You make **possible**

Cisco Enterprise NFV Deep Dive and Hands-On Lab

TECCRS-3006

Will Allison – Solutions Architect
Ramesh Kalimuthu – Technical Marketing
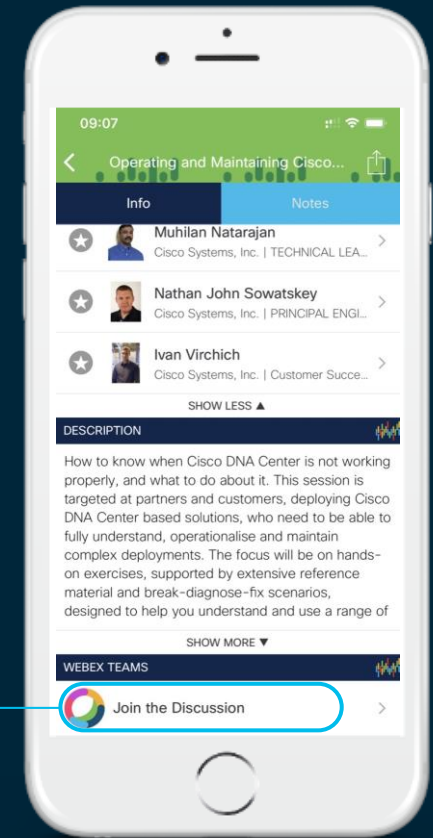Ryan Shoemaker – Solutions Architect

Software Defined Branch

Cisco Webex Teams

Questions?
Use Cisco Webex Teams to chat
with the speaker after the session

How

1. Find this session in the Cisco Events Mobile App
2. Click "Join the Discussion"
3. Install Webex Teams or go directly to the team space
4. Enter messages/questions in the team space

Keynote — 09:30

BRKCRS-1579
SD-WAN Powered by Meraki — 11:00

BRKRST-2041
WAN Architecture and Design Principal — 11:00

BRKCRS-2110
Delivering Cisco Next gen SD-WAN with Viptela — 14:00

BRKCRS-2113
Cloud Ready WAN for IAAS and SAASA with Cisco SD-WAN — 17:00

BRKRST-2377
SD-WAN Security — 08:00

BRKRST-2095
SD-WAN Routing Migration — 16:00

BRKRST-3404
How to choose the correct branch device — 16:00

BRKRST-2791
Building and using Policies with Cisco SD-WAN — 08:00

BRKRST-2560
SD-Wan Machine Analytics, Machine Learnings and IA — 08:00

BRKRST-2096
SD-Wan Proof Of Concept — 11:00

BRKRST-2093
Deploy, monitor and troubleshoot — 11:00

BRKARC-2012
ENFV Architecture, Configuration and troubleshooting — 11:00

BRKRST-2559
3 Steps to design SD-WAN On Prem — 14:00

BRKRST-2097
Conquer the Cloud with SD-WAN — 14:45

BRKRST-2095
SD-WAN Routing Migrations — 16:45

Keynote — 17:00

Cisco Live Celebration — 18:30

GURU

BRKRST-2091
SD-WAN Datacenter and Branch Integration Design — 09:00

BRKOPS-2826
SD-WAN as Managed Services — 11:00

SD-WAN

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Breakouts

Agenda

- Intro to SD Branch
- Platforms (ENCS, CSP5K, UCS E-Series)
- VN Functions – Network Services
- NFVIS – Virtualization Layer
- Lab Modules 1 & 2
- VNF Packaging
- Deploying VNFs with the GUI
- Lab Modules 3 & 4
- Monitoring and Troubleshooting a Virtual Environment
- Lab Module 5
- Leveraging APIs to Deploy VNFs
- Lab Module 6
- Network PnP
- Orchestration – Cisco DNA Center
- Lab Modules 7 & 8
- Orchestration – NSO and vManage
- Conclusion and Use Cases

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Who We Are

Will Allison

- Technical Solutions Specialist
- Joined Cisco 2013
- Based in San Jose, California
- Was part of dCloud solution team working on eNFV Solution since solution introduction
- Now part of innovations team focused on Cisco DNA Center and ISE

Ramesh Kalimuthu

- Technical Marketing Engineer
- CCIE #3881
- Joined Cisco 1998
- Based in San Jose, California
- Part of Business Entity responsible for direction of eNFV solution

Ryan Shoemaker

- Technical Solutions Architect
- CCIE #7405
- Joined Cisco 2000
- Based in Chicago, Illinois
- Part of EN Sales organization focused on LAN & WAN solutions

The branch and WAN cannot keep up...

Poor user experience
- Delays enabling new connectivity
- Inconsistent application performance

Complex to operate
- Difficult to manage multiple network devices
- Increasing bandwidth demands

Difficult to secure
- Support non-traditional devices
- Can't use the internet for SaaS

Why Virtualize? Motivations for the Enterprise

CAPEX

- Deploy on standard x86 servers

- Economies of scale

- Service Elasticity
  - deploy as needed Simpler architectural paradigm

- High availability

- Best-of-breed

OPEX

- Deployment Flexibility

- Reduction of number of network elements

- Reduction of on-site visits
  - Deployment of standard on-premise hardware
  - Simplification of physical network architecture

- Leveraging Virtualization benefits
  - Hardware oversubscription, Fault Tolerance

- Increased potential for automated network operations

- Re-alignment of organizational boundaries

What is Software Defined Branch ?

Services — "A single hardware platform that supports SD-WAN, routing, integrated security and LAN/Wi-Fi functions that can all be managed centrally."[1]

Simplicity — "(It) is a way of extending software-defined principles to a branch location. It is characterized by a simple hardware ecosystem, remote centralized management, and automation through programmability."[2]

Speed — "Consolidate hardware network functions into a single software platform that can deploy business-critical services in minutes."[3]

[1]NetworkWorld   [2]SDXCentral   [3]Cisco

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Benefits of Cisco Software Defined Branch
Simplified Management

Simplify day to day operations

Quickly roll out new services and locations

Consistent network policies through the entire enterprise network to the cloud

Use vManage, Cisco DNA Center, MSX/NSO to manage your Branch

Cisco Software Defined Branch - Summary

SD-Branch is an architectural choice

Controller lead, modular architecture that allows for use of best-of-breed network function service chain in Enterprise Branch.

Turn-key automation of Enterprise service-chains

Cisco SD-WAN controllers are used for automation, management and orchestration, though Cisco SD-WAN is **not** a requirement

Can be used to address a number of use-cases

- SD-WAN migrations
- Security / Compliance
- Hardware consolidation and Branch Virtualization
- Local file, Print and DDI (DHCP, DNS, IPAM) services

Built on Enterprise Network Compute System (ENCS 5000)
Cloud Services Platform (CSP5000), UCSE (in ISR4K) with NFVIS
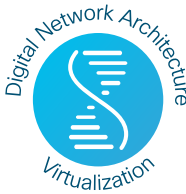
What is Software Defined Branch Architecture?
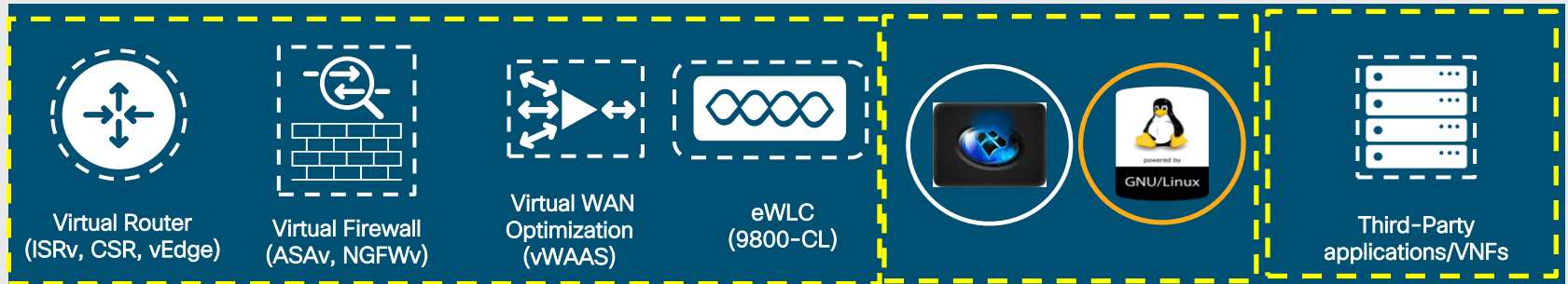## Solution Oriented Approach

Centralized Orchestration and Management
SDN Applications

Consistent, trusted network services across all the platforms
Network Services and Applications

Hardware and software independence
Virtualization Layer

Freedom of choice
Hardware platform
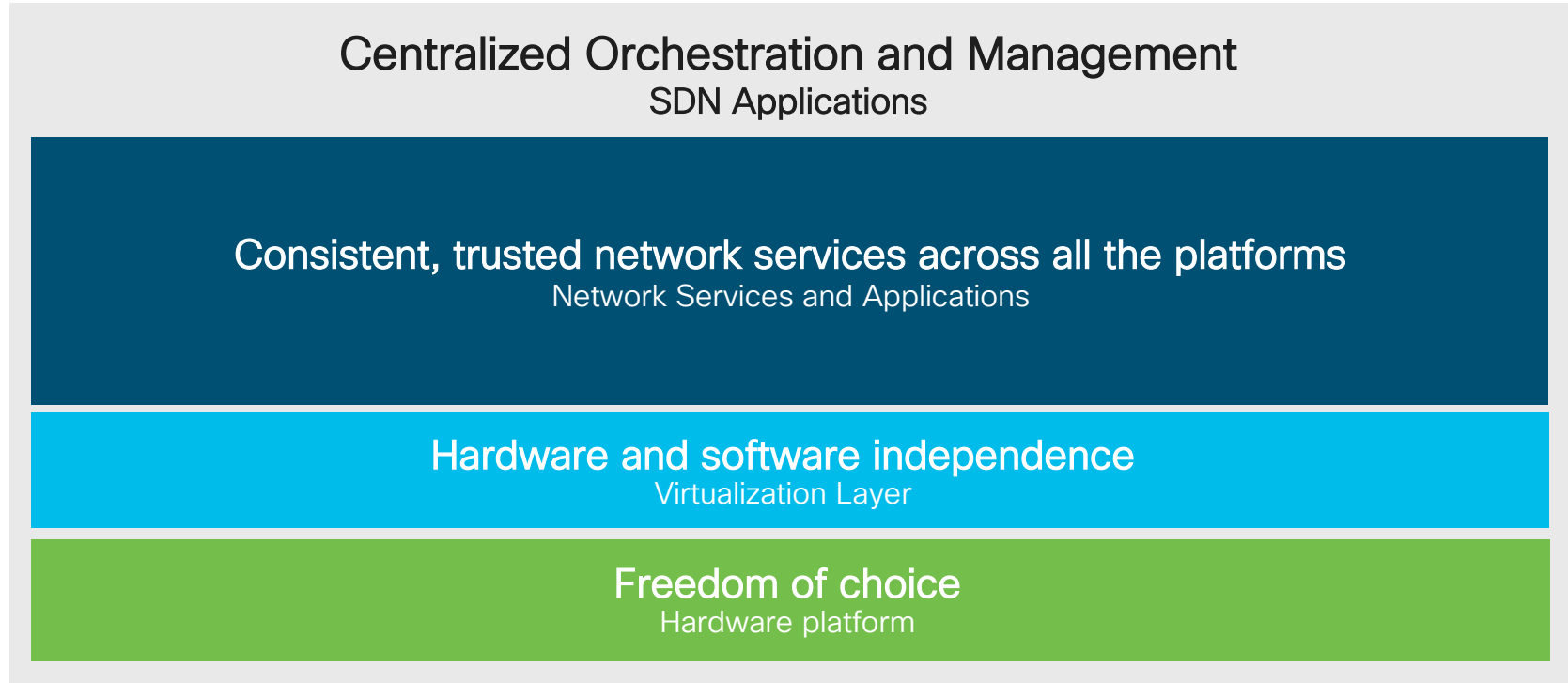
Software Defined Branch
Deploy Services on Any Platform

Digital Network Architecture — Virtualization

vManage / Cisco DNA Center / Network Service Orchestrator/ MSX

Virtual Router
(ISRv, CSR, vEdge)

Virtual Firewall
(ASAv, NGFWv)

Virtual WAN
Optimization
(vWAAS)

eWLC
(9800-CL)

GNU/Linux

Third-Party
applications/VNFs

Network Functions Virtualization Infrastructure Software (NFVIS)

Cisco 4000 Series ISR +
UCS® E-Series

Enterprise Network
Compute System
(ENCS)

CSP-5000
UCS-M5 C-Series

Select
3rd Party Hardware

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SD Branch Components

Hardware

Enterprise Network Compute System

Platform Built for Enterprise NFV
ENCS 5000 Series for the Branch
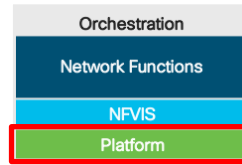
Best of Routing
& Compute

Complete
Virtualized Services

Open for Third Party
Services and Apps

Enterprise Network Compute System

ENCS 5100 Series
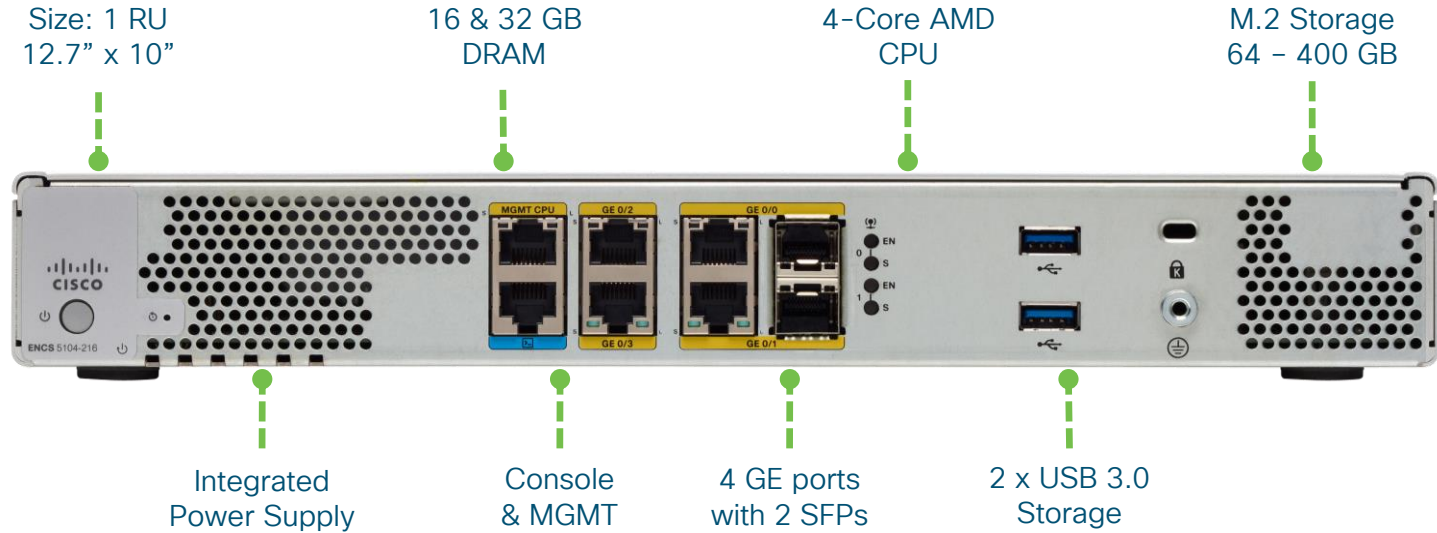
ENCS 5400 Series

ENCS 5000 Series – Chassis Options

ENCS 5104
4-Core

ENCS 5406
6-Core

ENCS 5408
8-Core
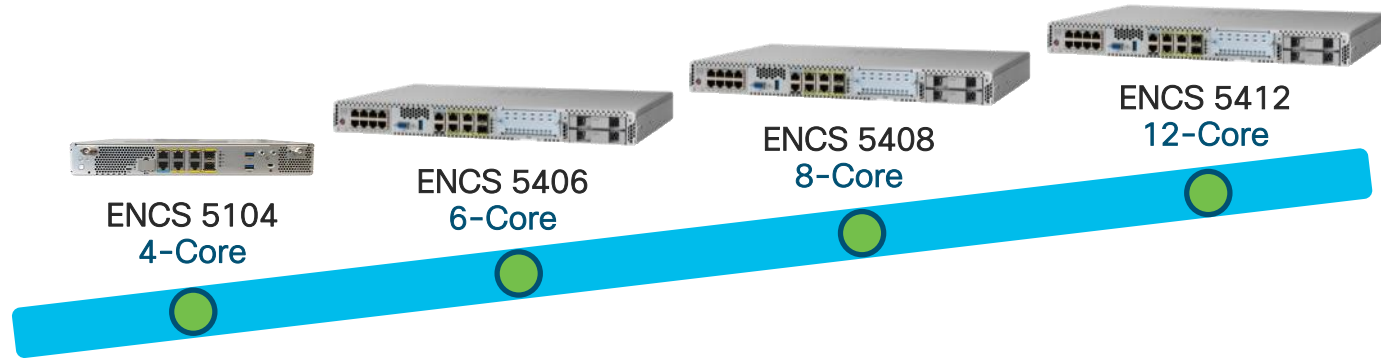
ENCS 5412
12-Core

	ENCS 5104	ENCS 5406	ENCS 5408	ENCS 5412
CPU	4-core, 3.4 GHz	6-core, 1.9GHz	8-core, 2.0GHz	12-core, 1.5GHz
LAN PoE	No	No	200W	200W
Capacity Guidance	ISRv + 1 VNF	ISRv + 2 VNFs	ISRv + 3 VNFs	ISRv + 5 VNFs

ENCS 5400 Series – I/O Side

Integrated Power Supply

16 - 64 GB DRAM

6, 8, or 12-Core Intel Xeon-D

Dedicated Lights-out Management (CIMC)

(Optional) Hardware RAID Controller

Internal M.2 Storage 64 – 400 GB

8 Integrated LAN Ports with Optional POE

USB 3.0 Storage

Network Interface Module for LTE & WAN

2 HDD or SSD RAID 0 & 1

Hardware Acceleration for VM Traffic

2 Onboard Gigabit Ethernet ports with SFP

ENCS 5100 Series - I/O Side

Size: 1 RU
12.7" x 10"

16 & 32 GB
DRAM

4-Core AMD
CPU

M.2 Storage
64 – 400 GB

Integrated
Power Supply

Console
& MGMT

4 GE ports
with 2 SFPs

2 x USB 3.0
Storage

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ENCS 5100 & 5400 Series Comparison

	5100 Series	5400 Series
CPU Vendor / Model	AMD Merlin Falcon, RX-421ND	Intel Xeon Broadwell D-1500 Series
CPU Cores / Frequency	4-core @ 3.4 GHz	6, 8, 12-core with Hyper-threading @ 1.5 – 2.0 GHz
CPU L2 Cache Size	2 MB	1.5 MB per core
Memory	16 – 32 GB	16 – 64 GB
Storage (M.2 SATA)	64 – 400 GB	64 – 400 GB
Storage (SFF)	–	2 disks with RAID (SATA, SAS, SED, SSD)
Dimensions	12.7" x 10" x 1RU	17.5" x 12" x 1RU
WAN Options	4 x GE	2 x GE, Cellular, T1, DSL, Serial
LAN	–	8 port Switch with Optional PoE
Hardware Offload	–	VM – VM Traffic, Crypto
Lights-out Management	–	Built-in CIMC
ISRv Performance	500 Mbps	2.5 Gbps

ENCS 5400 Series – Built-in Switch

- 8-port Gigabit Ethernet Layer 2 Switch

- Optional Universal PoE (Power over Ethernet)
  - 60W per port. Total = 200W
  - ENCS 5408 and ENCS 5412 only

- Managed through NFVIS – API, CLI & GUI

- Monitoring through Device GUI
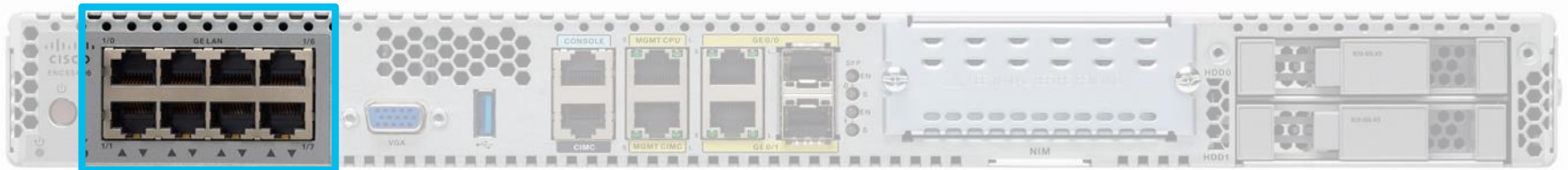
ENCS 5400 Power Supply

- Single Integrated Power Supply Unit
  - 250W for regular PSU
  - 500W for POE PSU (ENCS5408 & ENCS5412 only)

- Universal POE on built-in LAN ports (Up to 60W)
  - Total limit of 200W

- Field-replaceable unit

ENCS 5400 NIM Support

Category	Description	Minimum NVFIS Version
WAN 4G LTE (CAT3)	USA, Canada, Europe, Australia & selected LATAM / APAC	3.6.1
WAN 4G LTE (CAT6)	USA, Canada, Europe, Australia & selected LATAM / APAC	3.6.1
WAN T1/E1	1, 2, 4 & 8 ports	3.6.1
Voice T1/E1	1, 2, 4 & 8 ports	3.9.1
Async NIM	16 and 24 ports	3.8.1
WAN xDSL	Multi-mode VDSL2 / ADSL Annex A, B & M	3.9.1
WAN Ethernet	Dual-PHY: 1 & 2 ports	3.9.1

https://www.cisco.com/c/en/us/td/docs/routers/nfvis/install/encs-hig/CSX-HIG_chapter_01.html

ENCS 5400 CPU Allocation Planning
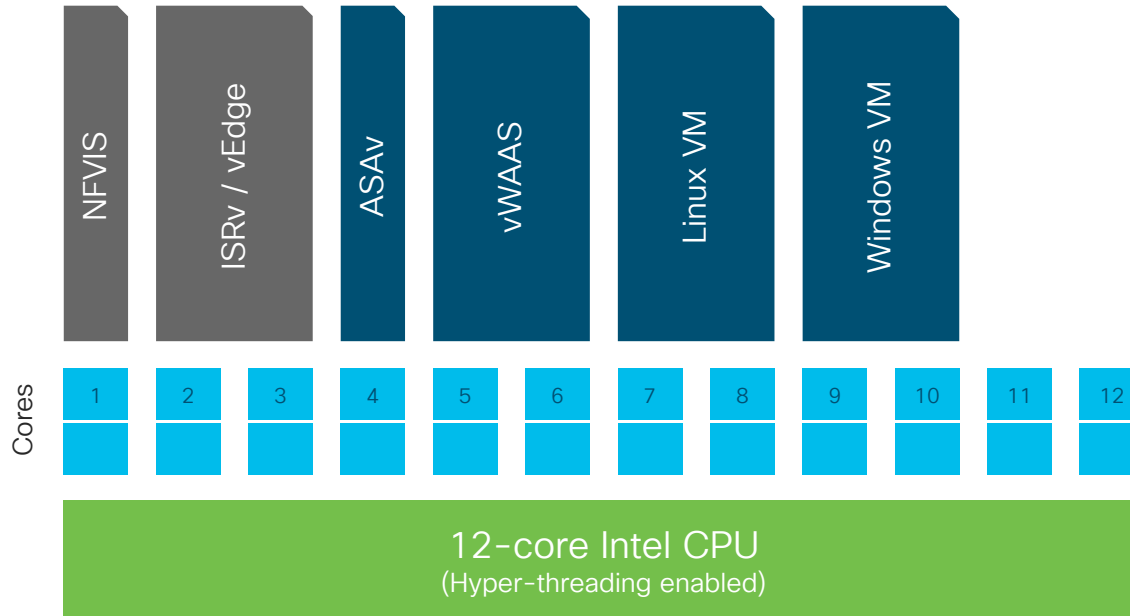
- 1 core = 1 vCPU = 1 physical core

- 1-core allocation for NFVIS to cover OS, Hypervisor & vSwitch functions

- 2-core minimum allocation for ISRv or vEdge

- Multiple VNF profiles target specific performance

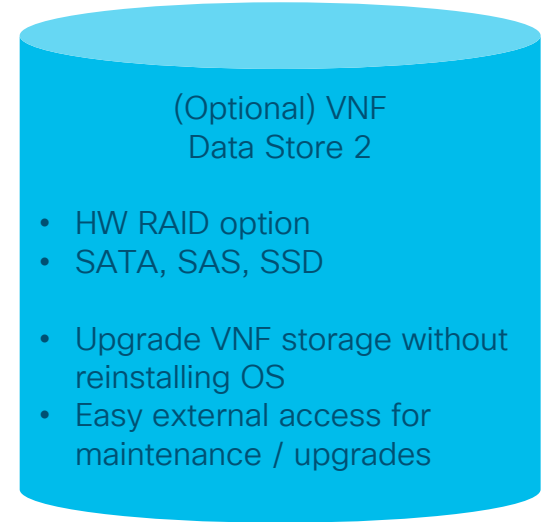- Cisco VNFs will be pinned to respective cores for performance.

ENCS 5100 CPU Allocation Planning
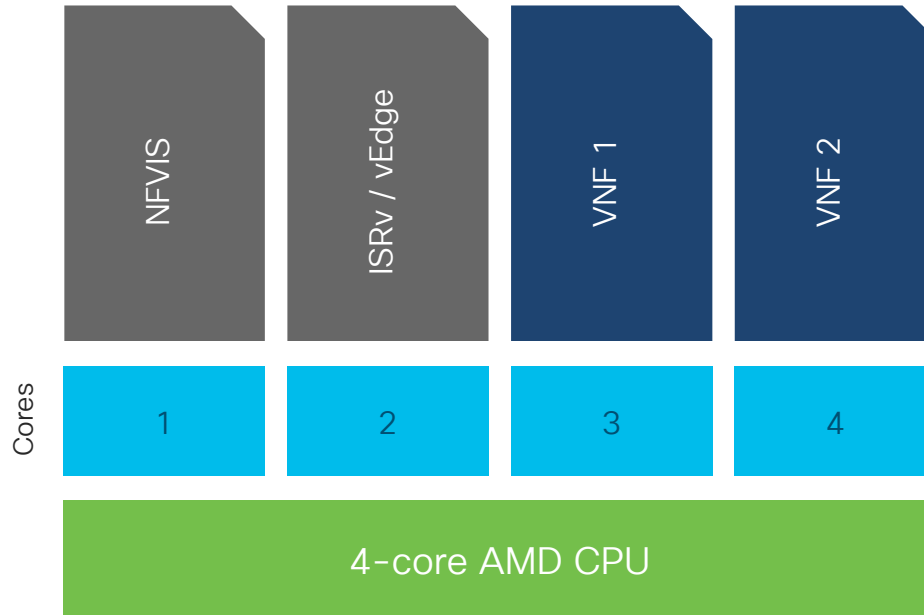
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- 1-core minimum allocation for ISRv or vEdge

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ENCS 5000 Storage Summary

USB Slot(s)

(Optional)

- Can be used as boot disk
- Copy files to other stores
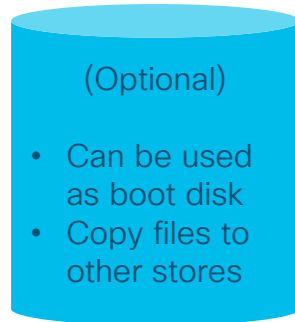
Motherboard M.2 SATA Slot

NFVIS Primary Install Partition ~20 GB

VNF Data Store1
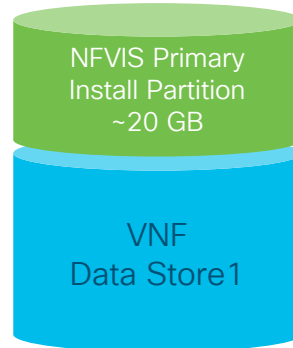
2 External Drive Bays (ENCS 5400 only)

(Optional) VNF Data Store 2

- HW RAID option
- SATA, SAS, SSD

- Upgrade VNF storage without reinstalling OS
- Easy external access for maintenance / upgrades

VNF Connections on Hypervisors

There are multiple ways a VNF can connect to a physical NIC of the underlying server/hardware

- Virtual switch – introduced by the hypervisor

- SR-IOV – by connecting the VNF directly to the physical NIC

- PCI Passthrough* – dedicating the entire NIC to the VNF directly

- DPDK – (Data Plane Development Kit) set of libraries to accelerate packet processing workloads by offloading to a CPU

*Not supported on NFVIS, intent is for multiple services to leverage I/O options

ENCS 5400 Internal Networking
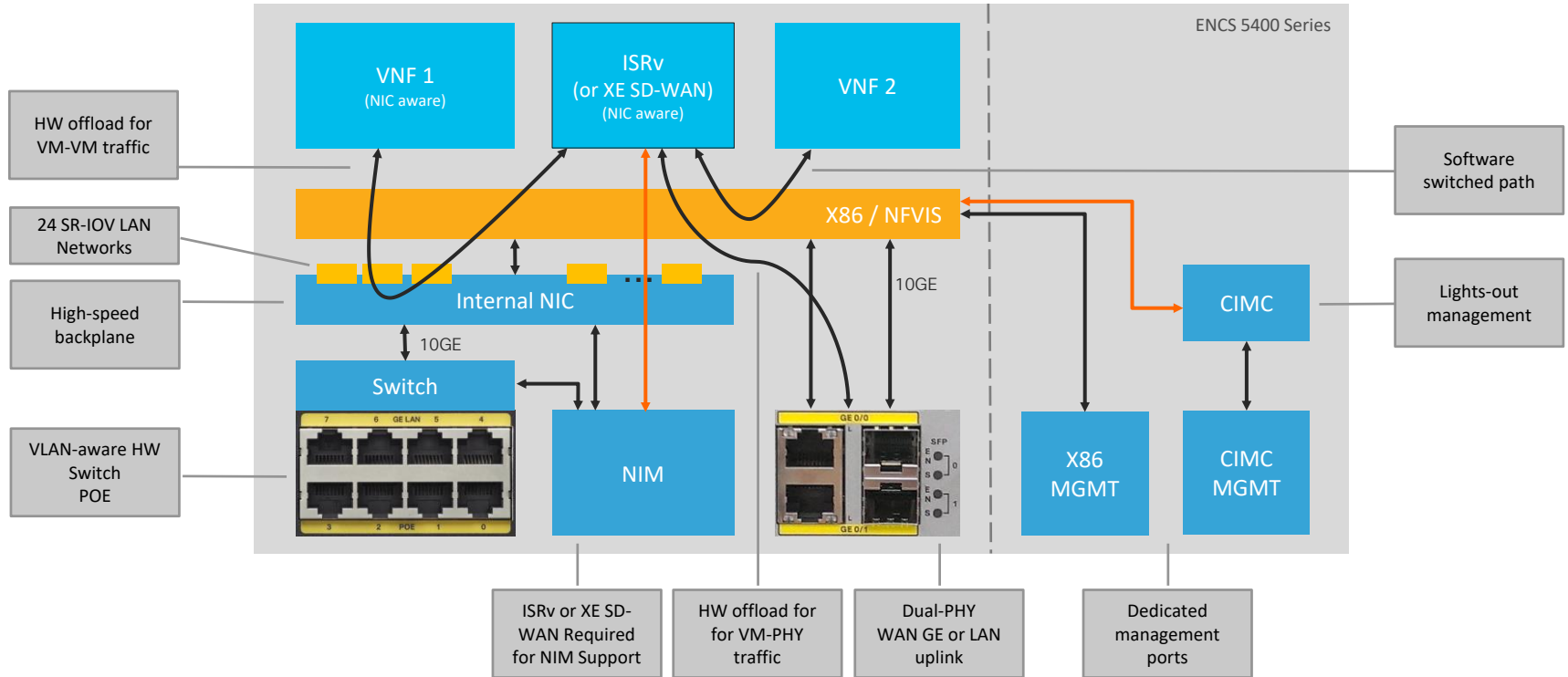
NFVIS Compare Networking Options

	SR-IOV	DPDK-OVS	OVS
	Performance		Flexibility
Service Chain Throughput	Service Chain throughput better than DPDK/OVS	Service Chain throughput near SR-IOV, better than non–DPDK OVS	Service chain throughput lower than DPDK and SR-IOV
NFVIS Default Cores + Additional CPU	1 core < 16core system 2 cores >= 16 core system	1+1 CPU <=16 core system 2+2 >16 core system 1+1GB mem in <=32GB system 1+2GB mem in > 32GB system	1 core < 16core system 2 cores >= 16 core system
Driver requirements in VNF	SR-IOV	NO Virtio required	NO Virtio required
Supported capability in platforms ***	ENCS54xx igb, igbvf, i40evf UCSEM3 front_10G ixgbvf UCS5K, CSP5K i40evf, ixgbvf	Yes 3.10.1 onwards Yes 3.12.1 onwards Yes 3.12.1 onwards	Supported

***Default LAN-VF increase from 6-to-16 in NFVIS 3.12.1 onwards
***Dynamic VF addition in CSP5K, UCSM5 in NFVIS 3.12.1 onwards

ENCS NFVIS Compare Networking Options

SR-IOV Packet Flow

Service Chain throughput better than DPDK/OVS
NO additional CPU required for NFVIS
SR-IOV driver support dependency on VNF

VM

vNIC

QEMU

pak memory are directly map to VM, there is no extra copying

OVS

NFVIS Linux Kernel

Physical NIC

VF   VF

PF

GE0/0

DPDK-OVS Packet Flow

Service Chain throughput near SR-IOV, better than non-DPDK OVS
+1 CPU required for NFVIS
NO additional driver dependency on VNF

Other VM   ISRV VM

DPDK-OVS In user space

Shared Memory to pass pak between VMs, no pak copying

Pulling pak from interface, no interrupt, no context switching between user mode and kernel mode, no extra pak coping

NFVIS Linux Kernel

GE0/0 NIC

OVS Packet Flow

Service chain throughput Slower than DPDK and SR-IOV
NO additional CPU allocated for NFVIS
NO additional driver dependency on VNF

VM

Virtio Front-End

QEMU

Shared Memory

NFVIS Linux Kernel

vHost-net Kernel Thread

OVS

TAP Driver

IGB Kernel Driver

GE0/0 NIC
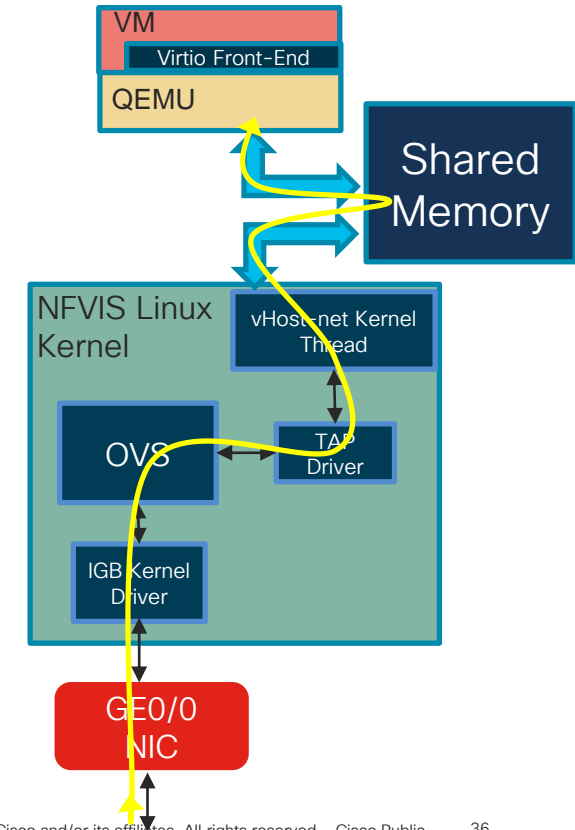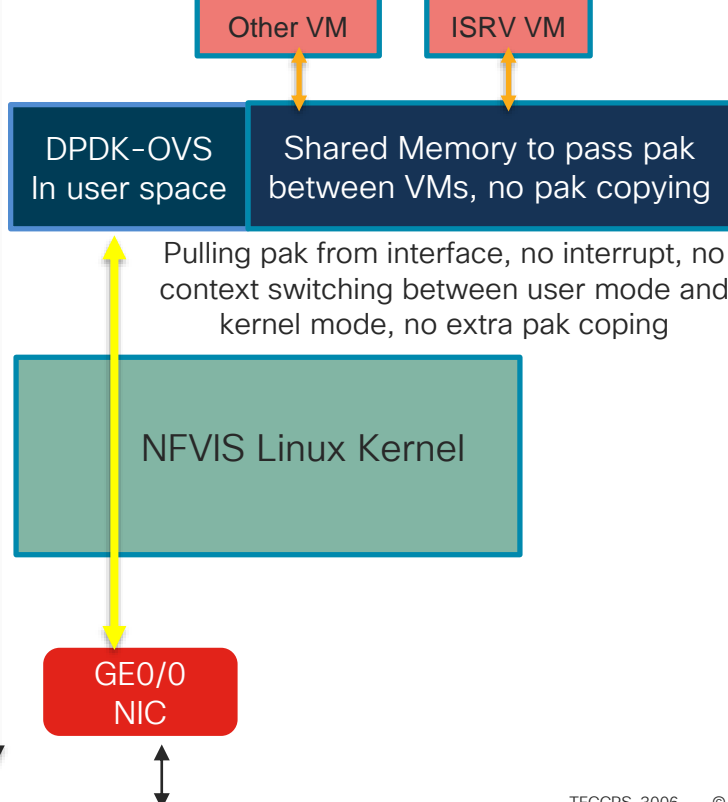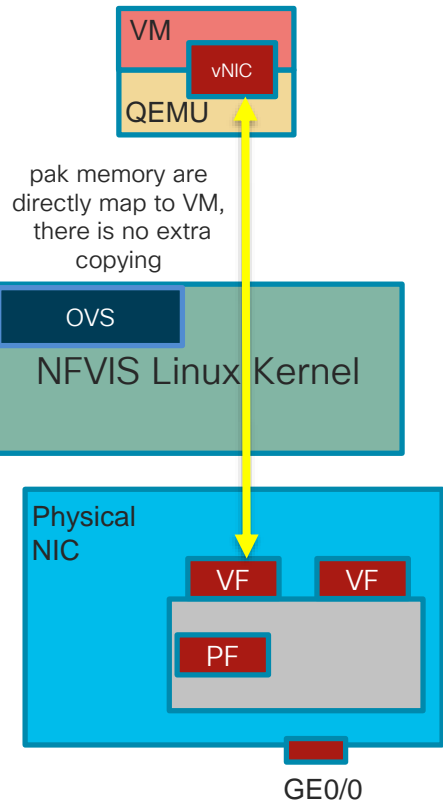
Performance Dependencies

Individual performance of a VNF depends on

- The underlying platform, the number of cores and the type and speed of the processor used
- The resources available for the VNF
- How the VM connects to the physical NICS – SR-IOV, DPDK, or OVS
- Finally The VNF itself. VNF must also be optimized to run in a virtual environment

- In case of a Multi-VNF environment, the net chained VNF performance also depends on
  - The weakest-link VNF
  - Use of virtual switches to copy packets from ingress to egress vNICs

Cloud Services Platform 5K

CSP 5216/5228

Front View

8 SSD or HDD Slots[1]

2 PCIe Slots:2x10G X520 or 4x10G X710

Rear View

[1] RAID10 used disks in multiple of 4, only 8 used out of 10 slots
RAID 10 reduces the available storage by half

2x10G Ethernet

CIMC / OOB LOM

CSP 5436/5444/5456

Front View

24 SSD or HDD Slots

6 PlCe slots: 2x10G X520 or 4x10G X710

Rear View

2x**10**G Ethernet

CIMC / OOB LOM

CSP 5000 SKUs:

	CSP 5216	CSP 5228	CSP 5436	CSP 5444	CSP 5456
Rack	1RU		2RU		
CPU Cores	16	28	36	44	56
Mem(16GB/32GB) (12x2 DIMM Slot)			(128GB Minimum) 384GB-768 GB Total Capacity		
PCIe NIC Slots	2		6		
On Board NICs (LOM)			2x10 GbE SFP+		
VIC			4x10/25 GbE SFP28		
1GbE (i350)			Y (Optional Add-in) 4x1GbE RJ45		
i520(2x10GbE SFP+)			Y		
I710(4x10GbE SFP+)			Y		
Max NIC ports	14 (2x4+4+2)		30(6x4+4+2)		
Min-Max BW	164GbE -200 GbE		324GbE-360GbE		
Disk slot(small form)	10 (useable 8)		24		
Disk Capacity	1.2*8/2=4.8TB(HDD)/3.8TB(SSD)		14.4 T(HDD)/11.5TB(SSD)		
Power 2 slots (AC)	1540 W(2x770)		2100W (2x1050)		

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NFVIS on CSP5K

- Supported with release 3.11 and Higher

- CSP5K can be ordered with either CSP-OS or NFVIS
  - CSP-OS is used in Secure Agile Exchange solution and positioned for DC virtualization strategies
  - NFVIS is vBranch solution and is used in Cloud On-Ramp for CoLo

- Replaces older CSP2100 Series Models

- More details can be found here:
  Installing NFVIS on CSP

UCS E-Series

Cisco UCS E-Series

Scalability

Performance

Intel Ivy Bridge

Cisco UCS® E140S

- Single-Wide Service module
- NFVIS, VMware, Hyper-V, Citrix certified
- Intel E3 4 core processor
- 16GB DRAM

Intel Broadwell

Cisco UCS® E160S M3

- Single-Wide Service module
- NFVIS, VMware, Hyper-V, Citrix certified
- Intel Broadwell 6 core processor
- 32GB DRAM
- USB 3.0 & 10Gb Interface

Intel Ivy Bridge

Cisco® UCS E160D

- Double-Wide Service Module
- NFVIS, VMware, Hyper-V, Citrix certified
- Intel E5 6 core processor
- 96GB DRAM

Intel Broadwell

Cisco UCS E180D M3/ 1120D M3

- Double-Wide Service Module
- NFVIS, VMware, Hyper-V, Citrix certified
- Intel E5 8 core processor
- 96GB DRAM

Cisco UCS E-Series Single-Wide Blade

Compact Blade Housed in Cisco ISR 4000 Series ISR Chassis

- UCS E140S M2 and E160S M3

8, 12, 16 GB and 32 GB DRAM options

Maximum 65 W power draw 80 percent less than server

Intel® 4 Core Xeon® E3 family quad-core processor
6 Core Broadwell

Configuration and management through CIMC/IMC SUP or UCSD

Remote and schedulable power management

One external 10/100/1000 and two internal GE ports
10/100 Ethernet management port

Two SD cards: One for the CIMC and temporary storage of OS and one as a blank virtual drive
No SD card on M3. UCS Flex Flash

Up to 2 SATA, SAS, or SSD hard drives

KVM console connector

USB 2.0 or 3.0 port for external device connectivity

Wire-free, plug-and-play modularity, low shipping weight (2.5 lb/1.1 kg)

Onboard hardware RAID 0/1 with hot-swappable capability

Cisco UCS E-Series Double-Wide Blade

Server Blade Housed in ISR 4000
– UCS-E140D/UCS-E160D/UCS-E180D/UCS-E1120D
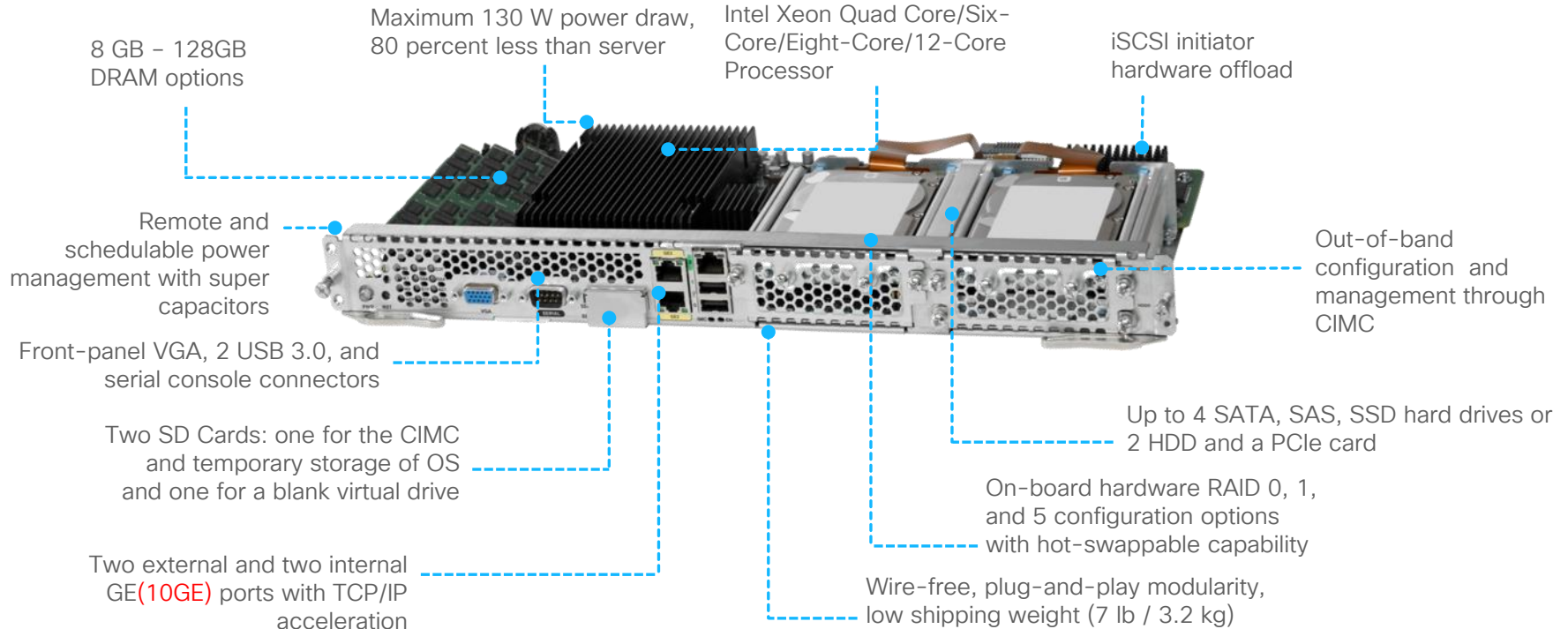
8 GB – 128GB DRAM options

Maximum 130 W power draw, 80 percent less than server

Intel Xeon Quad Core/Six-Core/Eight-Core/12-Core Processor

iSCSI initiator hardware offload

Remote and schedulable power management with super capacitors

Out-of-band configuration and management through CIMC

Front-panel VGA, 2 USB 3.0, and serial console connectors

Up to 4 SATA, SAS, SSD hard drives or 2 HDD and a PCIe card

Two SD Cards: one for the CIMC and temporary storage of OS and one for a blank virtual drive

On-board hardware RAID 0, 1, and 5 configuration options with hot-swappable capability

Two external and two internal GE(10GE) ports with TCP/IP acceleration

Wire-free, plug-and-play modularity, low shipping weight (7 lb / 3.2 kg)

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Virtual Network Functions

Network Services from Cisco
Consistent software across physical and virtual
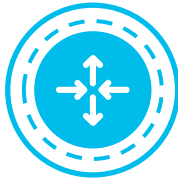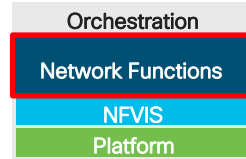
ISRv/SD-WAN

High Performance

Rich Features
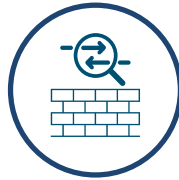
ASAv/FTD

Full DC-Class
Featured Functionality
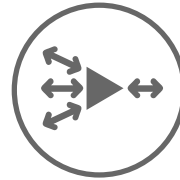
vWAAS

Application
Optimization and
Akamai Connect
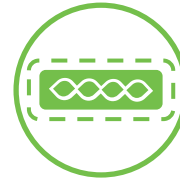
eWLC

Built for small and
medium branches

Windows Server

Active Directory, File
Share, Server
Applications

Linux

Custom Applications
DNS/DHCP

3rd Party

Network Services
Management &
Monitoring

Enterprise NFV Open Ecosystem

- Customers have flexibility to run third-party VNF of their choosing.

- Third-Party vendors may *choose* to submit their VNF for certification.

- No admission restrictions; third party may be complimentary to Cisco, or competitive. Requirements are the same regardless.

- Irrespective of certification, customers have flexibility to run third-party VNF of their choosing.

- More information: http://cs.co/3nfv

https://www.cisco.com/c/dam/en/us/solutions/collateral/enterprise-networks/enterprise-network-functions-virtualization-nfv/nfv-open-ecosystem-qualified-vnf-vendors.pdf

Third party VNF Certification Resources

Third-Party VNF Ecosystem Submission Process

Certification Program at DevNet, http://cs.co/3nfv

Vendor Status (Dec '19)

VNF Support Reference as of NFVIS 3.12.1*

VNF	Version
vEdge	18.4.1
ISRv	16.10.2 16.11.1b 16.12.1
cEdge	16.10.2
ASAv	9.12.1
vWAAS	6.4.3b-b-53
NGFWv	6.3.0-83
ThousandEyes	Agent 1.27.4
Fortinet	Fortigate 5.6.2
Palo Alto	PAN-OS 8.0.5
InfoVista	Ipanima v9.1.6.6
CTERA	6.0.4

*These images have been solution tested. Other images may function as well.

VNF Vendor – NFVIS InterOp Documentation

- Riverbed – Steelhead on ENCS
  https://support.riverbed.com/bin/support/static/f61qbecfce2t3gqfm3m28bdqi1/html/kbjj2jgpeosmda1rhfqcr7g6n1/sh_v_9.9_icg_html/index.html#page/sh_v_9.9_icg_html/sh_v_encs_install.html

- SilverPeak – EdgeConnect on ENCS
  https://www.silver-peak.com/documentation/silverpeak-edgeconnect-cisco-encs

- Palo Alto – VM Series Firewall on ENCS
  https://docs.paloaltonetworks.com/vm-series/8-1/vm-series-deployment/set-up-the-vm-series-firewall-on-cisco-encs.html

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- VN Functions – Network Services
- **NFVIS – Virtualization Layer**
- Lab Modules 1 & 2
- VNF Packaging
- Deploying VNFs with the GUI
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- Monitoring and Troubleshooting a Virtual Environment
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NFVIS

Purpose built Network Hypervisor
Enterprise NFV Infrastructure Software (NFVIS)
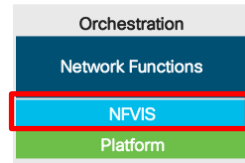
Network Hypervisor

- Supports segmentation of virtual networks
- **Abstract CPU, memory, and storage resources**

Zero-Touch Deployment

- **Automatic connection to PnP server**
- Highly secure connection to the orchestration system
- Easy day-0 provisioning

Security

- **Secure Chain of Trust**
- Secure overlay for management and monitoring
- VNF secure boot
- Role Based Access Control

Lifecycle Management

- **Provisioning and launch of VNFs**
- Stop and restart services
- Dynamically add and remove services
- Failure monitoring and and recovery
- VNF Backup Restore

Service Chaining

- **Elastic service insertion**
- PNIC tracking and VNIC update
- Multiple independent service paths based on applications or user profiles
- Host and VM Statistics, Packet Capture

Open API

- **Programmable API for service orchestration**
- Rest and NETCONF API
- Netconf Notification

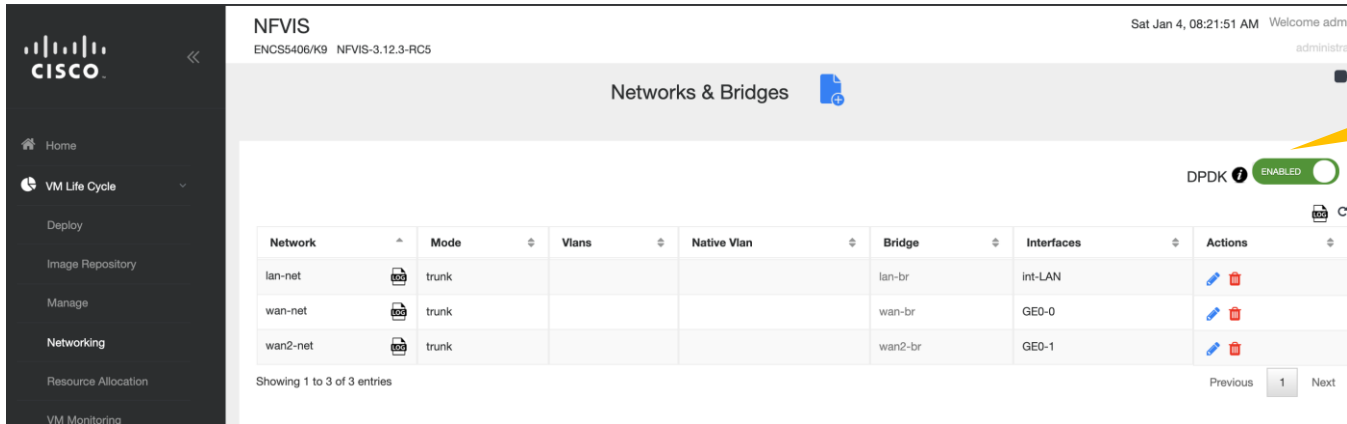# NFVIS Architecture
Not Just KVM, Power in software

PnP Server

vManage NSO

Console SSH

DNA Center

Portal

NFVIS

NETCONF | CLI | REST

Image Management	Plug-n-Play	vDaemon	Confd	Web Server/Portal	VM Life Cycle Manager	* Cluster Management
Storage Management	Resource Manager	Service Chaining	Health Monitor	Host Management	AAA	Statistics Collector
Hardware Management	libvirt	Open vSwitch	Qemu	Collectd	Syslogd	Snmpd

CentOS Linux 7.6 + KVM + Kernel Drivers

* Roadmap

Default System Configuration on ENCS
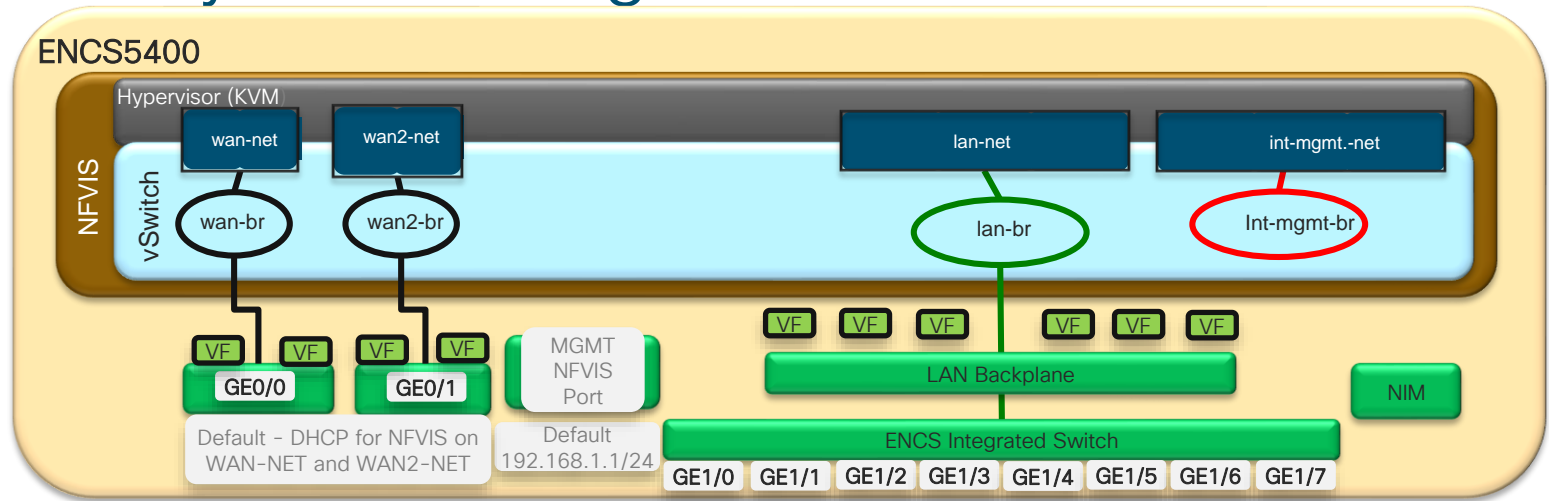
- NFVIS can be accessed by default via the FP GE WAN ports or via the dedicated Management port

- NFVIS 3.10+ Default association: GE0-0 to wan-br, GE0-1 to wan2-br. Both wan-br and wan2-br are enabled for DHCP by default. DHCP is attempted(cycle between GE0-0, GE0-1) until one of the ports acquire DHCP address. PnP will be attempted over the wan facing network with path to default gateway. Pre-NFVIS 3.10, no wan2-br created by default, no dhcp by default via GE0-1.

- The Management port on ENCS is set to to 192.168.1.1 to access NFVIS

- All Switch ports – GE 1/0 to GE1/7 is associated to LAN bridge

- An internal management network (int-mgmt-net) and a bridge (int-mgmt-br) is created and is internally used for system monitoring.

DPDK Improves Throughput of VNFs

- Enable DPDK if SR-IOV drivers not available on VNF
- DPDK is enabled globally on ENCS
- Cannot be disabled once enabled (requires reimaging or factory reset ENCS)
- Some monitoring tools (SPAN and Packet Capture) will no longer function with DPDK

DPDK Enabled Globally on Networking Page

Trustworthy Technologies for Enterprise Networking

Built-in security features that defend against today's threats

Image Signing

Creates a unique digital signature for a block of code. Signed images may be checked at runtime to verify that software has not been modified.

Hardware Anchored Secure Boot

Helps ensure that code is authentic and unmodified. Anchors the microloader in immutable hardware, **to** prevent Cisco devices from executing tainted software.

Trust Anchor Module (TAm)

A tamper-resistant chip featuring nonvolatile secure storage, SUDI, and crypto services including RNG, key store, and crypto engine.

Hardware Authenticity Check

Uses a X.509 SUDI certificate to verify hardware authenticity. Runs only after the secure boot process has completed and software has been verified to be trusted.

HW Assisted Virtualization

Process and Memory segmentation for data isolation and protection with better performance.

Cisco ENCS 5000 Series

SUDI for Cisco Plug & Play

The Secure Unique Identifier (SUDI) is an X.509 certificate that provides factory-installed device identity. Enables secure remote on-boarding of devices.

SE Linux

Fine-grained system level access control to better protect against privilege escalation attacks

Modern Cryptography

Provides secure, up-to-date encryption so that encrypted data communications in-transit and at-rest remains confidential.
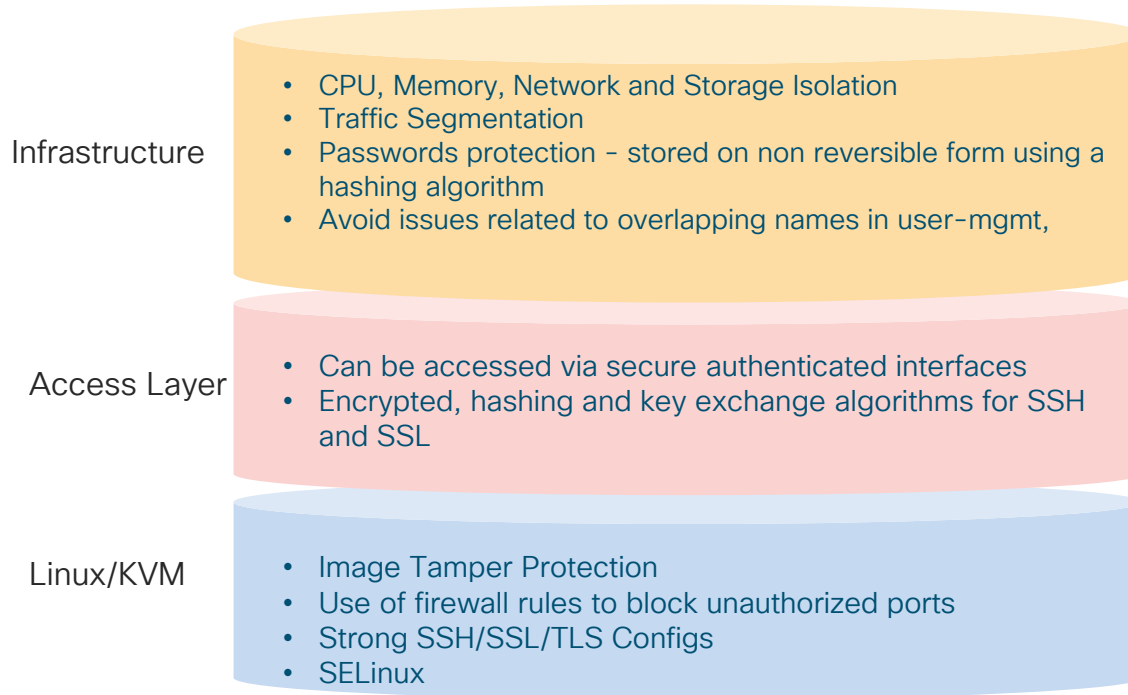
Factory Reset

One command to reset the device to factory-original settings to protect sensitive data when the device is out of direct control.
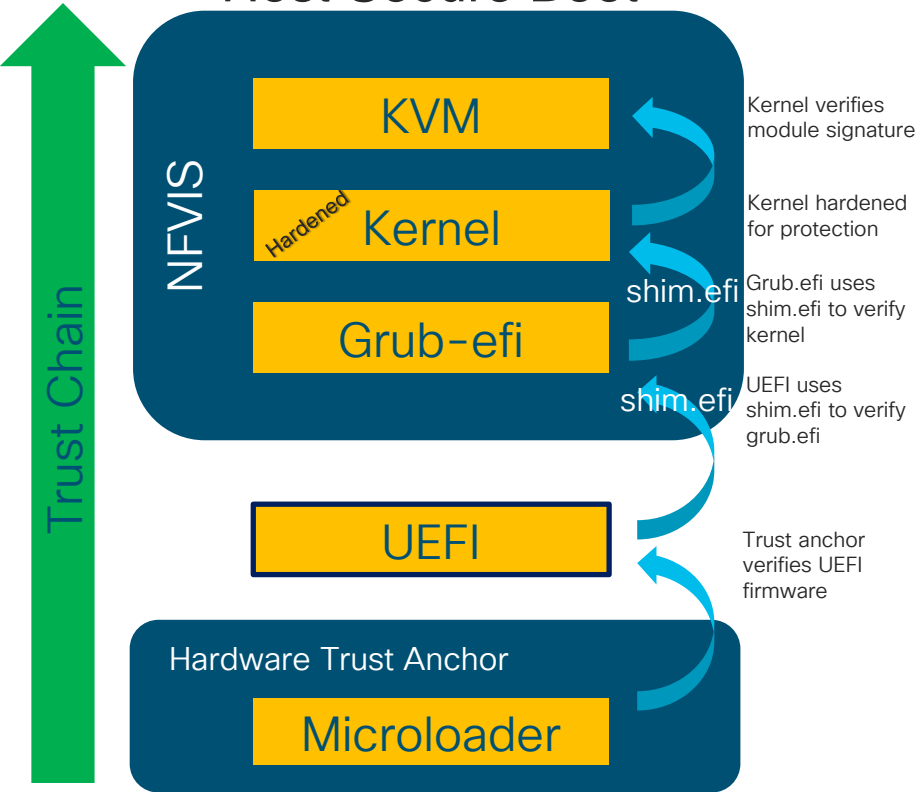
Secure Development Lifecycle (SDL)

A repeatable, measurable process designed to reduce vulnerabilities and enhance the security and resilience of Cisco solutions.

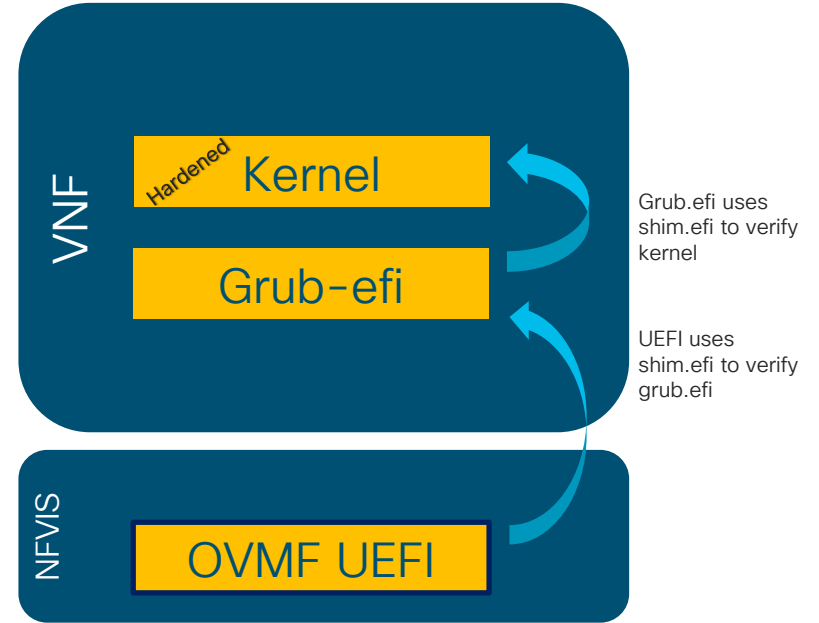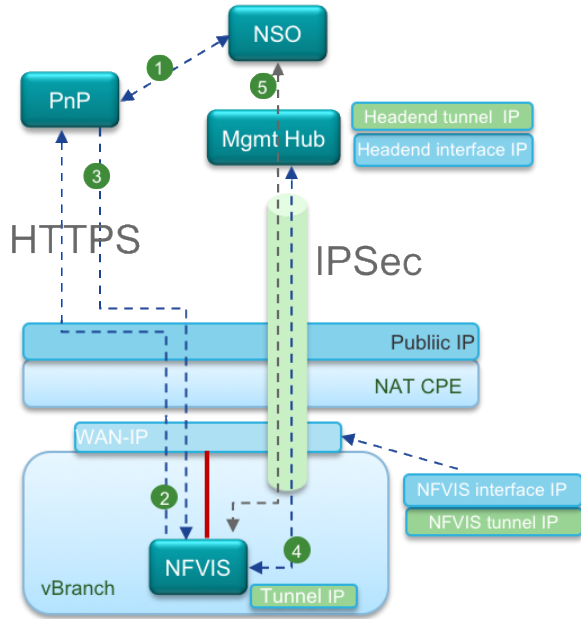# Security embedded at all layers of software

Infrastructure

- CPU, Memory, Network and Storage Isolation
- Traffic Segmentation
- Passwords protection – stored on non reversible form using a hashing algorithm
- Avoid issues related to overlapping names in user-mgmt,

Access Layer

- Can be accessed via secure authenticated interfaces
- Encrypted, hashing and key exchange algorithms for SSH and SSL

Linux/KVM

- Image Tamper Protection
- Use of firewall rules to block unauthorized ports
- Strong SSH/SSL/TLS Configs
- SELinux

Security: Chain of trust

Host Secure Boot

NFVIS
- KVM
- Kernel (Hardened)
- Grub-efi

shim.efi

shim.efi

Trust Chain

UEFI

Hardware Trust Anchor

Microloader

Kernel verifies module signature

Kernel hardened for protection

Grub.efi uses shim.efi to verify kernel

UEFI uses shim.efi to verify grub.efi

Trust anchor verifies UEFI firmware

VNF Secure Boot

VNF
- Kernel (Hardened)
- Grub-efi

NFVIS
- OVMF UEFI

Grub.efi uses shim.efi to verify kernel

UEFI uses shim.efi to verify grub.efi

Secure Overlay for OOB management

Target Deployment Models using Secure Tunnels

Use case 1: Secure Overlay – NAT CPE

Use Case 2: Secure Overlay – **DHCP** WAN IP **w/o** NAT CPE
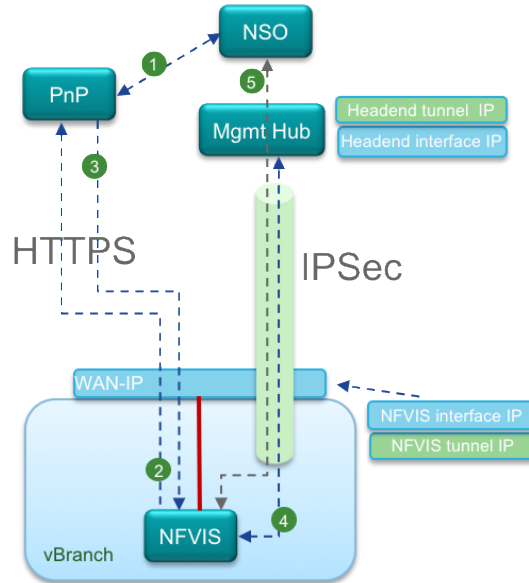
Use Case 3: Secure Overlay – **Static** WAN IP **w/o** NAT CPE
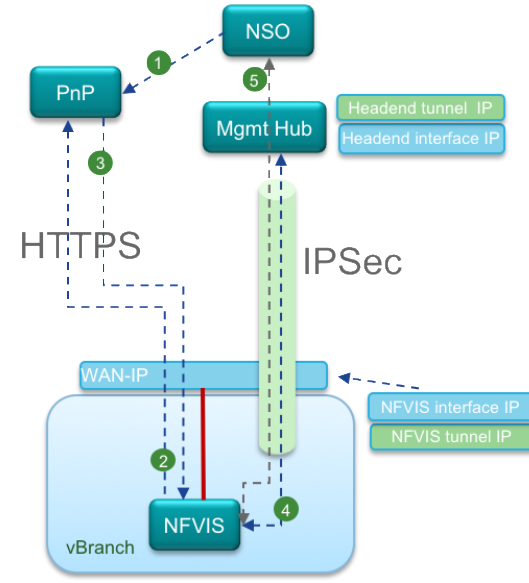
Router – Private IP from NAT GW
NFVIS –Private IP from NAT GW. Tunnel Overlay IP

NFVIS – Initially uses WAN IP. Will move to Private IP
Router – Will be spun up and assigned WAN IP

NFVIS – Initially uses WAN IP. Will move to Private IP
Router – Will be spun up and assigned WAN IP

Solution – Hypervisor Management Overlay
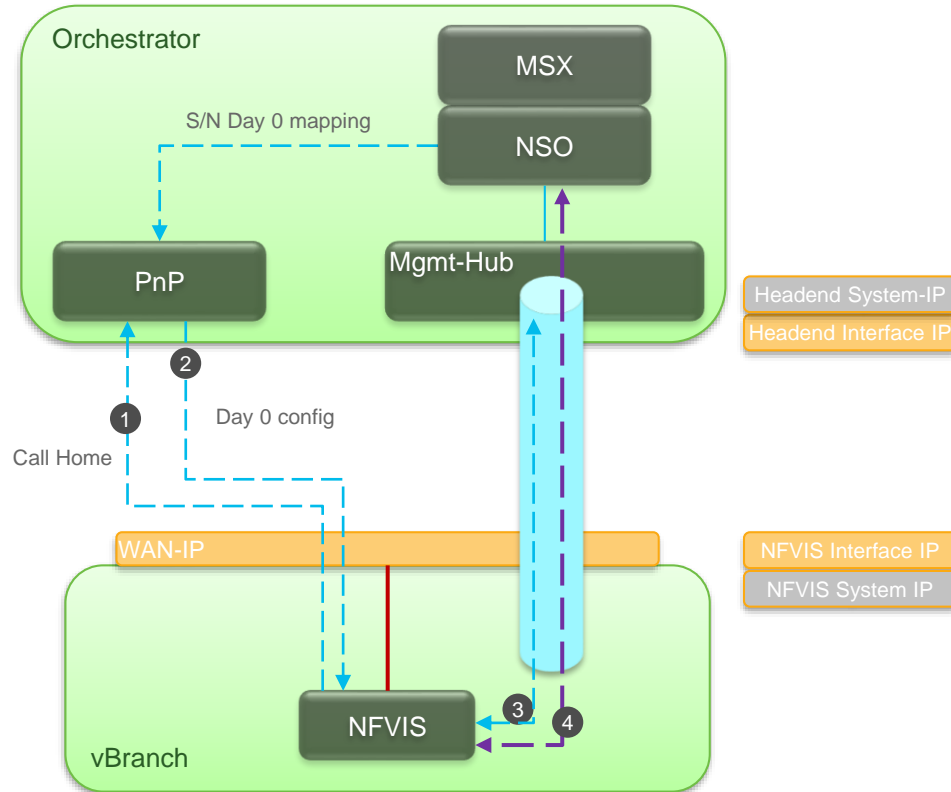
Solution – Overlay and Single Public IP
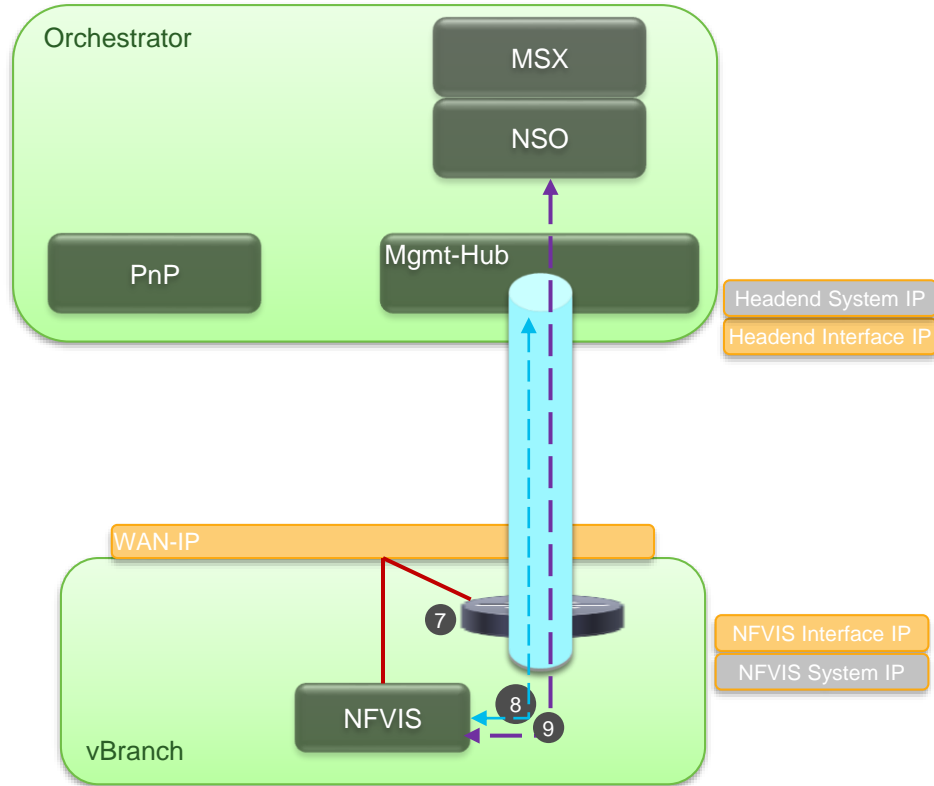
Solution – Single Public IP Failover

Backup and Restore

NFVIS Backup Restore

vBranch Topology DEPLOYED

BACKUP
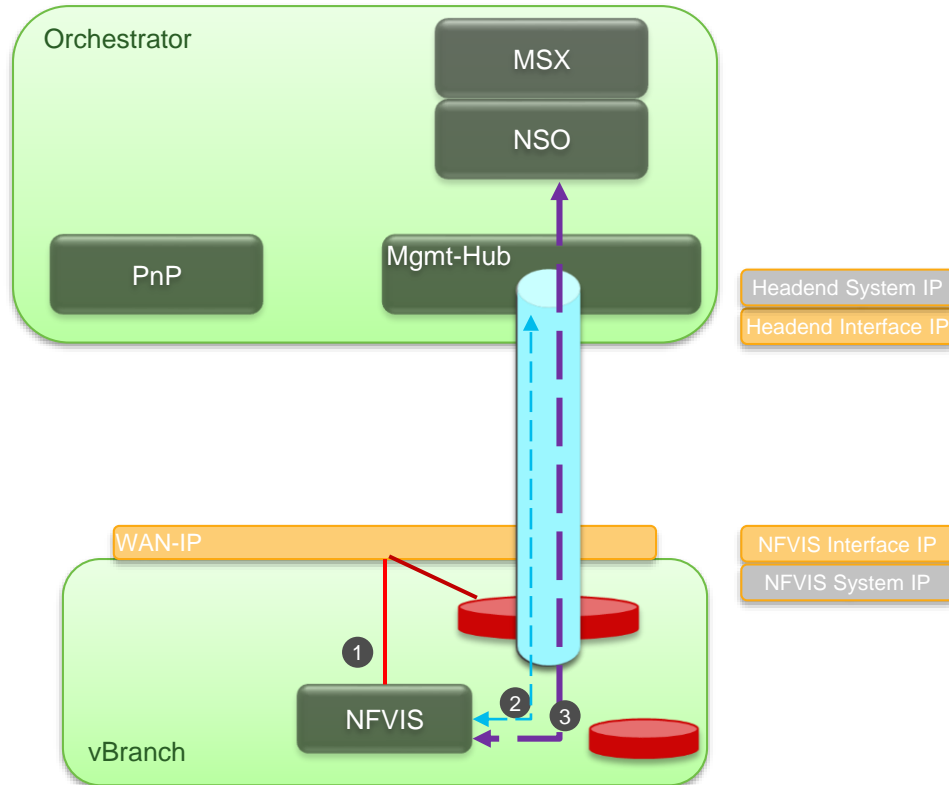
Optional Per VNF vs Complete Topology Backup
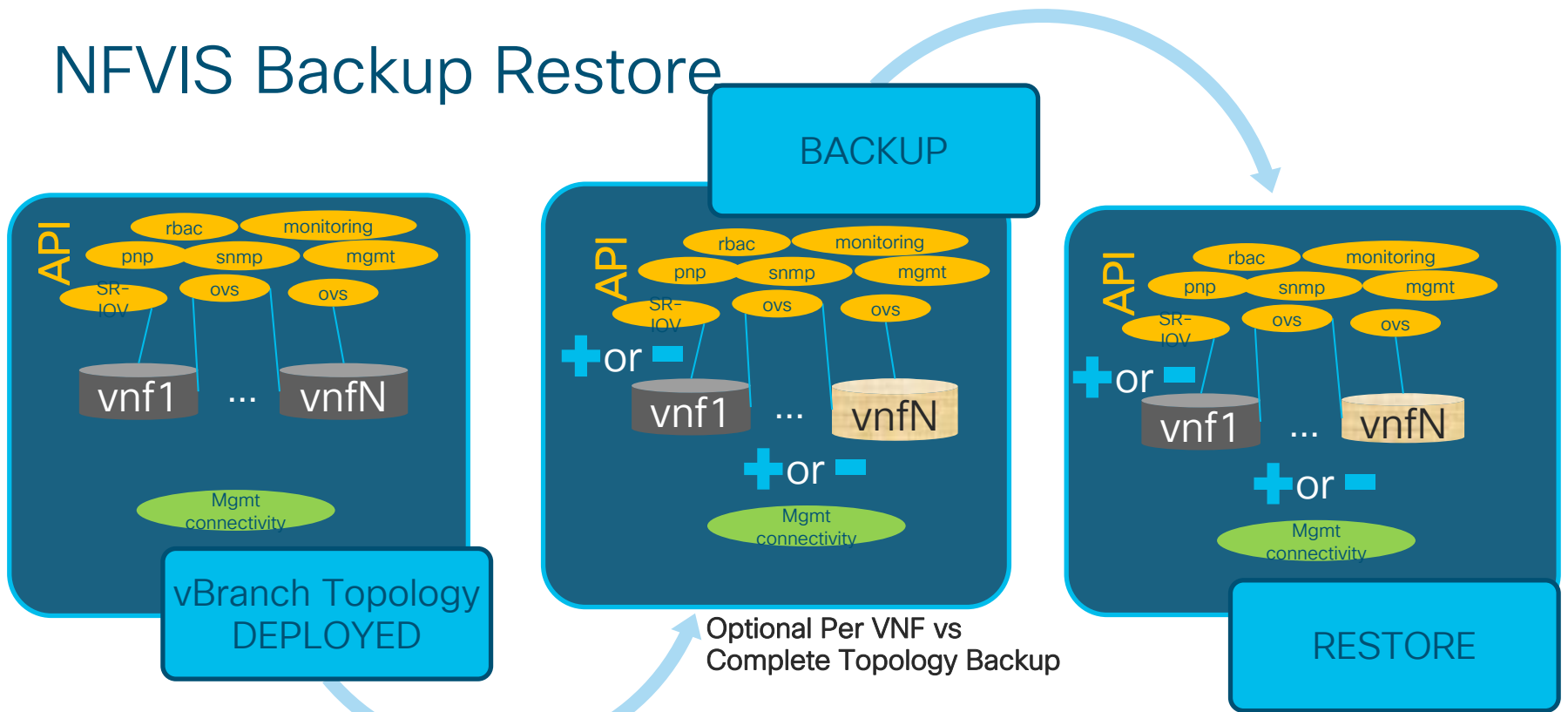
RESTORE

Restore from No-VNF-disk-Backup will result in Re-Deploy of VNF.
VNF License is subject to change.
VNF package reqd in image repository.

Backup/Restore CLIs

Use-cases enabled with NFVIS 3.12 features

High Availability Design

- PNIC tracking for OVS and SR-IOV LAN/WAN interface on ENCS
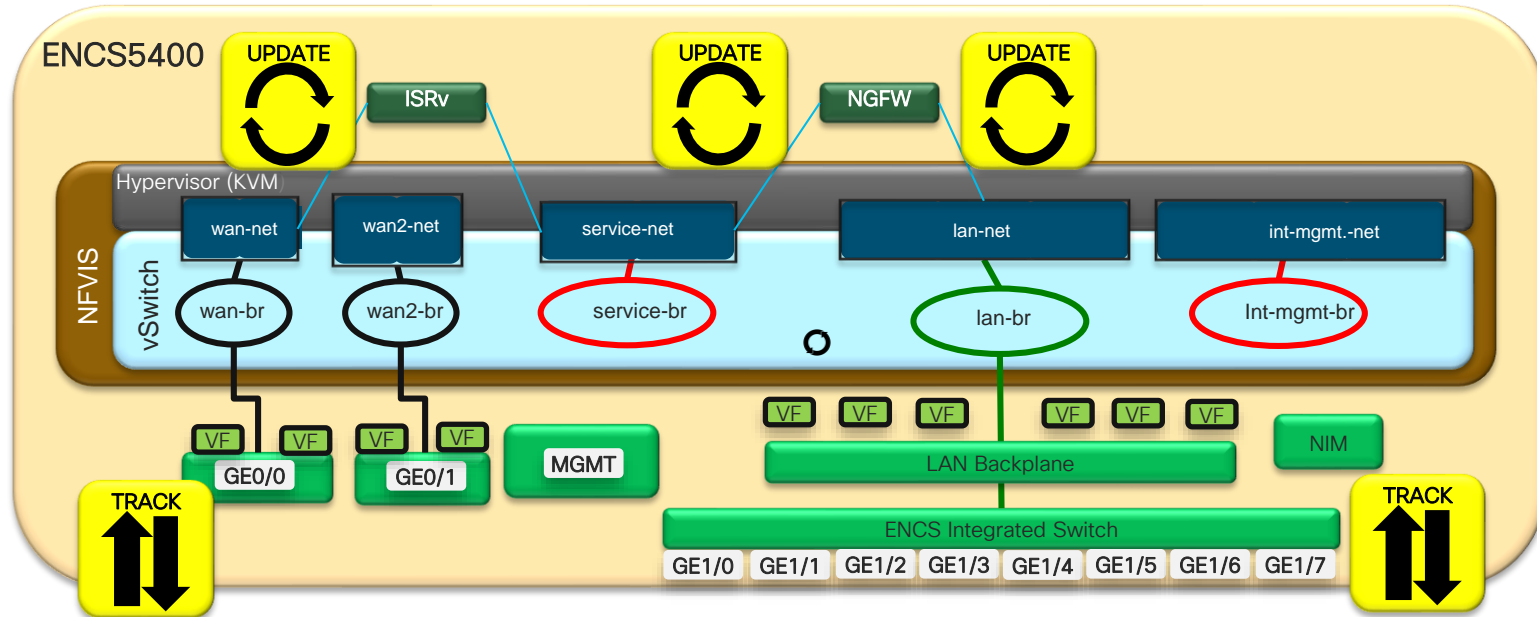- Validated with VRRP/HSRP designs

Performance Improvement

- OVS-DPDK performance improvement across supported platforms ENCS, CSP5K, UCSC-M5, UCSE

Horizontal VNF scaling and multitenant design

- Configurable SR-IOV VFs for VNF scale for CSP platform. LAN VFs increased from 6 to 24 on ENCS platforms.
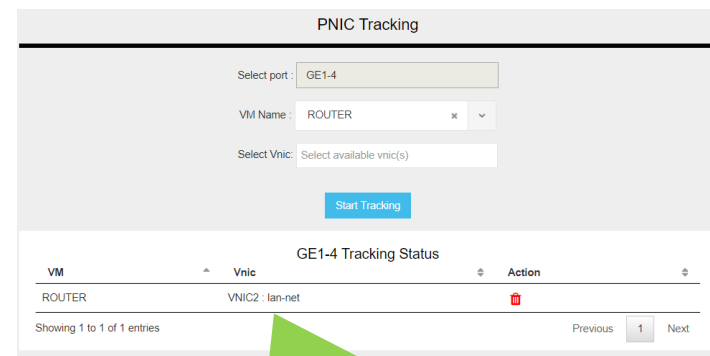
NFVIS PNIC Tracking, VNIC Update

- PNIC tracking works for ports associated with OVS, works on LAN and WAN facing ports. **Available starting NFVIS 3.10.1 release.**

- PNIC tracking is useful in High Availability Designs. HSRP, VRRP like stateful features depend on interface status to switch between ACTIVE and STANDBY modes.

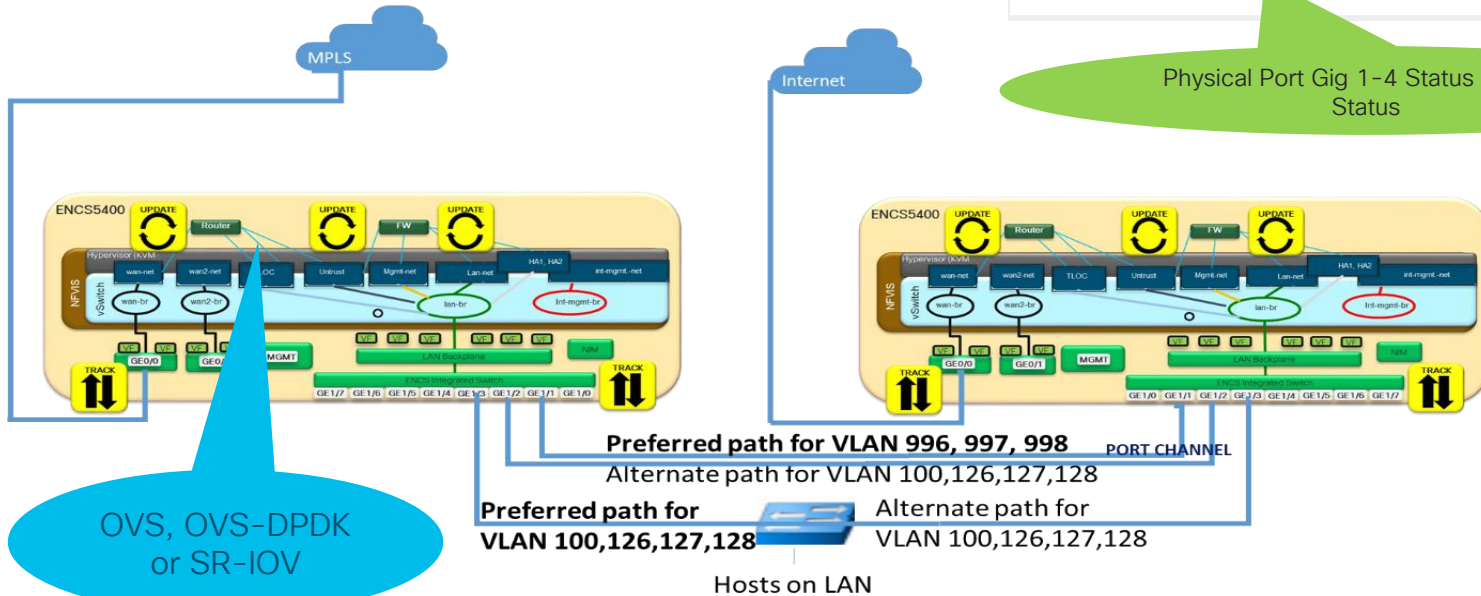- PNIC state can be propagated to multiple vnics based on association

ENCS vBranch Design
Device, Service, Link Redundancy

Validated VRRP/HSRP Design with PNIC Tracking

Physical Port Gig 1-4 Status == vNIC Status

OVS, OVS-DPDK or SR-IOV

Preferred path for VLAN 996, 997, 998
Alternate path for VLAN 100,126,127,128

Preferred path for VLAN 100,126,127,128
Alternate path for VLAN 100,126,127,128

PORT CHANNEL

Hosts on LAN

Horizontal VNF scaling and multitenant design
Dynamic SR-IOV

- Allow user to delete and create SR-IOV networks

- Allow user to configure a PNIC to disable SR-IOV / enable SR-IOV with specified number of VFs and switch mode

- Use cases
  - expand number of SR-IOV networks on high capacity PNICs and support deploying more VMs attaching to SR-IOV networks
  - support DPDK PNIC

- PNIC SR-IOV in NFVIS fresh installation is not changed
  - Each of PNIC has default number of VFs created
  - Default SR-IOV networks are created

VNF Storage IO Optimization

Problem

Disk space allocation and initialization consume additional time, leading to slow Disk IO.

Solution

For the VNF services, Pre-allocate storage via Thick-provision and Initialize sectors at the time of deployment

How

Create VNF package with following meta-data. NO additional actions required to enable Storage optimization, deploy the VNF

- Thick Disk Provisioning with Eager Zero<thick_disk_provisioning>true</thick_disk_provisioning>
- <eager_zero>true</eager_zero>

API enhancements

| Features	Description
Configurable vcpu topology	Some of the thirdparty VNF (ex. Aruba WLC) require **Socket, Core and Thread** specified in addition to the number of cores. Default is to allocate the number of cores and Socket, Core, Thread definitions is populated by system.
AAA auth order, include local	When AAA is configured, users defined local will be used first and subsequent step is to look up AAA server. Prior to this release, when AAA enabled, local user database is not used until AAA server reachability is lost.
APC UPS support with power level notifications	During AC power loss, when switched to using UPS, available power level (amount of time) is notified via syslog.
SNMP support for per core CPU usage	
GUI session timeout configurable	

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- Deploying VNFs with the GUI
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Introduction to the Lab

Lab Topology
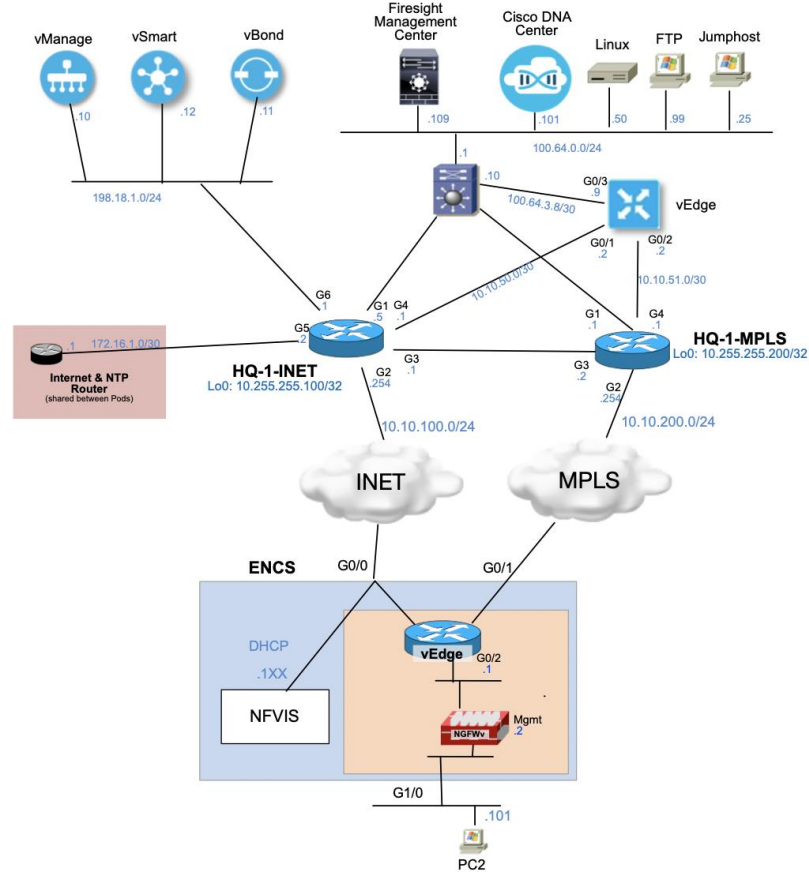
Lab Overview

- Access the lab through AnyConnect and Microsoft Remote Desktop (RDP)

- Reference Sheet has your credentials

- Sharing head-end infrastructure

You have been assigned

POD 1

To access:

1. Launch AnyConnect to *128.107.211.202*
   Username: *enfv-pod01*
   Password: *CLEUR2020*

2. Open a browser to *https://server.enfv.lab/RDWeb*
   Username: *enfv-pod01@enfv.lab*
   Password: *C1sco12345?*

Accessing the Lab
– Walkthrough

Lab Modules 1 & 2

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VNF Packaging

Why Package?

- Better Scalability
  - Provides a way to distribute and deploy VNFs consistently
  - Same package used for multiple VNF sizes
- Simplification
  - Available with packaging utility or GUI
  - VNFs instantiate already configured
- Customization
  - Set key parameters such as console access, core pinning, driver support and disk pre-provisioning
  - Implement your configuration

VNF format support on NFVIS

- NFVIS is based on a Linux distribution with KVM

- Can deploy any VNF with a QCOW2 extension (standard KVM file format)

- However, NFVIS can also support additional file formats
  - .ISO, .IMG, .RAW
  - Has ability to convert a VMDK file into QCOW2 using NFVIS CLI

  nfvis# image-convert myimage.vmdk myimage.qcow2

- NFVIS provides users flexibility by creating a package to deploy on NFVIS
  - Similar to creating an "OVA"

VM Packaging Utility

- Downloaded from NFVIS
- File is "nfvisvmpackagingtool.tar"
- Unpack for files:
  - nfvpt.py
  - image_properties_template.xml
  - nfvis_vm_packaging_utility_examples.txt

Packaging Utility Details

- Process uses Python and nfvpt.py utility with a combination of parameters to package the VM.

- The VM packaging utility contains the following
  - **nfvpt.py**—It is a python-based packaging tool that bundles the VM raw disk image/s along with VM specific properties.
  - **image_properties_template.xml**—This is the template file for the VM image properties file and has the parameters with default values. If the user provides new values to these parameters while creating the VM package, the default values get replaced with the user-defined values.
  - **nfvis_vm_packaging_utility_examples.txt**—This file contains examples on how to use the image packaging utility to package a VM image.

Using nfvpt.py Packaging Tool

Required Fields

-o	Package filename (will make it .tar.gz)
-i	Disk image (multiple images separated by comma)
-t	VNF Type (e.g. ROUTER, FIREWALL)
-n	VNF Name
-r	VNF Version
--monitored	Monitored by NFVIS (default is false)
--optimize	Dedicate/Pin cores for function (default is false)

Optional Fields*

--console	Console port available (true or false)
--eager_zero	Pre-provision disk space (default is false)
--SR-IOV	Support for SR-IOV drivers (true or false)
--SR-IOV_list	Supported SR-IOV drivers (igb,igbvf,i40evf)
--bootstrap	List of files to bootstrap VNF during provisioning
--profile	Flavors possible with list of resources required (e.q. ISRv-Small,"ISRv small profile",2,4096,8192)
--custom	Key / Value pairs for configuration variables (listed as key:[KEY_NAME],val:[VALUE_NAME}

Example (ISRv):

python nfvpt.py -o ISRv-16.12 -i isrv-universalk9.16.12.01a-vga.qcow2 -n "Cisco IOS-XE Virtual Router" -t ROUTER -r 16.12.01 --monitored true --console true --eager_zero true --SR-IOV true --SR-IOV_list igb,igbvf,i40evf --bootstrap ovf-env.xml:ovf-env.xml --bootstrap iosxe_config.txt:iosxe_config.txt --min_vcpu 2 --max_vcpu 8 --min_mem 4096 --max_mem 8192 --min_disk 8 --max_disk 8 --vnic_max 8 -- optimize true --profile ISRv-small,"ISRv small profile",2,4096,8192 --profile ISRv-medium,"ISRv medium profile",4,4096,8192 --default_profile ISRv-small --custom key:HOST_NAME,val:"" --custom key:LOOPBACK_IP,val:""

*Not the entire list

vEdge VM Packaging using the Package Utility (nfvpt.py)

Input parameters

image_properties_template.xml

cloudinit.cfg

meta_data

vendor_data

viptela-edge-genericx86-64.qcow2

Packaging Utility

```
./nfvpt.py -o vedge17.3.2 -i viptela-edge-genericx86-64.qcow2  -n
vedge.17.03.02 -t ROUTER -r 17.03.02 --monitored false --
privileged true --bootstrap
/dir/latest/user_data:cloudinit.cfg,/dir/latest/meta_data.json:met
a_data,/dir/latest/vendor_data.json:vendor_data --min_vcpu 2 --
max_vcpu 8 --min_mem 4096 --max_mem 8192 --min_disk 8 --max_disk 8
--vnic_max 8 --optimize true --nocloud true --profile vEdge-
small,"vEdge small  profile",2,4096,8192 --profile vEdge-
Standard,"vEdge Standard profile",4,4096,8192 --default_profile
vEdge-Standard --custom ORGNAME, --custom OTP, --custom UUID, --
custom SYSTEM_IP, --custom VBOND,
```

Final Package

vedge-17.3.2.tar.gz

- cloudinit.cfg: mounted as /openstack/latest/user_data

- meta_data: mounted as /openstack/latest/meta_data.json

- vendor_data: mounted as /openstack/latest/vendor_data

Creating a Package using the NFVIS GUI

Access the utility from VM Life Cycle -> Image Repository -> Image Packaging

Create a new VM Package

Upload the QCOW2 binary and Day 0 config

Define Flavors

- Flavors set the CPU, Memory, Storage requirements for a VNF

- Helps with one-click automated deployment

Create Package, Download or Register

- Once the package is created, you can then download it and reuse it on other NFVIS systems
- Register the VNF within NFVIS to deploy it

Register new Package so that it appears under Image registration (image and profiles)

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Deploying a VNF on NFVIS using the GUI

Deploying VNFs Using NFVIS GUI

VM Life Cycle -> Deploy
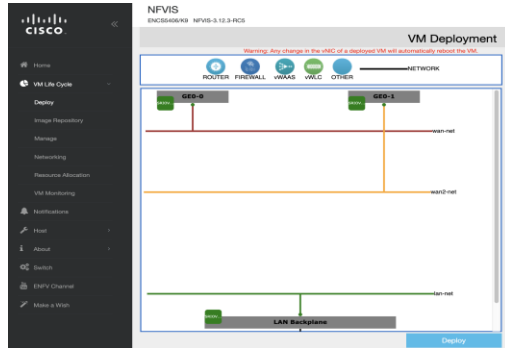
"Draw" the desired topology
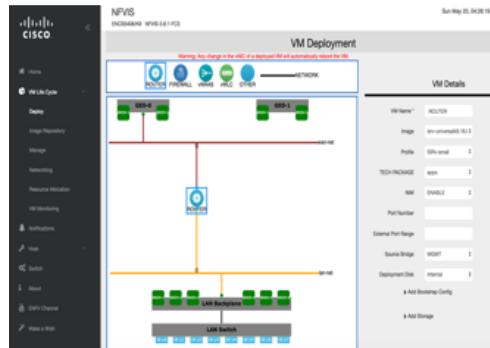
Enter VNF properties and Deploy
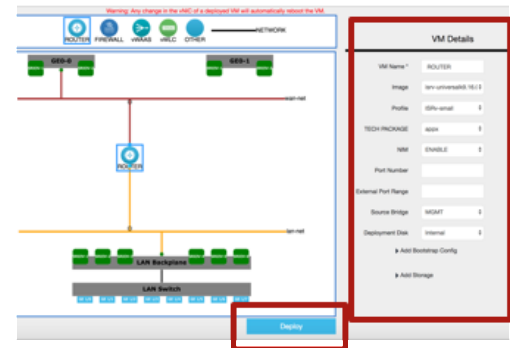
Image Profiles

Resource footprint for VNF deployment

Number of CPUs allocated to VNF. Dedicated or Shared based on Package properties

Memory allocated to VM during deployment

Disk space allocated during deployment, Choose specific disk during deployment

Profiles

Profile	CPU	Memory (MB)	Disk (MB)	Source Image	Action
ASAv10	1	2048	8192	asav9101-routed.tar.gz	🗑
ASAv30	4	8192	16384	asav9101-routed.tar.gz	🗑
ASAv5	1	1024	8192	asav9101-routed.tar.gz	🗑
isrv-medium	4	4096	8192	isrv1664.tar.gz	🗑
isrv-small	2	4096	8192	isrv1664.tar.gz	🗑

Showing 1 to 5 of 6 entries

Previous 1 2 Next

Dedicated CPUs vs. Hyperthreading vs. pinning
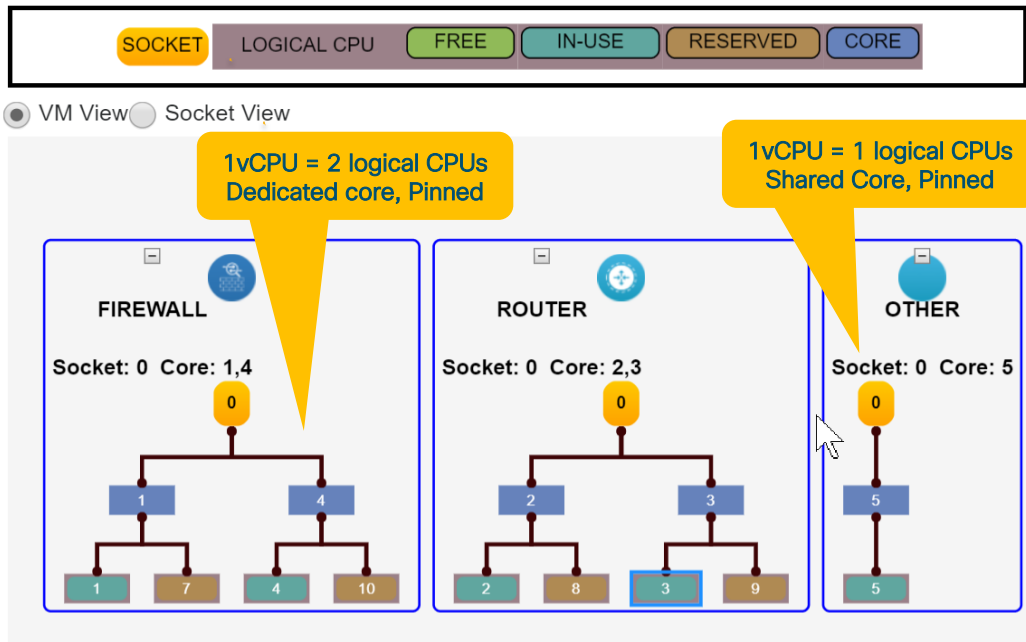
Best Practice :

For predictable performance, Dedicate Core for Virtual Network Functions like vRouters, vFirewall, etc.

Lightweight Compute Applications based on TCP could share cores, host more applications

Bridges and Networks
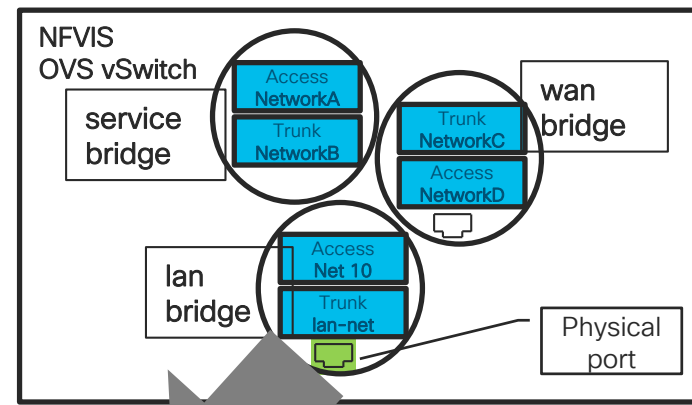
L2 Switch
broadcast domains
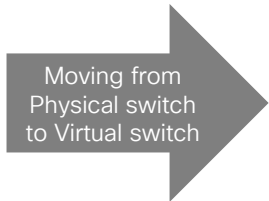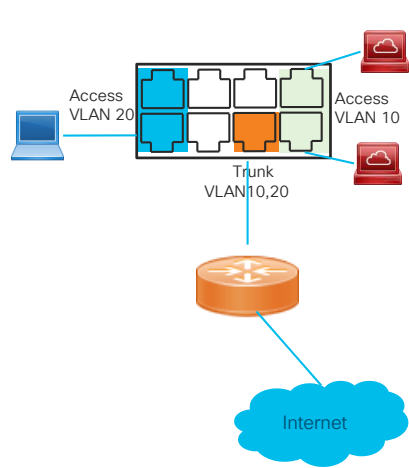
Moving from
Physical switch
to Virtual switch
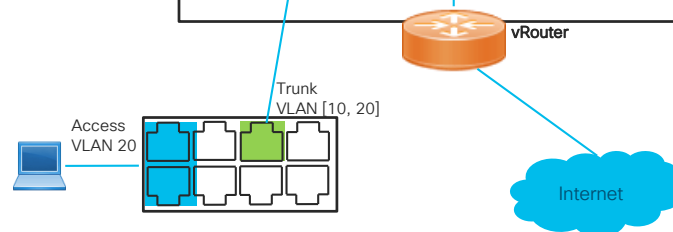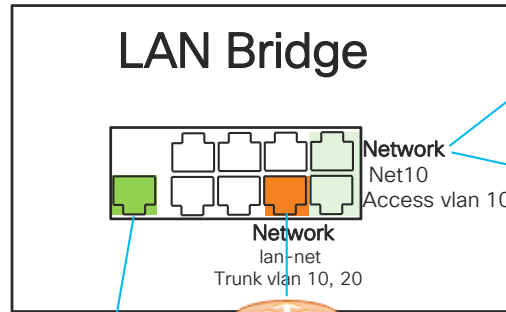
Bridges & Networks (Contd.)
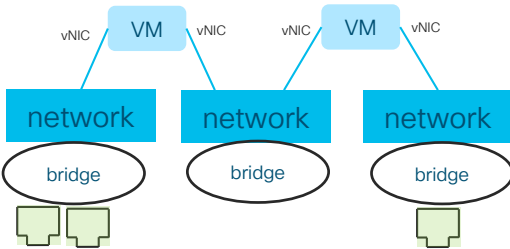
**SR-IOV vnic
Trunk or Access via CLI.**

Mode
Trunk /
Access

Network (lan-net, wan-net) is logical representation of like group (Trunk or Access) of ports in vswitch (lan-br, wan-br).
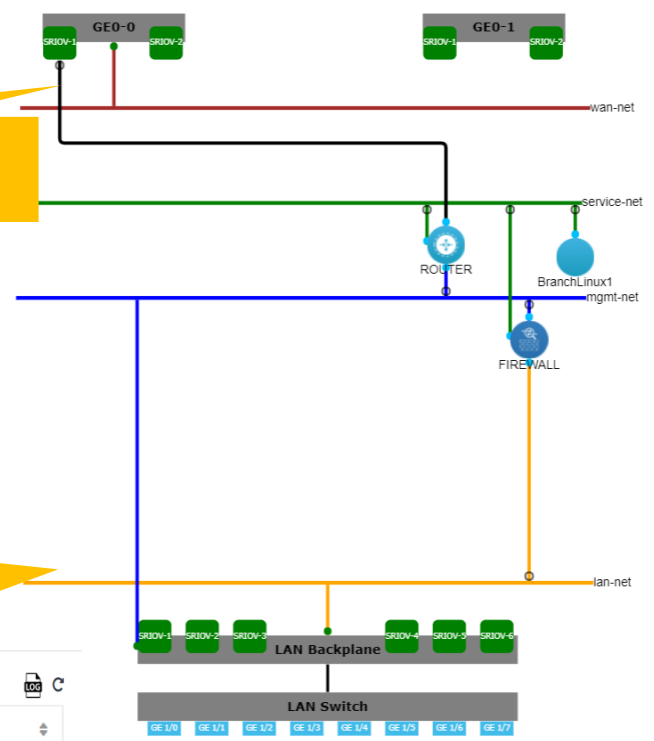
Network		Mode	Vlans	Native Vlan	Bridge	Interfaces	Actions
lan-net	LOG	trunk	101,102		lan-br	int-LAN	✏️ 🗑️
mgmt-net	LOG	access	100		lan-br	int-LAN	✏️ 🗑️
service-net	LOG	trunk			service-br		✏️ 🗑️
wan-net	LOG	trunk			wan-br	GE0-0	✏️ 🗑️

Showing 1 to 4 of 4 entries

Previous 1 Next

NFVIS Management Network
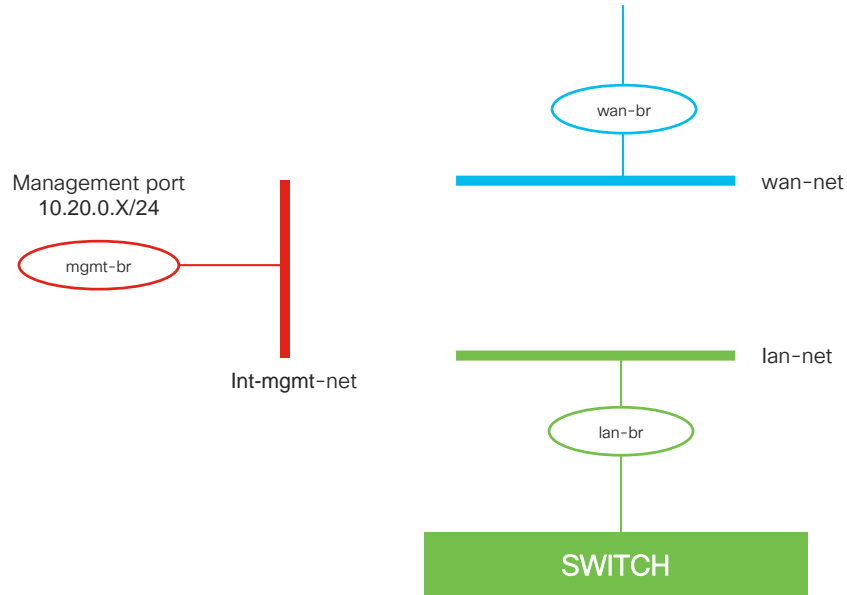
- int-mgmt-net predefined in NFVIS

- Used to connect to VMs

- Also used to monitor VMs

- If the VM fails to respond to heartbeat from the NFVIS, after 3 attempts of re-launching the VM, the Status will report 'Error'.

- Uses 10.20.0.X/24 by default

- Can be modified with CLI command

    vm_lifecycle networks network int-mgmt-net subnet int-mgmt-net-subnet address *ip-address*gateway *gateway-ip-address*netmask *netmask*dhcp { true | false }

NFVIS Built-in Recovery

- NFVIS can monitor deployed VNF for failure

- On VNF failure detection, NFVIS can auto-restart the VNF

- Downtime experienced will depend on the VNF boot up time

- Can still run the branch off one hardware

- VNF would use the same license again
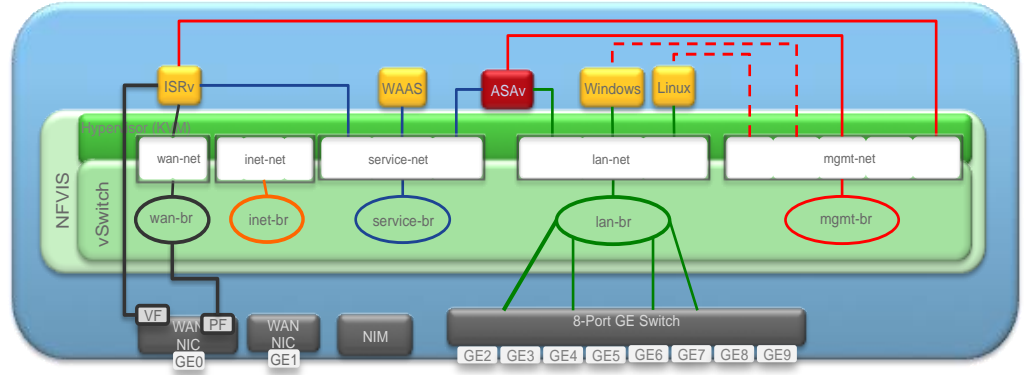
The first interface of the deployed VM will be used for internal monitoring.
- By default local portal attaches vNIC0 of the monitored VM to int-mgmt-net.
- If the VM fails to respond to heartbeat from the NFVIS, after 3 attempts of re-launching the VM, the Status will report 'Error'

How to connect a VM to LAN Ports

VM interface is a trunk
- Connect VM to LAN-SR-IOV-x
- Or lan-net.
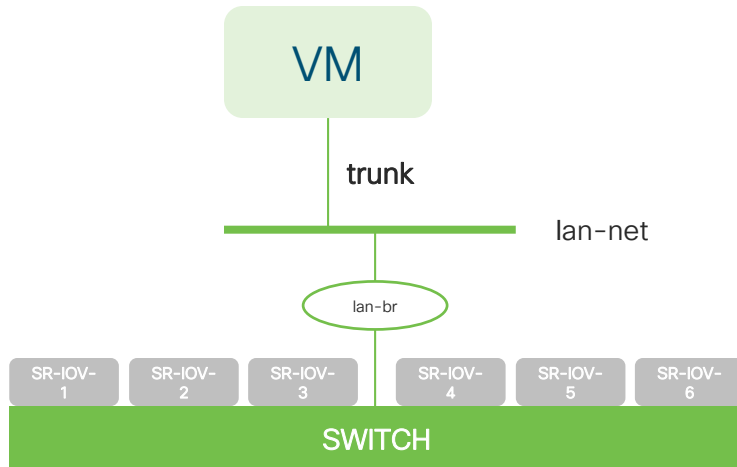
VM interface is untagged
- Connect VM to LAN-SR-IOV-x or lan-net.
- Create a new network for it to connect to
- Set network to access mode with the desired vlan
- Set bridge to lan-br.
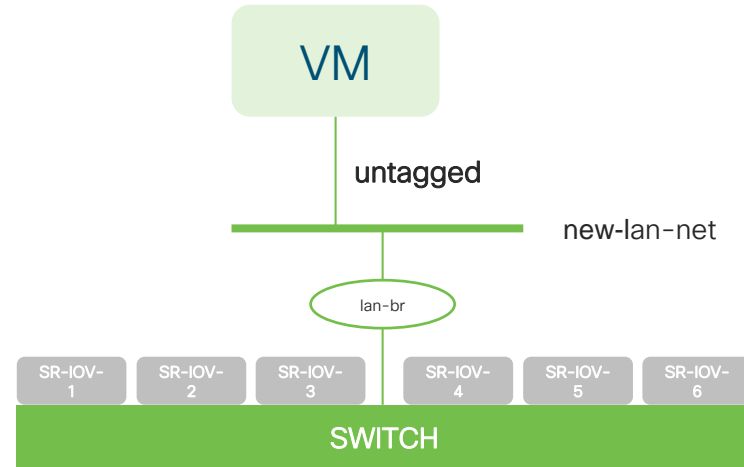
LAN Ports

- LAN Ports (GE1/0 - 7 on ENCS 54xx, GE0/2 and GE0/3 on ENCS 5104)

- Interfaces intended to be used for LAN access.

- ENCS 54xx, ports are part of an 8-port switch
  - connects to Intel XL710 NIC, which then connects to NFVIS.
  - Means that individual physical interfaces from the switch are not exposed to NFVIS, we essentially just **have a trunk from NFVIS to the switch**. Unlike the WAN ports, **you can't create a network that maps directly to a physical port on the L2 switch**. You must send **appropriately tagged traffic to the L2 switch**, and it will then be sent out in accordance with the switchport configs.
  - OVS connectivity is provided from the XL710 to the default lan-br. lan-br is a member of lan-net, which **by default is in trunk mode**.

- On the 5104, GE0/2 and GE0/3 are mapped to lan-br. This is strictly an OVS bridge, not an L2 hardware switch like the 54xx.
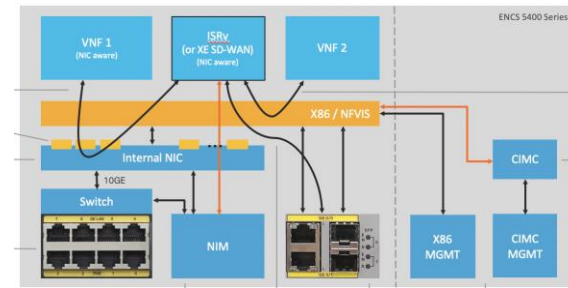
Access the VNF Console from NFVIS

NFVIS – shows list of VM names

```
vbo-UCPE1# show system deployments
NAME                          ID  STATE
----------------------------------
1511257222.vEdgeCloud  7    running

vbo-UCPE1#
```

NFVIS – console request to a deployed VM

```
vbo-UCPE1# vmConsole 1511257222.vEdgeCloud
Connected to domain 1511257222.vEdgeCloud
Escape character is ^]

viptela 17.2.0

vedge login: admin
Password:
Welcome to Viptela CLI
admin connected from 127.0.0.1 using console on vedge
vedge#
```

Notes:

- VNF must be packaged with "Serial" console as enabled while using the VNF packaging tool
- ISRv must have "platform console serial" configured (requires a reboot of ISRv)
- ASAv must have a file on Disk0 called use_ttyS0 (requires a reboot of ASAv)

https://community.cisco.com/t5/firewalls/can-t-access-isrv-or-asav-console-from-nfvis-on-cisco-encs/td-p/3308862

Accessing VNF using Port Forwarding from NFVIS

VM Details

VM Name *	ROUTER
Image	ISRv-CLEUR20.tar.gz
Profile	ISRv-small
VNC Password	
HOST NAME	RTR1
POD NUMBER	3
Port Number	22
External Port Range	2022
Source Bridge	✓ wan-br
	wan2-br
	MGMT
Deployment Disk	

During VM Deployment:

Three Key Fields:

Port Number - what port on VM to forward to for SSH
External Port Range – What port to use on NFVIS
Source Bridge – What IP of NFVIS to use

- wan-br
- wan2-br
- MGMT

Caveats:

- VNF package must have "console" parameter enabled
- NFVIS uses internal management network to forward
- Source bridge set to reachable IP for NFVIS

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- **Lab Modules 3 & 4**
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Lab Modules 3 & 4

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Enterprise NFV Monitoring

VNF ISRv

| Syslog and SNMP CPU Utilization | Show CLI Memory Utilization | NetFlow Interface Stats | EEM Scripts |

Hypervisor NFVIS

- NFVIS supports REST and NETCONF APIs that can be used to export all Host and VNF specific information
- CLIs are also available to monitor and export data
- All data is exported via NETCONF. Need a NETCONF client to receive data
- Host and Interface SNMP MIBS
- Exporting to external Syslog Server

Hardware ENCS

- Monitoring via Cisco Integrated Management Controller for Platforms that support it.
- CIMC supports an exhaustive list of MIBS which can be used to monitor every aspect of the underlying hardware
- CPU, Memory, Interface and Disk Stats

ENCS Monitoring Capabilities

- NFVIS

  - Syslog Messages & Netconf Notifications

  - SNMP Traps

  - SNMP MIBs

  - API for environment monitoring (Hardware)

  - API for host resource usage (CPU, disk, memory, port)

  - API for VNF resource usage (vCPU, disk, memory, port)

- CIMC

  - SNMP Traps

  - Syslog Messages

  - Event Log

  - APIs for hardware information

ENCS Monitoring Capabilities
NFVIS Syslog/Notifications Messages

- Network Connectivity
- Login/Authentication
- Host/Disk Management
- NFVIS Upgrade
- NFVIS VMLC Message
- NFVIS Secure Overlay/DPDK Messages
- NFVIS Certificate Management
- CIMC Management

ENCS Monitoring Capabilities
NFVIS Monitoring Documentation

- Documentation

  - https://www.cisco.com/c/en/us/td/docs/routers/nfvis/user_guide/b-api-reference-for-cisco-enterprise-nfvis.html

  - https://www.cisco.com/c/en/us/td/docs/routers/nfvis/config/3-12-1/nfvis-config-guide-3-12-1.html

  - CIMC – https://www.cisco.com/c/en/us/support/servers-unified-computing/ucs-e-series-servers/products-installation-and-configuration-guides-list.html

CIMC Management MIBS

CISCO-UNIFIED-COMPUTING-EQUIPMENT-MIB

CISCO-UNIFIED-COMPUTING-FAULT-MIB

CISCO-UNIFIED-COMPUTING-MIB

CISCO-UNIFIED-COMPUTING-MEMORY-MIB

CISCO-UNIFIED-COMPUTING-NOTIFS-MIB

CISCO-UNIFIED-COMPUTING-PROCESSOR-MIB

CISCO-UNIFIED-COMPUTING-STORAGE-MIB

CISCO-UNIFIED-COMPUTING-TC-MIB

ITU-ALARM-TC-MIB

SNMPv2-MIB

SNMPv2-CONF-MIB

SNMPv2-SMI-MIB

SNMPv2-TC-MIB

SNMP-FRAMEWORK-MIB

INET-ADDRESS-MIB

CISCO-SMI

CISCO-TC

- Memory, processor, and storage MIBS used for SNMP query for memory, CPU, and disk/controller (SNMPGET, SNMPWALK)
- Notifications and fault generate trap events

CLIs for Monitoring

Stats: content for graphical display

```
show system-monitoring host [cpu | disk | memory | port] stats
show system-monitoring vnf [cpu | memory] stats
```

Table: summary (e.g. min / max / average)

```
show system-monitoring host [cpu | disk | memory | port] table
```

Default collecting duration is 5min

Query for a specific collecting duration via API / CLI.

NFVIS Notifications for Monitoring and Troubleshooting

- NFVIS sends notifications for
  - *vmlcEvents* (VM Lifecycle)
  - *nfvisEvents* (NFVIS)

- Use NFVIS CLI or GUI to query notifications

```
nfvis# show notification stream vmlcEvent
notification
 eventTime 2017-02-17T22:27:20.292+00:00
 vmlcEvent
  status SUCCESS
  status_code 200
  status_message Image creation completed successfully.
  image isrv-universalk9.16.03.01.tar.gz
  vmlcEvent vm_source
   !
  vmlcEvent vm_target
   !
  vmlcEvent event
    type CREATE_IMAGE
   !
```

NFVIS Notification Events

- VM Life Cycle Events

CREATE_IMAGE
DELETE_IMAGE
CREATE_FLAVOR
DELETE_FLAVOR
VM_DEPLOYED
VM_ALIVE
VM_UPDATED
VM_UNDEPLOYED
VM_RECOVERY_INIT
VM_RECOVERY_COMPLETED

VM_STOPPED
VM_STARTED
VM_REBOOTED
VM_MONITOR_UNSET
VM_MONITOR_SET
VM_RECOVERY_CANCELLED
VM_RECOVERY_REBOOT

- NFVIS System Events

WAN_DHCP_RENEW
INIT_STATUS_CHANGE

NETWORK_CREATE
NETWORK_UPDATE
NETWORK_DELETE

SNMP Support on NFVIS

- NFVIS supports versions 1 and 2 of SNMP

- Configuration can be done via Portal, CLI, and API

- NFVIS currently supports these standard MIBS
  - SNMPv2 MIB
    - Object ID (OID): 1.3.6.1.2.1.1
    - http://www.oidview.com/mibs/0/SNMPv2-MIB.html
  - IFMIB (interface data)
    - OID: 1.3.6.1.2.1.2
    - http://www.oidview.com/mibs/0/IF-MIB.html
  - Entity MIB (entity data)
    - OID: 1.3.6.1.2.1.47
    - http://www.oidview.com/mibs/0/ENTITY-MIB.html

Syslog in NFVIS

- NFVIS can send Syslog messages to Syslog servers

- Syslogs are sent for NETCONF notifications from NFVIS

- This feature is used to configure the remote logging servers

- Configuration can be done via Portal, CLI and API

- Syslog messages have the following format:

<Timestamp> hostname %SYS-<Severity>-<Event>: <Message>

2019 Jan 16 15:36:12 nfvis %SYS-6-CREATE_FLAVOR: Profile created: ISRv-small

2019 Jan 16 15:36:12 nfvis %SYS-6-CREATE_FLAVOR: Profile created: ISRv-medium

2019 Jan 16 15:36:13 nfvis %SYS-6-CREATE_IMAGE: Image created: ISRv_IMAGE

Syslog Server Configuration

- A maximum of 4 remote syslog servers can be configured.

- Server configuration parameters are:
  - Remote server's address
    (IPv4 / IPv6 / DNS Name)
  - Protocol to be used for sending the syslogs
    (TCP or UDP, default is UDP)
  - Port of the syslog server
    For UDP, the default port is 514
    For TCP, the default port is

Syslog severity Configuration

- By default, the logging severity of syslogs is 'informational'
  - i.e. All syslogs at 'informational' severity and higher will be logged.
- The logging severity can be changed to one of:
  - debug
    informational
    notice
    warning
    error
    critical
    alert
    emergency

Troubleshooting

Exposed low level Linux show commands without having to go to root

- Low level Show commands under "Support" keyword
- Provides stats from OVS, provides TCP data dump and output from virsh commands

Example: How to verify if the Day 0 configuration is attached to the VNF when instantiated by NFVIS?

Step1: Get the list of VNFs running on NFVIS

```
nfvis# support virsh list
Id   Name                    State
----------------------------------------------------
 19   1509553386.ROUTER          running
```

Step 2: Next check if there is a config drive generated with the day 0 configuration you added to the package

```
nfvis# support show config-drive 19
-rw-r--r--. 1 qemu qemu 397312 Nov  1 16:23 /cisco/esc/esc_database/nodejs/VM/ae828bab-3e90-4a53-ba97-
14aa0db258f2/ae828bab-3e90-4a53-ba97-14aa0db258f2-hdd.config
```

Step 3: Once verified that config drive is present, next look at the contents of the drive by using

```
nfvis# support show config-drive content 19
```

At the tail end you should see the configuration that you packaged with the VNF

Troubleshooting

Example 2 : How to verify if your VM is actually enabled for serial console?

Step1: Use the support virsh dumpxml <id>

```
nfvis# support virsh dumpxml 19
```

The virsh dumpxml command lists out exactly how the VNF was deployed on NFVIS. It lists out the properties that was enabled as well

For the above example by using the virsh dumpxml command look for key word Serial, if you see the following in the output then you know the VNF was enabled for Serial Console on NFVIS.

```
<serial type='pty'>
    <source path='/dev/pts/0'/>
    <target port='0'/>
    <alias name='serial0'/>
  </serial>
```

Troubleshooting (specific to config drive)

Issue	Cause	Debug	Fix
Image registration fails	if package is not *.tar.gz (doesn't have the required files on slide#27	Look at the error message on portal/API response code. Also look at ESCManager.log NFVIS#show log /var/log/esc/escmanager.log | include Image_name	Repackage using local portal or packaging tool
Image registration fails	Checksum is not correct – maybe packaging tool /local portal not used to package the VM	Look at the error message on portal/API response code. Also look at ESCManager.log NFVIS#show log /var/log/esc/escmanager.log | include Image_name	Repackage using local portal or packaging tool
VM deployment fails	VM is monitored VM. VM is not attached to int-mgmt-net (it can be attached to any nic) when deployed using API. By default local portal attaches nic0 of the monitored VM to int-mgmt-net.	Look at the API response code. Also look at ESCManager.log NFVIS#show log /var/log/esc/escmanager.log | include vm_dep_name	Undeploy VM Re-Deploy using local portal or using API attach int-mgmt-net to one of the nics

Troubleshooting (contd...)

Issue	Cause	Debug	Fix
VM deployment fails	VM is a monitored VM and bootup_time is not specified in the payload bootup_time is boot time required for VM to boot in seconds (+ve value)	Look at the error message on portal/API response code. Also look at ESCManager.log NFVIS#show log /var/log/esc/escmanager.log | include vm_dep_name	Re-deploy using local portal (default bootup_time is local portal is 600 seconds) Or deploy using API and specify a reasonable, positive value for the VM to boot in seconds. Some MSX need longer time to boot.
VM deployment fails	VM is a monitored VM and kpi_data is not provided in the payload	Look at the error message on portal/API response code. Also look at ESCManager.log NFVIS#show log /var/log/esc/escmanager.log | include vm_dep_name	Re-deploy using local portal (it attaches kpi_data) Or deploy using API and specify a kpi_data
VM deployment fails	Bootstrap config file is tokenized and the key, value pairs are passed during deployment using API. But static ip address is used through the deployment payload for this VM for int-mgmt-net which was already assigned by the system for other MSX.	Look at the API response code. Also look at ESCManager.log NFVIS#show log /var/log/esc/escmanager.log | include vm_dep_name	Use a different unused ip address for the int-mgmt-net.

SPAN and Packet Capture

- SR-IOV or OVS vnic can be spanned (port replicated) to a Packet capture VM
- TCPdump can be done via GUI or CLI on OVS vnics

| Maintenance and Reset | SPAN | NFS Mount | Password Management |

SPAN Session:
2

Destination: ● Interface ○ Vlan
BranchLinux1.vnic0

Source(s): ● Interface ○ Vlan
✕ FIREWALL.vnic1

Traffic Direction:
rx-tx

Submit

SPAN Sessions

Destination (Interface/Vlan)	Source(s) (Interfaces/Vlans)	RX Traffic Interfaces	TX Traffic Interfaces	Bridge	Status	Actions
BranchLinux1.vnic0	ROUTER.vnic2	ROUTER.vnic2	ROUTER.vnic2	service-br	SUCCESS	🗑

Showing 1 to 1 of 1 entries

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Lab Module 5

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Deploying a VNF on NFVIS using APIs

What is an API?

"It's a way for two pieces of software to talk to each other."

Application Programming Interface (API)

API Examples

Representational State Transfer (REST)

- API framework intended to build simpler web services than SOAP

- Another use for the HTTP protocol

- Popular due to performance, scale, simplicity, and reliability

- Technically an API framework

GET

POST

PUT

DELETE

{REST}

NETCONF (NETwork CONFiguration) Protocol

- Designed as replacement for SNMP

- Standardized in 2006 / Updated 2011

- Leverages SSH and XML

- Defines transport and communication
  - Titled coupled to YANG for data

NETCONF Communications

Manager

```
<?xml ?>
<rpc-reply>
    <data>
        <interfaces>
            <interface>
                <name>Gig
                <type>ian
```

NETCONF | XML | YANG Data

NETCONF | XML | YANG Data

Agent

XML			
Content	Configuration / Operational Data	`<data>`
Operations	Actions to Take	`<get>`, `<get-config>`, `<edit-config>`, etc
Messages	Remote Procedure Call (RPC)	`<rpc>`, `<rpc-reply>`
Transport	TCP/IP Method	SSH
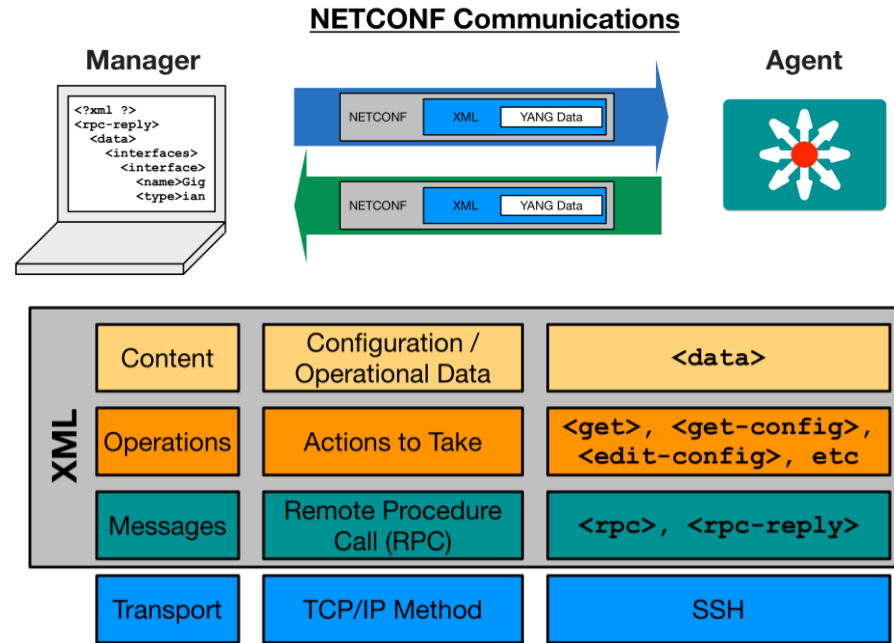
RESTCONF Protocol

- Provide REST API like interface to network

- Standardized in 2017

- Supports XML and JSON

- Defines transport and communication
  - Titled coupled to YANG for data

Content	Configuration / Operational Data	XML or JSON
Operations	Actions to Take	GET, POST, PUT, PATCH, DELETE
Transport	TCP/IP Method	HTTP
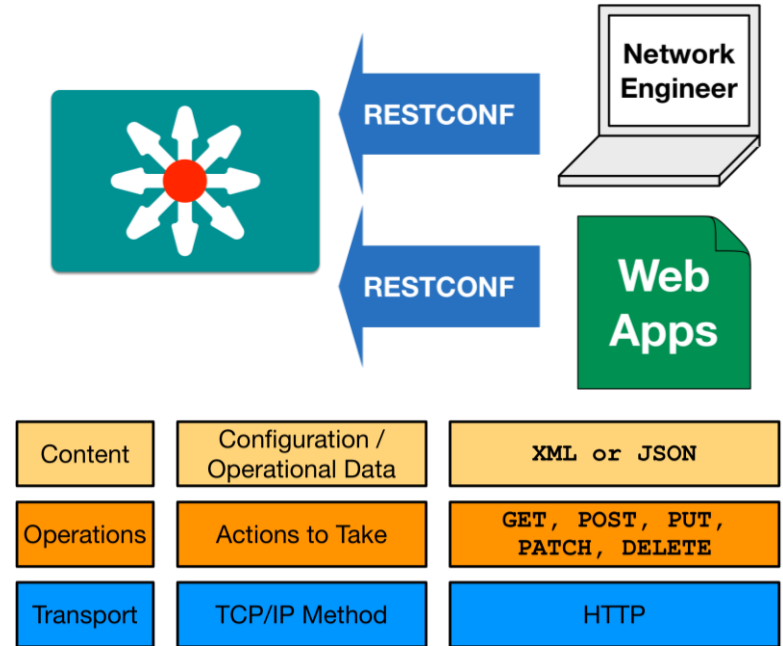
Let's Look a Bit More at REST

Rest
How does it work

Client Request

GET, POST, PUT, DELETE

API Service

Do Something

Response

JSON, XML, TEXT

Client Action
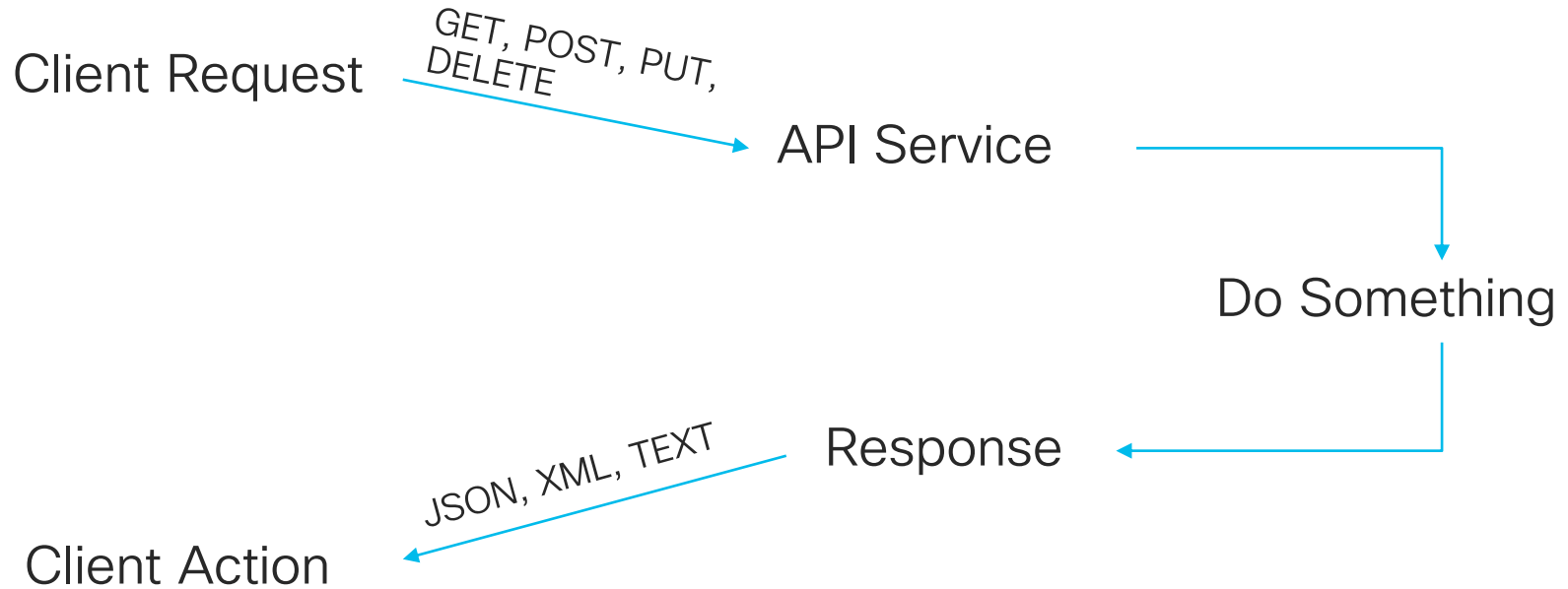
The URI – What are You Requesting?

http://maps.google.com/maps/api/geocode/json?address=sandiego

Server — Resources — Parameters

- http:// or https://
  - Define whether secure or open http

- Server or Host
  - Resolves to the IP and port to connect to

- Resource
  - The location of the data or object of interest on the server

- Parameters
  - Details to scope, filter, or clarify a request. Often optional.

HTTP Methods: What to do?

HTTP Verb	Typical Purpose (CRUD)	Description
POST	Create	Used to create a new object, or resource. *Example: Add new book to library*
GET	Read	Retrieve resource details from the system. *Example: Get list of books from the library*
PUT	Update	Typically used to replace or update a resource. Can be used to modify or create. *Example: Update the borrower details for a book*
PATCH	Update	Used to modify some details about a resource. *Example: Change the author of a book*
DELETE	Delete	Remove a resource from the system. *Example: Delete a book from the library.*

REST – Request with NFVIS

Uri: https://{{NFVIS_IP}}/api/config/vm_lifecycle/tenants/tenant/admin/deployments?deep

Server   Resources   Parameters

- Client Request
  - Header:
    - Content-Type: application/json or application/xml
    - Authorization: basic username and password

  - Action
    - **Get**: Retrieve Data.
    - **Post**: Create new Record.
    - **Put**: Update a Record, if it does not exist, Create it.
    - **Delete**: Remove Record.

Response Status Codes: Did it work?

Status Code	Status Message	Meaning
200	OK	All looks good
201	Created	New resource created
400	Bad Request	Request was invalid
401	Unauthorized	Authentication missing or incorrect
403	Forbidden	Request was understood, but not allowed
404	Not Found	Resource not found
500	Internal Server Error	Something wrong with the server
503	Service Unavailable	Server is unable to complete request

Headers: Details and meta-data

Header	Example Value	Purpose
Content-Type	application/json	Specify the format of the data in the body
Accept	application/json	Specify the requested format for returned data
Authorization	Basic dmFncmFudDp2YWdyYW50	Provide credentials to authorize a request
Date	Tue, 25 Jul 2017 19:26:00 GMT	Date and time of the message

- Used to pass information between client and server

- Included in both REQUEST and RESPONSE

- Some APIs will use custom headers for authentication or other purpose

JSON Data Format

- Basic JSON `{"key": "value"}`

- Flat JSON
```
{
    "data": {
        "title": "A New Hope",
        "franchise": "Star Wars",
        "category": "Sci-Fi"
    }
}
```

- JSON Array
```
{
    "data": [{
        "title": "A New Hope",
        "franchise": "Star Wars",
        "category": "Sci-Fi"
    }, {
        "title": "Avengers: Endgame",
        "franchise": "Marvel",
        "category": "Action"
    }]
}
```

Example: Calling a REST API

method →

URL →

GET ▾ | {{NFVIS}}/api/config/vm_lifecycle/tenants/tenant/admin/deployments | Params | **Send** ▾ | Sa

Authorization | Headers (3) | Body | Pre-request Script | Tests ● | Cook

Key	Value	Description	⋯	**Bulk Edit**	P
☑ Content-Type	{{Content-Type}}				
☑ Accept	{{Accept}}				
☑ Authorization	{{Authorization}}				
New key	Value	Description			

Body | Cookies | Headers (9) | Test Results | | Status: **200 OK** | Time: **188 ms** | Siz

Pretty | Raw | Preview | JSON ▾ | ⇥ | 🗐 🔍 | Save Re

```
1   {
2       "vmlc:deployments": {
3           "deployment": [
4               {
5                   "name": "1527621039"
6               },
7               {
8                   "name": "1527622398"
9               },
10              {
11                  "name": "1527698789"
12              }
13          ]
14      }
15  }
```

← Response Body

Determining How to Use NFVIS APIs

- Understanding NFVIS REST calls – begin at documentation
  - [NFVIS REST Guide](#)
  - Navigate to Appropriate API Section

- Examine details of REST call of interest
  - Method required
  - URL
  - Additional data needed in body

API Reference for Cisco Enter...

Chapter: Resource APIs

› Chapter Contents

- CPU Allocation Summary API
- Resources CPU APIs
- Resource Precheck APIs
- Resources VM APIs

URL

CPU Allocation Summary API

This API provides the total number of CPUs available for use, and the total number of CPUs that are already used by VMs.

Table 1. CPU Allocation Summary API

Action	Method	Payload Required	API
To get information on the number of CPUs allocated to VMs and the CPUs that are already used by VMs.	GET	No	api/operational/resources/cpu-info/allocation

method

System Monitoring APIs

System Operations APIs

SPAN Session and Packet Capture APIs

Upgrade Package APIs

Factory Default Reset APIs

Using APIs

- Option 1: CURL Command in CLI
  - cURL (Client URL) – Command line tool to transfer data by using URL based syntax.

curl -k -i -u admin:Cisco#123 -H Accept:application/vnd.yang.data+xml -H content-type:application/vnd.yang.data+xml -X POST https://201.0.0.157/api/config/vm_lifecycle/tenants/tenant/admin/deployments --data

'<deployment><name>ISRv_SW_dep</name><vm_group><name>VM_GROUP_1</name><image>ISRv_IMAGE</image><flavor>ISRv-small</flavor><bootup_time>600</bootup_time><recovery_wait_time>0</recovery_wait_time><recovery_policy><action_on_recovery>REBOOT_ONLY</action_on_recovery></recovery_policy><interfaces><interface><nicid>0</nicid><network>int-mgmt-net</network><port_forwarding><port><type>ssh</type><protocol>tcp</protocol><vnf_port>22</vnf_port><external_port_range><start>20022</start><end>20022</end></external_port_range></port><port><type>telnet</type><protocol>tcp</protocol><vnf_port>23</vnf_port><external_port_range><start>20023</start><end>20023</end></external_port_range></port></port_forwarding></interface><interface><nicid>1</nicid><network>GE0-0-SR-IOV-1</network></interface><interface><nicid>2</nicid><network>GE0-1-SR-IOV-1</network></interface></interfaces><scaling><min_active>1</min_active><max_active>1</max_active></scaling><kpi_data><kpi><event_name>VM_ALIVE</event_name><metric_value>1</metric_value><metric_cond>GT</metric_cond><metric_type>UINT32</metric_type><metric_collector><type>ICMPPing</type><nicid>0</nicid><poll_frequency>3</poll_frequency><polling_unit>seconds</polling_unit><continuous_alarm>false</continuous_alarm></metric_collector></kpi></kpi_data><rules><admin_rules><rule><event_name>VM_ALIVE</event_name><action>ALWAYS log</action><action>TRUE servicebooted.sh</action><action>FALSE recover autohealing</action></rule></admin_rules></rules><config_data><configuration><dst>bootstrap_config</dst><variable><name>TECH_PACKAGE</name><val>security</val></variable><variable><name>ngio</name><val>enable</val></variable></configuration></config_data></vm_group></deployment>

Using APIs

- Option 2: Postman
  - Postman is GUI based tool to simplify using REST calls.

Postman
Easy to Learn, API Development Tool

Method

API
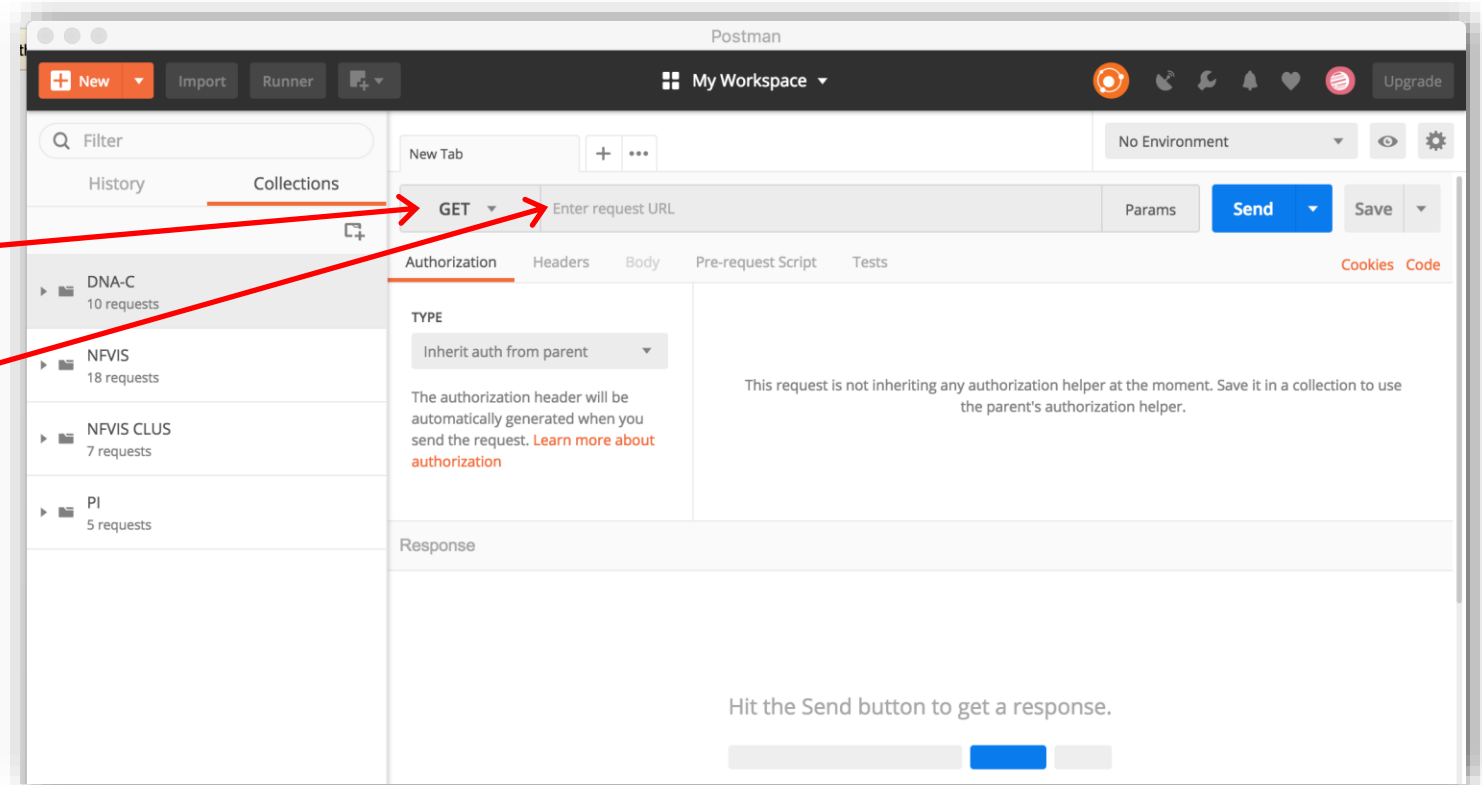
Get VNF Inventory List Using Postman

More Efficient Use of Postman

- Variables – used to quickly change values in saved REST calls
  - Environment
  - Collection

- Scripts – used to execute code against returned data
  - Javascript
  - Set Variables

Variables in Postman

- Rather than change dynamically changing objects, use variables to complete

- Variables can be set in Environment or Global

- Can then be called for API tests

Why Environment Variables

If we look at this API call...

GET ▼	https://10.91.13.183/api/config/vm_lifecycle/tenants/tenant/admin/deployments
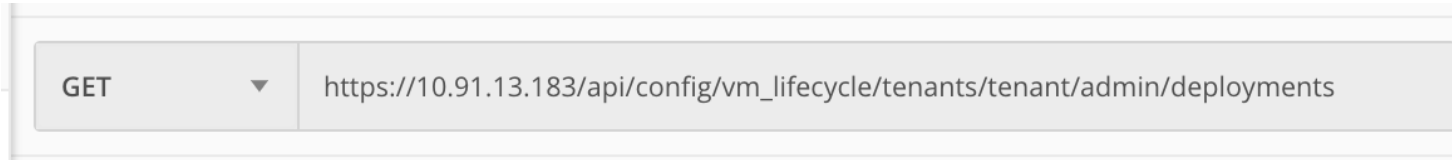
What happens if we change the NFVIS we're using?

Not a big deal to change this value for one or a few API calls...

But what if there are dozens of calls?

Simple Environment Variable Example

Using Environment Variable

We Can Use Output to Assign Variables

Postman Function *Tests*:

- Allow execution of Javascript coding to perform actions after information is returned by the API call.

- Can be used to populate Environment or Global Variables.

Then Use New Variable in Future API Call

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How About Deploying a VNF?

We can use a REST API call for that too…


```
{
  "deployment": {
    "name": "RTP-vEdge",
    "vm_group": {
      "name": "RTP-vEdge",
      "image": "vedge-18-3-1.tar.gz",
      "flavor": "vEdge-Small",
      "vim_vm_name": "RTP-vEdge",
      "bootup_time": -1,
      "recovery_wait_time": 0,
      "interfaces": {
        "interface": [{
          "nicid": 0,
          "model": "virtio",
          "network": "mgmt-net"
        },
        {
          "nicid": 1,
```

POST {{NFVIS}}/api/config/vm_lifecycle/tenants/tenant/admin/deployments

Send   Save

Params   Authorization ●   Headers (2)   Body ●   Pre-request Script   Tests   Cookies Code

none   form-data   x-www-form-urlencoded   raw   binary   Text

What Can We Do With All This?

Combine API's with Programming Languages
- Python - becoming defacto language for network programming
- Go
- Ruby
- Others

Allows more powerful methods of automating deployment

Example:
www.github.com/rshoemak/NFVIS-coding

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- Deploying VNFs with the GUI
- Lab Modules 3 & 4
- Monitoring and Troubleshooting a Virtual Environment
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- Leveraging APIs to Deploy VNFs
- **Lab Module 6**
- Network PnP
- Orchestration – Cisco DNA Center
- Lab Modules 7 & 8
- Orchestration – NSO and vManage
- Conclusion and Use Cases

Lab Module 6

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Network PnP

PnP Solution Components

DNA-C (PnP Server) (1)
Auto-provision device w/ images & configs.

DNA Center

Policy | Automation | Analytics

Customer On-Premise

PnP Connect
Cloud-based device discovery

PnP Connect (4)
Redirects devices to On-Prem DNA-C

PnP Protocol (3)
HTTPs/XML based Open Schema protocol

SUDI Capable devices

PnP Agent (2)
Cisco® switches, routers, and wireless AP

PnP Helper App* (5)
Delivers bootstrap status and troubleshooting checks

* DNA-C Support in Roadmap

PnP Overview

- Cisco Network Plug-and-Play solution provides
  - Simple, secure and unified approach to provision devices with zero-touch deployment
  - Designed for users to instantiate a device into network, provision it without manual intervention.

- PnP Agent
  - Runs on NFVIS device
  - Auto-discover PnP server
  - Provides device UDI (Serial Number, PID) to server
  - Bulk provisioning of user credentials

- When NFVIS platform is powered on, Cisco Network PnP agent discovery process starts. This, in turn, discovers the IP address of the PnP Server.

PnP Server Discovery Options

Automated

1. DHCP with option 43
   PnP string: 5A1D;B2;K4;I172.19.45.222;J80 added to DHCP Server

2. DNS lookup
   pnpserver.<your domain> resolves to Cisco DNA Center IP Address

3. Cloud re-direction https://devicehelper.cisco.com/device-helper
   Cisco hosted cloud, re-directs to on-prem Cisco DNA Center IP Address

Manual

4. CLI or NVFIS Local Portal GUI configuration

PnP DHCP with option 43

The Cisco PnP agent automatically discovers the IP address of the Cisco Network PnP server specified in the DHCP option 43 string.

Example of DHCP options 43 configs on DHCP server:

```
ip dhcp pool P_ENCS_18375
host 172.19.183.75 255.255.255.0
hardware-address 00f2.8bc3.4a54   //* mac address of NFVIS WAN Bridge
default-router 172.19.183.1
domain-name cisco.com
dns-server 172.19.183.147
option 43 ascii "5A;B2;K4;I172.19.152.41;J80”
```

PnP DHCP with option 43

```
option 43 ascii "5A1D;B2;K4;I172.19.152.41;J80"
```

I: PnP Server IP

J80: Remote Server Port 80

K4: Protocol HTTP

B2: Address type IPv4
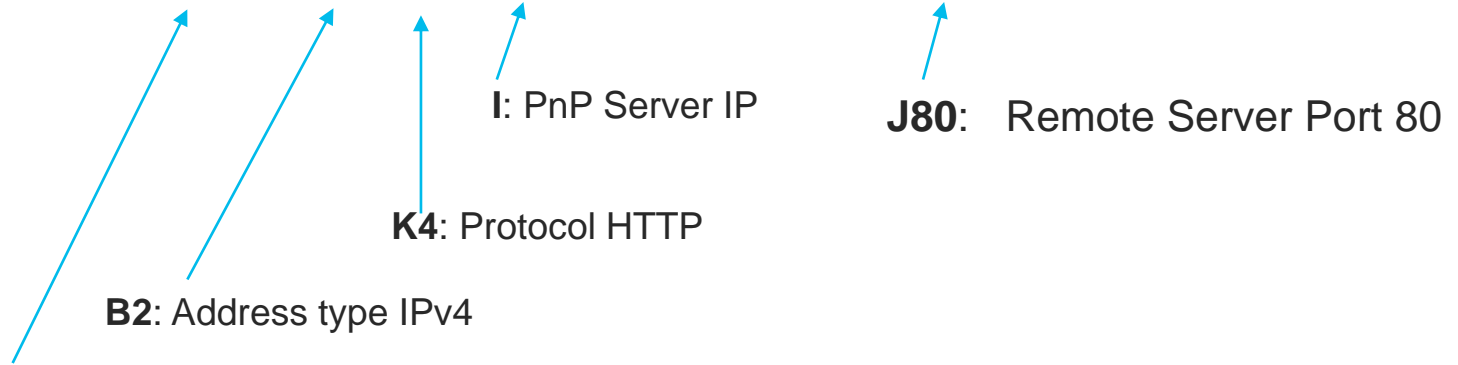
5A1D: PnP DHCP ID, version 1 and debug on

For more details on DHCP option 43 for PnP please see:
https://www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Plug-and-Play/solution/guidexml/b_pnp-solution-guide.html

Old DevNet article archive & Best reference for PnP Option 43 syntax)
https://d1nmyq4gcgsfi5.cloudfront.net/site/open-plug-n-play/learn/learn-open-pnp-protocol/

PnP DHCP options 43 – CLI

```
nfvis# show system settings-native wan dhcp

system settings-native wan dhcp enabled
system settings-native wan dhcp offer true
system settings-native wan dhcp interface wan-br
system settings-native wan dhcp fixed_address 172.19.152.252
system settings-native wan dhcp subnet_mask 255.255.255.0
system settings-native wan dhcp gateway 172.19.152.1
system settings-native wan dhcp lease_time 86400
system settings-native wan dhcp message_type 5
system settings-native wan dhcp name_servers 172.19.152.221
system settings-native wan dhcp server_identifier 172.19.152.221
system settings-native wan dhcp renewal_time 43200system settings-native wan dhcp rebinding_time 75600
system settings-native wan dhcp vendor_encapsulated_options "5A;B2;K4;I172.25.217.8;J80"
system settings-native wan dhcp domain_name NA
system settings-native wan dhcp renew 2017-01-20T09:44:42-00:00
system settings-native wan dhcp rebind 2017-01-20T21:14:13-00:00
system settings-native wan dhcp expire 2017-01-21T00:14:13-00:00
```

PnP DHCP options 43 – CLI

```
nfvis# show pnp
pnp status response "PnP Agent is running\n server-connection\n    status: Success\n
time: 20:55:13 Sep 28\nbackoff\n    status: Success\n    time: 20:55:13 Sep 28\n"
pnp status ip-address 172.19.152.41
pnp status port 443
pnp status transport https
pnp status created_by dhcp_opt43
pnp status dhcp_opt43 1
pnp status dns_discovery 0
pnp status cco_discovery 0
pnp status timeout 60
nfvis#
```

PnP DHCP options 43 – Local UI

PnP DHCP options 43 UI

PnP DNS Lookup

Construct a fully qualified domain name (FQDN), using the preset hostname "**pnpserver**", based on the network domain name configured on the DHCP server.

Example of DNS lookup configurations on DHCP server:

```
ip dhcp pool P_ENCS_18375
     host 172.19.183.75 255.255.255.0
     hardware-address 00f2.8bc3.4a54
     default-router 172.19.183.1
     domain-name cisco.com
     dns-server 172.19.183.147
     ip host pnpserver.cisco.com 172.19.152.41
     ip dns server
```

PnP DNS Lookup – Local UI

- Click Edit, Select Method : Automatic and Options : DNS Discovery

- Click Save. A new PnP DNS Discovery starts.

Verify PnP DNS Lookup - CLI

```
nfvis# show pnp
pnp status response "PnP Agent is running \n server-connection\n
status: Success\n    time: 02:41:17 Sep 29\nbackoff\n    status: Success\n
time: 02:41:17 Sep 29\n"
pnp status ip-address 172.19.152.41
pnp status port 443
pnp status transport https
pnp status created_by dns_discovery
pnp status dhcp_opt43 0
pnp status dns_discovery 1
pnp status cco_discovery 0
pnp status timeout 60
nfvis#
```

PnP Cloud Redirect

- This method uses the Cisco Cloud Device Redirect tool available in the Cisco Software Central.
  - User needs to have a Cisco CCO and Smart Account in advance.

Example of Cloud Redirect configurations on DHCP server:

```
ip dhcp pool P_ENCS_18375
    host 172.19.183.75 255.255.255.0
    hardware-address 00f2.8bc3.4a54
    default-router 172.19.183.1
    domain-name cisco.com
    dns-server 172.19.183.147
    ip host devicehelper.cisco.com 64.101.32.10
    ip dns server
```

PnP Cloud Redirect – Cisco Account

In order to use Cisco Cloud Device Redirect tool, user needs to have a Cisco Account in advance.

Launch Cisco Software Central at https://software.cisco.com in browser and **Click "Login In"**

PnP Cloud Redirect (cont'd)

English [Change] 👤   📖 PnP ▾   PNP· ⋮ ▾

Plug and Play Connect

Feedback Support Help

Devices | Controller Profiles | Network

| ➕ **Add Devices...** | ✏️ Edit Selected... | 🗑 Delete Selected... | ⟳ | | | | |

☐	Serial Number	Base PID	Product Group	Controller	Last Modified	Status	Actions
	[ ] ✕	[ ] ✕	Any ▾	Any ▾	📅 Select Range ▾	Any ▾	Clear Filters
☐	FDO213905WF	ISR4331/K9	Router	SDWAN-EFT-TME1	2018-Jun-06, 20:55	Redirect Successful	Show Log... ▾
☐	JAE16510AZ0	ASR1002-X	Router	SDWAN-EFT-TME1	2018-Jun-06, 18:57	Pending (Redirection)	Show Log... ▾
☐	JMX2023X000	IR809G-LTE-GA-K9	Router	ETI-FND-POC-DCLOUD	2018-May-29, 12:59	Redirect Successful	Show Log... ▾
☐	FTX2111Z093	IR829GW-LTE-NA-AK9	Router	ETI-FND-POC-DCLOUD	2018-May-17, 09:33	Redirect Successful	Show Log... ▾
☐	JMX2017X04S	IR809G-LTE-GA-K9	Router	ETI-FND-POC-DCLOUD	2018-May-15, 12:07	Redirect Successful	Show Log... ▾

cisco Live!

Verify PnP Cloud Redirect

```
nfvis# show pnp
pnp status response "PnP Agent is running \n redirection\n    status: Success\n
time: 13:32:29 Sep 29\nserver-connection\n    status: Success\n    time:
13:34:49 Sep 29\nbackoff\n    status: Success\n    time: 13:34:49 Sep 29\n"
pnp status ip-address 172.19.152.41
pnp status port 443
pnp status transport https
pnp status created_by cco_discovery
pnp status dhcp_opt43 0
pnp status dns_discovery 0
pnp status cco_discovery 1
pnp status timeout 60
nfvis#
```

PnP Static Discovery

- Provide PnP Server IP (e.g. 100.64.0.101) and Port 80
- Click Save. A new PnP static http discovery starts.

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Orchestration

Cisco DNA Center

Cisco DNA Automation
Simplified Deployment of Physical/Virtual Branches
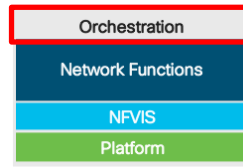
Onboard WAN devices & Services via 3 easy steps

APs

Office Site

ISRv/ENCS

WAN

Network Services DC

ISE

DHCP

Cisco DNAC
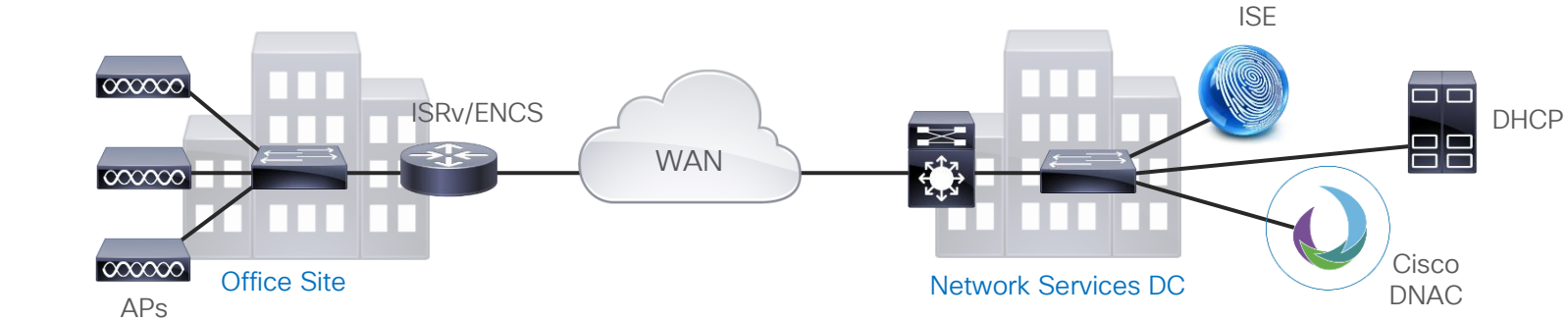
Branch Deployment in Minutes

1. Configure Network Settings, Service Provider & IP Pools

2. Design a Routing & NFV Network Profile

3. Assign to Sites & Provision Network Devices

Provisioning Process Flow

Design

```
┌─────────────────┐     ┌─────────────┐     ┌─────────────┐     ┌─────────────┐     ┌─────────────────┐
│ Provide         │ →   │ Specify     │ →   │ Define IP   │ →   │ Provide SP  │ →   │ Create Profile  │
│ Network Design  │     │ Credentials │     │ Pools       │     │ Settings    │     │ and Attach      │
│ Settings        │     │             │     │             │     │             │     │ Profile to Site │
└─────────────────┘     └─────────────┘     └─────────────┘     └─────────────┘     └─────────────────┘
```

Provision

```
┌─────────────────┐     ┌─────────────┐     ┌─────────────┐     ┌─────────────────┐     ┌─────────────────┐
│ PnP or Discover │ →   │ Claim/Assign│ →   │ Add device  │ →   │ Provision Device│ →   │ Specify Input   │
│ Devices         │     │ Device to a │     │ to          │     │                 │     │ parameters      │
│                 │     │ Site        │     │ Inventory   │     │                 │     │                 │
└─────────────────┘     └─────────────┘     └─────────────┘     └─────────────────┘     └─────────────────┘
```

ENCS based Virtual Branch Profile

| 1 Router WAN Configuration | 2 Router LAN Configuration | 3 Integrated Switch Configuration | 4 Custom CLI Configuration |

Virtual Services using Cisco Validated Designs
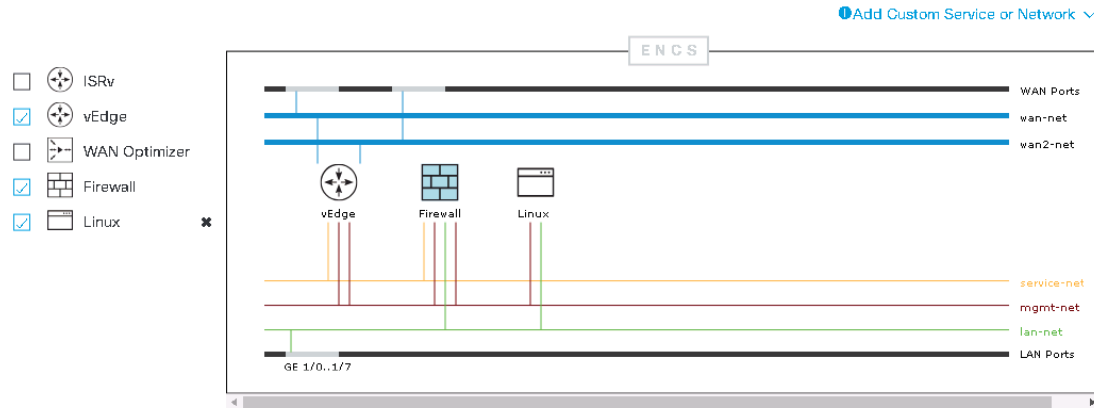
Support for 3rd party Services and App Hosting
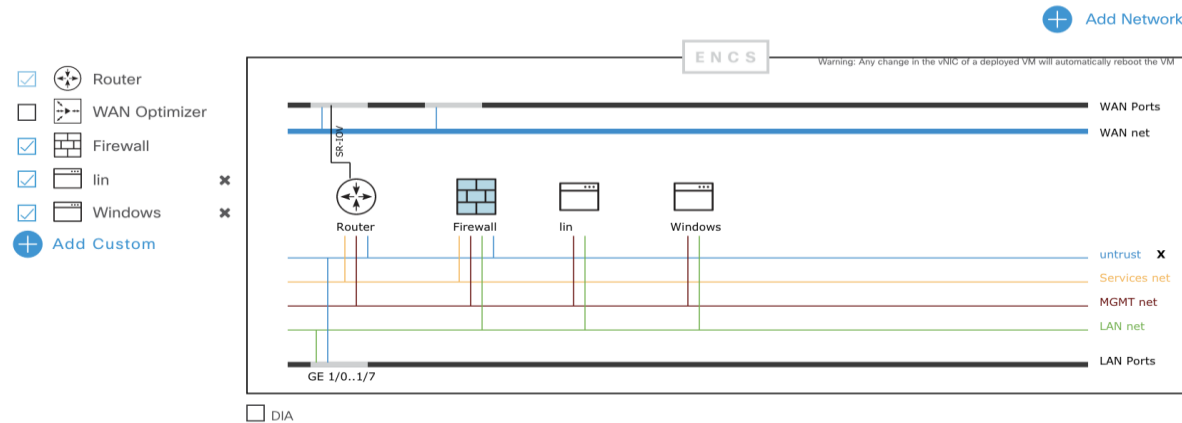
Add LAN Configurations

Router WAN Configuration

2 Router LAN Configuration

3 Integrated Switch Configuration

4 Custom Configuration

5 Summary

ENCS
PODXX

Link Type*

GigabitEthernet

○ L2   ○ L3   ○ Skip

Type*	VLAN ID/Allowed VLAN*	Description*	
Access	100	Data	⊗
Access	200	Voice	⊗
Access	300	Wireless	⊗

➕ Add Row

Add Additional Integrated Switch Configuration

DNA CENTER — DESIGN · POLICY · PROVISION · ASSURANCE · PLATFORM

Add Routing & NFV Profile

Router WAN Configuration — Router LAN Configuration — 3 Integrated Switch Configuration — 4 Custom Configuration — 5 Summary

L2 FOR ENCS - PODXX

Type*	VLAN ID/Allowed VLAN*	Description*
Access	100	Data
Access	200	Voice
Access	300	Wireless
Trunk	100,200,300	Trunk to External Switch

+ Add Row

Cancel · Back · Next

Custom Configuration Templates

Add Routing & NFV Profile

| ✓ Router WAN Configuration | ✓ Router LAN Configuration | ✓ Integrated Switch Configuration | 4 Custom Configuration | 5 Summary |

The following custom configurations are optional. You may skip the step and apply the configurations any time in the Network Profiles.

Attach Template(s)

Device Type	Template	Tag Name
NFVIS	✕ ⌄	PODXX
Cisco Integrated Services Virtual Router	✕ ⌄	PODXX

Assign the Profile to a Site

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Provision Router

Add LAN Parameters

✓ Confirm Profile   ✓ Router WAN Configuration   ③ **Router LAN Configuration**   ④ Custom Configuration   ⑤ Summary

s118_120_118-120dua
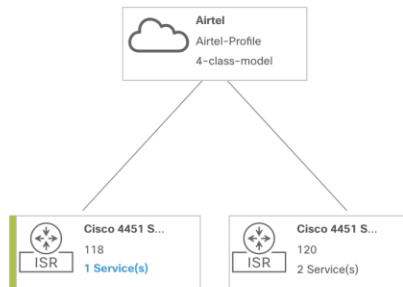
	Link Type*	Interface*	Option	IP-Pool/IP*
ISR 118	GigabitEthernet	GigabitEthernet0	DHCP	10.151.61.128/27
ISR 120	GigabitEthernet	GigabitEthernet0	DHCP	10.151.61.128/27

○ L2   ◉ L3   ○ Skip

Protocol Routing
OSPF

Protocol Qualifier
100

Preview Summary

SD-WAN
Integration

vEdge Cloud Provision Workflow in Cisco DNA Center

Select ENCS and Map to Site → vEdge – Input Parameters Obtained from vManage → Provision vEdge on ENCS with Day 0 config → Connect vEdge to vManage
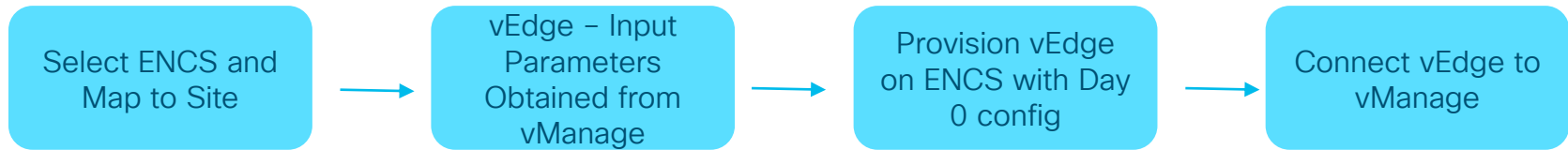
vEdge Cloud Onboarding through Cisco DNA Center

vManage Properties for Integration
- IP Address
- Username/ Password
- Port Details
- vBond information
- Organization Name
- Certificate for onboarding vEdge*

*Only needed if SD-WAN management deployment is using on-prem system with on-prem CA for PKI

Virtual vEdge On-boarding on ENCS
Provisioning Flow

Integration via APIs to vManage
- One Time Password
- UUID
- Service Chain vEdge with other services
- Day 1 registration of vEdge with vManage

vEdge Cloud and NFVIS Interface Mapping

vEdge Cloud	vEdge Cloud NIC Map KVM	vEdge Cloud NIC Map NFVIS
eth0	vNIC1	vNIC0
ge0/0	vNIC2	vNIC1
ge0/1	vNIC3	vNIC2
ge0/2	vNIC4	vNIC3
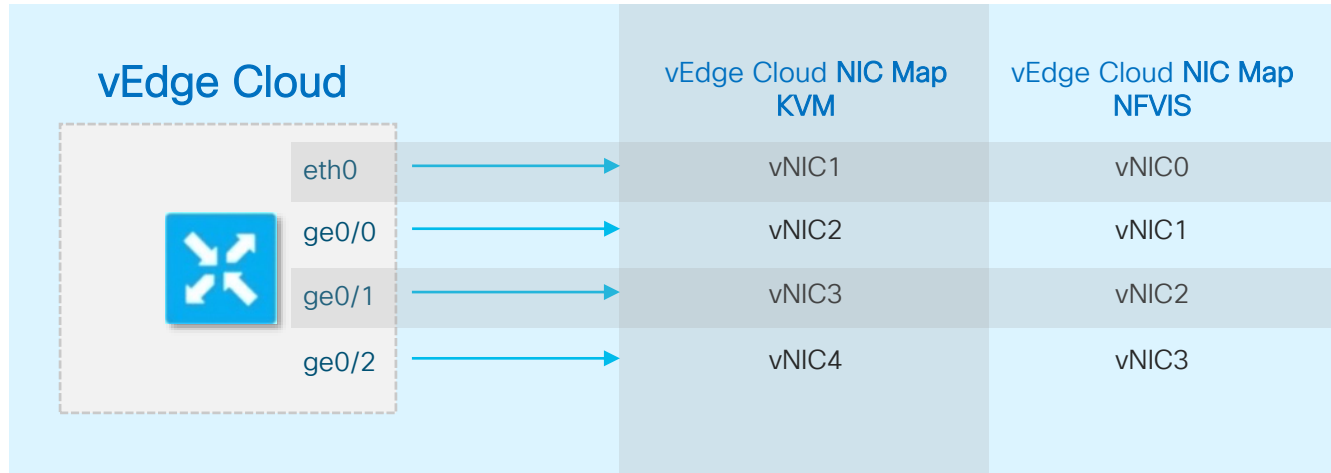
KVM NIC starting at 1 and NFVIS NIC starting at 0

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Lab Modules 7 - 8

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Network Service Orchestrator

Network Service Orchestrator (NSO) for Service Providers
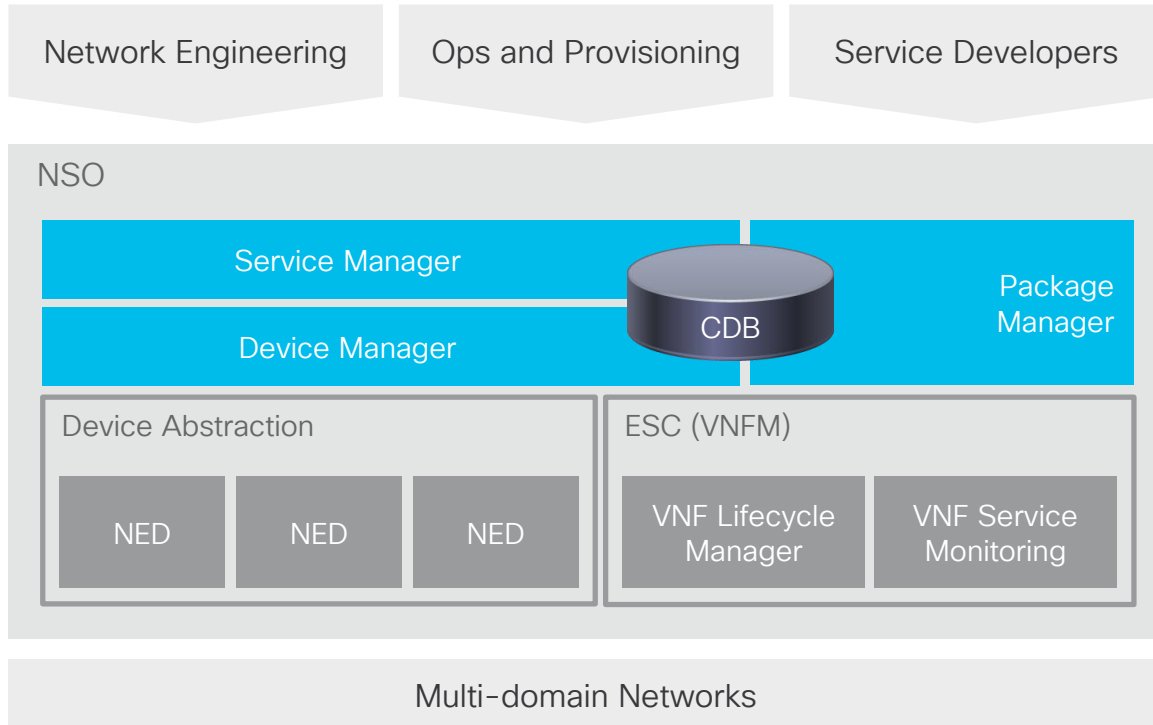
- Model-driven end-to-end service lifecycle and customer experience in focus
- Seamless integration with existing and future OSS/BSS environment
- Loosely-coupled and modular architecture leveraging open APIs and standard protocols
- Orchestration across multi-domain and multi-layer for centralized policy and services across entire network

Core Function Packs

- Ready-made implementations for specific features

- E.g. NFVO, ENFV, SD-WAN

- Productized, TAC supported

- 80/20 rule – reduce implementation cost and TTM

Current Core Function Packs

SD-WAN

vBranch
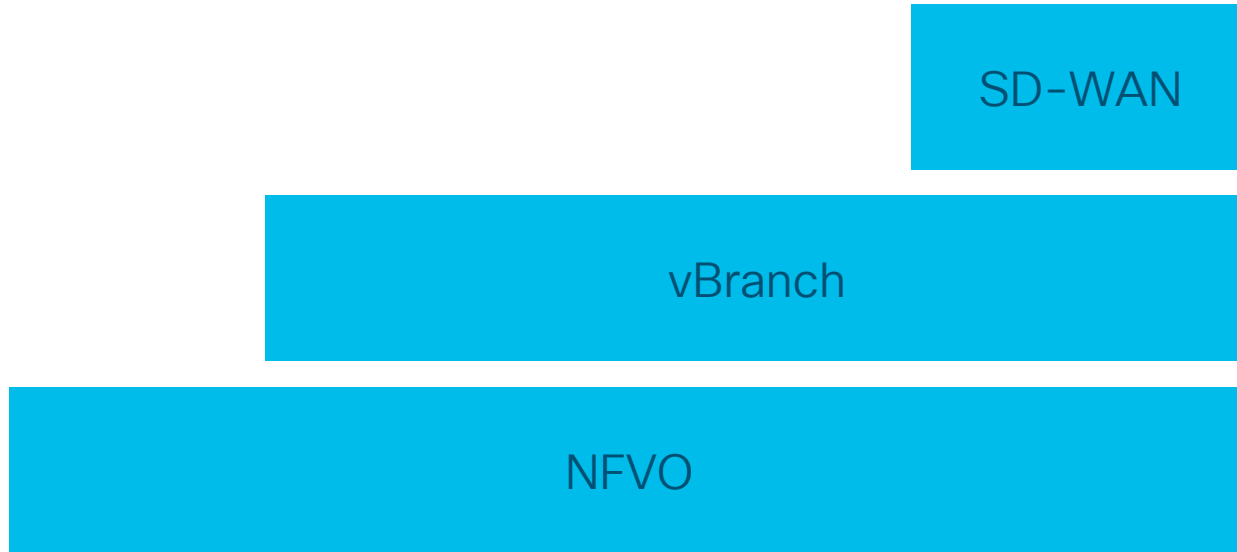
NFVO

NFV Orchestration with NSO NFVO

NFV Orchestration Challenges
Lessons Learned

CISCO'S NFVO PROVIDES...	...TO AVOID
A flexible software platform with open and ETSI-aligned architecture and interfaces	Proprietary technologies with specialized tooling driving long integration projects

NFV Orchestration Challenges
Lessons Learned

CISCO'S NFVO PROVIDES...	...TO AVOID
A flexible software platform with open and ETSI-aligned architecture and interfaces	Proprietary technologies with specialized tooling driving long integration projects
A fully multi-vendor stack to accelerate VNF onboarding to smallest effort *possible*	Hard-coded assumptions on VNF design and behavior requiring fundamental updates

NFV Orchestration Challenges
Lessons Learned

CISCO'S NFVO PROVIDES...	...TO AVOID
A flexible software platform with open and ETSI-aligned architecture and interfaces	Proprietary technologies with specialized tooling driving long integration projects
A fully multi-vendor stack to accelerate VNF onboarding to smallest effort *possible*	Hard-coded assumptions on VNF design and behavior requiring fundamental updates
An integrated set of lifecycle operations on network service and VNF-level	Procedural operations leading to expensive change life cycle

NFVO High Level Architecture

Service Lifecycle

VNF Lifecycle

NFVO: High Level Architecture Mapping

RFS Provisioning and Activation
Cisco NSO

- RFS Services
- VNFD, NSD Catalogue
- NSRs and VNFRs
- NFVI Resources

NFV Orchestrator (NFVO)
NSO NFVO Component

VNF   VNF   VNF

Or-Vnfm

VNF Manager (VNFM)
Cisco ESC

(Or-Vi)

NFV Infrastructure (NFVI)

Virtual Infrastructure Manager (VIM)

Service Lifecycle

VNF Lifecycle
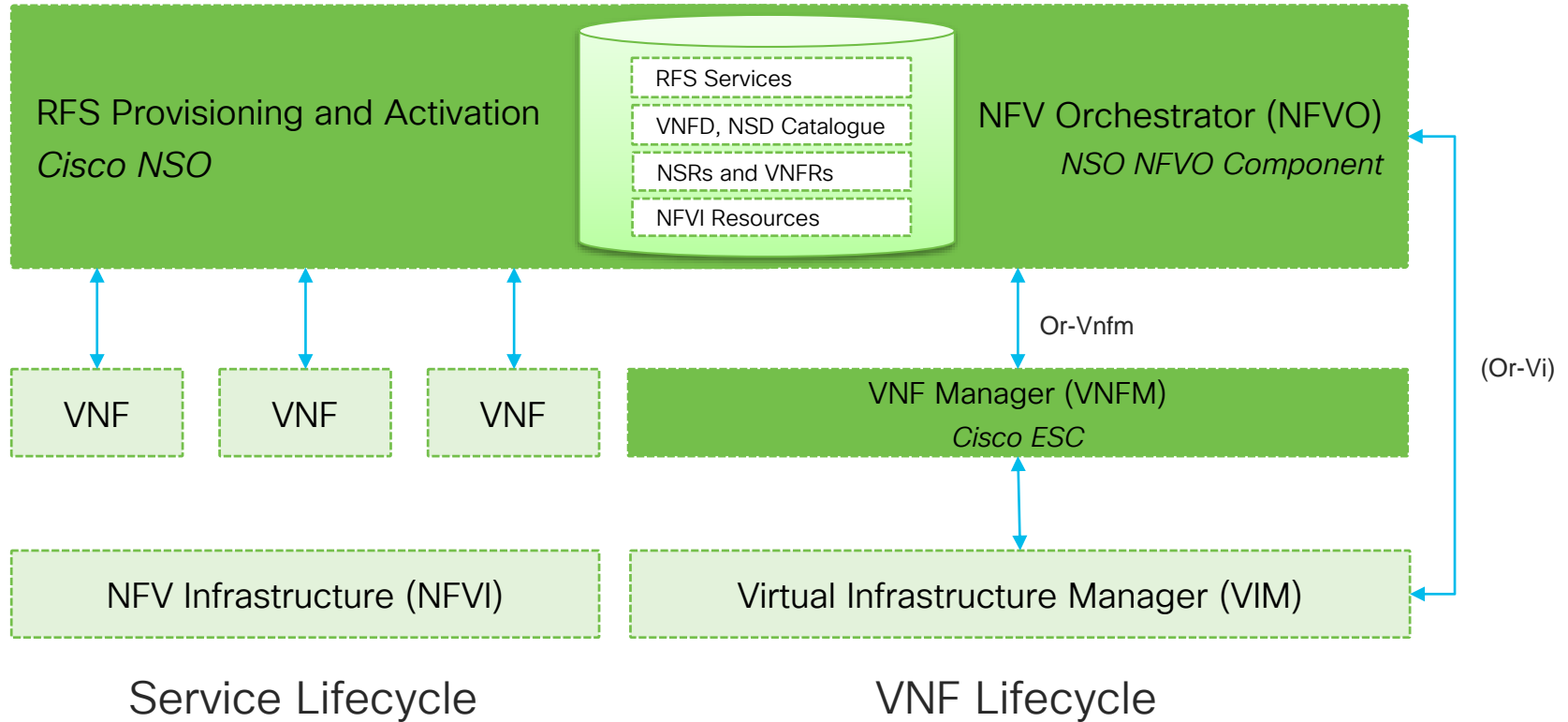
NSO vBranch Core Function Pack for ENFV Automation

ENFV Automated Operations – I
Branch CPE fully operational in minutes

Customer or Operator Portal

1. Pre-provision CPE
   Select branch template
   and enter device serial#

NSO w vBranch CFP

4. PnP request

2. Configure PnP
   Enter PnP server IP

5+. Configure CPE and VNFs

3. Restart
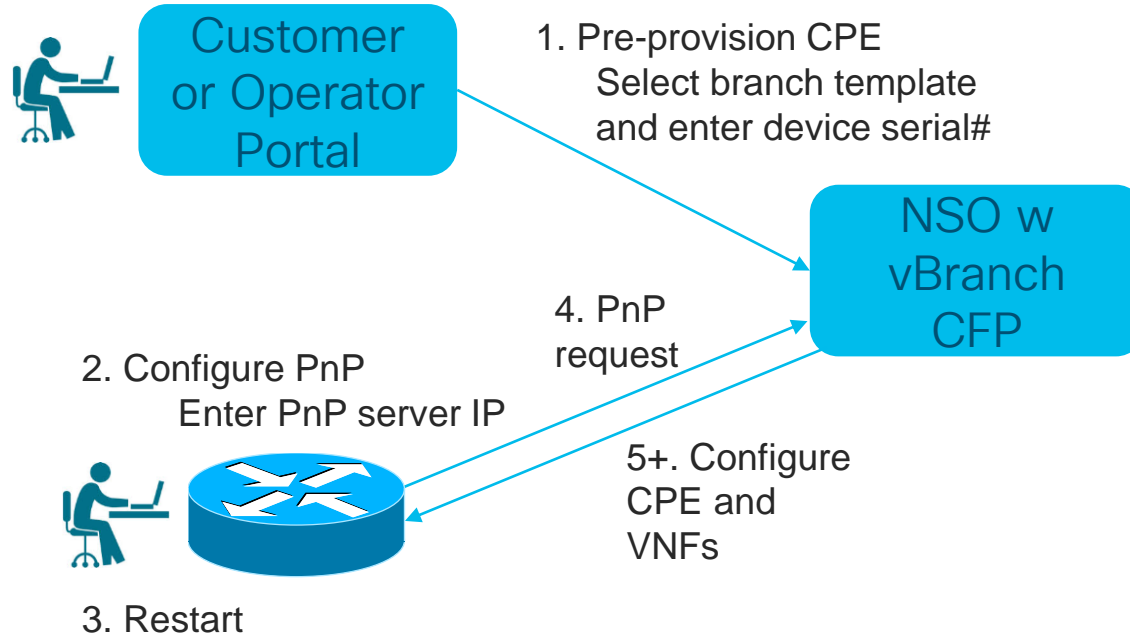
ENFV Automated Operations – II
Branch CPE fully operational in minutes
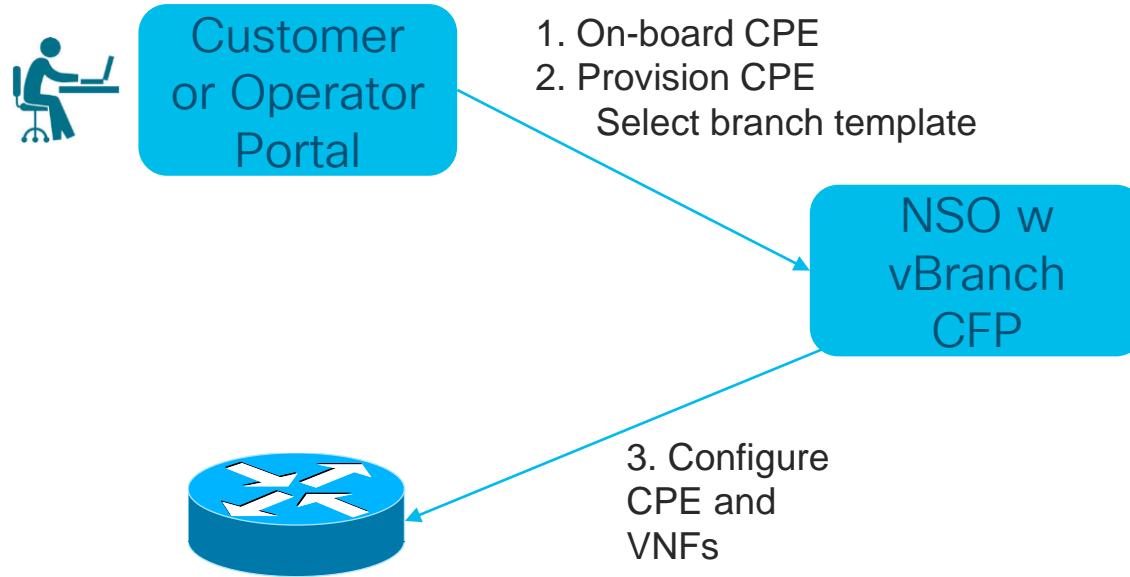
Definitions: Configuration Types

- Bootstrap configuration (Day-0)
  - e.g. IP/credentials/license
  - Set once

- Base configuration (Day-1)
  - Golden configuration – best practices for device role
  - Set once

- Service configuration (Day-2/n)
  - Configuration that changes over device lifetime, e.g. ACL, firewall rules, etc.
  - Create/Modify/Delete multiple times

Recent Release Enhancements

vManage NFV Automation workflow for SDWAN

Minimum Releases Required		
vManage	NFVIS	SDWAN
20.1.1	4.1.1	19.2.1 vedge-cloud 17.1.1 ISRv

1 Define ENCS device profile with services (vEdge Router) through ND workflow

Upload Serial File from Viptela Operations. Associate Template to vEdge UUID.

vManage

Control and Policy Elements
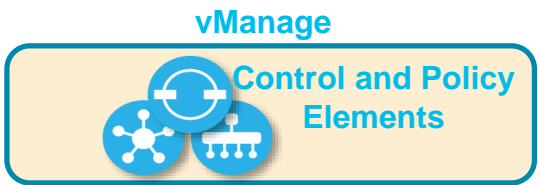
vBond

4 ENCS Device connects to vBond. vBond validates the ENCS device and sends the vManage IP.

Redirect Server Customer Smart Account — One place to manage all Cisco software assets

5 Device control connection

6 As part of device configuration, vManage pushes device settings along with service configs. If service is a vedge, it generates and downloads the cloud-init config file which contains UUID, vBond IP, System IP, Org-name and OTP.

8 vEdge control connection

9 Initial vEdge configuration from default template from vManage
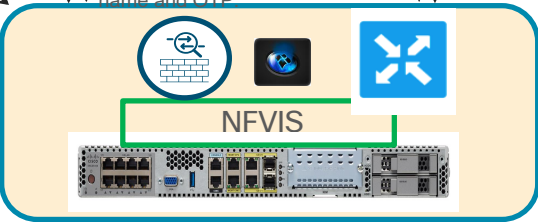
vEdge Service instantiated and loaded with Bootstrap Configuration cloud-int file. Chaining of VNFs occurs if requested. **7**

NFVIS

2 ENCS/NFVIS Device contacts cisco cloud redirect service devicehelper.cisco.com.

3 Device Serial Number is matched in Smart Account and redirected to vBond via PnP

vManage Capabilities for NFV
Image Repository
Network Design
VNF design
Deploy
Upgrade/Maintenance
Platform and VNF Monitoring

DEMO TIME

Agenda

- Intro to SD Branch
- Platforms (ENCS, CSP5K, UCS E-Series)
- VN Functions – Network Services
- NFVIS – Virtualization Layer
- Lab Modules 1 & 2
- VNF Packaging
- Deploying VNFs with the GUI
- Lab Modules 3 & 4
- Monitoring and Troubleshooting a Virtual Environment
- Lab Module 5
- Leveraging APIs to Deploy VNFs
- Lab Module 6
- Network PnP
- Orchestration – Cisco DNA Center
- Lab Modules 7 & 8
- Orchestration – NSO and vManage
- **Conclusion and Use Cases**

White box or not a White box

White Box – what could possibly go wrong?

All Cisco Stack vs White Box Stack

White Box Stack consists of...

"quality?"
"reliability?"
"support?"

"licensing cost?"
"compatibility with hardware?"
"support?" (again)

- COTS Hardware

- Unrelated hypervisor

- Disparate VNF collection

"cross component compatibility/duplication?"
"support?" (again) (multiple touch points now!)

- Orchestration?

"what's the glue?"
"Can it 'see' my hardware?"

so. many.
questions.

wobbling stack of uncertainty™

All Cisco Stack vs White Box Stack

All Cisco

vBranch is the key to success for the Cisco stack. Pre-defined templates are fully tested and supported strengthen the overall offer.

Opportunity to highlight synergies between products throughout the entire solution stack.

An integrated stack offers single vendor sourcing, and consistent cross-solution support.

| **MSX** *vBranch + SD-WAN* |
| ISRv | vEdge | ASAv | vWAAS | vWLC |
| **NFVIS** |
| **ENCS** |

| Orchestration |
| VNFs |
| Hypervisor |
| Hardware |

White Box

| **Non-Cisco** (Ericsson, etc..) |
| Cisco VNF | Palo Alto | Riverbed | Juniper | Fortinet |
| **Non-Cisco** *(KVM, Openstack, etc.)* |
| Cisco ? | Juniper | Advantech | Dell |

How well can a single orchestrator support multiple underlying components?

VNFs are on their own. Inconsistent licensing, hypervisor support, etc. weaken the stack.

How well does each VNF work with the chosen hypervisor?

No Cisco product in the white box space. ENCS and UCSE do not fit into white box model (pricing or technology)

Example: Cisco Stack vs Dell VEP 'white box'

vCenter?
The SD-WAN vendor's?
RedHat's? (CloudForm? OpenStack Platform Director?)
Some other vendor or open source*?

Good Luck! (you're going to need it)

Versa | VeloCloud | Silver Peak

Choice?: Three (only) vendors. SD-WAN only.

hypervisor
VMWare or RedHat

Extra cost: VMWare ESX isn't free if you want to manage it, RedHat isn't free. Both require support.

Single platform only, Ethernet only, Intel Xeon D2100 'up to'** 16 cores, 'up to' 64 RAM, max 1TB storage
Two expansion slots, but nothing for them

Summary of ENCS advantages over Competition

Superior Hardware Engineering

- Flexible, Expandable platform:
  4, 6, 8, 12 Core Options
  Up to 64MB RAM upgrades
  Up to 4 TB SATA, 1.2 TB SET, 1.8 TB SAS
  Disk Storage
  Upgradable in the Field !

- Support Multiple VNFs including those with high storage demand like vWAAS, vNAM, Windows Servers, Log Servers

- NIMs/WAN module support
  - 4G/LTE (without loosing integrated WAN ports)
  - T1/E1 (Up to 8 ports, no SFP with VNF/Core usage req'd as others)
  - xDSL*
  - Voice T1/E1, FXS, FXO*

Superior Operational Platform

- Integrated switch with 8 ports with PoE

- Hardware acceleration of VM–to–VM traffic flow (~30% performance improvement than our competitors for multiple VNFs)

- Support for Hardware RAID on 12" chassis for Redundancy

- Secure boot and BMC/CIMC Lights Out Server Management

- LTE modules can support Dying Gasp support that is available on NIMs. (SMS messaging)

- Enterprise class grade components (comparable to an ISR)

- Purpose built HW with > 7 Years lifetime versus general white box with ~ 3 Years

* Roadmap

NFVIS – True Network Hypervisor

- Designed Specifically for Enterprise deployments
  - Targeted for Networking teams in Enterprise organizations
- Optimized for the deployment and monitoring of Virtual Network Functions
  - Built-in VM monitoring capability allows for auto restart of VNFs when down
  - Avoids expensive truck rolls to remote sites
- Rich Open APIs
  - Industry standard API that allows integration with any Orchestration system
  - APIs available for both RESTConf and NETConf
  - APIs support includes
    - VM deployment
    - VM health monitoring
    - System resource (compute/memory/storage) management

- Zero touch deployment
  - Embedded PnP Client in NFVIS enables true Zero Touch Deployment model without any human intervention
  - Allows for quick and error free deployment of network services
- Automatic Resource Optimization for improved network performance
  - Optimized use of CPU, Memory and Storage for maximum performance of the different VNFs.
- Management GUI bundled in with NFVIS
  - Easy to use GUI eliminates complexity of dealing with the underlying hypervisor
  - Provides ability to draw network topology and instantiate a virtual branch
- Open Architecture Software stack
  - Allows for easy onboarding of any 3rd party software
- Secure and Trusted Infrastructure Software
  - Security tested and certified
  - FIPS and Common Criteria Certifications on Roadmap

Customer Use Cases
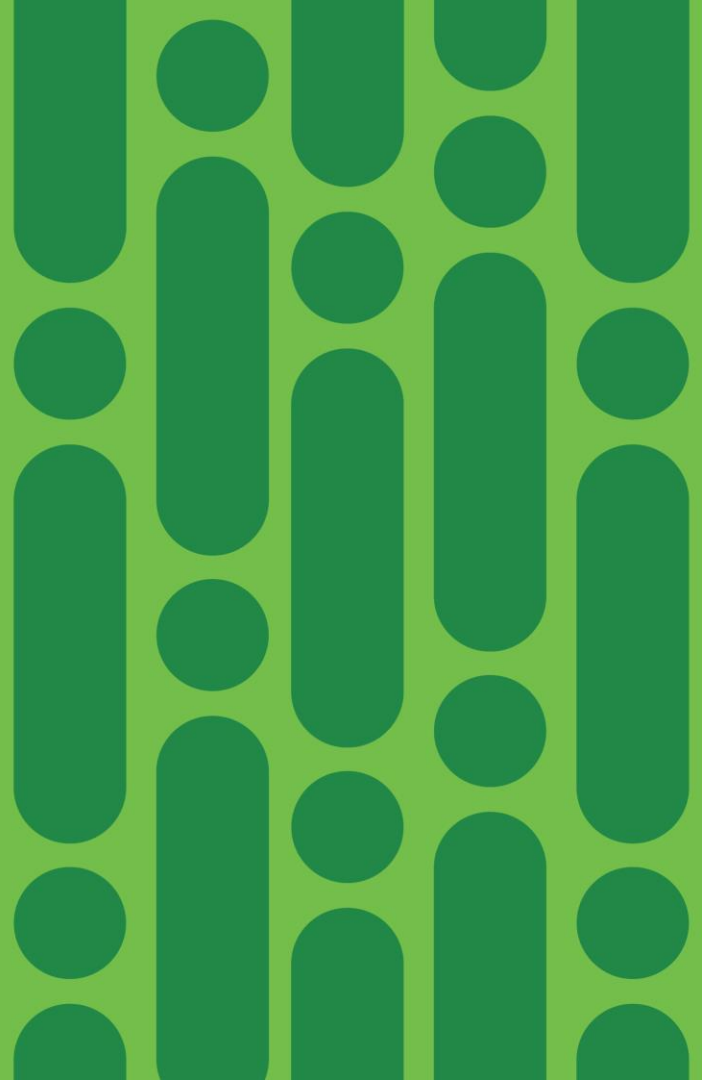
Straumann

- Global leader in tooth replacement and orthodontic solutions with 5000 employees across 5 continents

- Straumann currently deploys two Cisco 2951s, 1 Palo Alto Firewall and Riverbed for Wan Optimization across 70 locations.

- Converted them from a Riverbed customer to a vWAAS customer

- Preferred choice of FW vendor is PAN

- Want automation.
  - DNA Center addresses automation capabilities by adding editable topology, support for generic 3rd party VNF, adding custom networks etc.

From: 1 Routers, 1 FW and 1 vWAAS
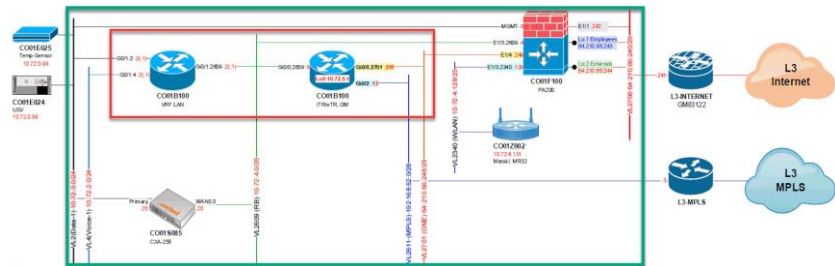
To: 1 Router, 1 FW and 1 vWAAS all in one platform
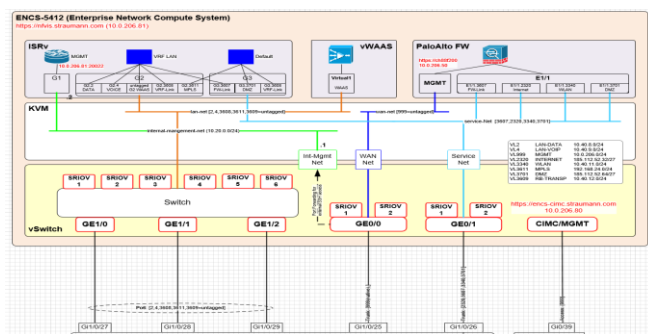
Investment Trust Company in NY

- Two major use case driving this
  - Redesign their WAN
  - Refresh their existing ISRs (2911s)

- As part of their WAN transformation they evaluated Cisco SD-WAN and other vendors
  - Cisco SD-WAN - Liked ease of manageability and feature
  - Liked the the ability to consolidate and host additional functions leveraging the Cisco SD-Branch/virtualization platform
  - This Cisco x86 platform also provided them with capability for backup connectivity to the sites with 4G-LTE

- Consolidated SD-WAN, WAN optimization and Firewall
  - The solution also provided them with High Availability between VNFs

Ethernet Transport	vEdge
LTE Transport	ISRv
WAN Opt	vWAAS
VNF Orchestration	DNA Center
SD-WAN Management	vManage
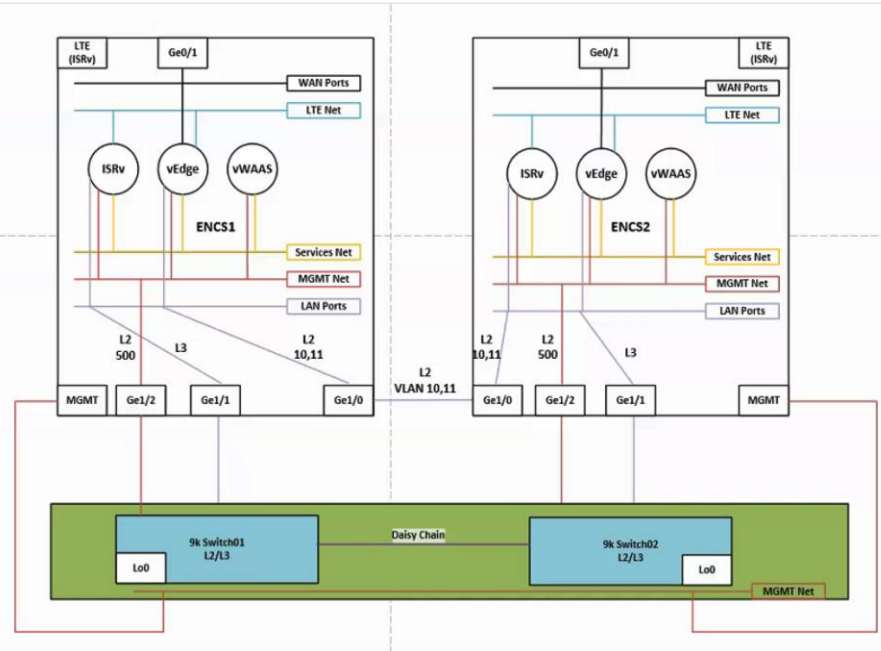
Multitenancy use-case with CSP5000

LAN Side

- vEdge VNFs connects to SR-IOV bridge on the lan side
- LAN side SR-IOV bridge also connects to physical interface
- dot1q connection from vEdge to lan interface
- Customer local network is on the lan side

vEdge TLOCs and ISRv LAN

- Each vEdge TLOC connects to SR-IOV
- ISRv has a dot1q interface for each transport inside separate VRFs connecting to SR-IOV bridge
- On SR-IOV, connection towards vEdge is configured as access while its configured as trunk towards ISRv

ISRv Transport

- ISRv is connected to 4XGE ports for WAN
- QoS is done on the ISRv interfaces connected to WAN uplinks
- Each WAN uplink interface is configured in the different VRFs

CSP5000

10GE port

SR-IOV connections vEdges

vEdge TLOCs

10Gig backplane

SR-IOV connections

ISRv

SR-IOV down to physical NIC

1GE port | 1GE port | 1GE port | 1GE port
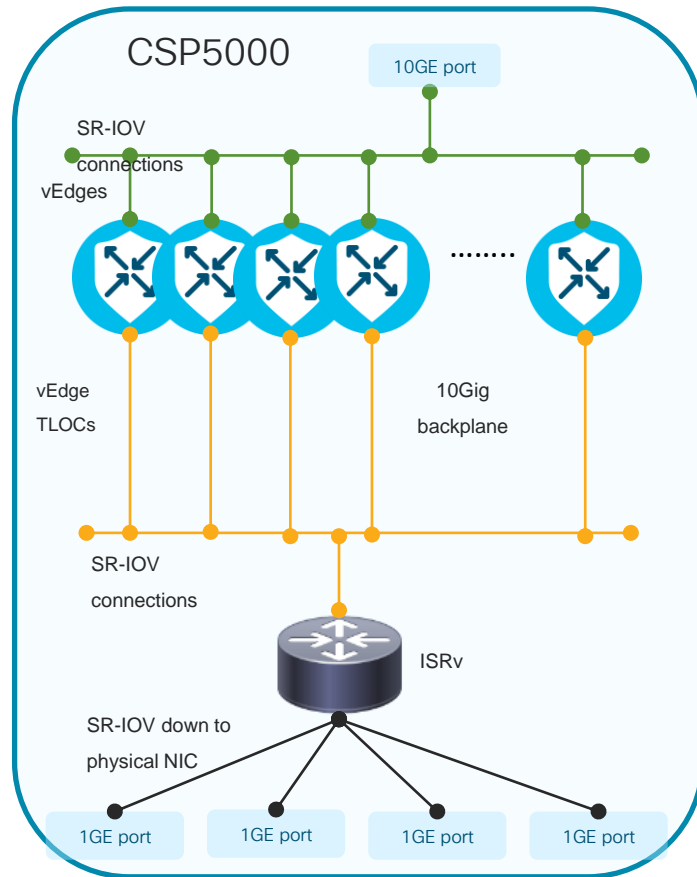
Bank in EMEA

- Cisco chosen after beating out the competition for 246 branches. Initial order for 165 branches.

- Key Requirements
  - Consolidation, Automation and Quickly isolate and troubleshoot problems.
  - Security is paramount with the bank.
    - Analyzed every component of the solution till it met their standards
  - Two key promises made by Cisco
    - Continue to invest in the solution
    - Complete Common Criteria certification

Why ENFV?

- Automation has been key
  - Bank has been exploring virtualization for a year now
  - Bank initially were engaged with other vendors. However no vendor was able to provide an end to end solution that included automation.
  - After running pilots at multiple branches and saw how easy it was to automate and spin up new sites, the customer was convinced with the Cisco solution.
  - They were able to eliminate multiple Windows workstations at every branch by virtualizing them
  - Chose the ENCS for its compactness

Large Bank in Canada

Bank's strategic investment is on Mobile Banking – Load the bank in a truck and drive it from location to location to grow their customer base

Wanted a solution that fits the following requirements

- IWAN enabled WAN router.
- Run routing, security and banking applications in a virtual environment
- 4G–LTE for WAN connectivity
- Hardware that can accommodate the above requirements and fits into the space available in the mobile trucks

Why ENFV?

- Hardware consolidation
- Integrated switch with POE capabilities
- Dual 4G primary WAN access
- IWAN Solution Integration
- Automation

Orange Business Services

- OBS has been one of the first customers to work closely with Cisco to launch their uCPE solution

- Looking to further strengthen their SD-WAN offering and is part of its strategy to move to software-defined networks (SDN) and intent-based networking.

Opens up new revenue models

Use Ciena Blue Plant as the orchestrater.

Use NFVIS NETCONF APIs for integration

Positioning ISRv with 3rd party VNFs

https://www.businesswire.com/news/home/20180206005830/en/Orange-Business-Services-Cisco-Bring-SD-WAN-Network

R&S related Cisco education offerings

Course	Description	Cisco Certification
CCIE R&S Advanced Workshops (CIERS-1 & CIERS-2) plus Self Assessments, Workbooks & Labs	Expert level trainings including: instructor led workshops, self assessments, practice labs and CCIE Lab Builder to prepare candidates for the CCIE R&S practical exam.	CCIE® Routing & Switching
• Implementing Cisco IP Routing v2.0 • Implementing Cisco IP Switched Networks V2.0 • Troubleshooting and Maintaining Cisco IP Networks v2.0	Professional level instructor led trainings to prepare candidates for the CCNP R&S exams (ROUTE, SWITCH and TSHOOT). Also available in self study eLearning formats with Cisco Learning Labs.	CCNP® Routing & Switching
Interconnecting Cisco Networking Devices: Part 2 (or combined)	Builds on ICND1 to provide capabilities needed to configure, implement and troubleshoot a small enterprise network. Including: understanding of Quality of Service (QoS), how virtualized and cloud services interact and impact enterprise networks, along with an overview of network programmability and the related controller types and tools that are available to support software-defined network architectures. Also available in self study eLearning format with Cisco Learning Lab.	CCNA® Routing & Switching
Interconnecting Cisco Networking Devices: Part 1	Understand layer 2 and layer 3 networking fundamentals needed to install, configure, and provide basic support of small/branch networks. Covers network device security and IPv6 basics. Also available in self study eLearning format with Cisco Learning Lab.	CCENT® Routing & Switching

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Design Cisco education offerings

Course	Description	Cisco Certification
Designing Cisco Network Service Architectures (ARCH) Version 3.0	Provides learner with the ability to perform conceptual, intermediate, and detailed design of a network infrastructure that supports desired capacity, performance, availability required for converged Enterprise network services and applications.	CCDP® (Design Professional) (Available Now)
Designing for Cisco Internetwork Solutions (DESGN) Version 3.0	Instructor led training focused on fundamental design methodologies used to determine requirements for network performance, security, voice, and wireless solutions. Prepares candidates for the CCDA certification exam.	CCDA® (Design Associate) (Available Now)

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Wireless Cisco education offerings

Course	Description	Cisco Certification
• Designing Cisco Wireless Enterprise Networks • Deploying Cisco Wireless Enterprise Networks • Troubleshooting Cisco Wireless Enterprise Networks • Securing Cisco Wireless Enterprise Networks	Professional level instructor led trainings to prepare candidates to conduct site surveys, implement, configure and support APs and controllers in converged Enterprise networks. Focused on 802.11 and related technologies to design, deploy, troubleshoot as well as secure Wireless infrastructure. Course also provide details around Cisco mobility services Engine, Prime Infrastructure and wireless security.	CCNP® Wireless
Implementing Cisco Unified Wireless Network Essential	Prepares candidates to design, install, configure, monitor and conduct basic troubleshooting tasks of a Cisco WLAN in Enterprise installations.	CCNA® Wireless
Deploying Basic Cisco Wireless LANs (WDBWL)	Understanding of the Cisco Unified Wireless Networking for enterprise deployment scenarios. In this course, you will learn the basics of how to install, configure, operate, and maintain a wireless network, both as an add-on to an existing wireless LAN (WLAN) and as a new Cisco Unified Wireless Networking solution.	1.2
Deploying Advanced Cisco Wireless LANs (WDAWL)	The WDAWL advanced course is designed with the goal of providing learners with the knowledge and skills to successfully plan, install, configure, troubleshoot, monitor, and maintain advanced Cisco wireless LAN solutions such as QoS, "salt and pepper" mobility, high density deployments, and outdoor mesh deployments in an enterprise customer environment.	1.2
Deploying Cisco Connected Mobile Experiences (WCMX)	WCMX will prepare professionals to use the Cisco Unified Wireless Network to configure, administer, manage, troubleshoot, and optimize utilization of mobile content while gaining meaningful client analytics.	2.0

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CISCO *Live!*

Cybersecurity Cisco education offerings

Course	Description	Cisco Certification
Understanding Cisco Cybersecurity Fundamentals (SFUND)	The SECFND course provides understanding of cybersecurity's basic principles, foundational knowledge, and core skills needed to build a foundation for understanding more advanced cybersecurity material & skills.	CCNA® Cyber Ops
Implementing Cisco Cybersecurity Operations (SECOPS)	This course prepares candidates to begin a career within a Security Operations Center (SOC), working with Cybersecurity Analysts at the associate level.	CCNA® Cyber Ops
Cisco Security Product Training Courses	Official deep-dive, hands-on product training on Cisco's latest security products, including NGFW, ASA, NGIPS, AMP, Identity Services Engine, Email and Web Security Appliances, and much more.	

For more details, please visit: www.cisco.com/go/securitytraining or http://learningnetwork.cisco.com
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Cybersecurity Cisco education offerings

Course	Description	Cisco Certification
CCIE Security 5.0		CCIE® Security
Implementing Cisco Edge Network Security Solutions (SENSS) Implementing Cisco Threat Control Solutions (SITCS) v1.5 Implementing Cisco Secure Access Solutions (SISAS) Implementing Cisco Secure Mobility Solutions (SIMOS)	Configure Cisco perimeter edge security solutions utilizing Cisco Switches, Cisco Routers, and Cisco Adaptive Security Appliance (ASA) Firewalls Implement Cisco's Next Generation Firewall (NGFW), FirePOWER NGIPS (Next Generation IPS), Cisco AMP (Advanced Malware Protection), as well as Web Security, Email Security and Cloud Web Security Deploy Cisco's Identity Services Engine and 802.1X secure network access Protect data traversing a public or shared infrastructure such as the Internet by implementing and maintaining Cisco VPN solutions	CCNP® Security
Implementing Cisco Network Security (IINS 3.0)	Focuses on the design, implementation, and monitoring of a comprehensive security policy, using Cisco IOS security features	CCNA® Security

For more details, please visit: www.cisco.com/go/securitytraining or http://learningnetwork.cisco.com
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Data Center / Virtualization Cisco education offerings

Course	Description	Cisco Certification
Introducing Cisco Data Center Networking (DCICN) Introducing Cisco Data Center Technologies (DCICT)	Get job-ready foundational-level certification and skills in installing, configuring, and maintaining next generation data centers.	CCNA® Data Center
Implementing Cisco Data Center Unified Computing (DCUCI) Implementing Cisco Data Center Infrastructure (DCII) Implementing Cisco Data Center Virtualization and Automation (DCVAI) Designing Cisco Data Center Infrastructure (DCID) Troubleshooting Cisco Data Center Infrastructure (DCIT)	Obtain professional level skills to design, configure, implement, troubleshoot next generation data center infrastructure.	CCNP® Data Center
Product Training Portfolio:DCAC9K, DCINX9K, DCMDS, DCUCS, DCNX1K, DCNX5K, DCNX7K, CACND, DSACI, HFLEX UCSDF, UCSDACI, DCUCCEN	Gain hands-on skills using Cisco solutions to configure, deploy, manage and troubleshoot unified computing, policy-driven and virtualized data center infrastructure.	
Designing the FlexPod® Solution (FPDESIGN) Implementing and Administering the FlexPod® Solution (FPIMPADM)	Learn how to design, implement and administer FlexPod® solutions	Cisco and NetApp Certified FlexPod® Specialist
Designing the VersaStack Solution (VSDESIGN) Implementing and Administering the VersaStack Solution (VSIMP)	Learn how to design, implement and administer VersaStack solutions	

For more details, please visit: http://learningnetwork.cisco.com
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Network Programmability Cisco education offerings

Course	Description	Cisco Certification
Developing with Cisco Network Programmability (NPDEV)	Provides Application Developers with comprehensive curriculum to develop infrastructure programming skills; Addresses needs of software engineers who automate network infrastructure and/or utilize APIs and toolkits to interface with SDN controllers and individual devices	Cisco Network Programmability Developer (NPDEV) Specialist Certification
Designing and Implementing Cisco Network Programmability (NPDESI)	Provides network engineers with comprehensive soup-to-nuts curriculum to develop and validate automation and programming skills; Directly addresses the evolving role of network engineers towards more programmability, automation and orchestration	Cisco Network Programmability Design and Implementation (NPDESI) Specialist Certification
Programming for Network Engineers (PRNE)	Learn the fundamentals of Python programming – within the context of performing functions relevant to network engineers. Use Network Programming to simplify or automate tasks	Recommended pre-requisite for NPDESI and NPDEV Specialist Certifications
Cisco Digital Network Architecture Implementation Essentials (DNAIE)	This training provides students with the guiding principles and core elements of Cisco's Digital Network Architecture (DNA) architecture and its solution components including; APIC-EM, NFV, Analytics, Security and Fabric.	

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Cloud Cisco education offerings

Course	Description	Cisco Certification
Understanding Cloud Fundamentals (CLDFND) Introducing Cloud Administration (CLDADM)	Learn how to perform foundational tasks related to Cloud computing, and the essentials of Cloud infrastructure, administration and operations	CCNA® Cloud
Implementing and Troubleshooting the Cisco Cloud Infrastructure (CLDINF) Designing the Cisco Cloud (CLDDES) Automating the Cisco Enterprise Cloud (CLDAUT) Building the Cisco Cloud with Application Centric Infrastructure (CLDACI)	Obtain professional level skills to design, automate, secure, provision and manage private and hybrid Clouds	CCNP® Cloud
Product Training Portfolio: CloudCenter: CLDCTR* UCS Director: UCSDF, UCSDACI Prime Service Catalog: PSCF, PSCI, PSCD MetaPod: MPODF20	Gain in-depth hands-on skills using Cisco solutions to configure, deploy, manage and troubleshoot Cloud deployments	

*Available Q3FY18

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Collaboration Cisco education offerings

Course	Description	Cisco Certification
CCIE Collaboration Advanced Workshop (CIEC)	Gain expert-level skills to integrate, configure, and troubleshoot complex collaboration networks	CCIE® Collaboration
Implementing Cisco Collaboration Applications (CAPPS)	Understand how to implement the full suite of Cisco collaboration applications including Jabber, Cisco Unified IM and Presence, and Cisco Unity Connection.	CCNP® Collaboration
Implementing Cisco IP Telephony and Video Part 1 (CIPTV1) Implementing Cisco IP Telephony and Video Part 2 (CIPTV2) Troubleshooting Cisco IP Telephony and Video (CTCOLLAB)	Learn how to implement Cisco Unified Communications Manager, CUBE, and audio and videoconferences in a single-site voice and video network. Obtain the skills to implement Cisco Unified Communications Manager in a modern, multisite collaboration environment. Troubleshoot complex integrated voice and video infrastructures	CCNP® Collaboration
Implementing Cisco Collaboration Devices (CICD) Implementing Cisco Video Network Devices (CIVND)	Acquire a basic understanding of collaboration technologies like Cisco Call Manager and Cisco Unified Communications Manager. Learn how to evaluate requirements for video deployments, and implement Cisco Collaboration endpoints in converged Cisco infrastructures.	CCNA® Collaboration

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Service Provider Cisco education offerings

Course	Description	Cisco Certification
Deploying Cisco Service Provider Network Routing (SPROUTE) & Advanced (SPADVROUTE) Implementing Cisco Service Provider Next-Generation Core Network Services (SPCORE) Edge Network Services (SPEDGE)	SPROUTE covers the implementation of routing protocols (OSPF, IS-IS, BGP), route manipulations, and HA routing features; SPADVROUTE covers advanced routing topics in BGP, multicast services including PIM-SM, and IPv6; SPCORE covers network services, including MPLS-LDP, MPLS traffic engineering, QoS mechanisms, and transport technologies; SPEDGE covers network services, including MPLS Layer 3 VPNs, Layer 2 VPNs, and Carrier Ethernet services; all within SP IP NGN environments.	CCNP Service Provider®
Building Cisco Service Provider Next-Generation Networks, Part 1&2 (SPNGN1), (SPNGN2)	The two courses introduce networking technologies and solutions, including OSI and TCP/IP models, IPv4/v6, switching, routing, transport types, security, network management, and Cisco OS (IOS and IOS XR).	CCNA Service Provider®
Implementing Cisco Service Provider Mobility UMTS Networks (SPUMTS); Implementing Cisco Service Provider Mobility CDMA Networks (SPCDMA); Implementing Cisco Service Provider Mobility LTE Networks (SPLTE)	The three courses (SPUMTS, SPCDMA, SPLTE) cover knowledge and skills required to understand products, technologies, and architectures that are found in Universal Mobile Telecommunications Systems (UMTS) and Code Division Multiple Access (CDMA) packet core networks, plus their migration to Long-Term Evolution (LTE) Evolved Packet Systems (EPS), including Evolved Packet Core (EPC) and Radio Access Networks (RANs).	Cisco Service Provider Mobility CDMA to LTE Specialist; Cisco Service Provider Mobility UMTS to LTE Specialist
Implementing and Maintaining Cisco Technologies Using IOS XR (IMTXR)	Service Provider/Enterprise engineers to implement, verification-test, and optimize core/edge technologies in a Cisco IOS XR environment.	Cisco IOS XR Specialist

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Internet of Things (IoT) Cisco education offerings

Course	Description	Cisco Certification
Managing Industrial Networks for Manufacturing (IMINS2)	An associate level instructor led lab based training focuses on common industrial application protocols, security, wireless and troubleshooting designed to prepare you for the CCNA Industrial certification	CCNA® Industrial
Managing Industrial Networks with Cisco Networking Technologies (IMINS)	This instructor led lab based training addresses foundational skills needed to manage and administer networked industrial control systems for today's connected plants and enterprises. It helps prepare plant administrators, control system engineers and traditional network engineers for the Cisco Industrial Networking Specialist certification.	Cisco Industrial Networking Specialist
Control Systems Fundamentals for Industrial Networking (ICINS)	For IT and Network Engineers, provides an introduction to industry IoT verticals, automation environment and an overview of industrial control networks (E-Learning)	Pre-learning for IMINS, IMINS2 training & certifications
Networking Fundamentals for Industrial Control Systems (INICS)	For Industrial Engineers and Control System Technicians, covers basic IP and networking concepts, and introductory overview of Automation industry Protocols.	Pre-learning for IMINS, IMINS2 training & certifications

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Data and Analytics Cisco education offerings

Course	Description
ANDMB – Data Management, Architecture and Applications	Provides hands on training with a technical mix of application, compute, storage and networking topics concerning the deployment of Big Data clusters.
ANDMA – Advanced Data Management, Architecture and Applications	Covers major architecture design to cater to different needs of the application, data center or deployment requirements. It provides architectural designs and advanced hands-on training on topics covering Scaling of cluster to thousands of nodes and management, Data Life Cycle management with HDFS tiered storage, and different approaches for Multi-tenant Hadoop cluster deployments with Openstack

Data and Analytics training page: http://www.cisco.com/c/en/us/training-events/resources/learning-services/technology/data-analytics.html
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Digital Business Transformation
Cisco education offerings

Course	Description	Cisco Certification
For Technology Sellers:		
Adopting the Cisco Business Architecture Approach	Builds skills to discover and address technology needs using a business-focused, consultative sales approach, broadly applicable and targeted to prepare for the digital transformation journey that is demanded across the business world.	Cisco Business Architecture Analyst
Applying Cisco Business Architecture Techniques	Provides tools and skills training to prepare the learner to use a business led approach to technology solutions sales and deployments. This continues the journey begun with the Adopting the Cisco Business Architecture Approach above	Cisco Business Architecture Specialist
Mastering the Cisco Business Architecture Discipline	Builds skills, and proven, real-world techniques to prepare for a Business architect leadership role in the sales and deployment of transformative technology solutions.	Cisco Business Architecture Practitioner
Cisco Customer Success Manager Specialist	Prepares for the crucial role that drives adoption and enablement, ensuring that customers achieve their expected business outcomes, and reduces churn/increases renewal for services and subscription based products.	Cisco Certified Customer Success Manager

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