WHITE PAPER

Communications Service Providers
SD-WAN

Intel Tests Versa Operating System (VOS) SD-WAN on HPE Telco Blueprint Solutions

Versa Operating System (VOS) SD-WAN tested using Red Hat OpenStack with Open vSwitch-Data Plane Development Kit (OVS-DPDK) infrastructure with 25 Gb Intel® Ethernet Network Adapter XXV710

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Supporting the computing needs of a modern branch office requires an agile broadband service to access cloud-based resources in addition to continuing connectivity to legacy databases and systems via multiprotocol label switching (MPLS) networks. Software-defined wide area network (SD-WAN) services support both of these network types and have become an IT priority in many enterprise deployments today.

Communications service providers (CommSPs) are building out a new network that supports SD-WAN services. A common network design features cost-effective universal customer premises equipment (uCPE servers) on site at branch offices, connected to the CommSP's SD-WAN infrastructure built with higher performance virtual CPEs (vCPE) at the network edge or to SD-WAN servers at the central office.

When using network functions virtualization (NFV) in these servers, CommSPs can support additional virtualized services to meet customer needs and improve profitability as services can be added without upgrading the hardware. Even so, one of the key challenges in deploying virtualized network functions (VNF), especially over software infrastructure, is ensuring that the performance of the network services can be measured and is deterministic.

In order to quantify the performance of virtualized SD-WAN solutions, Intel coordinated a test of the Versa Networks SD-WAN software running on a uCPE from Hewlett Packard Enterprise (HPE) with Red Hat Enterprise Linux and Red Hat OpenStack Platform. The tests were conducted and a proof of concept (PoC) was developed for a tier 1 CommSP to support a roll out of NFV SD-WAN services.

Many uCPE SD-WAN solutions are implemented in a server powered by the Intel® Xeon® D processor or Intel Atom® processor product lines as a bare metal appliance. This proof of concept showcases the possibilities of running a similar workload that has been virtualized on a 2nd generation Intel Xeon Scalable processor-based server utilizing an Open vSwitch-Data Plane Development Kit (OVS-DPDK) infrastructure.

A typical use case that could take advantage of the compute power of a 2nd generation Intel Xeon Scalable processor-based server is one where the SD-WAN connects branch offices using uCPE devices on customer premises back to the CommSP's data centers as shown in Figure 1. Each customer premises uCPE features SD-WAN capability for connecting to the data center along with other VNFs that vary based on the needs of the branch offices.

The data center network terminates the SD-WAN connections and routes the data traffic via 25 Gbps backbone connections to the internet/public cloud or to an enterprise headquarter data center via a multiprotocol label switching (MPLS) virtual private network (VPN). This is where the proof of concept described in this white paper sheds light on the performance of SD-WAN with a 25 Gbps pipe.

Table of Contents

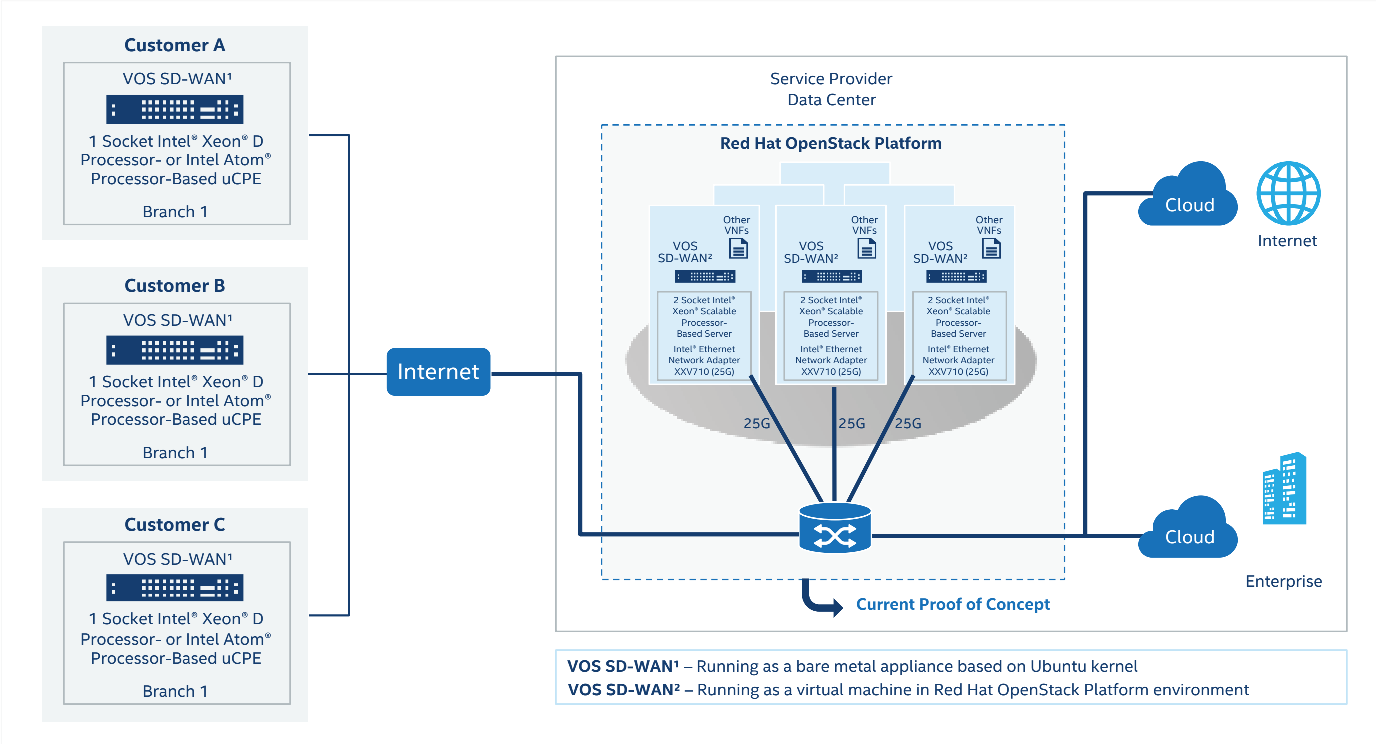

Figure 1. Example of a CommSP SD-WAN network.

HPE Telco Edge Blueprint uCPE Servers

The servers used in the tests are from the HPE ProLiant DL380 Gen10 Server family and based on the HPE Telco Edge Blueprint for multi-access edge computing (MEC) systems. The HPE Telco Edge Blueprints are validated platforms that enable network and service agility with open and optimized infrastructure for NFVI workloads at the network edge.

The product family incorporates 2nd generation Intel Xeon Scalable processors for data center servers and Intel Xeon D processors for the branch office uCPEs, Intel® Ethernet Network Adapters for Data Plane Development Kit (DPDK)–accelerated networking, and Intel® Solid State Drives (Intel® SSDs). The servers are constructed using non-uniform memory access (NUMA), which configures the CPU and memory in a way that allows multiple virtual machines or containers to share memory locally for improved performance.

The HPE Telco Edge Blueprint is part of a family of solutions that also includes the HPE Telco Core Blueprint solutions. The combined product families offer CommSPs a solution for building an NFV infrastructure that extends from the core to the network edge. The components of the HPE Telco Edge Blueprint include the following:

- Industry-leading, Network Equipment-Building System (NEBS) level 3 compliant HPE ProLiant DL380 Gen10 servers and HPE Edgeline 4000 Converged Edge systems with ProLiant m510 server cartridge, powered by Intel Xeon D processors.
- HPE Nimble Storage all-flash arrays combine a flash-efficient architecture with HPE InfoSight (which offers predictive analytics) to achieve fast, reliable access to data and 99.9999% guaranteed availability.
- Support for open standards such as Redfish API for multivendor platform management.
- High-performance 100 GbE HPE top-of-rack switches.
- Optional NFV Platform Software (NPS) Toolkit that can be utilized for automated deployment and configuration of the NFVI stack.

HPE Telco Blueprints are designed for scalability via modularity and reliability with no single point of failure. All system components are tuned with optimal BIOS and NIC configurations for carrier-grade performance and incorporate Redfish API and other open industry standards. HPE Telco Blueprints are optimally designed and validated with close technical collaboration from leading VIM and SDN partners, and are offered with end-to-end support.

Red Hat OpenStack Platform

Red Hat OpenStack Platform is co-engineered with Red Hat Enterprise Linux to deliver a scalable and more secure foundation for building a private or public infrastructure-as-a-service (IaaS). It offers a highly scalable, fault- tolerant platform for the deployment of cloud-enabled workloads and virtual network functions (VNFs) required for solutions like SD-WAN.

Red Hat OpenStack Platform natively supports the enhanced platform awareness (EPA) features to deliver deterministic performance improvements through CPU pinning, huge pages, non-uniform memory access (NUMA) affinity, and network adaptors (NICs) that support SR-IOV and OVS-DPDK.

In addition, its distributed compute nodes capability enables organizations to build an edge computing architecture that helps increase efficiency, gain insights faster, and provide enhanced customer offerings that create differentiation.

Red Hat OpenStack Platform's distributed compute nodes also allow CommSPs and enterprises to extend compute capabilities to headquarters and branch offices, simplifying the management and operations of a SD-WAN solution deployed across multiple locations.

Versa Secure SD-WAN Solution

Versa Secure SD-WAN is a cloud-native multi-tenant software platform that delivers software-defined layer 3 (routing) to layer 7 (application) services with full programmability and automation. The Versa Secure SD-WAN software platform delivers SD-routing, SD-WAN, SD-security, and SD-branch functions for the WAN edge.

The Versa Secure SD-WAN solution is composed of four deployed software components:

Versa Operating System (VOS), formerly known as FlexVNF, is intelligent multi-service and multi-tenant edge software that delivers scalable, segmented, programmable, and automated SD-infrastructure (SD-routing, SD-WAN, SD-security and SD-branch) at the branch. It provides both software-defined networking and security features in a single software package along with advanced contextual dynamic application traffic steering and service chaining.

It is a single software platform that incorporates networking and security, including full-featured advanced routing, and uCPE virtualization support. This provides a highly flexible branch services platform that can deliver both Versa native capabilities—including SD-WAN, next-generation firewall (NGFW), unified threat management (UTM), NG-IPS, secure web gateway (SWG), anti-virus, ransomware protection, and more—and can host third-party virtual network functions. VOS is centrally managed and provisioned by Versa Director and provides carrier-grade operational capabilities that include a distributed control and data plane fabric with built-in elasticity and capacity on demand.

Versa Director offers centralized control and management for both connectivity and services. This platform simplifies the creation, automation, and delivery of services based on VOS. Versa Director provides the essential management and provisioning capabilities needed to deliver Versa's Secure Cloud IP platform, VOS network, and security services. It simplifies and automates the creation, delivery, management, and operations of Versa networking, SD-WAN, and security services. It provides the central management interface for configuration, policy creation and templates, service management, and real-time monitoring for Versa and third-party services.

Versa Controller is the network-wide controller with data security features that manage the distributed control-plane across the SD-WAN fabric. The Versa Controller works in conjunction with Versa Director to propagate reachability, policies, and connectivity services for the SD-WAN overlay, providing a control-plane entry point for all VOS SD-WAN branches.

Versa Analytics provides holistic big-data driven visibility, base-lining, correlation, and predictive analysis for network, application usage, and security events. It provides the contextual insights into application, user, device, and location with advanced reporting and event correlation with 360-degree insights for networking and security. Versa Analytics analyzes and correlates data sent from both the VOS and third-party VNFs to present critical data points as actionable analytics and reports. Its tight native integration with Versa Director ensures optimized storage, search, and performance. The Versa Secure SD-WAN solution delivers complete networking and security services for branch offices and cloud/data center applications. The multi-tenant cloud-native networking, SD-WAN, and advanced security software platform provides robust flexibility and elasticity with high performance for WAN edge deployment use cases where security is paramount.

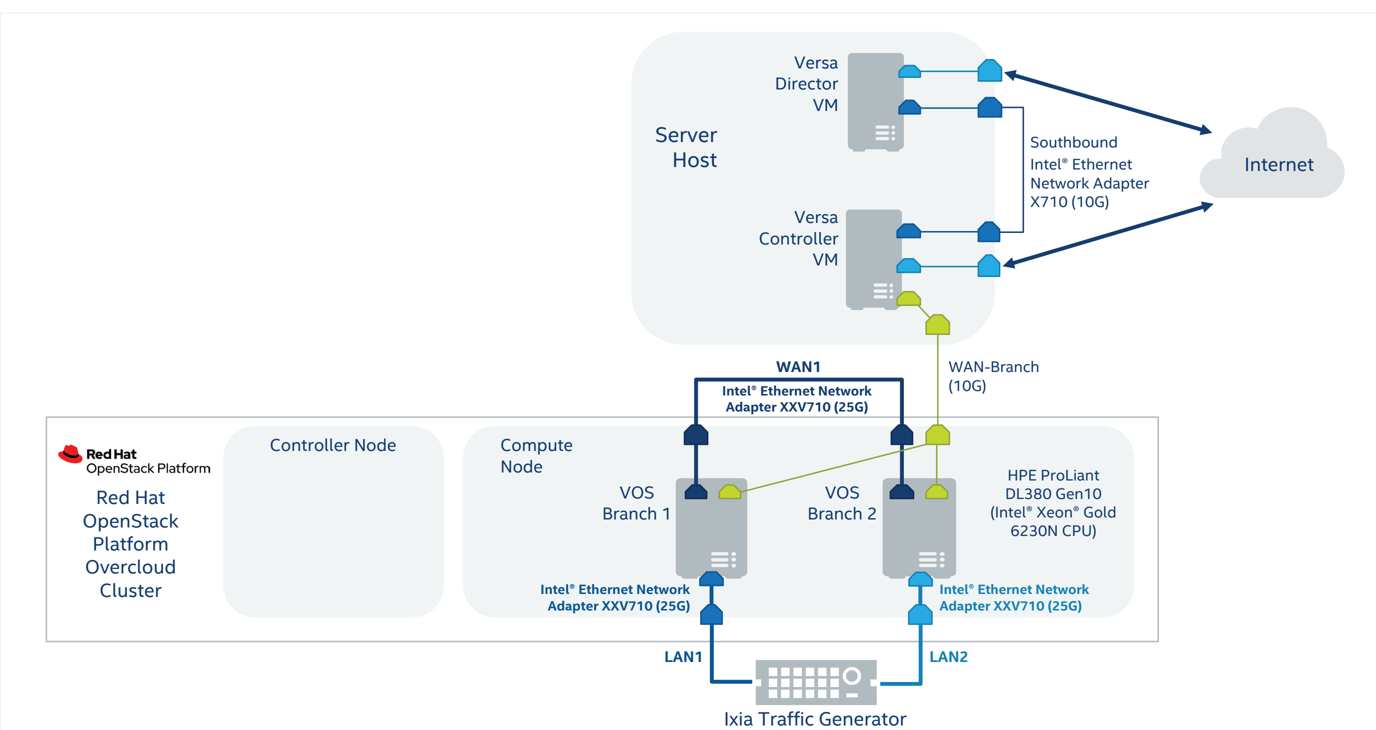

Figure 2. Test setup for Versa Secure SD-WAN solution

Test Setup

Intel conducted performance testing on the Versa Secure SD-WAN solution using a single HPE ProLiant DL380 Gen10 server acting as a compute node. Red Hat OpenStack Platform was deployed as a private cloud in a lab at Intel using a standard high-volume server as a controller node and an HPE ProLiant DL380 Gen 10 server as the compute node with two virtual machines acting as branch nodes and running VOS. A third server acting as a host for Versa SD-WAN Controller and Versa Director virtual machines was also used in the test (see Figure 2).[1]

INGREDIENT	CONFIGURATION	QUANTITY
CPU	Intel® Xeon® 6230N CPU @ 2.3 GHz 20C/40T, 125 W	2
Memory	HPE Part Number: P03052-091 2933 MT/s 32 GB , Total 384 GB	12
NIC	Quad-port 10 Gb Intel® Ethernet Controller X710	1
	Dual-port 25 Gb Intel® Ethernet Network Adapter XXV710	2 (1 per NUMA node)
Storage	HPE SCSI Disk EG001200JWJNK 1200GB	2
LAN on Motherboard (LOM)	1 Gbps port for PXE/OAM	1
	1 Gbps port for Management NIC	1

Table 1. HPE ProLiant DL380 server hardware configuration for system under test.

TOPIC	INGREDIENT	SW VERSION DETAILS	
Firmware	BIOS Microcode	HPE BIOS - U30 v2.13 (09/04/2019) 0x500002c	
	Network Adapter	6.01 0x80003554 1.1747.0	
Host	OS	Red Hat Enterprise Linux	RHEL7.8-kernel- 3.10.0-1127.el7.x86_64
	Orchestrator	Red Hat OpenStack Platform	13
	Hypervisor	KVM/QEMU	2.12.0
	Libvirt	Libvirt	4.5.0
	Docker	Docker	Version 1.13.1, build 64e9980/1.13.1
	APPs	DPDK	18.11.5
	APPs	OVS	2.11.0
	Drivers	i40e	2.8.20-k
		Ixgbe	5.1.0-k-rh7.7
		NVMe	1.0
Guest	VNF	VOS SD-WAN	16.1R2S10
	Drivers	i40evf ixgbevf	3.2.3-k 4.1.0-k-rh7.7

Table 2. HPE ProLiant DL380 server software configuration for system under test.

MENU (BIOS/PLATFORM CONFIGURATION (RBSU))	PATH TO BIOS SETTING	BIOS SETTING
Processor Options	Intel® Hyper-Threading Technology	Disabled
Power and Performance Options Configuration	Intel® Turbo Boost Technology	Disabled
	Energy Efficient Turbo	Disabled
	Uncore Frequency Scaling	Maximum
Memory Configuration	Memory Controller Interleaving	Enabled
Virtualization Options	Intel® Virtualization Technology (Intel® VT)	Enabled
	Intel® Virtualization Technology for Directed I/O (Intel® VT-d)	Enabled
	SR-IOV	Enabled

Table 3. HPE ProLiant DL380 server BIOS configuration for system under test.

Grub settings for the system under test:

cat /proc/cmdline
BOOT_IMAGE=/boot/vmlinuz-3.10.0-1127.el7.x86_64 root=UUID=566687de-3830-4c23-b9cf-b2d936de8ec3 ro console=tty0 console=ttyS0,115200n8 crashkernel=auto rhgb quiet default_hugepagesz=1GB hugepagesz=1G hugepages=256 intel_iommu=on iommu=pt intel_pstate=disable processor.max_cstate=1 intel_idle.max_cstate=1 isolcpus=1-19,21-39 skew_tick=1 nohz=on nohz_full=1-19,21-39 rcu_nocbs=1-19,21-39 tuned.non_isolcpus=00100001 intel_pstate=disable nosoftlockup

CPU allocation for Intel® Hyper Threading Technology disabled scenario is shown in Table 4.

SOCKET 0				SOCKET1			
CPU	PROCESS	CPU	PROCESS	CPU	PROCESS	CPU	PROCESS
0		10		20		30	
1		11		21		31	
2		12		22		32	
3		13		23		33	
4		14		24		34	
5		15		25		35	
6		16		26		36	
7		17		27		37	
8		18		28		38	
9		19		29		39	

KEY	PROCESS	CORE ASSIGNMENT
	OS Cores	0,20
	OVS DPDK Master Core	1,21
	OVS DPDK Poll Mode Driver (PMD)	2,3,4,5,22,23,24,25
	VOS Branch 1 cores	26,32,27,33,28,34,29,35
	VOS Branch 2 cores	15,8,9,10,16,11,6,17
	Nova vcpupin set	6-19,26-39
	Emulator pin	12(VM1), 30(VM2)

Table 4. CPU allocation for Intel® Hyper Threading Technology disabled scenario

Demonstration of Platform Capabilities

Along with optimized hardware and software configurations, the test setup has taken advantage of the Intel Xeon processor technologies noted below. The Intel Xeon Scalable Platinum processor offers up to 28 cores per socket and frequency up to 3.6 GHz for next-level performance.

The features include the following:

- Intel® Ultra Path Interconnect (Intel® UPI) speed at up to 10.4 GT/s to boost multi-processor data flow.
- Enhanced memory bandwidth and performance across six memory channels at DDR4-2666 MHz, 2933 MHz for one DIMM per channel operation.
- Accelerated throughput with two fused multiply-add (FMA) operations of Intel® Advanced Vector Extensions 512 (Intel® AVX-512) per CPU.
- Advanced reliability, availability, and serviceability (RAS).

Another technology that is highly advantageous for virtualized environments is the Intel® Virtualization Technology (Intel® VT). It provides hardware abstraction to allow multiple workloads to coexist and share common resources while maintaining full isolation.

Intel® Ethernet network products deliver continuous innovation for high throughput and performance for networking infrastructure. Intel® Ethernet Network Adapters provide highly optimized network virtualization and fast data path packet processing, especially when combined with the Data Plane Development Kit (DPDK).

In order to demonstrate the potential of the Intel® architecture in a Red Hat OpenStack Platform-based virtualized cloud deployment, each compute server was configured with a set of Enhanced Platform Awareness (EPA) features along with the above-mentioned platform technologies. These include:

- Huge page support: This EPA feature enables very large pages to improve system performance by reducing the amount of system resources required to access page table entries.
- OVS with DPDK acceleration: The result of integrating DPDK with OVS is a set of DPDK-accelerated network devices that allow packets to be processed solely in a userspace, which provides significant acceleration of I/O traffic between the virtual switch and a connected network interface card (NIC).
- CPU Pinning: This EPA feature enables the pinning of guest virtual CPUs to physical cores and therefore ensures that an application will be executed on a specific pool of cores. When enabled with CPU isolation, it ensures that other processes will not be scheduled in that pool.
- Non-uniform Memory Access (NUMA) topology awareness: This EPA feature ensures that the virtualized workload gets its resources from the right socket where the NIC ports catering the data path traffic lie. This includes allocating cores and memory from the appropriate socket when spawning a virtual machine.

Test Cases

In this testing, performance was observed at Layer 4-UDP with Ixia IxNet, which is used to generate packets and measure performance. Figure 3 shows the measured throughput of the SD-WAN branch-to-branch encrypted traffic, where the branches are deployed as two virtual machines. The system under test (SUT) was configured as an SD-WAN only, SD-WAN with NGFW, and SD-WAN with NGFW and NG-IPS for various packet sizes ranging from 64 bytes up to 1,400 bytes.

Test Results Analysis

VOS SD-WAN also utilizes the open source Data Plane Development Kit (DPDK), a series of libraries that accelerate packet processing workloads in virtual environments. For packet sizes larger than 1,280 bytes, the L4-UDP throughput reaches up to 15 Gbps for SD-WAN and SD-WAN with NGFW test cases. All the test cases are carried out using a VOS running on eight physical cores.

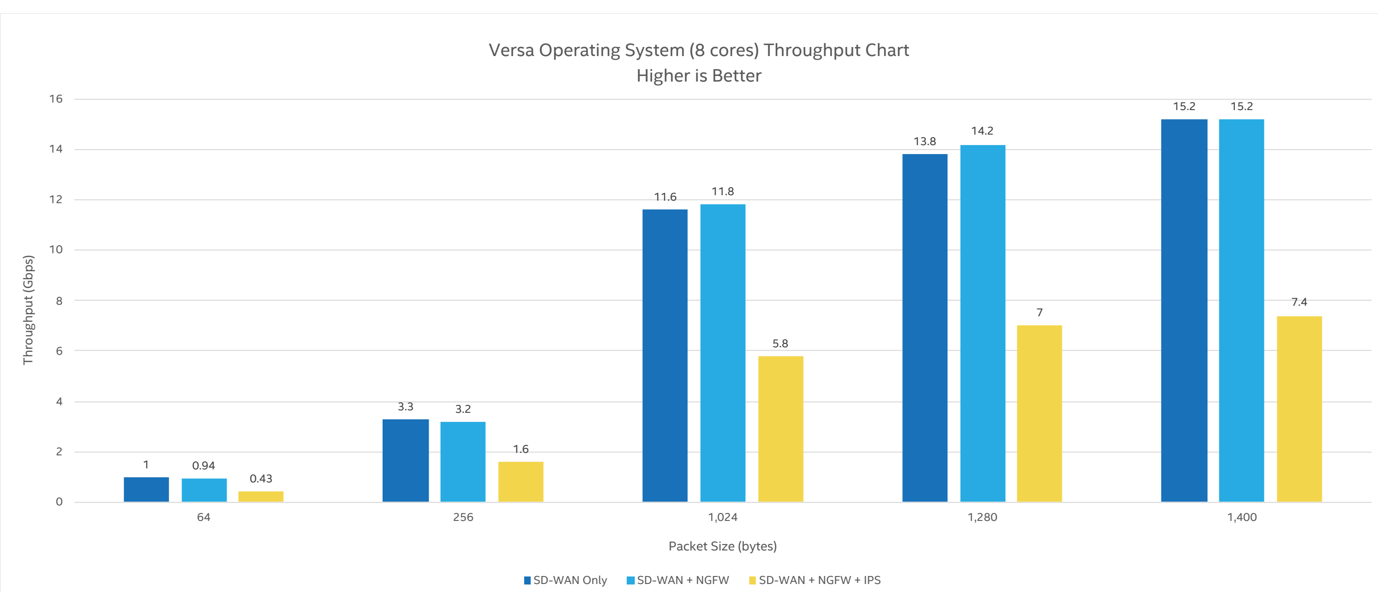

Figure 3. Test results of Versa Operating System (VOS) SD-WAN in a virtualized environment.

Conclusion

In an optimized environment as described above with various EPA features and platform technologies enabled, the tests showed consistent, repeatable, and deterministic SD-WAN performance. The test results benefited from the use of the 25 Gb Intel® Ethernet Network Adapters XXV710 as virtual interfaces to provide up to about 30% of throughput line rate in a virtualized environment accelerated with OVS-DPDK. Moreover, this did not require any changes to the software application running in the OVS-DPDK environment.

Indeed, an infrastructure based on single root input/output virtualization (SR-IOV) methodology could also provide close to 100% line rate of the network interface's capability.

However, an SR-IOV infrastructure may not be applicable for many CommSPs who have deployed network services environment based on OVS-DPDK. SR-IOV may also require changes to the software of the VNF, which may not be feasible all the time.

With applicable OVS-DPDK infrastructures, this SUT provides better performance when compared to traditional kernel OVS implementation.[2] Using a 2nd generation Intel Xeon Scalable processor-based HPE ProLiant DL380 Gen10 server, the tests showcased that VOS can be deployed in a Red Hat OpenStack using the Intel® Ethernet Network Adapter XXV710 to offer higher performance compared to traditional OVS to allow network services chaining applicable to CommSP use cases.

Learn More

Intel® Network Builders: https://networkbuilders.intel.com

Hewlett Packard Enterprise ProLiant DL Servers: https://www.hpe.com/us/en/servers/proliant-dl-servers.html

Versa Networks SD-WAN: https://www.versa-networks.com/

Red Hat NFV: http://www.redhat.com/NFV

Red Hat OpenStack Platform: https://www.redhat.com/en/technologies/linux-platforms/openstack-platform

Notices & Disclaimer

[1] Testing was conducted by Intel in July 2020. For configurations, see Tables 1, 2, 3 and 4.

[2] See https://download.01.org/packet-processing/ONPS2.1/Intel_ONP_Release_2.1_Performance_Test_Report_Rev1.0.pdf and https://software.intel.com/content/www/us/en/develop/articles/open-vswitch-with-dpdk-overview.html for examples of performance on a traditional kernel OVS implementation. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.

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