

Reinventing telcos for the cloud

White paper

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1 Executive summary

By 2020, mobile broadband networks will need to be prepared to deliver gigabytes of data per user per day for around USD 1 per GB, despite the added challenge of unpredictable traffic patterns. In addition, with new apps and services emerging continuously, those operators that can implement new services rapidly will create a distinct competitive advantage.

The telco cloud is a key enabler in which the human possibilities of technology are being expanded to address all these requirements. Cloud computing shifts network functions away from dedicated hardware platforms into virtualized software components that can be implemented on general-purpose hardware, much of which can be pooled in centralized data centers. As well as delivering major savings in hardware and management costs, this approach also increases the flexibility and agility of the network to promote innovation.

There are four key areas, or dimensions, that need to be developed to enable a full telco cloud deployment:

- Network Function Virtualization (NFV) uses IT virtualization technology to separate network functions from the underlying hardware. For a full telco cloud implementation, virtualization is complemented by a complete, dedicated cloud platform and management system.
- Software Defined Networking (SDN) separates the control plane from the forwarding plane, making the networking programmable via open interfaces with a centralized control function. This enables the dynamic allocation of physical networking resources according to different demands and will play a vital role in various networking domains, e.g. the datacenter or the backhaul network.
- The radio access network (RAN) is particularly challenging for network virtualization and cloud implementation.
 - There are strict real-time requirements and latency constraints for many functions, which mean the RAN will continue to require a distributed topology, including dedicated hardware to support signal processing in the base stations. However, following the path of centralized coordination new options arise for RAN functionality implemented on general purpose processors (GPPs).
 - Operators are looking to deploy differentiating, cutting-edge services with the best-possible consumer experience as rapidly as possible. Mobile Edge computing can provide a solution that effectively introduces a distributed cloud platform very close to the end user. The use of virtualized resources and a virtual resource manager in the RAN can support several concurrent applications and makes it easy to deploy or withdraw applications and content to meet changing market needs.
- One of the main benefits of cloud computing is the harmonization and reduction of management effort involved in operating a network, for which increased automation will be crucial. A global network orchestrator (GNO) is needed to allow this network automation and enable on top SON, CEM and service fulfillment across the entire network.

The pace of technology development means no vendor can provide a complete telco cloud ecosystem on its own. Partnering, open source software and open APIs are vital for extracting the greatest innovation out of an open ecosystem and for supporting multivendor deployments. There are a variety of initiatives that aim to create a telco cloud ecosystem that supports the co-existence of traditional networks and cloud environments and gives operators the option of choosing the most competitive hardware and cloud platform for their specific needs. The Open Platform for NFV (OPNFV) is a new open source project that aims to accelerate the evolution of the telco cloud.

While securing the communication network and its infrastructure always receives high attention from operators and vendors, securing the network built from VNFs requires new concepts. Since VNFs share the same physical compute infrastructure, special precautions must be taken to shield the VNFs from “attacks”, either intended or unintended. In a telco cloud environment there are various technologies that can be used such as virtual firewalls, security zones and virtual tenant networks.

To seize the opportunity to play a strategic role in this dynamic market, operators will need to carefully select a path of transformation of their network, forge strategic industry partnerships and choose a vendor who has deep understanding of technology and offers end to end expertise to help them migrate to a cloud network.

Nokia Networks has been a leading proponent of the telco cloud from an early stage. As far back as 2011, Nokia Networks launched Liquid Core. Since then, Nokia Networks has run proof-of-concepts and live cloud trials to provide the technology foundation for commercial readiness of the telco cloud.

2 Why the telco cloud must be a top strategic priority for operators

Mobile broadband operators face evolving challenges and exciting new opportunities to build profitability.

The continuing growth in data traffic is perhaps the most obvious. Growth is almost unbounded, driven by booming demand for HD video and the arrival of new devices and services. While this calls for investment in new network capacity, identifying the optimum investments is complicated by traffic patterns that are increasingly unpredictable. This was demonstrated starkly in September 2014 when Apple released its iOS 8 operating system. Weighing in at 1.3 GB the update generated 50% higher network traffic than normal at one time in the United States.¹

Maintaining a great network experience for subscribers against this backdrop is extremely important, and will become critical as a principal driver of revenue. Agile innovation and the ability to offer exciting new services also have roles to

1. Digital Trends <http://www.digitaltrends.com/mobile/apple-ios-8-update-hogs-internet-traffic/#ixzz3SCxKhdP6>

play. Traditional lead times for new developments in telco services can run into months, but today operators are competing with web players who can pump out new services from conception to launch within days.

At the same time that these demands for capacity, agility and quality are growing, operators are looking to improve profitability by drastically driving down the cost of delivering each bit.

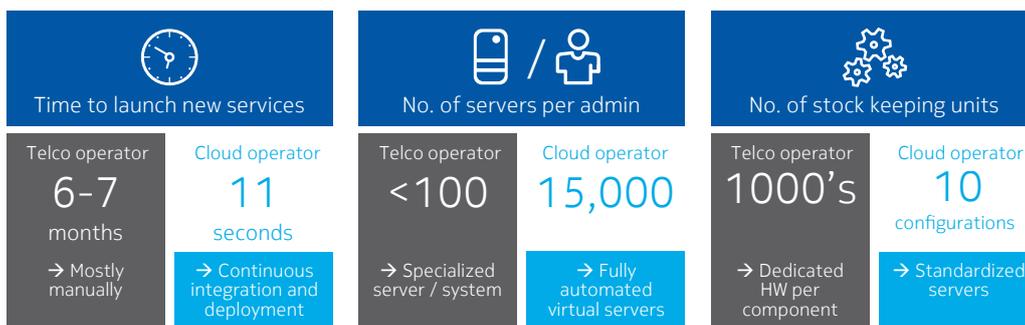
As part of its Technology Vision 2020, Nokia Networks believes that by 2020, networks will need to deliver gigabytes of data per user per day for around USD 1 per GB.

Telco cloud is a key enabler to manage these challenges. The benefits of the telco cloud are similar to those already well-proven by cloud computing in the IT environment, namely lower capital and operational costs and increased business agility.

2.1 Delivering more network capacity, quality and agility at lower cost

When looking at today’s communication environment and the services we are using we can see a tremendous change compared to 10-15 years ago. While telco services have been provided by operators, the Internet has been available mainly via fixed access and IT-driven applications (like email or online portals) provided either by operators or by application services providers (e.g. Yahoo). However, this has changed completely with the border between telco and IT services disappearing mainly because of the rise of the smartphone and innovations such as Skype, Facebook, What’s app and others.

The options open to mobile operators to monetize services on top of pure connectivity are being steadily eroded. One major reason for this is the productivity gap between the OTT service providers using the latest IT technology (cloud computing and storage) and telco operators with their traditional network equipment and services platforms. OTT providers can operate their services with much higher efficiency as virtualization and cloud principles allow them to use standard and automated data centers. They also enjoy more agility and flexibility as services are defined in software and can be deployed and changed much faster to customer needs.



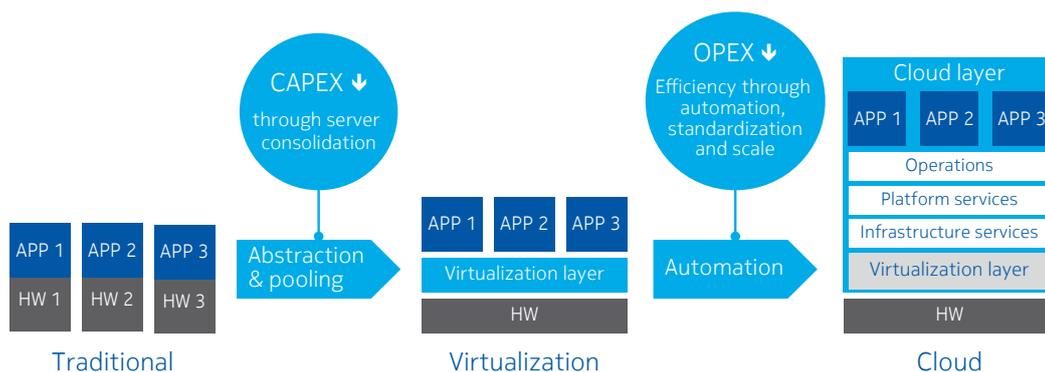
Graph 1: Performance gap of telco vs. cloud operators

The telco cloud allows operators to win back their competitiveness in services, using the same IT technology, processes and tools as OTT service providers. At the same time, the telco cloud helps operators to also gain these benefits in the network layer, enabling higher utilization of hardware to improve the cost per bit for connectivity.

3 Introduction: What is the telco cloud?

Cloud computing has been transforming the IT industry over the last decade. It has helped to drive down costs, improve business agility and has enabled new business models.^{2,3}

The gains are due to the separation of software-based applications from the underlying hardware via virtualization and a highly automated way to operate the applications on a hardware platform with a cloud management system (see graph 2).



Graph2: Via virtualization to cloud data centers

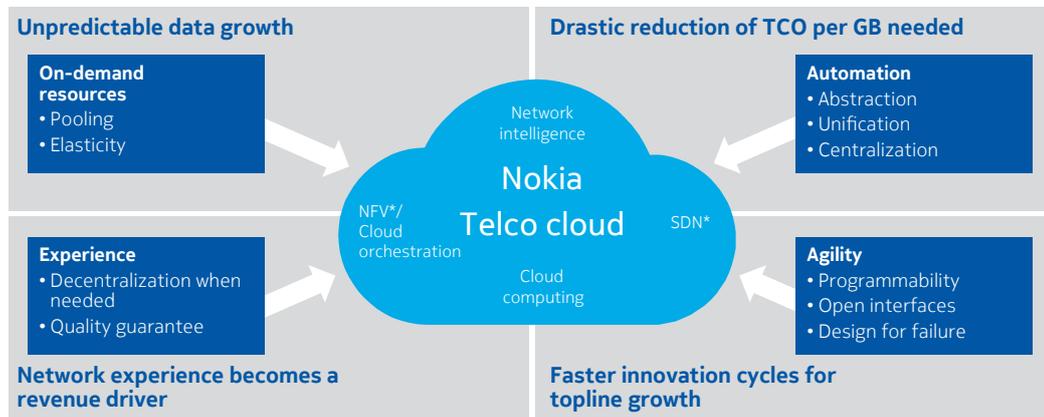
These cloud design principles are being applied to telco networks and telco applications built according to the traditional infrastructure approach. This is creating the foundation for what we call the telco cloud using the main industry programs like Network Function Virtualization (NFV), Software-Defined Networking (SDN) and Mobile-Edge Computing (MEC). However, as telco applications are not just web-based IT applications, specific requirements need to be considered to ensure a superior customer experience and these may place new requirements on the platforms and tools being used.

2. Forbes <http://www.forbes.com/sites/louiscolombus/2013/04/10/making-cloud-computing-pay-2/>

3. CIO.com: <http://www.cio.com/article/2387672/service-oriented-architecture/how-cloud-computing-helps-cut-costs--boost-profits.html>

3.1 Key success factors for the telco cloud

How the cloud approach can answer telco challenges



*NFV: Network Function Virtualization; SDN: Software-Defined Networking

Graph 3: Telco cloud help to address the challenges

Shifting telco resources to the cloud can help operators cope with unpredictable data growth by creating large pools of resources that can be deployed to support the distributed network as needed.

Adopting a centralized and standardized infrastructure enables operators to deploy a high level of automation in network operations. It also makes it easier for developers to design applications and services that can run on the resulting platform in a standard way.

This automation and standardization will drastically reduce costs and this will probably be the key driver for operators when they initially consider adopting the cloud approach. However, it's also the key enabler for business agility and this will become an increasingly important driver for success going forward.

Agility paves the way for new ways of working that can massively speed up service development and deployment. In addition, by lowering the costs of a new service turning out to be a failure, coupled with the reduced risk of failure in the first place, makes innovation far more attractive.

4 Four dimensions in building the telco cloud

Nokia Networks believes there are four key areas, or dimensions, that need to be developed to enable a full telco cloud deployment. The approach set out in this white paper will enable mobile networks to support several cloud stacks simultaneously, offering maximum flexibility and protecting investments.

4.1 Network Function Virtualization

The first step in adapting cloud computing technology for the telco domain is to virtualize service and control functions in the core network. Network

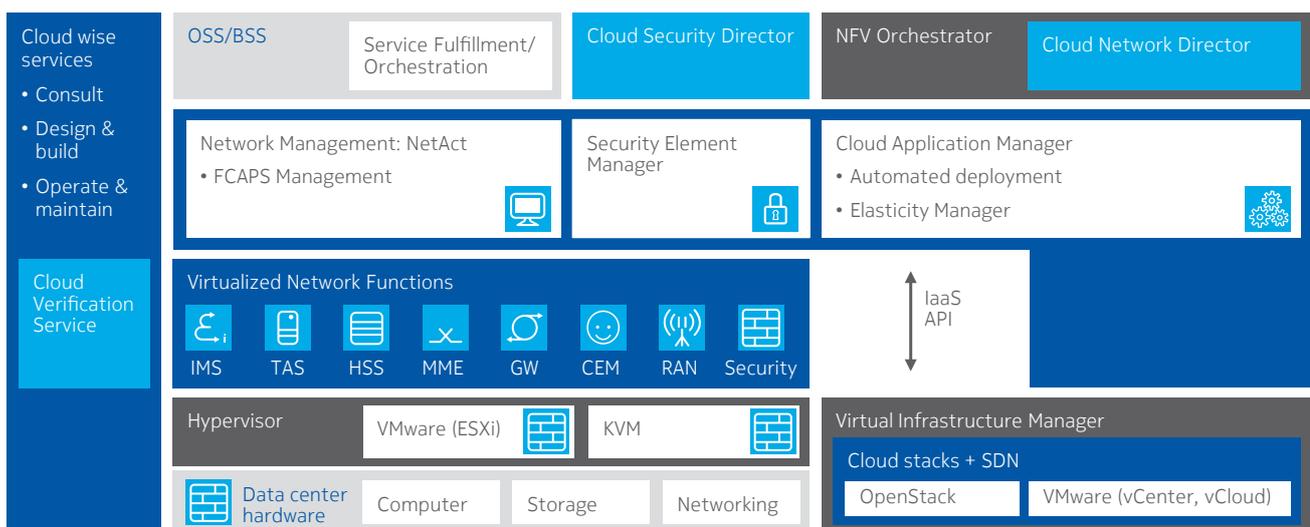
Function Virtualization (NFV) leverages IT virtualization technology to separate network functions from the underlying hardware. By 'building' the necessary functionality in software, NFV enables the use of non-proprietary, commoditized hardware. NFV is applicable to any data plane packet processing and control plane function in fixed and mobile network infrastructures.⁴

In other words, previously discrete and vertically integrated network elements can be implemented in a cloud platform to form a private Infrastructure as a Service (IaaS) cloud. This approach is widely adopted in IT, but existing management features in IT-style cloud stacks do not provide the necessary capabilities to translate directly into the telco domain.

For a full telco cloud implementation, virtualization needs to be complemented by a complete, dedicated cloud platform and management system. This must include classical network management for legacy systems, plus virtualized network function, cloud orchestration and application management to achieve the full benefits of automated provisioning and elastic scaling of the network.

In the case of Nokia Networks telco cloud architecture, this additional capability is delivered by a deployment, monitoring and orchestration component that enables the network elements to run independently of the virtual infrastructure.

One potential issue with cloud infrastructure is that the application interfaces (APIs) provide a risk of possible vendor lock in, which operators typically try to avoid. The industry therefore needs to agree on a restricted number of variants in API design or promote the use of open source solutions, which at least offer a quasi-industry standard.

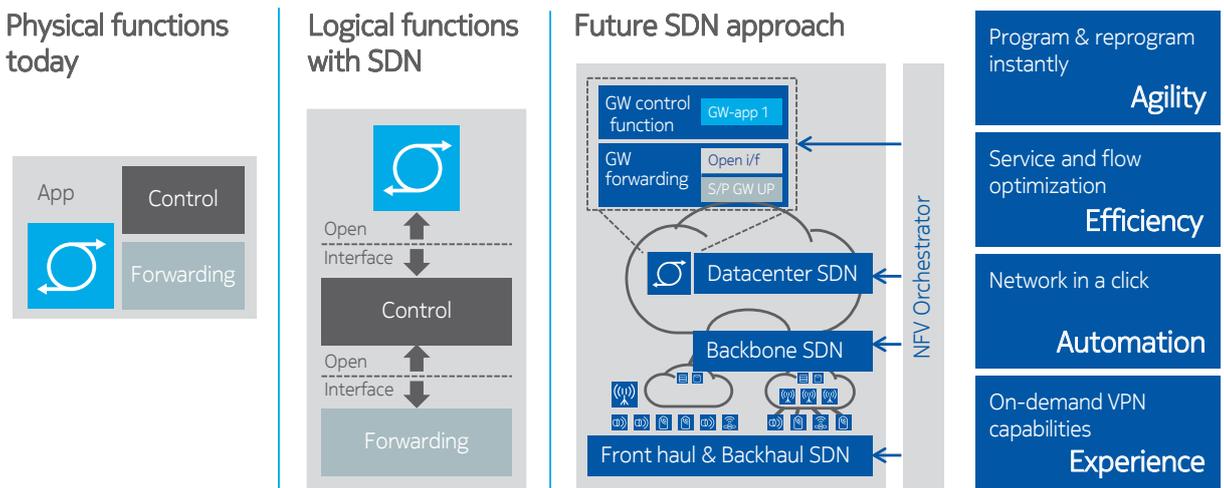


Graph 4: Clear separation of infrastructure, network, and management layer in NFV architecture

4. ETSI NFV Whitepaper (http://portal.etsi.org/NFV/NFV_White_Paper.pdf)

4.2 SDN in mobile networks

Using software defined networking (SDN) will play a vital role in future mobile networks. There are four areas in which this is important.



Graph 5: Software defined networking for creating a programmable infrastructure

Using SDN technologies to virtualize the data center LAN enables the infrastructure management to offer the application software on-demand on a dedicated virtual tenant LAN governed by Service Level Agreements (SLAs). The tenant LAN shields the application traffic from other traffic within the data center. Without this feature it would be much more costly to build a secure telco cloud.

In the case of packet gateways, SDN serves as a tool to separate the control plane from the forwarding plane, making the network programmable via open APIs with a centralized control function. The separation of the control and forwarding functions allows each to be scaled independently, which is extremely helpful when the balance between the signaling load and the user plane traffic can vary depending on the application.

Full separation of the control and the forwarding function within the gateway allows for additional service chaining. A conventional gateway does more than simply route packets. It also provides functions that include tunnel termination, deep packet inspection, network address translation and ciphering. To reduce costs and latency, virtualization allows these functions to be applied to each data stream only as required.

Traffic patterns and user behavior in mobile networks are very dynamic. SON capabilities automatically adjust the radio access network parameters to optimize the user experience. However, it is also important to dynamically optimize the backhaul network according to actual traffic needs. Through programmability enabled by SDN, SON functions can now simultaneously optimize RAN and transport parameters for better network utilization.

IP core wide area network are likely to be enhanced gradually with programmability introduced by SDN. There are two drivers. Firstly, end users expect on-demand delivery of VPN services for their application services. Secondly, in a distributed compute environment for virtualized network functions, the network function software will occasionally migrate to different locations for the network service to deliver a better customer experience. This flexibility needs dynamic adjustment of the wide area network connections, which can be delivered through an SDN-enhanced IP core network.

4.3 Cloud enhancement of the RAN

The radio access network (RAN) is a particularly challenging environment for potential network virtualization and cloud implementations. There are strict real-time requirements and latency constraints for many functions, and these limitations mean that the RAN will continue to require a distributed topology, including dedicated hardware to support signal processing in the base stations.

4.3.1 Striking a balance between distributed and centralized functions

The constraints of latency and real-time applications are likely to become more demanding in the next generation of RAN technologies, that is 5G.

There is a growing trend to centralize certain control functions of the RAN. This is driven by several developments, including Heterogeneous Networks (HetNets) that populate the macro network with an overlay of small cells to provide affordable extra capacity, especially in high-density traffic hotspots such as airports or shopping malls. Here a macro base station (BTS) may play a coordinating role across several small cells, rather than fully distributing control functions across all of them.

Operators may opt to deploy a 'central scheduler' element to take on high-level control functions in the RAN. This would reduce the need for such high-meshed signaling links between the BTSs, resulting in lower latency and easier implementation. A central scheduler would require additional computing power.

Load balancing and traffic steering have an increasingly important role as the traffic load continues to rocket, because dynamic resource allocation can help operators to offset the traffic load, minimize overcapacity and optimize investment. However, these measures require a broad view of activity across the network in order to make effective balancing and steering decisions. Similarly, SON also requires a centralized view to make the most appropriate decisions on resource allocation.

At the same time, there is a trend for such new control functions to be implemented on general purpose processors (GPPs), so they are well suited to run in a data center environment, rather than requiring dedicated, distributed network elements.

Cloud computing can help operators cope with these trends:

- Hardware virtualization and abstraction allow operators to deploy software on various types of processor.
- Virtual infrastructure management enables software to be deployed dynamically either to the BTSs or a centralized control function, as appropriate.
- Orchestration and federation ensure the optimal distribution of control software across the available resources to meet the requirements of services and applications for latency and redundancy. In other words, it safeguards the quality of experience for end users.

This will help in terms of simplifying and reducing the cost of network management and deployment, which may be the initial incentive for operators to explore the telco cloud. Looking ahead, it will also improve operators' ability to accommodate the fast-changing requirements of current and future cellular networks. This added agility promotes the faster deployment of new RAN functionalities that adapt to deployment conditions established by the operator and provides the network with forward compatibility with changing radio requirements in coming generations of network technology.

4.3.2 Mobile Edge Computing

The days of differentiating on coverage and capacity are long gone. Operators are looking to deploy differentiating, cutting-edge services with the best-possible consumer experience as rapidly as possible.

A full cloud stack can provide a solution that effectively introduces a distributed cloud platform very close to the end user. The use of virtualized resources and a virtual resource manager can support several concurrent applications and makes it easy to deploy or withdraw applications and content to meet the changing needs of the market.

Nokia Liquid Applications

The Nokia Radio Application Cloud Server (RACS) implements a full cloud stack that is tightly integrated with the base station. It represents an outdoor-capable, highly distributed cloud computing environment. RACS can access information buried deep within the RAN to maintain the best end user experience.

RACS functionality may be deployed across thousands of locations, but they can all be managed by a common application framework manager, which provides a deployment, federation and orchestration function to co-ordinate operations throughout the distributed cloud. It distributes new services and applications according to the needs of the operator and end user.

With applications, services and content placed close to mobile subscribers, real-time network information can be used to transform the customer experience and support rapid service innovation and deployment in the network.

As a more centralized approach becomes the norm, RACS will also support a more centralized cloud framework.

4.4 End-to-end management and orchestration

One of the main goals in introducing cloud computing is the harmonization and reduction of management effort involved in operating a network. However, software-based substitutes for network elements, separating control and data plane functions, introducing new components and functions, and the need to distribute functionality across virtualized resources all call for fresh thinking in network management and operations to avoid offsetting the potential savings. Increased automation will therefore be crucial.

The data and application architecture will also evolve to drive automation, not just for individual network functions or within a network domain, but also across network domains to enable network-wide management applications and service fulfilment.

A new functional area, called a Global Network Orchestrator (GNO) is needed to enable the necessary automation. Such an orchestrator must contain the processes, sequences, resources, topologies and functions needed to automatically deploy and manage applications and services across the entire mobile broadband network.

It must also provide network information as input for applications like SON, Customer Experience Management (CEM) and Service Fulfillment. With access to information about the status of various network functions, the management applications optimize the network end-to-end, rather than optimize individual network functions or areas.

The orchestrator then ensures that changes requested and initiated by the automated operational processes and the SON and CEM functions do not interfere with each other.

For the GNO concept to work successfully across the entire network it will naturally need to integrate network functions from different suppliers. The industry therefore needs to agree the type of interfaces and standardized capabilities that a GNO will use.

The preparation for these standards has already started with ETSI NFV. The NFV work item Management and Orchestration (NFV MANO) aims to describe a framework for the management and orchestration of VNFs, including interfaces and the interworking with other operations and management systems. The latest specification published in December 2014 focuses on the management and orchestration of virtualized infrastructures and network functions as well as on the lifecycle management of network services. The end-to-end management of services is not yet in the current scope of the work.

Nokia Cloud Network Director provides the GNO capabilities described above for the mobile core and packet core network services.

5 Creating telco cloud solutions

5.1 The vital need to build open ecosystems

The old ways of doing business, such as developing everything in house, do not work anymore. This is simply too slow and inefficient. The telecom industry can only stay competitive, agile and effective by collaborating more with different players.

The pace of technology development means no vendor can provide a complete telco cloud ecosystem on its own. Partnering and open source software and APIs are vital for extracting the greatest innovation out of an open ecosystem and for supporting multivendor deployments.

The Open Platform for NFV (OPNFV) is a new open source project that aims to accelerate the evolution of NFV. OPNFV will establish a carrier-grade, integrated, open source reference platform that industry peers will build together to evolve NFV and ensure consistency, performance and interoperability among multiple open source components. Because multiple open source NFV building blocks already exist, OPNFV will work with upstream projects to coordinate continuous integration and testing while filling development gaps.

The initial scope of OPNFV will be on building NFV Infrastructure (NFVI), Virtualized Infrastructure Management (VIM), including application programmable interfaces (APIs) to other NFV elements, which together form the basic infrastructure required for VNFs and Management and Network Orchestration (MANO) components. OPNFV is expected to increase performance and power efficiency; improve reliability, availability, and serviceability; and deliver comprehensive platform instrumentation.

Nokia Networks adopts a partnering strategy

Nokia Networks is collaborating with different partners to offer telco cloud solutions compliant with ETSI NFV principles. This provides operators with an open source-based cloud that meets their reliability and availability requirements and accelerates their transition to NFV deployments.

Nokia Networks is committed to building a telco cloud ecosystem that supports the co-existence of traditional networks and cloud environments and gives operators the option of choosing the most competitive hardware and cloud platform for their specific needs. The company supports multiple cloud stacks, including VMware Inc. and OpenStack, allowing operators to pick the cloud technology that best fits their business and technology needs:

- Nokia Networks has developed its telco cloud on top of VMware virtualization technology in close cooperation with VMware Inc. Telecom infrastructure related requirements are injected to the ESXi hypervisor and vCloud Director roadmaps.
- Nokia Networks enables VNFs to run on a cloud infrastructure layer that integrates HP data center hardware, hypervisor and virtual infrastructure manager. This enables cloud environments built on open source technologies, with a choice of development tools, deployment models and freedom from vendor lock-in. As well Nokia Networks can utilize HP Helion OpenStack® technology to benefit from HP's industry leading OpenStack expertise.
- Nokia Networks collaborates with Red Hat, Inc. to enable efficient operation of the Nokia virtualized core network functions and management systems on top of Red Hat's OpenStack technology. Red Hat is the largest contributor to OpenStack.
- The Juniper Networks® MetaFabric™ data center architecture, including Contrail – Juniper's network virtualization and cloud network automation solution based on SDN, extends the Nokia Networks telco cloud solution. Nokia Networks and Juniper's bundled solution, delivered through carrier-grade services, will provide operators with an open ecosystem telco cloud solution, based on OpenStack.

Nokia Networks opens the opportunity for third party providers to certify their tested software components running on its telco cloud platform and in the process adding value to its own virtual network functions.

Certification will ensure smooth deployment and management of applications onto the Nokia Networks telco cloud platform. It completes integration with Nokia's core applications, where operators can build a customized ecosystem using the easily-scaled integrated application.

5.2 Assuring Telco Cloud Security

While securing the communication network and its infrastructure always receives high attention from operators and vendors, securing the network built from VNFs requires new concepts. Since VNFs share the same physical compute infrastructure, special precautions must be taken to shield the VNFs from “attacks”, either intended or unintended. In a telco cloud environment there are various technologies that can be used such as virtual firewalls, security zones and virtual tenant networks.

If operators took no measures, virtualized telco applications would be arbitrarily placed by the Virtual Infrastructure Management. This could lead to a highly sensitive application like the Home Subscriber Server being placed in the same hypervisor as a Web server. The logical separation between the functions is broken and an attacker that gains access to the Web server could easily get to the sensitive contents of the HSS database.

This threat can be avoided by structuring the virtualized telco network into security zones, which ensure that only applications with comparable functional criticality and, therefore, similar security requirements, are placed on the same hypervisor. While the ‘security zone’ concept doesn’t diminish the probability of attacks, it significantly reduces their impact.

In a similar way to security zones, traffic with comparable functionality and security requirements – for example signaling, control, data – is assigned to different virtual LANs connecting the different telco applications, avoiding the danger that unauthorized access to one type of traffic allows access to all traffic.

Data exchanges between telco Virtual Machines (VMs) must employ mutual authentication and integrity protection to guarantee that only authorized VMs talk to each other and that integrity violation can be detected. Encryption must also be considered. The same principles apply even more for the protection of telco cloud management traffic. Network management systems are the brain of the virtualized telco network, meaning that traffic encryption is essential.

Virtualization and cloud computing introduce a new virtual networking layer - the traffic between VMs on the same host hardware and the traffic between different host hardware units. This raises the need for virtual security appliances in the telco cloud to achieve a grade of security comparable to physical networks.

When the Global Network Orchestrator (GNO) automates the instantiation of network functions, it needs a Security Orchestrator as supporting functionality, which enables the GNO to select and request appropriate security functions from the available resources, either virtual or physical ones.

Nokia offers a comprehensive set of security products and helps with security consulting expertise to create operator-optimized solutions.

5.3 Applying the necessary expertise

Telco Cloud is a 'business transformation' fuelled by virtualization technology which offers extreme flexibility in operator's network. Multitude of technologies and multiple software makes networks complex to manage. Operators are looking for able vendor partner who can provide business value in this transformative process and operations at the same time.

Successful and secure migration to telco cloud is a complex task for any operator, one that demands in-depth know-how and experience.

Such expertise is needed by operators to prepare for the telco cloud and ensure it will meet their needs, taking into account suitable virtualization technologies and the operator's existing and potential hardware partners. Once a solid blueprint is drawn up, the design and building of the telco cloud requires specialized expertise to ensure tight integration and solid security vital for the fault-free migration of telco services. Then it's a matter of ensuring the deployed telco cloud is operated and maintained to its fullest potential, from software maintenance to the training of personnel.

Nokia Networks cloud wise services

Nokia Networks has been an industry leader in bringing the benefits of the cloud to the telco and ensuring the cloud can meet the high-performance demands of carrier-grade operations. The progress we made in this area has enabled us to build a knowledge base and level of expertise around the telco cloud that other vendors find hard to match.

This wisdom is encapsulated in our **cloud wise services** that help operators as they transform their networks to the cloud, deploy cloud applications, build the right security, and run their infrastructure and applications.

Another of our initiatives is the development of a strong Telco Cloud partner ecosystem, through which operators can get comprehensive cloud solutions that meet the highest quality and security standards. Certifying partners who work with us creates solutions that are tested, functional and supported by Nokia Networks.

Operators benefit from the flexibility of a choice of applications, components, platform and the right service expertise for Telco Cloud migrations. We provide this through our dedicated cloud engineers for horizontal and vertical integration backed by a pool of experts and supported by a global delivery center backbone.

The road towards commercial readiness of telco cloud

Nokia Networks has been a leading proponent of the telco cloud from an early stage. As far back as 2011, Nokia Networks launched Liquid Core.

Since then, Nokia Networks has run proof-of-concepts and live cloud trials to provide the technology foundation for the telco cloud. These projects have demonstrated core network software executed on virtualized infrastructure, with the virtualization of network functions such as IMS and TAS, which are required for VoLTE, HSS front-end as well as MME and S/P Gateway for vEPC.

Further projects have shown telco cloud readiness for VoLTE and vEPC and verified the automated deployment and elastic scaling of virtualized network elements, live migration of virtual machines from one server to another, and recovery from hardware failures.

Leading operators completed the first Voice over LTE (VoLTE) calls on a private telco cloud infrastructure using Nokia Networks technology and expertise. Supported by the Nokia Networks commercial portfolio and a cloud management system that controls the VoLTE applications in operators' private telco cloud, the projects have proven telco cloud's readiness for VoLTE. Nokia Networks cloud wise services for VoLTE have helped operators ready their architecture for multi-vendor integration and core migration, while specialized project management ensured high-quality project delivery.

The successful end-to-end testing, conducted in the operator's live LTE network with user devices, provides a preview of how operators can combine best voice quality and richer communication services with the most competitive and cost-effective infrastructure platforms.

Nokia Networks has completed multiple proof-of-concept and benchmark testing projects with tier 1 operators, proving not only vEPC functionality and performance when deployed on top of Nokia Networks virtual infrastructure, but also when deploying vEPC in multi-vendor environments and on top of third party virtual infrastructures. Like VoLTE, the vEPC is supported by Nokia Networks cloud management products and portfolio, which allows the operator to effectively and automatically manage the vEPC.

Through simplification of the network operability and architecture, Nokia Networks is able to support solutions and services with fast and simplified deployment for cloud use cases such as M2M/IoT traffic handling, MVNO and Enterprise.

These have been major milestones along the road to the first commercial deployment of the Nokia Networks telco cloud solution in a live multivendor network of a major operator in 2014. VoLTE and telco cloud are principal technologies that will help operators to address new business opportunities and deliver a superior voice experience to their customers, with the vEPC solution addressing various new traffic segments.

In 2014, Nokia Networks announced the Middle East and Africa's first Liquid Applications deployment in a commercial operator network. Liquid Applications, a distributed cloud solution, is enabled by the Radio Applications Cloud Server (RACS). This will provide Zain KSA with enhanced 4G throughput and backhaul savings, and will put it into a position to deliver customized applications such as augmented reality and location-based services due to its exposure to real-time network data.

6 Conclusion

It's largely the massively improved speeds of communication networks that have enabled cloud computing to become so widespread in the IT domain in recent years. This has led to massively reduced costs and greater efficiency across a broad spectrum of industries. So it's rather ironic that the peculiar requirements of the communications industry have meant that the concept of centralizing network functions in a cloud architecture remains in its infancy for telco networks.

That is starting to change, as the necessary steps to achieve full telco cloud capability become clear.

The development is ongoing, but the potential advantages for operators that start to ready their networks now will be enormous, not only in terms of efficiency savings, but also in terms of network agility. That agility will give forward-looking operators an unprecedented ability to respond quickly to changing market needs. This will keep them ahead of the competition by enabling them to innovate with exciting new apps and services in a small fraction of the time it would previously have taken. What's more, the risks associated with such adventures in innovation will be far less than today, because they will not require changes in the network hardware.



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