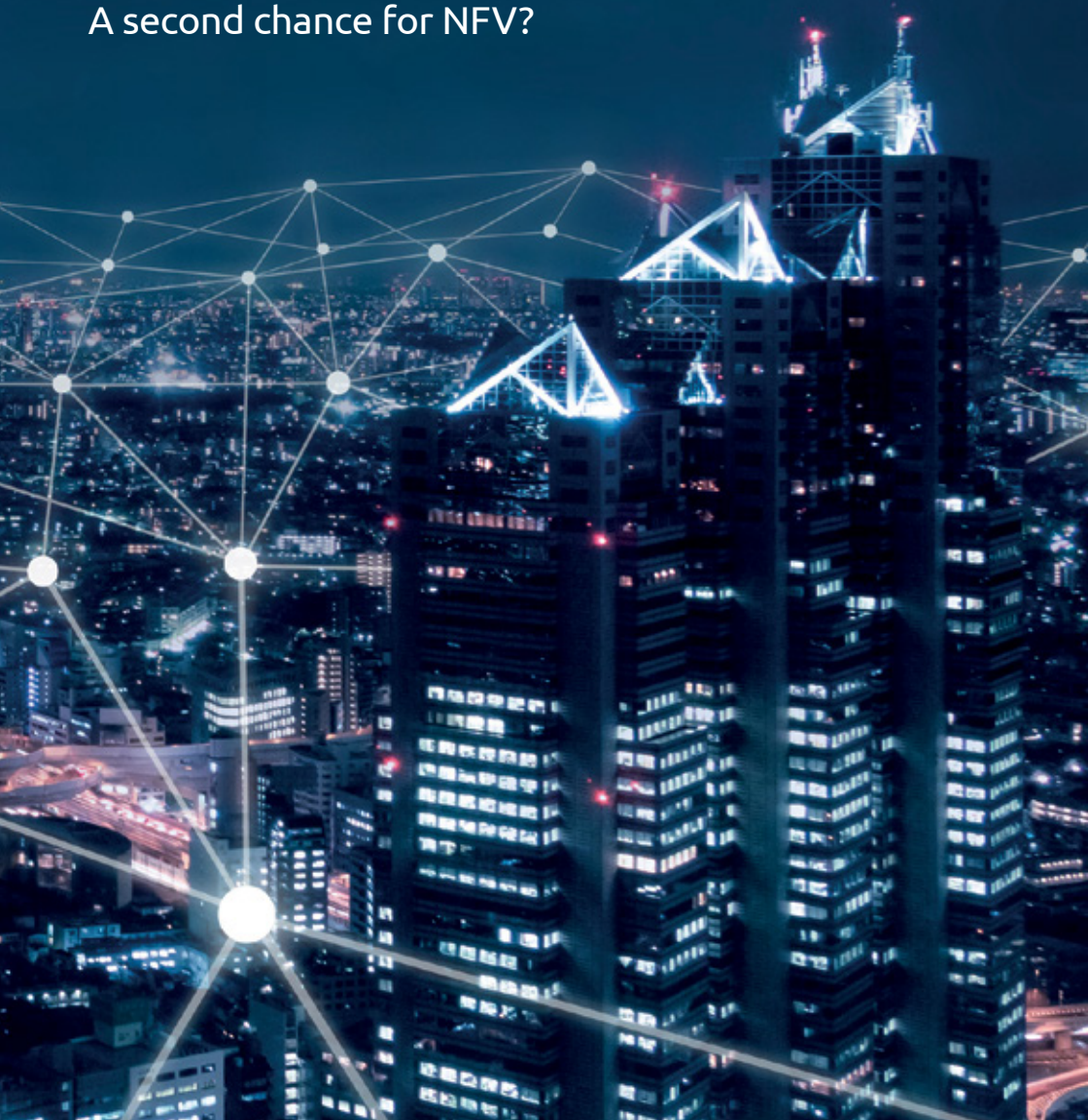
Capgemini engineering

ORCHESTRATING 5G AND OPEN SOURCE

A second chance for NFV?



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Executive summary

This paper presents a retrospective of network function virtualization (NFV), highlighting the context and the main use cases that made NFV a promised land in telecom.

NFV is still waiting to be widely adopted by network operators, who do not see the return on investment that justifies procuring the technology and fail to see solutions to the challenges highlighted herein.

Open source in telecom thrived with the birth of NFV (and SDN) and is now becoming a common approach to development in this industry. Standardization groups that have been reluctant in the past, are currently turning to open source as a way of validating their work and speeding up the adoption of new standards.

The two most prominent platforms in open-source orchestration and their relationship with the most relevant standards development organizations (SDOs) regarding 5G and related technologies are also discussed. The paper also elaborates on the opportunities deriving from the added value of open source in telecom and the need to address specific challenges for a production-ready NFV.

Introduction

NFV has been in the telecom glossary for most of the last decade. However, a series of challenges of a distinct nature (e.g., organizational, technical, and operational) have constrained the realization of its promised benefits. With the rising interest in network softwarization, the influence of open-source communities in the networking ecosystem has significantly boosted, creating ideal conditions for new market entrants and the disruption of traditional networking business.

With 5G networks right on the curve, this whitepaper provides an overview of NFV's history, its motivation, key use cases, and success-blocking challenges. It describes the role that open source is playing towards its future – although late – success, providing the crucial example of orchestration solutions. In parallel, the paper attempts to provide answers to the following important questions:

- What will be the role of NFV in 5G?
- How is open-source software influencing the future of NFV?
- Why is open source increasingly relevant for the telecom business?

Background

NFV origins

Legacy's approach to network equipment was based on proprietary software and hardware, and fixed network functions. This significantly limited network scalability and incentivized overprovisioning traffic strategies (i.e., network dimensioning for estimated traffic peaks), which led to costly sub-utilization of network resources. Simultaneously, there was a need for frequent (network) hardware investments taking into account highly error-prone future traffic estimates, which was an additional contribution to increased capex (and decreased ARPU).

Motivated by the continuous pursuit of efficiency, NFV was devised as the separation of software and hardware, with telecom operators intending to unlock some of the benefits from cloud-based companies.

The initial whitepaper on NFV, launched in 2012 by key telecom operators, emphasized the gains in approximating the networking and IT industries and highlighted the need for leveraging a standard IT virtualization technology to overcome the numerous issues associated with proprietary hardware. Identified benefits included reduced equipment costs and power consumption, improved time-to-market, multi-version and multi-tenancy network appliances, geo-based service launch, increased openness to new entrants, and the encouragement of innovation.

In other words, at a time where SaaS and PaaS offers were starting to reap big fruits for internet- and cloud-centric businesses, operators intended to unlock the same advantages that these companies possessed, such as high service deployment and update agility time-to-market, resource elasticity and associated cost efficiency, and reduction of vendor lock-ins. It might be said that the joint materialization of these benefits is still one of the holy grails for telecom operators, currently pursued in the form of cloud native networks.

NFV as the driver of business transformation

Networking virtualization and softwarization bring two substantial changes compared to traditional network equipment. On the one hand, the software is placed as the main functionality enabler, increasing the vendor's investments in software teams and boosting the role that community-based open-source solutions have in development and network functions. Consider the large number and relevance of projects released within the Linux Foundation (e.g., OpenDayLight, ONAP) and ETSI (Open Source MANO).

On the other hand, there's a shift from ASICs to COTS hardware, with increased interest by operators in white boxes, coupling lower investment costs with increased visibility and control over the network operation. With the shift from proprietary hardware to vendor-supplied software, traditional vendors are cornered into adapt or die circumstances with increased collaborations through open-source communities.
They must collaborate with service providers and competing vendors, and center the commercial roadmap on solutions deriving from open-source versions, but with added features.

In parallel, this shift opened the doors both to new players, unrestrained from any chains associated with the traditional vendor approach, and to major software-centric IT companies, which while having mastered for years the right methodologies for agile software development must now adapt their fast failure software development approach to the high reliability and SLA strictness required in the telecom industry.

A series of challenges, such as vendor silos, technological and standardization immaturity, and cultural or skill barriers, have however led to a monetization latency effect with NFV. We will refer in more detail to these later in the paper and also discuss some of the factors that are contributing to their removal.

Key use cases

The initial ETSI NFV use cases document proposed a preliminary but already extensive list of use cases (e.g., VNFaaS, VNPaaS, VNF forwarding graphs/service chaining), at a time when very limited PoCs existed. However, in their road to NFV, most operators started through one of the following key use cases:

vCPE: virtual customer premises equipment (vCPE), in particular, virtual enterprise CPE, moves branch offices' functionality, usually available through dedicated hardware (e.g., firewall), into the virtualized network functions running in COTS servers located in the operator network. This helps in reducing network operation and hardware costs. Emerging services such as SD-WAN are already being deployed as VNFs running over vCPE platforms.

Virtualization of the mobile core network: the virtualization of LTE's EPC (vEPC) is highly attractive, given the possibility to reduce network complexity and associated operational challenges. Flexible network function allocation (e.g., S-GW, P-GW) according to fluctuating traffic and its actual geography provides greater network efficiency. Being an essential service to EPC (e.g., adding VoIP SMS or VoLTE support), vEPC and vIMS are usually coupled together.

Virtualized content delivery network: this use case leverages the possibility to instantiate and manage a CDN (and associated services) as a tenant over an operator network. This unlocks the possibility of placing content closer to the edge and provides CDN providers with an enhanced interface for obtaining information held by the network operator (e.g., user location).

Other relevant use cases include vRAN, which addresses HW resource congestion at mobile base stations, and network slicing, driven from 5G specifications.

Mobile networks and NFV: past and future

Why NFV still matters

NFV emerged at a time when most 4G network deployments were recent or under planning. This drove the first NFV PoCs and solutions to be designed around 4G technologies, being one of NFV's key use cases that of vEPC, i.e., the virtualization of (4G's) evolved packet core. This use case unlocked automation and agility over additional use cases, e.g., mobile broadband, enterprise services, VoLTE, or IoT. However, while 4G served as NFV's test environment for demonstrating its advantages, it simultaneously posed several challenges that not only prevented it from reaping all its potential benefits but also delayed and threatened its monetization.

Building on this maturation period, 5G promises to enable the full spectrum of NFV benefits. As the telecom industry now recognizes, these go well beyond the much acclaimed capex and opex reduction and include service agility as a core driver, i.e., the ability to launch and update services in much reduced time, allowing quick reaction to market status – or its anticipation.

Role of NFV in 5G

The possibility to deliver multiple use cases targeted at very distinct sectors with correspondingly diverse requirements (e.g., latency vs. throughput focus) while efficiently using the resources of a common infrastructure, is one of the key 5G promises. NFV paves the way for this by introducing automated instantiation, operation, and release of services, and increasing visualization capabilities on virtualized services and associated resources' usage. These same capabilities originated one of 5G's key innovations: network slicing.

By decoupling software from hardware, NFV enables agile and automated service deployment over virtualized instances in custom off-the-shelves (COTS) hardware. 5G thrives on this feature to enable the deployment of multiple virtualized networks (network slices) in shared physical infrastructures, both in isolated network sections and in an end-to-end fashion, i.e., considering both access (including multiple RANs) and core networks. Finally, NFV strongly influenced 5G design and standardization, with 5G system core architecture embedding service-based principles (e.g., user plane and control plane functions split, function modularization) aiming precisely at the optimal usage of NFV and SDN developments.

Key challenges

Technological barriers

With the release of ETSI NFV architecture and use case documents, the remaining telecom industry immediately recognized the potential behind network virtualization. R&D departments worldwide began working on the technological barriers and sequentially, proof of concepts emerged everywhere. The first set of demonstrations clearly showcased the benefits of NFV, but the telecom industry was still unsure about the performance of virtualized network functions when compared to their equivalent physical components (on a lesser scale, it still is).

Achieving the same throughput and latency in a deterministic manner of dedicated and network-optimized circuits on top of COTS servers was and still is a major challenge. Besides performance, reliability is also a major concern with the additional complexity brought by virtualization, and at the end of the day, the five 9's still need to be guaranteed. Enhancing the performance and reliability of virtualization technologies to the level of physical systems will continue to be a major challenge for the following years.

Operations modernization

Another problem that arose was that all these PoCs were designed in labs as silos, and there was no clear indication on how to integrate NFV with the myriad of business and operational systems that telecom providers were already using. Even TM Forum didn't have an answer on how to adapt their information model to accommodate NFV services and their respective VNFs.

Thus, stemmed the concept of end-to-end orchestration, also known as multi-domain orchestrator or even service orchestrator, positioning NFV as a technologic domain parallel to other already existing domains within the telecom architecture (e.g., SDN).

Meanwhile, cloud computing gained incredible momentum and cloud-based services started threatening traditional telecommunication services such as voice, messaging, or multimedia content delivery but NFV was still failing to provide business cases that justified the investment.
The problem is not the technology, it is deeper than that and a culture shift is needed, one that promotes service agility, automation, and much improved time-to-market.

DevOps is more than a collection of software development practices, being also a different way of doing business that needs to be integrated into day-to-day operations, especially in a heavily regulated industry like telecommunications. Many changes have already been made and are still being made, but there is still a lot of ground to cover if telecom providers do not wish to become the dumb-pipe provider in today's digital world. Model-driven engineering must be adopted to enable business-driven development and the new interfaces between telecom providers and vendors must be defined.

Open-source driven organizations

A traditional cornerstone of telecom operators has been the use of vendor proprietary solutions, which most of the time are not interoperable between different vendors – even when fully compliant with SDO's specifications. The introduction of NFV has triggered a significant shift regarding this, which is the use of open-source implementations of open standards specifications, thus creating a greater impact on interoperability than the use of standards alone.

One good example is OpenStack, an open-source project for a datacenter management platform referred to as VIM in ETSI NFV's scope. Today, many vendors have already adapted to the monetization of open source and have their own version of OpenStack, sharing a common base with specific proprietary technologies to enhance certain aspects such as performance, reliability, or deployment automation. Nevertheless, monetizing open-source technologies is still a challenge in an industry with a long tradition of proprietary solutions. The value of open-source is more evident now, and companies are still catching up on how to benefit from it by taking unique approaches, given their context within the telecom market.

This openness to open-source technology is not only causing a major impact on business relationships within the telecom industry but also influencing standardization groups. The latter is now more open than ever to collaborating with major open-source projects such as the ones hosted by Linux Foundation Networking Fund (LFN), which are accelerating the development of innovative solutions and increasing harmonization across different platforms. The gap between innovation, development, and production is ever decreasing and the stakeholders in the telecom industry must adapt to this new digital world.

Open source has gained its place within the telecom industry with the introduction of NFV and has shown the importance of it as a driver for innovation, exploration, and validation. The next section presents the two most prominent open-source orchestration platforms for NFV and digital services, highlighting their approach and focus on tackling the challenges presented in the previous section.

Open source in orchestration

OSM origins

Open Source MANO (OSM) first emerged at MWC 2016, where its features were demonstrated by the means of an L3 VPN service where value-added services could be accommodated (e.g., VoIP). It was announced as an ETSI-hosted and operator-led initiative for delivering an open-source NFV MANO stack through best-in-class open source workflows and tools, to meet the requirements of production NFV networks (e.g., common information model) and ensure service fast development and delivery. It stems from Telefonica's OpenMANO, Canonical's Juju (VNF manager), and RIFT.io's orchestrator, covering both service and resource orchestration.

OSM scope and features

Given its link with ETSI, it is regularly updated according to – and influencing – NFV reference architecture and specifications. It is actively used at ETSI NFV Plugtests and European 5G research projects. OSM is essentially focused on NFV orchestration and VNF management and is organized in two main scopes: run-time and design-time. The first aims at simplifying service and life cycle management, comprising SDN controller provisioning, plugin-based VIM integration, and support for specific VNF managers. The second is characterized by a model-driven environment comprising a network service definition and a GUI for rapid service design and VNF management (e.g., onboarding or deployment).

OSM has been enriched with multiple releases toward the support of 5G networks, through features such as the support for 5G network slicing (considering network functions and their resources), physical and hybrid network functions (key for integration with legacy equipment), along with a focus on stability, and an improved CI/CD pipeline. Its latest version, Release 6, paves the path for multi-domain orchestration, addressing orchestration of edge-based compute, the easier management of complex services through network service primitives, and service assurance taking into account additional network services and slices context.

ONAP origins

Around three years ago, AT&T, one of the world's most prominent telecom operators published the ECOMP (enhanced control, orchestration, management, and policy) whitepaper, where it presented its Domain 2.0 program. The program focused on leveraging cloud technologies and network virtualization to offer services while reducing capital and operations expenditures and achieving significant levels of operational automation.

This whitepaper took the world by storm by condensing different views in distinct areas of what was needed to transform the telecommunications industry.

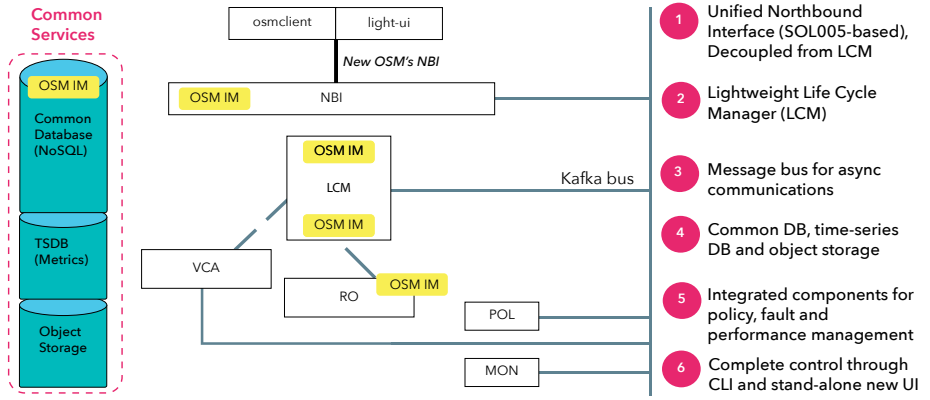


Figure 1: OSM (Release 5)

It addressed widely discussed topics in SDOs and industry forums such as visual service design, improved time-to-market and revenues, network agility and elasticity, policy-driven operational management, and the use of analytics and AI for enhanced context awareness. All of this was combined with the best practices and key architectural references in cloud computing, which included microservice-based architecture, model-driven service design, DevOps, and closed-loop automation. It indeed was a revolutionary document that defined the cornerstones for the next-generation of operation support systems (OSSs).

Across the ocean, China Mobile, China Telecom, and Huawei started the open-source project Open Orchestrator (Open-O). It gained some attention because, contrary to other emerging open-source orchestrators that mainly focused the datacenter side of the infrastructure, it presented a hierarchical architecture of orchestrators with network (SDN-O) and NFV (NFV-O) orchestration combined by placing at the top the cross-domain orchestrator (Cross Domain-O). At the time of its launch, Linux Foundation (LF) was hosting two important projects in network virtualization, OpenDaylight and Open NFV. By being part of LF, Open-O would share the same foundation and the support from the LF open-source community, which strongly contributed to the birth of ONAP. ECOMP also tried to join LF, but LF refused to host two competing orchestration projects. Thus, Open-O and ECOMP merged into a single project (ONAP), one of the largest open-source projects ever.

ONAP: the emergence of a behemoth project

ONAP combines characteristics and components from both projects, retaining the wide scope and cloud native approach of ECOMP and the advanced architecture and mechanisms of Open-O towards NFV. With that in mind, ONAP is divided into two frameworks (inherited from ECOMP):

- **Design-time (SDC):** the design-time environment comprehends all the mechanisms for designing services, resource onboarding, and programming the platform using a model-driven approach
- **Run-time:** the run-time environment comprehends all the operational systems for policy-based service and resource management

Apart from these two major frameworks (depicted below), it is also worth mentioning the VNF SDK (inherited from Open-O) to ease the VNF integration, ONAP operations manager (OOM), to manage the life cycle of ONAP components, and the various modeling, benchmark, and validation projects.

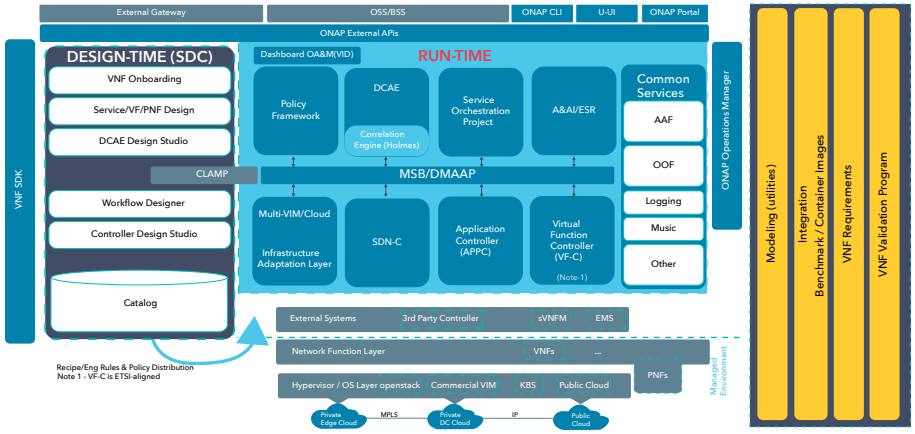


Figure 2: ONAP – the emergence of a behemoth project

ONAP has been working close to SDOs and is the only open-source platform aligned with TM Forum. The TM Forum Frameworx program constitutes a suite of best practices and standards for the telecom industry, which covers business processes, information models, operation and business support systems, and respective integration and business metrics. Additionally, ONAP is also aligned with relevant workgroups in MEF and ETSI and is working closely with 3GPP for the support of 5G networks.

The technological innovations and large scope in a production-oriented platform justify the wide interest and participation of telecom operators and vendors alike. Nevertheless, as one of the largest open-source projects, it makes the exploration and adoption of ONAP difficult because of the inherent complexity and the high number of resources required to deploy it.

Opportunities and competition

From challenges come opportunities

Understanding the cloud computing industry, not only the technologies but also the monetization paths, is pivotal for a good market strategy, especially in telecom, which has been slow to react to the quick pace of the digital world. Earnings from legacy telecom services such as voice or connectivity have been slowly decreasing and failing to compete with aggressive offers from over-the-top players, even when the latter relies on the former to reach the end client.

In comparison with cloud-computing (or even digital services), the telecommunications market has been traditionally closed to small enterprises for different reasons. Among these are the heavy SLA requirements, where credibility and being big enough for sue-and-collect in case anything goes wrong are a major concern, and the burden of vendor lock-in, pushing network operators to favor vendors with previously established relationships for easier integration. For smaller companies, the path for monetization has been targeting lower-tier network operators, a self-contained service or providing a compelling business case to justify the partnership or acquisition by larger companies with a wide footprint in this industry.

Looking at NFV as part of the digital transformation of the telecom industry, cloud computing may provide some clues to what a successful strategy should be based on.

The adoption of cloud computing has been the basis for various distinct and successful business models in many companies, but the cornerstones have always been the same: quick and easy deployment of novel services enabling fast time-to-market, and a scalable infrastructure based on business growth supported by service life cycle automation, or in other words capex and opex savings. The growing push from the industry for open-source multi-domain orchestration (namely from OSM and ONAP) makes way for market players' willingness in validating its benefits against the current ecosystem complexity and roadblocks faced by NFV implementations.

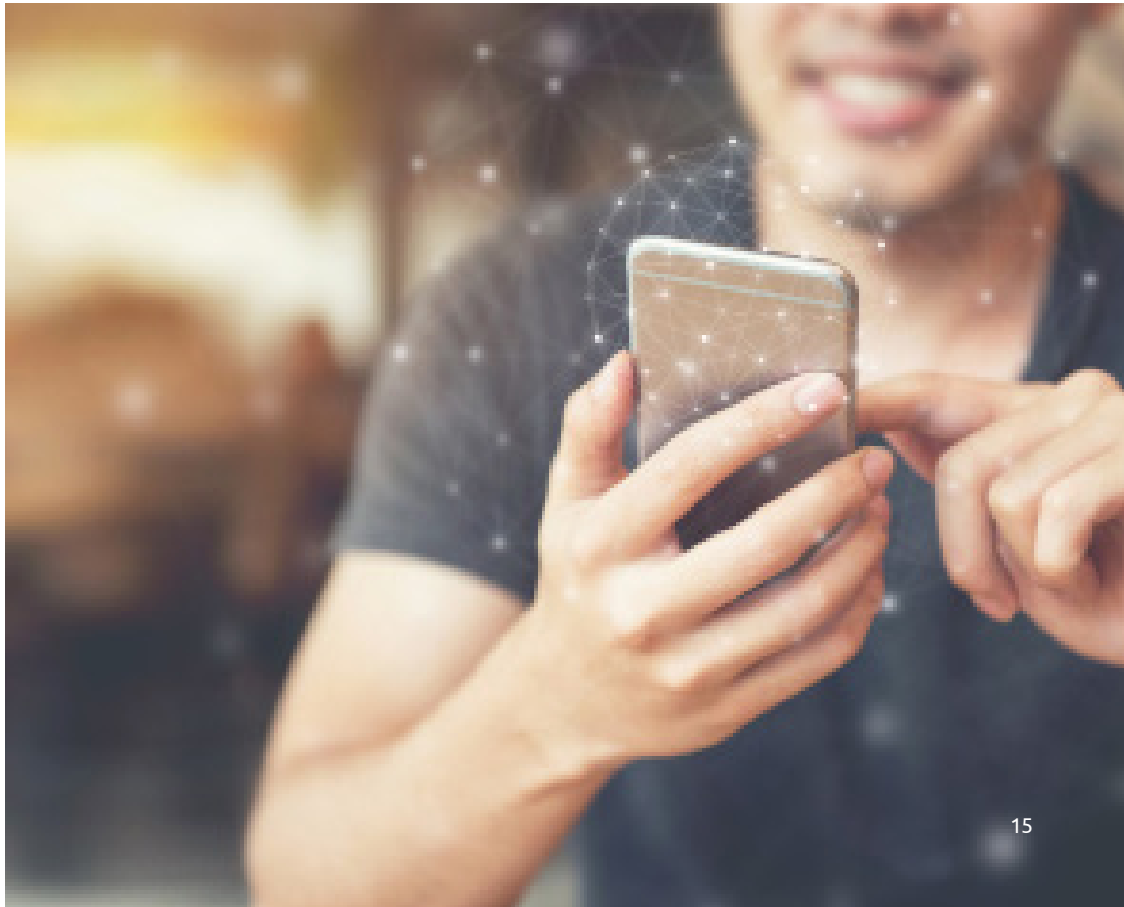
Once full integration of interfaces and individual VNFs, abstraction from vendor silos, and the support of an end-to-end automation is accomplished, the truly streamlined process for NFV based network services (instantiation, scaling, management, and monitoring) will become a reality. On top of that, product-like versions with levels of support and maintenance are required to ensure proper service life cycle management.

These factors combined will be the basis for the democratization of the telecom market, where small enterprises or even start-ups will have the means to enter and, in some cases, compete with already established and dominant players.

A digital world paves the way for a new telecom market

The digital transformation of the telecom market is fostering the participation of an increasing number of companies, even without having any previous work within the telecom industry (directly and/or indirectly). These new players, either SMEs or big companies coming from the IT industry, have one thing in common: they address specific user needs without being tied to the traditional ways of doing business. One example is SD-WAN, which is gaining momentum with telecom clients by addressing needs that were not fulfilled by traditional network operator VPNs and had the potential to foster NFV or benefit from it.

NFV has been failing to provide the necessary business cases for network operators to invest in it because it has been focusing too much on the technology and not on the services they can provide. The companies that understand the cloud computing market and cloud-native services will be able to leverage NFV and respective technologic enablers to thrive in a world of digital services. Herein, open-source orchestration will be key to remove current roadblocks and explore novel and more intelligent mechanisms in operational systems.



Conclusion

A second chance for NFV is coming with the deployment of 5G networks and the intent of network operators is to go cloud native. Network operators and digital service providers will benefit from open-source orchestration platforms, which have been evolving since the birth of NFV. The level of maturity and adoption in both platforms presented here justifies a careful but ongoing effort to put them into production, especially when considering that they will provide the reference architecture and interfaces regarding orchestration systems.

By adopting and integrating them into their stack of operational systems, providers may benefit from future-proof readiness towards digital-based services, including NFV and 5G. Additionally, the telecom industry may benefit from this adoption in the medium to long term. By looking into today's widely adopted open-source platforms, they ease the integration of new services and complementary systems where community awareness is the key to addressing current requirements and future needs.

The telecom market is evolving and in it, there is a place for new and current companies, with or without a background in telecom, that are quick to adapt and reinvent themselves. In a market that is still evolving and defining the rules of success, it is more important than ever to be aware and understand novel trends to define aggressive strategies that exploit them. With this in mind, a strong connection to research and development will be the key to survive Darwin's law.

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For more information please visit:
www.capgemini-engineering.com

Contact us at:
engineering@capgemini.com