Hewlett Packard Enterprise

Network functions virtualization

Contents

Technical white paper

Introduction

Network functions virtualization (NFV) is a core structural change in the way telecommunication infrastructure gets deployed. This in turn will bring significant changes in the way applications are delivered to service providers. Through disaggregation of the traditional roles and technology involved in telecommunications applications, NFV will bring cost efficiencies, time-to-market improvements, and innovation to the telecommunication industry infrastructure and applications.

This disaggregation will be enabled by changing the industry's traditional approach to delivery of applications from a closed, proprietary, and tightly integrated stack model into an open, layered model, where applications are hosted on a shared, common infrastructure base.

This paper reflects Hewlett Packard Enterprise's view on how cost will be reduced and how major innovations will be introduced as NFV is adopted. The associated dynamics will be analogous to the dynamics that enterprise IT has undergone over the last decade—and its associated benefits. NFV brings these market dynamics and efficiencies to the core revenue-generating applications of telecommunications.

The requirements and open standards that underpin NFV are being developed by a European Telecommunications Standards Institute (ETSI) industry specification group (ISG). Hewlett Packard Enterprise has several contributing members in this group.

This paper also outlines Hewlett Packard Enterprise's view on the "roadmap" to NFV, including the evolution of role(s) of different types of vendors in the market structure. We specifically highlight the architectural principles Hewlett Packard Enterprise will promote to secure its customers the most value, and therefore the competitive edge, in a world of increasing competition.

NFV building on key enterprise IT trends and technologies

One lens we can look through to understand the future of NFV is a view on what has happened in enterprise IT. NFV uses traditional IT virtualization techniques on commodity hardware (compute, storage, and networking) to consolidate network applications onto industry high-volume servers and storage, which allows the industry to gain from both the cost and innovation dynamics of traditional IT. It is possible today to use commercial-off-the-shelf (COTS) IT infrastructure to do complex tasks that have traditionally required custom hardware builds on specialized application-specific integrated circuit (ASIC) or digital signal processing (DSP) devices (thanks to recent technologies such as the packet processing capabilities found in the latest CPUs).

Within enterprise IT applications, server and storage sprawl and complexity cause most organizations to spend more than 70 percent of their budget and resources on maintenance and operations—and less than 30 percent of time and money on innovation, the things that help the business be more competitive. As a result, most IT organizations have seen a widening gap between what the business demands and what IT can deliver. They lack the agility to respond to business requests in a timely manner.

At Hewlett Packard Enterprise, we believe that the only way for enterprise IT and networks to shift resources from operations to innovation is through infrastructure convergence. Therefore, we are developing the blueprint for the data center of the future that accelerates the provisioning of IT services and applications by integrating servers, storage, networking, security, power, cooling, and facilities into shared pools of interoperable resources, all managed through a common management platform.

The first step for most organizations has been one of standardization—to increase quality and speed of IT service delivery with lower cost of operations and better, more efficient management. This could include moving to a small number of approved standard configurations, based on industry standards with reusable components and implemented in a consistent fashion with consistent management tools. The end result of this step is a more standards-based, modular, and reusable infrastructure.

The second step for IT has been one of virtualization, moving from physical server, storage, and networking environments to virtualizing the entire data center, increasing the quality of the service delivered and making IT more responsive and aligned to the needs of the business.

What virtualization and automation have achieved in the data center is what NFV aims to achieve for the revenue-generating applications run by CSPs. Thus, NFV will build on the journey that enterprise IT has undertaken.

Virtualization is a step on the journey to cloud, and in the world of enterprise IT, applications are evolving to services, and the role of the CIO is evolving to become that of a service broker.

Later in this paper, we will show how NFV can be enhanced by close coupling (within the HPE architecture) with software-defined networking (SDN). This is because, just as with the stresses and strains seen within enterprise IT, network resources and operational processes have been stressed and stretched thin for years. SDN inserts both service intelligence and application intelligence into the infrastructure layer for a more robust network with hardware-independent flexibility. The network can be programmed as if it were a single entity, with features readily added or expanded as needed from a central controller. Data flows can be adjusted dynamically to meet application needs amid changing network conditions. Rules for network switches can be changed on the fly.

NFV is a catalyst for structural market change

With the rapid growth of rich media applications and the decrease in voice revenues, CSPs find themselves in a position of exploding network traffic while their revenues are stagnating. They face competition from over-the-top (OTT) players that are agile, flexible, and able to roll out revenue-generating services much faster than the CSP. CSPs are aware that their network capacity utilization can be poor as they have to engineer their networks for peak traffic rates and have no way of utilizing the spare capacity this creates. Enterprise IT demonstrates a more efficient way to manage the delivery of multiple networked applications through shared virtualized infrastructure. NFV applies virtualization to the telecom core network functions and the associated core and value-added applications of a CSP, enabling the CSP to reduce cost and improve time to market.

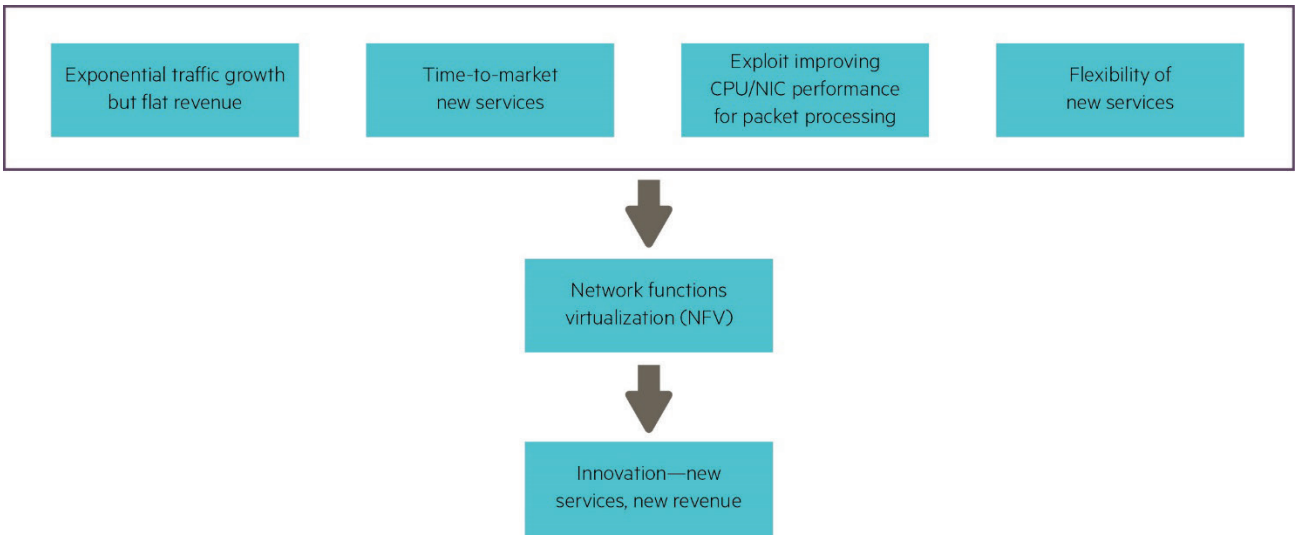


Figure 1. NFV drivers and enablers

NFV will transform the way CSPs architect and design parts of their networks using standard IT virtualization technologies. NFV will allow a CSP to consolidate many applications and networking appliances onto industry-standard high-volume servers, switches, routers, and storage. Through NFV, CSPs will automatically benefit from any major advances and disruptions that appear in IT.

NFV enables significant benefits through deployment of virtualized network applications on shared infrastructure, and it brings additional benefits through IT like layering and purchasing decisions:

- Direct cost savings with improved utilization and wider adoption of standard industry servers for core telecom applications in a shared compute infrastructure
- Greater flexibility with a cloud fulfillment model where, for example, applications can be readily deployed without delays, speeding time to market
- NFV also allows for a simplification of the planning and scaling of the network as new hardware can be quickly added to meet demands without long network appliance procurement processes
- Allowing CSPs to add or delete application or service capacity on demand to meet the elastic needs of the network. This will allow the CSPs to run the networks more efficiently and reuse a shared pool of compute resources for various functions, thereby reducing operational costs

Additionally, having a uniform infrastructure produces operational savings by reducing management complexity and its associated cost. This frees up valuable resources to innovate and contribute to CSP differentiation.

NFV is complementary to SDN although NFV can be implemented without SDN. SDN allows IT and network operations to apply business logic directly to emerging software-based networks and dynamically introduce new services faster with lower management costs and with less complexity. SDN unlocks overprovisioned, underutilized, and constrained networks to gain value from networks. It enables network simplification by abstracting away complexity.

NFV and SDN can be combined to create greater value as SDN extends to the network infrastructure the agility that server virtualization brings to the compute infrastructure. Hewlett Packard Enterprise foresees that functions being virtualized today eventually become virtualized network services within an SDN architecture.

Demonstrating in-depth integration of the two is a key requirement fulfilled within the HPE architecture.

Table 1. NFV and SDN comparison

NETWORK FUNCTIONS VIRTUALIZATION (NFV)	SOFTWARE-DEFINED NETWORKING (SDN)
By leveraging standard IT virtualization technology to consolidate many network equipment types onto industry-standard high-volume servers, switches, and storage, NFV provides a model to meet CSP challenges around reducing CAPEX, improving manageability, decreasing time to market, and encouraging a wider ecosystem.	SDN enables the emerging software-based networks that allow IT and network operations to apply business logic directly and dynamically to introduce new services faster, lower management costs with less complexity, and commoditize many network functions, reducing CAPEX. SDN is an enabling technology that challenges current practices by decoupling the control plane from the data forwarding mechanisms.

The NFV value delivery system will consist of many vendors, with some vendors taking on several roles to meet CSP needs. This will be the case through a multiyear transition phase while the ecosystem and technology mature to fully deliver on the NFV objectives. To explain Hewlett Packard Enterprise's point of view and how we see the market maturing, we will highlight four of the core roles and how we believe they will evolve over time:

- **Network infrastructure providers:** Companies that can deliver the core compute, storage, and network capabilities that are at the core of the NFV infrastructure. These companies will also take on the challenge of determining how to enable more demanding applications by introducing new types of resources (such as digital signal processing capabilities) into this "elastic" infrastructure.
- **Infrastructure orchestration providers:** Companies that enable the orchestration of the underlying core platform to enable the virtualization and orchestration of the infrastructure. While typical IT cloud capabilities are well developed, these players will focus on enabling this layer to deliver on the often more stringent requirements of telecommunications. Orchestration in NFV may include VNF orchestration or cloud management (compute and network virtualization). Hewlett Packard Enterprise operates in both spaces.
- **Application providers:** Consisting of both the providers of the critical applications that today are delivered in the traditional model and new innovative providers that will enter the market. The critical applications are often delivered on standard computer architectures. However, many are still delivered on proprietary hardware to meet performance and quality requirements. The primary challenge for the providers of critical applications will be to evolve existing network functions that have been developed for bespoke appliances as well as standard computer architectures, to more effectively execute in a cloud environment while also taking advantage of the new infrastructure to migrate more demanding applications onto the infrastructure as it evolves. New innovative application providers should enter the market as the availability of an open infrastructure should boost the strength of this ecosystem, which today is limited by route to market and complexity of deployment of new applications.
- **System integrators (SIs):** Organizations that will take ownership for the end-to-end implementation of systems incorporating applications and NFV infrastructure.

Vendors currently take on a combination of the above roles and will continue to do so as the market transitions to NFV. For example, the traditional network equipment providers (NEPs) will in some cases continue to play the role of application provider, system integrator, etc. NFV will allow them to deliver applications in more of an ISV model as NFV standardizes on the shared, open infrastructure.

It is also important to recognize that end-to-end application guarantees are delivered to CSPs at a cost by today's vendors. NFV enables CSPs to selectively choose the SI for specific applications when such guarantees are needed. However, to achieve the maximum economic benefit from NFV, it is also clear that, similar to the IT industry, CSPs will increasingly have to evaluate where such service-level agreements (SLAs) are strictly necessary from the vendors, and where the CSP can more cost effectively carry the risk.

Hewlett Packard Enterprise's architectural point of view

The open architecture described in this paper has two key modules: the NFV infrastructure, realized with HPE NFV System, and the hypervisor-independent NFV Orchestrator, which is HPE NFV Director. The architecture delivers a vision for an open solution that ensures customers can access the best technologies to deploy NFV. The architecture has a deep alignment with SDN and specifically Hewlett Packard Enterprise's developments in this area. The architecture is based on the NFV architecture developed and published by ETSI, and is notable for its openness to Hewlett Packard Enterprise products or third-party solutions.

Hewlett Packard Enterprise's NFV architecture is based on a layered approach that allows our customers to incrementally add new functionality and also gives customers the openness and flexibility to work with the tools and vendors they prefer.

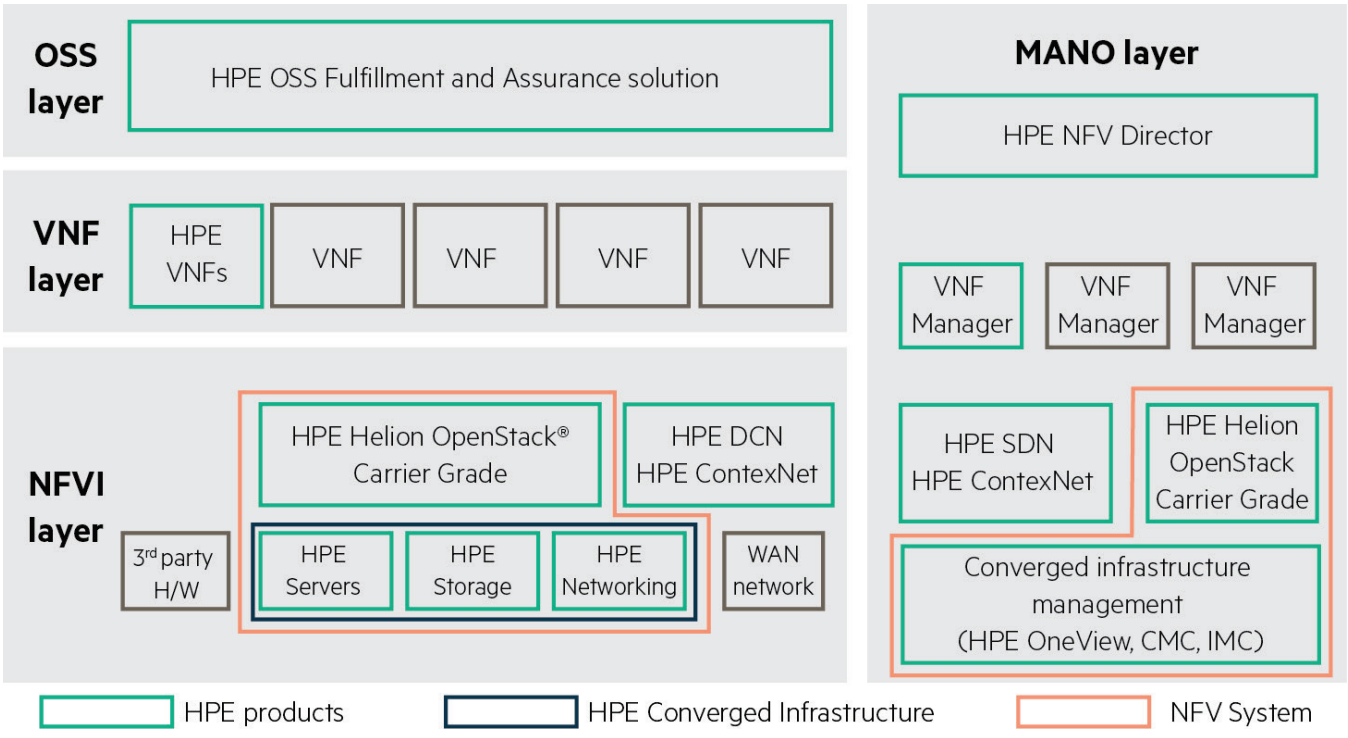


Figure 2. HPE NFV foundation architecture

For the infrastructure layer, we provide HPE NFV System, which comprises preintegrated, workload-optimized systems to run virtualized functions on the carrier network, based on the latest technologies in easy-to-buy, manage, and support models. We also support the buildout of NFV infrastructure (NFVI) using our OpenNFV architecture. We support various deployments of hypervisors with single root input-output virtualization (SR-IOV) data plane development kit (DPDK), providing ISVs and CSPs a way to achieve line rate networking performance on Hewlett Packard Enterprise servers. This allows carriers to run their networks with the same hardware that IT uses.

HPE NFV System is a complete NFV platform that includes the areas highlighted in figure 2. NFV System allows both CSPs and their suppliers to more easily deploy NFV solutions since the system is preintegrated at the factory and orderable by a single SKU. The Starter Kit solution is a single rack that comprises control, compute, and storage. We've leveraged the key learnings from dozens of proof-of-concept (PoC) activities and lab work, and created NFV System kits that are optimized for NFV workloads. All the engineering guesswork and product selection are done, which greatly increases speed-to-value.

HPE Helion OpenStack Carrier Grade is bundled with HPE NFV System and available separately to provide a cloud compute operating system that is based on the industry de facto standard (OpenStack) but made robust for CSP environments with built-in availability and resiliency. Also bundled with NFV System are compute and networking virtualization (KVM, AVS), which are essential to run NFV out of the box. SDN controllers may be integrated in a solution to provide more flexibility and are needed for more sophisticated use cases such as inter-data-center connection or service chaining.

Included in the HPE NFV System bundle is our converged infrastructure management solution, HPE OneView, which provides a single, collaborative management platform that is built for speed. It allows IT/network teams to work and collaborate in a more natural and automated way. It's a software-based approach to lifecycle management that automates operations to reduce the cost and time to deliver NFV infrastructure with an open development platform designed to rapidly adapt to business needs. This programmable platform, built on the REST application programming interface (API), allows you to scale beyond your data center walls to the cloud.

Thanks to a strong heritage in management software, Hewlett Packard Enterprise has rich portfolio offerings to support carriers in their journey to integrate the entire NFV stack into their existing operating support system (OSS) and business support system (BSS) solutions. Our solutions range from traditional fault management to complex services-based management supporting the complete fault, configuration, accounting, performance, and security (FCAPS) needs for our carriers.

Built on and integrated into our operations support system portfolio, NFV Director is critical to the actual operationalization of NFV. Ensuring the capability to manage NFV in heterogeneous, multivendor, and geographically distributed environments is a key differentiator for Hewlett Packard Enterprise. We bring our deep experience and expertise in both telco and IT to ensure HPE NFV Director addresses all the key functionality required, and that NFV can be managed consistently with existing telecom resources.

Hewlett Packard Enterprise's leadership role in NFV

As a leading IT vendor, Hewlett Packard Enterprise is naturally positioned to leverage our strength from the IT enterprise market and bring this strength, scale, and experience to bear for NFV. This is demonstrated by our:

- Leadership role in key standards development organizations including ETSI NFV, OpenCloud Connect, OPNFV, OpenDaylight, ONF, TM Forum, and OpenStack
- Release of NFV System, a major contribution to the NFV journey that brings a simple integrated solution for NFV platforms to bear for our customers and partners
- NFV Director, which provides orchestration, VNF management, and analytics to the NFV solution
- Commitment to NFV through the introduction of a commercial virtual services router (VSR) based on commercially deployed Comware software and a number of telecom VNFs across home subscriber server, policy and charging rules, and media resource function areas
- Proven experience and product offerings that address quality of service (QoS) requirements, meeting stringent latency, scalability, high availability, and real-time performance specifications; these include our home location register (HLR), core router, and switches that are deployed in core network applications
- Leadership in SDN with the largest portfolio of OpenFlow switching products and multiple SDN options, including carrier-grade SDN

Through our broad participation in the infrastructure layer, as well as Hewlett Packard Enterprise's deep telecom product experience, we have developed a structure of product and market experience that allows us to support the journey to NFV from the wide variety of angles required to fully enable NFV in a comprehensive way. As with Hewlett Packard Enterprise's role in enterprise IT, we will rely on an ecosystem of partners to deliver this value.

As a packaged NFV platform provider, with our release of NFV System, Hewlett Packard Enterprise has begun to build on our existing position as the largest provider of standards-based computer platforms deployed in telecommunications environments. Hewlett Packard Enterprise has established this position by leveraging our IT product base into the telecom market. This is the basis for a significantly improved cost curve for many telecommunications services.

Hewlett Packard Enterprise enables the transition to NFV in several ways:

- We support the standardization of the core platforms and their evolution to support more demanding networking specific applications (including bearer plane applications).
- We support NEPs (as well as other application vendors) in moving to a standardized platform (server, storage, and networking), as well as continuing to support these vendors in their role as the trusted SIs for the industry.
- We have released a carrier-grade version of HPE Helion OpenStack, which allows deployment of NFV solutions using the industry-leading OpenStack cloud operating system, but with the manageability, performance, and availability demanded in a CSP environment.
- Our software portfolio includes industry-leading fault and event management, performance management, configuration and compliance, and security tools to monitor, visualize, manage, secure, and configure the NFV infrastructure.

In addition, Hewlett Packard Enterprise as an infrastructure orchestration provider offers NFV Director to deliver VNF orchestration. Delivering the key components that enable the orchestration of the world's cloud infrastructures, Hewlett Packard Enterprise is also a leading contributor to many industry organizations such as OpenStack and ETSI NFV.

Hewlett Packard Enterprise provides a coherent portfolio of open technologies and services that support the deployment of NFV applications developed by our NEP and ISV partners, as well as by Hewlett Packard Enterprise. Our OpenNFV Program provides a framework for partners to advance their solutions in the marketplace.

OpenNFV comprises the following:

- Technology and architecture—Open, NFV-ready architecture that enables a transition for CSPs to NFV, pulling in NEP and emerging ISV solutions and components as needed
- OpenNFV Labs—An environment in which integration, collaboration, and testing can occur is a safe environment ahead of deployment to carrier networks
- Partner program—Access to SDKs, APIs, training, and integration resources to get applications tested and ready for CSPs, thereby advancing innovation while reducing risks
- Proof of concepts (PoCs), deployments, and services—Catalog of PoCs already completed and ready for deployment; world-class service designed to get you in service and operationalized

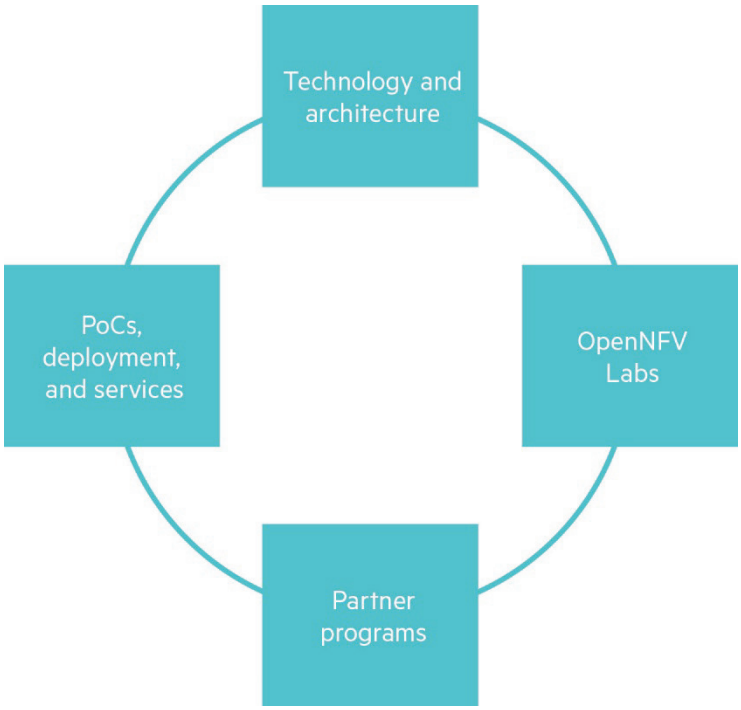


Figure 3. The HPE OpenNFV Program

The HPE NFV Reference Architecture and portfolio supports all the core roles operating within the NFV ecosystem.

Hewlett Packard Enterprise recognizes the immense strength of the existing vendors and acknowledges that their roadmap to NFV requires close collaboration to fully realize the value that the new technology can bring to the CSP community. Hewlett Packard Enterprise aims to be the provider of choice to our customers, in whichever role they choose to play (an NEP that chooses to implement and deliver network applications, NEPs or ISVs that choose to be pure NFV application providers, CSPs that decide to buy and integrate their NFV solutions themselves, or a systems integrator proposing solutions to their customers).

NFV adoption

NFV represents a significant transformation. Hewlett Packard Enterprise views the evolution of NFV in four phases or steps as shown in figure 4. Each phase delivers incremental benefits, from reduced OPEX to facilitating an agile services environment that encourages speedy development of new and innovative applications and services.

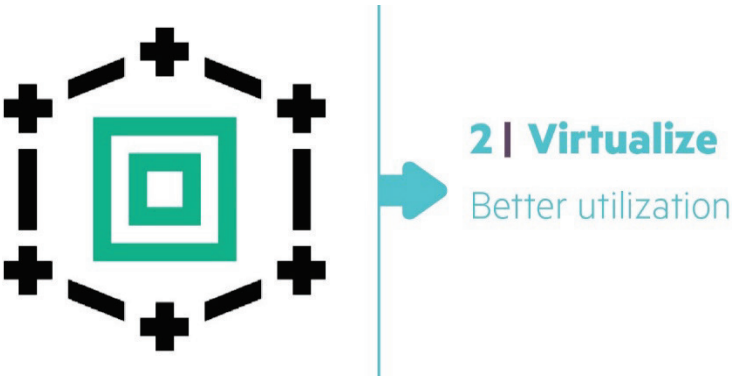
In phase 1, network functions are decoupled from hardware; in phase 2, network infrastructure resources are virtualized; and in phase 3, the network is cloud enabled, or "cloudified."

It's phase 4, however, that is the most advanced phase of NFV, which produces the greatest benefits to service providers. In this phase, monolithic network functions are broken down—or "decomposed"—and rewritten to perform natively in the NFV environment.

NFV isn't a single solution at any point in time. NFV will evolve in stages. Each stage will drive more innovation and faster delivery of applications and services. These stages represent a sequence of technology innovation. You can jump ahead to any stage as the technology matures.

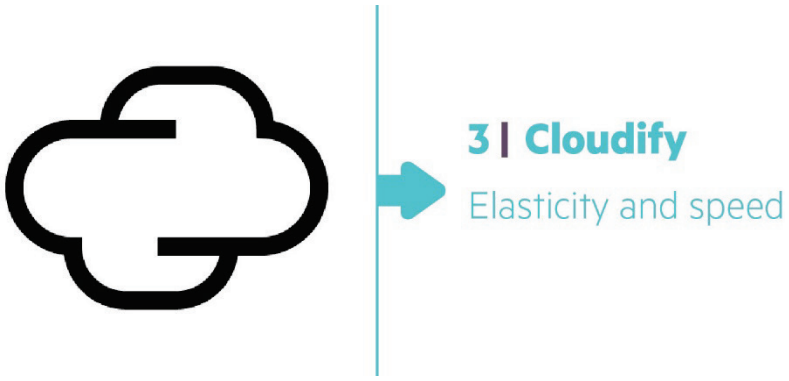
Network functions separated from underlying hardware, deployed as software on standardized platforms

- Unchains you from proprietary, closed solutions to deliver more flexibility in your DC and network, as well as reduce costs/complexity
- Innovation comes from more efficient operations—standardized platforms streamline maintenance and reduce management overhead



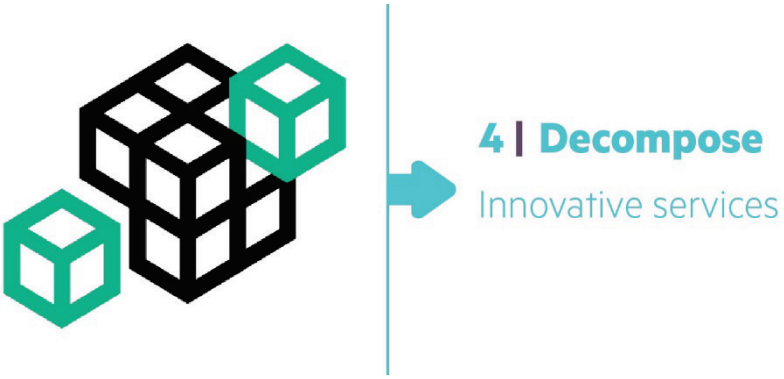
Network functions deployed on hypervisor-driven, virtualized infrastructure resources

- Lets you achieve higher utilization/densities and get improved cost efficiencies and the ability to scale up/down rapidly
- Innovation comes from reduced infrastructure burdens; higher utilizations mean fewer systems in operation and more rapid response to customer demand variations



Wide-area network operated as part of the cloud, holistically aligned and consumed with compute and storage pools

- Lets you achieve consistently efficient network-wide resource utilization, respond dynamically to shifting traffic patterns and customer demand, and instantiate services dynamically through the use of automation
- Innovation comes from extremely efficient resource utilization, radically streamlined just-in-time delivery, and the ability to scale and introduce services dynamically



Network, compute, and storage architecture and resources are distributed; monolithic network functions are decomposed into elemental building blocks (subfunctions) selectively integrated into resource pools deployed where they're needed; services are the recomposition of these microservices

- Lets you (or your customers) compose new and improved services from the building blocks, through the use of service-aware interfaces that provide a seamless integration of network, compute, and storage resources
- Innovation comes from dramatically enhanced capacity to quickly deliver new, innovative, and adaptive apps and services

Figure 4. NFV application evolution: the stages of NFV

Senior-level client discussions now tend to focus on where to start rather than simply on feasibility, as the industry is now moving from proof of concept into production environments. What's the initial use case that can bootstrap NFV deployment? Our top three cases so far based on actual deployments and proof of concepts are virtual customer premise equipment (vCPE), virtual evolved packet core (vEPC), and NFV data center (building a private cloud for NFV). Many other use cases are currently being deployed and in proof of concept.

Acronyms

ATCA	Advanced telecommunications computing architecture
COTS	Commercial off the shelf
CPE	Customer premise equipment
CSP	Communications service provider
DPDK	Data plane development kit
ETSI	European Telecoms Standards Institute
ETSI ISG	ETSI industry specification group
ETSI MANO	ETSI management and orchestration
GTM	Go-to-market
HA	High availability
HLR	Home location register
HSS	Home subscriber server
ISS	Industry standard server
ISV	Independent software vendor
LTE	Long-term evolution
M2M	Machine to machine
NEBS	Network equipment building system
NEP	Network equipment provider
NFV	Network functions virtualization
NFVO	NFV orchestration
NIVR	Network interactive voice response
OSS	Operations support system
OTT	Over the top
PoC	Proof of concept
SDN	Software-defined network
SI	Systems integrator
SLA	Service-level agreement
TTM	Time to market
vCPE	Virtual customer premise equipment
VFW	Virtual firewall
VIMS	Virtual infrastructure management system
VLB	Virtual load balancer
VMM	Virtual machine manager
VNF	Virtualized network function
VSR	Virtual service router

Conclusion

The introduction of NFV is a core structural change in the telecommunication infrastructure marketplace. NFV will bring cost efficiencies, time-to-market improvements, and innovation to the telecommunication industry infrastructure and applications. NFV will achieve this through disaggregation of the traditional roles and technology involved in telecommunications applications.

Whether you are just starting or significantly along your NFV journey, the following are some considerations to keep in mind when selecting technology partners:

- Technology and architecture—Does the solution follow sound architectural principles that the industry has adopted, and which have been proven in PoCs? Is the technology widely fielded and provided by a proven vendor? Is support readily available?
- Openness—How open is the solution? Will you be able to keep your options open with vendor selection (a fundamental premise of NFV)?
- Specificity to target application—Does the solution address the unique requirements of an NFV environment? Will it take you beyond just simple virtualization and into cloudification and then decomposition of your network so that you can realize all the benefits of NFV? Is the solution optimized for NFV workloads? Is the solution designed to handle the rigor of CSP environments?

As an NFV platform provider, Hewlett Packard Enterprise builds on our existing position as the largest provider of standards-based computer platforms deployed in telecommunications. This is the basis for a significantly improved cost and innovation curve for many telecommunications applications, and Hewlett Packard Enterprise will extend this to NFV through its NFV platform.

Learn more at

hpe.com/csp/nfv

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