Possibilities

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SD-WAN and Network Functions Service Chaining

Alexey Romanov
Consulting Engineer
DGTL-BRKENS-1100

Agenda

- Introduction
  - SD-WAN Architecture Overview
  - ENCS Platform Overview
- VNF Service Chaining in SD-WAN
  - VNF and Network Types
  - Virtual Branch Design Scenarios
- Virtual Branch Management
  - Automation of Service Chain Deployments
  - SD-WAN Operations Cycle
- Takeaways

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SD-WAN Architecture Overview

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Cisco SD-WAN Architecture

Orchestration Plane

- First point of authentication
- Distributes list of vSmarts/ vManage to all vEdge routers
- Facilitates NAT traversal

Management Plane

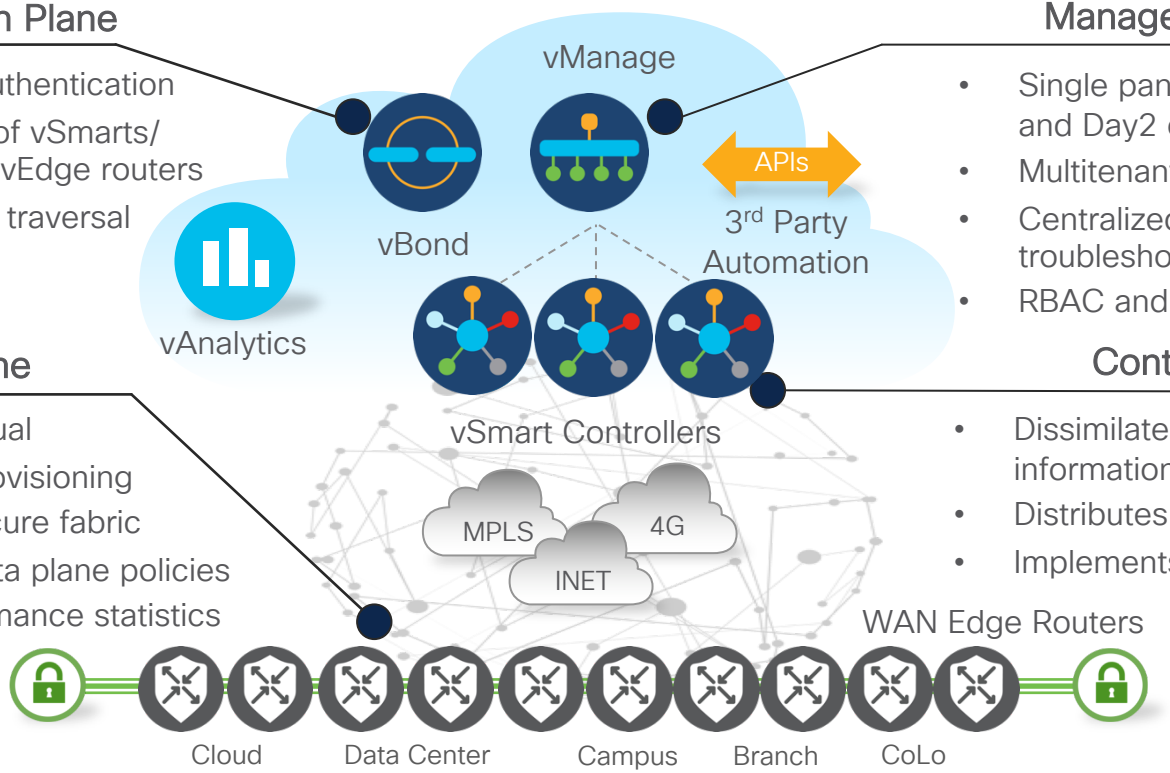
- Single pane of glass for Day0, Day1 and Day2 operations
- Multitenant or single-tenant
- Centralized provisioning, troubleshooting and monitoring
- RBAC and APIs

Data Plane

- Physical or virtual
- Zero Touch Provisioning
- Establishes secure fabric
- Implements data plane policies
- Exports performance statistics

Control Plane

- Dissimilates control plane information between vEdges
- Distributes data plane policies
- Implements control plane policies



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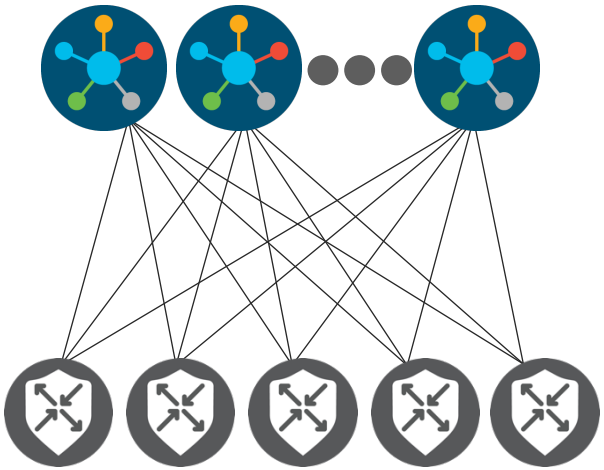
Network-wide Control Plane

Cisco SD-WAN

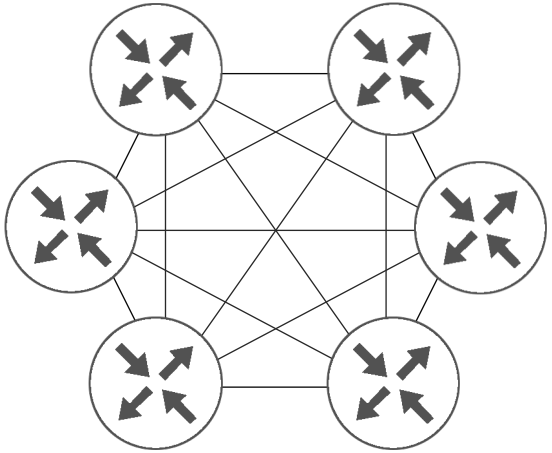
Network Control Plane



Data Plane + Local Control Plane

O(n) Control Complexity
High Scale

Traditional



Integrated Control and Data Plane

O(n^2) Control Complexity
Limited Scale

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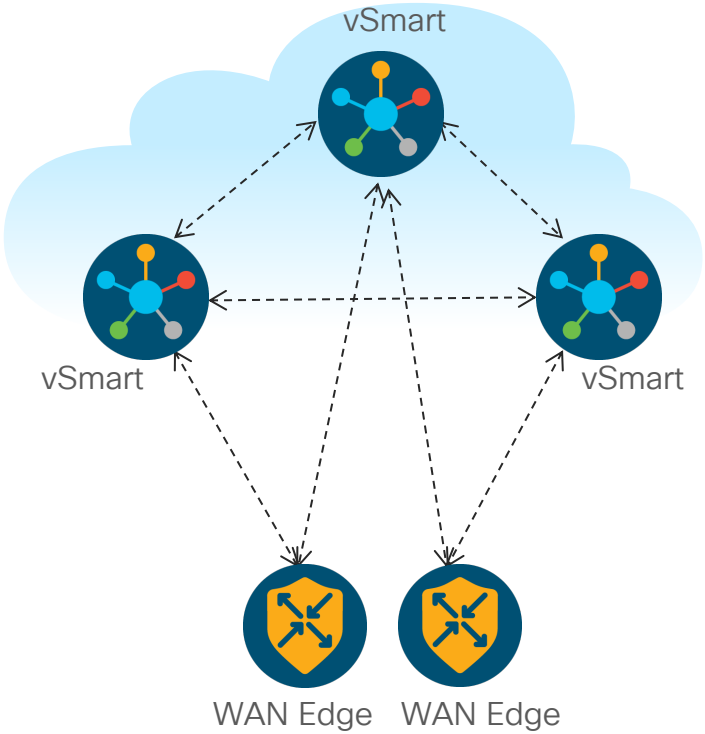
Overlay Management Protocol (OMP)



- TCP based extensible control plane protocol
- Runs between WAN Edge routers and vSmart controllers and between the vSmart controllers
  - Inside TLS/DTLS connections
- Leverages address families to advertise reachability for TLOCs, unicast/multicast destinations, service routes, BFD up/down stats and Cloud onRamp for SaaS probe stats
- Distributes IPSec encryption keys, and data and app-aware policies

Note: WAN Edge routers need not connect to all vSmart Controllers

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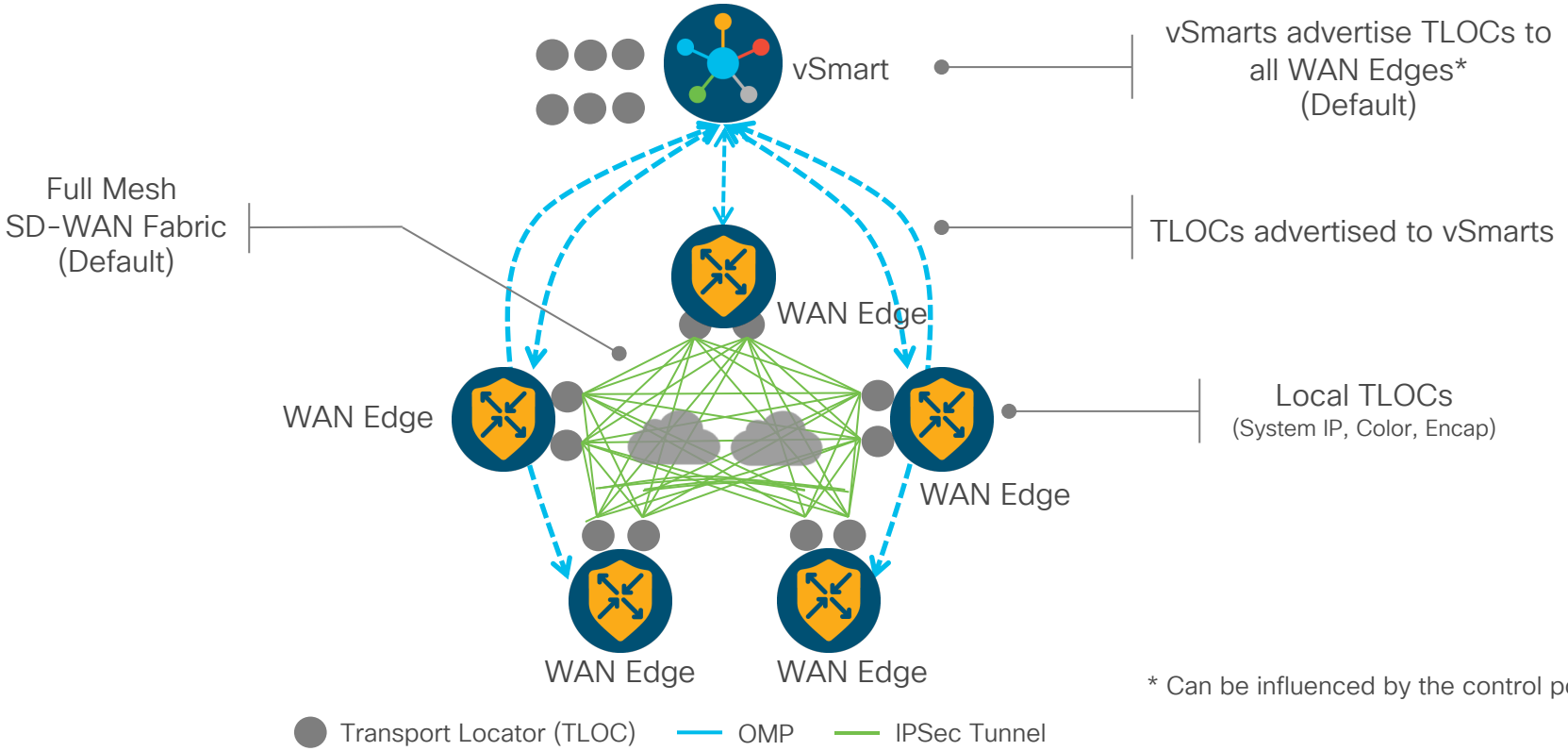
Transport Locators (TLOCs)



* Can be influenced by the control policies

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vManage Demo

ENCS Platform Overview

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What is Enterprise Network Compute System?

Unified Computing System (UCS)

+

Small Office/Home office SOHO device

Router + Switch

=

Enterprise Network Compute System (ENCS)

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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

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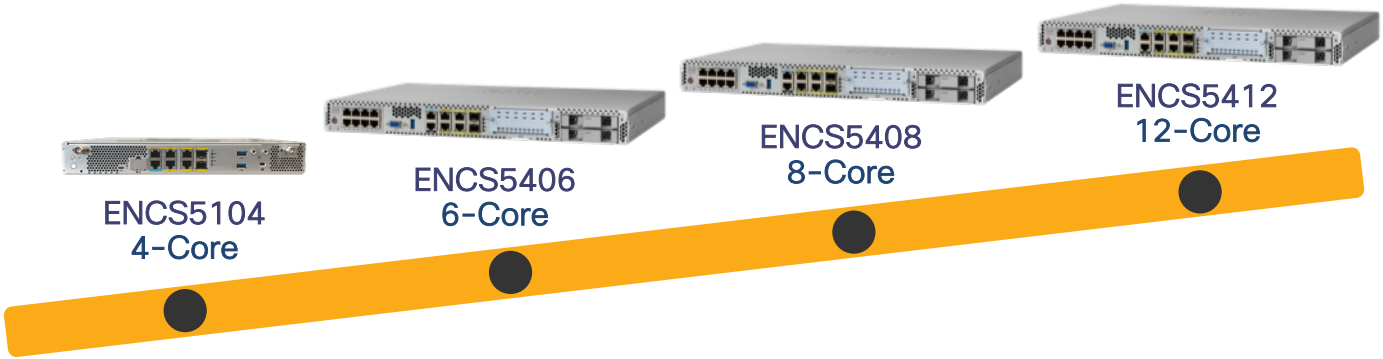
ENCS 5000 Series – Chassis Options



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

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NFV and NFVIS

What and Why Network Function Virtualisation?

Prior to NFV – physical appliance per network function in each branch

Router

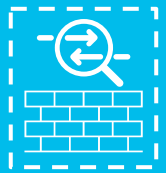
Firewall

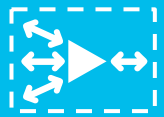
WAN optimization

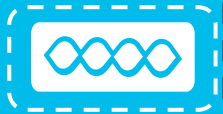
Wireless LAN Controller

NFV gives an opportunity to combine multiple network functions in one ENCS device

Virtual Router (ISRv,CSR,vEdge)


Virtual Firewall (ASAv, NGFWv)


Virtual WAN Optimization (vWAAS)


vWireless LAN Controller (WLC)

Third-Party applications/VNFs

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Purpose built Network Hypervisor Enterprise NFV Infrastructure Software (NFVIS)

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

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

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

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

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

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

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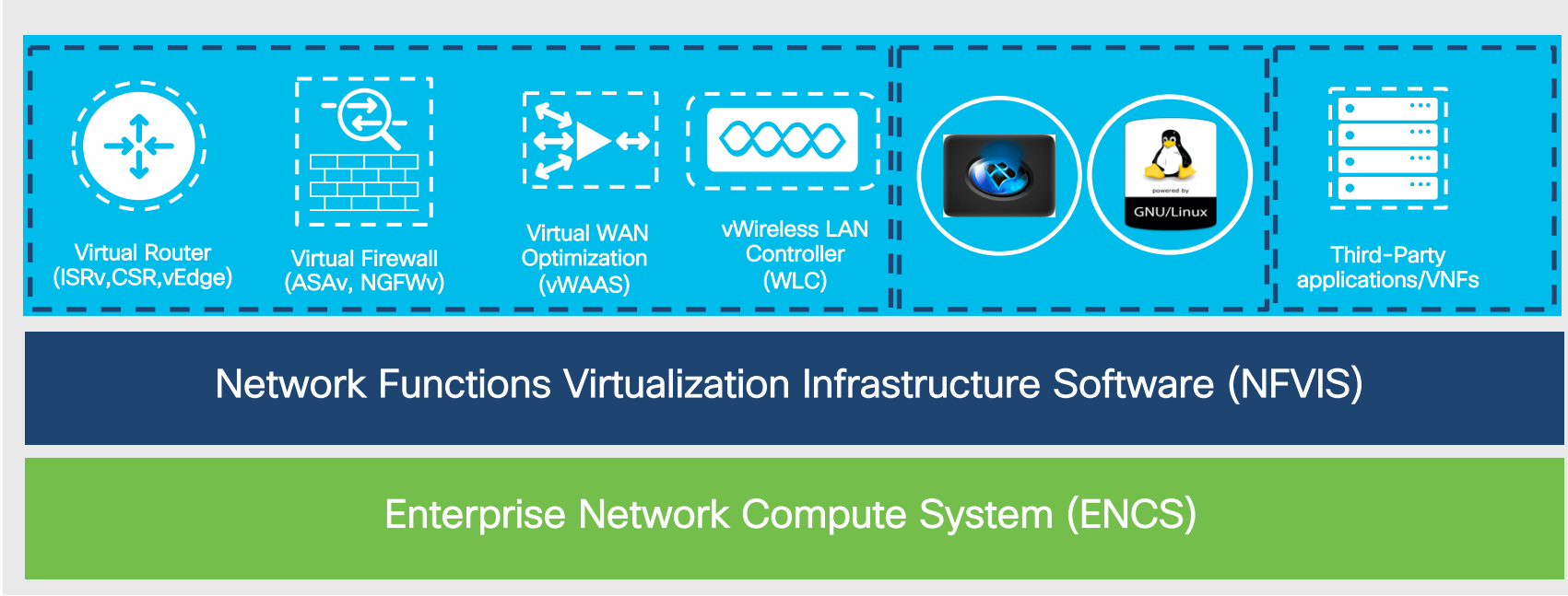
Network Functions Virtualization Infrastructure Software (NFVIS)



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ENCS Demo

VNF Service Chaining in SD-WAN

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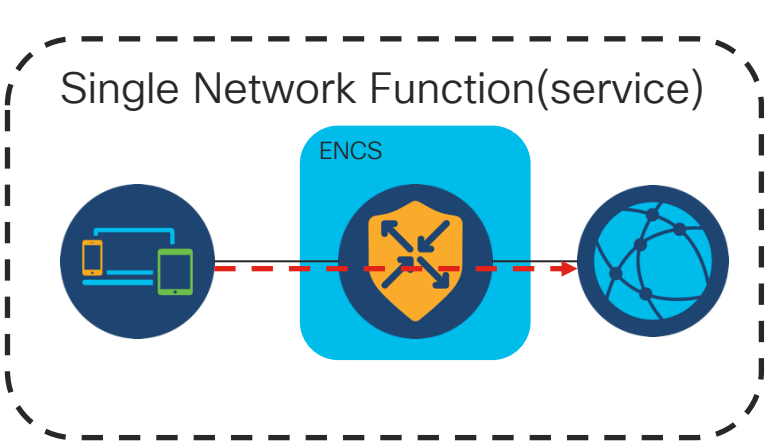
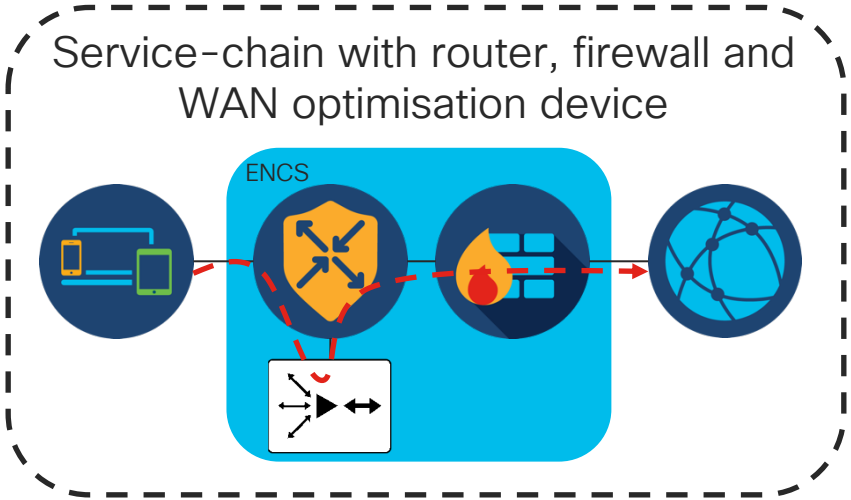
VNF and Network Types

What is Service Chain?





Traffic flow

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Where Do We Start With Virtual Branch Design?

- What Virtual Functions do we need?
- What are the bandwidth requirements?
- Single-homed, dual-homed, multi-homed site?
- L2 or L3 connectivity on the LAN side?

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What SD-WAN Relevant VNFs are Certified?

- Firewalls:
  - ASAv, FTDv, Checkpoint Cloud Guard, FortiGate, NETSCOUT vAED, Palo Alto VM
- Routers:
  - ISRv, vEdge Cloud
- WAN Optimisation:
  - vWAAS and Riverbed SteelHead

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Interface Types

- Open vSwitch(OVS)/virtio - bridges and virtual networks for service chaining between VMs
- SR-IOV - High performance networks
- DPDK – Data Plane Development Kit skips the Linux kernel by processing packets directly in the user space.
- PCI Passthrough – dedicating the entire NIC to the VNF directly

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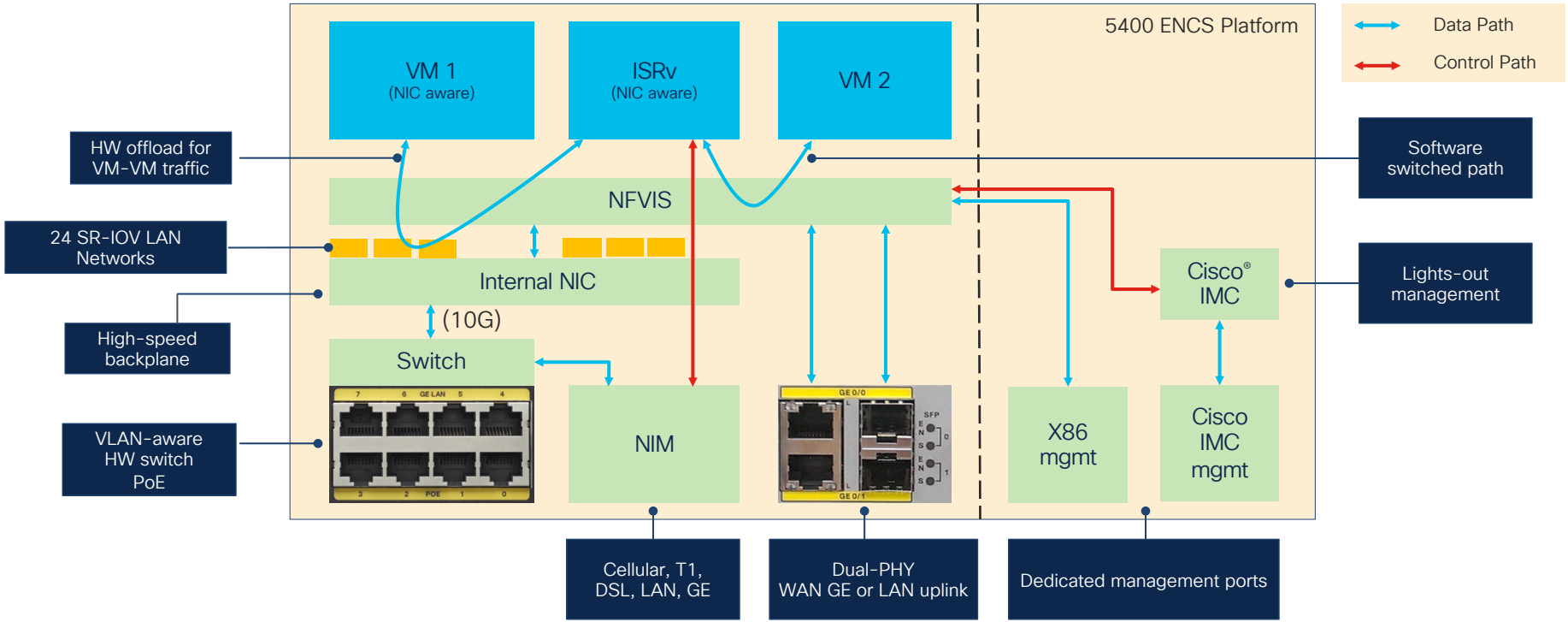
5400 ENCS Internal Networking



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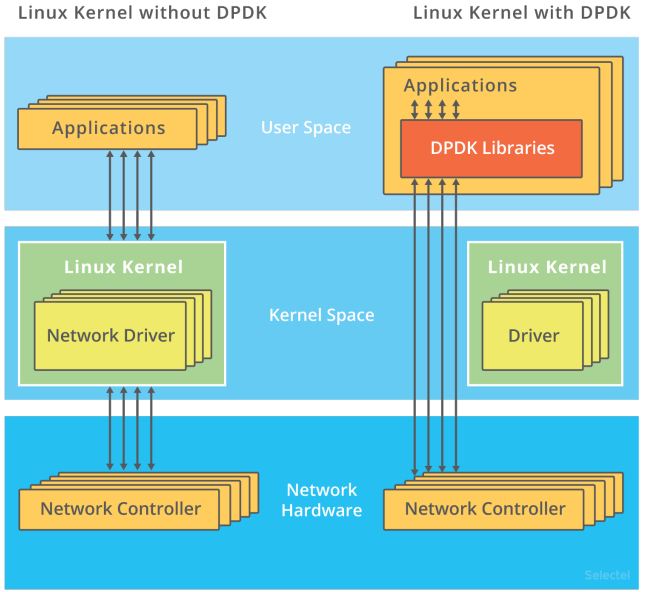
Data Plane Development Kit (DPDK)

- DPDK skips the Linux kernel by processing packets directly in the user space.
- DPDK reserves a CPU that is constantly polling for new packets.
- Additional resources allocated – 1 CPU and 1 GiB of RAM



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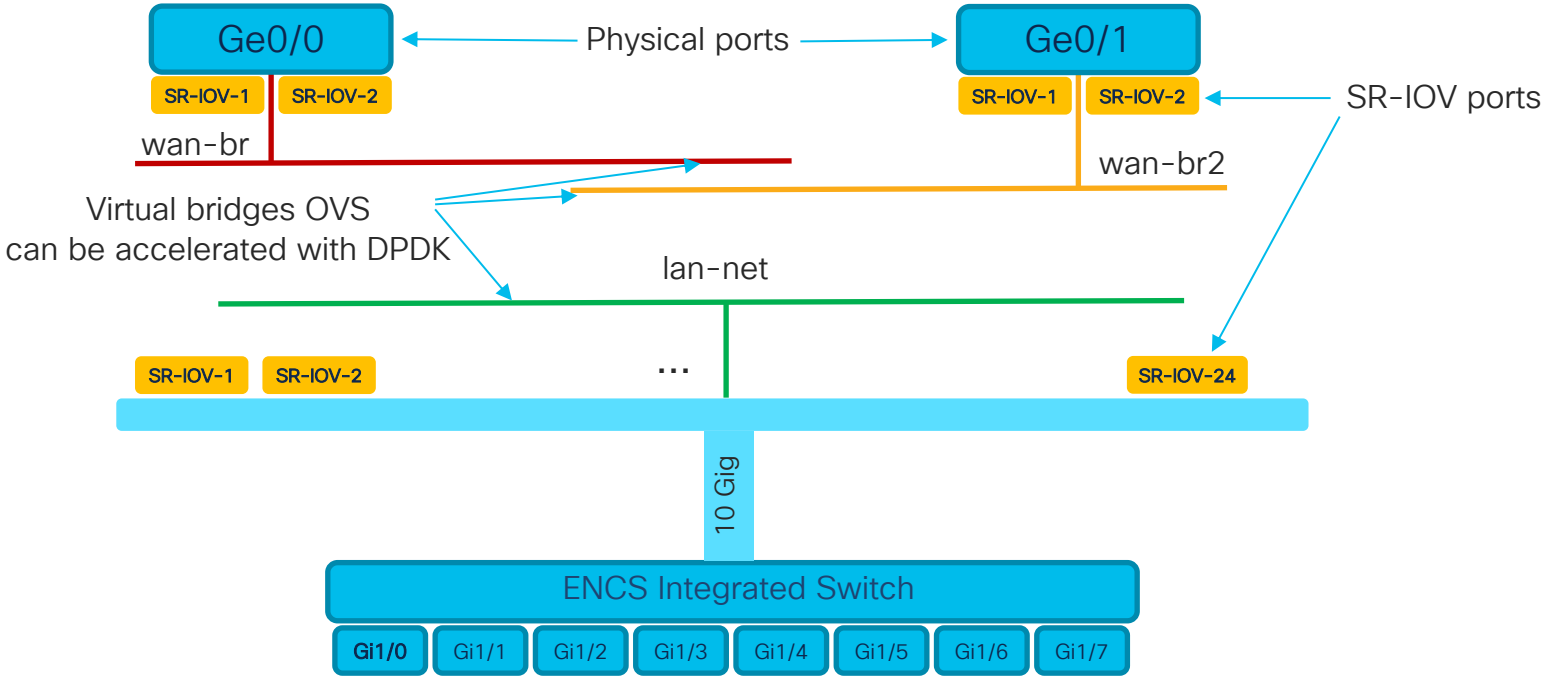
Design Considerations

How to Read the GUI?



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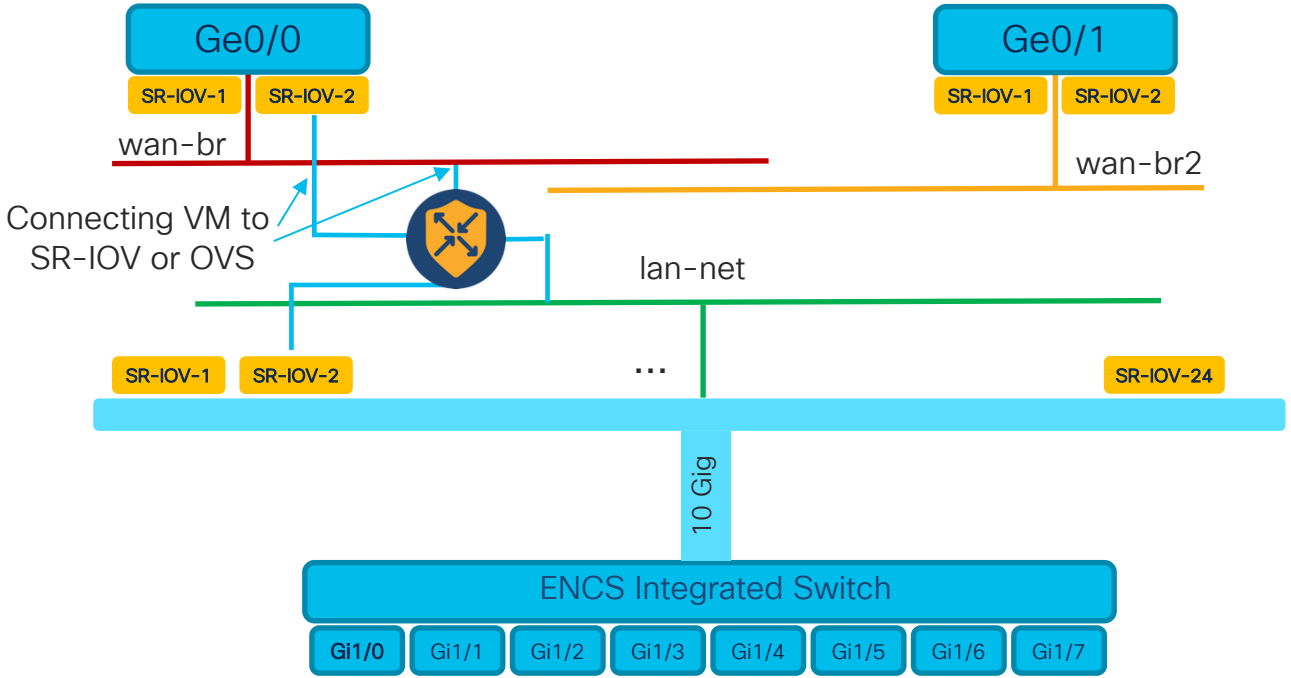
Adding VNF to the Picture



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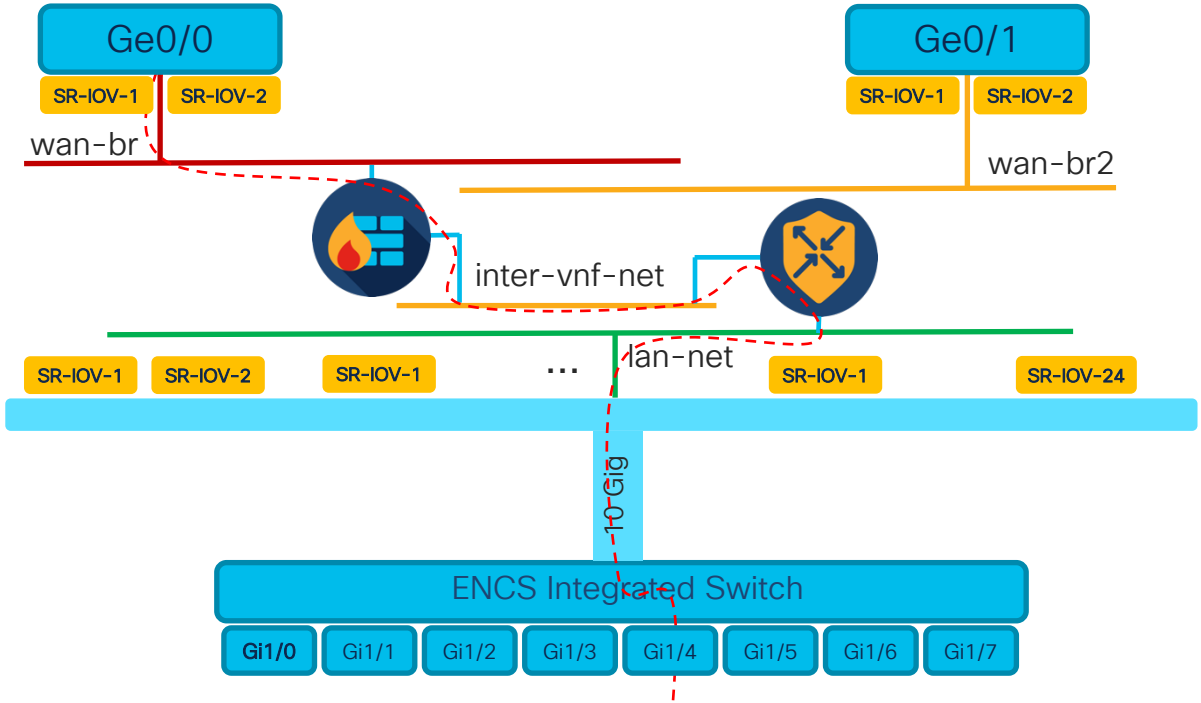
Connecting Multiple VNFs



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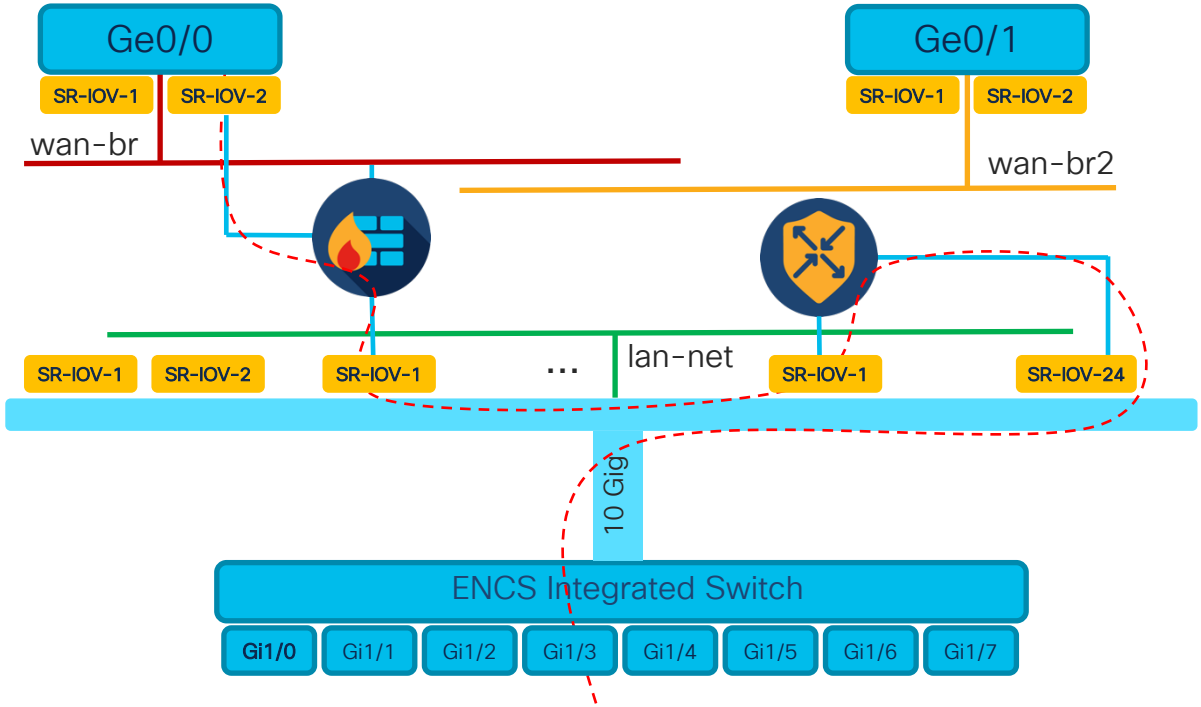
Connecting Multiple VNFs



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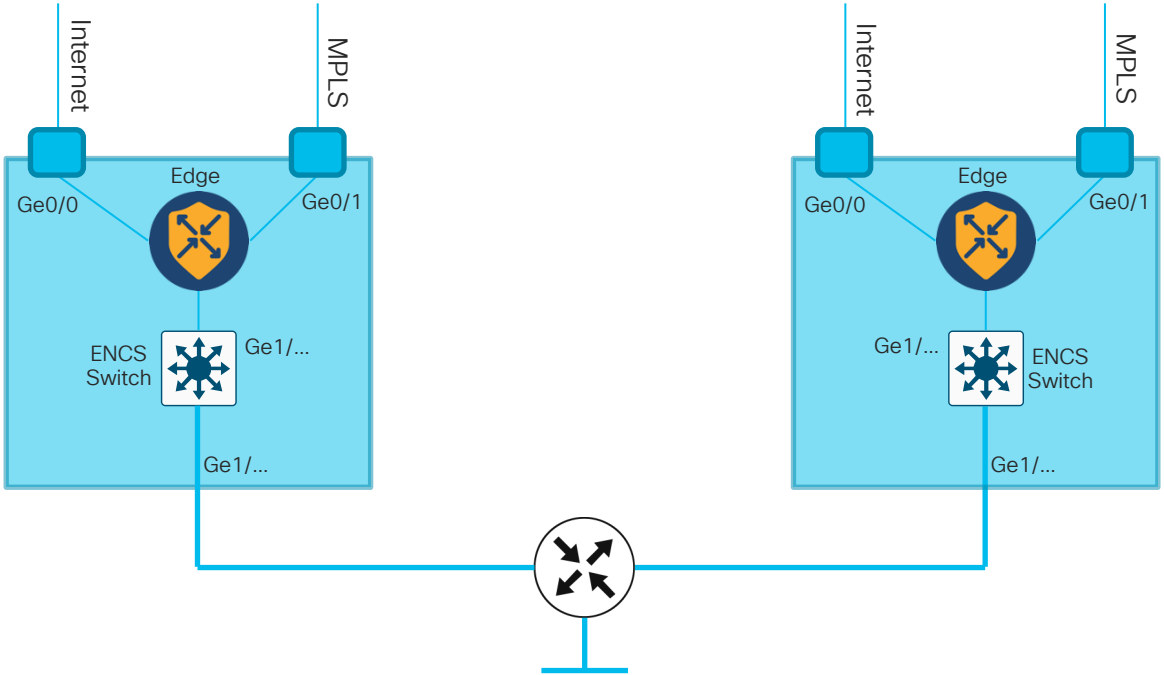
Multi-Homed Site – L3 on the LAN side



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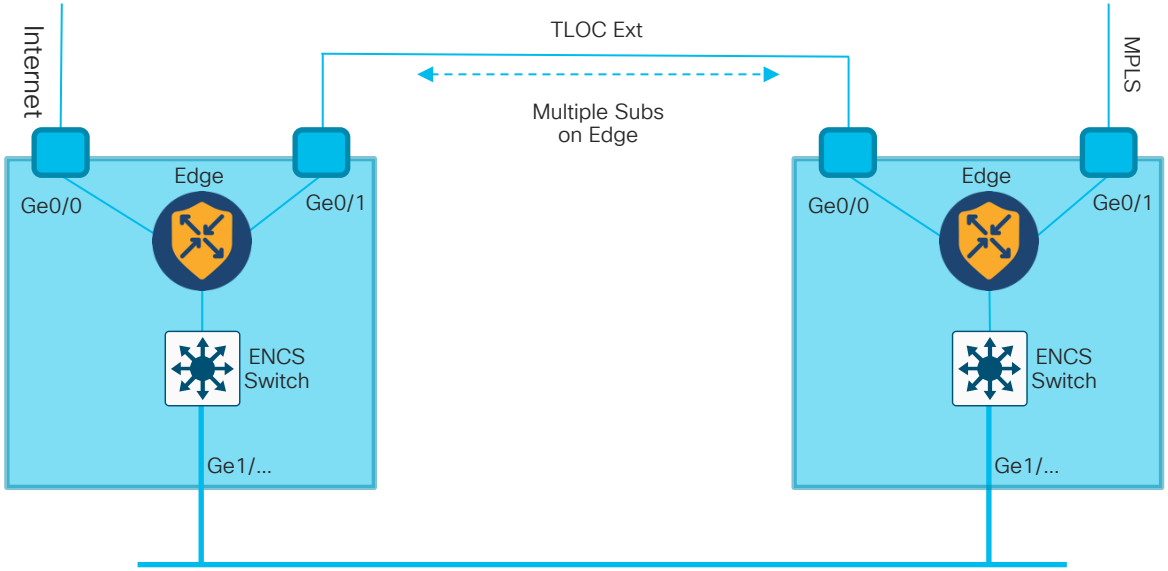
TLOC Extension Options



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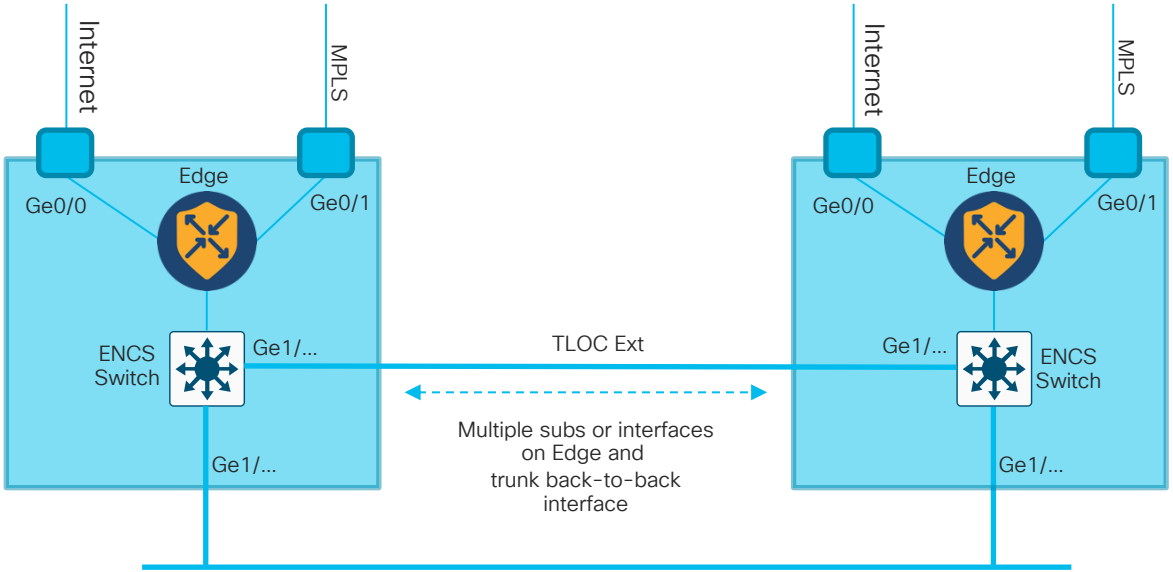
TLOC Extension Options Cont.



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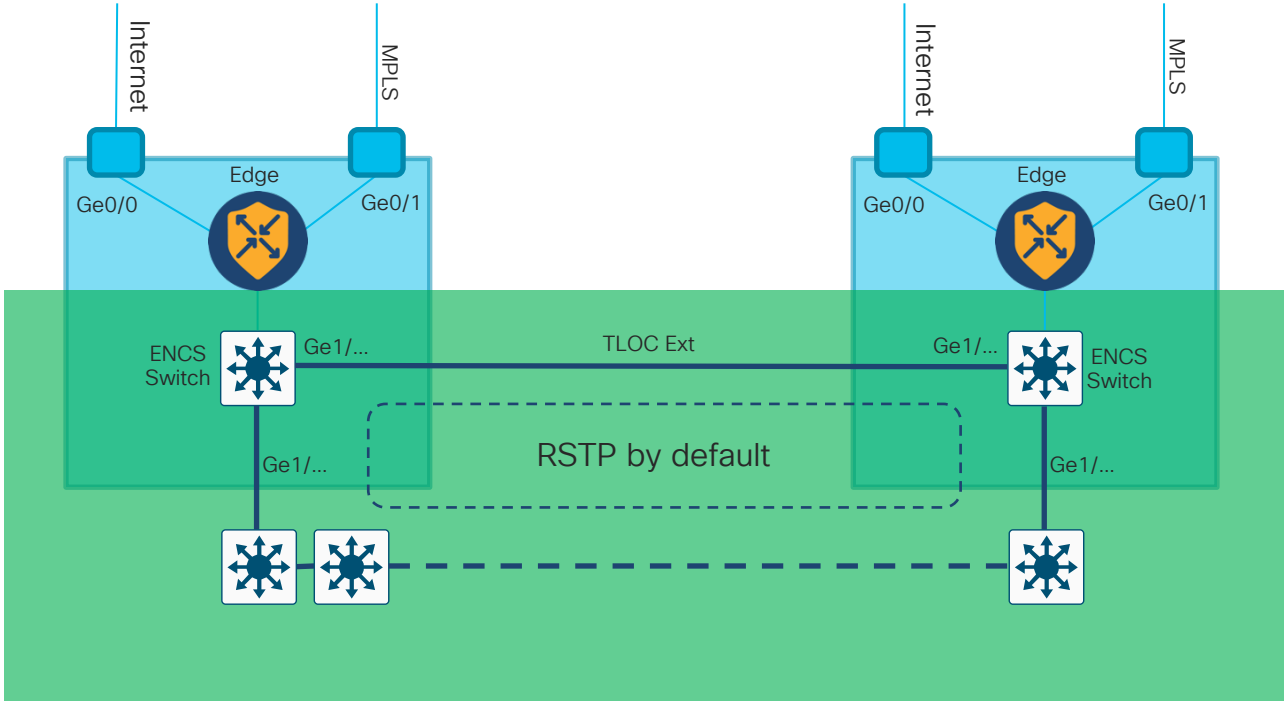
Spanning Tree Design

- Based on the LAN connectivity you might need to plan L2 domain design
- RSTP is the default spanning-tree mode
- RPVST is not supported
- MST is configurable via CLI



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Using VLANs

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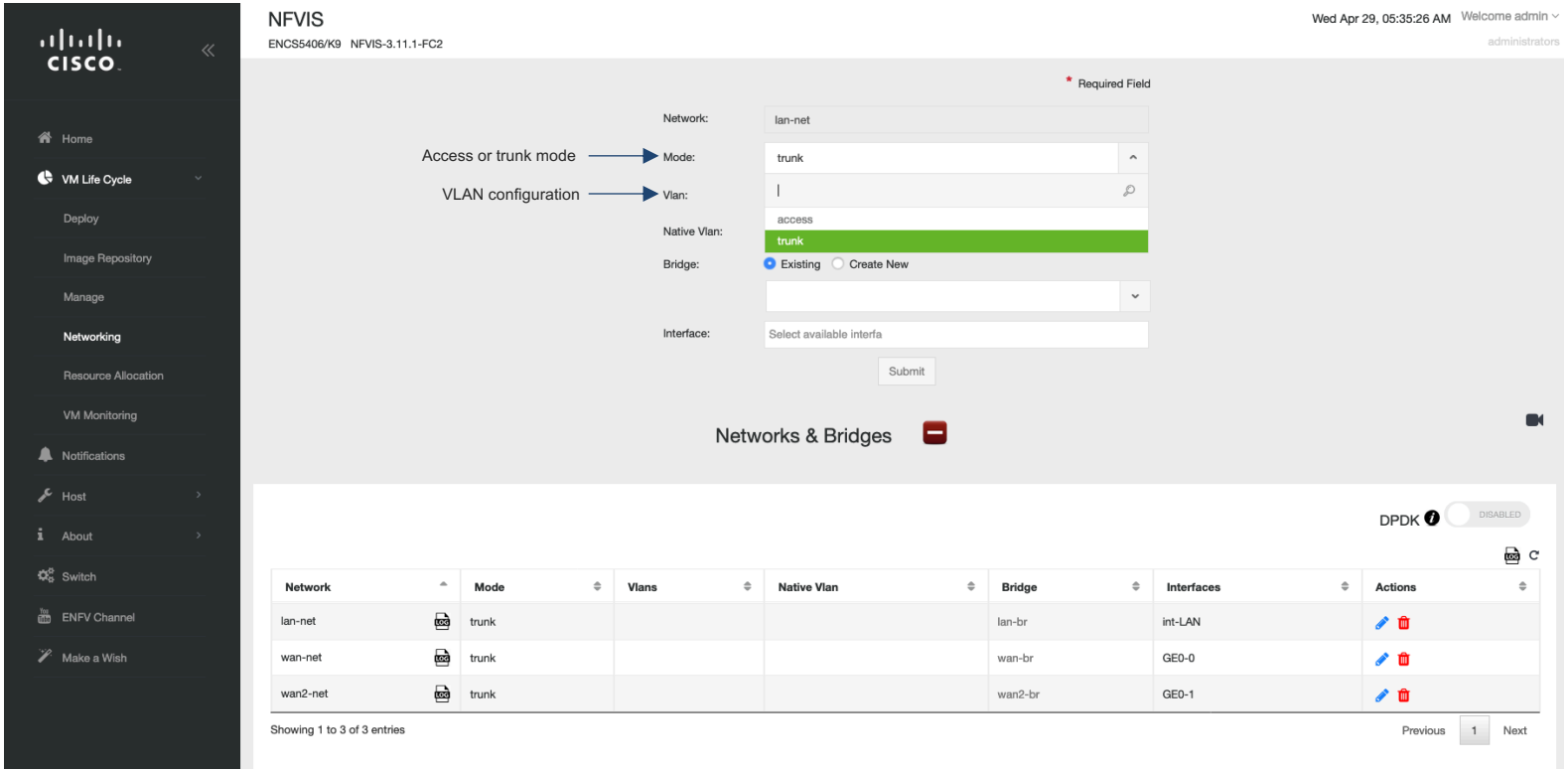
Configuring VLANs on Virtual Networks



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Configuring VLANs on SR-IOV prior to 3.12

- SR-IOV is configured as trunk by default
- Configuration changes on SR-IOV should be applied before attaching VM to SR-IOV port
- If you don't want to change NFVIS configuration you can just configure sub-interface on the VM

Configure SRIOV port in NFVIS:

```
conf t
networks network GE0-0-SRIOV-1
trunk true
native-vlan [ 10 ]
vlan  [ 100 200 ]

networks network GE0-0-SRIOV-2
trunk false
vlan  [ 100 ]
```


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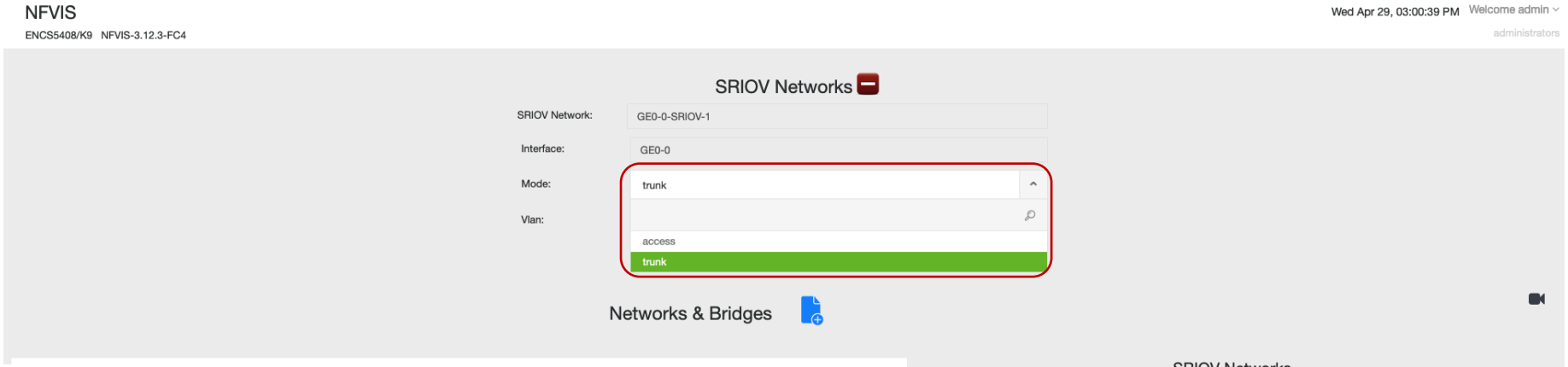
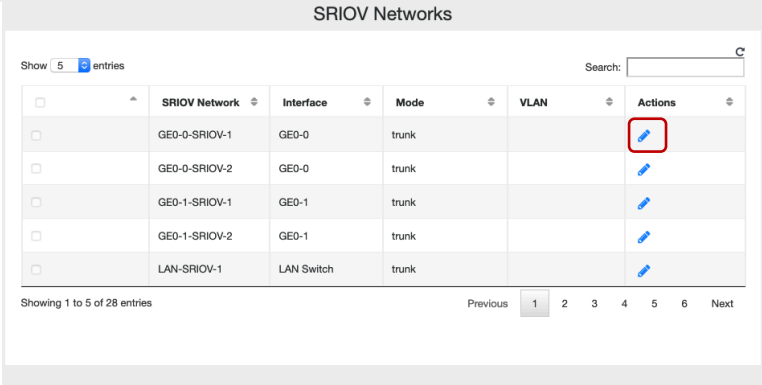
Configuring VLANs on SR-IOV starting 3.12



Starting 3.12 you can change SRIOV configuration in:
VM Life Cycle->Networking tab



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Adding VLANs to the Switch

Once you configured VLAN on the ENCS Switch port, don't forget to add it to VLAN list

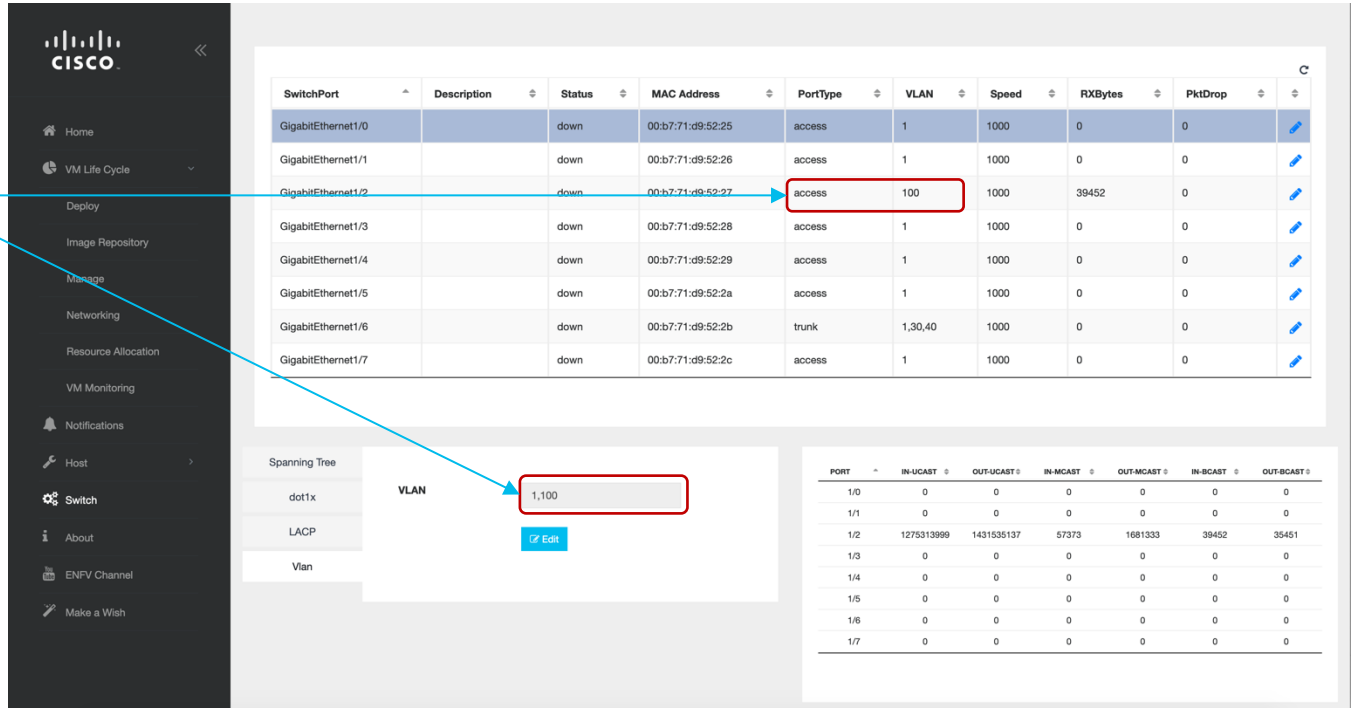

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Image Management and VNF deployment

VM Image Packaging

- Converting qcow2 and img images into tar.gz
- Adds SR-IOV drivers to images
  - ISRv package ".tar.gz" is available on cisco.com
  - To create vEdge Cloud package you need build-in tool in the NFVIS GUI or use python script in the CLI
- A tar.gz file containing
  - qcow2 disk image (*.qcow)
  - Image properties file (Image_properties.xml)
  - Package Manifest (package.mf)

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VM Image Package Files

- Image properties file (Image_properties.xml)
  - VM Type
  - Resource requirement (vCPU, Memory etc.,)
  - Profile

```
<?xml version="1.0" encoding="UTF-8"?>
<image_properties>
    <vnf_type>ROUTER</vnf_type>
    <name>ISRV</name>
    <version>RELVER</version>
    <bootup_time>600</bootup_time>
    <root_file_disk_bus>virtio</root_file_disk_bus>
    <root_image_disk_format>qcow2</root_image_disk_format>
    <vcpu_min>1</vcpu_min>
    <vcpu_max>8</vcpu_max>
    <memory_mb_min>4096</memory_mb_min>
    <memory_mb_max>8192</memory_mb_max>
    <vnic_max>8</vnic_max>
    <vnic_names>vnics:1:GigabitEthernet2</vnic_names>
    <vnic_names>vnics:2:GigabitEthernet3</vnic_names>
    <vnic_names>vnics:3:GigabitEthernet4</vnic_names>
    <vnic_names>vnics:4:GigabitEthernet5</vnic_names>
    <vnic_names>vnics:5:GigabitEthernet6</vnic_names>
    <vnic_names>vnics:6:GigabitEthernet7</vnic_names>
    <vnic_names>vnics:7:GigabitEthernet8</vnic_names>
    <root_disk_gb_min>8</root_disk_gb_min>
    <root_disk_gb_max>8</root_disk_gb_max>
    <console_type_serial>true</console_type_serial>
    <sriov_supported>true</sriov_supported>
    <sriov_driver_list>igb</sriov_driver_list>
    <sriov_driver_list>igbvf</sriov_driver_list>
    <sriov_driver_list>i40evf</sriov_driver_list>
    <pcie_supported>true</pcie_supported>
    <pcie_driver_list>igb</pcie_driver_list>
    <pcie_driver_list>igbvf</pcie_driver_list>
    <pcie_driver_list>i40evf</pcie_driver_list>
    <monitoring_supported>true</monitoring_supported>
    <monitoring_methods>ICMPPing</monitoring_methods>
    <low_latency>true</low_latency>
    <privileged_vm>true</privileged_vm>
    <cdrom>true</cdrom>
```

```
<bootstrap_file_1>ovf-env.xml</bootstrap_file_1>
    <bootstrap_file_2>iosxe_config.txt</bootstrap_file_2>
    <custom_property>
        <tech_package>ax</tech_package>
        <tech_package>security</tech_package>
        <tech_package>ipbase</tech_package>
        <tech_package>appx</tech_package>
    </custom_property>
    <custom_property>
        <ngio>enable</ngio>
    </custom_property>
    <profiles>
            <profile>
                <name>ISRv-mini</name>
            <description>ISRv-mini</description>
                <vcpus>1</vcpus>
            <memory_mb>4096</memory_mb>
            <root_disk_mb>8192</root_disk_mb>
            </profile>
            <profile>
                <name>ISRv-small</name>
            <description>ISRv-small</description>
                <vcpus>2</vcpus>
            <memory_mb>4096</memory_mb>
            <root_disk_mb>8192</root_disk_mb>
            </profile>
            <profile>
                <name>ISRv-medium</name>
            <description>ISRv-medium</description>
                <vcpus>4</vcpus>
            <memory_mb>4096</memory_mb>
            <root_disk_mb>8192</root_disk_mb>
            </profile>
    </profiles>
    <default_profile>ISRv-small</default_profile>
</image_properties>
```


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VM Image Package Files Cont.

- Bootstrap Configuration file (ovf-conf.xml)
  - Login username and password
  - Mgmt interface

```
<?xml version="1.0" encoding="UTF-8"?>
<Environment
xmlns:oe="http://schemas.dmtf.org/ovf/environment/1">
  <PropertySection>
    <Property oe:key="com.cisco.csr1000v.config-version.1" oe:value="1.0"/>
    <Property oe:key="com.cisco.csr1000v.enable-ssh-server.1" oe:value="True"/>
    <Property oe:key="com.cisco.csr1000v.login-username.1" oe:value="cisco"/>
    <Property oe:key="com.cisco.csr1000v.login-password.1" oe:value="ciscoIsrv123!"/>
    <Property oe:key="com.cisco.csr1000v.mgmt-interface.1" oe:value="GigabitEthernet1"/>
!!!GigabitEthernet1-nicid(0)-int-mgmt-interface-don't change ip address or don't shutdown
    <Property oe:key="com.cisco.csr1000v.mgmt-ipv4-addr.1" oe:value="${NICID_0_IP_ADDRESS}/24"/>
    <Property oe:key="com.cisco.csr1000v.mgmt-ipv4-network.1" oe:value=""/>
    <Property oe:key="com.cisco.csr1000v.license.1" oe:value="${TECH_PACKAGE}"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0001" oe:value="vrf definition Mgmt-intf"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0002" oe:value="address-family ipv4"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0003" oe:value="exit-address-family"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0004" oe:value="address-family ipv6"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0005" oe:value="exit-address-family"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0006" oe:value="exit"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0007" oe:value="interface GigabitEthernet1"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0008" oe:value="vrf forwarding Mgmt-intf"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0009" oe:value="ip address ${NICID_0_IP_ADDRESS} ${NICID_0_NETMASK}"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0010" oe:value="no shut"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0011" oe:value="exit"/>
    <Property oe:key="com.cisco.csr1000v.ios-config-0012" oe:value="ip route vrf Mgmt-intf 0.0.0.0 0.0.0.0 ${NICID_0_GATEWAY}"/>
  </PropertySection>
</Environment>
```


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VM Image Package Files Cont.

- Package Manifest (package.mf)
  - Checksum
  - File type, name

```
<!-- sha1sum - for calculating checksum -->
<PackageContents>
  <File_Info>
    <name>isrv-ucmk9.16.10.2-vga.qcow2</name>
    <type>root_image</type>
    <sha1_checksum>9a61ef4e7c79fe6f6d6cf9fa5b3651dac7780624</sha1_checksum>
  </File_Info>
  <File_Info>
    <name>image_properties.xml</name>
    <type>image_properties</type>
    <sha1_checksum>3f78a87d67cfd55e9ba108e7b36b119e0534ef16</sha1_checksum>
  </File_Info>
  <File_Info>
    <name>isrv_ovf_env.xml</name>
    <type>bootstrap_file_1</type>
    <sha1_checksum>aad802de6ef10dc4b4b4c13d7d5d9991e4d89a8c</sha1_checksum>
  </File_Info>
</PackageContents>
```


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Image Packaging GUI

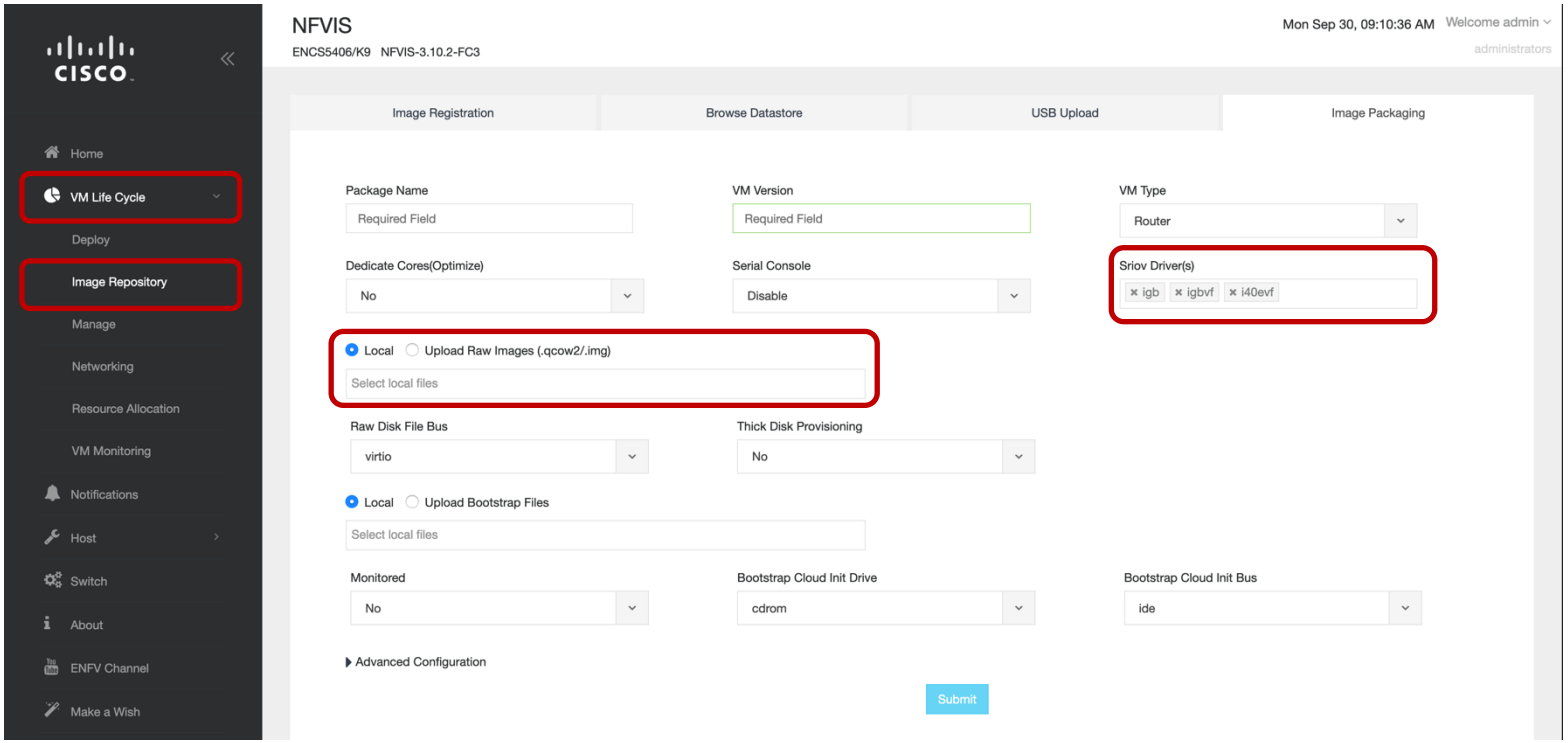

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Image Packaging GUI Cont.

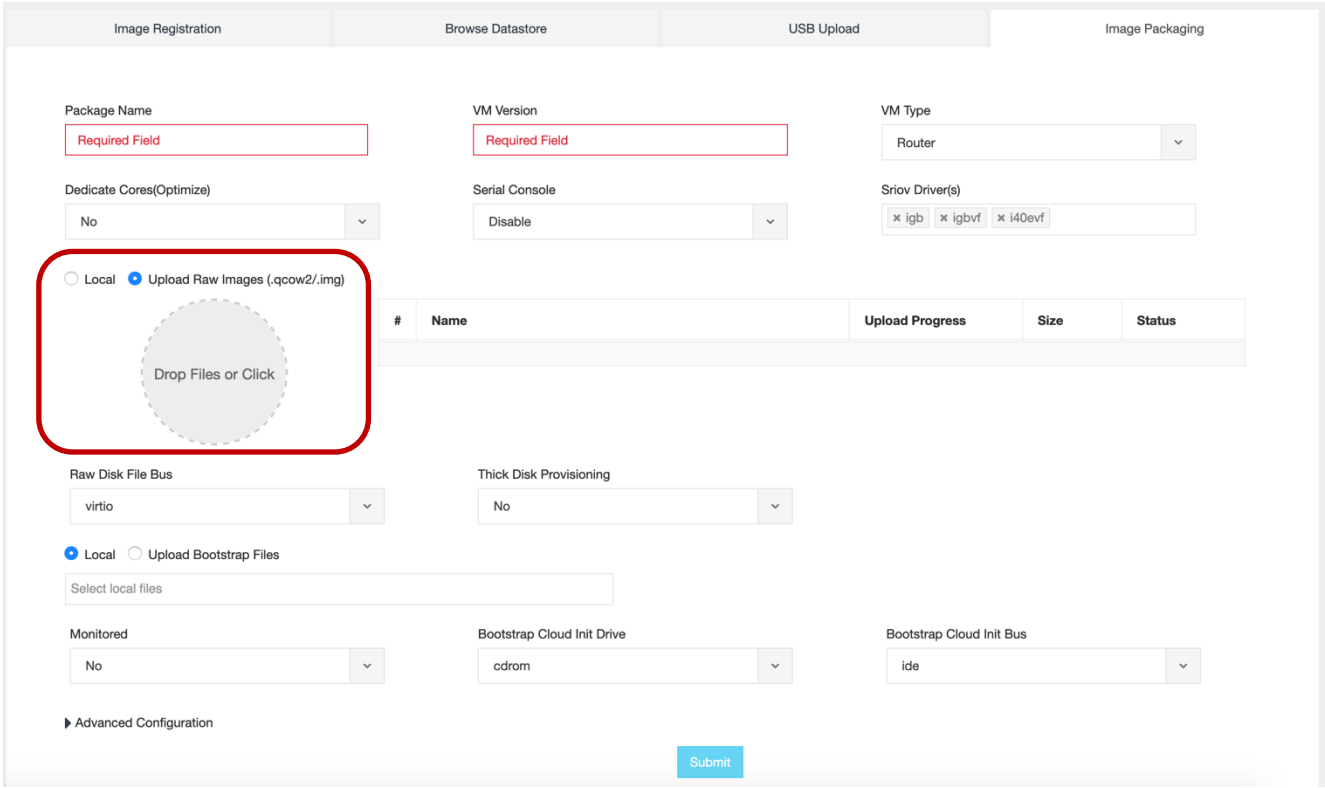

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Image Packaging GUI Cont.

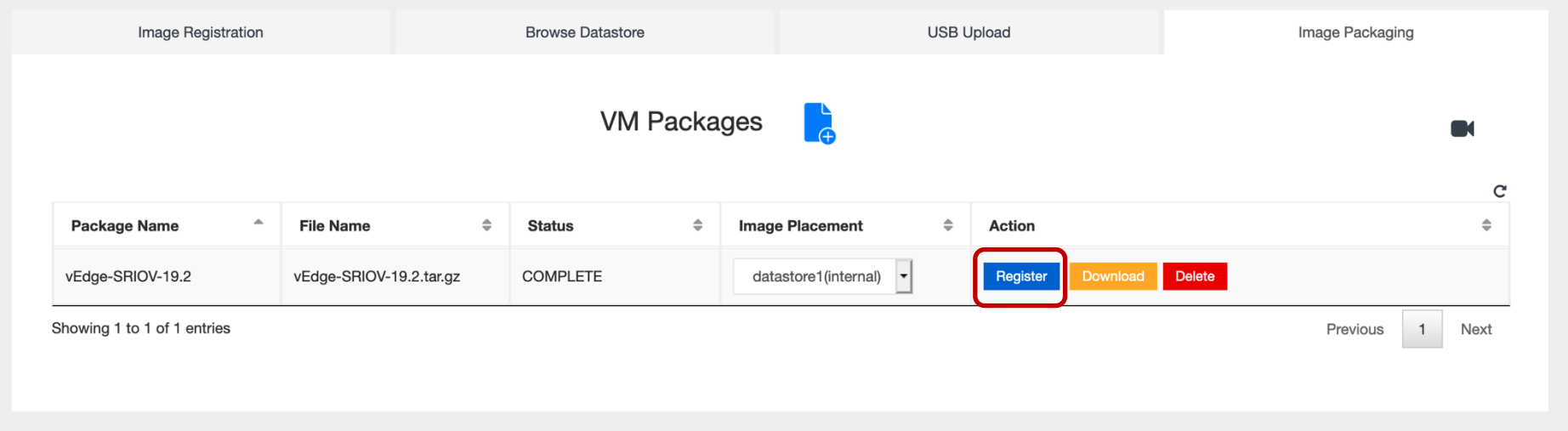

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Image Packaging CLI

- VM packaging utility located in **VM Life Cycle->Image Repository->Browse Datastore->data->intdatastore->vmpackagingutility**
- 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.
- *nfvpt.py -o isrv.16.10.04 -i isrv-universalk9.16.10.04.qcow2 -n ISRv.16.10.04 -t ROUTER -r 16.10.04 --monitored true --privileged true --bootstrap ovf-env.xml:file1,ios-xe.txt:file2 --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 --sriov_list igb,igbvf,i40evf --custom key:PASSWD,val:secret*

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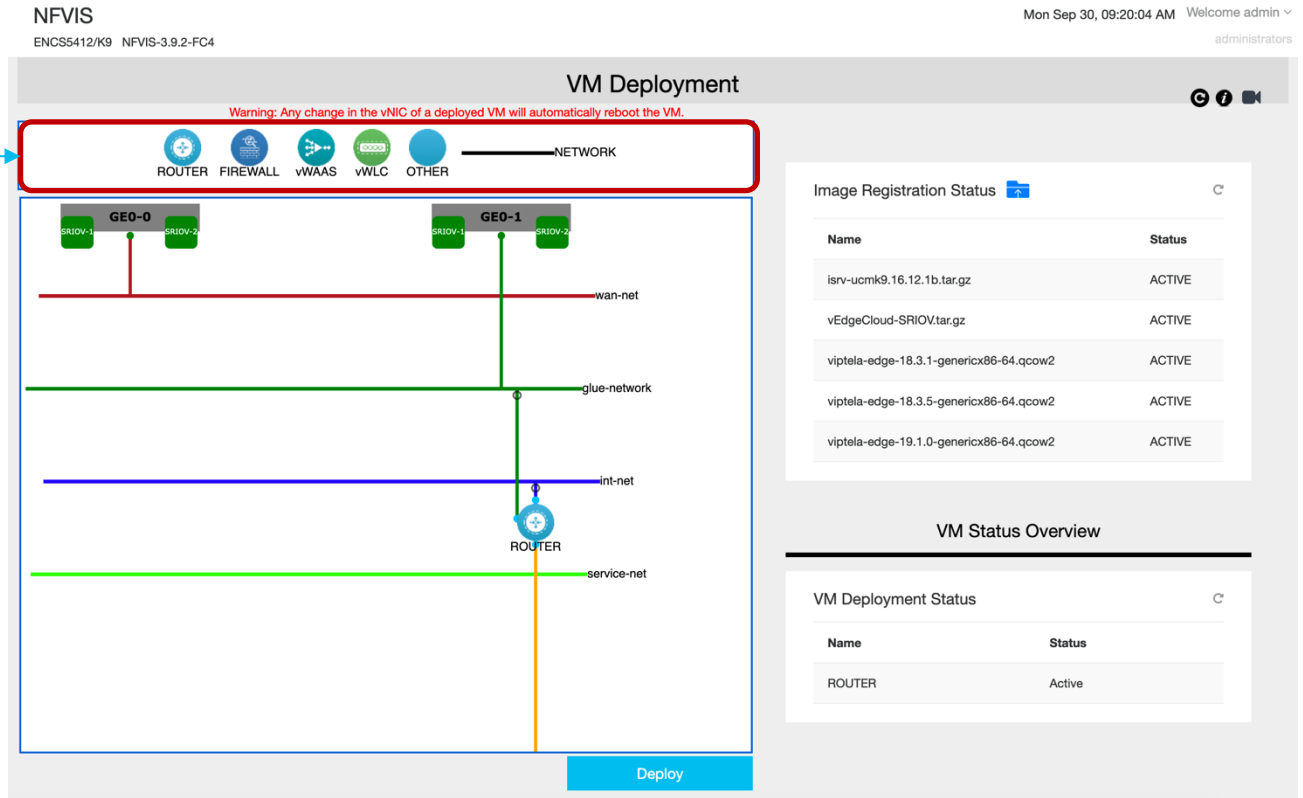
VM Deployment

Deploying VM

Drag and drop VM type or new virt/io network to the area below



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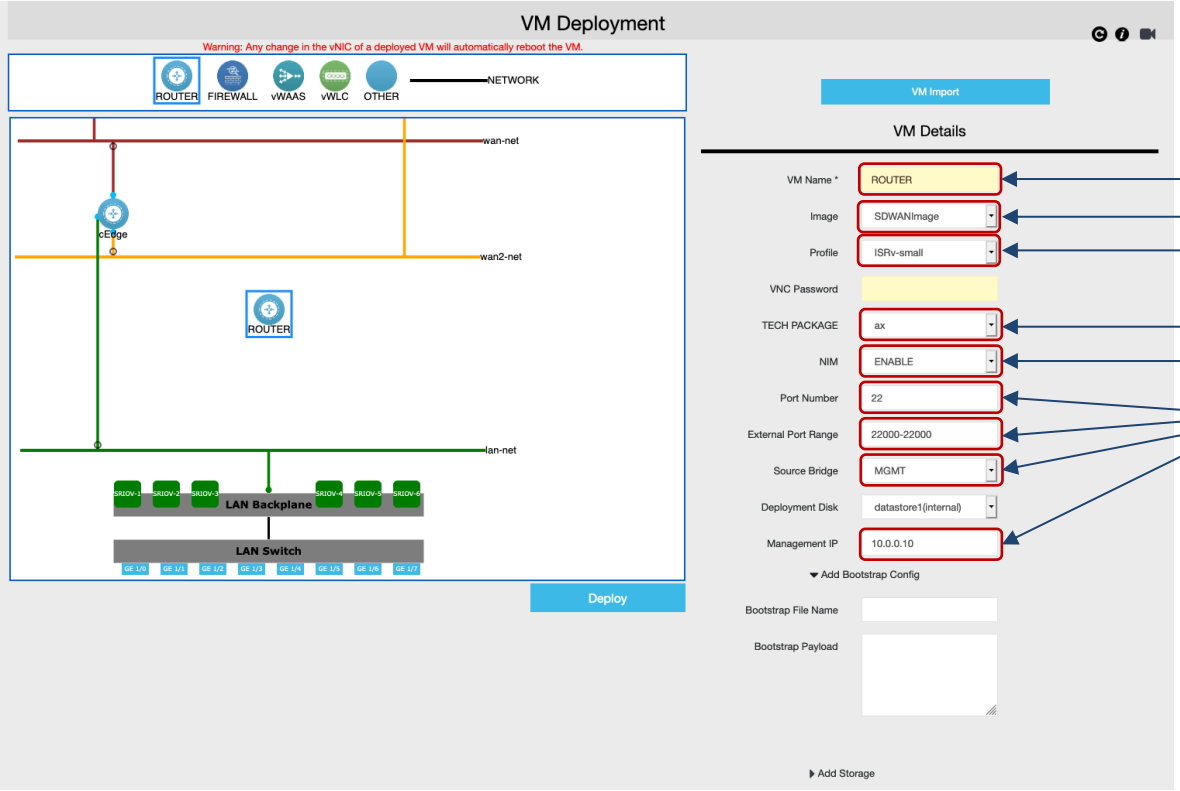
Deploying VM Cont.



VM name

Image you are going to use

Resource allocation profile or flavour, also defines maximum performance in terms of tunnels and throughput

Technology package licence type

NIM support

Management configuration, port forwarding, internal MGMT bridge and management ip from the configured subnet

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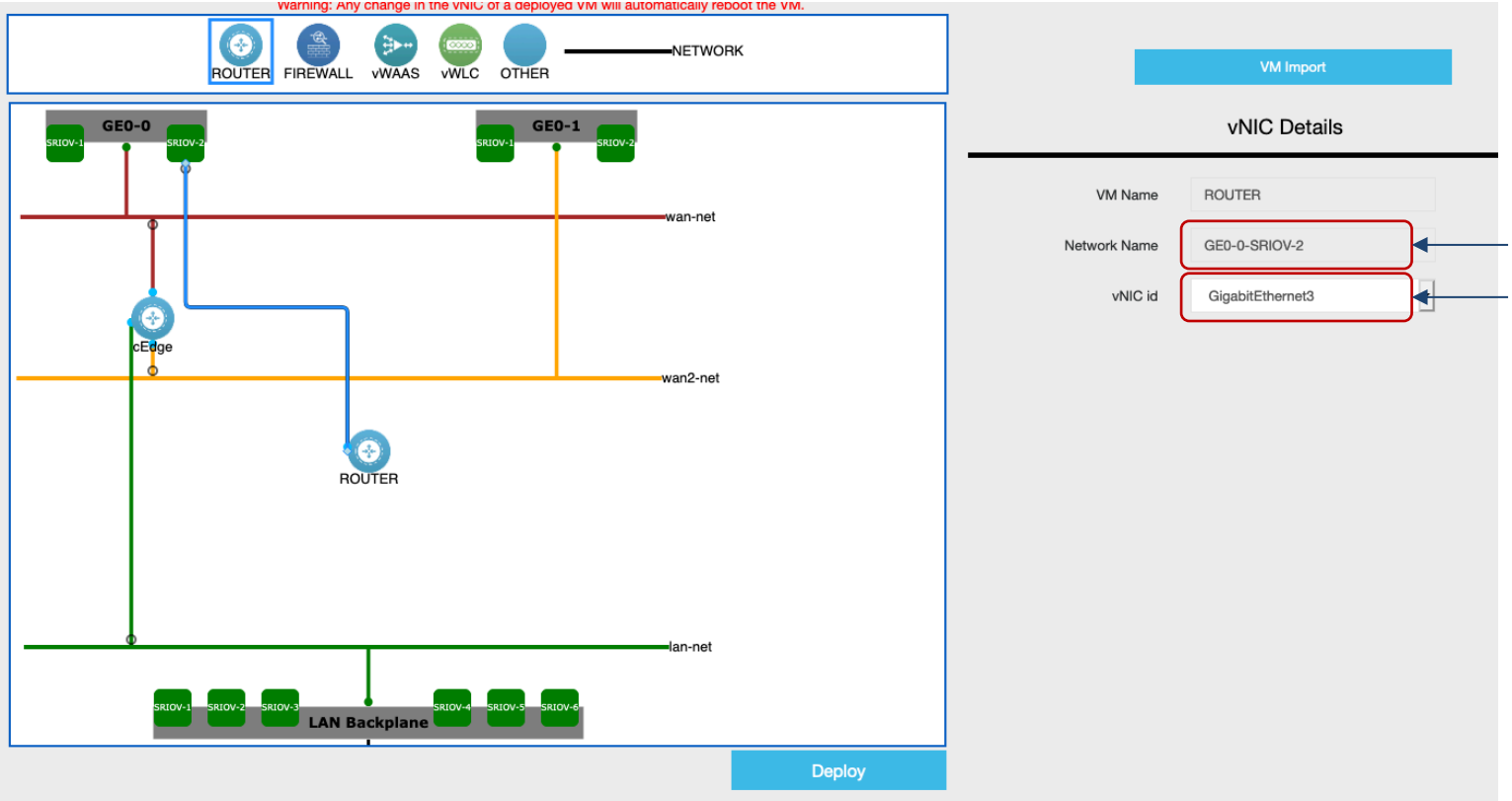
Deploying VM Cont.



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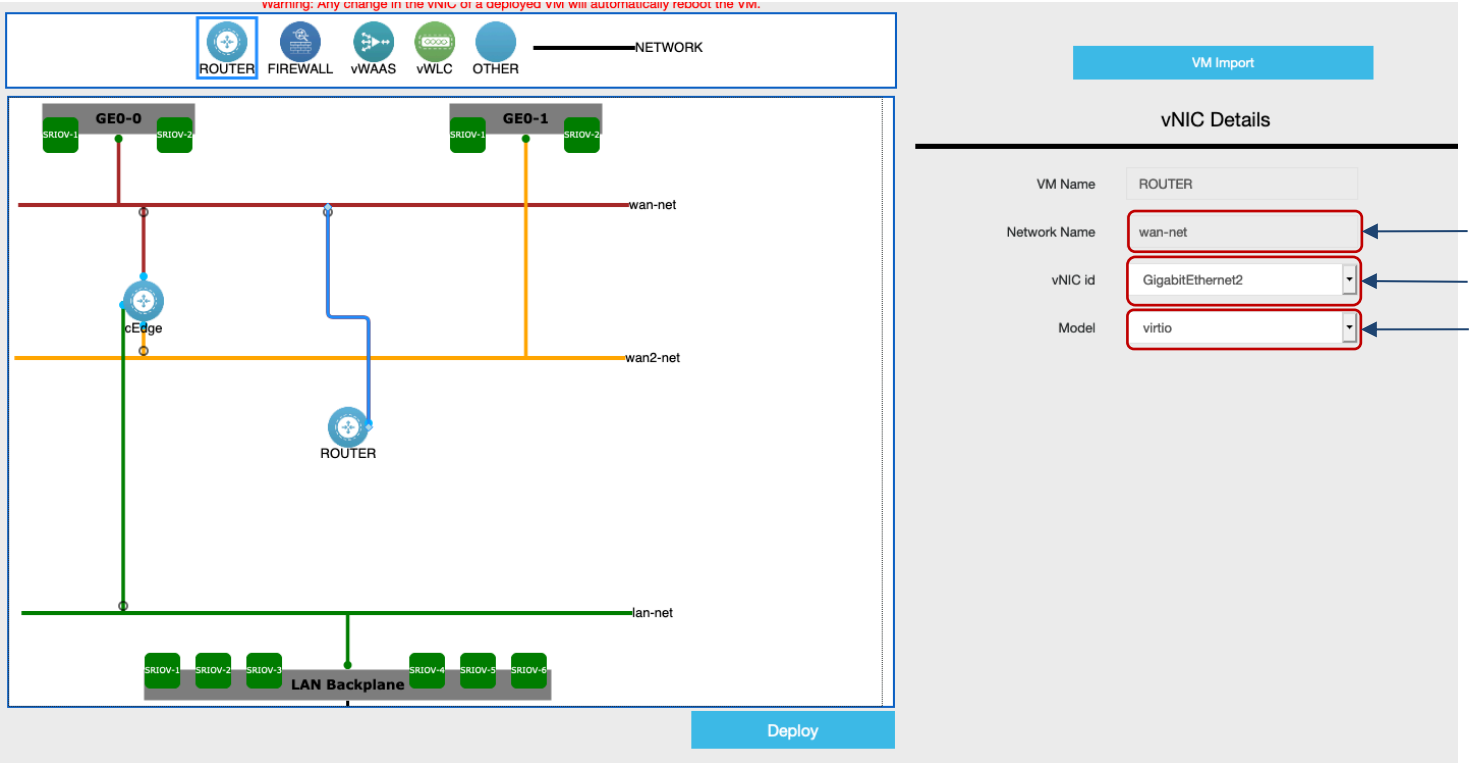
Deploying VM Cont.



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vEdge Cloud and ISRv Flavours

- vEdge Cloud using 1 core for the system and the rest for the forwarding, you can have 2 flavours 2 cores or 4 cores
- vEdge Cloud gives better performance with 8 Gig of RAM
- ISRv will also take 1 core for OS others for forwarding
- ISRv can allocate additional cores for security features which require use of containers

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Interface Performance

- SRIOV and DPDK in theory should provide performance close to interface speed, in reality performance is affected by feature set, DPI, Firewall, IPS etc. it all slows down the maximum performance and needs to be tested.
- OVS is capable to provide performance up to a few hundred Mbps with same remarks regarding feature set.
- PCI path-though same as SRIOV and DPDK
- VNF can have performance limitations, also important to look at the datasheet before deploying high performance interfaces.

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Monitored VM Caveat

- When VM is monitored – it is connected to internal NFVIS management network.
- If this address is not reachable, NFVIS will reload the VM (be careful applying template from vManage).
- If after 3 reloads VM is not reachable on this management interface, it will be moved to the error state even being fully operational.
- If VM is not monitored first interface you create will be management interface

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VM Deployment Demo

High Availability Design Considerations

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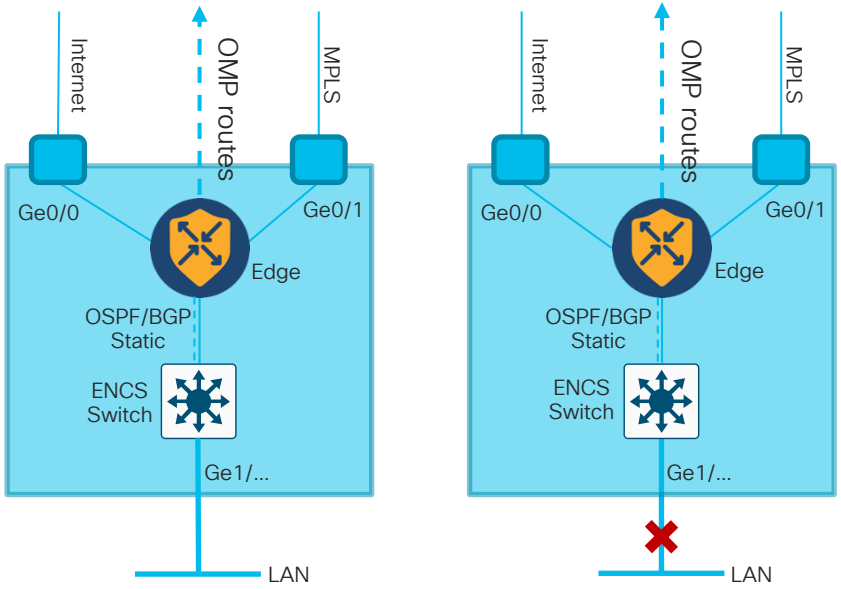
LAN Failure

- OMP update time is equal to routing protocol timers
- BFD is not supported on SD-WAN VNFs till 20.2/17.3
- WAN bandwidth can be utilised but traffic is dropped on the remote end



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VRRP LAN Failure

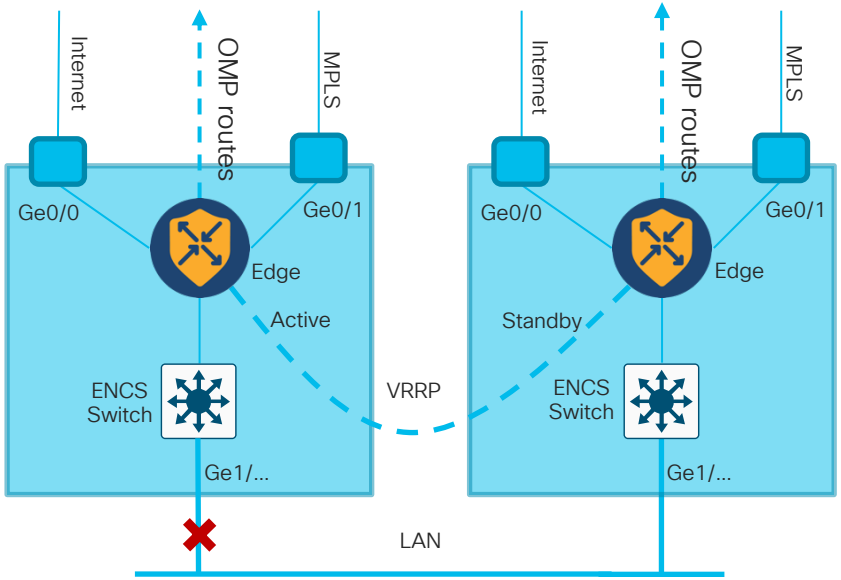
Port tracking is developed to resolve this issue.

Configuration example:

```
conf t
switch
interface gi1/…
track-state <vm_name> <NICID>
```

To find NICID:

```
show vm_lifecycle deployments
<vm_name>
```



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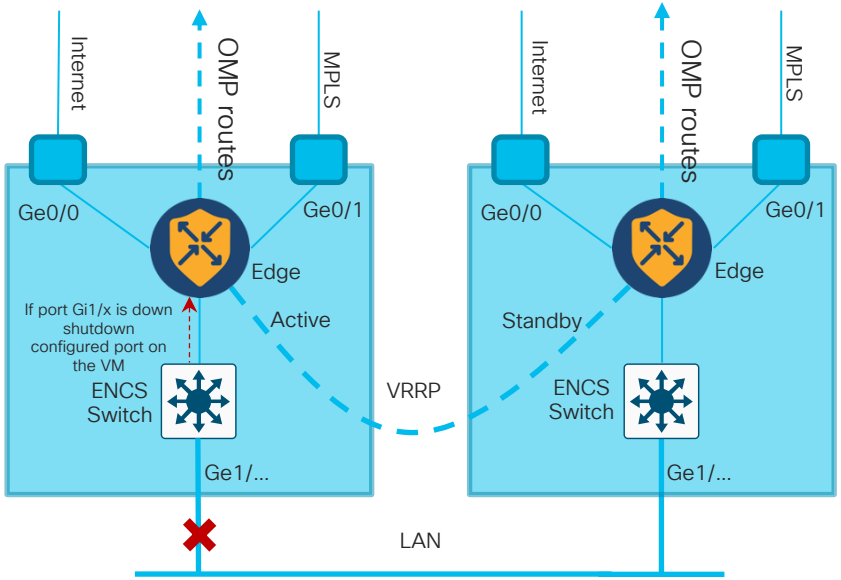

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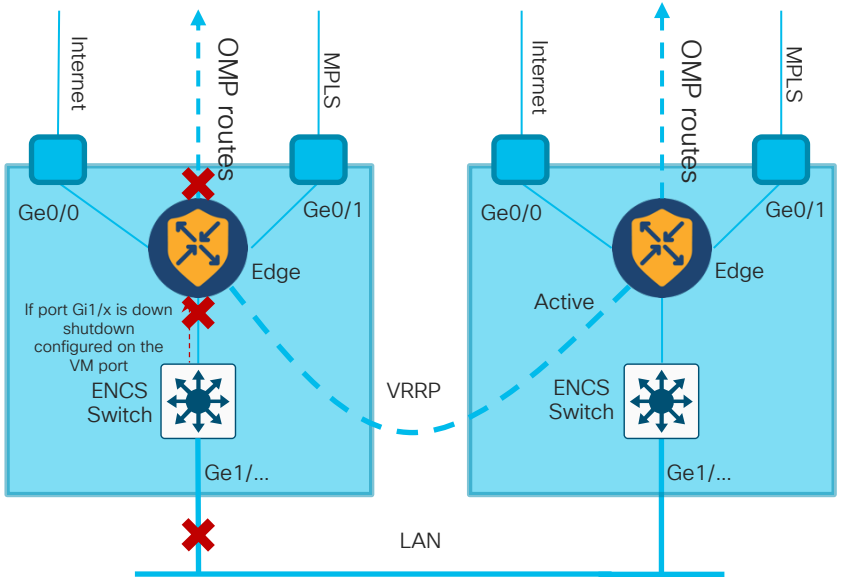

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Few Caveats For vEdge Cloud

- For vEdge Cloud VRRP on SRIOV is supported starting 19.2 but due to Intel NIC packet processing, additional fixes in the drivers needed and full support expected in NFVIS 4.2.1 July 2020
- Port tracking for SRIOV is supported on NFVIS 3.12.3
- DPI supports ~140k flows per CPU.

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Virtual Branch Design Scenarios

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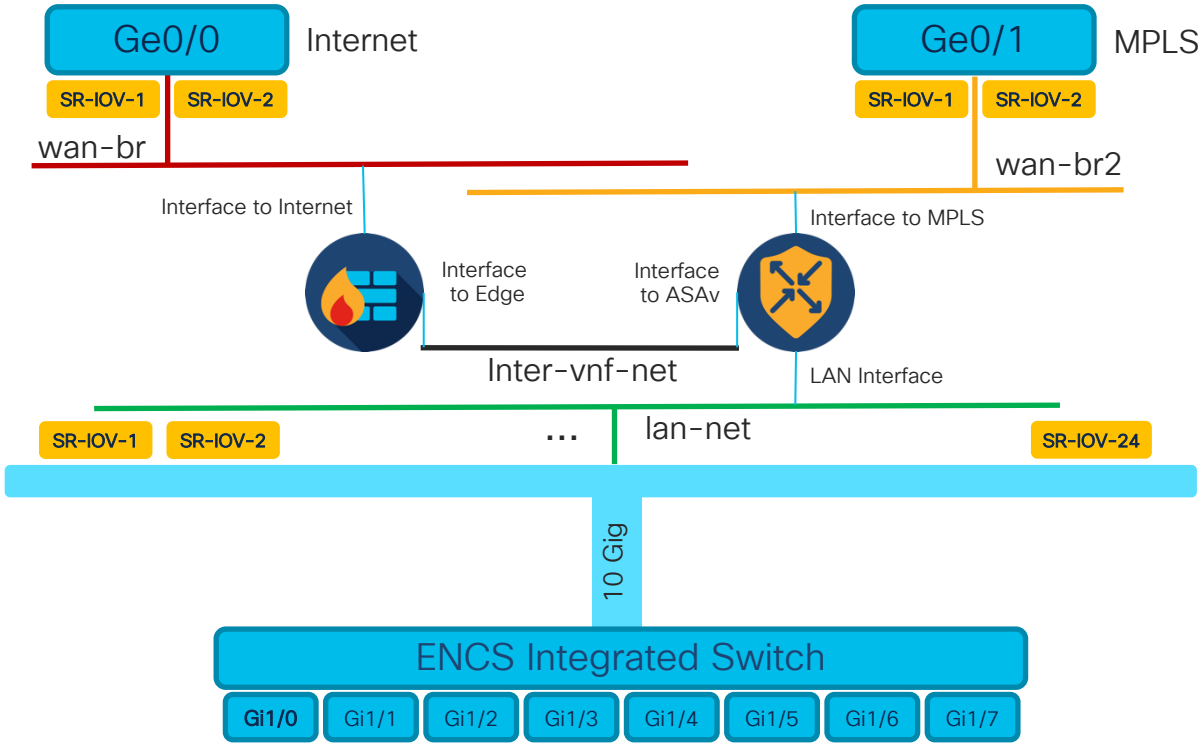
vEdge/ISRv + ASAv + OVS



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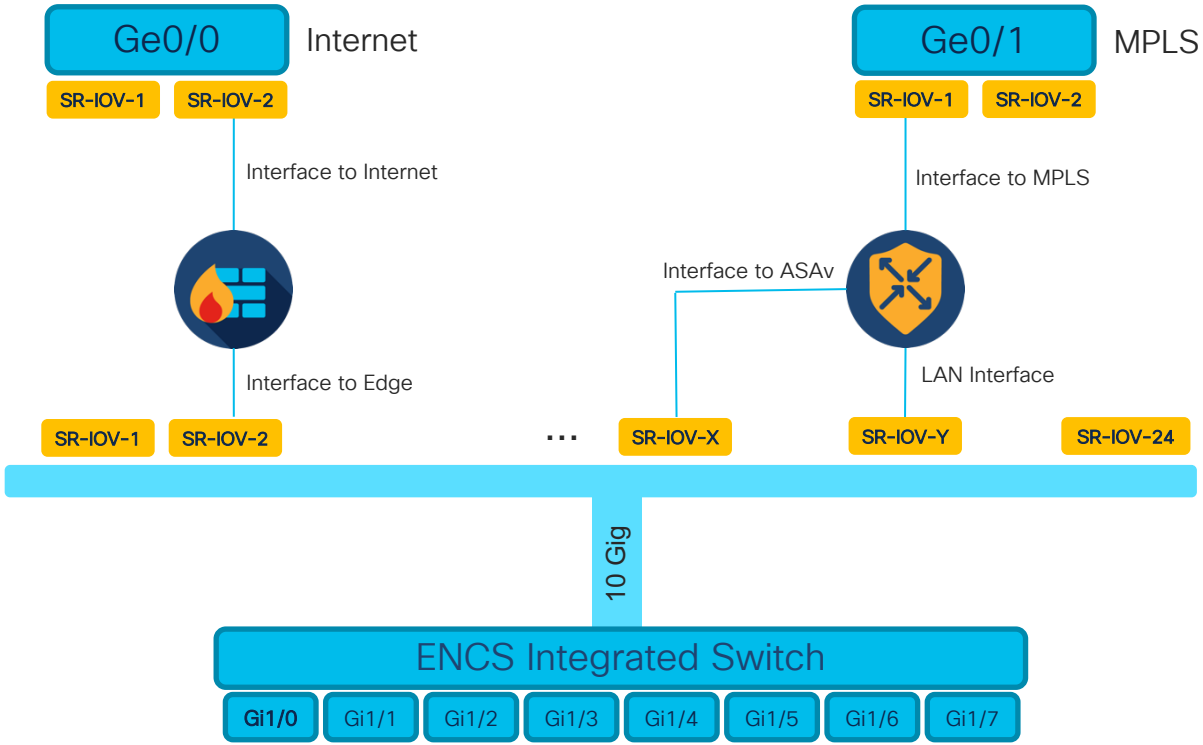
vEdge/ISRv + ASAv + SRIOV



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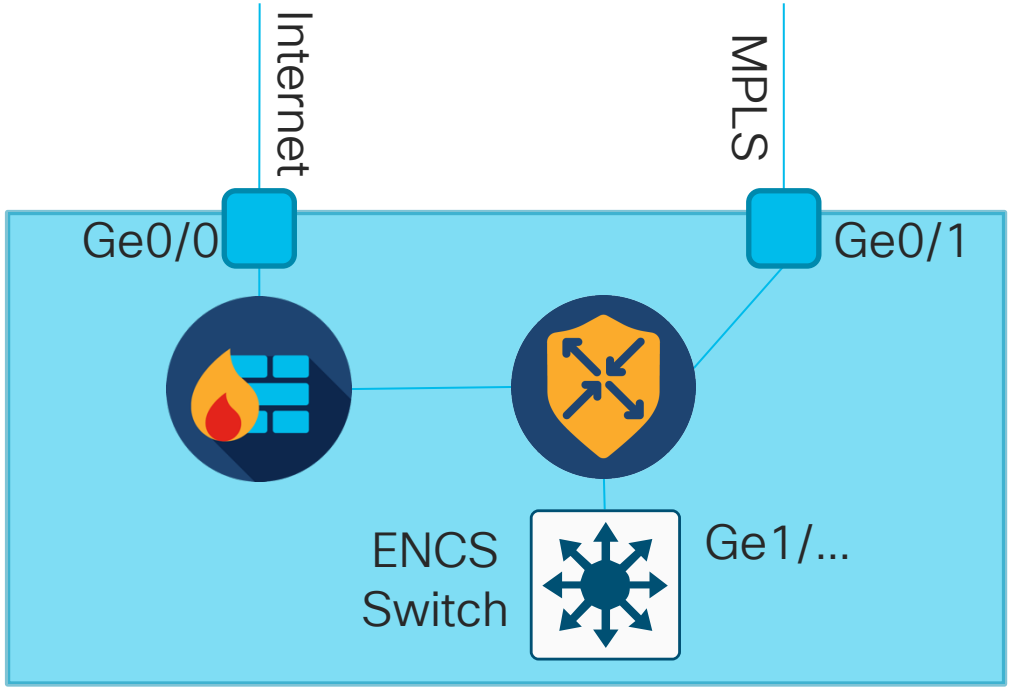
vEdge/ISRv + ASAv



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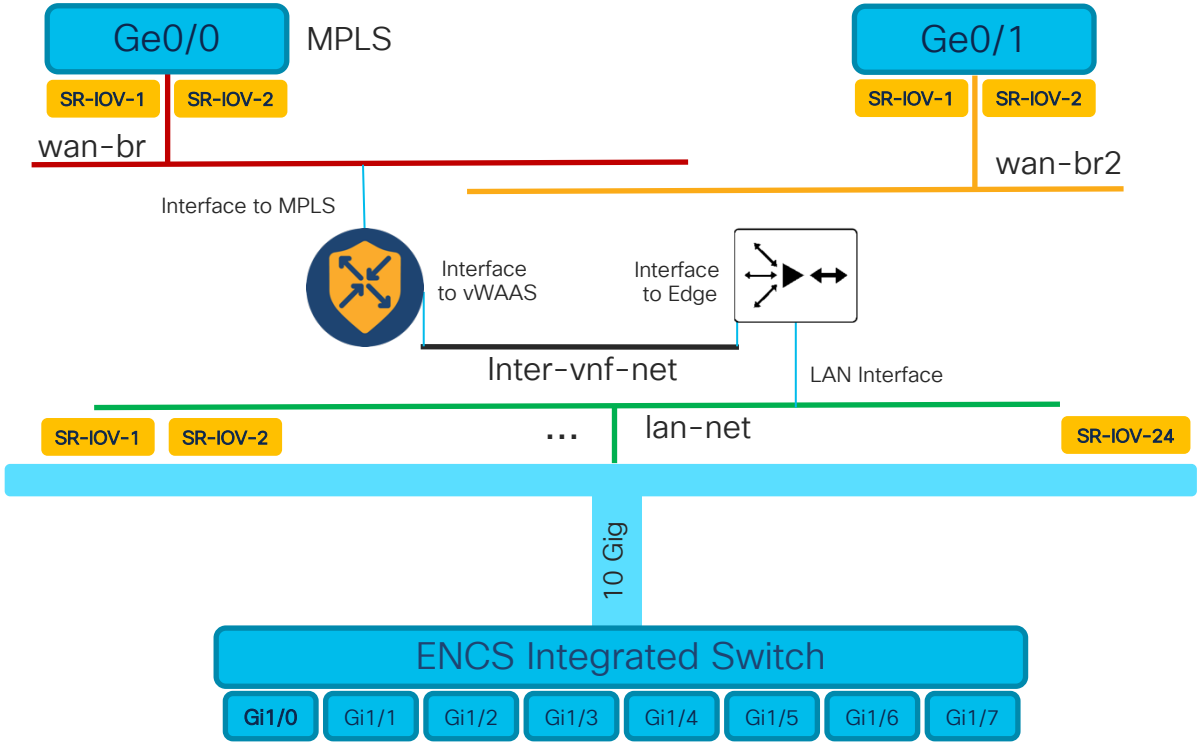
vEdge/ISRv + vWAAS/SteelHead In-path + OVS



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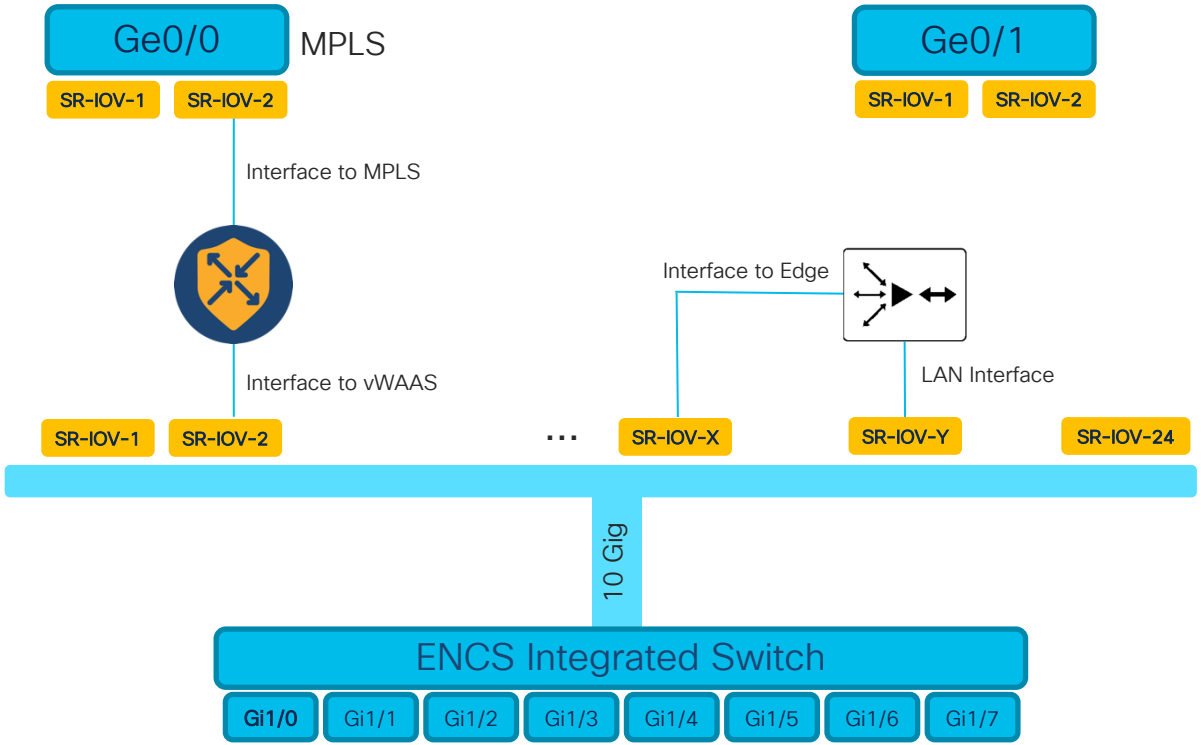
vEdge/ISRv + vWAAS/SteelHead In-path + SRIOV



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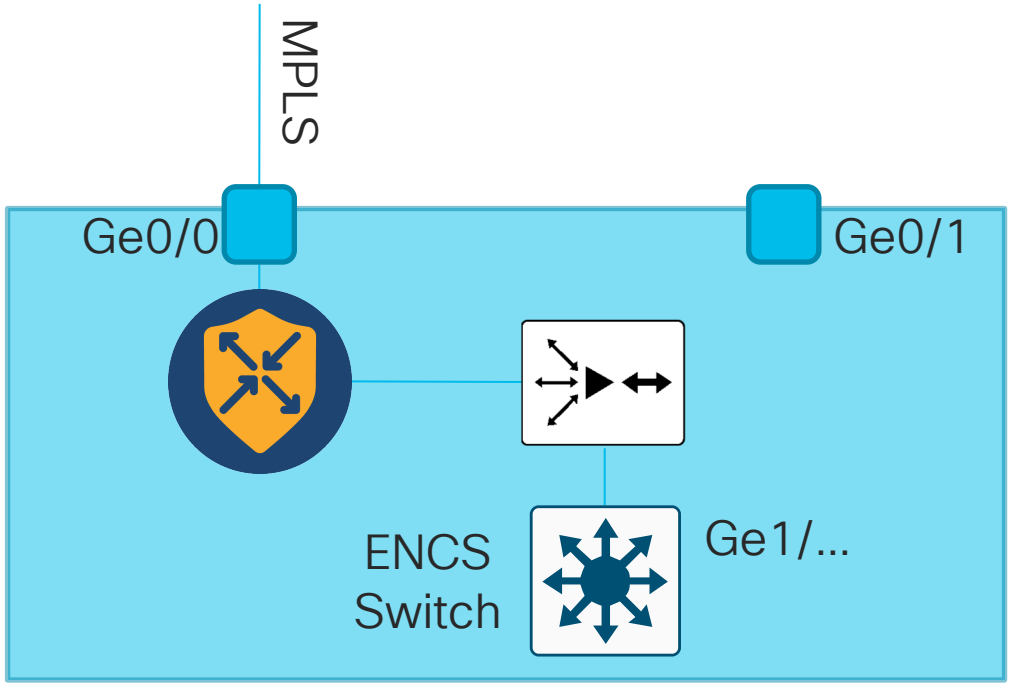
vEdge/ISRv + vWAAS/SteelHead In-path



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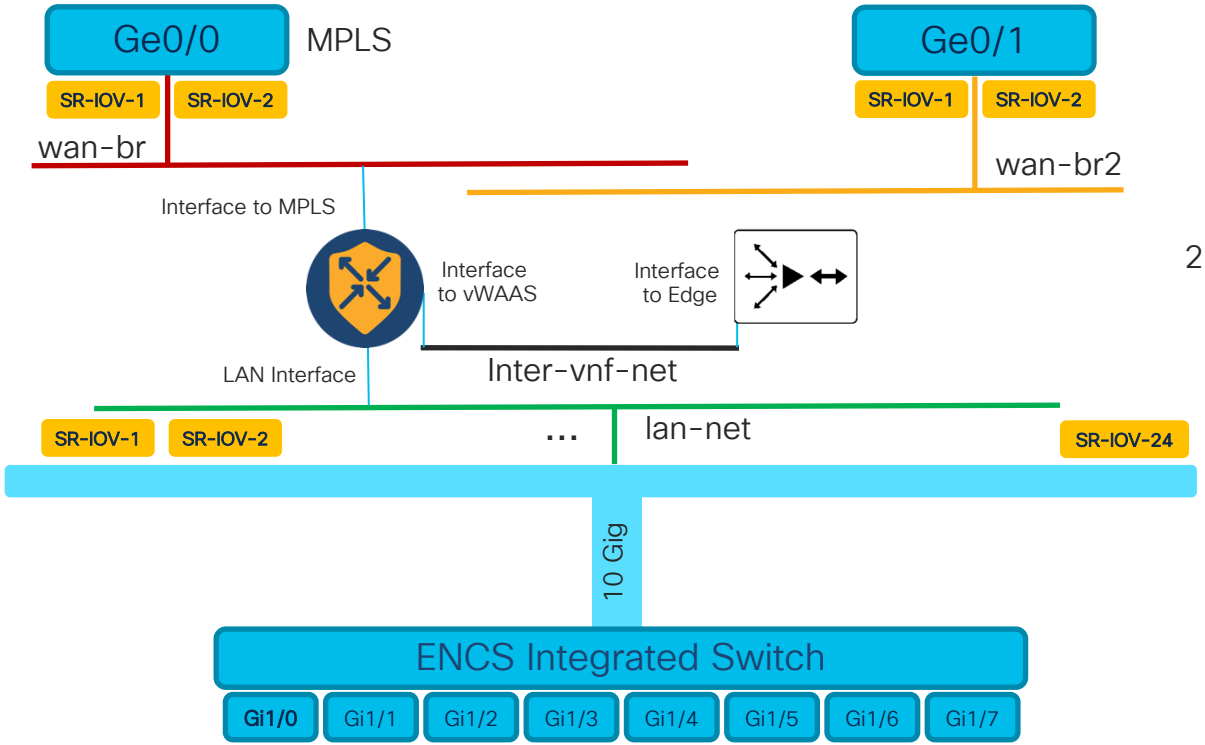
ISRv + vWAAS Out-of-path + OVS



*Supported starting 20.1/17.2.1 with AppNav-XE and full SD-WAN WAAS integration

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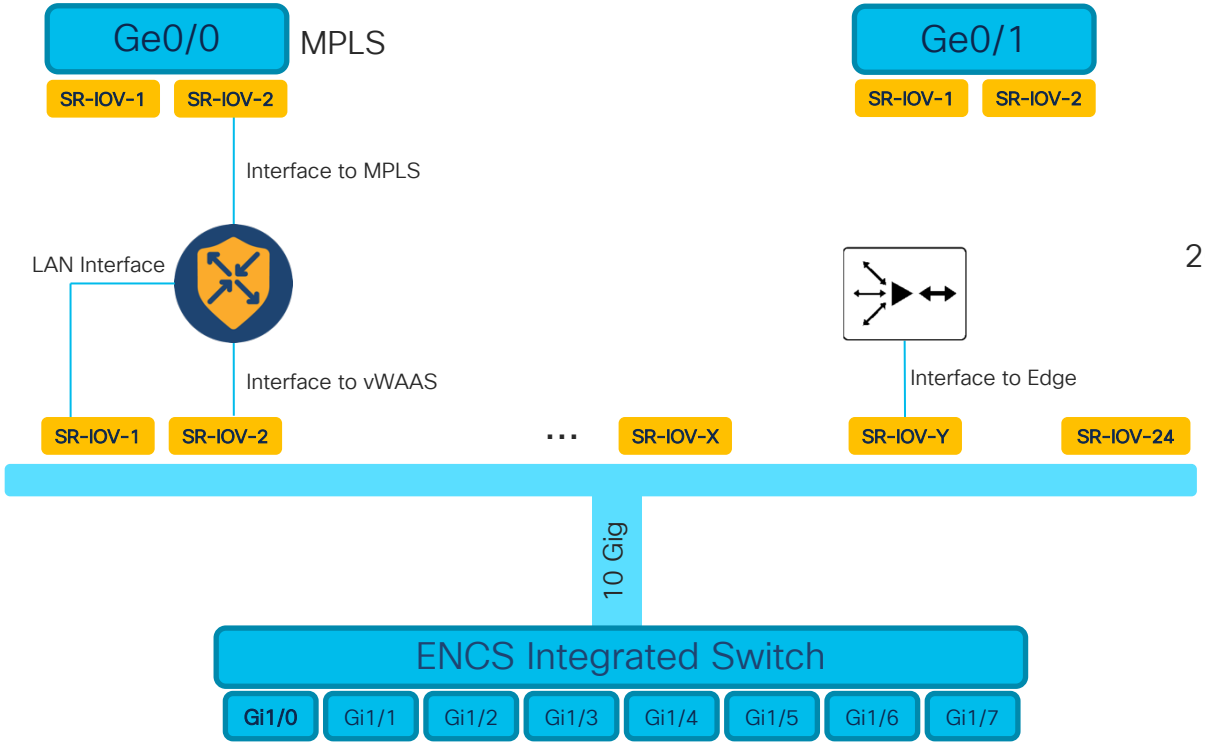
ISRv + vWAAS Out-of-path + SRIOV



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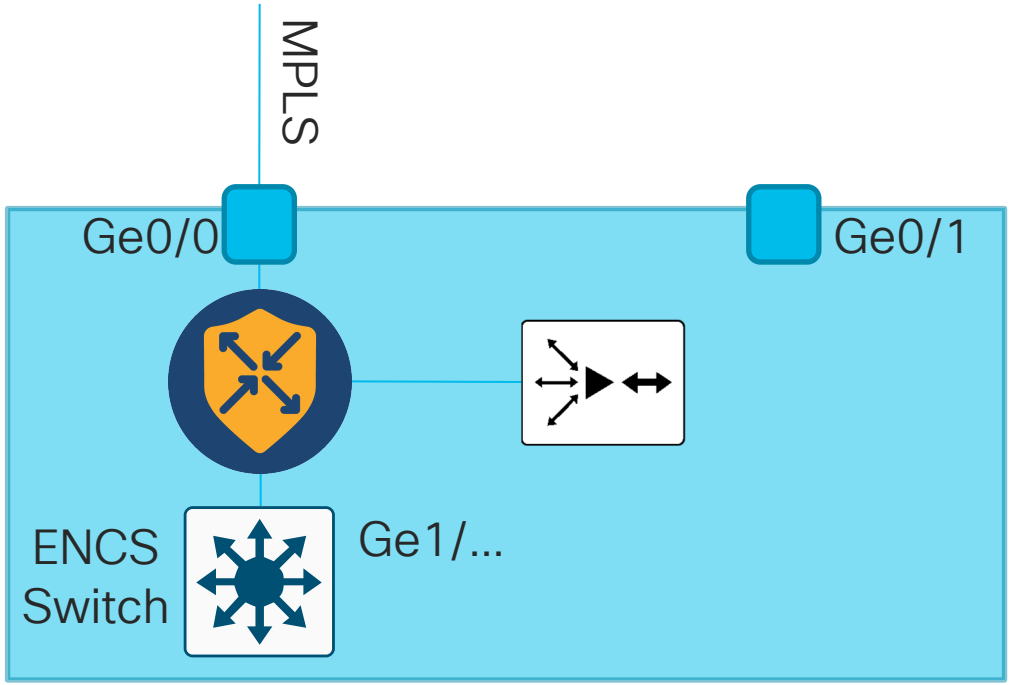
ISRv + vWAAS Out-of-path



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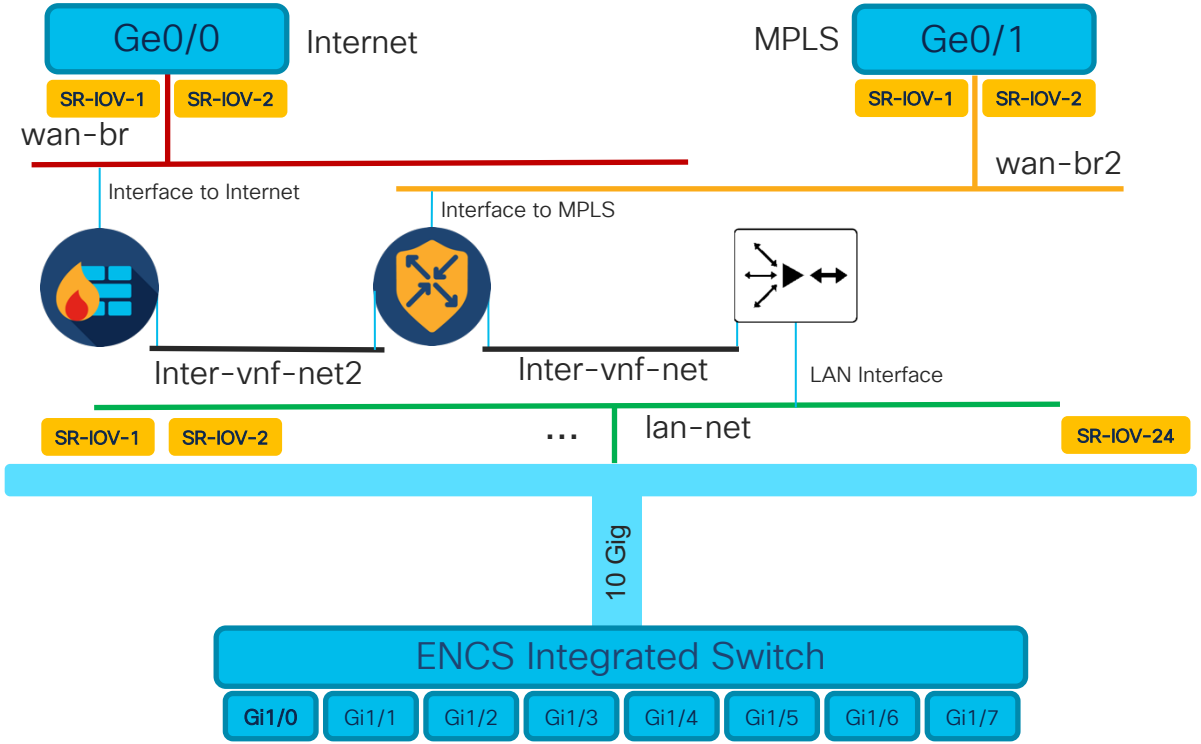
vEdge/ISRv + vWAAS/SteelHead In-path + ASAv +OVS



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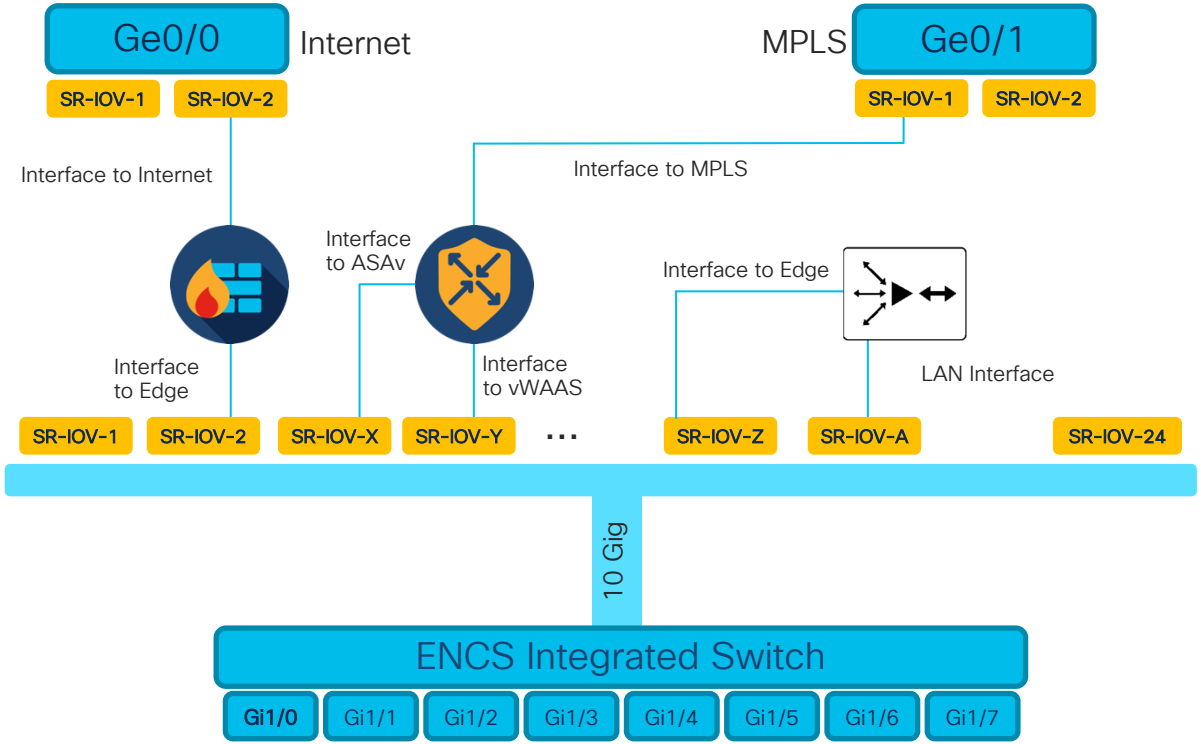
vEdge/ISRv + vWAAS/SteelHead In-path + ASAv + SRIOV



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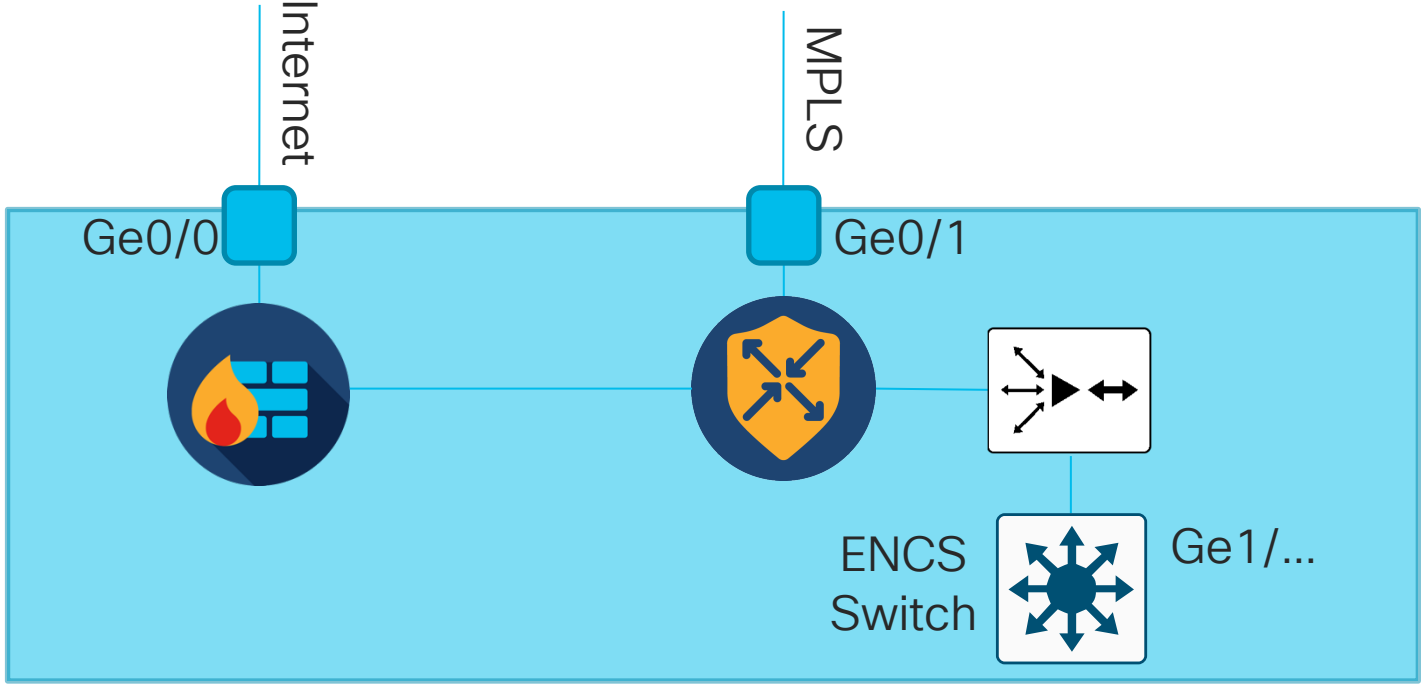
vEdge/ISRv + vWAAS/SteelHead In-path + ASAv



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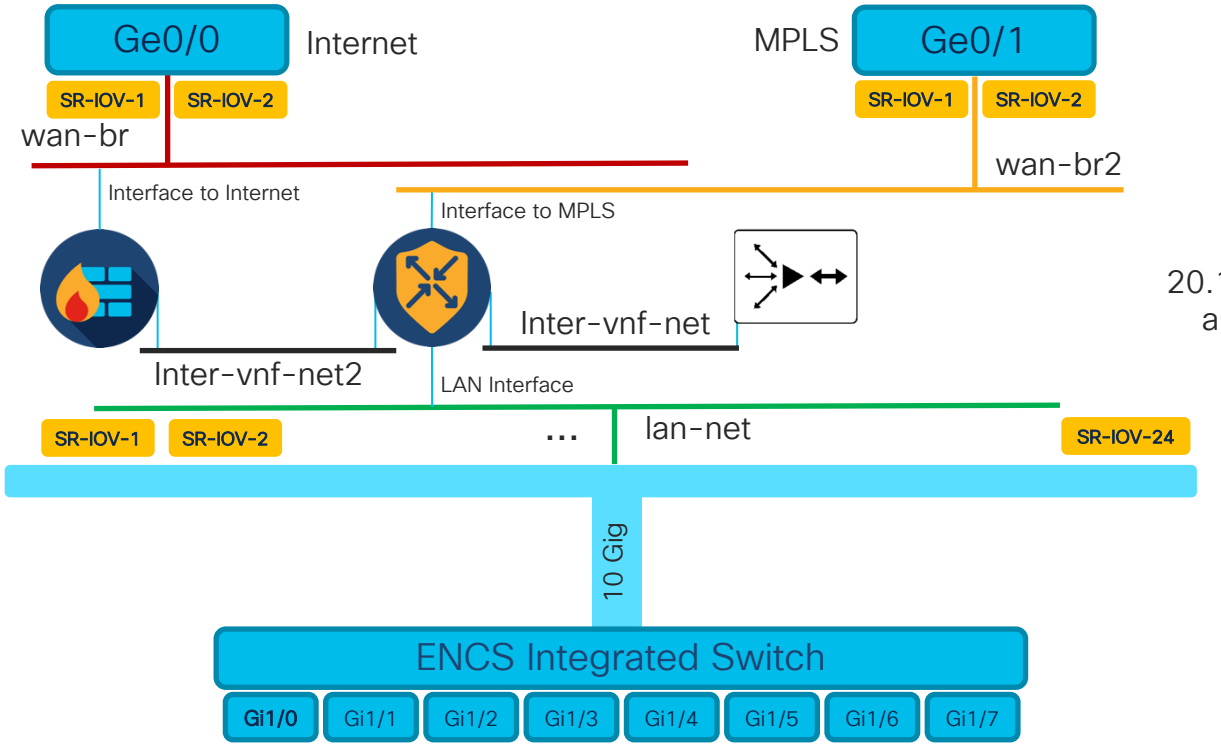
ISRv + vWAAS Out-of-path + ASAv +OVS



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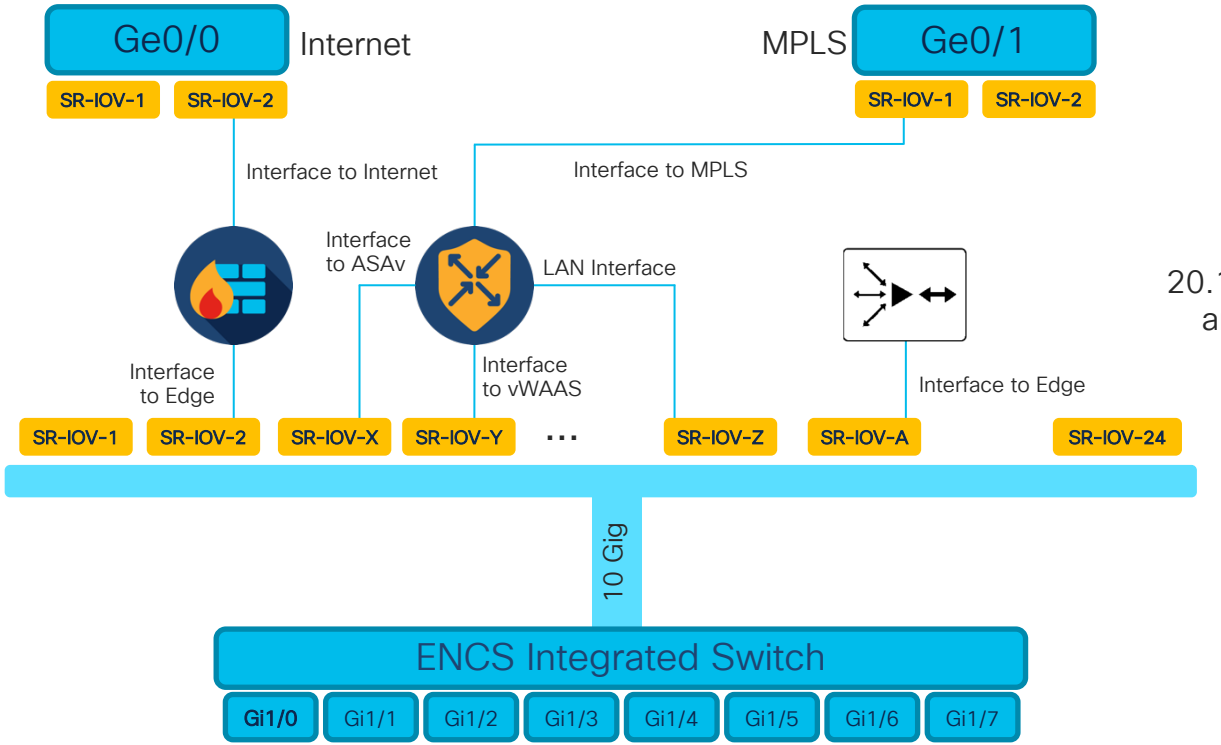
ISRv + vWAAS Out-of-path + ASAv + SRIOV



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ISRv + vWAAS Out-of-path + ASAv

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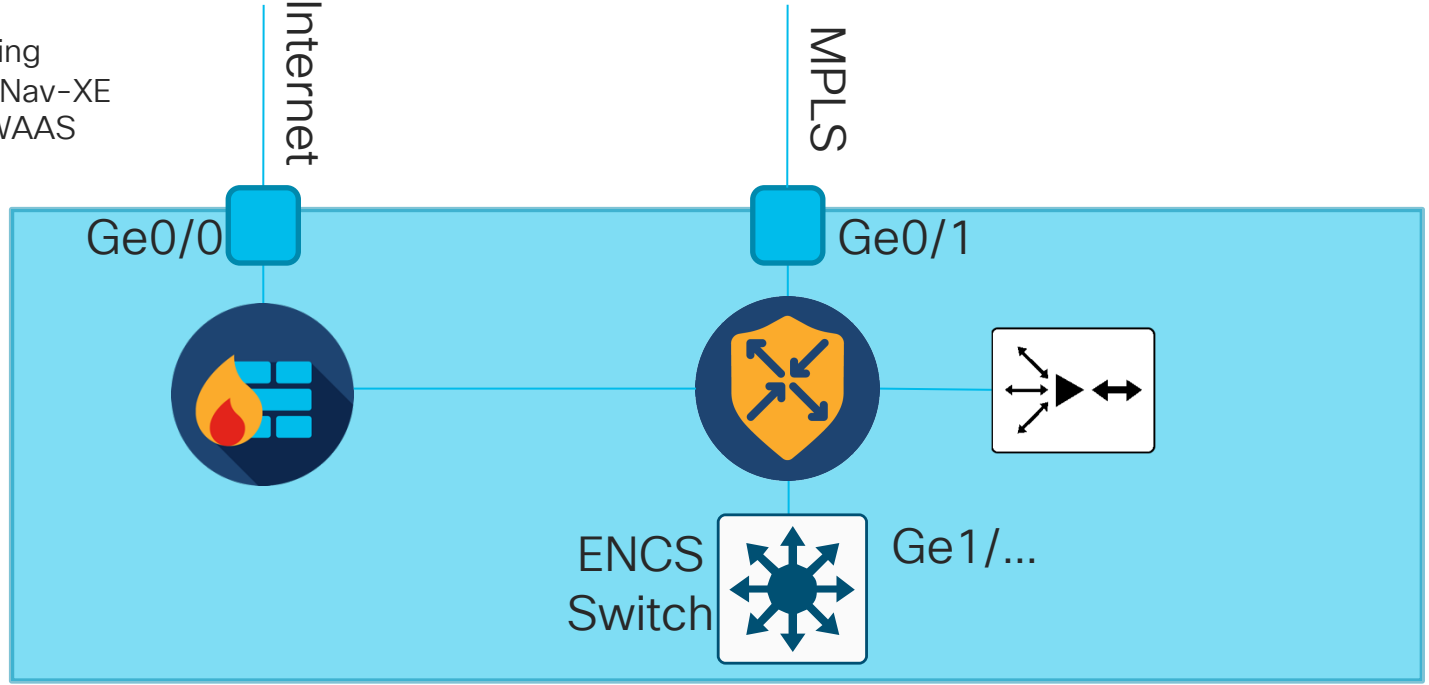

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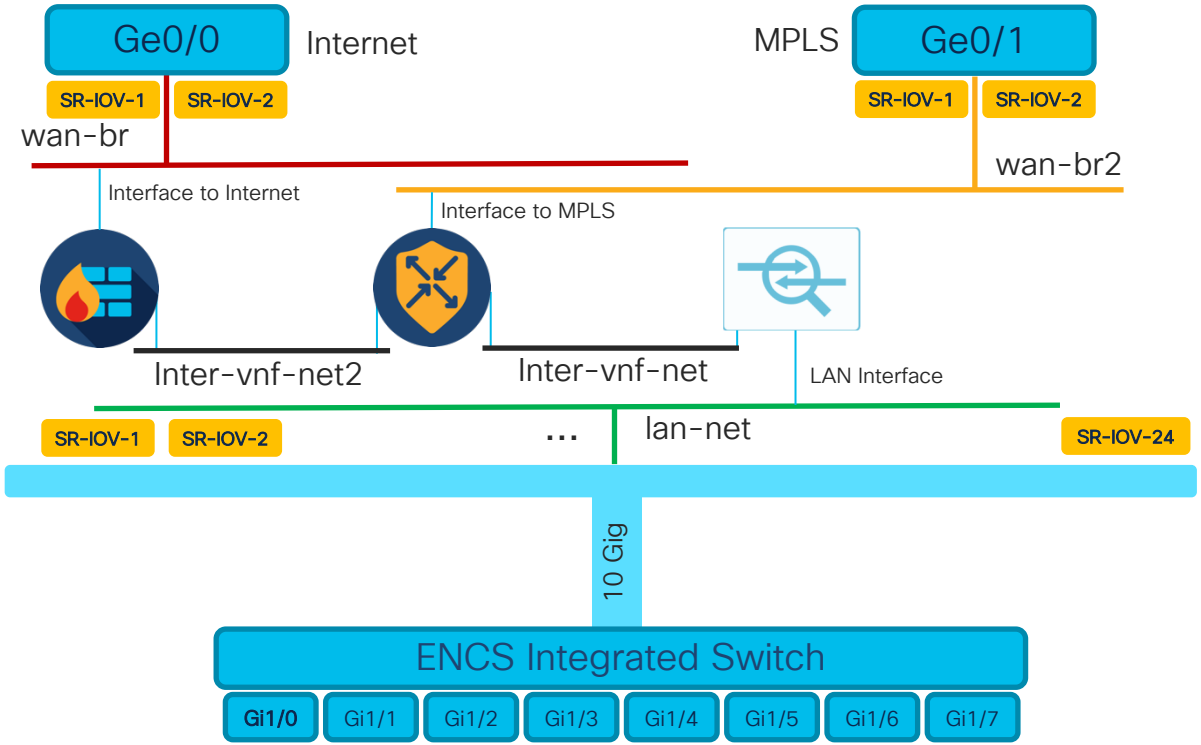
vEdge/ISRv + FTD + ASAv +OVS



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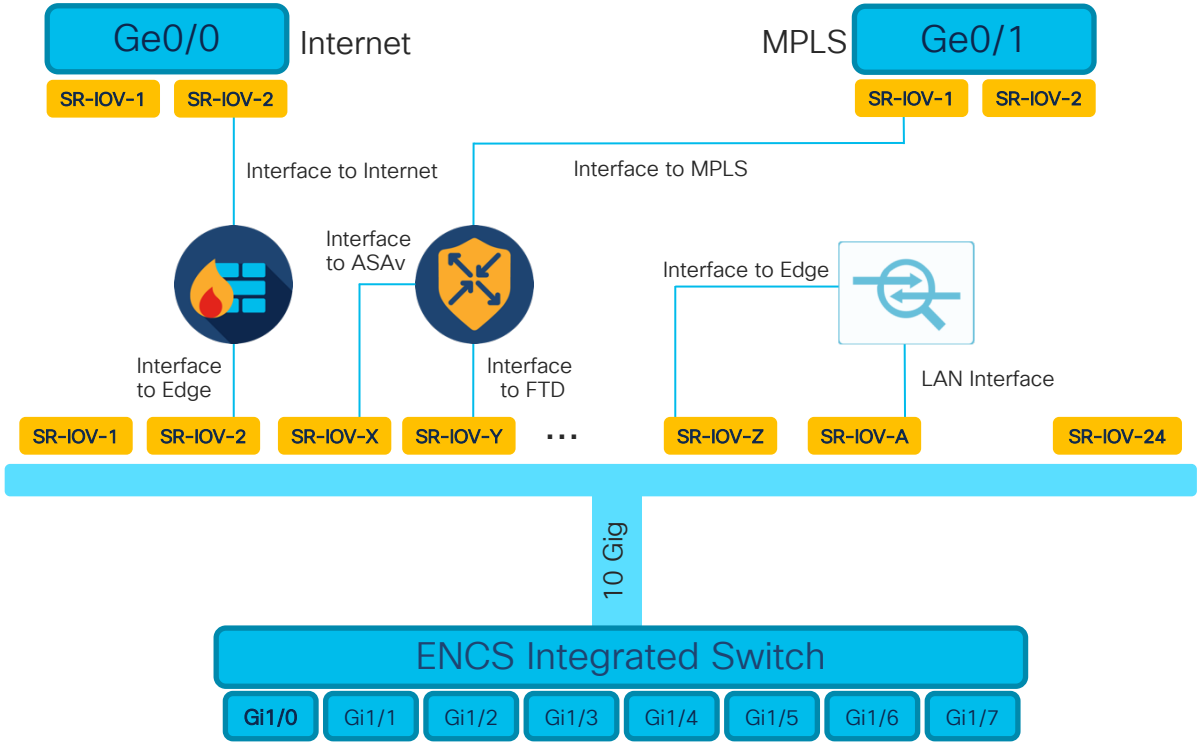
vEdge/ISRv + FTD + ASAv + SRIOV



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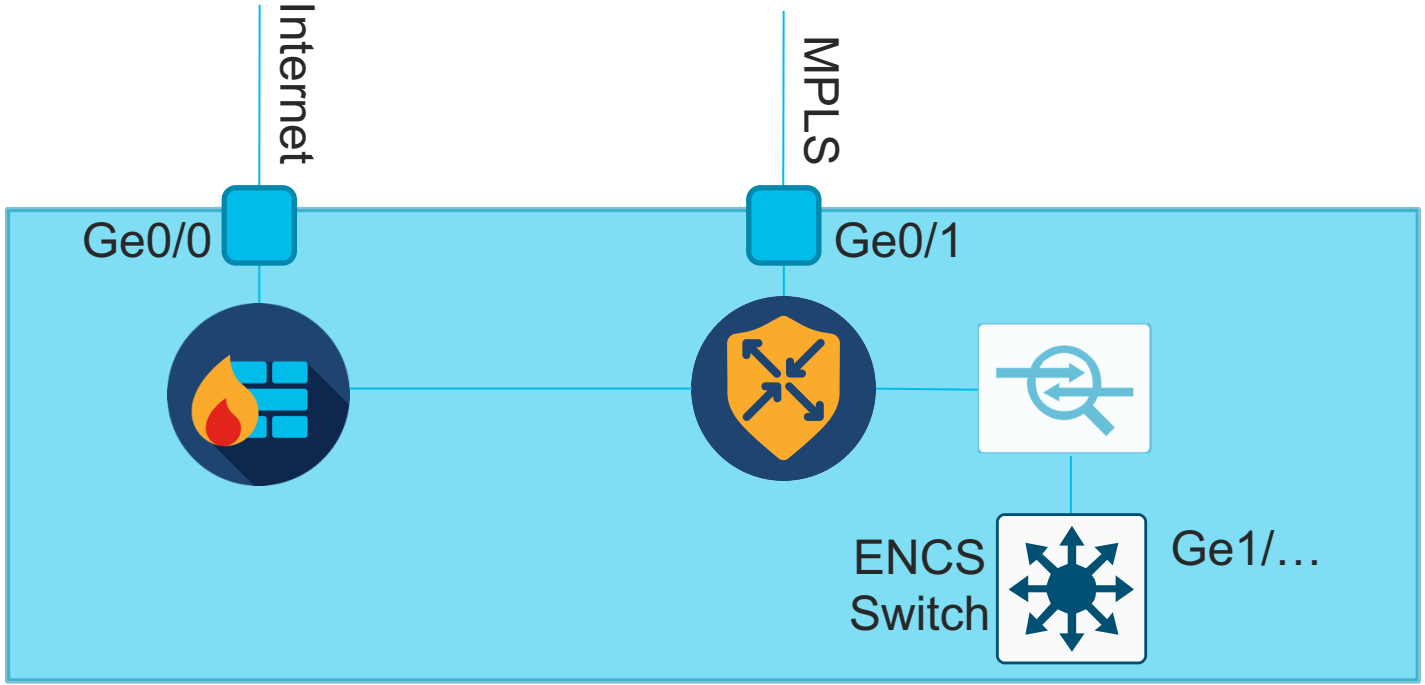
vEdge/ISRv + FTD + ASAv



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Virtual Branch Management

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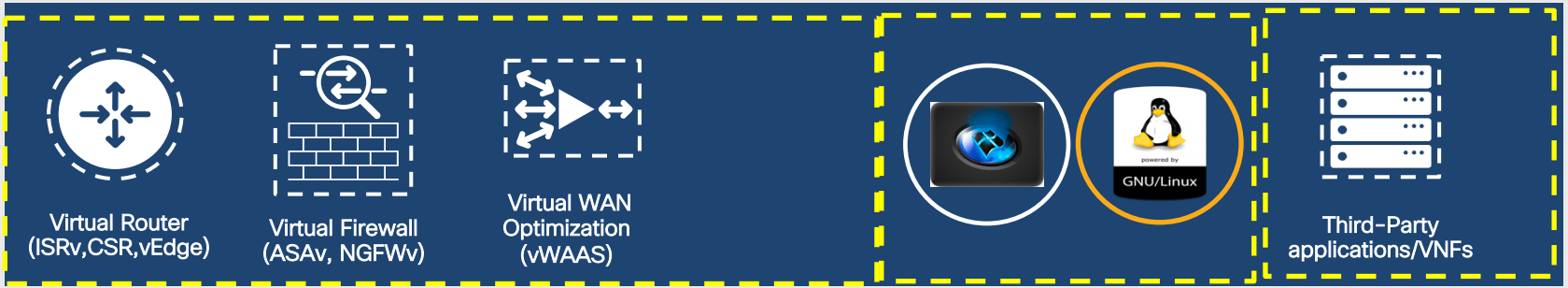
Automation of Service Chain Deployments

cisco Live!

Software Defined Branch
Deploy Services on Any Platform

vManage / Cisco DNA Center / Network Service Orchestrator/ MSX



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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Orchestrators

- Network Service Orchestrator(NSO)
  - Using NETCONF for device configuration
  - CLI management and configuration, requires programming skills
- Managed Services Accelerator (MSX)
  - Using NSO under the hood
  - User friendly Graphical Interface
- DNA Center
  - Using REST for configuration
  - User friendly Graphical Interface
- vManage (Coming soon)
  - Using NSO under the hood
  - Build-in SD-WAN solution

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Demo

SD-WAN Operations Cycle

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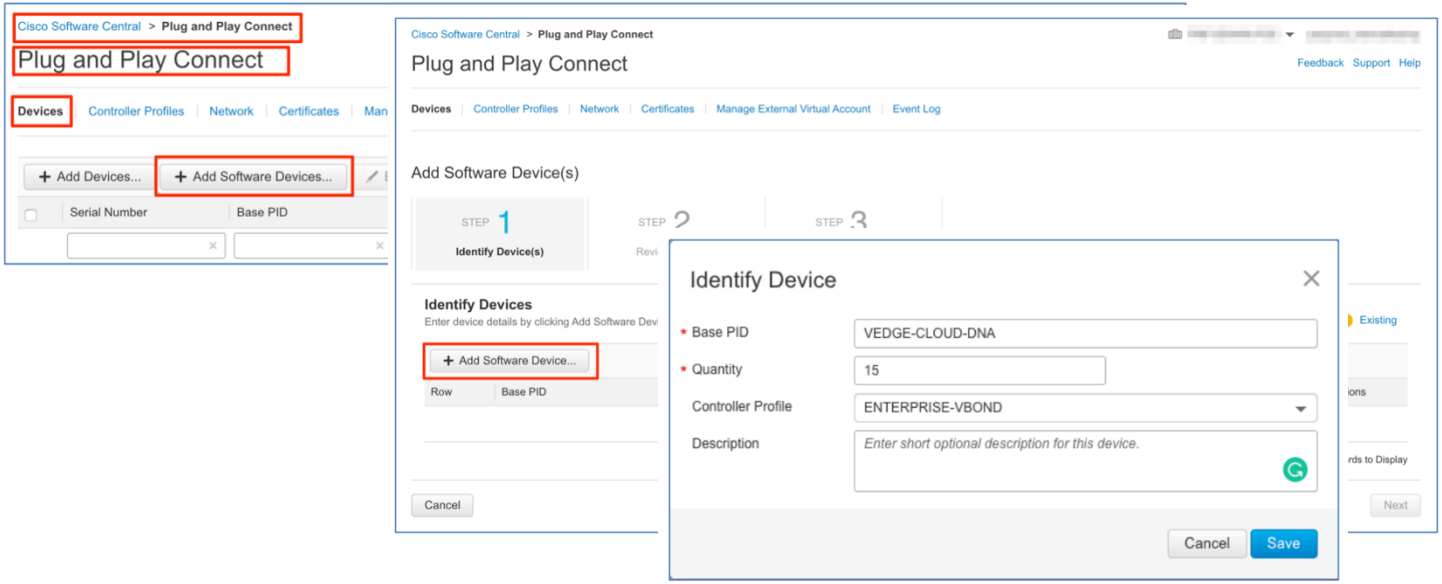
Virtual Device Onboarding

To add virtual routers like ISRv, CSR, vEdge Cloud to vManage log in to the Plug and Play portal, click Add Software Devices:



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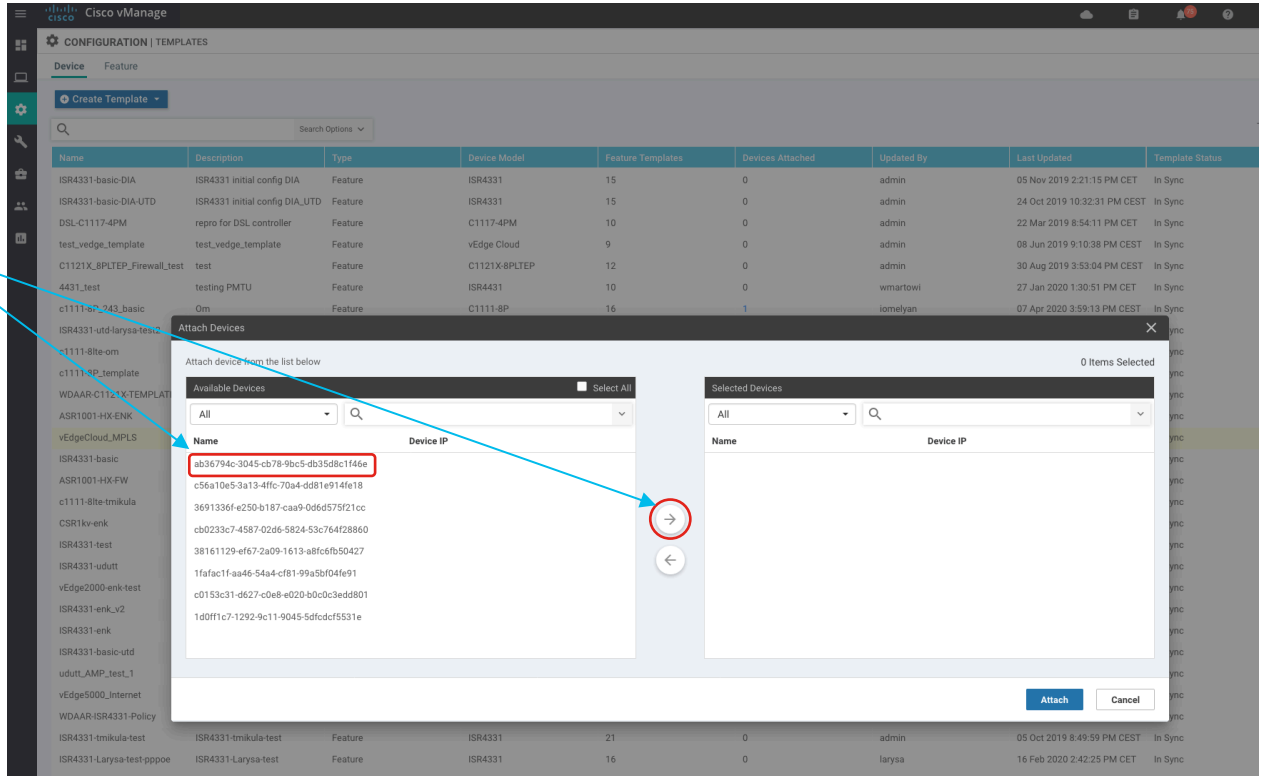
Virtual Device Day 1 Config

Attach available token to the template



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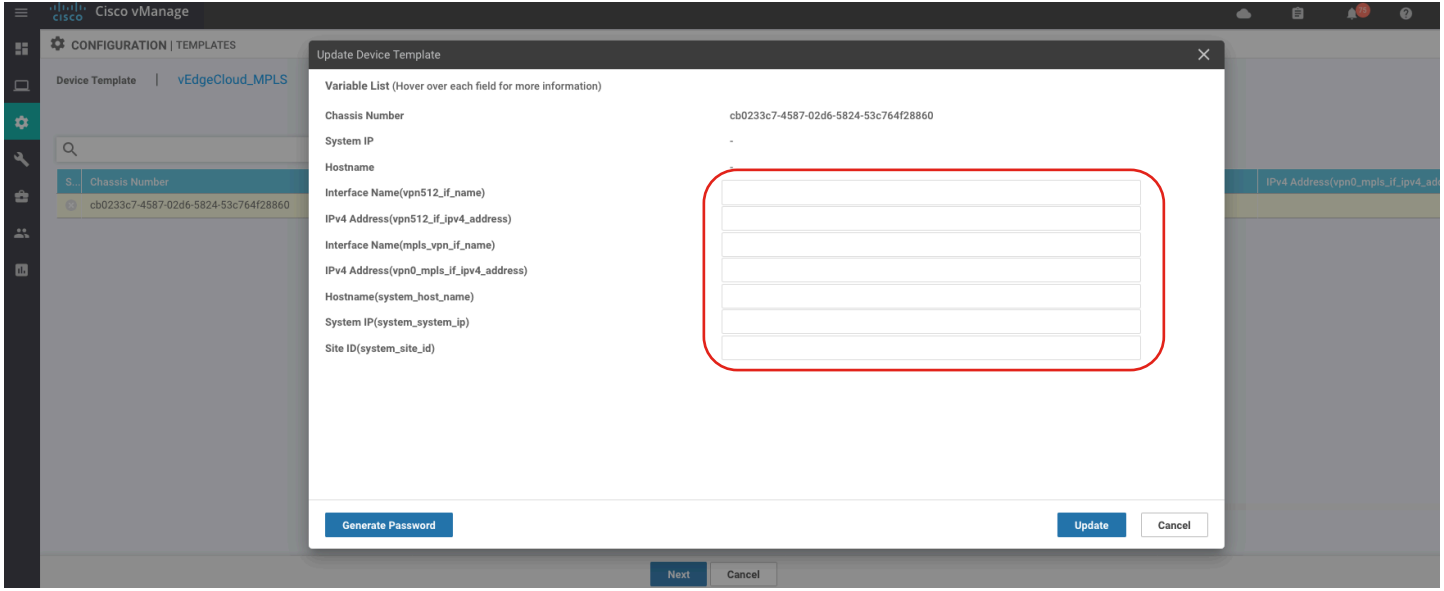
Virtual Device Day 1 Config

Fill all the variables:



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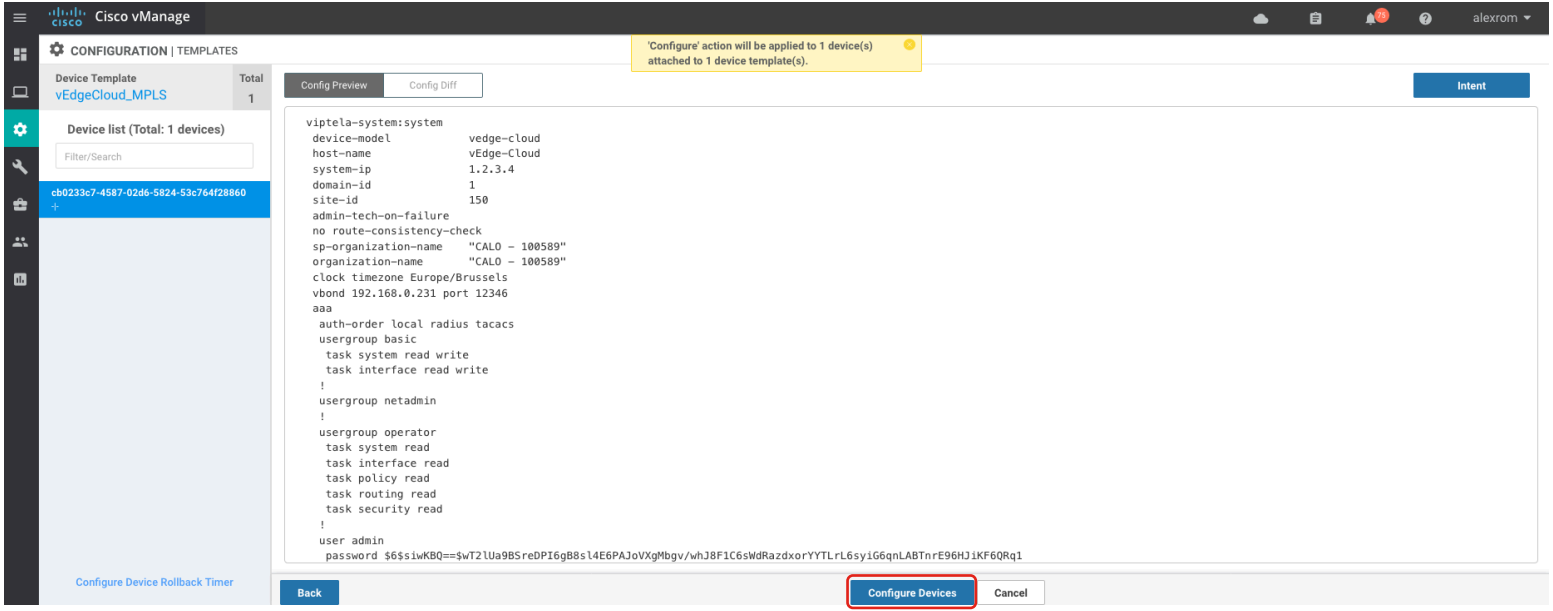
Virtual Device Day 1 Config

Schedule configuration:



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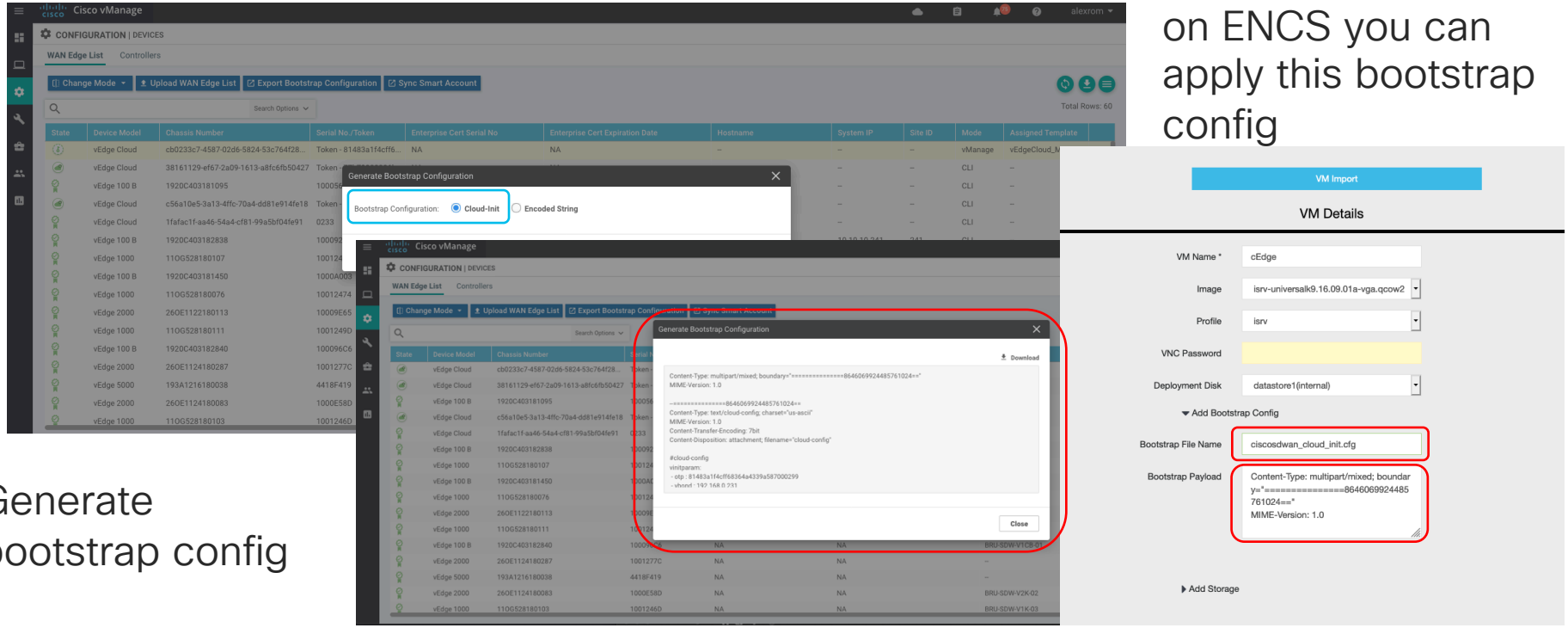
Virtual Device Day 1 Config

While provisioning VM on ENCS you can apply this bootstrap config



Generate bootstrap config

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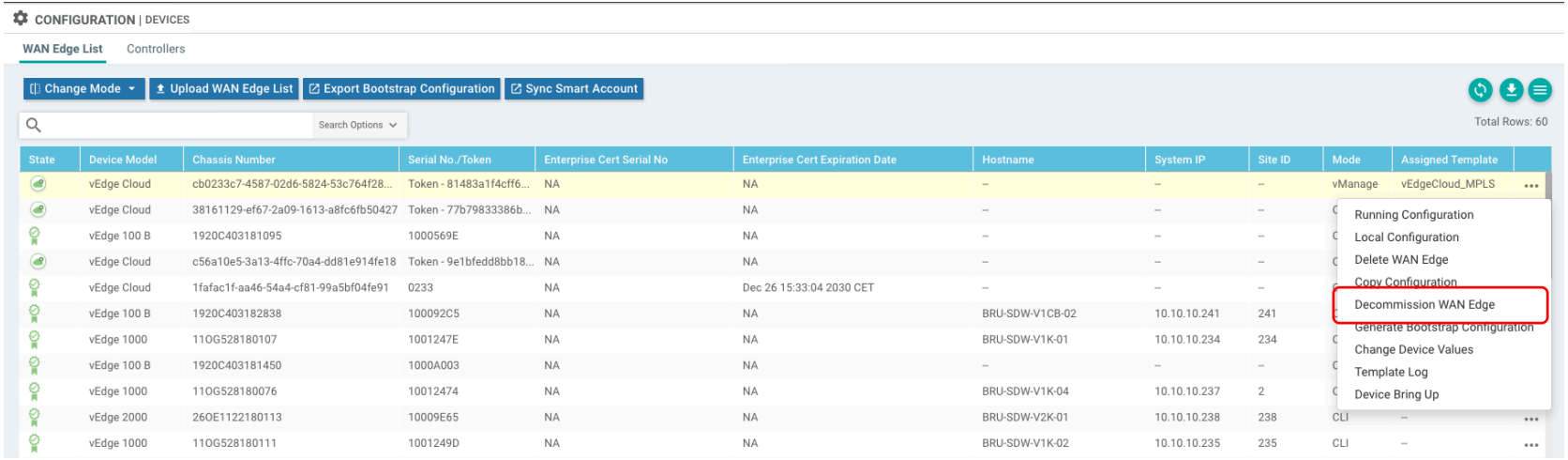
Decommission WAN Edge

If you need to free previously allocated token use “Decommission WAN Edge” option, if you choose “Delete WAN Edge” you will have to sync smart account to use this token once again.



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Takeaways

Takeaways

- Replace multiple devices in the branch with VNF Service Chains
- Plan Virtual Branch based on the performance, throughput and solution requirements, treat this task as a regular network segment design.
- Use NFVIS build-in failure detection mechanisms for faster convergence
- Automate your virtual branch deployment

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Thank you

Possibilities

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