



VMWARE vCLOUD NFV
SUCCEED IN A MULTI-CLOUD WORLD

Enabling 5G-ready Clouds

NFV objectives have evolved quite significantly from the initial need for CSPs to virtualize the infrastructure to being able to scale with technology, products, and services into new and adjacent markets. There is acute focus on operational transformation with CSPs driving continuous innovation and rapid service deployment for 5G and IoT use cases. Applications, services, and greater network intelligence is being deployed at the network edge to deliver higher QoE and security.

A key enabler of this transformation is the Telco Cloud – an operating model that leverages programmable networks, with NFV and SDN being key enablers. With the ability to run a multitude of network functions on off-the-shelf servers, CSPs can provision and scale services faster and substantially reduce costs.

However, as with any uncharted territory, there are several challenges to the implementation of needed technologies and go-to-market strategies. CSPs need the ability to select the Virtualized Network Function (VNF), NFV Infrastructure, and Management and Orchestration (MANO) solutions that best suit their current and future requirements. However, the reality is that CSPs are faced

with a wide range of vendors in various stages of developing VNFs and deploying VNFs from multiple vendors in a consistent and manageable way is proving challenging.

With its vision of delivering any application on any device on any cloud, VMware has extended its technology to cross every infrastructure boundary there is, from the data center into public and telco clouds, and the network edge supporting edge clouds and IoT devices.

Furthermore, open technologies that promote interoperability and faster innovation are essential. However, with CSPs needing virtualized solutions that deliver the carrier-grade “five-nines” reliability, they are often exposed to the complexity, hidden costs, inconsistent tooling, and lack of carrier-grade support characteristic of several open-source implementations.

With its vision of delivering any application on any device on any cloud, VMware has extended its technology to cross every infrastructure boundary there is, from the data center into public and telco clouds, and the network edge supporting edge clouds and IoT devices.

AT A GLANCE

VMware vCloud NFV is a fully integrated, modular, multi-tenant Network Functions Virtualization (NFV) platform. It provides compute, storage, networking, management and operational capabilities enabling operators to simplify, scale, and secure production NFV services. The transformative platform allows Communications Service Providers (CSPs) to accelerate time to market and increase revenue with new services, streamline operations, reduce network infrastructure costs, and deploy elastic business models for telecommunication workloads.

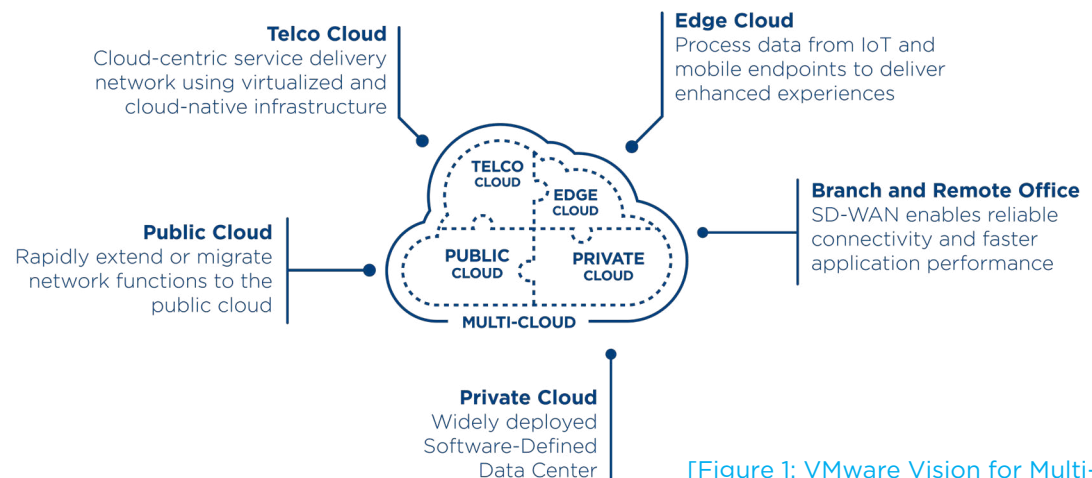
VMware Vision for Multi-Cloud

VMware vCloud NFV platform is a key technology that fulfills this multi-cloud vision. Purpose-built for demanding carrier environments, the modular NFV platform lets CSPs deploy both third-party and in-house VNFs with the confidence that all the component solutions will interoperate efficiently, instead focusing on delivering profitable applications and services to their customers.

Through its use of open, virtualized, and cloud-native application designs, the vCloud NFV platform also helps CSPs realize the benefits of open-source frameworks. With vCloud NFV

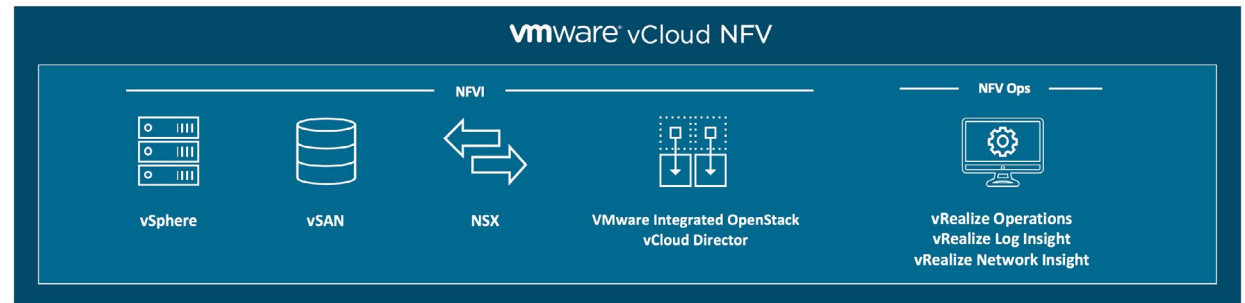
OpenStack, HEAT & YAML based imports, open extensible vendor-neutral APIs and SDKs for managing VNF lifecycle and runtime operations, and Kubernetes integration, CSPs have a proven, high-performance platform to accelerate production NFV workload deployment and service innovation.

Finally, deep integration with public cloud platforms such as Amazon AWS, along with hybrid cloud networking technologies like VMware Hybrid Cloud Extension (HCX), abstract on-premises and cloud resources and presents them to the CSP applications as one continuous hybrid cloud, offering ultimate deployment flexibility and cloud economics.



[Figure 1: VMware Vision for Multi-Cloud]

VMware vCloud NFV: A production-proven NFV platform



[Figure 2: VMware vCloud NFV Platform Components]

KEY BENEFITS

Accelerated Network Performance and Scale: High Performance Packet Processing, Scalable Data Plane Networking, Enhance Platform Awareness

Intent Based Assurance: Capacity Planning & Forecasting, Proactive Avoidance, Issue Isolation & Remediation, Dynamic Optimization

Carrier-Grade Networking: Increased Network Resiliency, Native Container Networking, Multi-Cloud Networking

Advanced Security: Micro-segmentation for VMs and containers, RBAC, API rate limiting, Transport and Data Encryption

Open Standards: 2018.02 OpenStack Queens, Kubernetes/CNI Support, ONAP & OSM Compliant

Production Proven: 55+ operators, 120+ production implementations supporting 400M+ subscribers

Certified VNF Ecosystem: 75+ certified VNFs across mobile network services, vEPC, vIMS, vCPE, SD-WAN, and Security

VMware vCloud NFV is a modular NFV platform that several of the world's leading CSPs rely on to develop modern cloud computing stacks to support new revenue streams while lowering costs. It supports a broad set of VNF applications, creating a large ecosystem for CSPs to deliver innovation at a rapid pace at scale. Its flexible platform architecture allows CSPs to deploy applications and services today for 4G networks, deploy services at the edge, and seamlessly migrate to 5G networks.

With automation, scalability, and a flexible platform for creating and delivering new services, CSPs can begin to match the agility of cloud service providers.

VMware vCloud NFV platform includes industry leading virtualization products – VMware vSphere®, VMware vSAN™, and VMware NSX®, a choice of Virtualized Infrastructure Managers (VIMs) – vCloud® Integrated OpenStack and VMware vCloud Director®, and NFV operations management capabilities including VMware vRealize™ Operations™, vRealize® Log Insight™, and vRealize Network Insight™.

With automation, scalability, and a flexible platform for creating and delivering new services, CSPs can begin to match the agility of cloud service providers.



VMware vSphere provides carrier-grade virtual compute designed to run modern and traditional applications side by side for optimized performance, high availability, fault tolerance, and workload optimization.

VMware vSAN offers simple hypervisor-converged storage embedded in the hypervisor that can be co-located with the VNF workloads to minimize jitter and latency.

VMware NSX enables granular overlay networking and security at the hypervisor level, providing distributed network services for VNFs including granular network isolation using NSX micro-segmentation and simplified operations.

The vCloud NFV platform also provides CSPs with a choice of VIMs – VMware Integrated OpenStack and vCloud Director – for lifecycle management of NFVI compute, storage and networking for both VM and container based workloads.

VMware vRealize Operations Manager, vRealize Log Insight, and vRealize Network Insight are fully integrated and provide real-time NFV operations monitoring, analytics, and optimization.

Built on industry-leading virtualization and cloud-native technologies, the VMware vCloud NFV platform is uniquely capable of empowering CSPs to achieve the full benefit of NFV.

Its combination of modularity, freedom of choice through open standards and multi-vendor VNF support, mature ecosystem, future-ready agility, and carrier-grade support distinguish it from other offerings.

KEY ADVANTAGES:

ACCELERATED NETWORK PERFORMANCE AND SCALE:

Facing rapidly increasing data traffic and demand for enhanced user experiences, CSPs are renewing their focus on architecting the network for optimum application throughput, response times, scale, and service continuity. Control and User Plane Separation (CUPS) is quickly becoming fundamental to the 5G toolbox, enabling flexible network deployment, operation, and independent scaling between control plane and user plane functions, while not affecting the functionality of the existing nodes.

With the flexibility to deploy user plane (UP) nodes closer to the telco edge, a CUPS-based vCloud NFV deployment facilitates reduced latency and increased throughput for applications without increasing the number of control plane (CP) nodes. This also allows for the independent evolution of the CP and UP functions, including their placement and scaling.

This approach also aligns well with other



evolving techniques such as Multi-Access Edge Computing (MEC), where the UP nodes become the data plane for MEC servers, and Network Slicing, where CSPs can dynamically create a network slice to form a complete, autonomous and fully operational network customized to cater to different diverse market scenarios.

Furthermore, vCloud NFV delivers continuous availability, service continuity, breakthrough network performance, and simplified management, leveraging NSX Managed Virtual Distributed Switch (N-VDS) and DPDK principles, SR-IOV, optimized data plane techniques in VMware vSphere, and elastic resource scaling across vSphere clusters. Data Plane VNFs can be deployed in data plane-intensive clusters and use N-VDS Enhanced mode that provides dedicated CPU resources for enhanced network performance. Control and Management plane VNF-Cs can be provisioned to use N-VDS Standard mode which supports overlay and VLAN-backed networking, achieving complete resource isolation.

INTENT BASED ASSURANCE:

Deploying new services on-demand, with real-time scaling, monitoring, and proactive avoidance, has now become imperative. CSPs leverage vCloud NFV to achieve assured application performance based on business and operational intent, increased capacity utilization without

resource contention, 360-degree visibility with real-time insights, root cause analysis and remediation, and reduced operational costs through real-time predictive analytics, contextual troubleshooting, and closed loop automation.

CARRIER-GRADE NETWORKING AND SECURITY:

CSPs are increasingly seeking networking and security platforms that provide consistent connectivity, QoS, integrated security, and inherent automation to deliver applications and services, when and where needed. vCloud NFV facilitates this fundamental shift in networking capabilities by offering complete multi-tenant service separation, consolidated network functions in NSX including NAT and load balancing, simplified administration of application QoS profiles, enhanced network resiliency and distributed stateful firewalling, and cross-cloud and native PaaS support.

Built on industry-leading virtualization and cloud-native technologies, the VMware vCloud NFV platform is uniquely capable of empowering CSPs to achieve the full benefit of NFV.



UNIFIED VIRTUALIZED ENVIRONMENT:

With CSPs looking for increased flexibility and efficiency in bringing new services to market, the ability to programmatically deploy services anywhere from the data center to cloud, to branch, and the edge, and across different technologies, including VMs and containers, is becoming key. With vCloud NFV, CSPs can deploy both VM and container workloads on a VIM with a single network fabric, allowing them to seamlessly deploy hybrid workloads where some components run in containers and others in VMs.

EXTENSIBLE PLATFORM:

With support for more than 75 VNFs, service orchestration, service assurance platforms, and VNF managers, vCloud NFV allows CSPs to operationalize NFV incrementally, starting with the NFVI/VIM and the base set of VNFs required for service delivery. This not only returns a better business case but also ensures the CSP can minimize the need for new operational skills and processes; providing a more manageable on-ramp to NFV-based service deployment. With extensible vendor-neutral APIs and SDKs for managing VNF lifecycle and runtime operations, the vCloud NFV platform integrates with service orchestrators, VNF Managers, and existing service assurance platforms, allowing CSPs to roll their own

service stack to meet their service delivery needs.

SIMPLIFY NETWORK OPERATIONS

NFV promises to give CSPs unprecedented agility and flexibility in deploying and operating their networks. However, it also introduces a host of operational challenges that CSPs must address to make this network transformation efficient and cost effective. VMware has engineered these capabilities and more into the vCloud NFV platform through its Operational Intelligence framework. VMware vCloud NFV takes a full lifecycle approach to operations management.

It incorporates core attributes such as simplification, multitenancy, proactivity, and efficiency across all aspects of large-scale telco operations, including:

- **Service on-boarding** capabilities including service and resource discovery, security and alert definitions, multi-tenant dashboards and network micro-segmentation
- **Unified visibility** from applications to infrastructure, capacity and performance monitoring, dashboards and analytics, and API/SDK access

OPERATIONS MANAGEMENT



- **Capacity and utilization analysis** including trending, forecasting, remediation, and resource reclamation
- **Service issue isolation** including SLA and performance degradation alerts, recommendations, and 360-degree network and application visibility
- **Automated workflows** for closed-loop optimization, predictive resource scheduling, and pattern recognition-driven alerts

This fully integrated operational intelligence computational platform provides a high degree of agility and efficiency out of the box, enabling seamless Day 0, Day 1, and Day 2 operations. In addition to keeping the lights on and ensuring the highest degree of service quality, the operational intelligence platform also provides real-time service optimization and forecasting capabilities integrated into a single solution.

A Multi-Service Multi-Tenant Platform Returning ROI for NFV

The evolution from static, appliance-based network elements to an agile, virtualized Telco cloud environment enables CSPs to drive down costs while establishing a common platform for new service innovation and revenue expansion.

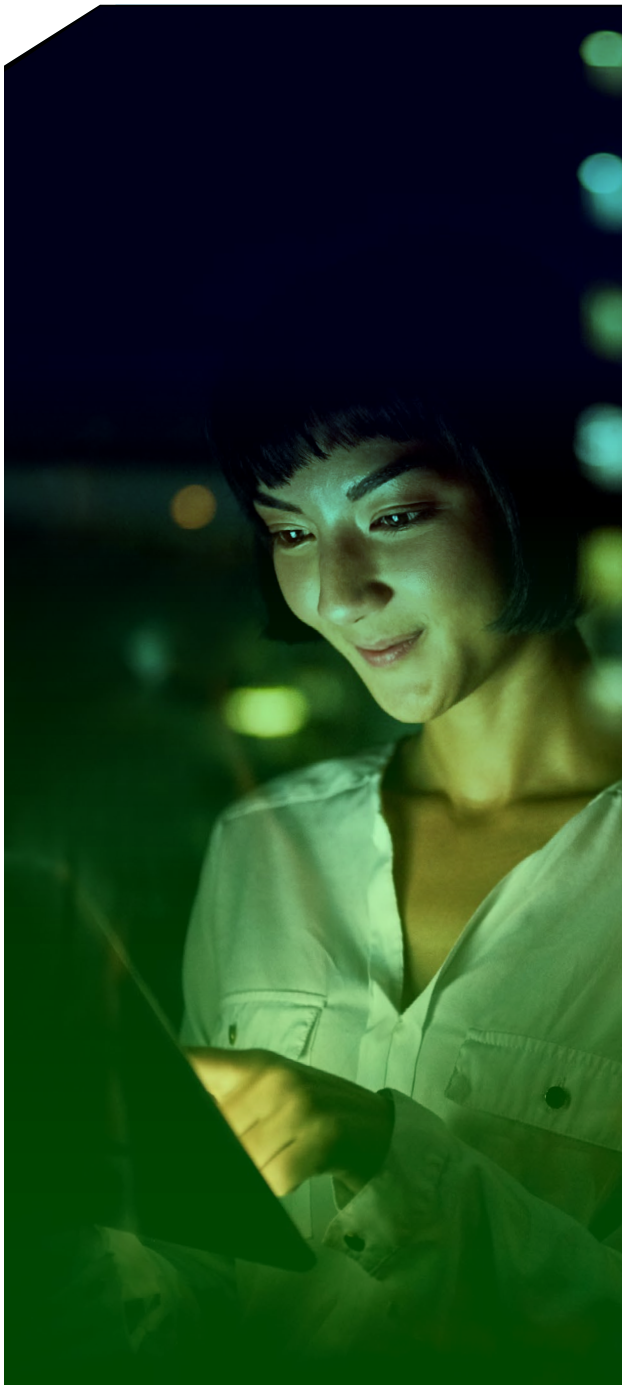
VMware vCloud NFV provides a robust multi-services platform with tight integrations with a wide range of industry-leading VNFs, creating a solid foundation for an agile Telco cloud architecture. This secure NFVI environment can be shared across lines of businesses and multiple tenants, allowing for convergence of telco network, IT, and B2B services into a multi-cloud architecture.

Complete tenant resource isolation is achieved using policy-based allocation of isolated compute, storage, and networking resources mapped to individual tenants of the cloud(s), providing complete tenant and VNF isolation. Provider and tenant based roles and service policies further help establish delegated access, and availability and performance boundaries across the cloud(s).

This multi-services platform approach allows CSPs, tenants, and customers to share a common pool of resources, creating a portfolio of network, managed hosting, and cloud services on demand, driven by orchestration techniques similar to those managing workloads in cloud data centers.

VMware vCloud NFV provides a robust multi-services platform with tight integrations with a wide range of industry-leading VNFs, creating a solid foundation for an agile Telco cloud architecture.

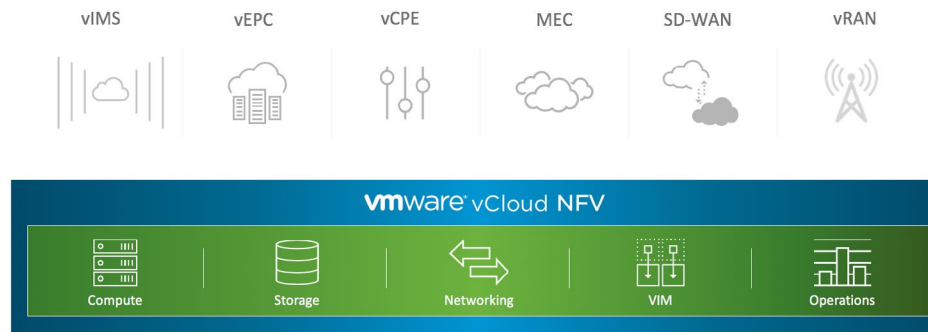
Service agility is further enhanced through standard and pre-defined tenant services that can be deployed on-demand in response to changing customer and network requirements. Tenant-specific portals and northbound APIs enable several operational intelligence capabilities including monitoring, issue isolation and remediation, automation workflows, and capacity planning and forecasting.



A Plethora of Diverse Use Cases

As much as NFV is about technology innovation, it is about business model and services innovation too. New service descriptions, pricing models, go-to-market strategies, all make up the key pillars of a successful realization of NFV based services.

With its platform based approach, VMware vCloud NFV fundamentally enables CSPs to develop, deploy, and run a wide variety of virtualized services in order to meet expectations from customers who are demanding a range of services.



VIRTUAL IMS (vIMS):

Virtualizing the IMS core gives CSPs a cost effective, flexible solution to deploy IP telephony services, such as VoLTE, quickly, efficiently and reliably while offering a high Quality of Experience for subscribers. With simplified network provisioning, accelerated network performance with end-to-end operations management, optimized resource management, a complete set of logical networking and security elements including switching, routing, QoS and monitoring, and a vast and growing partner ecosystem of VNFs, vCloud NFV ensures top performance, security, and service resiliency to launch vIMS based services faster to market.

VIRTUAL EPC (vEPC):

The explosion of data, video and devices is driving CSPs towards an agile, virtual network that can scale with new innovative services while reducing complexity and costs. vEPC is a key enabler in CSPs streamlining and automating the network core for emerging 5G and IOT services. The multi-tenant vCloud NFV platform helps operators accelerate customer onboarding, optimize the Quality of Experience (QoE) and network utilization through dynamic capacity allocation, and expand to differentiated services with flexibility in footprint and scale.

VIRTUAL CUSTOMER PREMISES

EQUIPMENT (vCPE)

Virtualizing the Customer Premises Equipment (CPE) allows CSPs to host services in their cloud, including VPN, routing and security functionalities, giving customers the flexibility to select their services when and where they want. The open, modular, carrier-grade vCloud NFV solution lays the foundational fabric for vCPE, allowing CSPs to accommodate increasing network complexity, meet continued growth in demand for capacity, and add future virtualized value-added-services including v-FW, v-IDS, v-VPN, v-SBC, and v-IP-PBX.

MULTI-ACCESS EDGE COMPUTING (MEC):

By making MEC available across access networks, from LTE/5G to wired/wireless LANs, CSPs are uniquely positioned to drive the adoption of next-gen applications at the network edge including CDN, 5G and IoT applications, traffic steering/shaping, location services, video processing, augmented reality, connected cars, and security and compliance. The benefits of carrier-grade performance, health management, service continuity, cloud orchestration, and automation, along with independence from proprietary hardware and service separation in a multitenant shared infrastructure, make vCloud NFV and MEC a compelling area of infrastructure investment for CSPs.

SOFTWARE-DEFINED WAN (SD-WAN):

As enterprise applications and services move to the cloud, delivering services to branch offices requires a new level of service reliability, application performance and security that SD-WAN offers. CSPs can leverage the vCloud NFV platform to simplify deployment of SD-WAN services, centralize orchestration and operations management, and programmatically provision the integrated networking and security functionalities which provide a complete set of logical networking elements and services including switching, routing, QoS and monitoring.

IOT/CONNECTED CAR:

The tremendous growth in IoT presents enormous opportunities for CSPs, particularly in the automotive industry, where the connected car is the focus of intense innovation. This is driving increased connectivity densities, higher data rates, and differentiated class-of-service profiles. CSPs can capitalize on these opportunities in several ways including providing converged communications applications that enhance the car's private network services, differentiated service levels for low-latency, low-power applications, aggregated data intelligence services, and hosted and managed cloud services. The vCloud NFV platform delivers the differentiated classes of service, optimized resource allocation, integrated operational intelligence, and application-level security required to capitalize on the burgeoning revenue opportunities in automotive IoT services.

SMART CITIES:

Cities are becoming denser and at the same time citizens are demanding more modernized and sustainable services, driving an acute need for cities to develop smarter public services. By leveraging their technological and operational expertise, and a vast mobile infrastructure that can enable edge clouds, CSPs are uniquely positioned to become trusted partners to

help develop these smart city services including networked transportation and mobility, analytics, water/waste management, video surveillance, and internet hotspots. With over 75 certified VNFs, vCloud NFV provides a flexible platform for developing these smart city solutions that require carrier-grade performance and scale, multi-tenancy, simplified VNF onboarding and operations, and a flexible topology for control and data planes.



CARRIER-GRADE SUPPORT

VMware offers a broad spectrum of support options, ranging from self-help and basic support to business and mission critical offerings, including:

- Add-on services to Production Support
- New SLAs for service restoration of NFV platform
- MCS SLAs for enterprise environments
- Dedicated support teams, 24/7
- Dedicated Service Account Manager
- Enhanced proactive and reactive support
- Limited onsite support as required, or option to purchase on-site resident assistance

VMWARE READY FOR NFV

The VMware Ready for NFV program is a certification program that recognizes VNF partners that have made commitments to the vCloud NFV platform. VMware Ready for NFV certified partners have completed a range of operability and interworking assessments in a dedicated accreditation facility and have access to VMware product roadmaps and solution development strategies in order to ensure their solutions continue to maximize the potential of the underlying vCloud NFV platform. Customers can look to the VMware Ready for NFV certification program as proof of close VNF integration with the vCloud NFV platform.

VIRTUAL NETWORK FUNCTIONS

ERICSSON

NOKIA

HUAWEI

ATHONET

affirmed

CISCO

Metaswitch
Networks

MAVENIR
SYSTEMS

FORTINET

riverbed

velocloud

VERSA
NETWORKS

silver peak

netrounds

radisys

benu
networks

CITRIX

NetNumber

Infoblox

Check Point
SOFTWARE TECHNOLOGIES LTD.

f5

WANGEL

PROCERA

Openwave
Mobility

AIO

Symsoft

Atos

CSG

FLASH
networks

TREND
MICRO



Infrastructure That Evolves With Modern Applications and Services

As evidenced by a growing number of our customer engagements, there is momentum among CSPs looking to leverage cloud-native methodologies to increase their competitiveness and build an environment where they can spin up services quickly while realizing operational gains. However, turning to cloud-native VNFs can be quite complex – both technically and organizationally.

The cloud-native VNFs have to be orchestrated and there must be a services layer that manages automated deployment, scaling, monitoring, and healing. The vCloud NFV platform supports container-based VNFs with integrated container orchestration and management support.

Enabling VM and container-based network functions to run from a single Virtual Infrastructure Manager. The deployment of VNFs can be virtual machine only, containers only, hybrid – where a container will run in VMs providing security and isolation features – and heterogeneous mode, where some VNFs will run in VM, some in containers,

alongside a mix of both, allowing CSPs to evaluate their deployment methods as per their requirements.

Further, by supporting open-source orchestration options built on open standards (TOSCA, HEAT, YANG, etc.), the vCloud NFV platform lets operators build the management capabilities they need while minimizing vendor lock-in by participating in an open community of like-minded operators.

With the largest ecosystem of application and hardware vendor support, and continual evolution of platform interfaces to meet changing market requirements, VMware vCloud NFV provides CSPs with a single platform capable of supporting all business functions today and for the future. With comprehensive cloud-native solutions across the stack from infrastructure to application, and open source technologies for interoperability and rapid innovation, CSPs can take advantage of the latest advances to develop cloud services quickly and easily.



THE TIME IS NOW

VMware has been working with leading CSPs globally over a number of years to deliver NFV-based service platforms that are transforming their businesses through significant reductions in costs and increases in service agility.

Proven in production, VMware customers have seen deployment times fall from years and months to weeks and days, even hours. The maturity of VMware's integrated virtualization platform, associated operational support capabilities, and resource management is enabling CSP customers to rapidly adopt new ways of deploying service infrastructure and embracing a new era of telecommunications where the operator is empowered to deliver services with uncompromised cloud-grade performance and reliability.

Learn More

For additional information about VMware vCloud NFV:

Call 1-877-VMWARE (outside North America, dial +1-650-427-5000)

Visit <http://vmware.com/go/nfv>.

Join us online:

