Independent market research and competitive analysis of next-generation business and technology solutions for service providers and vendors

HEAVY READING
WHITE PAPER

Operator Success in the New Age of the Software-Defined WAN

A Heavy Reading white paper produced for

nuagenetworks
From Nokia

viptela

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INTRODUCTION

Initially launched as an enterprise do-it-yourself (DIY) appliance play with the potential to cannibalize existing MPLS revenues, software-defined wide-area network (SD-WAN) has rapidly become a managed services offering – one that any provider hoping to serve the business market must have in its portfolio. That includes traditional telecom network operators, cloud providers, managed service providers and cable operators.

Service providers across the board are trying to understand how to succeed in this promising new area. But what are the tools and technologies needed to succeed?

This white paper takes an in-depth look at the emerging SD-WAN market from the service provider perspective. The paper outlines the drivers for SD-WAN, details the benefits of offering SD-WANs for service providers and charts a realistic course for the evolution of SD-WANs in the era of virtualization and network functions virtualization (NFV).

THE RISE OF THE SOFTWARE-DEFINED WAN

No one can argue that over the past 20 years, consumers have benefitted tremendously from the boom ubiquitous broadband connectivity, including DSL, cable modems and, more recently, wireless 4G access. Yet the model for enterprise network connectivity – particularly at remote and branch office sites – has changed very little during that time. For many enterprise networks, access is via MPLS over relatively low rate (1.5 Mbit/s) leased lines.

Meanwhile, major shifts are taking place in enterprise consumption and delivery. First, the cloud delivery model has moved from its consumer market origins into the enterprise. Businesses are increasingly comfortable with – and demanding – cloud-based applications, such as Microsoft Office 365, Salesforce, Cisco WebEx, Concur, and many others. These applications have different usage patterns and greater bandwidth consumption compared to centrally-hosted enterprise applications of the past.

The second shift comes from the fact that all enterprise users are also consumers when they leave the office. Average fixed broadband connectivity in the U.S. reached 55 Mbit/s in the first half of 2016, according to Speedtest, and consumers readily stream their videos and movies from YouTube and Netflix. Yet their office connections are woefully behind.

Enterprise IT and telecom managers realize that the traditional MPLS and leased-line model cannot keep pace with the new application requirements. We identify three main challenges:

1. At more than $200 per Mbit/s, leased lines are not economical for many software-as-a-service (SaaS)/Internet applications.
2. They are not suited for cloud applications, since they add extra latency by routing through the enterprise data center.
3. MPLS circuits are rigid connections that are slow to add and make changes to, such as adding capacity.

Yet, despite the many changes brought about by cloud, IT/telecom managers do require security and centralized control for their remote and branch users. This is where the new SD-WAN comes into play.

Definition of SD-WAN

Heavy Reading defines SD-WAN as a software overlay approach for connecting, monitoring and controlling enterprise WANs. SD-WAN integrates a central policy repository (controller) that drives configuration, management and optimization of services and devices based on policy/software and in an automated fashion.

There are two broad adoption scenarios for SD-WANs, as described below:

- **Enterprise DIY:** In this scenario, an enterprise buys SD-WAN products directly from the SD-WAN vendor or vendor channel partner and builds and manages the SD-WAN network itself. Enterprises gain the SD-WAN benefits of lower capex and opex with rapid response to application/user demands but are fully responsible for managing the SD-WAN and underlying network connectivity on their own. This was the original vision of SD-WAN. With the DIY approach, enterprises get full control of their own SD-WAN, but with added complexity (and costs) for their IT departments. A certain scale is required to justify DIY, but, even then, an enterprise may not choose to take on full control.
- **Operator-Managed Enterprise Services:** In this scenario, network operators contract with one or more SD-WAN vendors and offer SD-WAN services to their enterprise customers, which pay monthly fees to the operator to cover costs including equipment rental, software licenses, selected features, connectivity options, and selected levels of customer support. In this model, network operators typically host the SD-WAN controller and manage policies globally, while enterprises get branch customer premises equipment (CPE) devices suited for SD-WAN, along with a customer Web portal to order services on-demand and manage policies within the parameters set by the operator's service. While SD-WAN was initially perceived as a threat to their connectivity revenues, network operators are increasingly developing SD-WAN managed services strategies, due to a combination of demand from their own customers and opportunities for new business.

This white paper is specifically targeted at network operators and so focused specifically at the operator managed services opportunity for SD-WANs.

One of the key use cases for adopting SD-WAN – whether it is enterprise DIY or service provider-managed – is hybrid WAN, in which enterprises select the WAN connectivity from a host of different options, based on the applications and their performance and service-level agreement (SLA) requirements.

The hybrid WAN architecture itself is not new to enterprises, but the on-demand agility and high-granularity of control is new – due to SD-WAN. Early hybrid WANs were largely manual with limited ability to control and make network changes. SD-WAN brings both software programmability and application awareness for on-demand changes to connectivity, based on individual applications and customer-defined policies.

The Open Network User Group (ONUG), one of the largest user groups in the networking and storage sectors, detailed the top 10 business requirements for SD-WAN enterprise usage and adoption. Collectively, although not exhaustive, these 10 requirements (shown in **Figure 1**) nicely define the function and scope of SD-WANs.

Figure 1: Set of 10 SD-WAN Business Requirements for Enterprises

	Business Requirements
1	**Active-Active Architecture**: Sites connect to applications through Internet and private WAN
2	**CPE**: physical or virtual form factor
3	**Secure Hybrid WAN**: Dynamic traffic engineering across Internet and private WAN based on application policy, and aware of network availability/degradation
4	**Visibility, Prioritization & Steering Applications**: Specifically, business critical and real-time applications per security, corporate governance and compliance
5	**High Availability & Resiliency**: Optimal for client user experience
6	**Layer 2 & 3 Interoperability**: With directly connected switch and/or router
7	**Management Dashboard/Portal**: By site, application and VPN performance level
8	**Controller With Open APIs:** For access and management, forward specific log events
9	**Zero Touch Deployment**: Agility in deployment and provisioning
10	**FIPS 140-2 Validation Certification**: Encryption with automated certificate lifecycle management

Source: ONUG SD-WAN User Group, October 2014

Technology Enablers

Many technologies had to come together and mature in order for SD-WAN to become commercially viable. As discussed above, ubiquitous, reliable, high-speed broadband connectivity is one of the enabling technologies. SD-WANs run on top of existing networks, including fixed-line DSL and cable, wireless and MPLS. These underlying networks can be a mix of different access technologies (such as DSL and MPLS) and even different access network providers.

Low-cost networking hardware is also required, including lightweight network interface devices (NIDs) and increasingly commercial off-the-shelf (COTS) hardware. SD-WAN vendors are building software products and coupling them with low-cost hardware to sell appliances to end users. The key benefit of this model is that vendors focus all of their expertise on software while taking advantage of commodity hardware innovations that the meet software's performance specs. Early SD-WAN products were sold on specific hardware servers (to ensure consistency in early deployments), but the clear trend is toward hardware-independent products, and as we discuss later in the paper, virtual CPE (vCPE) hosting multiple virtual network functions (VNFs).

As noted, the most significant innovation in SD-WAN comes through software. Centralized software control is a key enabling software architectural innovation as management, configuration and policy decisions are made centrally and pushed out to the endpoint locations through communications between the central controller and all of the endpoints connected to the SD-WAN. The architecture described above is consistent with SDN (i.e., separation of the control plane from the data plane), though not all SD-WAN vendors promote their products specifically as SDN, perhaps due to the use of proprietary control protocols or, alternatively, because they feel the "SDN" tag may deter some customers.

Along with centralized software control, application-aware routing is another critical software component of SD-WAN, and table stakes for any SD-WAN product. Application-aware

routing is the intelligent forwarding of application traffic across the WAN ensuring that pre-defined, per-application performance metrics, or SLAs, are met at the lowest costs. For example, a video application may require a high-bandwidth connection but could tolerate some jitter, so it is placed on the best-effort broadband Internet link, because that link meets the application's requirements. A voice over IP (VoIP) call originating from the same branch site, however, requires a high-quality connection but far less bandwidth, so it is placed on the low-speed T1/MPLS circuit, meeting the requirements of the application.

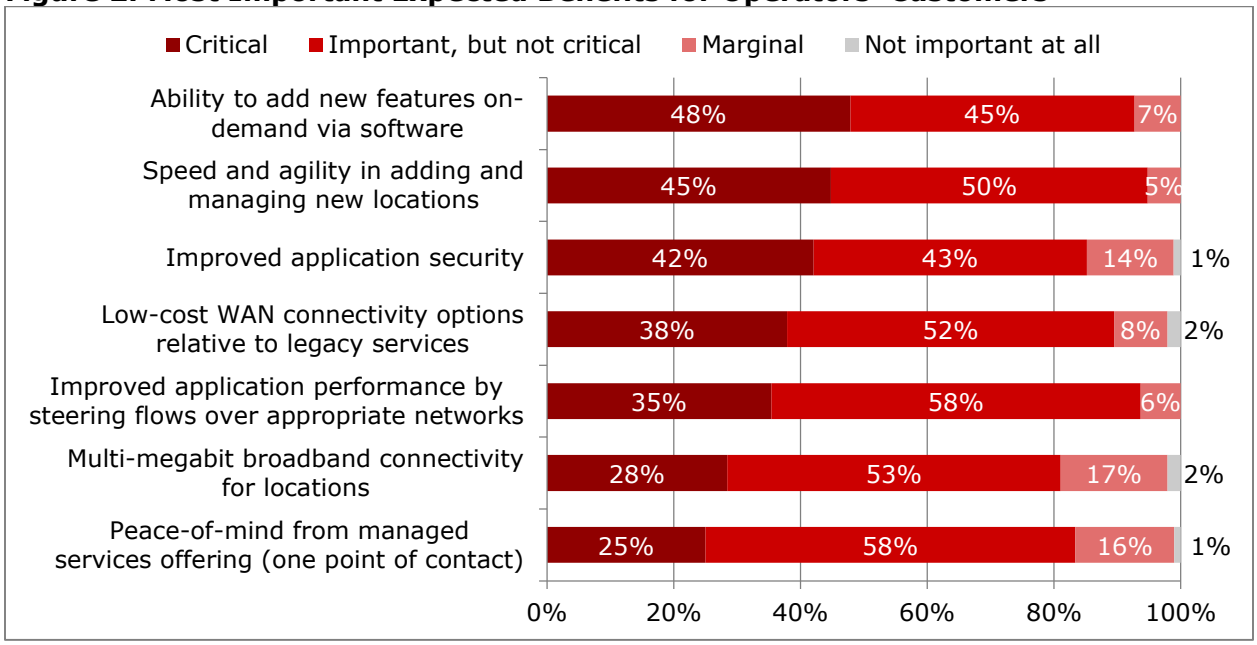
Thus, with application-aware routing, routing decisions are made based on the identity of the applications and combined with the centrally-managed policies residing in the SD-WAN controller and with performance data derived from the network itself. As with SDN, routing decisions are adjusted automatically and in real time, based on applications, defined policies and network performance, etc.

To be clear, application-aware routing as a function is not unique to SD-WAN, as it is also a function used in analytics applications and next-generation firewalls, among others, but it is a critical enabler to the SD-WAN value proposition. For this reason, application-aware routing will be provided by SD-WAN vendor itself and is not one of the functions that will be available via third-party VNFs (as we discuss in detail later in the paper).

KEY BENEFITS OF SERVICE PROVIDER SD-WAN

In offering SD-WAN managed services, operators see a number of benefits to their enterprise customers, as shown in a December 2016 Heavy Reading survey on the subject. Full results are shown in **Figure 2**.

Figure 2: Most Important Expected Benefits for Operators' Customers



N=96
Source: Heavy Reading December 2016 Operator Views on Emerging SD-WANs Survey, Sponsored by ADVA

Operators identified three key customer benefits:

- The ability to add new features on-demand via software (selected as critical by 48% of respondents)
- Speed and agility in adding and managing new locations (selected as critical by 45%)
- Improved application security (selected critical by 42%)

In addition, operators see good benefits in low-cost WAN connectivity and improved network performance. While operators recognize that low-cost connectivity is an important benefit of SD-WAN, they are not positioning low cost as one of the primary benefits of a managed services offering.

Rather, network operators are prioritizing the software-enabled benefits of deployment speed, agility and automation. Speed and agility give enterprises the ability to respond and adapt to cloud and SaaS-based application growth in their branch locations, thus addressing the lack of flexibility of today's MPLS-based networks. Software automation also simplifies and lowers costs for adding and making changes at branch office locations. This benefit is particularly important for enterprises managing hundreds or even thousands of different locations.

In addition to the software-driven benefits above, operators put a strong initial focus on application security. This is no surprise as network security is perhaps the biggest concern for CIOs and IT directors today. Application-aware routing allows users to assign security policies based on application type, and centralized control allows enterprises to set centralized security policies, which reduce risk by reducing access to changes. In addition to these basic functions, operators (and SD-WAN vendors) have coupled security functions (such as firewalls and antivirus) with their SD-WAN products in order to provide the required security for branch connectivity.

Natively integrating such functions does require an agile, on-demand software platform and blends SD-WAN into NFV, as those functions are added as VNFs running independent of appliance hardware. Indeed, as discussed in the next section, the trajectory of SD-WAN – as offered by network operators – is ultimately as a component of an overall NFV strategy.

EVOLUTION PATH OF SD-WAN

Early Focus: From Point-Products to Integrated Managed Services

The earliest operator SD-WAN managed services simply took ownership of enterprise customers' SD-WAN appliances (i.e., the DIY networks) and managed the SD-WANs on the customers' behalf. While getting a foot in the door for SD-WAN managed services, this dedicated network and appliance approach has multiple longer-term limitations, including the inability to scale efficiently, a tendency to set operators up to compete primarily on price, and a lack of integration with operators' overall next-generation strategies.

Smart operators (including the operators profiled later in this paper) quickly realized that there is a more strategic approach to managed SD-WANs, and in the past year have started rolling out managed services that add the value of *integration*. By combining multiple functions and services together, operators are able to add real value to SD-WANs that enterprise customers cannot match on their own.

The first step is integration with legacy routed networks and routing protocols, and particularly with MPLS. The reality is that MPLS networks will remain in operation for many years even as Internet broadband expands. SD-WANs rely, ultimately, on their underlay transport networks, and Internet broadband networks cannot provide the same guarantees of traditional private lines. Applications with stringent performance requirements will continue rely on MPLS/private lines for many years to come.

Key to the hybrid WAN value proposition is the availability of multiple underlay network options so that enterprises can choose the right access network for the right application and that includes MPLS. Additionally, some MPLS networks will continue to operate separate from the SD-WAN altogether, and interworking between pure MPLS networks and the SD-WAN is needed.

The other important area of integration for SD-WAN managed services is the combination of SD-WAN with other VNFs. Security is the most immediate area for combination. Enterprises need their branch connections to be secure, so some vendors are providing this functionality natively to meet this need. Other important functions to combine with SD-WAN include WAN optimization, deep packet inspection (DPI), network address translation (NAT), etc.

At this early stage, the SD-WAN VNF ecosystems are nascent and generally vendor-driven. Some functions are developed by vendors in-house; others are third-party VNFs, but they are part of the SD-WAN vendor's approved ecosystem. As we discuss in the next section, over time we expect VNF ecosystems to become network operator-driven (as opposed to vendor-driven) and broaden in quantity and scope, and in vendor diversity.

Longer-Term Focus: Full Integration Into NFV Strategy

The long-term operator plan for SD-WAN clearly is full integration into their overall NFV strategy, and particularly as part of vCPE. Heavy Reading operator surveys consistently point to virtualized enterprise CPE as the first use case for NFV, and for good reason. Operators have chosen vCPE because of its strong, immediate business proposition and its technical viability.

On the business side, the vCPE model allows operators to quickly deliver network functions to enterprise customers on-demand via software. vCPE also reduces opex, because delivering functions as software VNFs as opposed to hardware eliminates costly on-site installations (truck rolls) and challenging upgrades.

It is not coincidence that the main benefits of SD-WAN cited by operators in our SD-WAN survey align very closely with the vCPE priorities of on-demand and rapid service delivery (detailed in **Figure 2** above). Opex savings with SD-WAN due to software automation is also important to operators, though this is primarily an internal benefit, as the dollar-for-dollar savings are not necessarily passed along to enterprise customers.

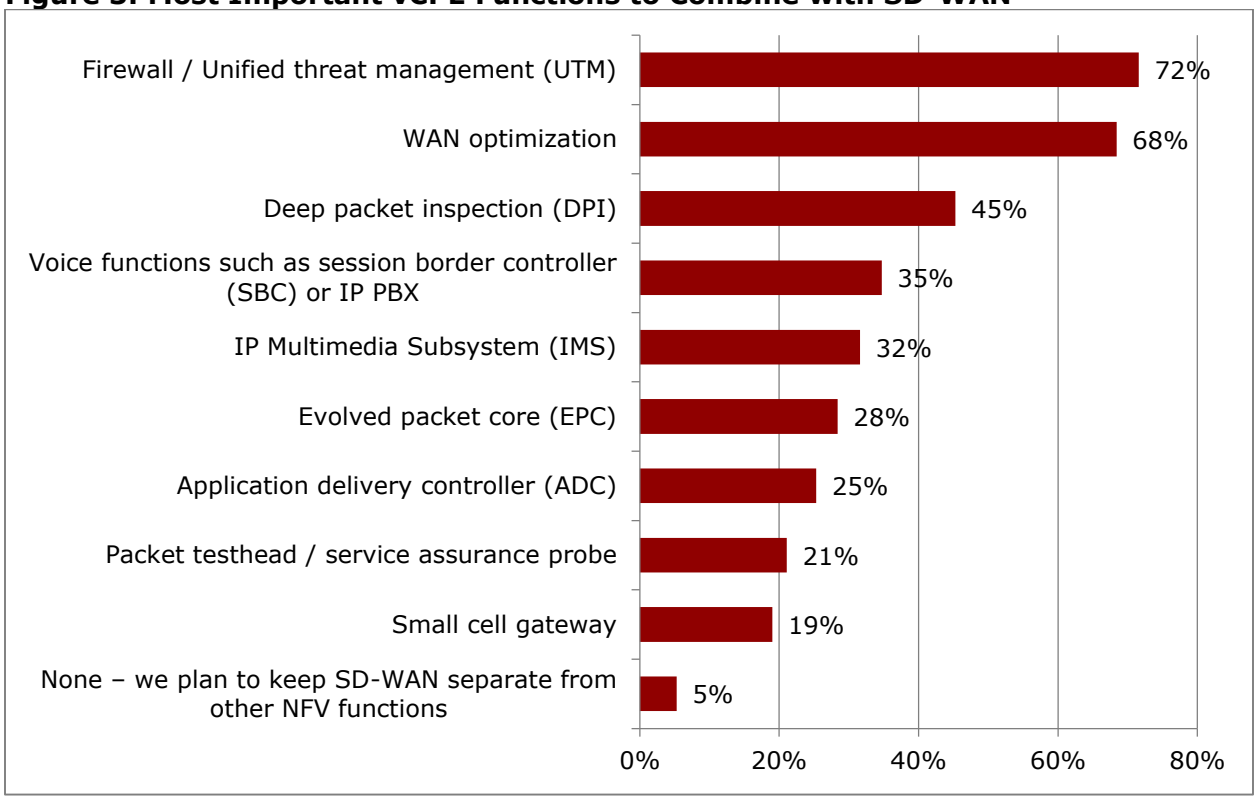
Indeed, operators tell Heavy Reading that software-based implementation and the ability to integrate with their overall NFV strategies are the two most critical technical factors in their SD-WAN strategies. Leading SD-WAN vendors are also hearing this message and are already driving products toward NFV integration.

SD-WAN's original purpose-built appliance model is quickly evolving into a multi-function CPE model that houses not just SD-WAN and vendor-specific security functions, but also

third-party VNFs. The ability to combine SD-WAN with multiple NFV functions will be a critical differentiator for network operators.

Heavy Reading believes that vCPE/NFV integration will be network operators' greatest differentiator versus the enterprise DIY model, as well as operators' primary deterrent against the MPLS network arbitrage dilemma – through which they retain customers but erode revenues. For these reasons, in our December 2016 SD-WAN survey, we asked operators to select the most important vCPE functions to combine with SD-WAN. The results are shown in **Figure 3**.

Figure 3: Most Important vCPE Functions to Combine with SD-WAN



N=95
Source: Heavy Reading December 2016 Operator Views on Emerging SD-WANs Survey, Sponsored by ADVA

EARLY ADOPTERS: OPERATOR CASE STUDIES

BT

SD-WAN is part of BT's Dynamic Network Services suite of business networking services, which introduces new software-based programmable network technology that enables an innovative range of flexible services and is based on NFV, SDN and SD-WAN. While the end goal of Dynamic Network Services calls for full integration of these three enabling technologies, BT is taking a phased approach to rollouts based on the combination of initial enterprise customer demand and relative maturity of these enabling technologies.

The operator has concluded that the demand for and maturity of SD-WAN is high and has placed SD-WAN rollout at the front end of its roadmap. Initial launch of BT's SD-WAN service, called Agile Connect, is planned for mid 2017. It is being developed to serve large, global enterprise using a cloud-based IT consumption model, and BT positions Agile Connect SD-WAN as a complement to its existing IP and Ethernet VPN services. BT's SD-WAN suppliers are Nokia's Nuage Networks and Cisco Systems.

Although a timeline has not yet been specified, BT's roadmap calls for the Agile Connect service to also integrate vCPE capability to provide "branch in a box" services using the centralized automation of the SD-WAN. Agile CPE will host network applications on site using a single physical CPE device that then delivers virtual services, and that CPE will be based on commodity x86 processors. BT states that, once available, Agile CPE will be fully integrated with the Agile Connect SD-WAN product to provide a full set of branch functions with a single physical device.

CenturyLink

An early mover, CenturyLink rolled out its SD-WAN managed services starting in July 2016, achieving domestic coverage across all 50 U.S. states by year end, speeds from 10 Mbit/s to 1 Gbit/s, CenturyLink-provided setup and support, and full IT automation.

CenturyLink is targeting its SD-WAN managed services at large enterprises that have many locations (hundreds or even thousands of sites) with similar requirements among those locations. These include retailers, fast-food chains, retail banks and others.

For these types of customers, CenturyLink SD-WAN provides the following key benefits:

- The ability to respond more effectively to cloud and SaaS-based application growth within branch locations
- Removing performance bottlenecks by increasing bandwidth
- Ensuring security standards are met with greater ease and efficiency
- Eliminating complexity
- Gaining greater visibility into network usage
- Accelerating data pulls and daily batch processing from brick-and-mortar locations

One of the key technical requirements for CenturyLink was multi-tenancy – the ability to support multiple different end customers simultaneously from the central office/point of presence (PoP). For CenturyLink, multi-tenancy gives them the ability to scale customers quickly and also economically, since new software and hardware is not required for every new customer addition.

CenturyLink's current SD-WAN supplier is Versa Networks. Additional SD-WAN suppliers are included in CenturyLink’s product roadmap.

SingTel

Singtel was one of the first service providers in Asia/Pacific to launch an SD-WAN service when it rolled out SingTel ConnectPlus in June 2015. Built upon a carrier-grade, fully redundant architecture with full control hosted in Singtel's private cloud, SingTel's end-to-end

managed SD-WAN service has been fully operationalized and is sold to enterprises in various industry segments across the globe.

The key differentiator for Singtel, as a service provider, is the ability to provide a one-stop-shop managed SD-WAN overlay service that integrates with its underlay network capabilities.

The key value propositions of Singtel's ConnectPlus SD-WAN are:

- The ability to address the underlay performance issues with its suite of "Better Hybrid" WAN solutions, including MPLS, business-grade global Internet and cloud access, all with SLAs.
- The ability to build intelligence into the network with a single overlay SD-WAN network fabric, which can simplify the complexity of managing a hybrid network, enable full visibility across disparate networks and make the hybrid network agile, optimal and software-programmable.
- The ability to integrate the SD-WAN overlay service and the underlay network infrastructure with full visibility across the network and applications layer.

Singtel's uses Viptela's SEN for its SD-WAN. The operator also plans to introduce regional ConnectPlus NFV, with vRouter, vFirewall and vWAN optimization.

Verizon

An early managed SD-WAN entrant, Verizon launched managed SD-WAN services globally in 2015, reaching more than 60 countries and successfully deploying SD-WANs across many customers, spanning thousands of locations around the world. Today, Verizon has multi-vendor SD-WAN deployments at scale and is continuing to evolve its technology and services. Verizon's strategic partnerships for SD-WAN are with Cisco and Viptela, and extend to join development to drive innovation.

Following the success of SD-WAN, in July 2016 Verizon launched Virtualized Network Services (VNS), a broad NFV-based set of services for enterprises that includes SD-WAN as one of its components. As an end-to-end service, Verizon delivers a turnkey solution, from design/planning services to continuous monitoring and management, with the goal of reducing the complexity of SD-WAN and NFV for its enterprise customers.

Verizon has a multi-vendor strategy for NFV that currently includes Juniper, Fortinet, Palo Alto, Cisco (security VNFs), Riverbed and Cisco (WAN optimization VNFs). Verizon is continuing to expand its list of NFV partners.

As an example of integrated services, Verizon enterprise customers can use SD-WAN to drive dynamic bandwidth decisions to adapt capacity based on application policy performance. Verizon is making strategic investments in application performance visibility correlated to application policy decisions. To enable flexible deployment models, Verizon can deliver SD-WAN services across both physical and virtual applications spanning the premises and hosted services, so that application policies are mapped from the premises to the SaaS-based cloud environment.

Key differentiators for Verizon include a flexible pay-as-you-go pricing, reduced hardware requirements, end-to-end management via a Web portal and flexible service tiers.

CONCLUSIONS

SD-WAN is an emerging software overlay approach for connecting, monitoring and controlling enterprise WANs. By centralizing policy and control and adding application-aware routing, SD-WANs automate configuration, management and optimization of services in a way that meets the needs of the cloud model, while reducing networking costs. What started out as a perceived threat to existing private-line/MPLS businesses is now poised to become a significant avenue to new revenue and a key source of differentiation – for those operators that adopt SD-WANs quickly and with a clear strategic focus.

That focus revolves around integrating SD-WANs into operators' overall NFV and vCPE strategies. It is no coincidence that the main benefits of SD-WAN cited by operators align very closely with the vCPE priorities of on-demand and rapid service delivery. By combining SD-WANs with multiple VNFs for branch locations, operators can meet their enterprise customers' branch networking requirements while providing a service that goes beyond the abilities of enterprise DIY, differentiates from other operator services and provides customer stickiness.

Operator adoption of SD-WAN is still in its early phase, but leading-edge operators – including CenturyLink, Verizon, SingTel and BT profiled in this paper, as well as others – are providing the blueprint for both SD-WAN and NFV for the enterprise.