

# Network Virtualization

The New Imperative in the Enterprise Data Center



## Key Considerations for Network Virtualization in the Enterprise

### Executive Summary

To maintain productivity and competitiveness, enterprises are increasingly adopting virtualization technologies and cloud architectures in their data centers. The addition of network virtualization to the data center has been a major boon to enterprises. Virtualization makes the network much more portable and scalable and simplifies network life-cycle management. Network virtualization works in conjunction with compute and storage virtualization to provide enterprises with quick provisioning, improved resource utilization, and operational efficiencies across the entire data center.

In evaluating network virtualization solutions, enterprises should look for compatibility with existing infrastructure, including hypervisor(s), physical switches, and the preferred cloud management platform or orchestration stack; the richness of its networking features, including support for multi-tenancy; the openness of a solution; and the extended ecosystem of products it supports. In addition, in selecting a cloud platform, enterprises need to understand how each cloud solution supports network virtualization.

The major cloud ecosystems in use are OpenStack with the KVM hypervisor, and VMware's vCloud Directory (vCD) and vCloud Automation Center (vCAC) with the ESXi hypervisor. HP is one of few vendors whose network virtualization and cloud solutions support both OpenStack and VMware environments. HP's commitment to open, interoperable technologies, broad ecosystem of partners and comprehensive services and expertise enables enterprises to leverage their existing compute, storage and network infrastructure investments and take advantage of state-of-the-art technology without being locked into a proprietary solution.

As a significant contributor to the OpenStack and Cloud Foundry communities, HP has helped develop technologies that meet enterprise requirements for flexibility, agility and automation. In addition, key HP network virtualization enhancements, such as distributed virtual routing and excellent control over the underlay network, ensure efficient, reliable traffic flows across and between data centers.

### Network Virtualization – The New Imperative in the Enterprise Data Center

Big data, mobility and the need for agility are among the trends driving enterprises to adopt virtualized, cloud-based IT infrastructures. In particular, the expectation of anytime, anywhere access is placing incredible demands on the network. To maintain productivity and competitiveness, enterprises need efficient, cost-effective ways to deliver data and applications to users. Virtualization technologies and cloud architectures directly address those requirements, making them key to the modern data center.

Until recently, virtualized compute and storage provided agility, scalability and cost-reduction but were held back by the lack of network virtualization (NV). Whereas provisioning compute and storage resources was automated and takes only minutes, network provisioning historically has been done manually and taken days, even weeks—a situation that has frustrated enterprises CEOs and application users equally.

NV closes this gap and completes the virtualization process, enabling data centers to provide the full suite

of cloud capabilities that businesses need, from on-demand self-service and rapid elasticity to flexible billing and department chargebacks. With NV solutions, IT can make network changes in minutes or hours, such as adding/removing VLANs, stretching the network across server racks or between data centers, adding/deleting firewall functionality, and adding/removing load-balancers on the fly.

The network has always played a foundational role in enterprise IT. Now with NV, the network can support the fast pace and scale of today's data center environments. NV combines with compute and storage virtualization to provide enterprises with quick provisioning, improved resource utilization, and operational efficiencies across the entire data center.

## Defining Network Virtualization and the Main Approaches

Similar to compute virtualization, NV creates a logical, virtual network by decoupling network functions from the hardware that delivers them. It simulates network functionality as a “virtual instance” that can be loaded onto general, off-the-shelf platforms. The physical devices are responsible for the forwarding of packets, while the intelligence of the network is delivered by software. A single hardware platform can support multiple virtual network instances.

The decoupling of the control and forwarding planes delivers superior operational efficiencies and reduces costs due to hardware independence. In general, a virtualized network can offer all the features and guarantees that a physical network offers, only with greater agility and flexibility. This makes NV ideal for the increasingly virtual data center environments that the network is being asked to connect.

There are two main NV approaches: the first programs the fabric directly, and the second relies on a network overlay. Programming the fabric, which usually consists of a mix of virtual and physical switches, requires using a flow-control protocol such as OpenFlow.

In situations where switches don't yet support SDN, or where enterprises choose to run a purely abstracted virtual network, the overlay approach is favored. Overlays require that packets be encapsulated to cross the network. There are a variety of ways to implement an overlay network, the most common of which is by modifying or replacing the virtual switch in hypervisor platforms so it can encapsulate and de-encapsulate packets that are tunneled through the physical network. Multiple encapsulation protocols are available. Currently, VXLAN is dominant in the market, and is supported in many physical switches and hardware-based Layer 4-7 devices.

Overlays provide agility and location flexibility without requiring an enterprise to upgrade or modify the existing physical equipment at the core of their network. However, this approach may have challenges in enforcing quality of service (QoS), or providing fast recovery from failures. A combined approach of orchestrating both overlays and underlays will tend to provide an ideal solution in the long run.

For enterprises that don't want to use fabric programming or overlays—for example, organizations with less complex application or multi-tenancy requirements-- using a dynamic VLAN solution is an alternative to full network virtualization. Making existing VLANs more dynamic through automation allows VLANs to be created or deleted on the fly and provides some of the benefits of NV.

## Benefits of Network Virtualization

With the enterprise drive towards providing more in-house, self-service and cloud-type solutions (such as Amazon, Azure and Google Compute), IT needs to ensure that the network is more agile than before. NV makes the network much more portable and scalable, delivers operational efficiencies, simplifies network life-cycle management, and makes it easy to deploy bandwidth. NV also reduces costs by providing hardware independence.

IT can use NV to provision private virtual networks for any application workload, as well as provide any associated security, acceleration or external connectivity services. These private networks can sit within a rack of servers or across multiple racks in a data center. This makes NV a key aspect of the increasingly virtualized data center.

<b>Flexibility</b>	NV lets IT quickly provision, move and scale the network to meet the changing needs of the virtualized compute and storage infrastructures.
<b>Automation</b>	The centralized, automated set-up of service chains, within Layer 3 and Layer 4-7 services, accelerates the roll out of services such as firewalls, IPS, etc.
<b>Multi-tenancy</b>	NV supports multiple silos and virtual networks running over the same physical links (even allowing for overlapping IP spaces).
<b>Reliability</b>	The ability to save and restore network topologies and configurations--via snapshotting, check pointing and rollbacks--allows for faster recovery from both bad configuration decisions and equipment failure.
<b>Simplified Deployment</b>	"Template-ized" deployments of standard application stacks, with built-in networking topologies, enables error-free and fast deployment of applications, pre-checks for compliance, and the adoption of networking best practices.
<b>Simplified Management</b>	NV provides centralized control over the distributed network; changes to the physical underlay network do not impact the virtual overlay, removing a lot of the complexity of ongoing connectivity management and maintenance. VMs can move without impacting the flow of traffic, and there's no need to manually reconfigure physical links or endpoint settings on the network.
<b>Agility</b>	IT can modify the network's topology or traffic handling without having to modify the existing physical network. For example, the endpoints can run a modified networking stack, with new protocols tunneled through existing physical legacy networks, without impacting existing networks.
<b>Security</b>	NV's support for micro-segmentation allows for application isolation, enhancing overall security by preventing malicious or unintentional access by a server in one domain to a server in another domain.

## NV's Main Use Case – Supporting Enterprise Virtualization and Clouds

Virtualization and cloud architectures let enterprises leverage commodity components, cookie-cutter designs and virtualization technology to deliver IT services dynamically. When deployed in the data center, cloud architectures enable IT to quickly scale work-loads and resources up or down in response to market conditions, business requirements, and customer expectations. Cloud benefits also include self-service delivery models and lower capital and operations expenses.

Clouds are commonly used for new application development, including internal, semi-public and public-facing web applications; prototyping new services and applications; and internal quality assurance testing. Increasingly, enterprises are using clouds as business differentiators to capture more market share and increase revenues.

For both enterprises and service providers, multi-tenancy is one of the most critical architectural elements across cloud use cases. Multi-tenancy allows resources to be shared in a way that preserves isolation across compute, storage and networking. In particular, network virtualization is being used to create on-demand, multi-tenant slices of an existing network to support web-facing and internal enterprise applications, and to enable cloud bursting to augment on-premises data center resources.

## Cloud Considerations and the Role of NV

In enterprise clouds, the key components of cloud architectures include:

<b>Compute resources</b>	Typically commodity servers running a hypervisor;
<b>Storage resources</b>	Includes distributed storage, a shared SAN/NAS solution, and storage management;
<b>Networking</b>	Includes physical and virtual routers and switches, and network orchestration/virtualization solutions;
<b>Cloud management platform</b>	Can be an open system, such as OpenStack and CloudStack, or a commercial offering, such as VMware vCloud Directory (vCD) and vCloud Automation Center (vCAC);
<b>Billing systems</b>	Includes business orchestration systems similar to the operations support systems (OSSes) and business support systems (BSSes) used by service providers.

When deploying a cloud, the first architectural decision is often the selection of a cloud platform. IT needs to evaluate each platform for its overall functionality and virtualization capabilities as well as the extended ecosystem of products it supports. Currently, the major cloud ecosystems in use are OpenStack with the KVM hypervisor, and VMware's vCAC and vCD with the ESXi hypervisor. Multiple industry efforts are also underway to allow different cloud management platforms to work with different hypervisors, such as OpenStack with ESXi. These efforts are either in the prototype stage or in limited trials today.

Enterprises interested in an open-source cloud management platform are using OpenStack. Developed and supported by a broad vendor base, OpenStack is viewed to be a less expensive platform than proprietary options and helps organizations avoid vendor lock-in. Virtual networking in OpenStack/KVM is provided via Neutron plug-ins. Enterprises may standardize on OpenStack or use it primarily for development purposes, running their production applications and services on a commercial cloud platform such as VMware vRealize Automation (formerly vCAC).

Enterprises that use VMware's hypervisor may employ the vSphere virtualization platform in conjunction with vRealize Automation for building and managing a private cloud. For hybrid clouds, VMware's vRealize Suite cloud management platform provides a management stack for IT services on vSphere and other hypervisors, physical infrastructure and external clouds.

Network virtualization across VMware's cloud platforms is provided by VMware NSX, a suite of logical networking elements and services -- including logical switches, routers, firewalls, load balancers, VPN, QoS, monitoring, and security -- that can be provisioned through any cloud management platform.

### Beyond Private Clouds - Other Enterprise NV Use Cases

Building a private cloud will often be the main driver for deploying NV, but NV can also provide value without a full cloud architecture. For example, NV allows enterprises to extend their network segmentation beyond the limits of 4,000 VLANs and reap efficiencies without necessarily implementing a full OpenStack or VMware vRealize implementation.

NV can also be deployed as a way to add agility to enterprise DMZs, providing the ability to dynamically chain network services such as firewalls, IPS, anti-malware appliances, and web proxies. NV gives IT the flexibility to turn such services on and off quickly, based on the source and destination(s) or even the type of applications that are transferring data. This service chaining use case will often require orchestration between an overlay and the physical underlay network, as network services transition from physical appliances to virtual appliances.

Finally, looking beyond private clouds, NV offers the ability to cloud-burst into hybrid clouds, extending the enterprise network into virtual environments running on an external cloud provider's infrastructure -- whether it's a privately-managed cloud from a telco provider or a virtual private cloud instance from an IaaS solution provider like Amazon. NV allows the enterprise network to span both internal and external resources, creating a seamless connectivity infrastructure over which applications can execute without consideration for location.

## Key Enterprise NV Requirements

When evaluating NV solutions, enterprises should ensure the solution they choose provides the following:

- *Infrastructure compatibility*, including support for the preferred cloud management platform or orchestration stack as well as hypervisor(s) and physical switches;
- *Management capabilities*, including visibility and analytics; usability; and automation and programmability;
- *Layer 2-3 and Layer 4-7 networking features*, including built-in L2/3 capabilities such as DHCP and DNS; L3 routing; NAT; L4-7 service chaining; and QoS; and
- *Other attributes*, including high availability; the openness of the solution and its compatibility with other cloud components; the solution's availability; and the supplier's stability and longevity.

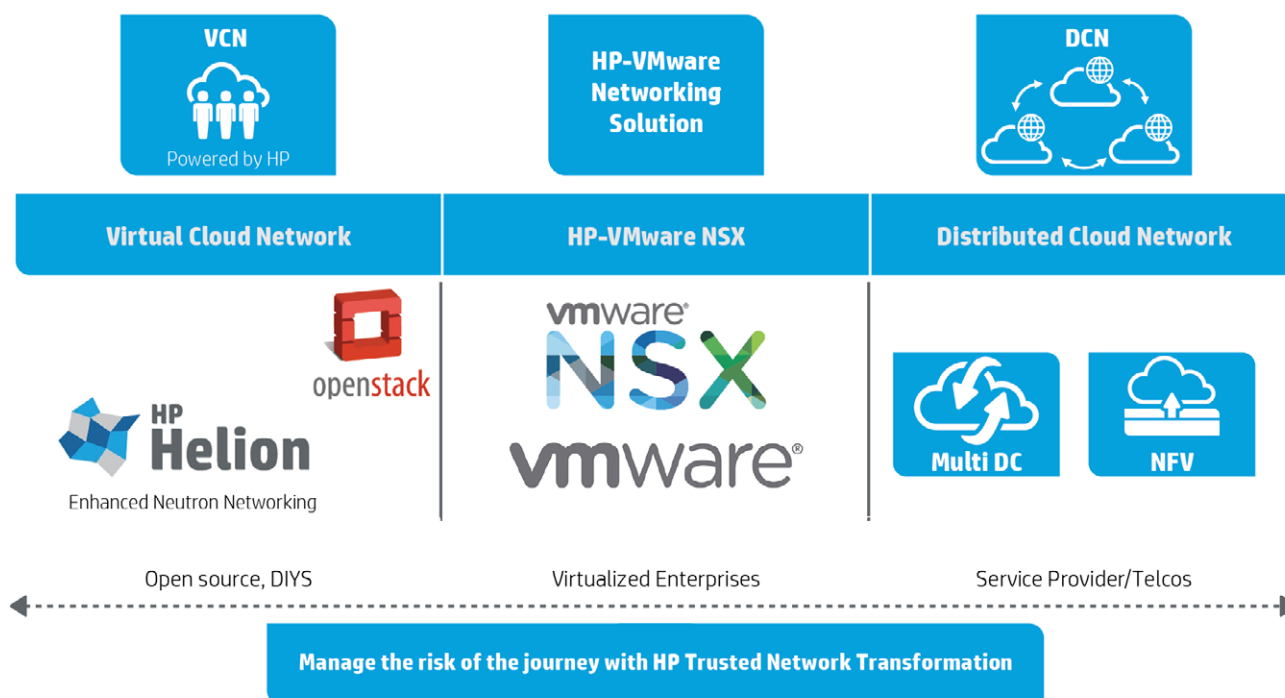
Cloud architectures and NV are fundamental to next-generation data center architectures. However, deploying these technologies can pose challenges for many enterprises. Lack of internal technical expertise and resources is a key issue. Likewise, migrating to a virtualized data center presents integration, availability, and security and compliance challenges. For example, there are few virtualization solutions available that support both VMware and OpenStack; in general, very few networking vendors integrate with VMware. Select vendors and third parties can help enterprises address these challenges and ease migration to a virtualized, cloud-based data center.

Given the move to cloud-based architectures to support data center virtualization, we'll now look in detail at how one vendor, Hewlett-Packard, addresses enterprise NV requirements and challenges.

## HP Cloud and NV Offerings

### HP Network Virtualization Solutions

Industry's most complete solution - addressing varied/complex use case requirements



HP has a broad portfolio of cloud, **software-defined networking** (SDN), and NV solutions designed for enterprises. HP combines a commitment to open, interoperable technologies with support for a broad ecosystem of partners, enabling enterprises to take advantage of state-of-the-art technology without being locked into a proprietary solution. HP's strong partnership approach also ensures customers can leverage their existing investments in compute, storage and networking infrastructure.

As a founding platinum member of the OpenStack Foundation and a leader in the OpenStack and Cloud Foundry communities, HP has taken a central role in developing technologies that meet enterprise requirements. For example, HP is a top contributor to the OpenStack Neutron project to deliver "networking as a service" between devices managed by other OpenStack services.

HP has built its **Helion** portfolio of cloud products on OpenStack technology, which gives customers a modular, highly scalable architecture with no hardware dependencies. Helion provides a common architecture for private, public, and hybrid clouds, including a common infrastructure and operations model across physical and virtual networks.

For multi-tenancy, Helion supports both VLAN- and VXLAN-based overlay architectures; this ensures that HP's SDN/NV solutions are agnostic to the physical underlay network and provide a migration from brownfield environments to new network installations. VLAN support is important for enterprises whose



installed networking infrastructure doesn't support VXLAN, and for smaller deployments where the scale of VXLAN isn't required.

For security, HP's network virtualization solution supports the common concepts of isolation and micro-segmentation within VM environments. For additional security services, HP's Helion and VMware solutions allow customers to employ additional services such as advanced firewalling or intrusion prevention systems for inspection of inter-VM or inter-segment traffic.

Customers that choose to use HP's physical networking gear, such as **HP switches**, gain additional functionality, including better visibility and finer-grained control, allowing for maximum resource optimization. HP physical devices integrate seamlessly with the HP network virtualization platforms.

## SDN and NV Solutions

HP's SDN/NV solution consists of HP and third-party physical and virtual switching infrastructure operating under the control of the **HP Virtual Cloud Networking (VCN) SDN application**. An enhanced networking module of HP Helion OpenStack, VCN provides virtualized, cloud networking that enterprises can use to build scalable, secure, multi-tenant networking infrastructures.

Another key component of HP's SDN/NV solution is the **HP Virtual Application Networks (VAN) SDN Controller**. In the SDN architecture, the control and data planes of the network are decoupled from each other. The underlying network infrastructure is abstracted from applications and network intelligence is centralized. The HP VAN SDN Controller software provides this unified control point, and is the heart of HP's SDN solution. VAN integrates with VCN, and is the foundation for HP's support for the most common OpenStack and VMware cloud platform combinations.

Equally important, HP supports the industry-standard protocols to directly provision both virtual (Open vSwitch) and physical (HP and third-party) network components. **HP SDN-enabled switches** allow for fine-grained control under the command of the VAN controller.

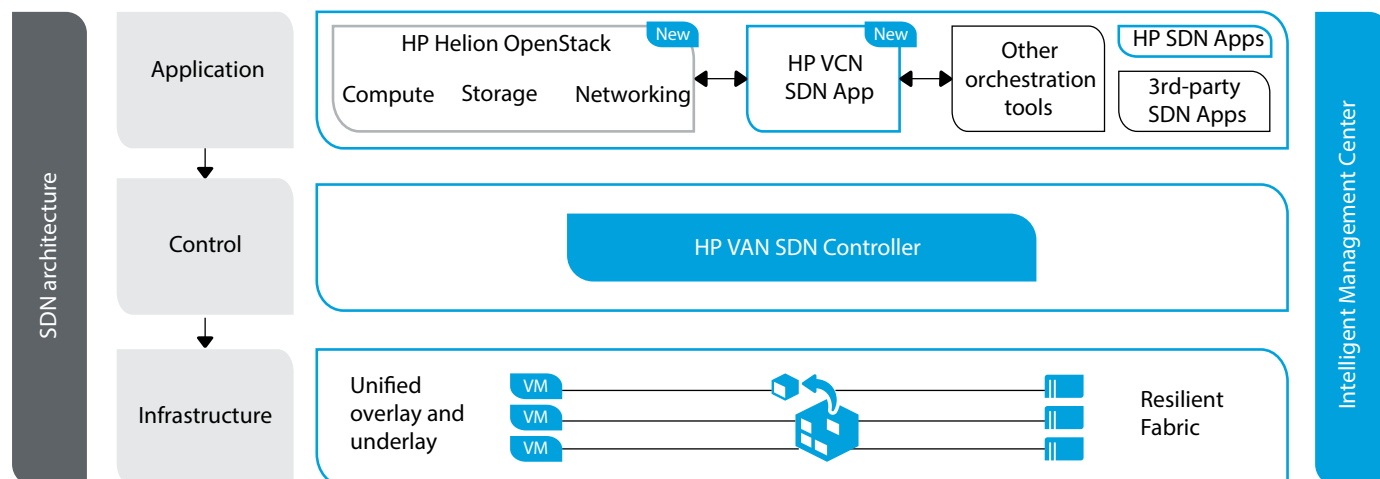
VAN gives IT unified control of the virtual and physical infrastructure, which simplifies network management, provisioning, and orchestration. Network ports, links, and topologies are all directly visible, enabling centralized policy administration and more effective path selection based on a dynamic, global view of the network. Enterprises benefit from ease of orchestration of multi-tenant environments, for example, and the enforcement of network policy for both mobile clients and servers.

In addition to the management capabilities built into VAN, HP provides extensible programming for the platform with support for RESTful APIs as well as a full developer SDK. As a result, customers and third-party developers can easily build applications to run on the controller.

Overall, HP ranks high for its commitment to open solutions and compatibility with other cloud components, from hypervisors and switches to cloud management platforms. The following sections highlight HP's OpenStack and VMware solutions, both of which rely on VAN.

## HP OpenStack Virtual Networking

For OpenStack environments, the HP Virtual Cloud Networking (VCN) app provides Neutron-based NV services while VAN SDN Controller provide unified control of virtual and physical network devices. VCN integrates with VAN and provides a number of capabilities, including multi-tenant isolation via centrally orchestrated VLAN or VXLAN-based virtual networks operating over standard L2 or L3 data center fabrics, as well as application isolation.



VCN is bundled with HP Helion OpenStack Neutron, which has unique HP enhancements, including distributed virtual routing (DVR), multi-hypervisor support, high availability, a VXLAN gateway, VPN and security group enhancements, and improved scalability. DVR, for example, optimizes and improves the scale of connections by supporting direct connectivity among different NV switches (VNS) as well as connectivity between virtual hosts and the external network.

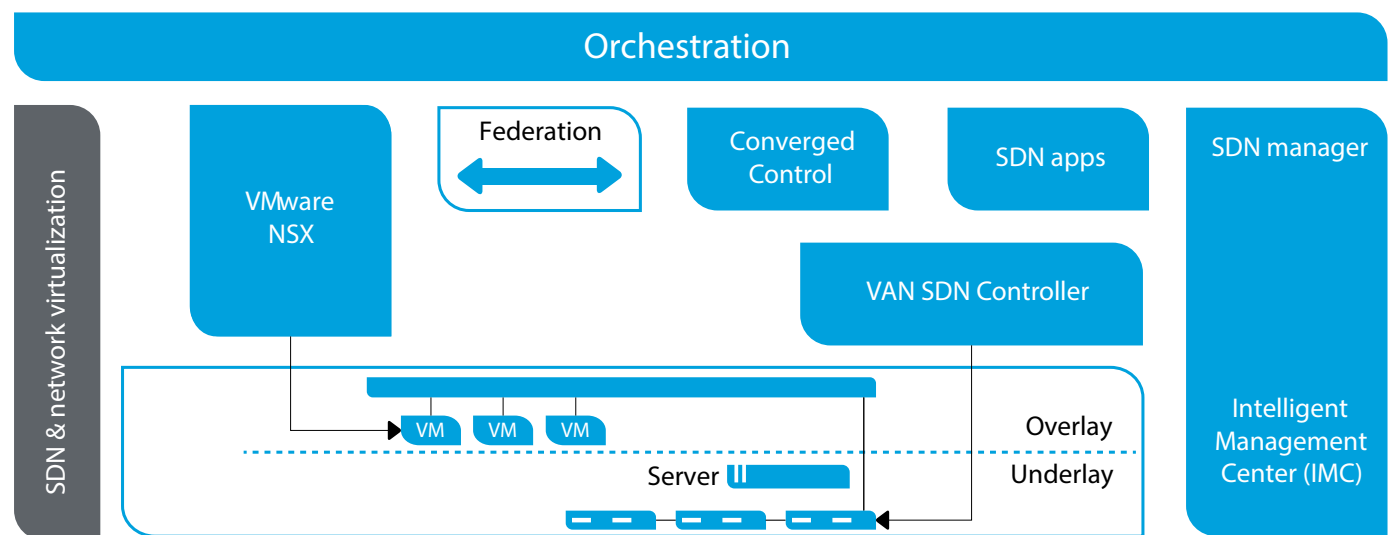
Conceptually, a DVR is a single entity, but it's implemented across all the SDN-enabled switches in the network. There is no single routing instance running on a single machine/hypervisor that all the virtual network switch traffic must route through. Rather, HP's DVR leverages Open vSwitch on KVM to send packets directly to the right location. DVR provides efficient routing by reducing the need for packets to traverse the network to a virtual router running on a network node. In multi-tenant environments, each tenant has its own DVR to define the connectivity among its virtual switches. In addition, HP supports a system-wide DVR that connects different tenants' virtual routers and defines the connectivity among tenants and to the outside world.

HP has contributed many of these Neutron enhancements back to the open source community, and is assisting with ongoing work to enhance Neutron with additional hypervisor support, bare-metal functions, service chaining, and SDN application integration.

## HP Support for VMware Environments

As part of its support for third-party products, HP collaborated with VMware to deliver the industry's first interoperable SDN solution. This federated solution provides unified automation and visibility of the complete data center network, improving agility, monitoring, and troubleshooting. The components of this HP-VMware networking solution include:

- **HP VAN SDN Controller**;
- **HP Converged Control SDN application**;
- **HP FlexFabric 5930 top-of-rack switch**; and
- VMware NSX network virtualization platform.



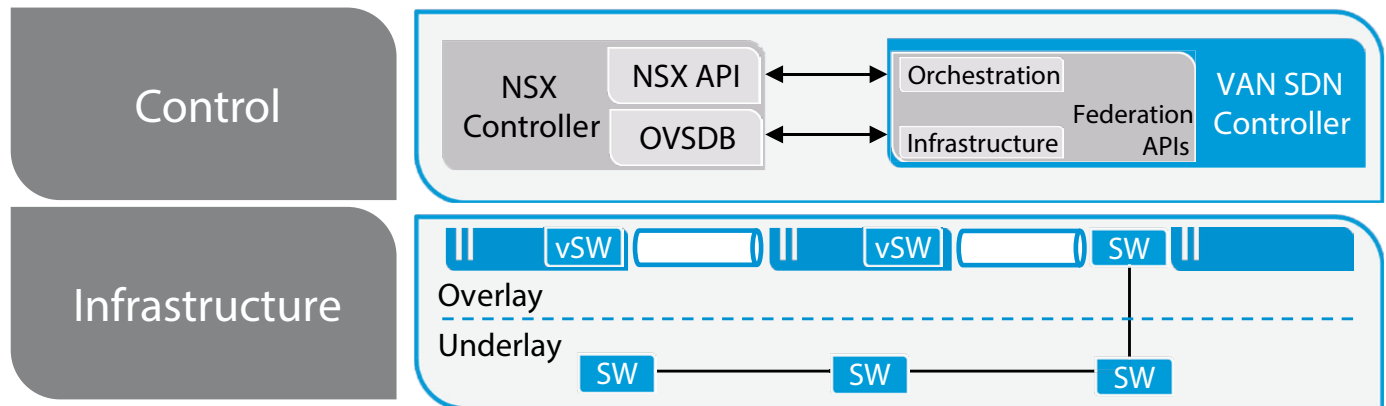
The HP VAN SDN Controller supports both the KVM and ESXi hypervisors, and federates the VAN controller and the VMware NSX network virtualization platform through federation APIs. NSX communicates with the VAN controller using the Open vSwitch database (OVSDB) management protocol. OVSDB is used to manage Open vSwitch instances, and manipulates a set of tables representing switch configuration data.

The HP-VMware federated solution integrates with both HP and VMware orchestration tools to provide cloud automation and agility. For example, HP supports the VMware ecosystem of cloud management platforms, including vCAC and vRealize, through its federation with VMware NSX. Additionally, the **HP Intelligent Management Center (IMC)**, along with the SDN Manager, provides single-pane-of-glass management for both virtual and physical networks. HP's support for a rich set of management applications and extensible programming capabilities ensure enterprises have the tools they need to realize NV's benefits.

HP-VMware integration also enables NSX to share virtual tunnel state information with the HP Converged Control SDN application and deliver virtual network tunnel endpoints on physical network devices, such as

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the HP FlexFabric 5930 switch, that support VXLAN. For mixed environments, the HP FlexFabric 5930 switch can be provisioned through the HP VAN SDN Controller to perform VXLAN/VLAN translation, acting as gateway to bring bare-metal servers or physical network devices into the virtual network.



Through the federation with NSX, HP is able to provide control over the underlay network from its HP VAN SDN Controller, which was designed to understand the coupling between overlay and underlay in order to improve QoS and failure handling. This is a key differentiator versus other solutions that integrate directly with NSX without a controller layer. An example of what's possible through this federation approach is the **orchestrating of long-lived (elephant) and short-lived (mice) flows** to optimize application performance.

With the HP VAN SDN Controller and NSX federation, enterprises benefit from the ability to:

- Unify virtual and physical devices, and bridge virtual and physical networks;
- Simplify network life-cycle management;
- Automate the provisioning of virtual and physical networks;
- Deploy additional bandwidth rapidly;
- Gain end-to-end visibility into network availability and performance;
- Perform root-cause analysis and troubleshooting of the entire network infrastructure; and
- Protect their investments and migrate to open, standards-based SDN.

### HP's Differentiation through Value-Added Capabilities and Services

HP complements its robust cloud and SDN/NV offering with a number of value-added capabilities. These include:

- **High availability:** HP's solutions are engineered for high availability across each component and are resilient to failures at each tier of the solution.
- **Robust networking and security features:** HP fully addresses enterprise requirements for network services, providing built-in support for: DHCP, DNS and VLANs at L2; static and distributed routing at L3, with support for BGP and ISIS; and at layers 4-7, both an L3 firewall and L4 stateful firewall, an L3 load balancer, L4-7 stateful load balancer, and VPN support. In addition, HP provides L4-7 service

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insertion capabilities, including service chaining and rewrite capabilities for MAC, IP and VLAN addressing, as well as both L2 and L3 QoS functionality. Note that L4-7 features may require the use of either the HP Virtual Services Router (VSR) for virtual services or HP MSR router for coordinating physical services.

HP also provides integration with third-party IP address management solutions from vendors such as BlueCat. HP's NV solutions also integrate with other HP SDN applications, such as the **HP Network Protector SDN Application**.

- **HP SDN App Store:** HP offers customers additional cloud and NV functionality through value-added applications designed to drive innovation and deliver the agility that enterprises need to stay competitive. The **HP SDN App Store** features applications from a dozen partners across major application categories, such as Real-Status Hyperglance for visibility, KEMP Technologies for load balancing, and BlueCat for IP address management.
- **HP Trusted Network Transformation (TNT):** HP also has a comprehensive portfolio of services to assist customers in planning, designing, deploying and supporting cloud and SDN/NV solutions. HP's TNT approach focuses on managing the risk of the transformation journey from current state to future vision. HP's TNT is designed to ensure that new network virtualization implementations interoperate with current environments to meet business and operational needs. TNT leverages HP's consulting experts and experience to create business and IT alignment, develop a business case, a transformation plan and roadmap to a future-state data center network by understanding current state and designing, integrating, migrating and deploying required solutions to achieve future state, at a pace that fits each customer's timeline requirements. TNT also offers training, certification and management of change for their client's IT staff to help them architect, integrate, and administer future-state solutions. HP's TNT leverages services offerings such as Transformation Experience Workshops that cover SDN, IPv6, and security; SDN Services that help identify opportunities for an SDN network transformation and build a clear SDN roadmap for the network and; an appropriate Support Services arrangement to ensure availability for user and business needs across the end-to-end network.

### Conclusion: Virtualizing the Enterprise Data Center

NV and cloud architectures are fundamental to next-generation data center architectures. Understanding how networking fits into the most popular cloud stacks, and how each stack provides NV, is key to reaping NV's many benefits.

Whether your enterprise is committed to OpenStack/KVM, VMware/ESXi or both, be aware that HP offers a unique set of NV capabilities, as well as support for both OpenStack and VMware ecosystems, including NSX. HP's SDN/NV solutions address enterprise requirements for infrastructure compatibility, rich networking and management capabilities, and high availability.

Few other vendors offer as open and comprehensive a set of **NV solutions**, or have HP's expertise to help enterprises plan for and migrate to a virtualized, cloud-based data center.

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