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HEAVY READING
WHITE PAPER

Open Source Infrastructure Software for vRAN Deployment and Operation

A Heavy Reading white paper produced for Wind River

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VRAN AND OPEN SOURCE INFRASTRUCTURE SOFTWARE

Mobile networks connect over 5 billion users and generate over $1 trillion of service revenue annually. With more than 7 million cell sites deployed globally, this makes radio access networks (RANs) the most important distributed network infrastructure in the world.

Operators spend around $32 billion annually on RAN equipment. By 2023, this figure will rise to $36 billion, according to Ovum, with 5G expected to account for 60% of the market. As operators enter the 5G era, the RAN is becoming increasingly software-driven and open. The largest equipment vendors are migrating from integrated single-vendor systems to more modular, open platforms. In parallel, a new wave of challengers is adopting software-led design principles to develop virtual RANs (vRANs) optimized for cloud deployment and operation.

These new approaches enable distributed, disaggregated RAN architectures that can be deployed on the same edge cloud infrastructure as other network functions and services. A major benefit of this new approach is to bring cloud-like operating models to the RAN, with greater automation and lower life cycle costs.

This white paper focuses on the software infrastructure operators need to deploy and operate open vRAN commercially at scale. Specifically, it discusses the suitability of StarlingX open source software to bringing cloud deployment and operating models to the highly distributed "far edge" cloud infrastructure that will run vRANs.

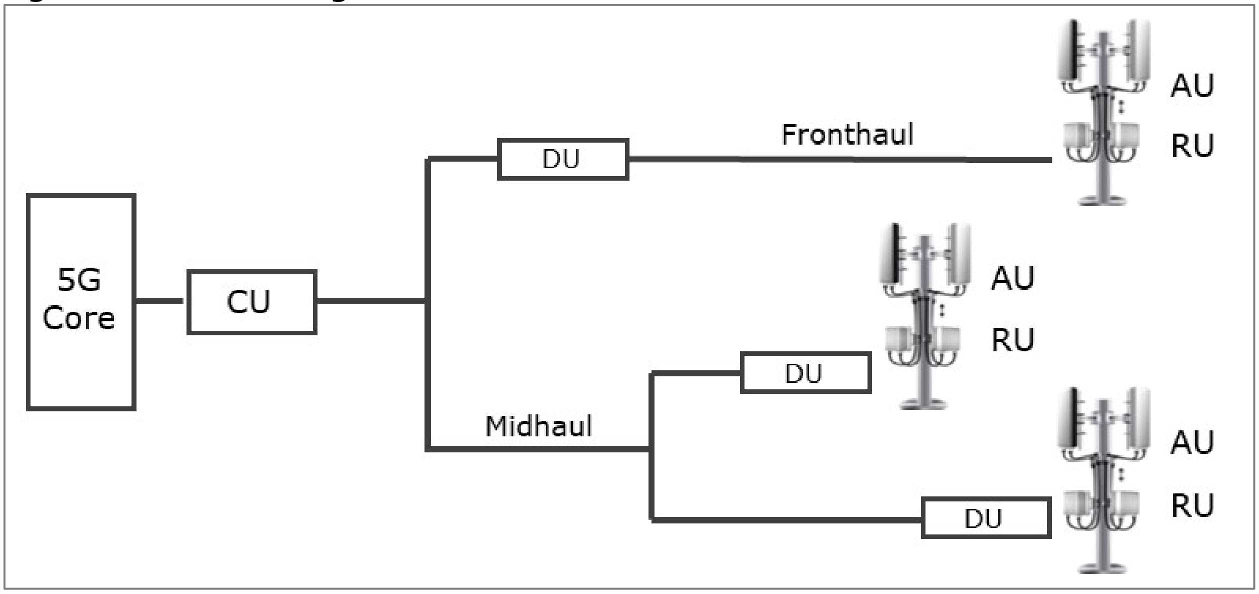
Open RAN Architecture

The mobile RAN is made up of functional modules that combine to create a radio base station, which connects to the network via an IP/Ethernet transport interface. The major functional units of a base station are the following:

- The **antenna unit (AU)**, which radiates and receives the wireless signal. **Active antenna units (AAUs)**, which are popular in 5G to support massive MIMO, also incorporate radio functions into the antenna.
- The **radio unit (RU)**, which amplifies and filters the signal and converts between analog and digital. The RU is the largest component of a base station bill of materials; it uses specialist radio frequency (RF) hardware.
- The **digital unit (DU)**, which processes baseband signal and schedules resources at a microsecond level, is fundamental to radio performance. Classically, baseband is a hardware function; however, new techniques that enable very low latency and jitter at the operating system level make it possible – and attractive – to virtualize DUs.
- The **centralized unit (CU)** handles Layer 3 tasks such as mobility management and device connectivity states. Classically, this is integrated with the DU, but increasingly is separated; the CU can be readily virtualized as a step toward vRAN.

These functional components (AU, RU, DU, CU) combine to form a radio base station, known as a "gNB" in 5G standards terminology. Because the 3GPP defines a logical and functional architecture, these components can be deployed in different ways by the vendor or operator. For example, virtualized and disaggregated or hardware-based and tightly integrated are both valid from a standards point of view. **Figure 1** shows how this logical architecture might be deployed.

Figure 1: Next-Gen Logical RAN Architecture



Source: Heavy Reading

For various reasons – R&D investment, radio performance, cost efficiency, support and maintenance, network management, and so on – radio base stations have generally been designed and integrated by a single vendor. There are, however, moves to open up and disaggregate the RAN. In the near term, these moves will help support specific use cases (such as enterprise, in-building, or rural coverage); in the longer term, they have the potential to affect the RAN industry structure. There are two major aspects of open RAN:

- **Create open interfaces between functional modules.** Such interfaces will enable operators to pursue new deployment models, foster competition and innovation, and source commercial-off-the-shelf (COTS) equipment from multiple vendors.
- **Decouple hardware from software.** This refers primarily to the virtualization of baseband software (DU and CU) to run on cloud infrastructure. New techniques are emerging to address the performance challenge of virtual basebands.

Cloud-Centric vRAN Deployment and Operations

There are numerous options for RU, DU, and CU deployment at edge locations. They can be integrated at a cell site (i.e., similar to a traditional radio base station), split across diverse edge sites according to use case, colocated with edge network functions and cloud services, or deployed on-premises at an enterprise or public venue.

These deployments bring new challenges to the operating model. In a classic RAN, base stations are managed by sophisticated but vendor-proprietary element management systems. In an open vRAN, the operator also needs to manage the edge cloud environment on which the vRAN applications and associated edge services are deployed. Because this is highly distributed infrastructure, with multiple edge locations, new cloud management tools are needed. Distributed edge cloud management is the key capability of the open source software infrastructure platform StarlingX.

With a distributed edge infrastructure, operators can apply cloud-like operating models to vRAN. This has advantages for the vRAN itself – for example, scaling baseband resources according to demand (e.g., during busy hours), power savings at quiet times, and executing in-service upgrades without having to visit the tower. Distributed edge infrastructure also enables the operator to deploy additional functions and services on the same server clusters and locations using the same tools. For example, at a multi-access edge compute (MEC) site in the aggregation network, the operator may want to deploy a 5G core functions, end-user services, content, and applications, in addition to a vRAN baseband pool.

OPEN SOURCE RAN SOFTWARE

To deploy virtual RAN on cloud infrastructure, operators need air interface software. RAN software stacks are now available from numerous vendors for LTE – usually from new entrant and challenger vendors – and several suppliers plan to offer 5G New Radio (NR) air interface stacks commercially in 2020. These are typically commercially supported proprietary stacks. In the RAN, open source is generally targeted at the infrastructure layer (the focus of this paper). However, interest in open source air interface, and open source RAN more generally, is increasing and there are several projects of significance, as shown in **Figure 2**.

Figure 2: Open Source RAN Initiatives

Initiative	Commentary
Open Air Interface Software Alliance	• Leading organization promoting open source air interface • LTE code available from Rel-8 onwards • 5G NR air interface software under development • Code used for demos and development; not yet production ready • Broad industry and academic support
O-RAN Software Community	• A collaboration between the O-RAN Alliance and Linux Foundation (LF) • Aims to enable the development of open source software for disaggregated RANs • Leverage LF network projects, especially in the edge domain (e.g., Akraino), and align with 3GPP • First high profile project is an open source RAN Intelligent Controller
TIP OpenCellular	• Several project groups working on open mobile access – for example: – OpenCellular is focused on open source software-defined wireless access platform to improve connectivity in remote areas – 5G NR is specifying disaggregated "white box" small cell/base stations – Open RAN focused on programmable RANs based on general purpose processing platforms (GPPPs) and disaggregated software

Source: Heavy Reading

Essential to open source RAN are general purpose processors to run baseband software. Classic radio basebands run on ARM and will continue to do so. However, interest in x86 is growing, as this allows the same server hardware to be used for radio and other cloud applications, driving economies of scale and common operating models. Silicon vendors are increasingly developing air interface software to sell with their products. Although these typically are not commercially-ready stacks, they leverage open source and provide a starting point for further development.

Additionally, several important trends are driving a transition to COTS-based radios. Most notably, a “white box radio” market is emerging thanks to open fronthaul interfaces from Telecom Infra Project (TIP) and the O-RAN Alliance. Because radios use embedded software, these white box radios are not comparable to white box switches or universal customer premises equipment (uCPE), in the sense that it is not possible/practical to run different vendor software on the radio hardware. However, radio products and reference designs are now available from multiple independent suppliers. COTS will bring some of the commercial benefits associated with white box switches/servers to the RAN.

STARLINGX EDGE VIRTUALIZATION PLATFORM

StarlingX is designed to be a deployment-ready infrastructure software stack to manage cloud assets and applications running at geographically dispersed far edge locations. It is a horizontal edge cloud stack that can support a broad range of applications across sectors such as industrial Internet of Things (IoT), transportation, roadside compute, smart cities, smart buildings, video distribution, mixed reality, uCPE, etc. StarlingX is especially suitable for applications with demanding latency and reliability requirements.

Regarding the mobile network, the scale of the edge opportunity is what makes it a target for StarlingX. The focus on performance also correlates closely with the ultra-reliable low latency communications (URLLC), massive IoT, and mobile broadband services that 5G is designed to support.

The StarlingX project was launched by the OpenStack Foundation, with support from Intel and Wind River, in May 2018. The software is offered under an Apache open source license. Its first release was in autumn 2018, with a second release scheduled for Q3 2019. The unique challenges of edge deployment addressed by StarlingX include the following:

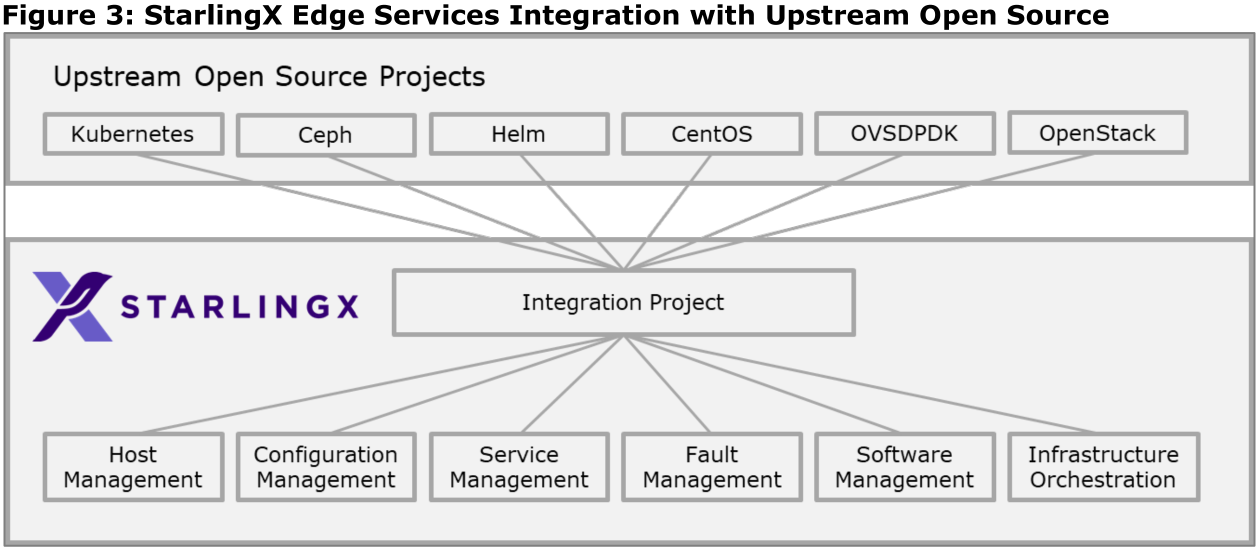
- **Ability to manage assets across large numbers of multi-edge locations.** For example, a largish European mobile network might have thousands of aggregation sites and around 20,000 cell sites.
- **Need for automation.** It is not practical to send staff to edge locations on a frequent basis, making zero-touch provisioning, operations, and life cycle management critical to the operation of a far edge RAN. This is one of the key objectives of StarlingX, and it could make a big contribution to vRAN efficiency.
- **Support for multiple use cases.** Edge services may have diverse performance requirements. For example, a 5G campus network deployed for industrial IoT must support 6x9s availability and millisecond latency, while a smart city camera network must support very high area-traffic densities.
- **Locations may be environmentally challenging.** Relative to data centers, edge sites may have access restrictions, power restrictions, weather exposure, non-redundant backhaul, etc. Hardened, integrated server/network equipment and/or Network Equipment Building System (NEBS) compliance may be required.

- **Ability to scale across a range of hardware form factors.** For example, scale from minimum footprint single servers (e.g., at a cell site) to two-server high availability solutions (e.g., at industrial sites) or multi-rack solutions at larger sites (e.g., at a central office).
- **Resilient operation.** Critical edge services need to continue to operate autonomously – even if network connectivity is interrupted.

StarlingX Services and Upstream Integration

StarlingX provides complete Day 1 and Day 2 management of upstream Kubernetes and OpenStack clusters, including services such as install, configuration, monitoring, updates, and more. In this sense, StarlingX can be thought of as part development project for edge cloud management services and part integration project with upstream Kubernetes and OpenStack, as shown in **Figure 3**. This outcome is an integrated, ready-to-deploy solution that enables system-wide orchestration and monitoring with shared configurations across edge cloud locations/instances.

Figure 3: StarlingX Edge Services Integration with Upstream Open Source

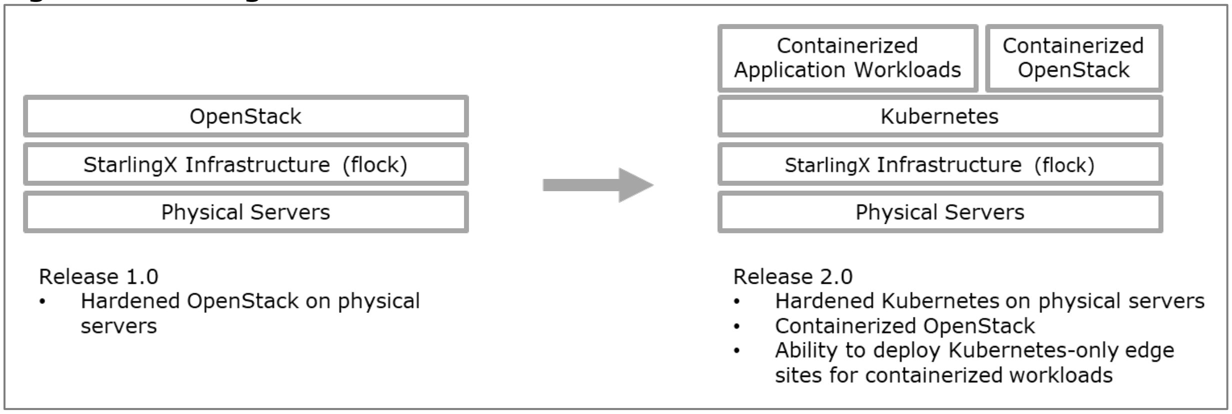


Source: StarlingX

The major differences between StarlingX releases are shown in **Figure 4** below. Release 1.0 supported OpenStack deployed on dedicated physical servers. Release 2.0, due in Q3 2019, supports Kubernetes and OpenStack workloads deployed on dedicated physical servers. In this release, OpenStack services will be containerized and will run, optionally, on top of a Kubernetes cluster. This will mean operators can use StarlingX to run Kubernetes-only edge sites with support for Calico container networking and pass-through interfaces for higher networking performance. It will also add support for native Docker runtime, Ceph-backed persistent volume claims, a local Docker registry, and Helm and Armada package management.

In a mobile network context, these Release 2.0 advances are important to support performance-intensive high throughput mobile network applications. Increasingly, network applications are now being written as cloud network functions (CNFs) to run containers. Where classic virtual network functions (VNFs), which run in virtual machines (VMs; e.g., in a 4G core control-plane function), are needed, Release 2.0 will support containerized OpenStack.

Figure 4: StarlingX Release 2.0 Is Cloud Native

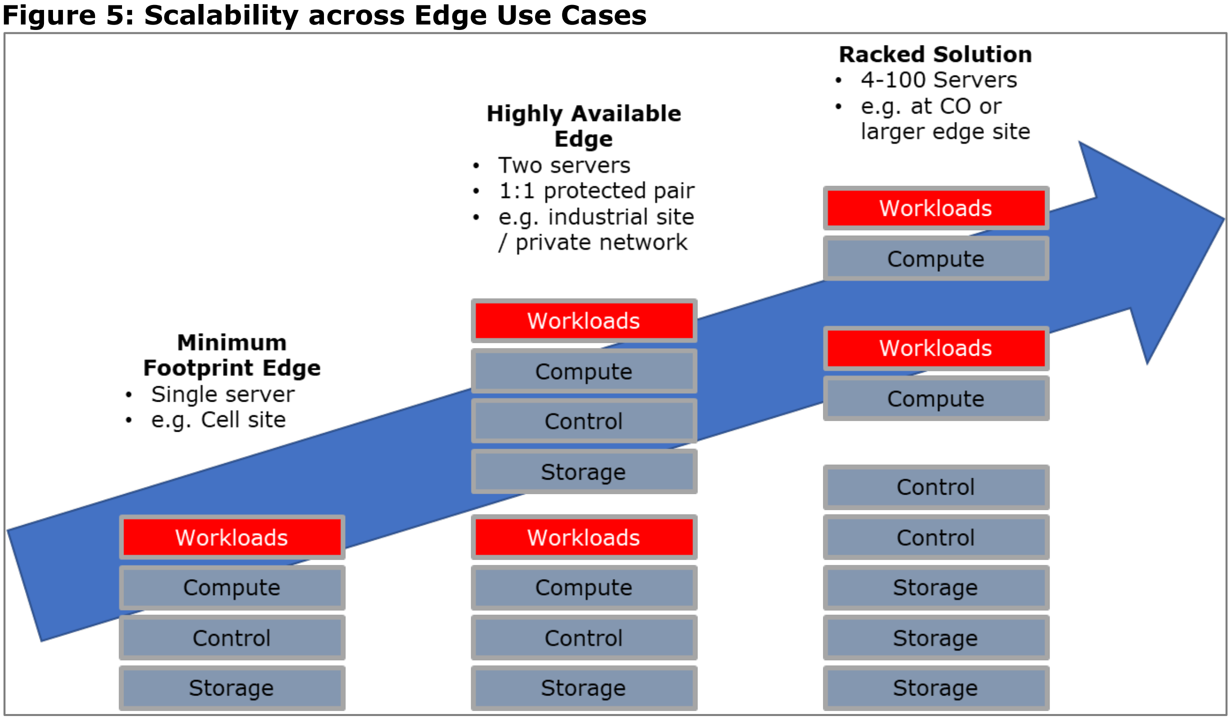


Source: StarlingX, Open Infrastructure Summit, 2019

Edge Deployment Flexibility

Mobile operators need a unified edge cloud management and network-wide orchestration. However, with multiple edge locations of different sizes with different facilities, they also need great flexibility in their deployment options. StarlingX is designed to scale across small footprint, low cost/low power single node servers up to full data center configurations. **Figure 5** shows three classes of edge hardware solution that are within the project scope.

Figure 5: Scalability across Edge Use Cases



Source: Wind River

To the left is a small footprint single server, such as might be deployed at a cell site, in a roadside unit for cellular vehicle-to-X, or at a branch office. A larger two-server hardware configuration might be needed where high availability is critical. An example of this might be an industrial site running vRAN and local industrial IoT applications within a private mobile network. In both these cases, hyperconverged hardware that integrates control/storage/compute to a single node is likely to be used. In some cases, the hardware will be in ruggedized form factors suitable for harsh operating conditions.

Racked hardware is more likely to be deployed at larger edge sites such as central offices or repurposed facilities in basements and offices. In a vRAN context, this could mean at hub sites such as used for cloud RAN baseband pools. These locations are closer to standard data centers, but nevertheless are often brownfield sites that are more likely to have environmental restrictions (power, access, fire, space weight, etc.) and may require hardened equipment. The requirement on StarlingX is to manage distributed multi-node clusters regardless of these factors.

SUMMARY: STARLINGX FOR VRAN

StarlingX is an open source infrastructure software stack used to manage geographically dispersed far edge cloud locations. It is especially suitable for applications with low latency and high reliability requirements, such as vRAN and the URLLC services emerging in 5G. The RAN market itself is at a transition point, with 5G deployment underway and open, virtualized systems now coming to market. To maximize the benefits of vRAN, operators need an underlying cloud platform designed to support network-wide configuration and management of far edge applications and infrastructure. StarlingX promises to bring cloud-centric operating models and efficiencies to the RAN.

There are several reasons why StarlingX is emerging as an appropriate platform for vRAN deployment and operation:

- StarlingX builds on well-established open source cloud management tools such as Kubernetes and OpenStack. It also leverages many other open source projects, with active communities, such as CentOS, Ceph, Helm, Calico, and more.
- A vRAN comprises a set of performance-intensive applications and is often deployed alongside other demanding mobile network functions. Containerization, support for multiple network interfaces, enhanced platform awareness (for VM placement and CPU pinning), time synchronization, and Layer 3 mesh networking have been adopted by the StarlingX project team to address these requirements.
- Integration between StarlingX and other edge initiatives, such as the open source Akraino, or with standards initiatives such as MEC is important to creating the overall edge cloud platform operators will need to run, not only vRAN, but also other network functions and end-user services at the edge. In many cases, vRAN will be part of a larger multipurpose, multi-access edge.

To learn more about StarlingX, visit www.StarlingX.io.

ABOUT WIND RIVER

This section was written by Wind River.

A global leader in delivering software for intelligent connected systems, Wind River offers a comprehensive, edge-to-cloud software portfolio designed to address the challenges and opportunities communications service providers face when evolving and modernizing their networks.

Wind River is focused on accelerating the massive innovation and disruption at the network edge by being active collaborators and contributors to the StarlingX project. As a commercial deployment of StarlingX, the Wind River Cloud Platform will be key to enabling new business opportunities and innovative applications across multiple market segments.

Visit www.windriver.com for more information.