Get ahead in the transition to a cloud-native telco services cloud

A practical introduction to the cloud-native value proposition for Communications Service Providers (CSPs) with an overview of Nokia Container Services

Application note

Abstract

Transforming to cloud-native infrastructure will enable CSPs to become more agile and efficient, helping them to compete better at pace in the 5G era. Software functions and applications built and managed using cloud-native container deployments are well proven by webscale companies. Yet adopting this approach is no small task for CSPs. Achieving the desired results will take careful planning, investment and execution.

Nokia is developing robust solutions that help CSPs make the transition as smooth and cost-effective as possible, supporting a mixed cloud environment in which traditional virtualized network functions run in parallel with cloud-native container-based functions.

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Overview

Introduced in 2012, Network Functions Virtualization (NFV) has been adopted in varying degrees by most Communications Service Providers (CSPs). This was largely thanks to the ETSI NFV Management and Orchestration (MANO) standard which offered common approaches and vendor interoperability.

However, the ETSI standard simply mimics traditional telco practices and replaces physical network functions and management with virtualized replicas. This has resulted in the telco industry missing an opportunity to embrace the full potential of virtualization in the form of cloud-native software and applications and a new mode of operations. Cloud-native approaches deliver more speed, greater agility and a simpler management structure than NFV.
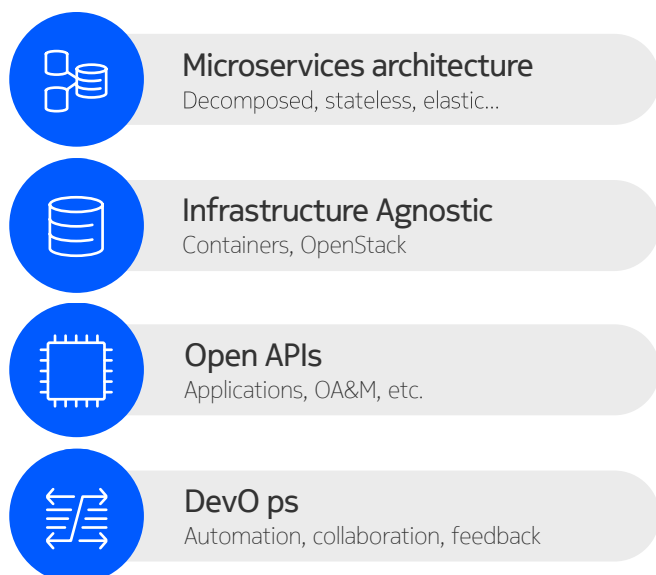
Achieving full cloud-native transformation will take effort and careful planning by CSPs. Consequently, during the transition period, they are likely to run a mixed cloud environment in which Virtualized Network Functions (VNFs) run on Virtual Machines (VMs), Cloud-native Network Functions (CNFs) run in containers hosted on VMs, and CNFs run in containers running on Bare Metal servers.

Why does cloud native matter?

Webscale IT service providers are highly efficient and agile. They can roll out new services and update existing services far more quickly than is possible on existing CSP infrastructures, even those that have become more software based. Webscale companies see automation as a strategic imperative, not just an operational convenience. Their relentless application of automation is enabled, in large part, by cloud-native methods and tools.

Such webscale agility has completely changed what enterprise and consumer customers want from service providers. They routinely expect self-serve, customized, instant-on services, which, using current best practices, CSPs cannot deliver easily.

Figure 1. What makes an application cloud native?

Microservices architecture
Decomposed, stateless, elastic...

Infrastructure Agnostic
Containers, OpenStack

Open APIs
Applications, OA&M, etc.

DevO ps
Automation, collaboration, feedback

CSPs can substantially lower their costs and improve their agility by deploying cloud-native networks, operations and services. Cloud native enables an almost endless list of benefits that make it a critical technology for CSPs:

- faster development of new services and service features

- accelerated deployment of customized services

- upgrading deployed software lowers the barriers to the rapid release of new capabilities

- running services close to customer end points to ensure lowest latency

In the case of 5G, cloud-native becomes essential. By being more agile and automated, CSPs can fully use 5G's capabilities like network slicing, and quickly implement new services and develop new markets, including Industry 4.0, Internet of Things (IoT), etc. This requires them to redesign architectures across their network, operations and services, using intelligence-driven automation and cloud-native methodologies.

CSPs face unique challenges

Typical ETSI NFV telco cloud environments are not set up for, nor do they have the management tools for, microservices-based applications and network functions running in containers. They were built using ETSI-defined NFV MANO specifications and ETSI-compliant commercial software stacks. These solutions create and manage VMs with OpenStack and VMware hypervisor-based environments. Many of these VM-based VNFs are governed by a framework that mirrors legacy telco appliance management models and this limits a CSP's deployment options. Moreover, commercial VNFs are typically deployed on vendor-specific virtual infrastructures to ensure proper operations, further limiting a CSP's options.

The initial remit for NFV was to decouple the network function from proprietary hardware, which was achieved for all but the most resource intensive, packet moving applications. MANO also enables the automation of lifecycle functions, but its telco-inspired layered structures ultimately limit these capabilities and overly-complicate the lifecycle management of VNFs and the cloud. Consequently, building and maintaining multivendor environments is more difficult than was first envisioned.

In contrast, and following the earlier adoption by Enterprise IT, webscale IT and increasingly, new entrant CSPs, are fully embracing containers and cloud native which has led to the development of a more robust ecosystem of open source communities and knowledge.[11] With software-based telco network functions looking more and more like IT applications, the need for two different management architectures, strategies, methods and tool sets is disappearing rapidly.
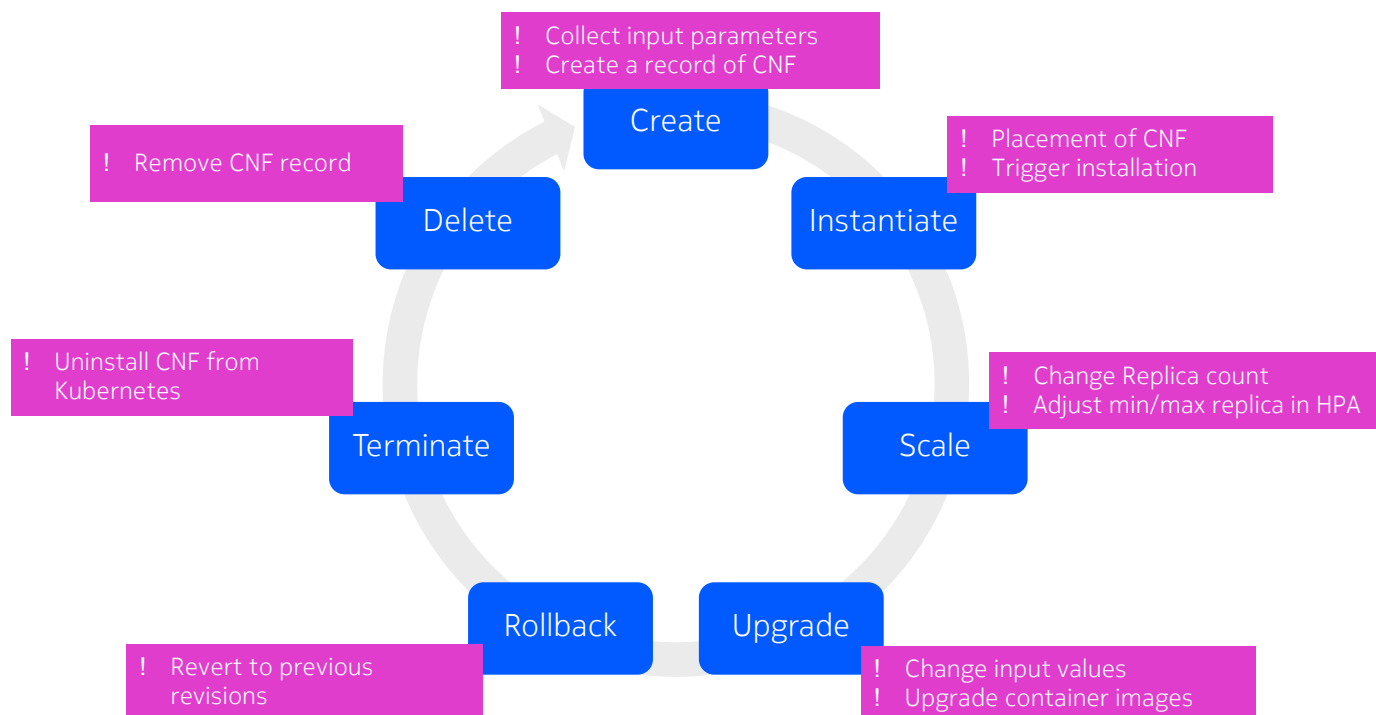
The route to cloud native for CSPs

The first step for CSPs is to install carrier-grade cloud infrastructure that is ready for microservices-based network functions and applications. These functions are deployed and run in containers instead of in virtual machines (VMs). However, moving towards cloud-native operations takes more than just adding containers - their deployment and lifecycles must be managed. This is best achieved by the Kubernetes open source project, which has its origins in Google's own cloud management practices. The Linux foundation says that Kubernetes is the most active open source community in the ICT sector today.

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1   "Application Container market worldwide is projected to grow by US$ 6.9 Billion, driven by a compounded annual growth of 31.8%." Research and Markets.

Kubernetes uses built-in workflows that simplify infrastructure and application lifecycle management by eliminating the need for a dedicated VNF Manager function as implemented by ETSI MANO. Using Helm as its packaging and deployment tool, Kubernetes can run major lifecycle management automation tasks like onboarding, instantiation, upgrade and termination (see Figure 2). This can be integrated with the DevOps pipeline to automate the Containerized Network Function (CNF) lifecycle.

Figure 2. Container lifecycle management actions

Create
! Collect input parameters
! Create a record of CNF

Instantiate
! Placement of CNF
! Trigger installation

Scale
! Change Replica count
! Adjust min/max replica in HPA

Upgrade
! Change input values
! Upgrade container images

Rollback
! Revert to previous revisions

Terminate
! Uninstall CNF from Kubernetes

Delete
! Remove CNF record

However, the ETSI NFV environment is embedded in many CSP systems, supported by years of experience and established operational procedures. This is likely to be a multi-year transition, with ETSI NFV and cloud native existing in parallel.

A CSP's move to cloud native will also depend on how quickly its suppliers redesign their solutions for microservices and a cloud-native infrastructure, and how quickly the CSP develops cloud-native operational procedures. CSPs can avoid excessive operational disruption by introducing solutions that maintain both new cloud-native software and procedures and their ETSI NFV deployments.

Supporting mixed cloud environments

Nokia's approach to readying the telco cloud for cloud-native applications uses Docker-based containers that are more manageable than VMs. Nokia automates the deployment and lifecycle management of containers and applications using Kubernetes and its supporting tools. Additionally, because most CSPs have network functions already running in VMs managed by VMWare or OpenStack, Nokia enables both environments to co-exist and be managed by the same operations team.

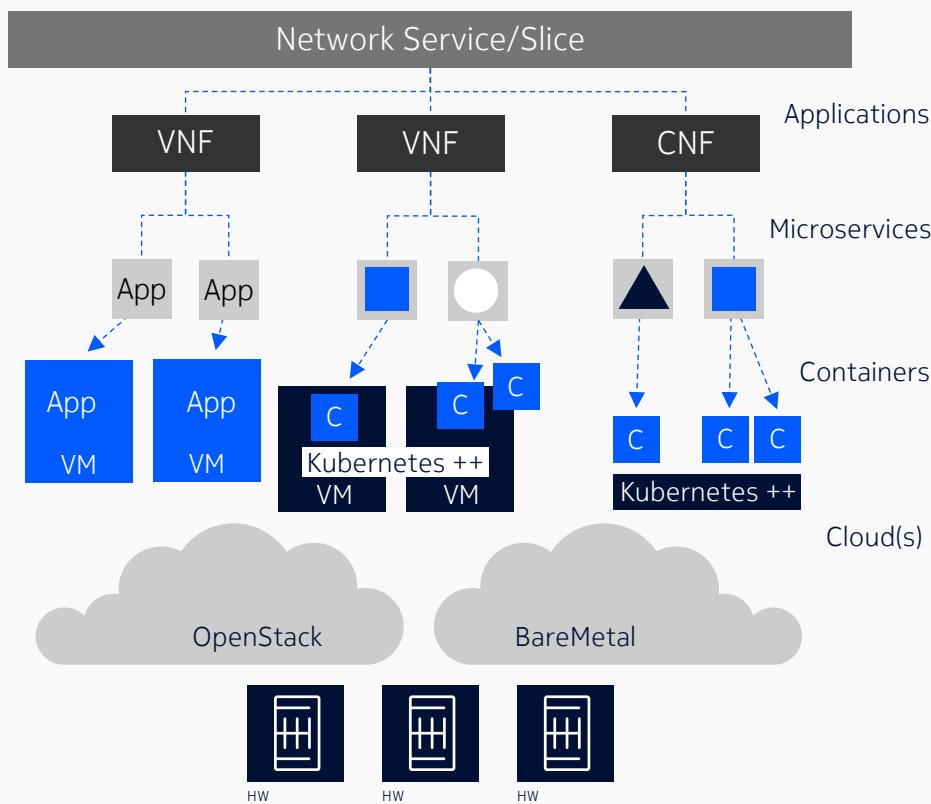Figure 3. Adding container support and cloud-native management methods

Figure 3 shows the layers of management for such a converged cloud, as well as the various cloud environments supported by Nokia cloud-native applications and management solutions. The left side of the illustration shows the co-existence of VMs and containers, including containers within VMs.

Deploying cloud-native containers on VMs is a supported configuration, though this configuration is not the most efficient in its use of infrastructure resources. The alternative of deploying containers on Bare Metal servers reduces the amount of cloud infrastructure management processes and promises to be more efficient and the most economically viable solution in the long term. That said, containers in VMs is a reasonable transitional approach, enabling operations teams to become comfortable with managing cloud-native applications, and moving to the more efficient Bare Metal server deployments over time.

The converged technology cloud illustrated in Figure 3 requires additional capabilities in the cloud management software stack. As we've noted earlier, Kubernetes together with several supporting tools

manage the cloud-native applications, and Nokia offers these tools in its new product, Nokia Container Services. While Nokia CloudBand provides the layered components of the ETSI NFV MANO model, namely the VIM, VNFM, and NFVO, Nokia Container Services offers functions and tools for carrier grade orchestration, operations, and lifecycle management of containerized, cloud-native network functions and applications. More on Nokia Container Services can be found in the next section.

Another important element of the Nokia converged cloud management solution is Nokia CloudBand Network Director. CloudBand Network Director orchestrates virtualized services in distributed, multi-tenant, multivendor cloud environments, unifying the management of ETSI NFV MANO and containerized cloud native.

As a resource orchestrator, CloudBand Network Director administers, monitors and optimizes NFV infrastructure resources and provides an aggregated view across geographically distributed NFVI nodes. As a network service orchestrator, the system supplies network services comprising multiple VNFs and CNFs and automates service lifecycles, including deployment, monitoring, workload scaling, updates and termination.

Adding a repository for CNF images and artifacts, the Helm client and a Kubernetes plug-in, CloudBand Network Director runs application CNF lifecycle and resource management tasks including:

- intelligent workload management across multiple infrastructures
- real-time monitoring, policy control and closed loop operations
- centralized onboarding of CNFs.

Leveraging the Kubernetes cluster API, CloudBand Network Director can also run infrastructure management for the cloud including:

- central Kubernetes cluster LCM triggers and configuration
- cluster capacity monitoring, closed loop
- plug-in-based Nokia/third party, on-premise/public infrastructure support.

Service vs. NFV vs. Container Orchestration

Like many tech buzzwords, "orchestration" is used in multiple contexts and can be confusing. Here we define orchestration in three areas:

E2E Service Orchestration is parsing subscriber-facing service components into their requisite resource-facing elements (physical and virtual) and coordinating their implementation.

NFV Orchestration manages the installation and LCM of virtual network functions in ETSI MANO environments.

Container Orchestration uses Kubernetes to automate the deployment, scaling, placement and management of clusters of containerized applications and network functions or application suites.
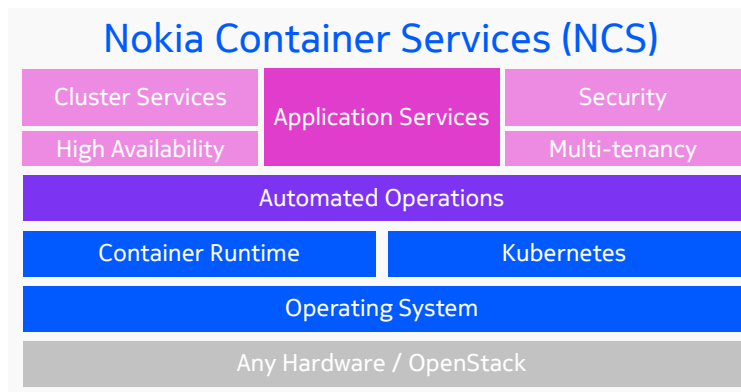

Nokia Container Services Overview

Nokia Container Services is a carrier grade, integrated set of hardened open source and Nokia-developed components for creating and managing cloud native. It delivers a container runtime element along with management and orchestration of those containers by open source software including Docker, Kubernetes and Helm. Container Services also provides fault and performance monitoring and management of Kubernetes clusters and the workloads deployed in them.

Nokia adds carrier-grade capabilities on top of multiple open source components to achieve multi-tenancy, user and image authentication and authorization, networking policies and resource isolation. Nokia also offers high availability capabilities for failure resiliency.

Figure 5. Nokia Container Services functional elements.

The key Nokia Container Services components include:

- **Kubernetes** for orchestrating (placement, scheduling and deployment) containerized workloads.
- **Container runtime** Docker for executing containers and managing container images on a node.
- **Kubernetes Cluster management**
  - Lifecycle management; including create, install, scale out/in, restart and upgrade
  - Multi-cluster management, sharing common services like telemetry between clusters
  - Fault and log management
  - Networking configuration.
- **Multi-tenancy** for O&M services shared across clusters and namespaces to enable a multiple container network.
- **High availability** for key components, including live cluster upgrades, Helm chart, image registry redundancy and others.
- **Automated operations** including cluster lifecycle orchestration and management, system backup and upgrades.
- **Application services** for applications management with Helm and command line interface-based lifecycle commands. Harbor registry stores Docker images and Helm charts.

- **Securing** the cluster and associated networking, as well as the applications running within, including networking policies, Pod Security Policy, Single Sign On, Role-Based Access Control, and hardening.

- **Operating System** images defined for running on hypervisors (in VMs) or on bare metal servers.

- **Anyplace** capabilities allow the creation and management of multiple clusters across different infrastructures and regions.

Nokia supports leading CSP in its cloud native migration

A leading mobile CSP aims to evolve from ETSI MANO to cloud-native networks, operations and services. Recognizing that running containers in VMs is an inefficient use of compute resources, the CSP has a clear preference for Bare Metal deployments.

As with many in the telco world, the CSP's network is multivendor. With around 5,000 servers in its Nokia CloudBand Infrastructure Software (CBIS)-managed cloud infrastructure, the CSP is pressing suppliers to shorten their development roadmaps and deliver cloud-native solutions as soon as possible.

Currently, the Nokia 5G Unified Data Management (UDM) core element is container-based and deployed in an OpenStack VM. Nokia is working with the CSP now to design the cloud-native environment it needs to complete its 5G core migration from running in VMs to running in containers on Bare Metal servers.

Given the complex nature of the CSP's mobile core and the need to update staff procedures and skill levels, the planning and design effort for transitioning to cloud native is considerable and underway.

Summary

Webscale service providers have shown how to manage large complex data centers and networks cost effectively and with great agility. Where CSPs typically take months to upgrade or launch services, webscale companies do it in minutes, largely because they have adopted cloud-native methods, tools, applications and infrastructure.

Many CSPs are determined to improve their network and organizational agility to achieve shorter time-to-market. Yet, they face challenges in the shape of a production telco cloud that must be maintained while they and their vendors evolve to cloud native. They face the challenge of building their network and operations teams' knowledge of the cloud-native environment, while also maintaining their current OpenStack or VMWare management environments. This calls for a converged management approach that supports existing ETSI NFV MANO deployments and cloud-native functions in containers during the transition period.

Full cloud-native transformation calls for a move away from containers running in VMs to containers on Bare Metal servers, which is a more efficient use of compute resources while being more easily automated and resulting in a more agile infrastructure.

This is no small task given the complexity of many CSP network environments. However, the prize is worth the effort as cloud-native transformation delivers a more agile, flexible, and efficient mode of operations for CSPs as we head deeper into the 5G era.

> "Large, reliable, distributed packet and message processing systems are the foundation of telecommunications networks, and many webscale concepts are built on this foundation. With that said, while optimizing their own networks and applications, webscale Internet companies have driven significant innovation in the cloud environment and created an ecosystem that Verizon and others can benefit from."
>
> **Rick Hornby, Verizon - Aug 2018**

Glossary

CBIS   Nokia CloudBand Infrastructure Software

CNF   Cloud-native Network Function / Containerized Network Function

Docker   Docker is a tool designed to make it easy to create, deploy and run applications in a loosely isolated environment called a container. The isolation and security allow many containers to run simultaneously on a given host. Containers are lightweight because they don't need the extra load of a hypervisor but run directly within the host machine's kernel. This means more containers can be run on a given hardware combination than using virtual machines.

Kubernetes   Kubernetes is a system for orchestrating and managing the lifecycles of containers and containerized applications.

Helm   Helm is a Kubernetes package and operations manager. Helm is used for creating new charts, packaging charts, installing and uninstalling charts using Kubernetes.

Helm Chart	Keeping with the nautical theme, a Helm chart is a bundle of information necessary to create an instance of a Kubernetes application. Applications or services can be defined in a Helm chart.
NFV	Network Function Virtualization
VNF	Virtual Network Function
MANO	ETSI standard architecture for Management and Orchestration. According to ETSI, MANO is responsible for deploying and connecting hosted elements or VNFs of virtual machine environments.
ETSI	European Telecommunications Standards Institute
NFVI	Network Function Virtualization Infrastructure (ex. CBIS)
NFVO	Network Function Virtualization Orchestrator (ex. CBND)
VNFM	Virtual Network Functions Manager (ex. CBAM)
Bare Metal	Bare Metal refers a compute server that is a single-tenant physical server, as opposed to hypervisor-managed compute resources. Bare Metal provisioning is the installation of the operating system along with requisite drivers and instrumentation needed to provision a server for hosting container-based applications.
UDM	Nokia Unified (subscriber) Data Management function in 5G Core