and orchestrate RAN resources across highly distributed edge compute platforms. With the disaggregation on the BBU into DUs and CUs, OSSs and orchestration systems need to decide which resources go where. And there will be more and more complex cell sites. The number of physical cell sites (i.e., not including multi-sectored antennas) will grow by an order of magnitude as a result of the rollout of 5G. The number of spectrum bands in use increases with 5G, along with the need to optimize those bands for best performance. Also, the introduction of dynamic spectrum sharing (DSS), which allows for multiple radio access technologies (RATs) to be used in a single spectrum band, adds more computation resources and complexity to the BBU. **Figure 2** shows Omdia's measurement and forecast of radio units and distributed sites globally, excluding China. China has been excluded because in-region service providers do not share transport infrastructure numbers. Additionally, informal estimates suggest China's numbers would more than double the market.

Figure 2: Global 5G radio sites, excluding China



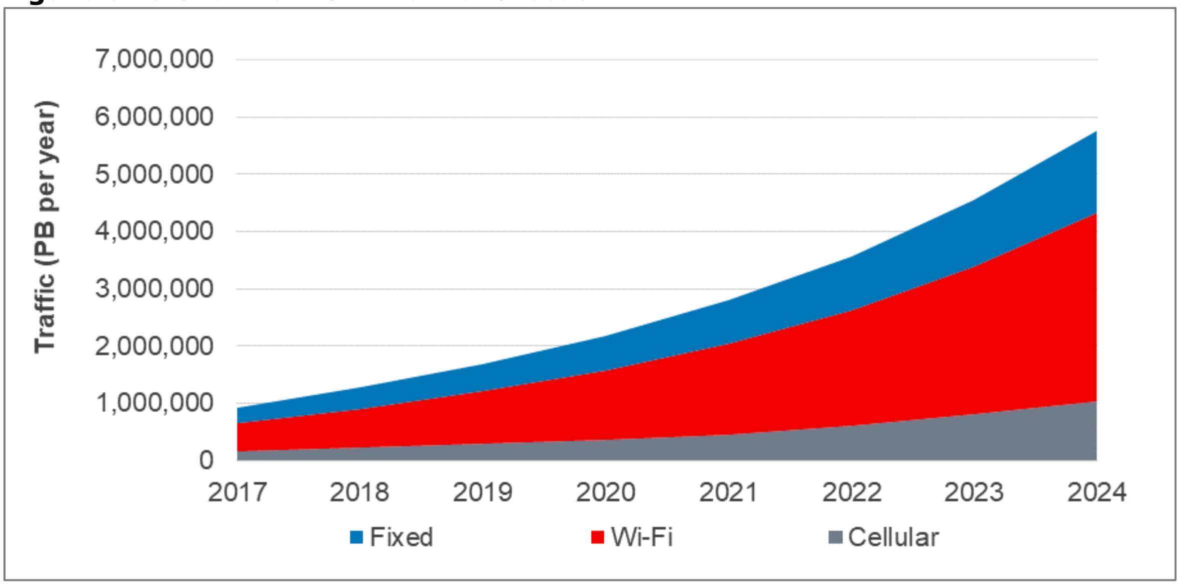
Source: Omdia

All this complexity will require a high level of operations automation and the need to visualize the entire RAN network.

There will also be considerable network stresses from traffic growth and the need for on-demand services:

- **Overall network traffic growth:** Omdia data shows network traffic continuing to double every three years (see **Figure 3**). Users are already generating more traffic from wireless devices than from wired devices. In terms of traffic, the vision of a wire-free world is becoming a reality. However, Omdia's estimates may be conservative. AT&T reports that since 2007, data traffic on its mobile network has grown by more than 470,000%. The largest driver of this growth was video traffic, which grew by more than 75% in 2019. Similarly, the GSMA postulates that network traffic will increase by 1,000% with 5G, and the accompanying infrastructure could require 2x to 3x as much energy.

Figure 3: Global network traffic forecast



Sources: Omdia, Heavy Reading

- **Video traffic dominance:** 80% of this traffic—both fixed and wireless—is video. Although this traffic is all video, it has widely varying traffic profiles, depending on the quality of the video and whether it is in real time or not. Social video makes up the majority of traffic, followed by ad-based video on-demand and then over-the-top (OTT) subscription-based video. Demand from end users for higher quality social video will ensure that the momentum of video traffic growth is maintained.
- **Internet of Things (IoT) penetration:** According to Omdia research, the number of IoT contracts awarded to carriers has grown from fewer than 10 worldwide in 2009 to 1,555 in 2020. Low bandwidth IoT apps with forgiving latency profiles are frequently carried on 2G or 3G technology, adding to the necessity to continue to support all previous generations of mobile technology at most cell locations.

Expanding the service provider role with 5G

In addition to these changes in network traffic and mobile infrastructure, there is a shift in how service providers see their role in a 5G network and a growing interest in how 5G can help the service providers address specific vertical markets and use cases. 5G is now generally considered to include edge computing, cloud native, container-based applications, and network slicing. While all of these ancillary technologies can be implemented in 4G, the growing consensus is that they are mandatory with 5G. Together, these technologies can revolutionize the network, but each one presents a complex challenge to the communications service providers (CSPs) from an OSS perspective. For example, let us take a closer look at network slicing.

A network slice is a logical end-to-end (E2E) network defined over virtualized resources on top of a common physical infrastructure. Network slicing supports multiple unique virtual networks on the same physical infrastructure. It allocates specific resources to an application, as follows:

- An IoT app
- A service (e.g., software-defined wide area networks [SD-WANs])
- A set of users (e.g., an enterprise)
- A network (e.g., an MVNO)

Resources can be dedicated to one network slice only or shared between many. The network slices can be deployed across any part of a service provider network (e.g., edge and core) and can span multiple carrier networks. Each network slice is designed according to the specific needs of the application or user, including speed, capacity, latency, security, and topology. The OSS models that evolved around the single vendor, physical, purpose-built RAN fall far short of the requirements of the physical+virtual+cloud, multi-vendor, multi-domain network that can support enhanced capabilities, such as network slicing in the evolved Open vRAN.

The same holds true for multi-access edge computing (MEC). CSPs are looking to support applications that demand a MEC solution due to a requirement for low latency, local compute requirements, data sovereignty regulations, network traffic load considerations, or a host of other reasons. Many CSPs view Open vRAN as the first step toward a full and robust MEC implementation. However, most vRAN edge nodes today are not capable of MEC in terms of ease of deployment, configuration, and management.

In the next sections, Heavy Reading discusses how OSS transformation must progress in order to support snowballing demands from the network and from CSPs introducing enhanced services and supporting new classes of applications.

TRANSFORMING OSS FOR OPEN VRAN AND AUTOMATED OPERATIONS

CSP deployment of Open vRAN solutions will challenge each stage of the network lifecycle from Prepare and Plan to Design, Implement, Operate, Optimize, and back to Prepare. The multi-vendor, virtualized function, distributed, and agile nature of Open vRAN requires changes and enhancements to the OSS and will impact each lifecycle stage. We will discuss how the OSS needs to evolve for each stage of the network lifecycle. First, however, there are three technologies that will underpin each step in the lifecycle and will be foundational to OSS transformation for Open vRAN: automation, active inventory, and cloud native.

Automation with artificial intelligence/machine learning

Leveraging artificial intelligence (AI) within the RAN domain provides benefits throughout the lifecycle, including:

- **Informed capex investment:** CSPs can roll out new sites and allocate radio and spectrum assets based on analytical insights.
- **Better experiences delivered to customers:** With the context-aware service experience use case, CSPs can optimize resources at the RAN based on specific service requirements.
- **Proactive operations:** Leveraging the predictive capabilities of AI, CSPs can become more proactive and responsive to network issues.
- **Reduced opex costs**: By using insights from AI to trigger automated workflows, CSPs can save opex costs incurred in the long term; for example, reducing costs in sending field engineers to radio sites to resolve issues on the network.

Standard analytics tools have been used to provide some of these capabilities in the RAN. However, as the scale complexity of the RAN network increases, more advanced capabilities are needed to meet the requirements of the CSPs and their customers; for example, take the analysis of key performance indicators (KPIs) from a group of 100 or more cells. What would take a network engineer a week to accomplish, can be accomplished by an AI solution in a matter of minutes.

In order to support the growth in traffic and cell sites from configuration to deployment to operation, operators must see a dramatic improvement in operational efficiencies. This means the majority of sites must be able to operate in a zero-touch, lights-out environment. To achieve this, carriers will rely increasingly on OSS, domain management, and orchestration solutions that leverage automation for each task in the network lifecycle.

Active inventory

The second foundational technology for the evolved OSS is the active inventory. An active inventory in the context of Open vRAN domain orchestration is a core intellectual asset. It is a real-time database of multi-vendor resources on the network, both virtual and physical, as well as services. It contains the definition of these resources, along with information about each resource. It can provide authentication and authorization functions for critical orchestration functions, such as configuration management, network slice management, and network assurance, to name only a few. The active inventory houses constantly updated, real-time information that, when leveraged by the capabilities of an evolved OSS, maximizes automation of the RAN and enables a new operational model.

Cloud native

Evolved OSS—everything from orchestration and inventory to configuration management and fault/performance management—must be cloud native. Just like VNFs to CNFs, an OSS can only be considered “evolved” if it is based on microservices, supports open APIs, and can be deployed on any container-based cloud platform. Service providers need the flexibility to run their evolved OSS functions in the public cloud, as well as their own telco clouds, to benefit from cloud agility, scale, and economics.

THE NEW ROLE OF OSS THROUGHOUT THE NETWORK LIFECYCLE

Carriers around the world know that their current method of designing and deploying and managing mobile networks will not hold up to near-term demands, let alone future demands. How will next-generation OSS support the different user requirements and traffic profiles without grossly overengineering the network, wasting infrastructure resources, and leaving customers vulnerable to security breaches? The scale and complexity of the network demands OSS transformation throughout the network lifecycle, as described below.

Network design and planning

The evolved OSS, with active inventory across the entire RAN, is able to identify exactly what is in your network, in real time. In the Open vRAN network, these assets can be physical or virtual, they can be from multiple vendors, and they can change quickly as virtual assets are deployed or torn down to accommodate real-time network load. Inventory is consolidated from existing OSSs and network systems and is used for e/gNodeB design, activation, and maintenance. Inventory systems should discover topology, network device configurations and services, and perform reconciliation. Without this ability, both short- and long-term network planning become unwieldy, operator-intensive, and not agile enough to keep pace with the expanding network. For long-term planning, the evolved OSS is able to leverage AI and machine learning (ML) to determine where cells should be located, the coverage and capacity that will be provided, the number of people covered within the area, and their current service consumption patterns. Building a view of the external environment and its impact on the radio environment will be required, in addition to information on the buying power of customers. These insights are relevant to assure ROI of network assets planned within an area. CSPs can use the advanced analytics capabilities of AI to create network plans that take into consideration all of these variables. Small cell planning is another use case in which ML will be useful in identifying precise locations for small cells.

Network deployment

Network deployment for the Open vRAN centers on evolved service and network orchestration. The scale and complexity of the Open vRAN network requires automation of the commissioning of eNB/gNB instances, as well as the optimal placement of VNFs and CNFs that are part of the vRAN service chain, including functions like security, for example.

Once vRAN resources have been instantiated, CSPs will need evolved configuration management for both physical and virtual assets to activate services. Modeling languages, such as YANG, will be important to automate configuration processes. Some greenfield network operators, such as Rakuten Mobile, boast a portfolio of only 10 different configurations for their networks. Telco operators normally maintain infrastructure with hundreds of different configurations. This has a significant impact on the carrier's ability to implement zero-touch deployments and lights-out management of their escalating number of vRAN locations.

In addition to managing configurations, the operator must also be able to manage the ongoing cycle of software updates in an automated way, particularly in the growing CI/CD DevOps culture of the CSPs as they move toward a cloud-native infrastructure.

Active inventory can be a significant asset in all of these tasks. It can be used to automatically detect new hardware, configure it automatically, and minimize human error. Following the planning of a new site, AI tools can be used to test network performance for different applications, such as virtual reality (VR) and online gaming measuring, for parameters like throughput and latency. The network can also be stress tested to make sure the design plans meet the specified service requirements before the site is deployed. Once deployed, with the use of a digital twin, AI can be used for the network verification process, saving the CSPs time and truck rolls.

Network optimization

Network optimization in the vRAN 5G network presents multiple new challenges for the CSP. The separation of the control plane and user plane, the numerous RAN functional splits between the DU and the CU, the potentially complex configuration of network slices are variables that did not exist before vRAN. Recognizing this, the O-RAN Alliance conceived of the RAN Intelligent Controller (RIC), which is a centralized controller, enabling the configuration, optimization, and control of RAN infrastructure at the edge before any aggregation points. The RIC assumes many of the optimization tasks previously handled by the BBU, such as mobility management, admission control, and interference management. Through the use of AI, the RIC is able to execute these tasks with greater speed and accuracy than the former BBUs, providing continuous network optimization and feeding into the OSS ML-based end-use quality of experience (QoE) optimization. The RIC can also be used to minimize drive tests. The BBU sends information to the RIC, which uses AI/ML to optimize QoE, further improving RAN performance.

Real-time network performance monitoring

Evolved network fault and performance management is a critical function of Open vRAN, spanning the entire domain from 5G new radio to NFV infrastructure (NFVI), VNF/CNFs, and vRAN software. It calls for real-time centralized monitoring and dynamic network assurance with automated root cause analysis using real-time network and service topology.

Through the use of AI, CSPs can implement predictive assurance by monitoring in near real time the performance of key KPIs either at the radio, cell, site, or RAN level. Based on this real-time network monitoring, CSPs can predict likely network outages or failures and implement automated remediation to correct them.

THE TRANSFORMED NETWORK CALLS FOR A TRANSFORMED OSS

Carriers started down the path toward software-defined, virtualized, and, ultimately, cloud-native networks more than 10 years ago. As carriers look to their 5G, as well as 4G rollouts, they are focusing on strategies to meet burgeoning demand, while removing cost and complexity. The move to an open and virtualized RAN infrastructure is key to this goal and the key to the Open vRAN is a transformed OSS.

- The mix of multi-generational RAN solutions, of physical and virtual solutions, of customized and open solutions, demands an OSS and orchestration solution that can operationally transform complexity into order, while improving performance.
- The continued staggering growth in the volume of traffic and the number of cell sites demands the use of automation. Incremental additions to the number of network operations personnel will not be able to handle the growth. A zero-touch, lights-out virtualized and disaggregated RAN environment is essential.
- End users are demanding better quality video and unlimited data. The current pandemic has underscored the fact that broadband access is an essential service. Each new generation of mobile technology delivers higher speed connectivity at a lower cost per bit. However, in order to improve, or even maintain their overall network ROI, carriers must consistently lower their costs and improve network efficiency. OSS transformation can help the carriers make optimal use of network resources, particularly as virtualized and Open RAN solutions proliferate.
- Cloud native adoption, CI/CD software engineering, and the further disaggregation of network applications like the vRAN into microservices promise to bring fantastic flexibility, increased utility, and higher performance to the network. However, they also mean hundreds, if not thousands, of software versions transmitted over the network daily. They also mean microservices being deployed or torn down with equal frequency, including RAN microservices. A transformed OSS, being cloud native itself, brings automation that is essential to the success of the cloud-native RAN and broader network.

One vendor that is taking some innovative steps in vRAN operations is Netcracker, as noted in the following section.

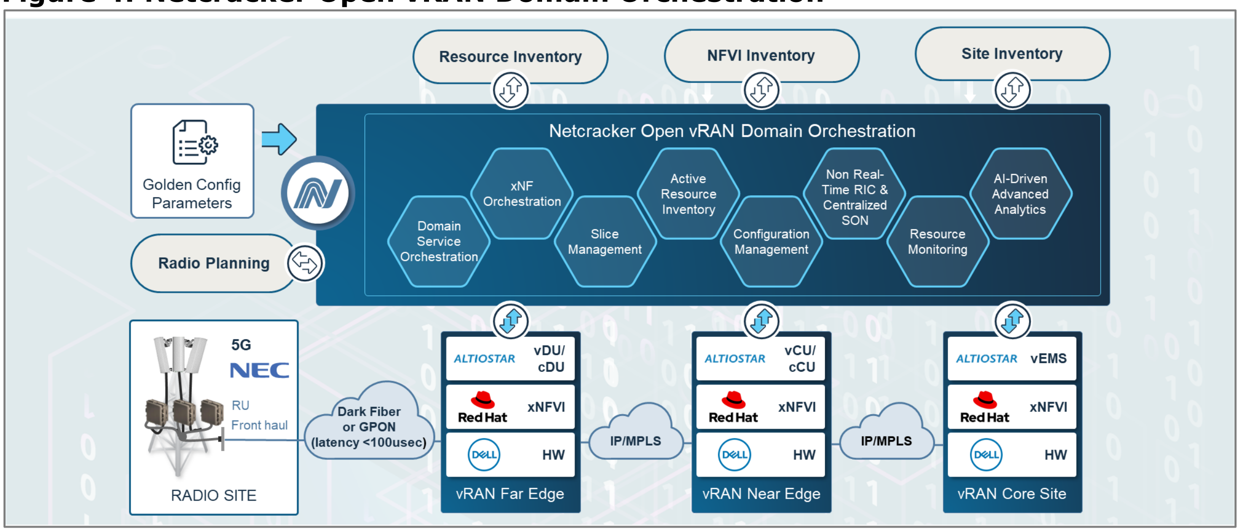
NETCRACKER OPEN VRAN DOMAIN ORCHESTRATION

This section provided by Netcracker.

The Netcracker solution for Open vRAN Domain Orchestration combines orchestration, OSS, and AI/analytics to fully automate the RAN domain, including planning, design, activation, assurance, and optimization. The solution leverages the expertise of Netcracker's parent company, NEC, and includes pre-integration with industry-leading partners in Open vRAN, such as Altiostar, Red Hat, and Dell.

Open vRAN Domain Orchestration provides a common automated operations environment for 4G and 5G RAN, including gNB and 5G RUs. Service orchestration for the domain supports 3GPP Network Slice Subnet Management Function for E2E network slicing powered by cross-domain service orchestration.

Figure 4: Netcracker Open vRAN Domain Orchestration



Source: Netcracker

The Open vRAN Domain Orchestration solution automates the E2E service lifecycle from planning and design to activation, optimization, and assurance across the entire multi-vendor domain of Open vRAN. It features:

- Automated planning and design to meet business KPIs.
- Fast activation of multi-vendor network functions for physical and virtual RAN.
- E2E visualization and optimization to maximize RAN performance.

With our advanced technology and proven expertise, we can optimize your evolution to Open vRAN and leverage it as a platform for service innovation and market growth. Read more.