Services at the Edge: Remote Hardware Lessons Learned

Verizon Product Case Study – 2 years on

15 November 2018

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Delivering Services at the Edge: A hardware perspective

1. Network Services at the Edge: Overview and Challenges
2. You got to start somewhere: Hardware 1.0
3. Black/Grey/White: The reality of HW/SW disaggregation
4. Delivery to the North Pole
5. Performance Matters – lessons applied by Dell
6. EDGE 2.0 : Making it Better

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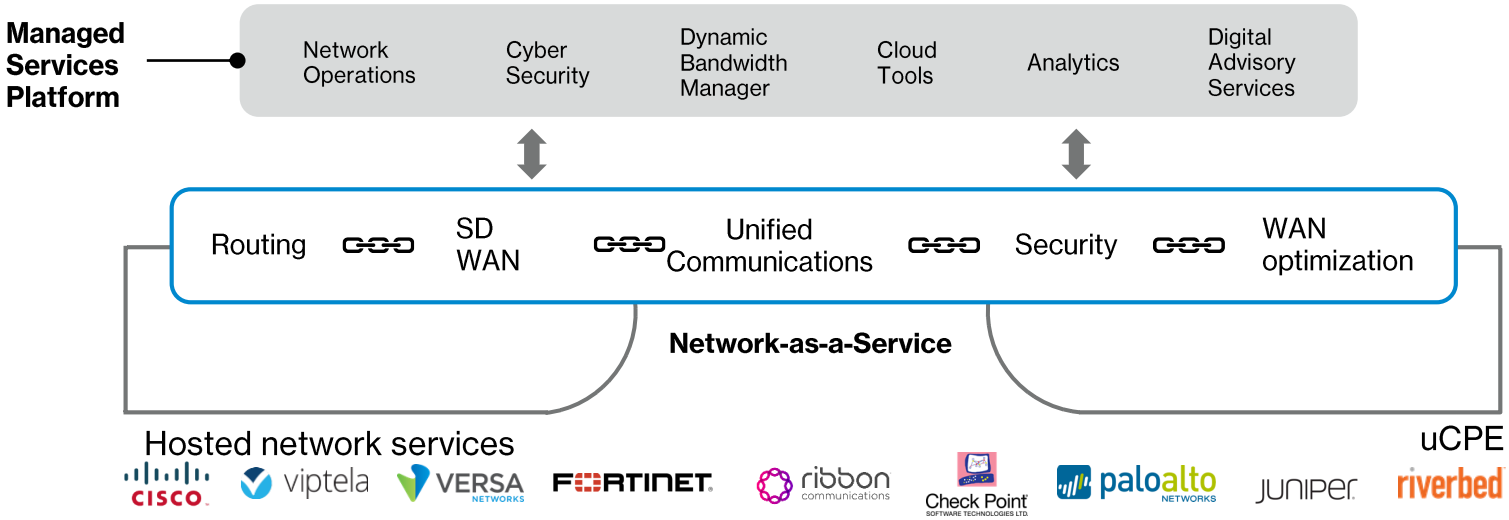
Services at the Edge: Hardware Challenges

- Rugged environments – tops of cell towers, light poles, etc.
- Hardware/Software Disaggregation – Is generic x86 really generic in an edge context?
- Can you assume that the software will work? What about app service chains?
- Problems with access, management and maintenance are multiplied
- Integration nightmares with a mix of in-house and multiple vendor applications?

Verizon Virtual Network Services Product Overview.



Certified multi-vendor ecosystem of Managed Network Services.	Replaces expensive customer premises equipment.	Global enterprise grade private cloud.	Usage based pricing w/o separate license investment.

Virtual Network Services delivery options.

Premises | **Hybrid** | **Hosted**

Full — **Managed Service Delivery** — **Monitor**

WAN Optimization | **Unified Communications** | **Security** | **Software Defined WAN** | **Routing**

Platform Options

Traditional WAN

Dedicated Hardware SD WAN

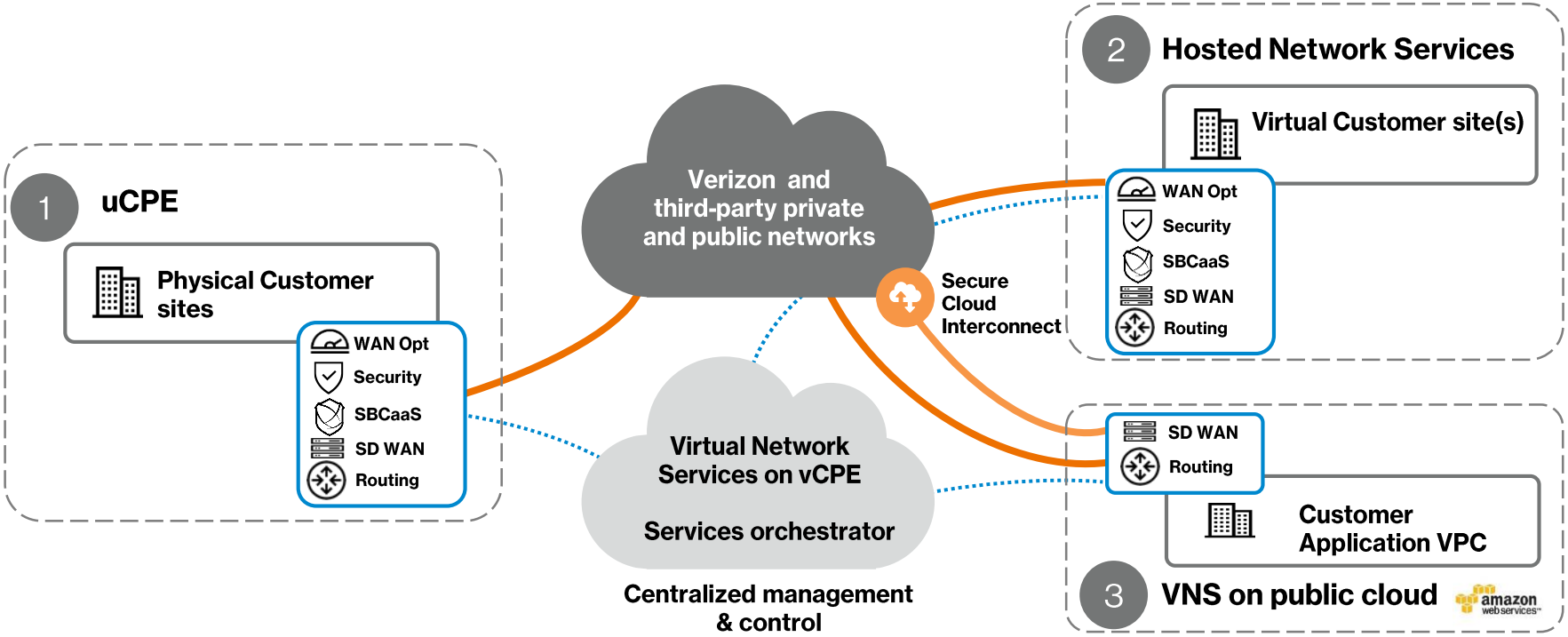
Universal CPE (uCPE)

Hosted Network Services

Public Cloud Amazon Web Services *

* Some restrictions apply.

Virtual Network Services: Deployment options.



You got to start somewhere: Hardware 1.0

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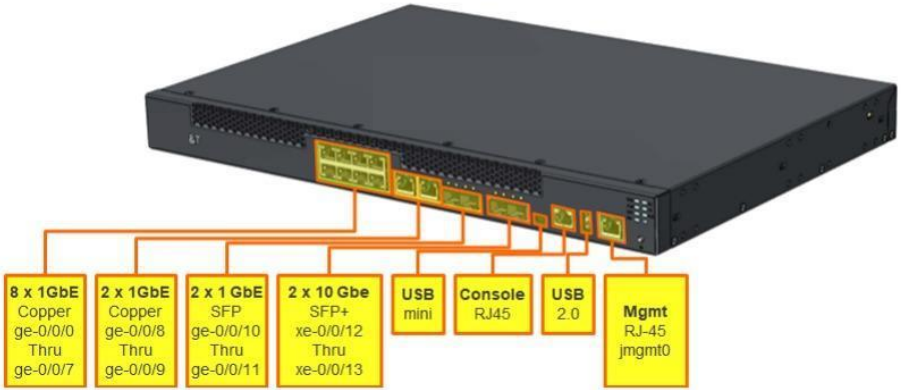
- One size fits all?
- Limited functionality
- Designed for indoor sites
- Greybox, not Whitebox
- Not integrated into other systems
- Didn't do the job...



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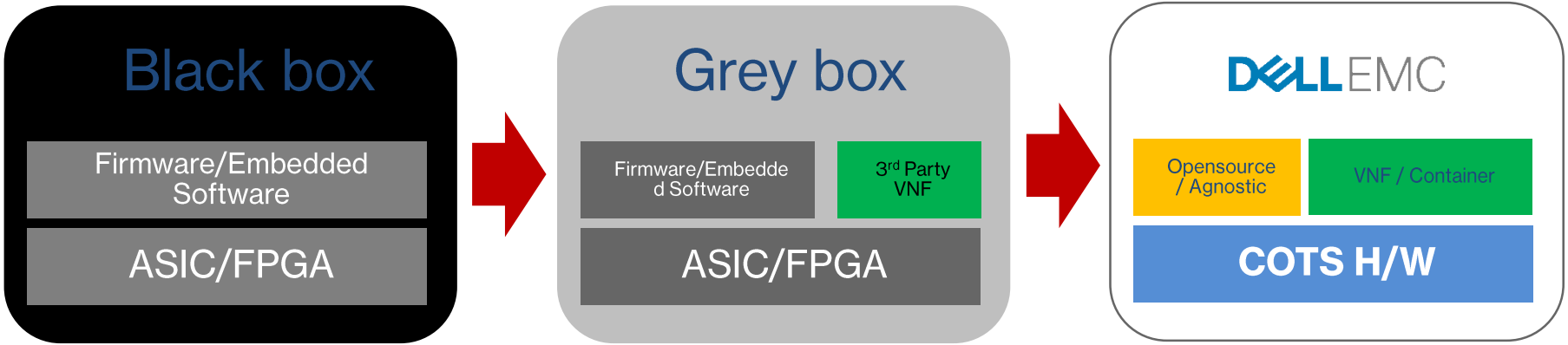
Black/Grey/White Boxes: What's it all mean?



- Proprietary "Black Box"
- One size fits all?, rigid closed system, vendor centric GTM
- Lock-in, vendor ecosystem

- "Grey Box" approach
- Let's in 3rd Party
- Rigid closed system, vendor driven.
- Lock-in, vendor ecosystem

- "White Box" approach
- Open vendor agnostic
- Mix and match to meet specific needs
- Full solution integration control

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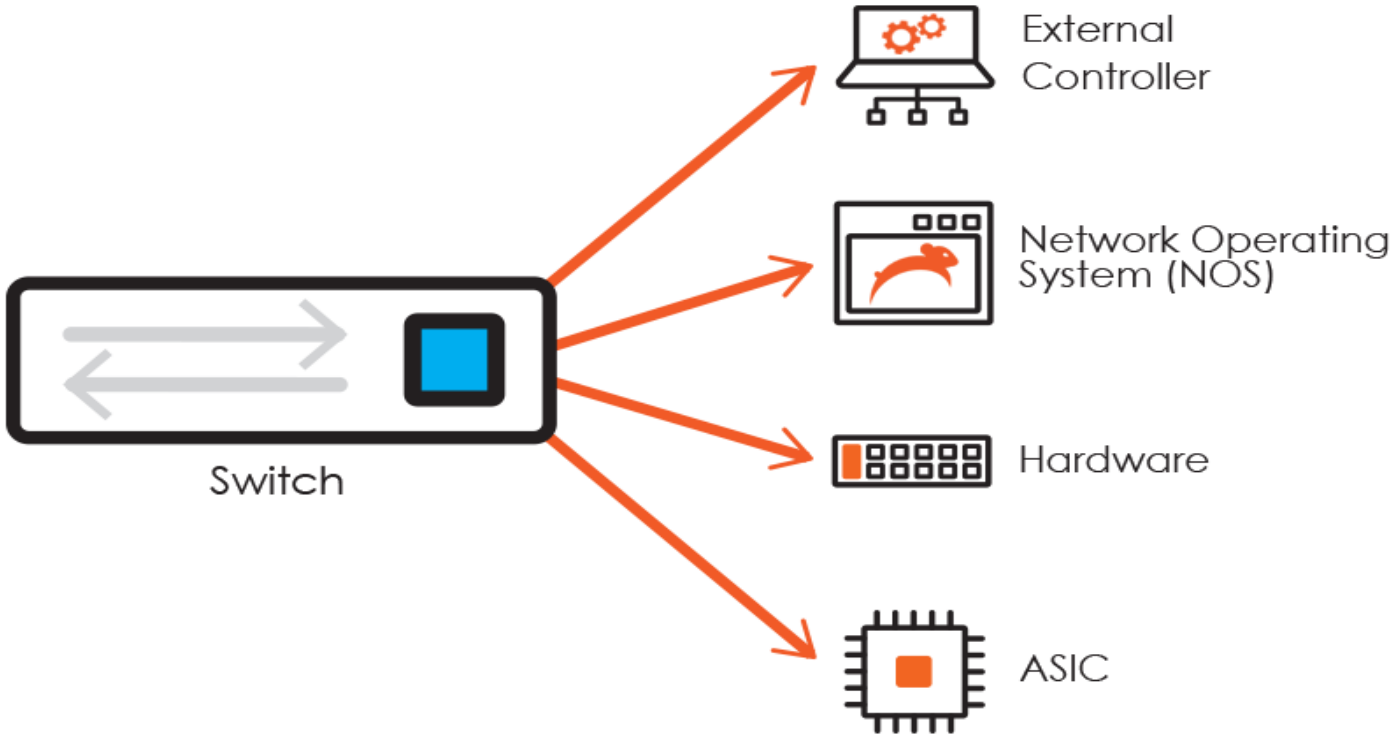
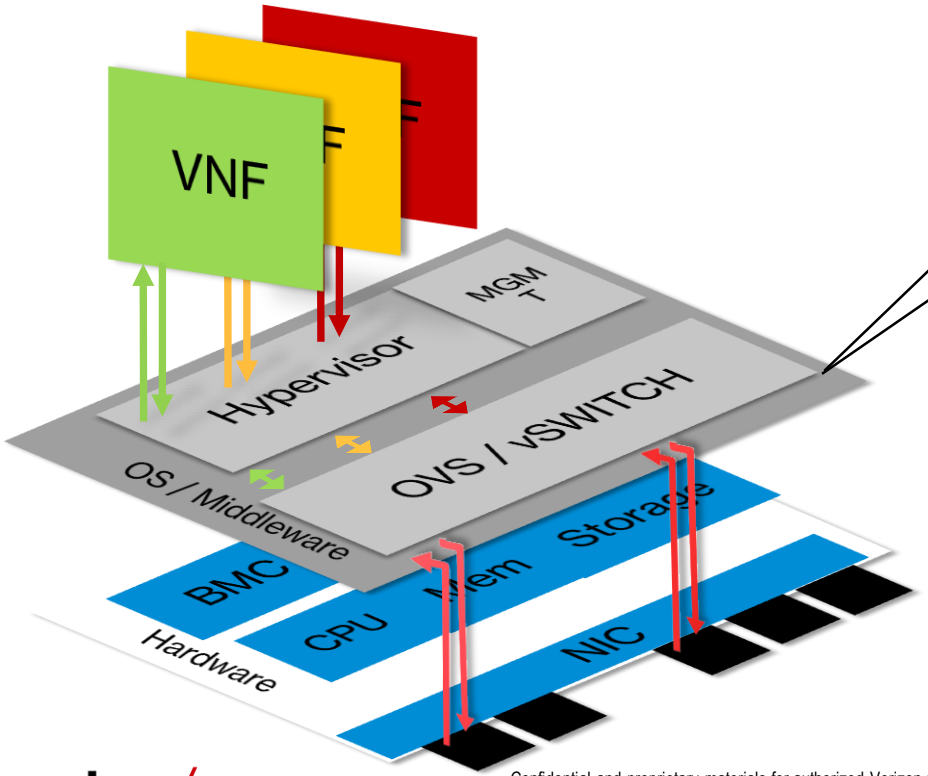
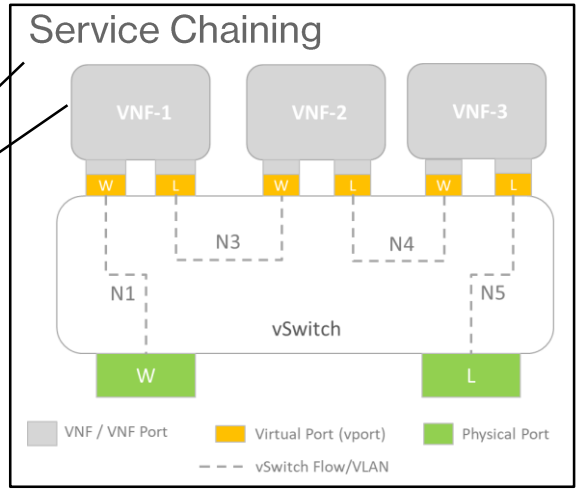
Black/Grey/White Boxes: Simplifying it further...



Whitebox Components

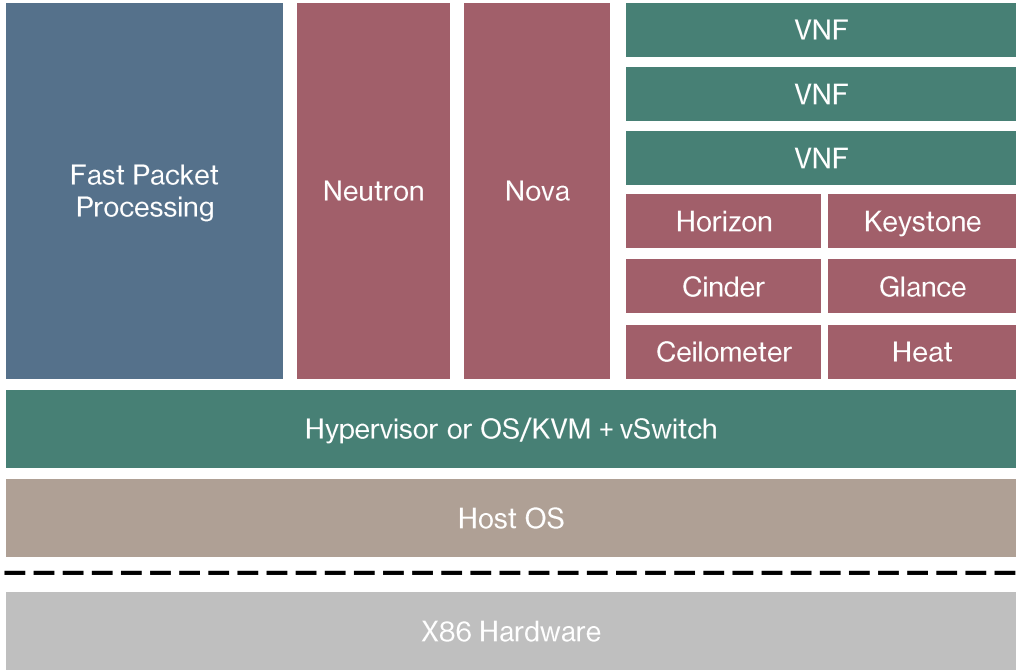




uCPE Software Components

Linux Management OS, Hypervisor, data acceleration with containerized OpenStack Agents and Controllers.

OpenStack at the edge enhances customers' SDN experience.



Verizon uCPE = x.86 hardware platform + OS/Hypervisor

The reality of HW/SW disaggregation

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- Avoiding vendor Lock-in - When you are not a hardware manufacturer, is this even possible?
- Is it better to buy an existing COTS product or build a specialized box from parts?
- Continuous integration in a hardware context -- Making sure it all works together has a different meaning when you DO need to worry about the hardware.
- Integration with existing systems that assume a single appliance is hard.
- Operational models and assumptions need to change.
- Hardware level ZTP to push disaggregation lower in the stack to avoid choke points.
- HW offload without proprietary ASIC.
- SD WAN applications becoming a virtual grey box on a Whitebox; kind of defeats the purpose.

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Updates and Maintenance: Total Cost of Ownership (TCO) Lessons Learned

- Platform – One size does NOT fit all!
  - Cost/functionality tradeoffs
- Provisioning decisions
  - Do you ship the HW preloaded?
  - Or download the SW remotely?
  - Zero Touch Provisioning – Harder than you think
- Lifecycle management
  - Upgrades/tech refresh – how long will the vendor support the hardware?
  - When/how should upgrades/tech refresh be done?

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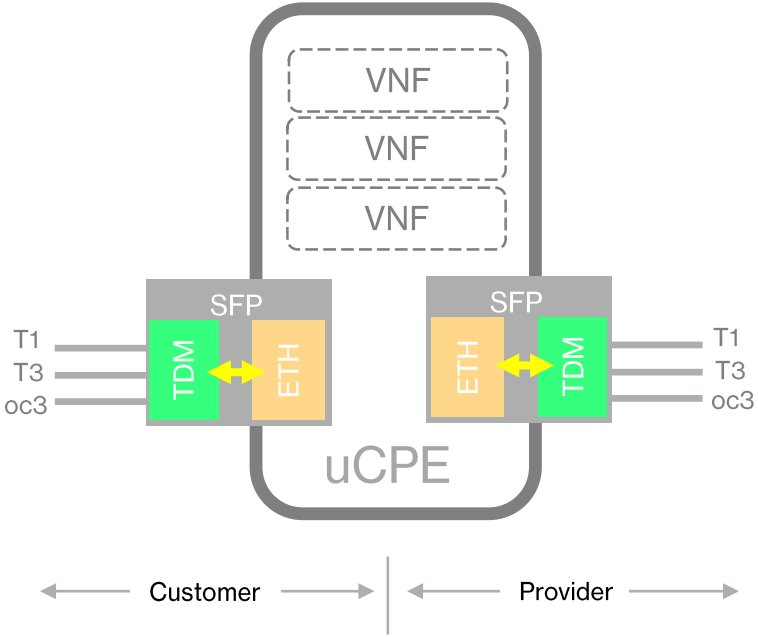
Updates and Maintenance: Upgrade In-Place

- Customer can keep existing access and equipment.
- Injection of a scalable SDN/NFV solution without costly hardware retrofits.
- SFP pluggable fits all existing hardware.



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Delivery to the North Pole: Global Supportability

- If you are a global company, with global customers, contracts matter
- Tax and regulation complexities limits distribution options
- Vendors need to have good homologation support
- Sparing and the maintenance supply chain is key
- Support Contracts – What they mean and why they are critical to the success of the project.
- High Availability considerations in remote locations – Which hardware is critical and what needs to be redundant.

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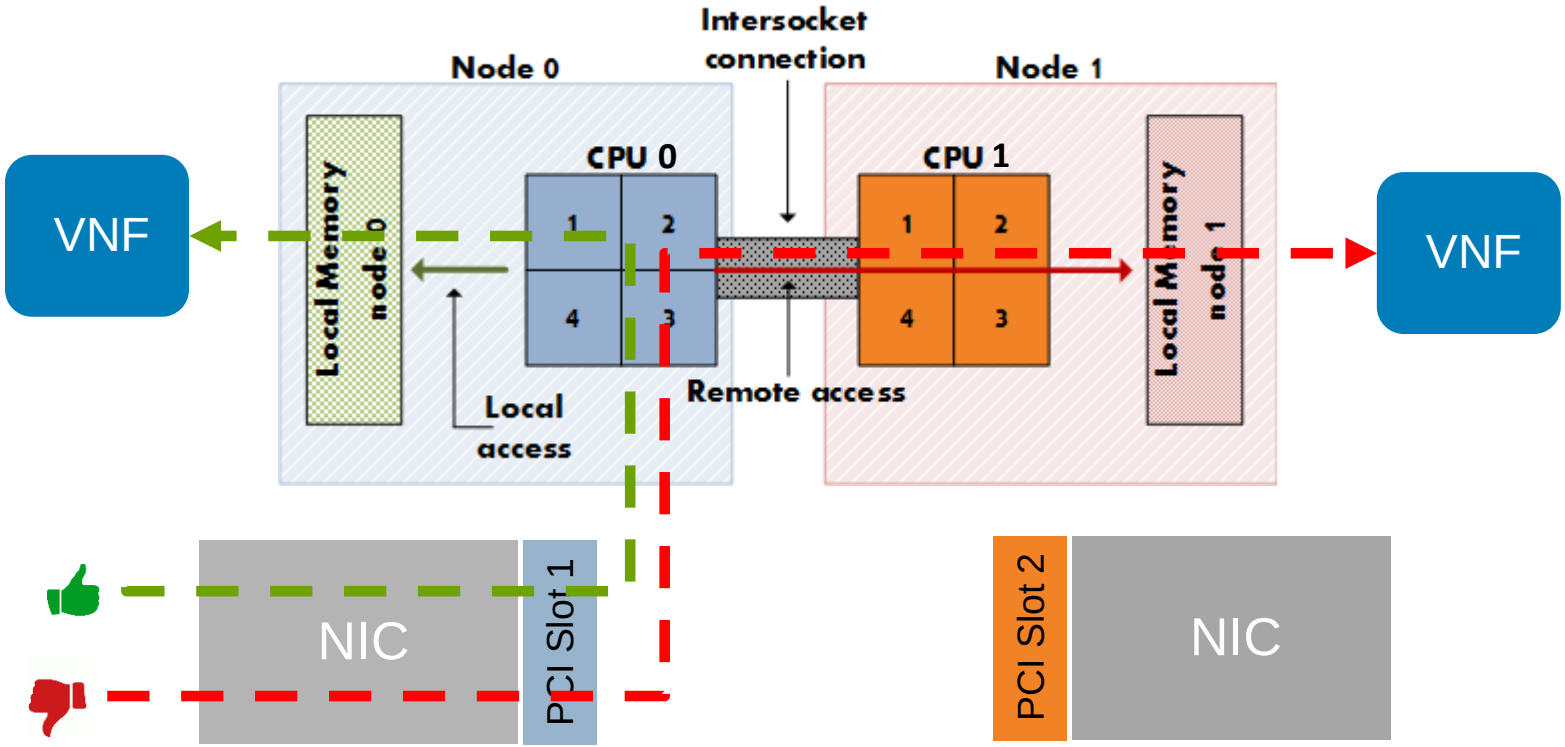
Performance matters..

NUMA awareness



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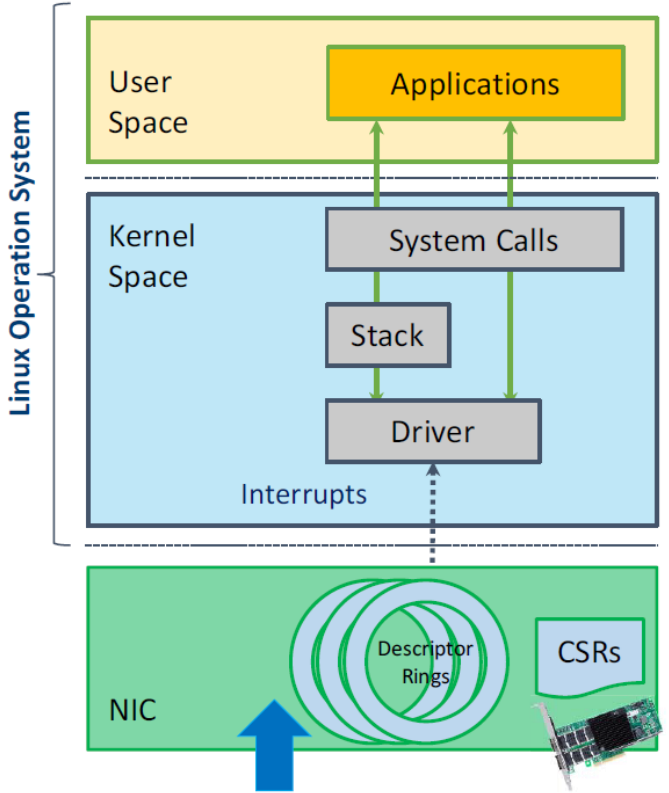
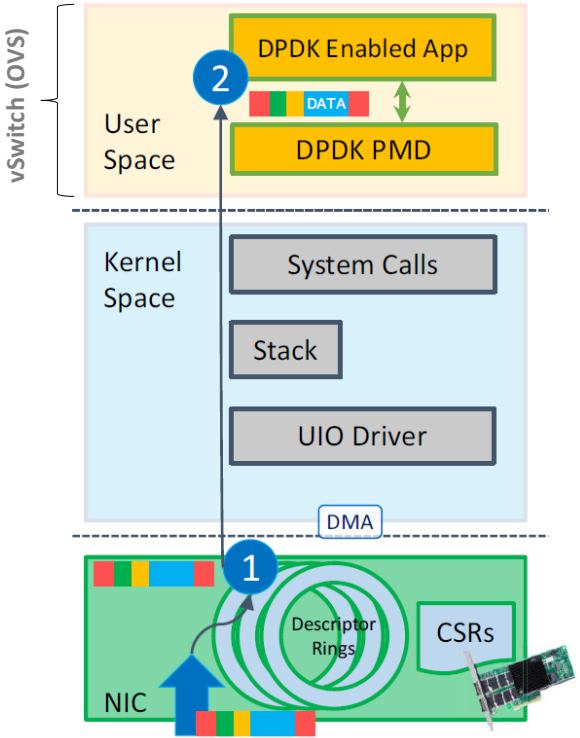
Performance Matters: Non-DPDK

- Traffic must pass through the kernel space.
- Interrupt based approach which is expensive to compute resources.
- Requires the core to service interrupt requests. Processing must stop to service the interrupt and then begin again.
- 10 GbE 64 byte frame size generates nearly 15 Mpps. That's 15 million processing interrupts per second.



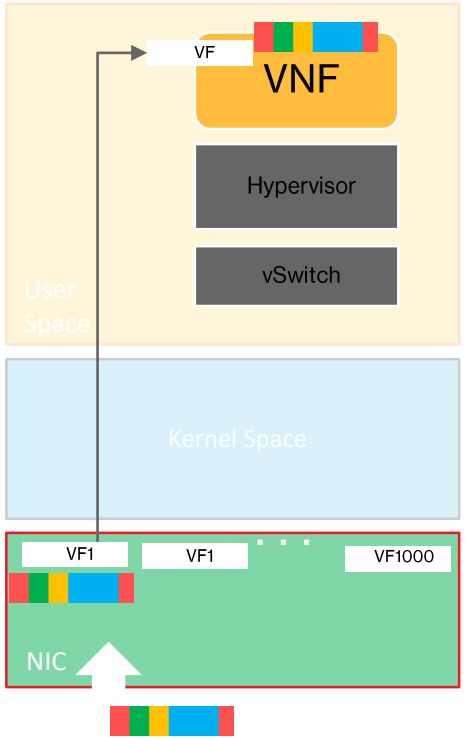
DPDK Enabled

- Traffic bypasses the Kernel space.
- No interrupts. Introduction of Poll Mode Driver (PMD).
- Packets stored in the ring buffer are polled by the DPDK enabled vSwitch (OVS) running in user space.
- Fewer processor interrupts equals higher performance.

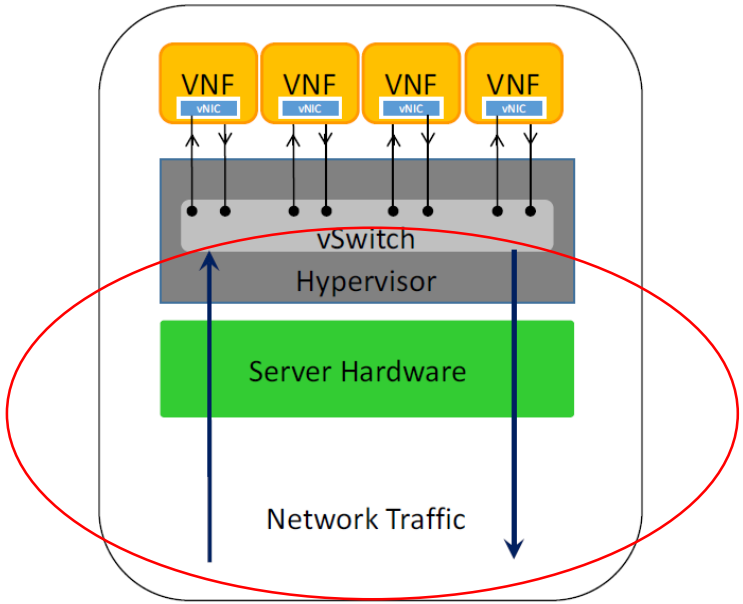


SR-IOV Virtual Functions

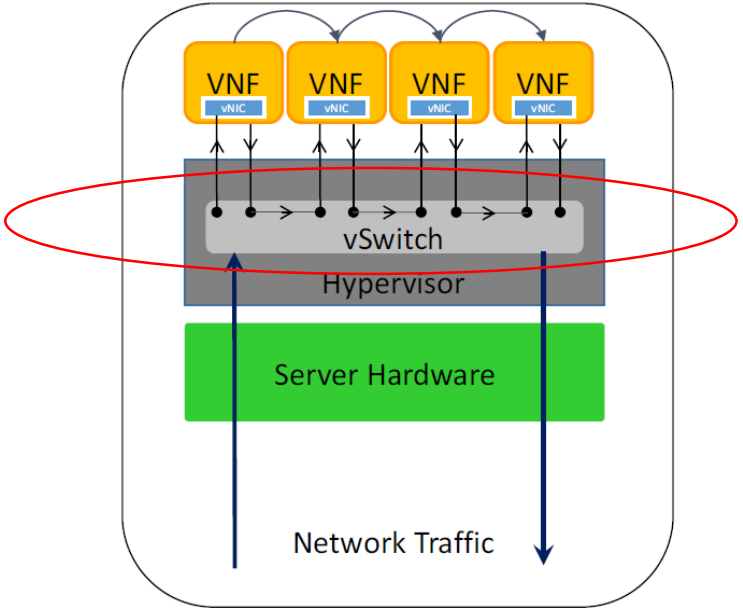
- Bypasses the Kernel space and hypervisor.
- Each physical NIC port is partitioned into 256 virtual interfaces (functions).
- VNF NICs attach to the virtual interfaces of the physical NIC directly.
- Offers the highest level of performance.



Basic Traffic Patterns

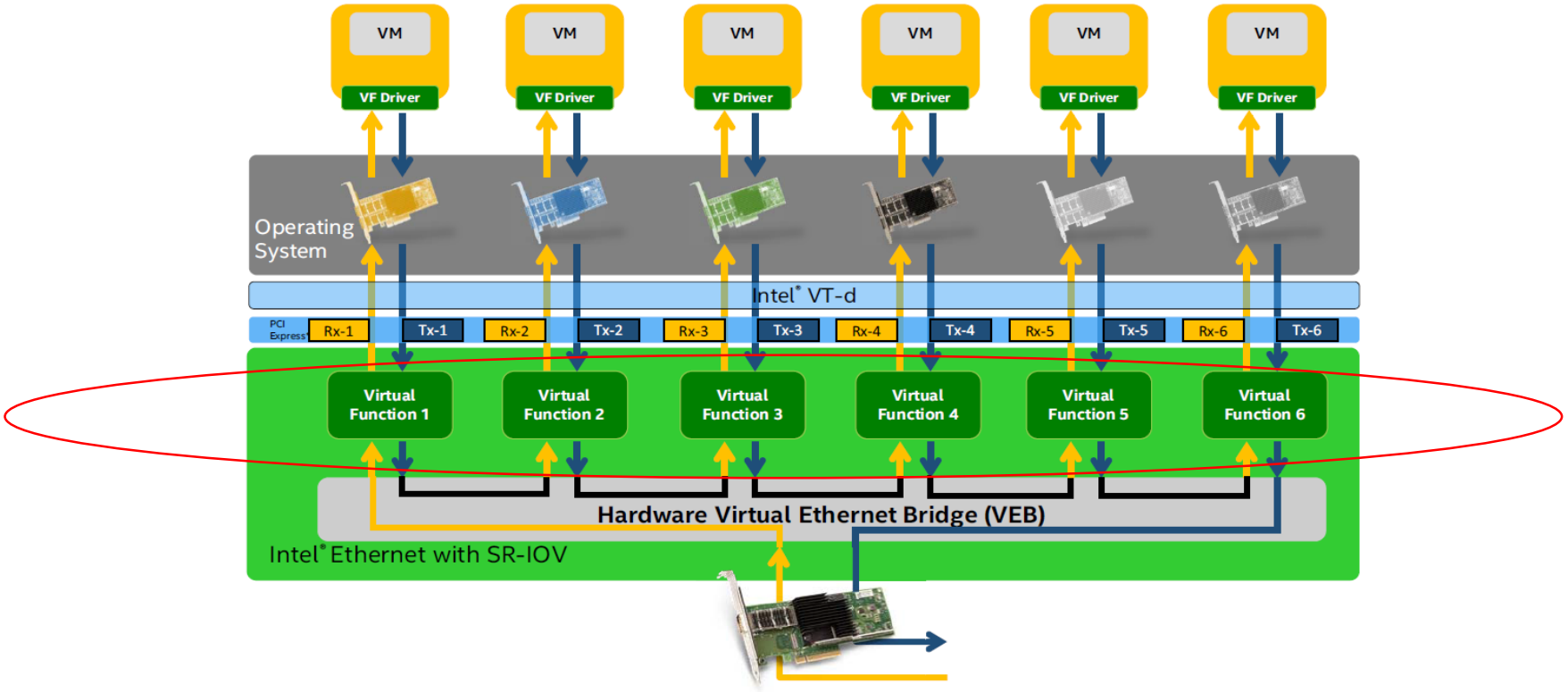


North/South



East/West

SR-IOV Service Chain Choke Point.



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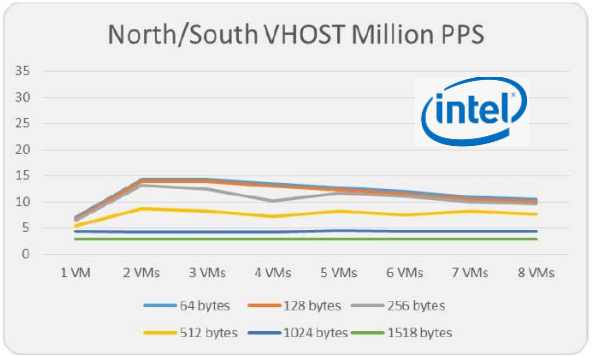
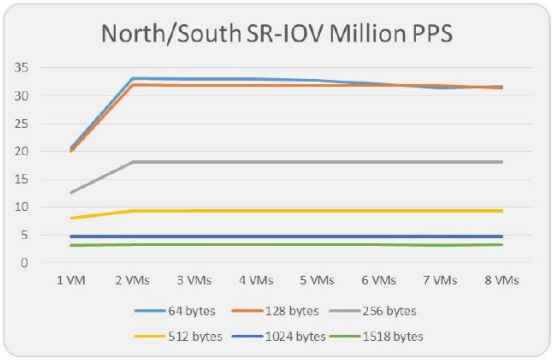
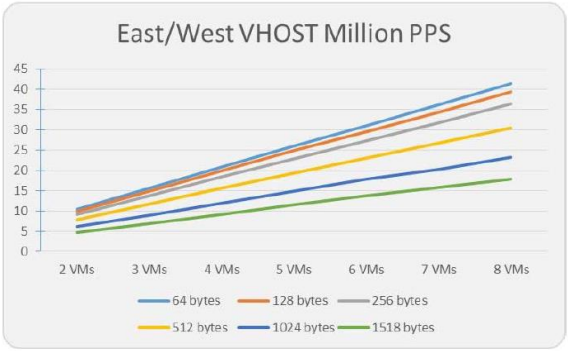
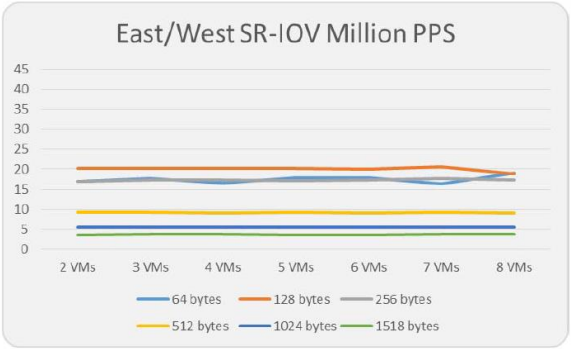
North, South, East and West

- SR-IOV vastly outperforms DPDK in North/South.
- As VMs are scaled up, SR-IOV throughput increased proportionally where as DPDK throughput began to drop-off as overhead load increased.
- DPDK-vHOST outperformed SR-IOV in East/West.
- As VMs are scaled up the same packet must transit the same PCIe interface multiple times.









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SR-IOV+DPDK vHost Approach.

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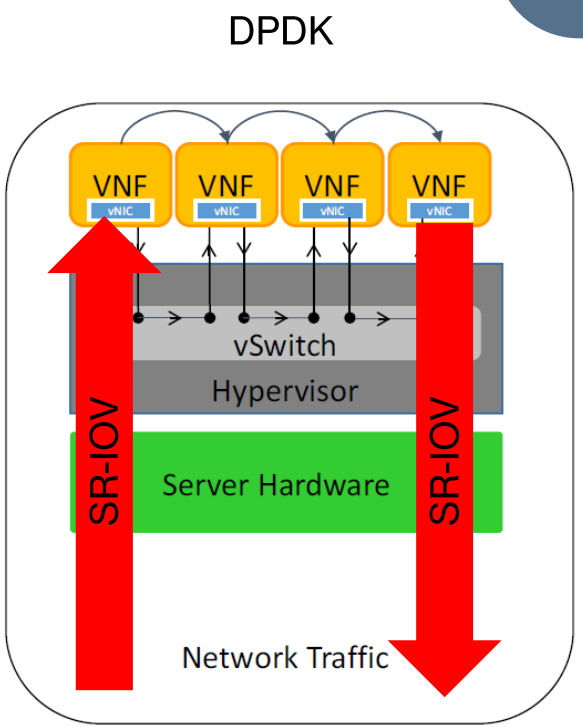
- Physical WAN / LAN connections are facilitated by SR-IOV.
- Intra-VNF connectivity is facilitated by DPDK.
- Does not require DPDK capable NICs.
- Opens opportunity for 3rd party smart SFP's (TDM, SA, Testing, etc).
- Leverages dataplane technology where it performs best.



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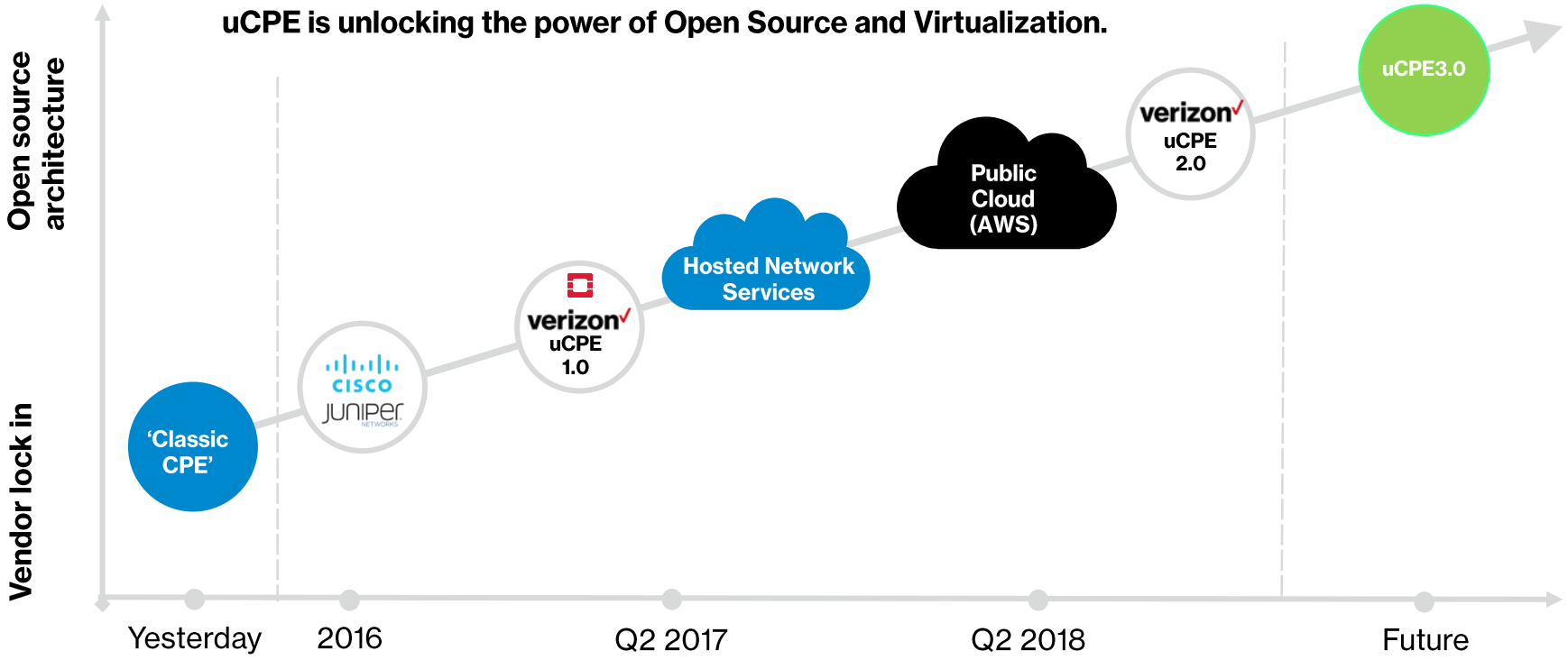
2.0

Universal CPE Evolution.



Orchestration and Onboarding

Apps	• Software Defined WAN • Virtual Network Services	**SD WAN**	**Security**	**WAN Optimization**	**Unified Communications**
Orchestration	• Automate deployment • Centralize change * • Closed loop assurance * • Policy management *	**Provision**	**Manage**	**Assure**	**Policies**
Onboarding	• Verizon Marketplace • E2E UAT Openstack ready	**Internal**	**Our partners**		**Streamlined NFVO certification**

CapEx Savings	**OpEx Savings**	**Agility**

* Availability planned for 2H 2018

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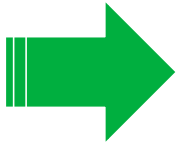
The Edge and Openstack in Production ...

6

1,000s

VMs deployed on the edge



Time to SCALE
10,000+ by year end 2019

The Edge and Openstack in Production ...

6

1,000s

VMs deployed on uCPE

Time to SCALE
10,000+ by year end 2019

30+

Certified Service chains

paloalto NETWORKS
JUNIPER
Lanner
riverbed
VERSA NETWORKS
ADVA
Check Point SOFTWARE TECHNOLOGIES LTD.
FORTINET
CISCO
ribbon communications

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Making it Better : 2.0

6

In Verizon's continuing quest to expand the capabilities of our Virtual Network Services (VNS) portfolio, we will be introducing additional universal CPE (uCPE) options on which to deliver our virtualized applications.

Extreme Automation	Higher Throughput	Faster Performance	Enhanced Cx	Platform Enhancements
Zero Touch Provisioning Automated upgrades MACD	The edge at the centre Demand for 10G	Complex service chains ⬇ Hardware and Software	In service scaling Pre staging	Demand for more - Ports - Disk - Tenant space

uCPE 2.0 hardware equipment will offer improved performance and choice.

6

Parameter	uCPE 1.0	uCPE 2.0
Performance/CPU More processing power to support feature demand	• Intel Atom low end devices • High end Intel Xeon-D	• Intel Atom C3000 (formerly Denverton) for low end devices • High end migrating to Intel Skylake D
Hardware/ports Voice of the customer asking for more ports to support complex design	• 4 ports on low end • 6-8 ports on high end	• Low end units moving to 8 port configuration • High end units will offer up to 12 ports
Hardware/throughput Support demand for higher throughput	• Mixed support for acceleration across the 1.0 units	• Support of DPDK + SRIOV packet acceleration techniques across all devices and all ports
Hardware/memory Support for WAN Optimization services requiring additional redundant disk	• Some low end units today use HDD • 3TB limit on high end	• M.2 SSD, higher performing RAM • High end increase to 8TB redundant disk
Availability and distribution Increase footprint	• Standard availability in North America, EMEA and APAC markets	• Expansion into Emerging markets
Functionality/Wifi/Bluetooth	• Basic WiFi and no Bluetooth support	• Equip with enhanced WiFi chips offering dual frequency support + Bluetooth.

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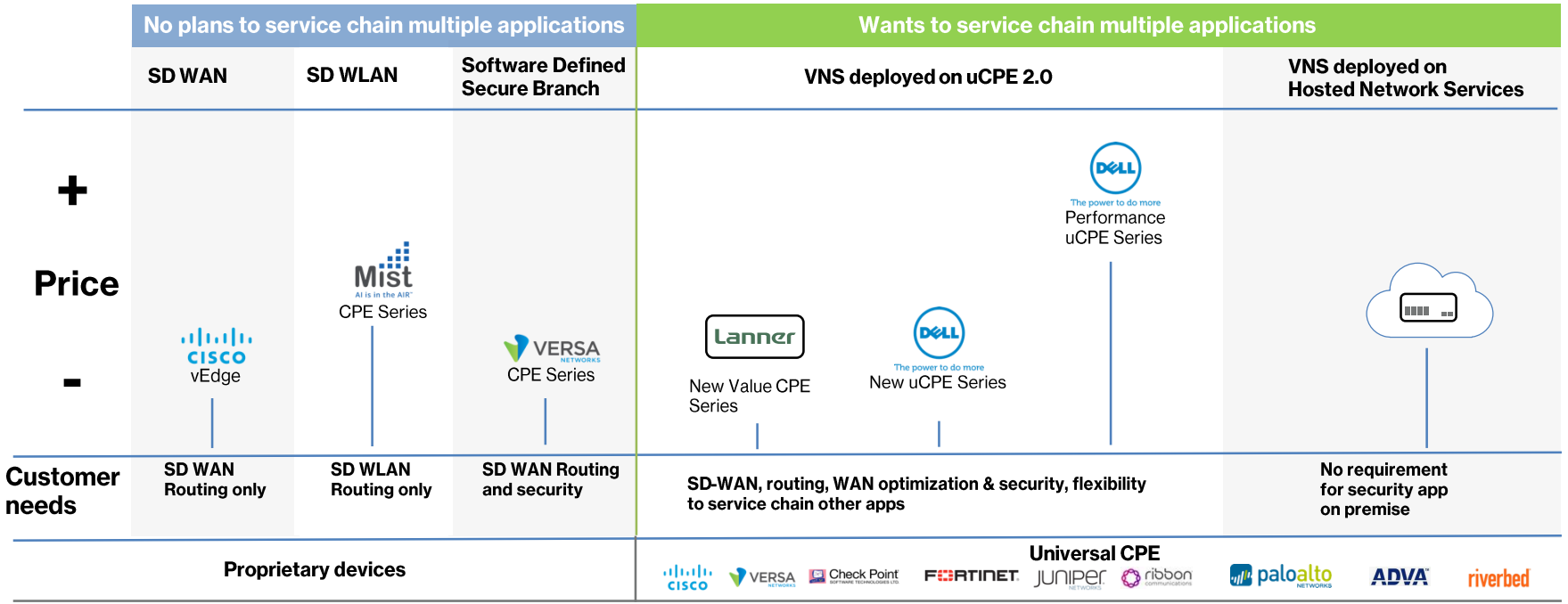
VNS & SD WAN platform options.



Questions?

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