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VIRTUALIZED IP MULTIMEDIA SUBSYSTEM ON VMWARE VCLOUD NFV

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1. Executive Summary

In response to growing consumer demand for media-rich applications, including music and video streaming, service providers are seeking the agility and flexibility necessary to bundle and scale new service offerings quickly and easily. IP Multimedia Subsystem (IMS) is the foundational element to a future-proof network architecture that will enable a range of services like consumer voice over IP (VoIP), rich communication services (RCS), voice over LTE (VoLTE), and voice over WiFi (VoWiFi). The new construct depends on network functions virtualization (NFV), and virtualized IMS (vIMS) is a true differentiator for mobile carriers looking to offer their consumer and enterprise customers converged mobile and fixed services.

Today, the leading service that IMS supports is VoLTE. But still, competition from over-the-top (OTT) providers and the drive to seek out new revenue opportunities are pushing service providers to expand their catalog of service offerings quickly and efficiently. vIMS is essential to augmenting IP-based telephony and unearthing the new revenue opportunities this capability provides.

Service providers weighing a move to NFV and specifically virtualized IMS must take into account a few significant considerations:

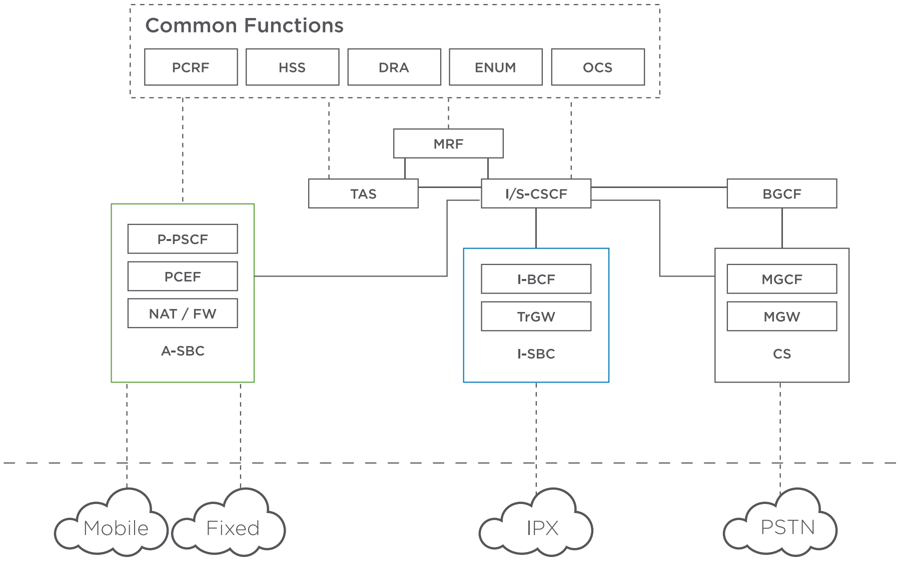
- How can I drive faster service agility and innovation toward new business models?
- How can I open my IMS infrastructure to external developers to enable me to compete with agile OTT providers?
- How does vIMS provide network elasticity and alignment to the 5G Mobile Core transformation?
- How can vIMS fit into a common platform with integrated automation, security, and operations management?

The answer to each of these questions reinforces the business case for virtualizing IMS as part of a broader move to NFV through the adoption of a secure, a highly available, multi-tenant platform like VMware vCloud NFV. This carrier-grade NFV infrastructure platform allows multi-vendor VNFs to share a pooled capacity of resources that can be intelligently orchestrated and automated for the provisioning and delivery of services, like VoLTE, VoWiFi, and RCS as a deployment in a multi-functional, cross-cloud environment.

2. Business Objectives for Virtual IMS

With the advent of VoLTE, IMS has become a key component of that voice-over-data transformation. With streamlined transport bearers, operators continue to migrate voice services to this lower-cost operating model. Though QoS improvement, voice continuity across VoLTE, and circuit-switched coverage continue to challenge operators, they have accelerated past this innovation and are looking for new offerings and new revenue opportunities for virtualized IMS.

In the initial design, centralized IMS cores paved the way from traditional soft switch architectures, interconnecting with mobile packet cores for the VoLTE transformation. The central IMS cores can be extended to other access networks such as WiFi and fixed. End-to-end QoS is vital, and so this single-tenant network design and evolution requires careful analysis for any configuration change, capacity expansion, and new innovation onboarding.



High-level IMS component architecture and interconnects

The IMS architecture represents a well-tiered architecture with separation of control and data planes; however, rapid on-boarding and differentiation are required to respond to market opportunities. To meet customer needs with varying SLAs and service characteristics, turning up multi-tenant or multi-instances of the IMS core are potential options to drive service agility and new innovations.

Rich multimedia telephony and communications services drive a significant demand on the data and signaling planes. As such, on-demand workload balancing, resource elasticity, and VNF scale are some of the critical parameters to consider for cost and operations efficiency.

Accelerating with Virtualized IP Communications

CSPs have been migrating to all-IP networking for operational and cost efficiencies, inherently accelerating the business case for converged, rich multimedia communications. A vIMS implementation can serve the needs across the fixed-mobile convergence. An operator can offer rich multimedia services from a common IMS service infrastructure irrespective of the end-point devices – mobile, fixed, laptop. Furthermore, the 5G Mobile Core technology advancements are paving the way for new communication service offerings spanning multiple industries and requiring differentiated classes of services and traffic characteristics.

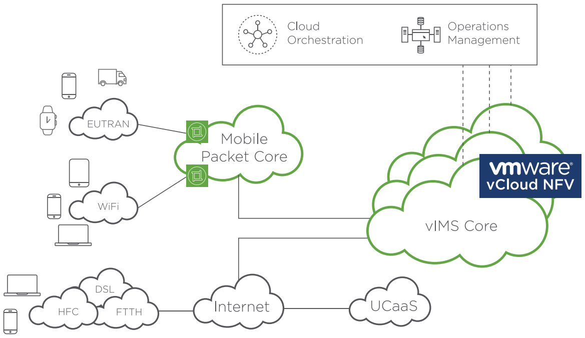
While there are myriad OTT IP communication services available in the market today, customers are emotionally invested with the operator for their converged communication needs. CSPs are battling strong headwinds from the OTT providers, however, so being able to provide the interoperable, innovative communication services with agility, quality, and competitive cost structures is key. With a virtualized IMS core, operators can instantiate instances of the cores rapidly to realize differentiated value services, connectivity, and operating characteristics that justify business models or fail-fast.

The VMware vCloud NFV platform supports vIMS, as well as a large ecosystem of virtual network functions (VNFs), that could be harnessed as part of an IMS service.

According to a 2015 Analysys Mason study, CSPs can achieve 33 percent net savings by implementing vIMS for VoLTE as compared to utilizing physical, on-premises IMS for VoLTE [Analysys Mason]. And CSPs considering the virtual IMS solution will find numerous other benefits in making the transformation, as well:

- Decoupling from costly, proprietary, and physical appliance vendor lock-in to innovate business and service models, together with the growing ecosystem of VNF providers and cloud services.
- Assurance of optimal, measurable QoS across the multimedia service offers for customer stickiness: Conversational voice for a given codec may demand under 65ms packet latency, 20ms jitter, and 0.3 percent packet loss from the IMS core, for example.
- Flexibility in deployment across distributed micro- and macro-datacenters to meet the communication service needs of their customers, from converged mobile and fixed networks to stitching the right IPX providers by feature, SLA, and access networks.
- Extensions with new communication services and chains in the central IMS core or virtual edges in an agile manner, and fail-fast if needed.
- Efficient management and operations of communications services across the converged network; Centralized, dynamic configuration and management of the IMS using SDN approaches to offload IT resources to focus on more strategic initiatives.
- Centralized cloud orchestration to onboard new customers, services, policy and control, and security profiles.

- Real-time monitoring to allow CSPs to monitor the health of their service offers over their networks and improve operational efficiencies in end-to-end QoS, capacity, issue isolation, remediation, incident reduction, proactive analytics for preventative maintenance, and more.
- Automating capacity on demand to scale-out and scale-in the vIMS footprint, maximizing the use of the CSP cloud infrastructure.
- Offering innovative new services like VoLTE and VoWIFI with seamless handoff, providing customers more flexibility in how the service is consumed.



Virtualized IMS core high-level architecture

Key Characteristics:

- Converged networks – mobile and fixed
- Low cost, fast TTM service agility
- Service onboarding automation
- Flexible, tiered class of services with quality
- High availability and dynamic scalability
- Multi-tenant, multi-service, and multi-vendor
- Extensibility to new business models

CSPs are investing in VoLTE, along with virtualized IMS. SNS Research reports that as of Q42016, more than 80 mobile operators have commercially launched VoLTE services. [SNS Telecom] Service providers have the core infrastructure in place to drive rich communications across mobile and fixed access networks. New service innovation and delivery across devices and networks are well within reach – far more accessible than with traditional, on-premises IMS.

While personalized services and seamless continuity across access technologies are important attributes of vIMS, it is the converged communications offerings across mobile and fixed access networks that remain key differentiators and the main revenue opportunity for operators. Value-added VNFs, or profiles, can include rich service offerings such as presence, address book, collaboration via web, voice, and video, international calling, voice recording, multi-party calling, toll-free calling, and visual voicemail, among others. These can be provisioned and onboarded rapidly to meet customer needs.

Cloud-based enterprise and wholesale telephony services also offer additional revenue opportunities for CSPs. Whether through a subscription model or via fully managed service with premium features and SLAs, virtualized IMS extends from on-premises models to cloud communications.

Network Elasticity to Meet Service Offers

Elasticity in an IMS core built with physical appliances is not possible, and forces the deployment to be the size of the largest peak load, even if that peak only occurs rarely. QoS, congestion control, premium SLAs, issue isolation, and heightened risks with multi-tenant reliability and availability are among the numerous challenges that hinder elasticity and agility in deployments based on physical appliances.

IMS is one of the key services that can benefit from virtualization. Besides VoLTE and ongoing rollouts, VoWiFi has also gained relevance to extend voice services to areas with poor cellular coverage and/or in-building situations. Within a voice offer, the virtual IMS deployment can range from a fairly scaled-down instance to a relatively large footprint with multi-tenancy – mostly defined by end-points, connections, traffic, and service characteristics – to meet the target business models. Fixed line IP voice for residential and enterprise customers further extends use of the IMS investment. WebRTC and other API-oriented clients can become gateways to the IMS core, as well.

The vCloud NFV platform provides this needed network, service, and resource elasticity to deploy and operate multi-tenant business models. Various vIMS components and value-added VNFs – partitioned by service type or customer segments, for example – can be dynamically scaled up or down to meet the demand by time of day. Control plane functions (call control, DRA, ENUM, policy, AAA) can be scaled independently of media functions, and resources shifted to international calling wholesale providers during the evening and night hours to meet capacity demands.

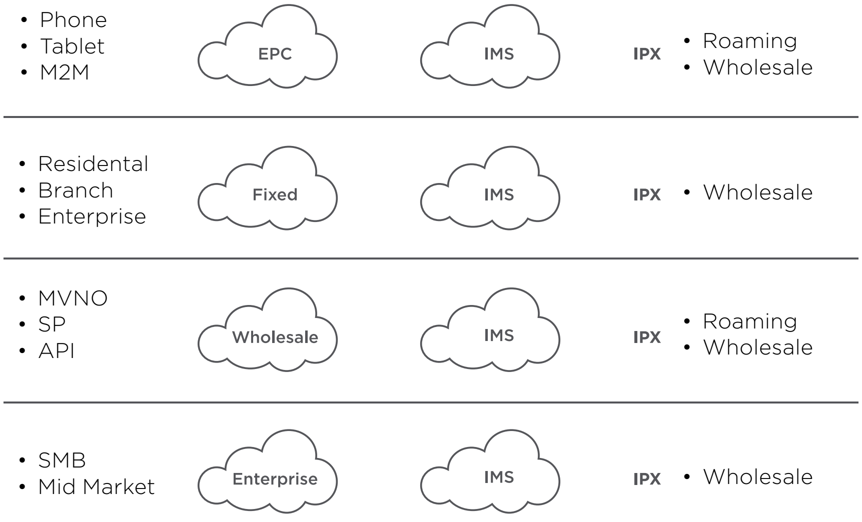
Target Topologies

Due to the nature of how IMS is deplyed in various purpose-built components, a virtualized deployment becomes very flexible in how it is layered across the cloud infrastructure. Virtual IMS can be designed as a centralized architecture and distributed micro data centers to address these challenges. Shared pools of common functions – such as signaling, routing, policy, LNP, E.164 directory, service monitoring, and billing, for example – can benefit either model. The vCloud NFV platform provides the necessary elasticity for such deployment models, with centralized service orchestration and operations management. Scale only those components that need it, exactly when they need it, then scale them back when the load has subsided.

- In a centralized deployment architecture, multiple customers with differentiated service features can be created as differentiated, segmented, separate network sections from a common shared infrastructure. vCloud NFV provides the necessary tenant and network isolation along with resource allocation and reservations to avoid contention and starvation. Trial slices can be rapidly on-boarded for new service innovation betas and fast-fail.

- In a distributed deployment architecture, multiple micro-datacenters can be created and partitioned by enterprise or access. If user localization and business models permit, regionalized micro data centers can benefit from lower latency and transport costs, translating to better pricing for the customer. vCloud NFV eases inter-datacenter communication with stretched networking over VXLAN and secure tunneling over IPSec or SSL VPN. This allows us to push those latency-sensitive services closer to the edge, consolidating and centralizing services to provide a flexible, stable design and maximize the use of cloud infrastructure.

Both approaches also provide flexibility to mix and match across IPX providers for roaming and wholesale voice interconnections, determined by price, features, and SLAs.



vIMS deployed over shared infrastructure or in distributed micro-datacenters

Scalability & Performance

Scalability and performance for optimal quality of experience are always a concerns for any service, especially voice services that are regulated and considered critical infrastructure. Virtual IMS paves the way to deploy not only multi-tenancy but also service classes such as those defined by the GSMA: voice, video, HD video, and WiFi IMS profiles for conversational, streaming, and interactive capability.

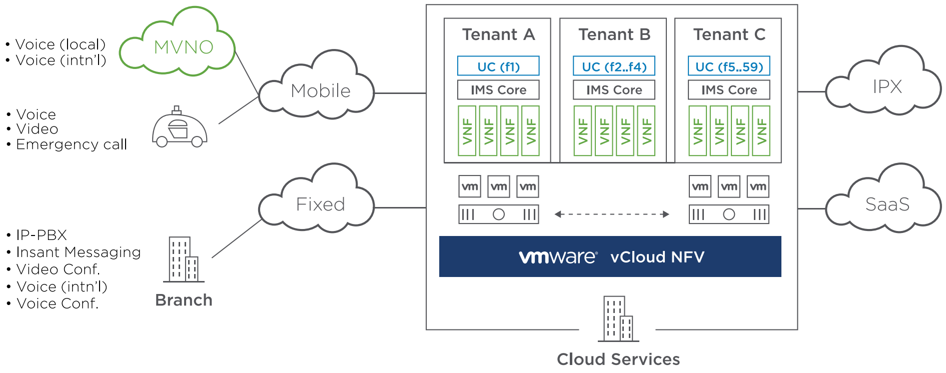
Multi-tenancy across lines of business such as enterprise, wholesale, and mobile virtual network operator (MVNO) can be network-sliced and operated with differentiated service levels (e.g. compute, network, performance), while emergency calling is implemented as a horizontal service with prioritized service levels across all tenants.

The software-defined functional components can be scaled independently across control and data, stitched and secured into service bundle offers with lower cost of operations and growth agility. With the vCloud NFV platform, auto-scaling capacity for the signaling plane is proactively monitored and recommended – scale-up the number of compute, storage, and networking resources and scale-out with additional virtual machines (VMs).

Virtualized Managed Service Clouds

Cloud-hosted rich multimedia IP communications services offer significant opportunities for new revenue. Leveraging software-defined agility benefits, IMS and telephony application instances can be realized for wholesale, enterprise, and M2M consumers. Cloud services such as Unified Communications (UC), IP-PBX, and emergency calling can be offered as a fully managed subscription service. A wholesale entity such as an MVNO may avail voice telephony service with IPX integrations for roaming and international calling features, while an enterprise may choose from a catalog of features such as instant messaging, video collaboration, international dialing, and multi-party calling to enrich their private branch exchange service subscription.

The vCloud NFV platform enables rapid onboarding of VNFs and cloud service integrations to create customer-specific service compositions for the commercial offer. Multi-tenant slices of shared infrastructure can be carved out to meet the service, security, and SLA requirements for the target customer. Security policy and control is integrated down at the VM level and provides safeguards from the public Internet.



vCloud NFV virtual managed service example for enterprise and wholesale customers

Network Monitoring and Operations

Ensuring availability and reliability of services and infrastructure across a heterogeneous ecosystem of diverse platform and vendors, network M&O continues to be one of the top priorities for operators. Network and IT operations have more tools in their environments, including device, radio, transport, engineering, traffic instrumentation, and application for analysis and optimization.

Monitoring within this diverse environment requires information collection and correlation aggregated across EMS platforms, virtual network function managers, and M&O platforms, to name a few of those vendors. With vCloud NFV, operational intelligence for service operations is baked into the horizontal platform.

- Continuous monitoring of resources and service allows for auto-scaling and auto-healing of VNFs proactively, ensuring optimal service operations. Both control and media-plane KPIs can be monitored and triggered for any anomalous behaviors.
- On-demand enablement of DPI VNFs can provide deeper issue isolation and root cause analysis (RCA).
- Operational intelligence can track service and customer SLAs within a network slice or regional virtual edge.
- Fully featured APIs and tools to integrate customized alerts and reporting on system health, and integration of legacy and new monitoring and management applications.

3. Advantages of vIMS on vCloud NFV

VMware vCloud NFV, an ETSI NFV-compliant platform, delivers carrier-grade infrastructure integrated with a robust operation and management toolkit. The platform is open to any VNF by offering a horizontal, multi-tenancy, multi-domain environment. VMware vCloud NFV features:

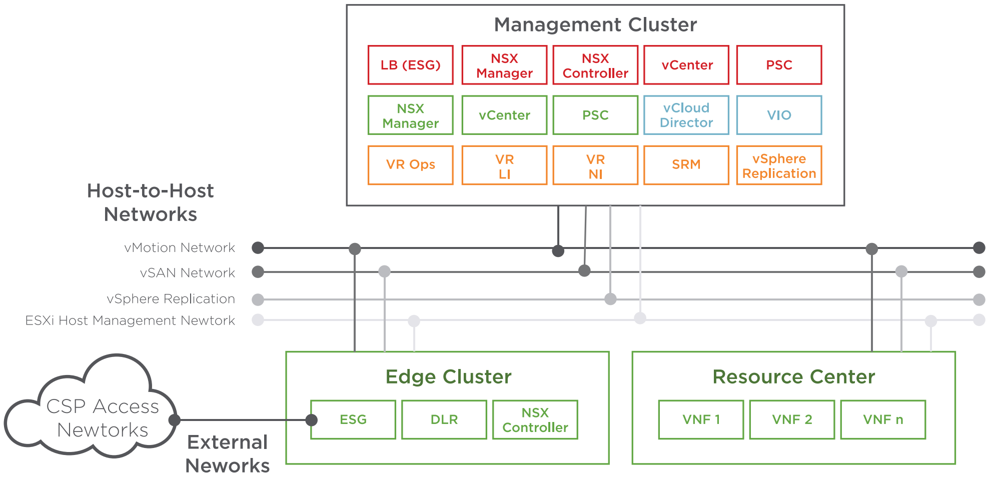
- **Integrated Dynamic Platform:** The VMware vCloud NFV solution is a modular, horizontal, common NFV Infrastructure platform based on ETSI standards. It is built on proven virtualization technologies for compute, storage and networking along with integrated dual multi-tenant Virtual Infrastructure Managers. It enables cloud centralized operations and management across the deployed topologies.
- **Software Defined Networking:** NSX for vSphere provides overlay networking technology for workloads, with integrated logical switches, routers, firewall, load-balancers, and VPN delivering connectivity, performance, and security in any carrier deployment. Logical overlay tunnels make VNFs completely agnostic to the underlying infrastructure. As a result, multi-VNFs with multi-services can seamlessly share the same infrastructure yet have complete isolation from each other. With VMware NSX, service providers can deploy security policies within the VNFs and the NFVI with fine-grained traffic segmentation that can be enforced at the perimeter, across workloads or VMs. Security profiles are bound to the VNFs, and thus migrate seamlessly across resource clusters.
- **Software Defined Storage:** While vSAN is an optional component of the vCloud NFV offering, it adds a number of advantages to the deployment. Virtual SAN pools together local DAS storage into a common sharable datastore, offering a much lower-cost solution across the platform. Through automated and centralized policy controls, storage can be attached and scaled as needed by application demand. The solution is fully integrated into features like vMotion, High Availability (HA), Distributed Resource Scheduler (DRS), and more.
- **Services Management Automation:** vCloud NFV provides flexible, automated VNF onboarding and full-service lifecycle management through multi-VIM capabilities, greatly accelerating new service onboarding and expanding customers with TTM. With VMware native vCloud Director (VCD) or VMware Integrated OpenStack (VIO) – a full OpenStack implementation – service providers can automate the process of deploying VNFs and NFVI resources including the configuration and provisioning of compute, storage, and networking resources. With policy-based provisioning, vCloud NFV simplifies the resource allocation for VNFs. This gives service providers a multi-tenant, robust VIM that automates and accelerates service deployment.
- **Carrier-Grade Performance and Availability:** The platform provides proven carrier-class performance, extending control and data-plane separated cluster design. Workloads can take advantage of the high performance fabric with built-in dynamic high availability and scalability to meet application demands. SLA guarantees are met through resource isolation, reservations, and dynamic workload placements with DRS and vMotion technologies. The platform can be scaled from a branch office virtual PoP to a large centralized datacenter, to achieve micro-datacenter and multi-tenant network sliced designs.

- **Integrated Operations Management:** This fully integrated single-pane cloud solution ensures and restores service levels using near real-time operation monitoring, analytics, automation and remediation. The solution provides an overall integrated and correlated view across service, access, network, virtual and physical tiers, with issue isolation and recommendations for RCA. Northbound triggering closes the loop with service and resource orchestration remediation and NMS/OSS notifications. The solution can be extended with custom data feeds and third-party domain and technology expert analytics systems.
- **Ready for NFV Partner Ecosystem:** *VMware Ready for NFV* is a certification program that ensures interoperability between VNFs and the vCloud NFV platform. The interoperability tests, performed by VMware engineers, assist partners in understanding and preparing for cloud operations over vCloud NFV.

An Integrated Dynamic Platform

The VMware vCloud NFV solution is an open platform implementation of the ETSI NFV ISG reference architecture (defined in GS NFV 002). The reference architecture paper can be found here. The rich set of capabilities in VMware vCloud NFV is designed with strict functional separation ensuring optimal resource usage, service management, and security. Distributing resources efficiently and achieving functional separation are achieved using a cluster construct:

- **Management cluster:** All management control-plane functions are in this cluster, as well as the operations and management components, themselves.
- **Edge cluster:** This cluster isolates and secures the VNFs from the wide-area network and transitions network traffic between the physical and the virtual domains, and vice versa.
- **Resource cluster:** Multi-tenant VNFs are hosted in this cluster with provided non-contended resource isolation and demand-driven elasticity for optimal performance and scale.



▶ The vCloud NFV platform cluster design benefits IMS core architectures, allowing them to effectively implement topologies with diverse access networks, service characteristics, traffic profiles, and peering interconnects. Whether the network and deployment topology is centralized or distributed, service onboarding, configuration, operations, and management can be orchestrated centrally.

Secured Virtualized Networking with VMware NSX

Virtualizing network functions offers numerous benefits, and one major advantage is the ability to programmatically and automatically deploy new services or extend and scale existing services. VMware NSX for vSphere is the virtualized networking tool underpinning all communication in VMware's vCloud NFV. Using a separation between control and data plane paradigms, demanding network workloads enjoy unhindered resources while control plane components remain unaffected by rogue VNFs.

NSX for vSphere has all the components needed to create a carrier-grade elastic service:

- NSX provides in overlay, the network and service isolation with carrier class service levels and fine-grained security and control.
- Service providers can extend data centers across locations while maintaining the same IP addressing and security policies and extending fault tolerance.
- By using standard protocols such as BGP and OSPF, the virtualized networking components are easy to integrate with the existing service provider networks.
- Built-in distributed logical routing can achieve low-latency network communications across VNFs and their components (VNF-C), minimizing the need to upgrade physical network components.
- NSX management and monitoring is integrated with the management systems such that monitoring VNF health covers a complete stack – from physical to virtual to application.

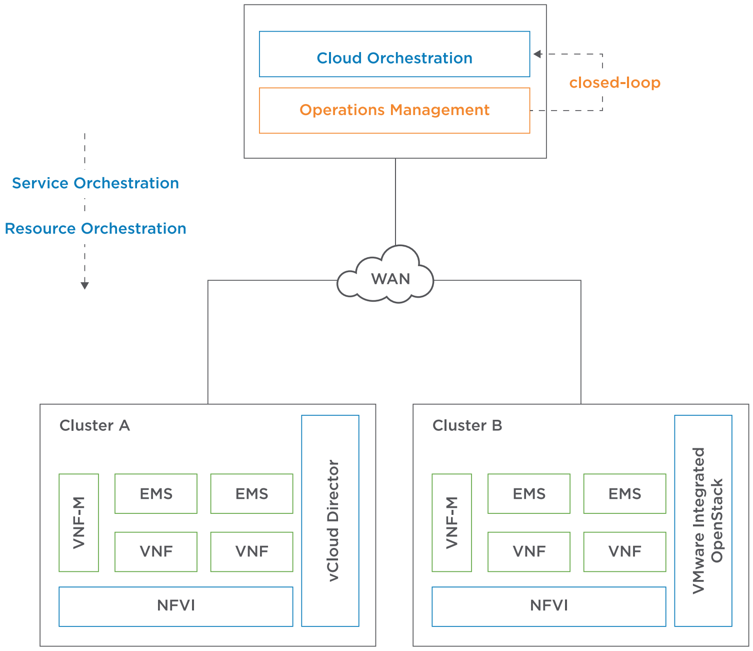
▶ With NSX for vSphere overlay networking, multi-tenant service-segmented networks can be isolated in the overlay and stretched networking established to common reusable functions, for example. Edge gateway networking provides secure IPSec and SSL tunneling across micro-datacenters and cloud services. Service and component resiliency can be achieved with stretched VXLANs across resource clusters to achieve desirable fault tolerance SLAs.

Micro-segmented security profiles can be provisioned at the edges of VMs to safeguard control plane traffic such as SIP and Diameter in the east-west and north-south traversal.

Service Management Automation

The vCloud NFV platform provides and exposes flexible VNF onboarding, from resource orchestration to service lifecycle management through multi-VIM capabilities.

Both VCD and VIO VIMs support templated service descriptions as well as multi-tenancy and robust networking, automating and accelerating service deployment and lifecycle management with closed-loop operations management.



Being fully compliant with the ETSI NFV architecture framework, the vCloud NFV platform also supports open APIs to third-party service orchestration components (NFV-O and VNF-M) leveraging TOSCA blueprints and YANG/NETCONF data modeling specifications. This also allows for customization and automation of the orchestrator to suit any deployment.

▶ IMS core and component VNF orchestration and management benefits from a northbound standardized API with flexible workflow integration into OSS/BSS and service creation automation. This allows providers to manage distributed sites centrally and minimize truck-rolls.

Service Availability

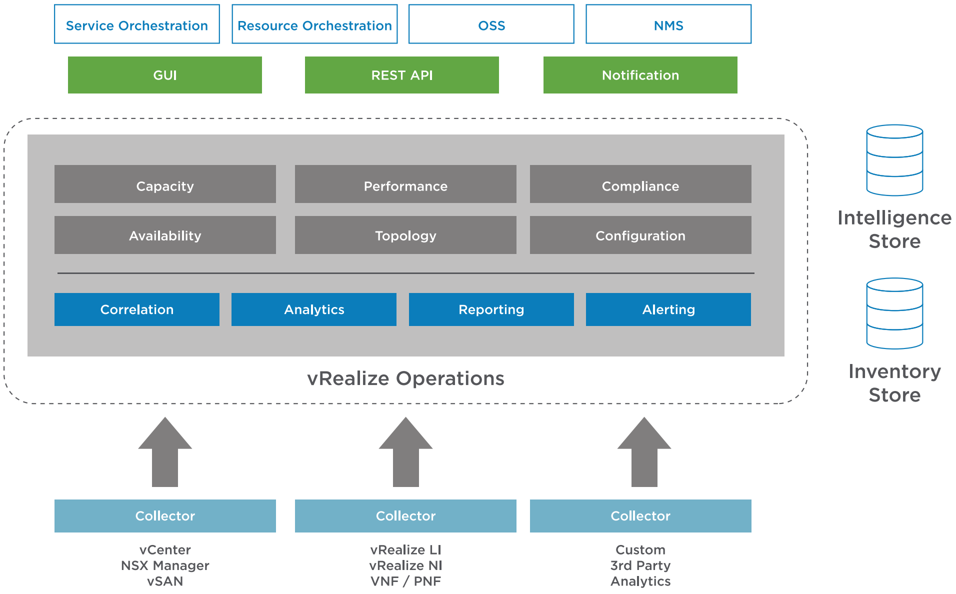
The vCloud NFV platform not only employs a well-thought-out redundancy design using active-active, active-standby, and N+1 architecture principles, it also integrates monitoring for proactive, automated, and semi-supervised service availability safeguards. If all proactive issue-avoidance mechanisms fail, components of a VNF are configured to automatically return to life using VMware's High Availability (HA) mechanism.

The vCloud NFV platform continuously monitors service performance characteristics as defined by SLAs and uses VMware's Dynamic Resource Scheduler (DRS) and vMotion technologies to balance live workloads with Enhanced Platform Awareness (EPA). vSphere Replication and Data Protection technologies provide VM-level data replication and continuous data backup to recover from an outage.

Integrated Operations Management

Historically, operations management approaches are a tedious aggregation of vertical management components across different vendor devices and OSS/BSS solutions. vCloud NFV is bundled with fully integrated operation monitoring, analytics, proactive avoidance, issue isolation, and remediation.

- **Monitoring and Remediation:** vROps provides complete visibility of all components responsible for the delivery of a service – from topology discovery to cross-tier physical and virtual hierarchies. Data is collected and computed near-real time (centralized or distributed) to provide correlated health, performance, capacity, and availability metrics. Prioritized alert and recommendations drive closed-loop integration into resource and service orchestration workflows for issue avoidance and remediation.



- **Issue Isolation:** The vRealize Log Insight tool captures all unstructured log and event data from the environment, providing log analysis and analytics for issue isolation. Unstructured to structured object models can be filtered for fault/error conditions, and optionally put under observation towards future alerts, presented in the single-pane.
- **Network and Security Troubleshooting:** vRealize Network Insight provides full visibility into virtual and physical networks as well as security engineering analytics. The engine is pre-integrated with the NFVI components, ingesting data ranging from network inventory and configuration metrics to IPFIX records, Security Groups, FW rules, IP Routes (across VXLAN/VLAN), and growing list of physical infrastructure elements metrics. It helps optimize network and security designs, surfacing gaps in network micro-segmentation compliance, security violations, traffic routing and performance, VM traffic analysis, flow monitoring (virtual to physical, E-W and N-S), and more.

▶ Virtual IMS and unified communications VNFs can benefit from centralized network monitoring, optimization, and issue isolation. vCloud NFV components in the management domain allow third-party developers to create plug-ins to enhance their understanding of the workloads they are monitoring.

Benefit from a framework to create new data adapters, KPI computations, alert profiles, recommendation, or custom dashboards, to name a few.

Service-centric enrichments for SIP/Diameter control or RTP data plan analysis can be extended into the operations management framework..

Partner Ecosystem

The vCloud NFV platform is pre-certified with Telco NFV solutions from our extensive partner ecosystem. Service acceleration is key and the VMware Ready™ for NFV partner program brings together the largest Technology Partner Marketplace with VNFs for telco solutions. The Cloud Management Marketplace offers a robust collection of extensibility tools, management packs, and content packs for monitoring and analytics integration into the vRealize Operations Management suite.

4. Conclusion

The VMware vCloud NFV platform allows CSPs to offer vIMS – and the derivative services enabled by this VNF – to their enterprise customers and consumers, creating new revenue streams for the service providers and reinforcing their bulwark against OTT competition. Because the vCloud NFV platform is modular and extensible, and surrounded by a rich ecosystem of partners, it enables CSPs to quickly build, tailor, and deploy offerings that meet the needs of their regional customers.

To learn more about VMware vCloud NFV, please visit http://www.vmware.com/go/nfv.

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