STRATEGIC WHITE PAPER

Nuage Networks Strategy for Open Systems

nuagenetworks
From Nokia

Abstract

Nuage Networks is the one SDN/network virtualization vendor that is truly embracing open systems and interoperability. A majority of its customers are also looking to deploy open source cloud management systems or open source server virtualization platforms like Linux™ containers. So, the Company has to take a strong stance on vendor-neutral solutions and lead the way with interoperability testing, standards and certification in multi-vendor environments. As an SDN vendor, Nuage Networks isn't looking to lock customers into specific switching hardware, or a particular server virtualization platform, cloud management system or hybrid cloud approach.

This document outlines the Nuage Networks open system strategy and efforts across the entire architecture, including the Company's work in the open systems community and various standards organizations. Points of integration with other solutions, such as cloud management systems or physical networking devices, are discussed with a view to how Nuage Networks enables interoperability.

CONTENTS

Benefits of open systems

The rapid acceleration of online business transformation is forcing networking organizations to continually do more with less, squeezing greater efficiency from a fixed or declining set of resources. Businesses that are slow to adapt to this online transformation run the risk of being marginalized or left behind.

Among the key technology drivers leading this transformation, which includes cloud computing and Software-Defined Networking (SDN), is a rapid shift to open source technology. Open source technologies drive down costs, reduce vendor lock-in, and accelerate innovation and development cycles. Even the world's leading development organizations, such as Google®, recognize that if you aren't leveraging open source technology in strategic places you cannot remain competitive.

But what is "open", and what benefits are really driving organizations to embrace open solutions as a primary strategy?

Nuage Networks:
The open, vendor-neutral approach to cloud networking and SDN

In any survey of the benefits from open systems, organizations repeatedly cite:

- Freedom to choose IT technology from multiple vendors (no vendor lock-in)
- Products from different vendors work together (reduced integration and deployment costs)
- Ability to protect existing investments (including hardware, software, people skills) while embracing new technology and innovations
- Rapid innovation (leveraging the contributions from many sources)
- Faster development and release cycles (not reinventing the wheel)

While many of these benefits overlap, the cumulative effect that organizations are looking for is reduced costs while accelerating the pace of innovation and solution deployments.

What attributes make a technology open in order to deliver these benefits? Unfortunately, many people have different perspectives on what makes a solution open, so there is no simple, catchall answer. But practically, "open" has now come to mean:

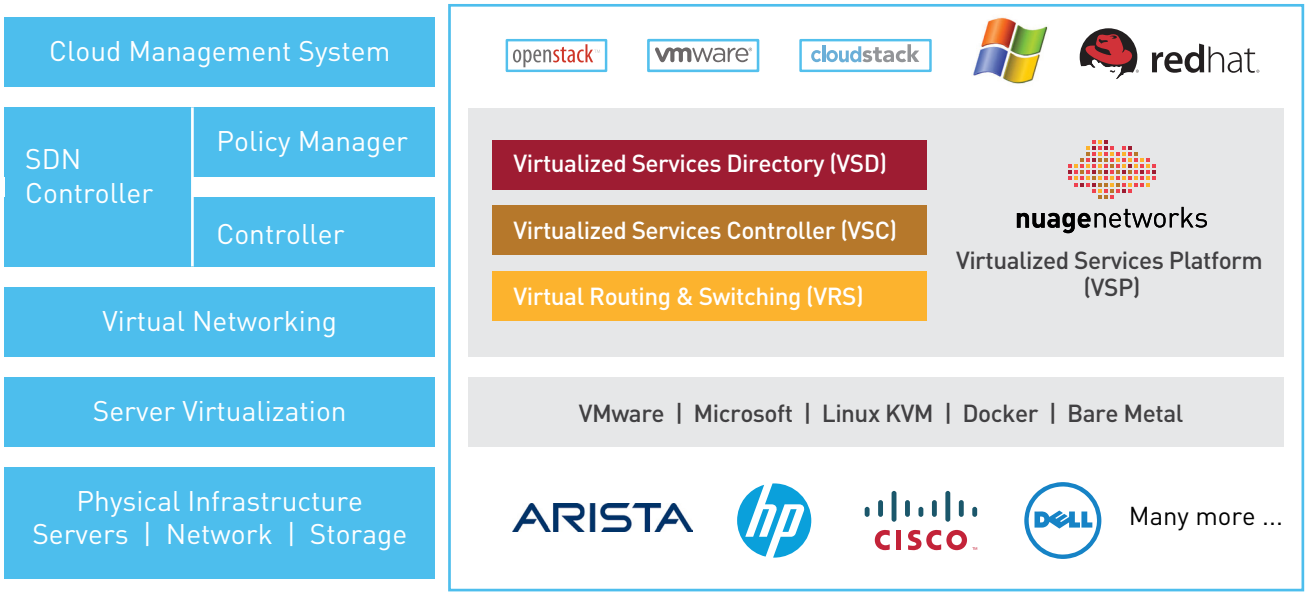
- **Open source** with a recognized community of developers and contributors
- **Open application programming interfaces (APIs)**
- **Standardized protocols** (including document and message formats)
- A large **multi-vendor ecosystem** of interoperable solutions

Any of these approaches could lead to greater interoperability, reduced costs and investment protection. Conversely, these are not sufficient conditions to ensure those benefits if the open community is not large enough or the specification broad enough to ensure vendor choice across a large enough range of solutions. Customers need to evaluate whether claims of open source or standard protocols really align with their strategic requirements and provide the interoperability benefits they will require years in advance. With this perspective on business requirements for open technology, this paper now considers how these various approaches have been applied to cloud architectures.

An open framework for cloud architectures

There are many points of integration between the functional layers in a cloud architecture. Adhering to standards around these points of integration enables interoperability between solutions from multiple vendors. In some cases the standard is formalized through a vendor-neutral standards group. In others a de facto standard arises due to the dominant market share of one vendor in one area that drives a large ecosystem of partners to align with that market.

FIGURE 1. Nuage Networks provides the SDN controller and virtual networking infrastructure for a multi-vendor cloud ecosystem across platforms and technologies.



As a result, cloud technology has quickly evolved into a multi-vendor ecosystem that is commonly called a "cloud stack" (not to be confused with the cloud orchestration software from Citrix® and Apache™ called CloudStack™). A generic cloud stack includes all the hardware and server virtualization, including SDN controllers and virtual networking, all the way up to the cloud orchestration software that automates the entire infrastructure of servers, storage and networking. This is illustrated on the left side of Figure 1.

Drilling down further into the emerging cloud infrastructure, it becomes apparent how open interfaces and protocols have contributed to real multi-vendor solutions as enterprises and services have built out functioning cloud architectures. For example, SDN controller technology typically supports higher-level cloud orchestration platforms (like OpenStack®) through REST-compliant APIs (generally called northbound APIs in the controller architecture). Standardized interfaces within OpenStack also allow networking vendors to provide a standard Neutron (the networking management framework of OpenStack) plug-in, allowing any vendor to support this open source cloud orchestration system.

By comparison, a combination of long-established and new networking protocols have standardized virtual networking and overlay networks across all network vendor equipment, virtual switches and cloud management systems. Examples of such protocols include VXLAN, OpenFlow™, or control-plane protocols such as BGP.

Open source communities have played an important role in the evolution of cloud architectures in at least two important areas: the cloud orchestration platform (both OpenStack and Apache CloudStack), as well as the SDN controller software (through OpenDaylight™, Floodlight or OpenContrail). Another key open source cloud component is the Open vSwitch (OVS), which has a rapidly expanding development community and is becoming a de facto standard for Linux™ deployments.

Open source projects generally ensure interoperability between solutions from multiple vendors and can shorten development cycles. However, they are not strictly required to achieve interoperability if other interfaces and protocols have been sufficiently agreed to by vendors and between products.

Open source communities have played an important role in the evolution of cloud architectures

As a result, there is not a one-size-fits-all approach when it comes to "open" in the emerging cloud ecosystem. The cloud industry has benefited from the open source approach of OpenStack as a multi-vendor cloud orchestration platform. Other widely-integrated commercial cloud systems with their own multi-vendor ecosystems from VMware® and Microsoft® also provide a great deal of flexibility and support for partner products. Similarly, even though OpenStack is a strategically important open source platform for enterprises and service providers, most organizations prefer to use a commercial implementation from Canonical®, Mirantis®, Red Hat®, SUSE® and others (or even a single vendor version from VMware that works only with the VMware cloud stack), rather than leveraging the source distribution directly.

A closer look at interoperability in the Nuage Networks VSP solution

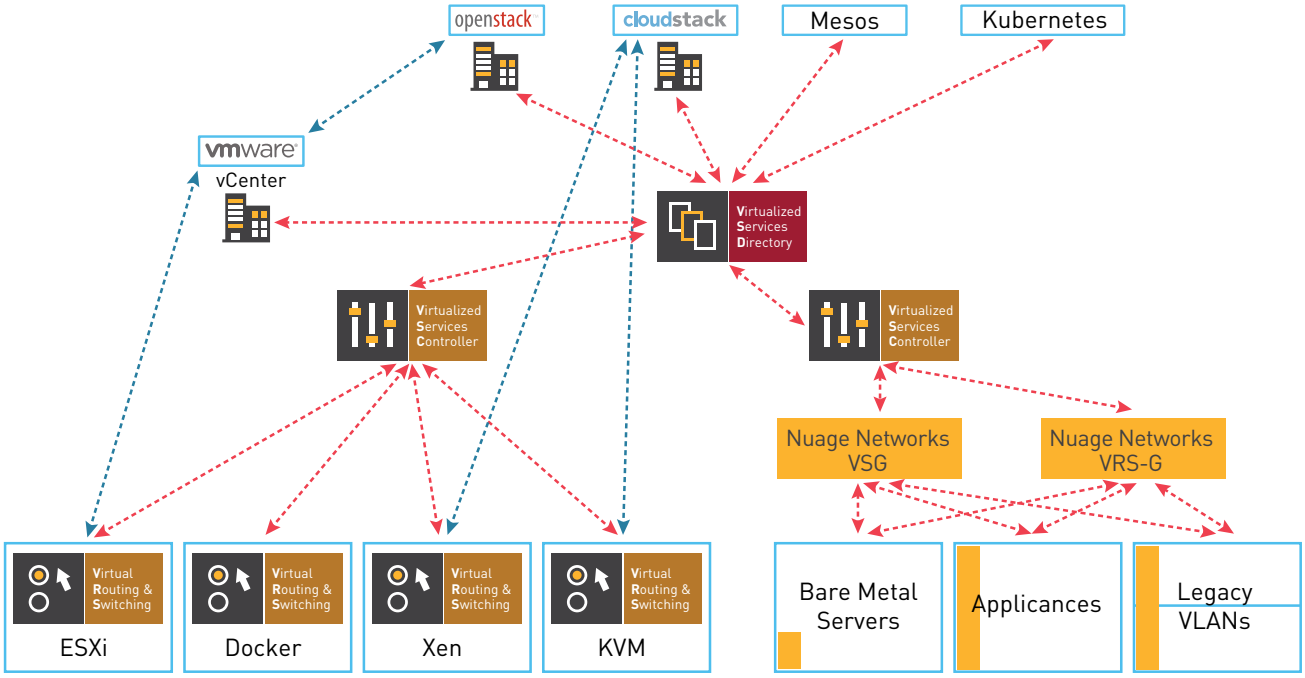
Nuage Networks Virtualized Services Platform (VSP) is the Company's virtual networking and SDN controller framework. The Nuage Networks VSP integrates readily with other components in a cloud architecture through:

- **Virtualized Services Directory (VSD):** the policy repository; it integrates with cloud management platforms through open RESTful APIs
- **Virtualized Services Controller (VSC):** the SDN controller; it integrate with all major hypervisors and Docker™-style containers, as well as bare metal applications through standard VXLAN protocol gateways in the Nuage Networks network appliance, or those available from leading networking vendors

Additionally, Nuage Networks incorporates a number of standard networking protocols to ensure compatibility of its virtual network overlays and SDN controller with other solutions. For example, Nuage Networks and Nokia were among the co-authors of the proposed IETF® standard for a VXLAN control plane (VXLAN-EVPN), using BGP.

Nuage Networks has also added integration with all leading VXLAN tunnel endpoints and gateways from networking vendors such as Arista and HP™.

FIGURE 2. Nuage Networks VSP is designed to support all major networking and server platforms, workload formats (including virtual machine, container and bare metal), and all major cloud orchestration tools (including OpenStack, CloudStack, VMware and Microsoft System Center Virtual Machine Manager)



Key open source and standards efforts of Nuage Networks

The following is a list of open source and standardization efforts that Nuage Networks is actively involved in today.

OpenStack

The OpenStack Neutron project provides an open framework that can be leveraged to build robust network services. Nuage Networks provides a plug-in that extends the capabilities of Neutron in terms of scalability, reliability and robustness.

Nuage Networks supports the plug-in across multiple distributions:

- Open source version of OpenStack
- Red Hat
- Mirantis
- Canonical
- Oracle®

For information on the contributions made by Nuage Networks to OpenStack:

- The plug-in architecture is described in the specification document: https://blueprints.launchpad.net/neutron/+spec/nuage-networks-plugin
- Contributions to OpenStack are on the Github OpenStack-VSP page: https://github.com/nuagenetworks/nuage-openstack-neutron
- Plug-ins and driver for Nuage Networks VSP can be found on the OpenStack Marketplace: https://www.openstack.org/marketplace/drivers/

CloudStack

Nuage Networks contributed network modularity code to the Apache CloudStack code base. The code enables network plug-ins — from any vendor — to be installed and upgraded without having to recompile the entire CloudStack build. Leveraging the modularity code, the Nuage Networks VSP plug-in for CloudStack provides the network scalability needed for large-scale networking environments.

For information on the contributions made by Nuage Networks to CloudStack:

- The plug-in architecture is described in the specification document: https://cwiki.apache.org/confluence/display/CLOUDSTACK/NuageVsp+Network+Plugin
- Platform extensions and Nuage Networks plugin are available via the Github Cloudstack-VSP page: https://github.com/apache/cloudstack/tree/master/plugins/network-elements/nuage-vsp
- The plug-in is integrated into the Cloudstack 4.6 distribution and greater: http://cloudstack-release-notes-ja.readthedocs.org/ja/latest/about.html

Nuage Networks products provide more flexibility and can take full advantage of the open source development community

Open vSwitch-based networking

OVS is a software-based switch that resides in hypervisors and forms the access layer network edge for virtual applications. Originally derived from the VMware Distributed Virtual Switch, OVS is becoming the default virtual switch for Linux distributions and for the KVM and Xen® hypervisors. It has a rapidly growing development community and a growing ecosystem of compatible vendors, including Nuage Networks.

OVS is the basis for the Virtual Routing and Switching (VRS) component within the Nuage Networks VSP for all hypervisors. Nuage Networks is actively involved in the OVS development community, contributing bug fixes and leveraging key feature enhancements and third-party integration into Nuage Networks products. Because Nuage Networks has no kernel-level dependencies within Linux, its products provide more flexibility and support across multiple distributions, and are able to take advantage of all the efforts of the broader open source development community more readily.

ETSI NFV Working Group

In November 2012 seven of the world's leading telecom network operators selected ETSI® to be the home of the Industry Specification Group for Network Functions Virtualization (NFV). Today, there is a large community working to develop the required standards for NFV.

Nuage Networks, as a leader in SDN and NFV technology, is a leading or core contributor to the following working groups:

- NFV Security
- NFV MANO
- Reliability
- Performance

IETF – Joint creation of EVPN standard for overlay networking

Ethernet VPN (EVPN) [RFC7432] can be used as a Network Virtualization Overlay (NVO) solution using various tunnel encapsulation options over IP. In particular, EVPN supports the VXLAN, NVGRE, and MPLS over GRE tunneling protocols. EVPN forms a standard control-plane for virtual networks, increasing the efficiency of cloud networks by removing the requirement for multicast flood and learn in virtual overlays. Nuage Networks is also actively involved in the IETF working group for NVO3 (Network Virtual Overlays: RFCs 7364, 7365).

For information on the contributions made by Nuage Networks to EVPN and other network overlays:

- IETF specification for EVPN Overlay co-authored by Wim Hendrickx of Nokia: https://tools.ietf.org/html/draft-ietf-bess-evpn-overlay-01
- Nokia/Nuage overview presentation on EVPN: https://conference.apnic.net/data/37/2014-02-24-apricot-evpn-presentation_1393283550.pdf
- European Advanced Network Testing Center (EANTC) for SDN Controller Interoperability includes Nuage Networks 7850 VSG and Nokia 7750 router: http://www.eantc.de/fileadmin/eantc/downloads/events/2011-2015/MPLSSDN2015/EANTC-MPLSSDN2015-WhitePaper_online.pdf

IETF – Jointly authored specification for Network Services Headers service chaining technology

Nuage Networks jointly developed the IETF submission for service chaining in a cloud network based on a protocol from Cisco® called Network Services Headers (NSH). Service chaining enables the routing of virtual overlay traffic to security and application services appliances, in sequential order based on application requirements, and independent of location. This removes the requirement that such service nodes be in-line with the flow of traffic.

For information on the contributions made by Nuage Networks to service chaining:

- NSH IETF Specification jointly authored by Wim Hendrickx of Nokia: https://tools.ietf.org/html/draft-quinn-sfc-nsh-04

Nuage Networks has also developed an open integration framework for third-party appliances, including F5®, Citrix, Palo Alto Networks®, vArmour®, and others.

OpenFlow and the Open Networking Foundation

Openflow was the first important protocol standard in SDN technology, delivered by the Open Networking Foundation (ONF) open source community in 2011. It standardizes how SDN controllers communicate and manage flow tables on a wide range of network devices. Nuage Networks relies on OpenFlow for communication between the Nuage Networks VSP solution's VSC and the Company's edge switches and gateways, VRS, VRS Gateway (VRSG) and Network Services Gateway (NSG). Nuage Networks also leverages the related Open vSwitch Database (OVSDB) protocol for communication to the virtual switch to control third-party hardware (Arista and HP) from the VSD.

Nuage Networks was the only vendor to successfully complete all ONUG interoperability tests in all categories

Open Networking User Group

Started in 2012, the Open Networking User Group (ONUG) became a forum for advancing customer requirements and standards in the SDN space. Examples of these requirements are common APIs to drive consistency across products, and consideration of the impacts of SDN technology on operational issues and processes. Nuage Networks continues to be an active participant in ONUG forums and to incorporate standards and requirements into future releases.

In April, 2015, Nuage Networks participated in the ONUG testing for virtual network overlay interoperability, which included 10 use case tests for vendors to certify. Nuage Networks was one of the only vendors to successfully complete all tests in all categories.

- For more information on ONUG interoperability testing and results: https://opennetworkingusergroup.com/onug-completes-groundbreaking-testing-of-commercial-solutions-against-requirements-outlined-by-onug-working-groups/

Nuage Networks VSP Software Developer Kit on Github

The Nuage Networks section on github provides tools, scripts and other development resources to the worldwide community:

- https://github.com/nuagenetworks

Summary

Nuage Networks is committed to open systems and delivering a product that works across vendors, platforms and cloud providers. The Company is leveraging standards where they can accelerate its efforts, and helping to drive standards where none exist. Nuage Networks does not believe that open source versions of commercial products necessarily ensure the most product innovation and the best way to ensure multi-vendor solutions and product interoperability.

Nuage Networks respects and supports the various open source projects contributing to the evolution of cloud architectures and is developing solutions that integrate with all of these major platforms. Although the Company has not moved to create an open source ecosystem for the Nuage Networks VSP platform, it has removed vendor lock-in with support for all overlay networking and SDN protocol standards. Nuage Networks gives customers the flexibility to use multiple operating system/hypervisor/virtualization platforms for years into the future, as well as a wide range of cloud management platforms.

Nuage Networks gives customers the flexibility to use multiple operating system/hypervisor/virtualization platforms for years into the future, as well as a wide range of cloud management platforms.

Nuage Networks customers benefit from a turn-key commercial distribution with full support and the maturity of a platform that has been deployed for years in major service providers around the world. This contrasts sharply with an open source distribution that may require extensive customization to be put into production or do-it-yourself integration. Nuage Networks has adopted an aggressive commercial pricing model. This, along with industry-leading support and professional services enable the Company to continue to innovate and offer industry-leading features, while standing behind a solution that will support organizations' cloud architectures going forward.

Acronyms

ACI	Application Centric Infrastructure
API	Application Programming Interface
BGP	Border Gateway Protocol
EVPN	Ethernet VPN
GBP	Group Based Policies
GRE	Generic Routing Encapsulation
IETF	Internet Engineering Task Force
MPLS	Multiprotocol Label Switching
NFV	Network Functions Virtualization
NSG	Network Services Gateway
NSH	Network Services Headers
NVO	Network Virtualization Overlay
ONF	Open Networking Foundation
ONUG	Open Networking User Group
OVS	Open Virtual Switch
SDN	Software-Defined Networking
VRS	Nuage Networks VSP Virtual Routing and Switching
VRSG	VRS Gateway
VSC	Nuage Networks VSP Virtualized Services Controller
VSD	Nuage Networks VSP Virtualized Services Directory
VSP	Nuage Networks Virtualized Services Platform
VXLAN	Virtual Extensible LAN