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Business white paper

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# BUSINESS CASE FOR OPEN VIRTUALIZED RAN

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## INTRODUCTION

The radio access network (RAN) connects cellular devices to a mobile network operator's core network. It provides an air interface toward cellular devices and handles all aspects associated with radio signal processing and radio resource control. It processes signaling associated with a subscriber attaching to the cellular network and using its services while moving around seamlessly. It is deployed as a large, geographically distributed assembly of nodes called base stations. Base stations come in many form factors optimized for specific deployments, however, all generally include a Base Band Unit (BBU) and a Radio Unit (RU).

- The BBU is a purpose-built appliance processing baseband signals in the digital domain, with RAN software tightly coupled with underlying hardware, which itself is based on special purpose custom ASICs, DSPs, and FPGAs.
- The RU generally executes digital/analog conversion as well as processing RF analog signals coming to/from antenna.

Traditional RAN equipment are closed, proprietary appliances. In general, mobile network operators spend up to 80% of their capital expenditure and up to 60% of their operating expenditure on RAN. Constant traffic growth and flattening revenue per subscriber has put enormous pressure on mobile network operators to evaluate alternative ways to reduce capital and operating expenses associated with RAN equipment.

Recent advancements in general-purpose compute as well as telco driven industry initiatives for open, standard interfaces within the RAN domain have led to Open Virtualized RAN (vRAN). It is based on the following technological principles:

- Fully decoupled software running on abstracted general-purpose hardware, with a best-of-breed approach
- Functional components implemented as abstracted software interacting via open standardized interfaces
- General-purpose edge compute infrastructure supporting multiple use cases and workloads, with vRAN workload as one of the tenants
- Cloud-native capabilities in deployment, lifecycle management, scaling, and redundancy of vRAN workload and underlying infrastructure

**vRAN brings the following additional benefits:**

**Flexibility**, as vRAN enables a best-of-breed approach versus a monolithic network infrastructure from a single provider in a traditional RAN model

**Scalability**, as decoupling of software from hardware allows for independent horizontal scaling of infrastructure to address constant evolution of radio access (for example, introduction of new features, access technologies, frequency bands), versus frequent vertical upgrades and infrastructure swap projects of appliance hardware

**Operational efficiency**, as an open underlying compute platform enables flexible management and automation of vRAN infrastructure based on wider tech industry achievements in infrastructure-as-a-code and cloud-native applications management

**Resilience to security threats**, as components of the system from one vendor can easily be exchanged for another, if the supply chain or vendor is deemed to be compromised

**Improved security**, as open interfaces enable monitoring to detect attacks

## BUSINESS BENEFITS

vRAN is based on deploying general-purpose compute infrastructure at the very edge of a cellular network. That same infrastructure can be used for deploying other edge use cases. Examples of the edge use cases are as follows:

- **Private networks and cellular breakout (Private LTE/5G)**
  Private networks give telcos an ability to sell a custom connectivity service to an enterprise, with ability to engineer connectivity (traffic routes, policies) around the needs of concrete enterprise use cases. Private network solutions provide an ability to architect the wireless network for the demands of concrete locations and use cases, while enjoying all the benefits of cellular technology—reliability, native seamless mobility over wide area, low-latency, and scalability. Building private networks and providing a cellular local-breakout for enterprise traffic requires core and breakout functions to be deployed at the far edge of a telco network or on enterprise premises. This use case requires an underlying general-purpose edge cloud to host necessary functions.

- **Multiaccess Edge Compute (MEC)**
  Having custom connectivity around enterprise needs is the first step for introduction of more advanced digital services at the edge—starting from providing a hosting platform for edge-enabled applications, to providing PaaS and SaaS services to enterprises. Modern edge-enabled applications (for example, AI-based video analytics, AR edge processing, and so on) require a powerful underlying compute platform, in many cases equipped with specialized accelerators (for example, GPUs or FPGAs). For this use case, the vRAN edge cloud platform will be able to co-host those enterprise MEC applications with vRAN functions.

- **Network slicing and distributed user plane**
  Network slicing is introducing differentiation on the services (with quality of service features as an example) and the way the network user plane/control plane and RAN is designed, managed, and associated to a network slice. This association can be dynamic, adding/removing components in different locations and changing parameters, but also scaling components, including the RAN components, as the number of user equipment (UE) increases or traffic increases. Also, management of the slice can be restricted to certain users, including the management of the RAN components of the slice.

High-reliability, low-latency communication, and enhanced mobile broadband use cases define a need for not only functional separation and independent scaling, but also optimal and dynamic placing of signaling plane and user plane functions in a network, based on operator policies and the demands of a concrete use case. Dynamically placing core user plane functions (for example, UPF or PGW/SGW-U) at the edge enables flexible traffic steering across the network as well as optimal scaling of user plane in response to growing heterogeneous traffic.

Underlying general-purpose edge clouds combine those use cases on the same hosting infrastructure, providing further synergies and improved return on investment for vRAN deployment. The following figure illustrates a multitenant, multipurpose telco edge cloud, running vRAN as well as other telco edge workloads on the same cloud platform.

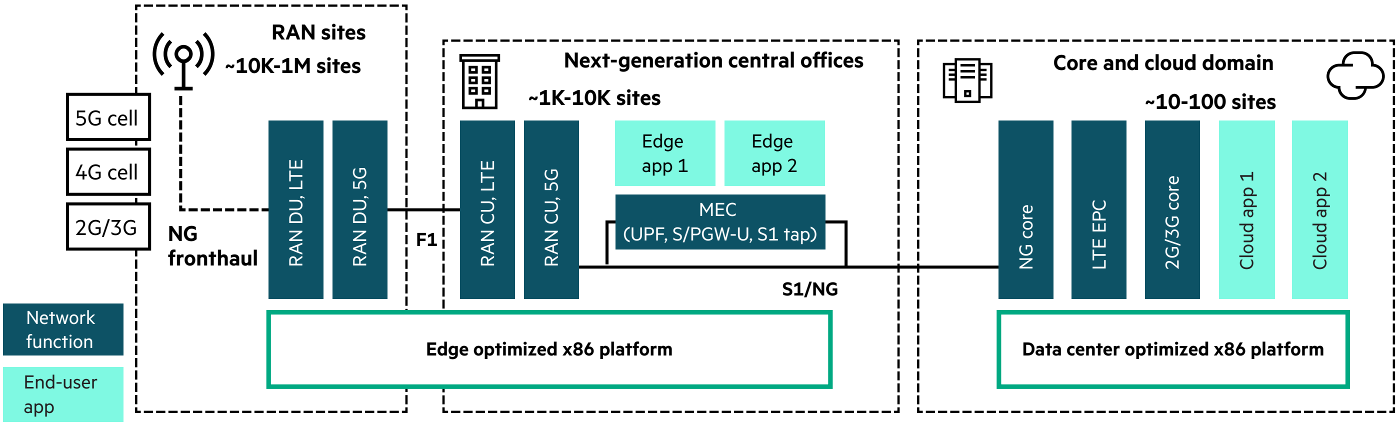


**FIGURE 1.** Universal telco edge cloud enabling multiple use cases

## TCO ANALYSIS

HPE, in partnership with leading best-in-class technology providers, analyzed major components of RAN CAPEX and OPEX based on a number of early vRAN deployments at Tier-1 mobile network operators. The following different RAN virtualization and deployment architectures were used:

- **Traditional RAN**
  RAN is implemented on monolithic appliances, coming from a single technology vendor in a given geography. It is fully distributed with the baseband processing functionality residing at RAN sites and processing signals for a given local base station.
- **vRAN 1.0 (CRAN, 3GPP Option 2)**
  The first step of vRAN, where real-time baseband processing functions are implemented as a monolithic appliance, while non-real-time baseband processing functions are implemented as virtualized Central Unit (vCU) and deployed as a VNF in the telco cloud. vRAN 1.0 is provided by a single technology vendor in a given geography.
- **vRAN 2.0, Distributed mode (Distributed vRAN, 3GPP Option 7.2)**
  In this deployment architecture, real-time baseband processing functions are implemented as virtualized Distributed Unit (vDU) at RAN sites, while vCU is centralized in the telco cloud. vRAN 2.0 is an open architecture, where a best-of-breed approach is applied toward selection of solution components.
- **vRAN 2.0, Centralized mode (Centralized vRAN, 3GPP Option 7.2)**
  In this deployment architecture, both vDU and vCU are centralized in an intermediate near edge facility, aggregating processing for ~10–100 base stations. This architecture is typically used by operators with significant assets in optical fiber at the last mile which meets requirements of next-generation fronthaul.

The following bar graph illustrates the 5-year TCO comparison between the alternatives and the table after that provides further insight into the main TCO contributing factors. All values are presented as relative percentage points, with 5-year TCO of traditional RAN taken as 100%.

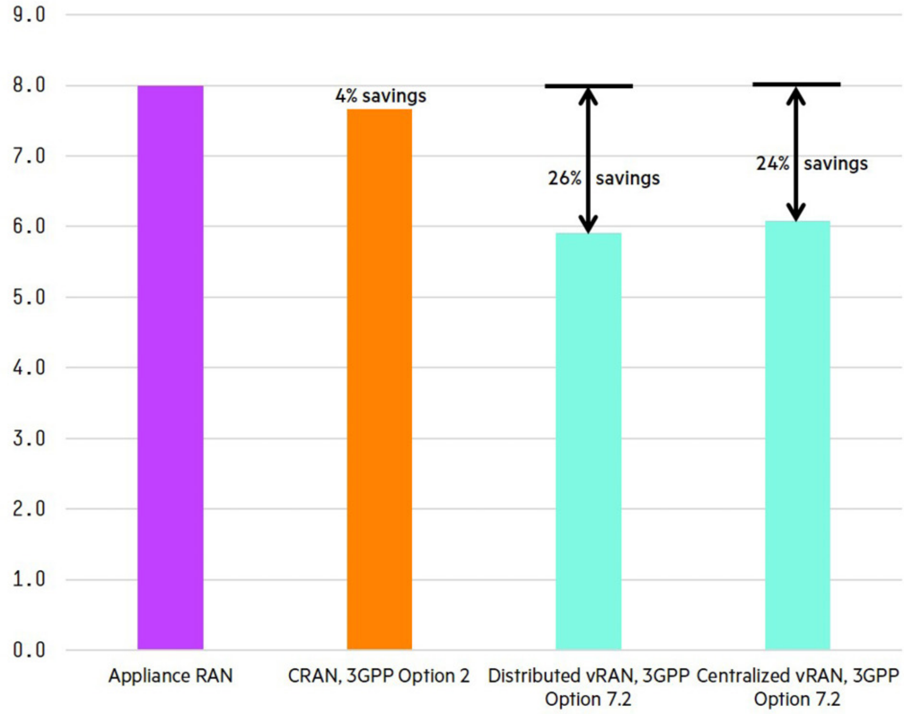


**FIGURE 2.** 5-year TCO of main vRAN deployment models versus traditional RAN

**TABLE 1.** TCO over 5 years for RAN deployment alternatives

| TCO component | Appliance RAN | CRAN, 3GPP Option 2 | Distributed vRAN, 3GPP Option 7.2 | Centralized vRAN, 3GPP Option 7.2 |
|---|---|---|---|---|
| **CAPEX** | | | | |
| Base station HW | 20% | 17% | 13% | 10% |
| Initial deployment | 6% | 5% | 6% | 3% |
| HW upgrade | 6% | 5% | 0% | 0% |
| HW expansion | 8% | 7% | 7% | 7% |
| Base station SW | 6% | 6% | 5% | 6% |
| Rollout and tuning | 5% | 5% | 3% | 1% |
| Initial deployment and tuning | 2.6% | 2.6% | 2.5% | 1.0% |
| Post-upgrade tuning | 1.6% | 1.6% | 0% | 0% |
| Capacity expansion | 0.8% | 0.7% | 0.7% | 0.2% |
| Transport network upgrade | 0% | 0% | 0% | 31% |
| Backhaul upgrade | 0% | 0% | 0% | 0% |
| Fronthaul upgrade | 0% | 0% | 0% | 31% |
| Reuse of general-purpose equipment | 0% | -1% | -13% | -10% |
| **OPEX** | | | | |
| Maintenance and health assurance | 13% | 13% | 10% | 10% |
| Site acquisition and rent | 50% | 50% | 47% | 20% |
| Electricity | 6% | 6% | 8% | 8% |
| **Total** | **100%** | **96%** | **74%** | **76%** |

Following are the key observations from this TCO study:

- vRAN 1.0 does not significantly change RAN TCO. It gains ~4% TCO over 5 years, mainly due to pooling of PDCP/RRC layers and associated savings in the overall processing needs. As PDCP/RRC layers represent an insignificant portion of overall baseband processing, the pooling saving is not enough to transform RAN TCO in any significant manner.
- vRAN 2.0 brings significant TCO improvement into RAN economics, up to 26% of reduction across 5 years. Given that RAN TCO constitutes around 50% of overall operator spend on a cellular network, vRAN 2.0 significantly improves overall CAPEX and OPEX of a telco operator. With fully decoupled software, vRAN 2.0 infrastructure scales horizontally and does not require vertical hardware upgrades to address evolution of network functionalities, typical for appliance RAN. That optimizes investment into RAN infrastructure, and decreases truck rolls and tuning efforts associated with hardware upgrades.
- Another significant factor contributing to vRAN 2.0's superior TCO is the ability to repurpose general-purpose infrastructure for additional use cases as well as leveraging general tooling for maintenance and lifecycle management of RAN infrastructure, versus in a closed ecosystem where specialized knowledge is required for appliance operation.
- Comparative efficiency of vRAN 2.0 Centralized mode is dependent on a balance between the cost of last mile transport upgraded to comply with next-generation fronthaul requirements, versus pooling gain and potential site rent savings due to equipment centralization. This balance is unique to each RAN market, as well as to each operator in a given market, and therefore very sensitive to assumptions. Table 1 is based on a somewhat balanced approach toward transport cost versus centralization efficiency, and therefore TCO between Distributed and Centralized modes does not differ much.
- This analysis of vRAN 2.0 TCO does not include the potential of optimized multivendor procurement policies which can be implemented by an operator toward technological suppliers, given that vRAN 2.0 enables a fully open best-of-breed approach toward components. Potential economic impacts of those new policies is marked by many telco operators as the number one driver for vRAN introduction, though this is not easily quantifiable.

## CONCLUSION

Telco operators are driving a more open and flexible RAN architecture by disaggregating the monolithic baseband processing of a base station into separate distinct layers. As evident in this paper, significant savings are achieved when virtualizing the RAN using general-purpose compute hardware. In addition, vRAN makes it easier to roll out additional revenue generating services. HPE is a leading infrastructure partner in virtualized core telecom networks and is ready to help telcos during their transformation journey to vRAN.

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