The bridge to possible

Cross-domain orchestration across DC and transport using NSO CFP for 5G

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BRKSPM-2685

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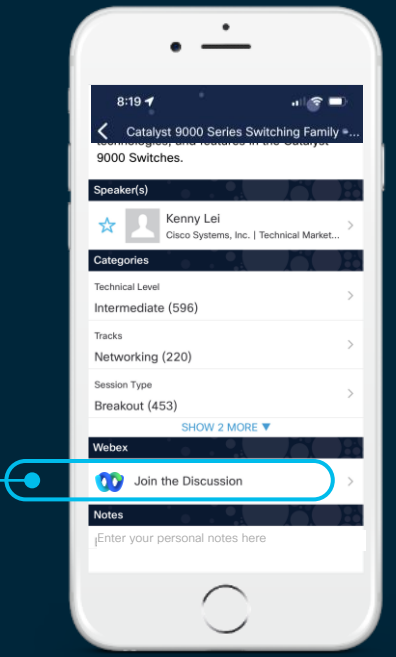

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Agenda

- Cross-domain orchestration requirements in 5G
- Scalable DC to transport handoff and network slicing using SR/MPLS
- Cross-domain automation using NSO CFP
  - Supported products/topologies
  - CFP Architecture, deployment options
  - Supported configuration
  - Demo for network slicing using Cross-domain CFP
  - CFP models and sample payloads
- Summary

Cross-domain orchestration requirements in 5G

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What is cross-domain orchestration?

Applications:
Open RAN, 5G, IOT, Edge

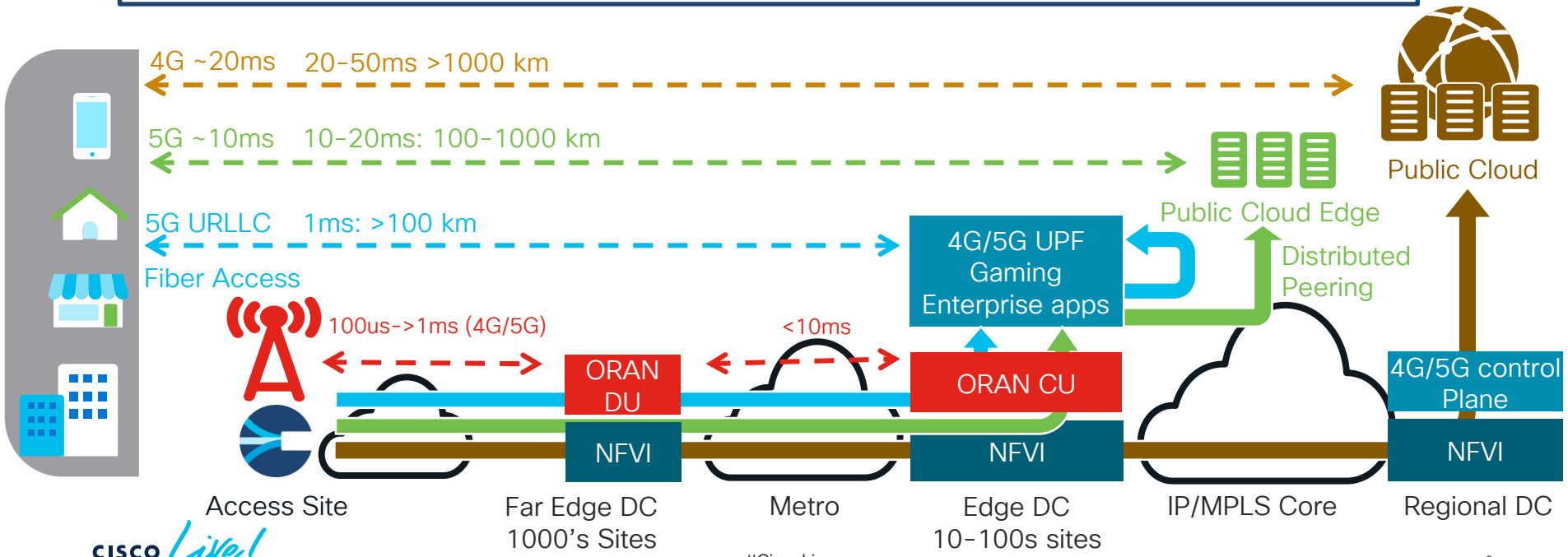
- ✓ Applications are hosted in the DC
- ✓ Application to application and user communication is through SP transport network

Cross-domain orchestration is essentially a synchronized configuration across different domains for faster time to deployment and provision/remove network resources on-demand

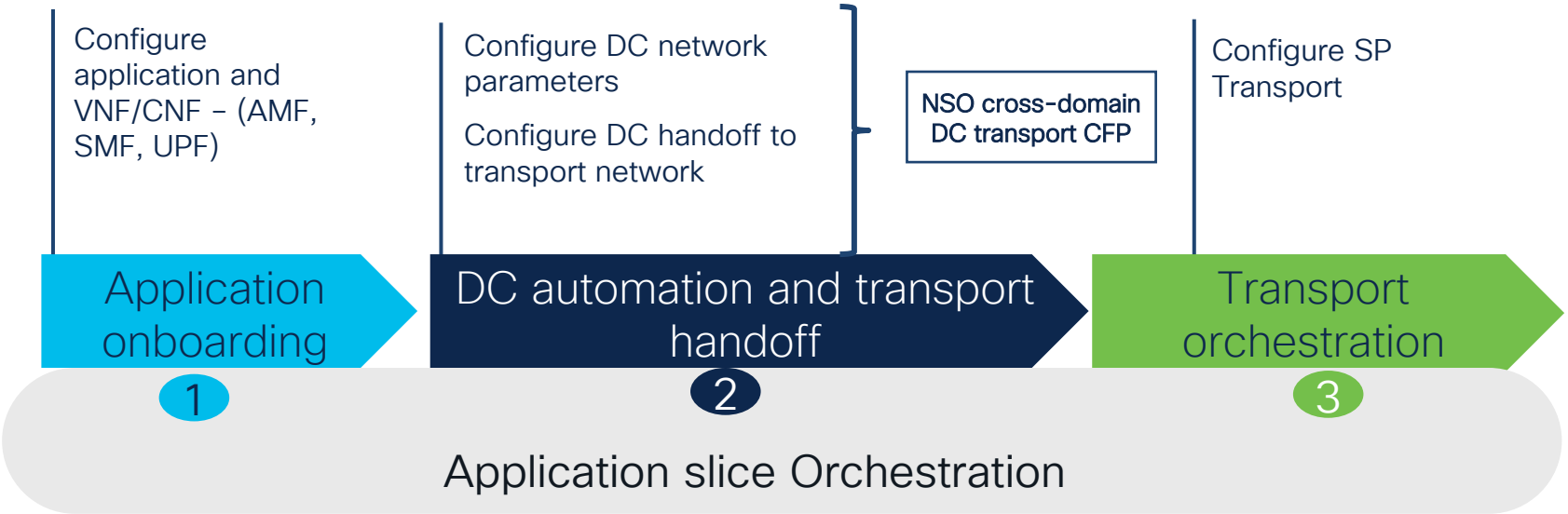
Network slicing use-cases

Multiple application on same Infra

- ✓ Open RAN (O-DU/O-CU)
- ✓ 4G/5G control plane
- ✓ Gaming
- ✓ Enterprise applications
- ✓ 4G/5G Data plane (UPF)
- ✓ URLLC applications

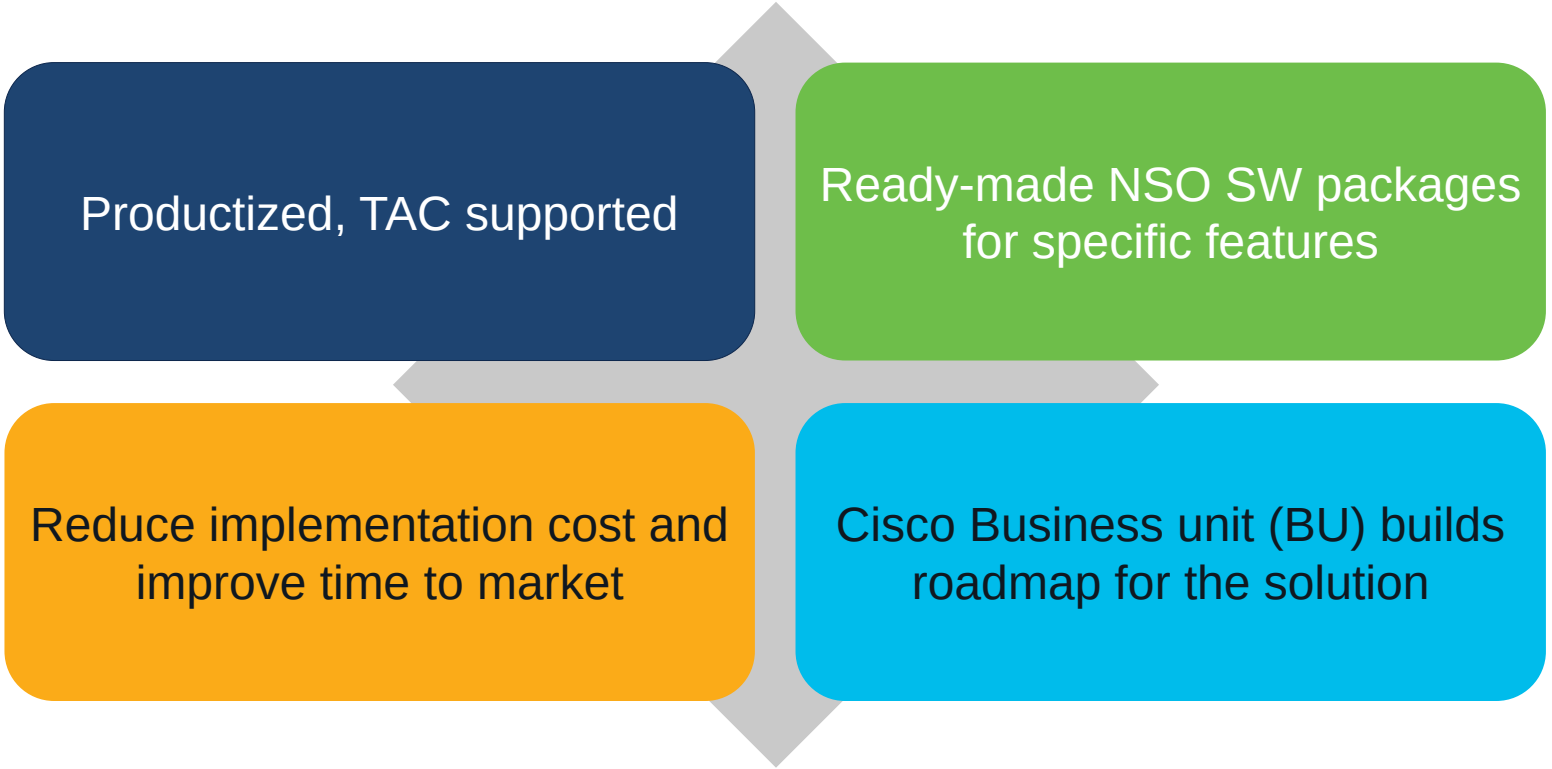


How to perform cross-domain orchestration?



NSO Core Function Packs (CFP)

Use-case driven approach for orchestration



Scalable DC to transport handoff and network slicing using SR/MPLS

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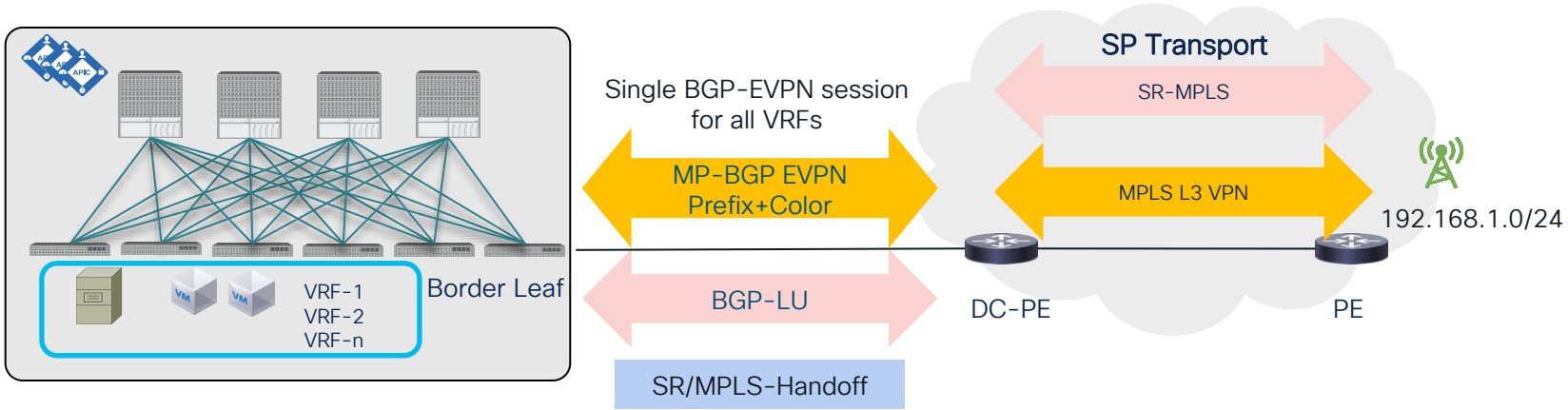
Scalable DC to transport handoff

- IOT, Enterprise services and 5G are driving high VRF scale requirement
- Automation and scalability is a challenge in VRF-lite solution

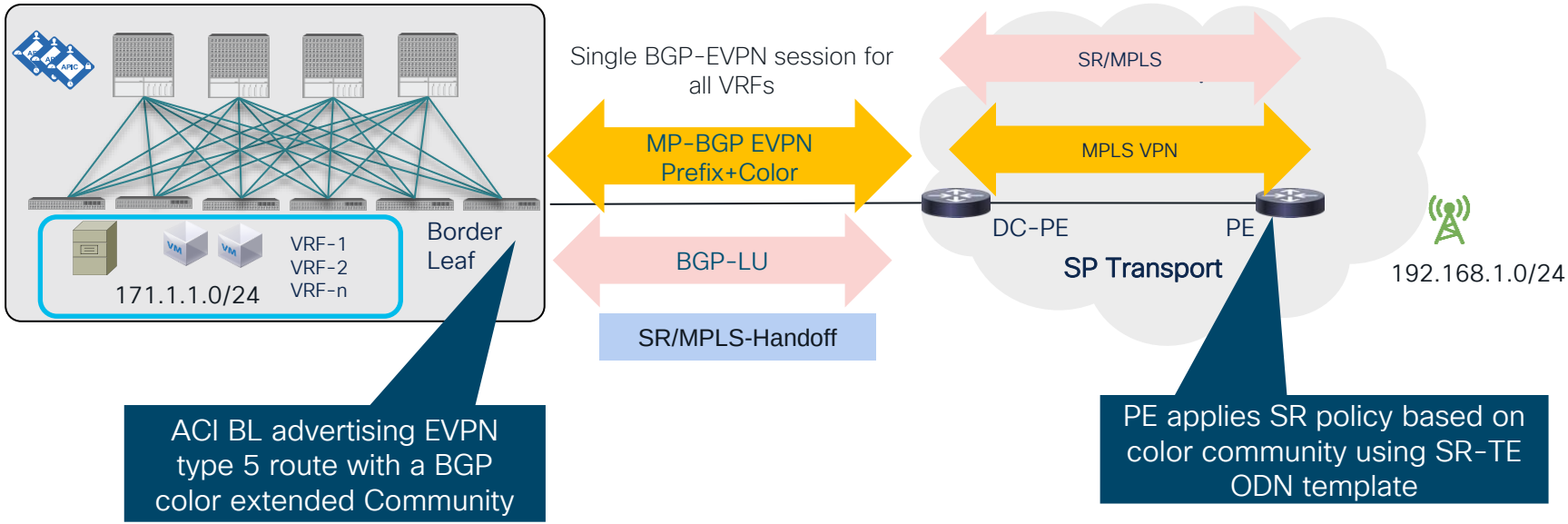
SR MPLS handoff provides

- Single control plane and data plane session instead of per VRF control plane and data plane session
- Unified SR/MPLS transport network



Consistent network policy across DC and transport

Advertise color community for a prefix from ACI BL, and use it on PE to define a SR policy in transport



Cross-domain automation using NSO DC SDN CFP

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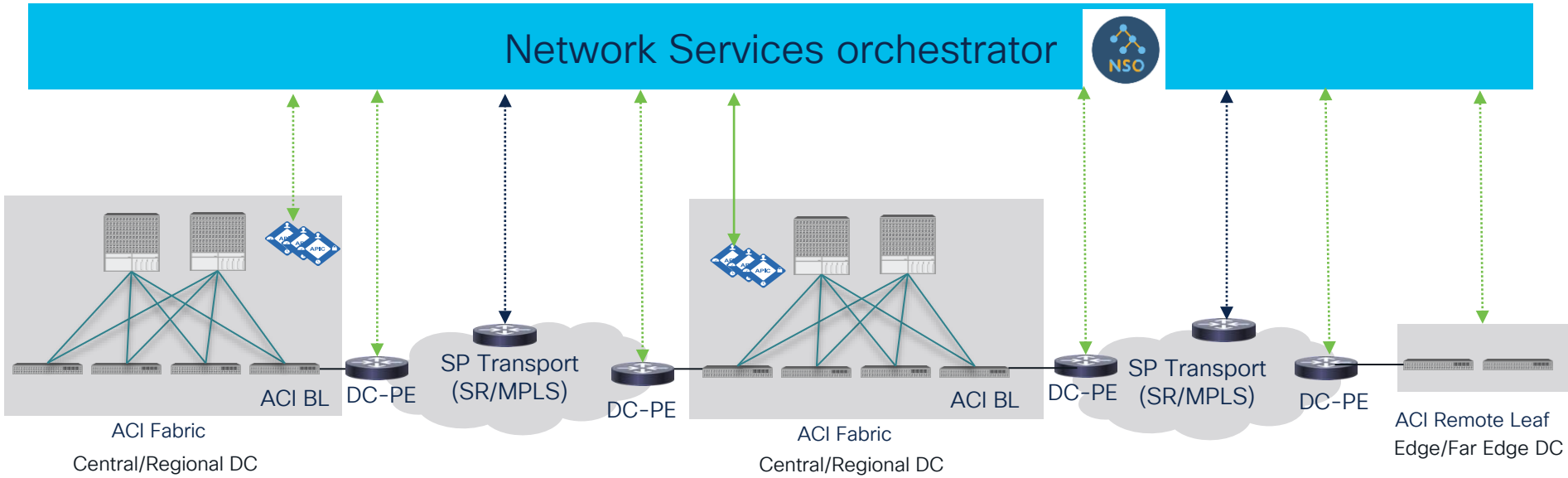
Supported Topologies for NSO DC CFP

- Multi-Domain Orchestration across Transport and DC
- Telco DC, and DC handoff provisioning for both IP and SR handoff
- Support of multiple ACI Fabrics, ACI Multi-Pod & ACI Remote Leaf



Layered Services Architecture: Speed and scale

Upper Node – Customer facing services (CFS)

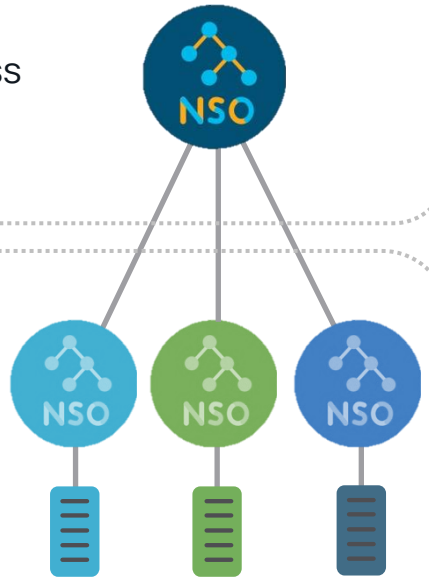
Provides automation across lower node boundaries.

Ex. cross-domain

Lower Nodes – Resource facing services (RFS)

Organized around customer defined boundaries

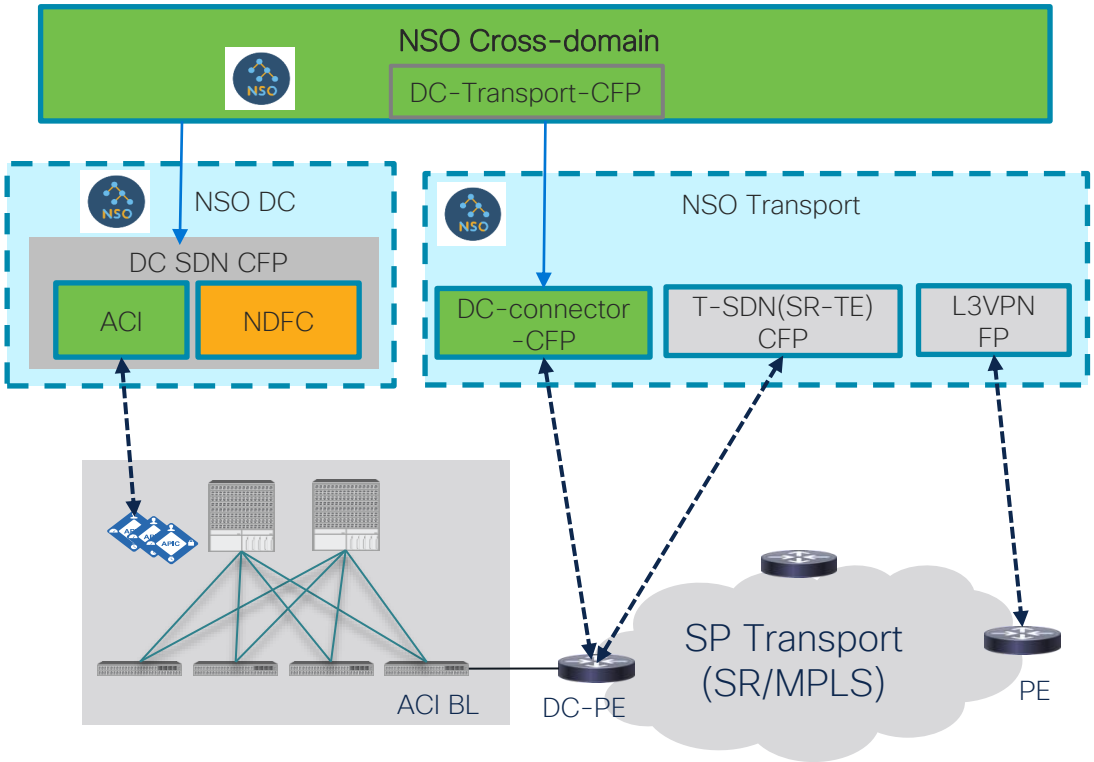
Ex. technology domain



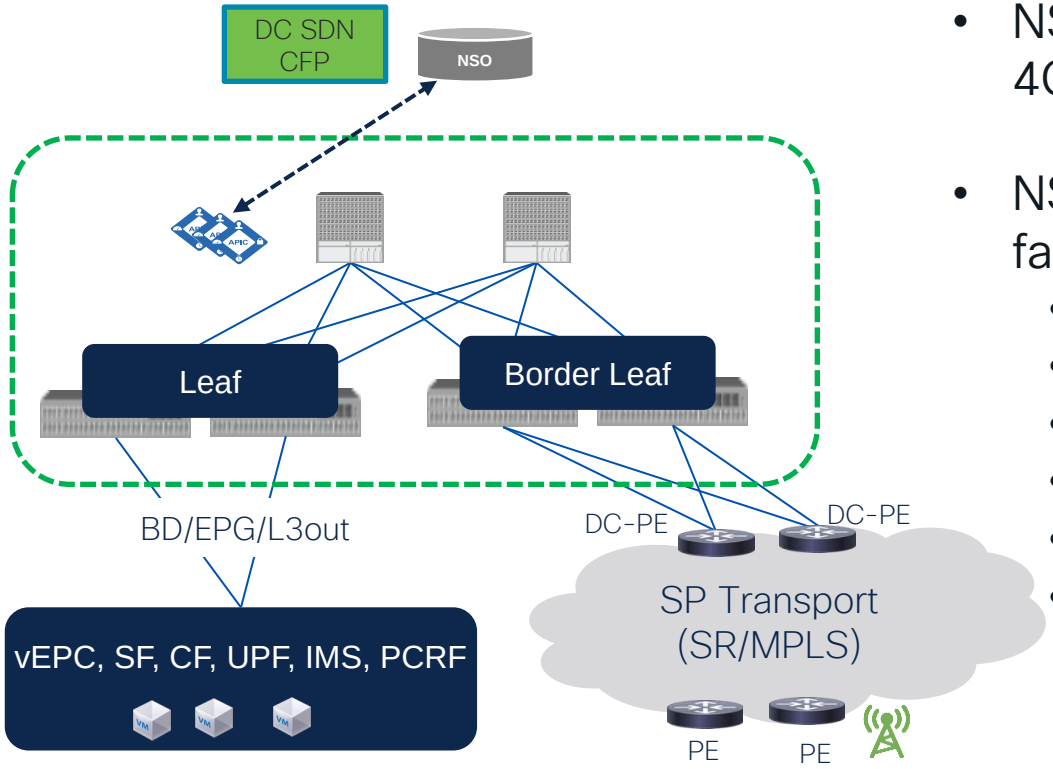
- Nearly unlimited horizontal scale-out
- Automate across domains and boundaries
- Improved performance through parallel service execution

NSO Cross-domain core function Pack

- Cross-domain CFP to provision DC to transport handoff for both IP and SR handoff using DC CFP and DC-Transport-CFP
- Multi-NSO support
- Support of Multiple ACI Fabrics from single NSO

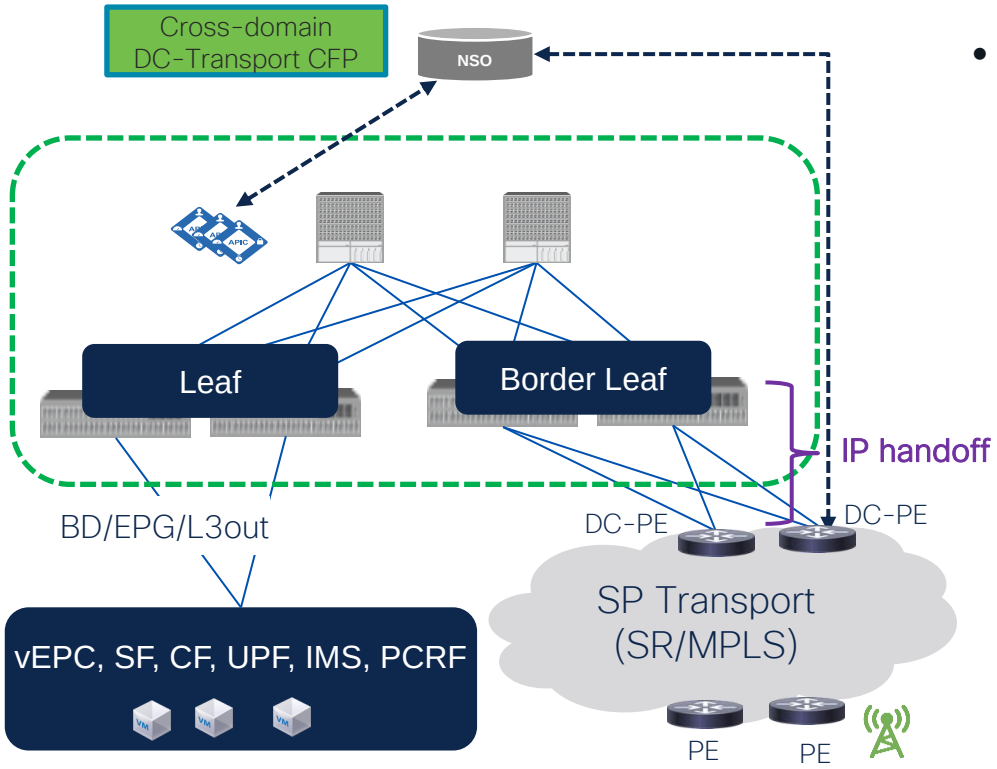


ACI CFP use-case
Telco cloud deployment



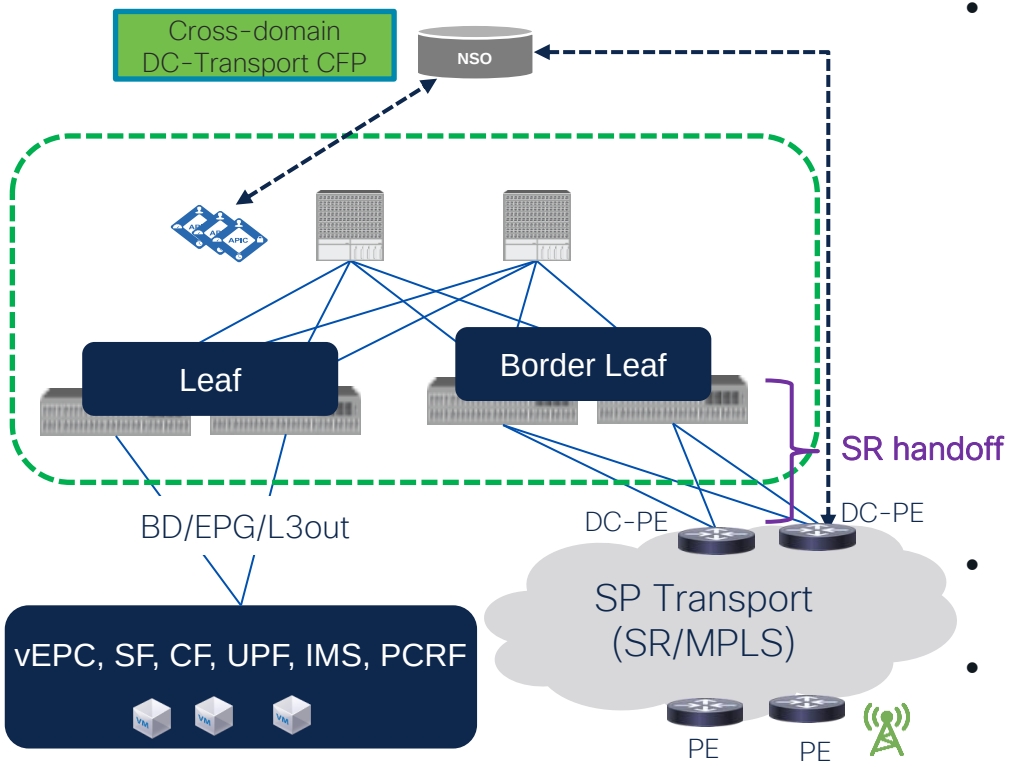
- NSO to push ACI policies to bring up 4G/5G services
- NSO will automate following in DC fabric
  - Interface, VLANs, policies
  - Tenant, EPG, BD, VRF, contracts
  - Routing (BGP, static route)
  - Route-maps
  - Service chaining (PBR)
  - QOS

Cross-domain core function pack (IP handoff)



- NSO will automate following on ACI BL and DC-PE
  - VRF, RT, RD, VPN
  - Physical/logical interface
  - VLAN and IP address management for interfaces between DC-PE and ACI BL
  - Router-id auto-allocation
  - Routing (BGP, static route)
  - BFD
  - Routing policies

Cross-domain core function pack (SR handoff)



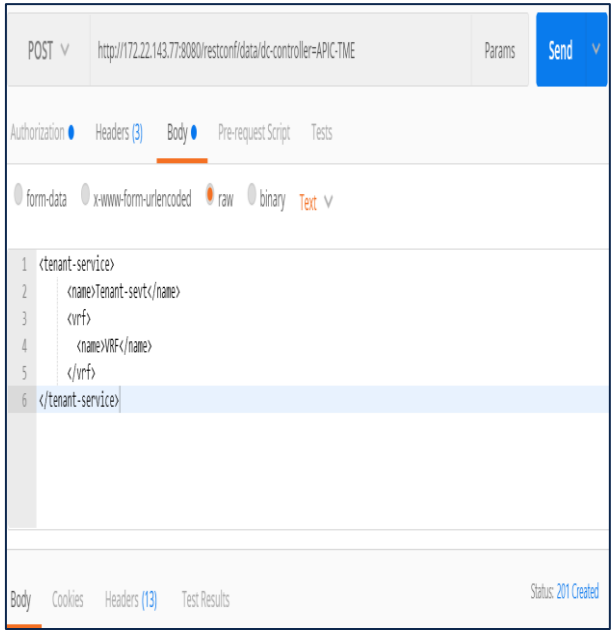
- NSO to automate following configuration on ACI BL and DC-PE
  - Configuration and management of VLAN and IP addresses for underlay BGP-LU, EVPN loopback, transport loopback, RD, RT, VLAN, SID, and Router-id
  - BGP EVPN and labeled unicast session
  - Single and Multi-hop BFD
  - Routing policies such as BGP color community
  - SR/MPLS QOS policies
- RT Translation from EVPN to L3VPN on DC-PE
- Map BGP color-community to SR policies on DC-PE

Flexible approach for automation

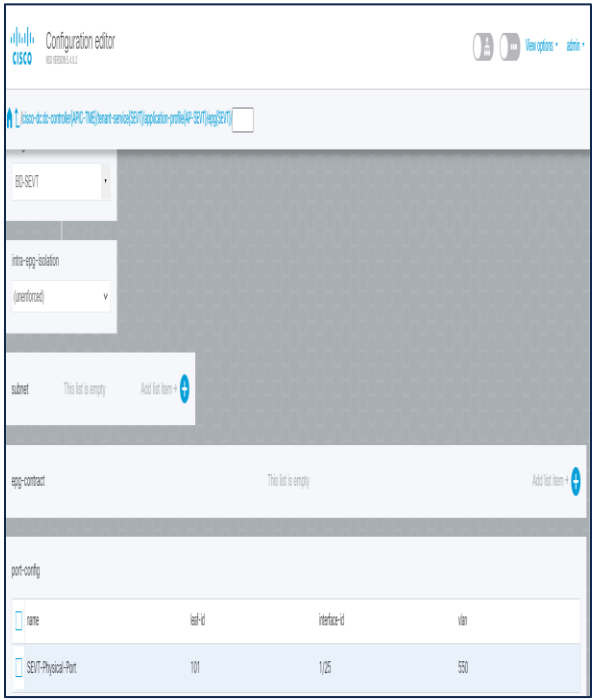
Multiple Operating Model

CLI | GUI | API

API



GUI

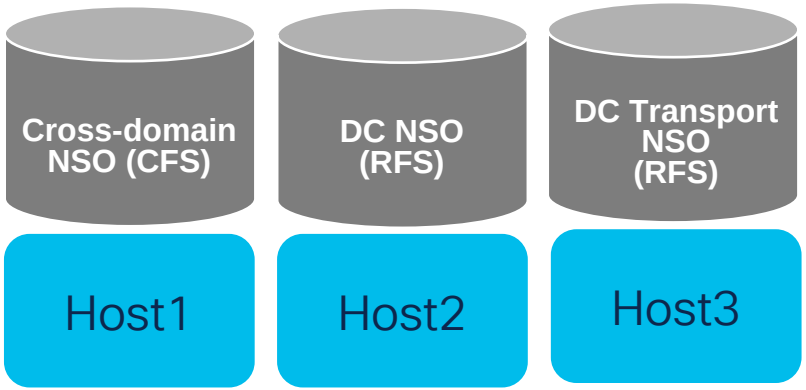


CLI

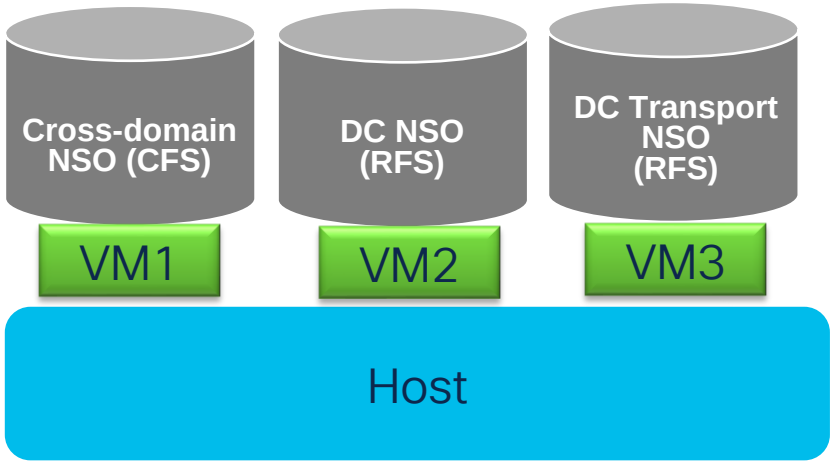
```
Entering configuration mode terminal
admin@ncs(config)# dc-controller APIC-TME
admin@ncs(config-dc-controller-APIC-TME)# tenant-service SEVT
admin@ncs(config-tenant-service-SEVT)# application-profile AP-SEVT
admin@ncs(config-application-profile-AP-SEVT)# epg SEVT
admin@ncs(config-epg-SEVT)# bridge-domain BD-SEVT
admin@ncs(config-epg-SEVT)# port-config SEVT-Physical-Port
admin@ncs(config-port-config-SEVT-Physical-Port)# leaf-id 101
admin@ncs(config-port-config-SEVT-Physical-Port)# interface-id 1/25
admin@ncs(config-port-config-SEVT-Physical-Port)# vlan 550
```

Physical Infra for hosting NSO

Option #1- Different Physical Host for hosting cross-domain, DC and Transport NSO (Recommended for production)



Option #2- different VM on same physical Host for hosting cross-domain, DC and Transport NSO (Ok for lab)

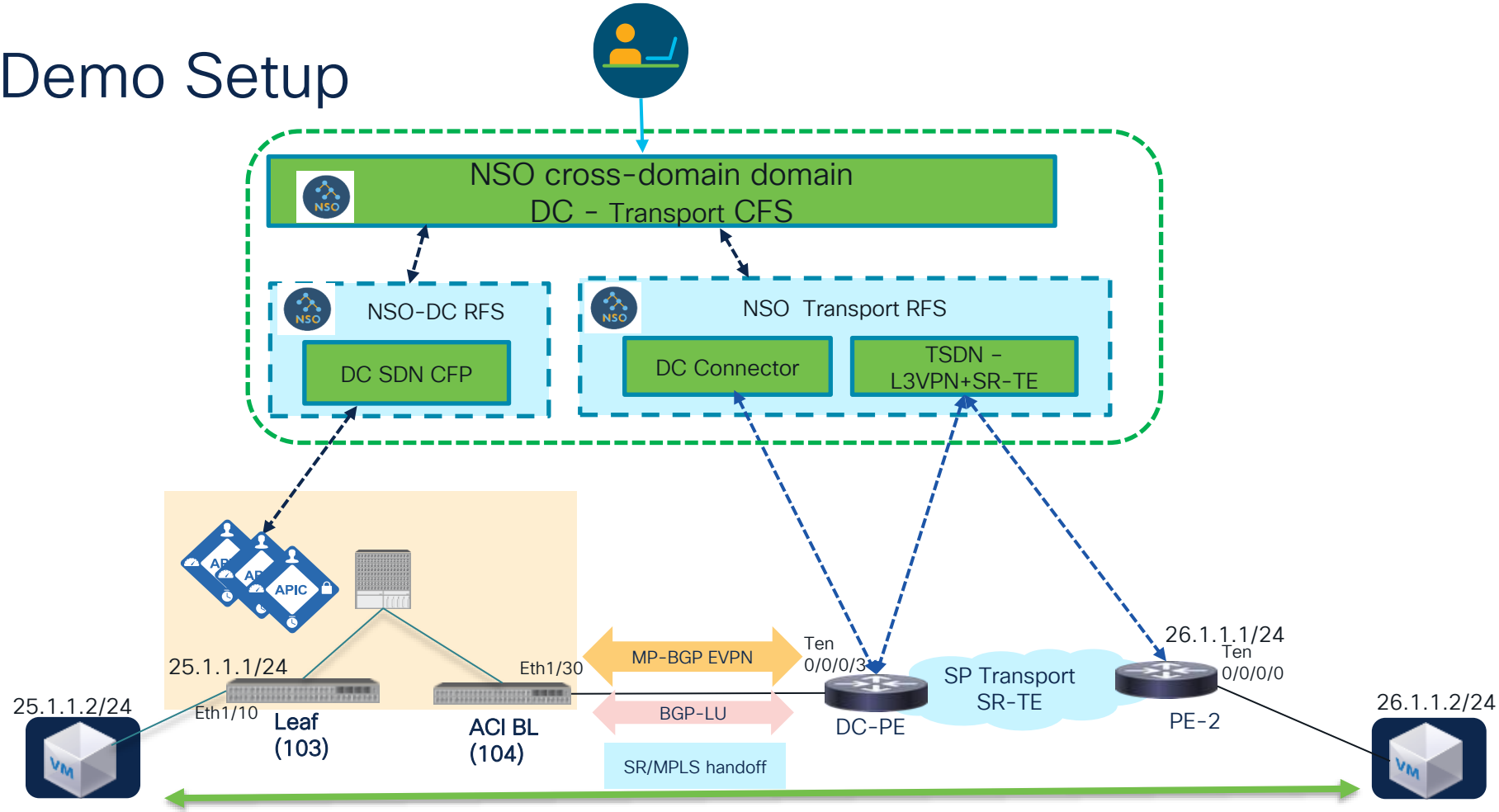


Demo

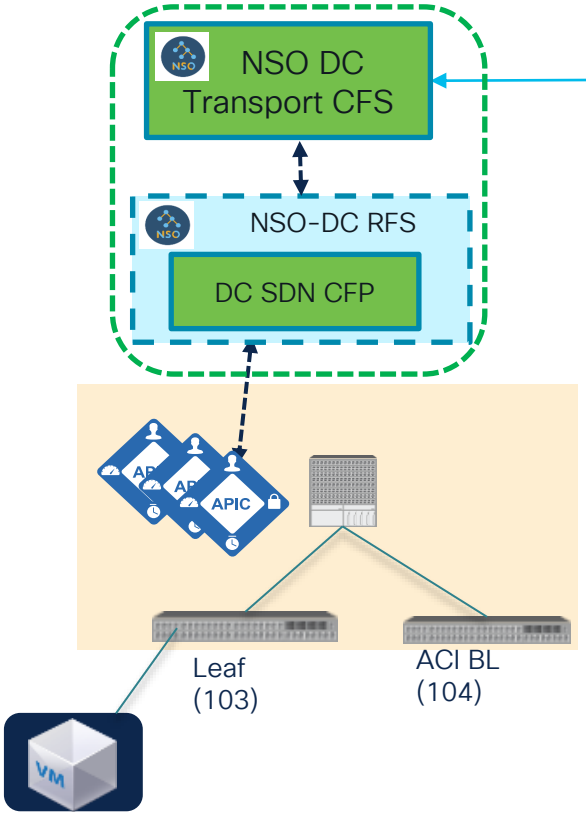
Demo Agenda

1. NSO DC and Cross Domain Transport Models
2. Provision DC CFP Services and validation
3. DC Transport EVPN Interconnect , Tenant L3VPN Service and Validation.
4. Transport SDN – PE – L3VPN and SR-TE ODN
5. End to End Verification

Demo Setup



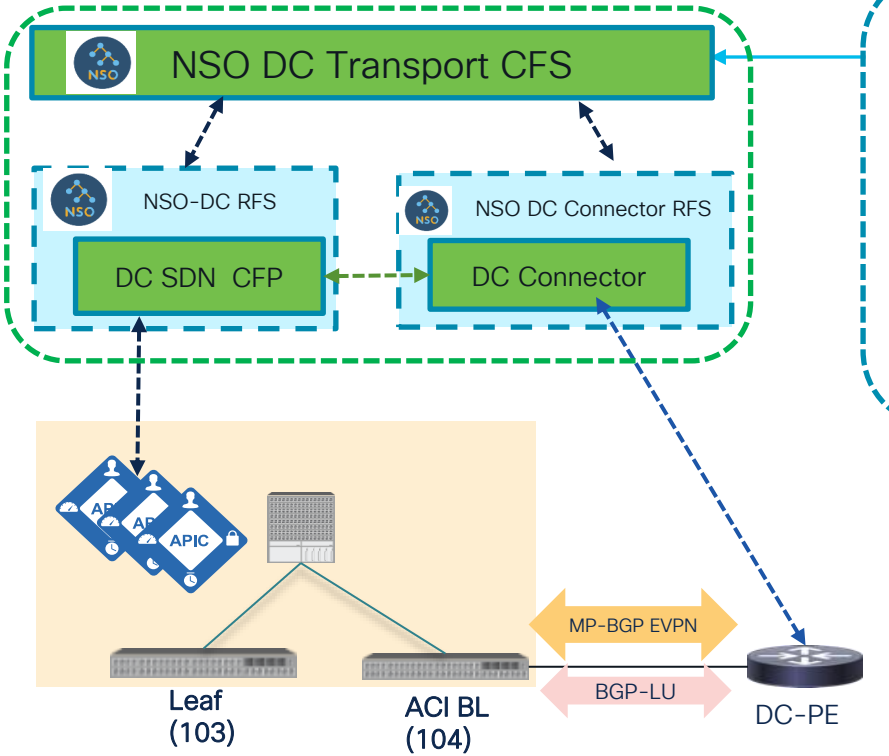
Data Center CFP Services



- Port Configurations
  - PE-Port
  - Server Port
- Tenant Service
  - Demo1
- DC Route Policy
  - Infra BFD
  - RPL-NSODemo

Configure DC Transport- SR Handoff

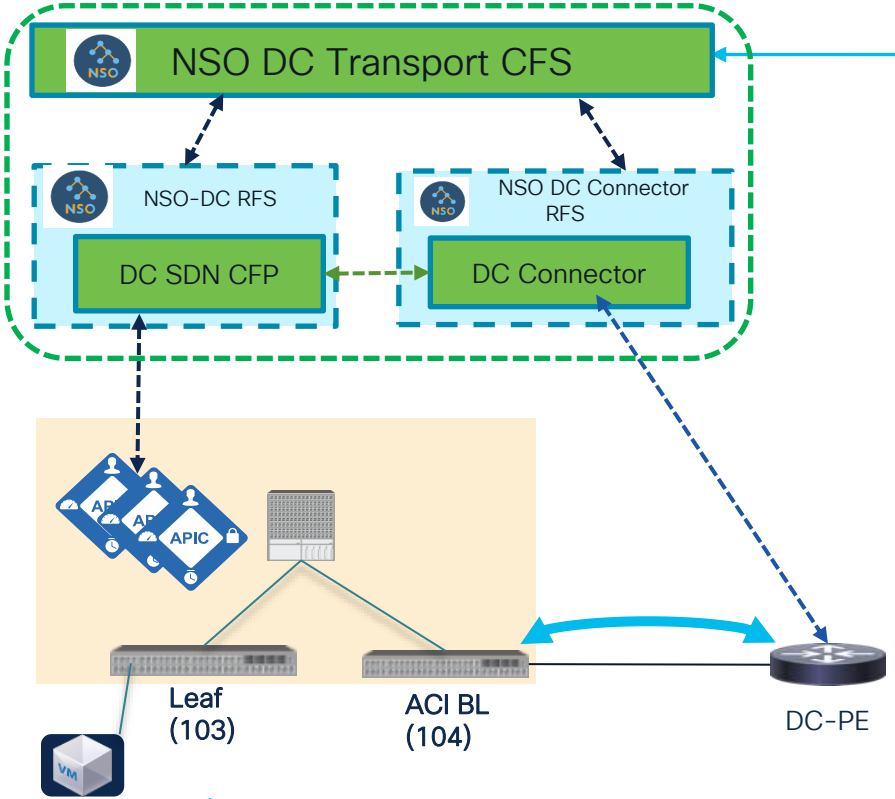
Physical Interface- EVPN , RT , IP Address across BL and DC-PE



- DCT Topology
  - DC Attributes
  - PE Attributes
- Interconnect
  - EVPN Settings

Configure DC Transport – Tenant L3OUT

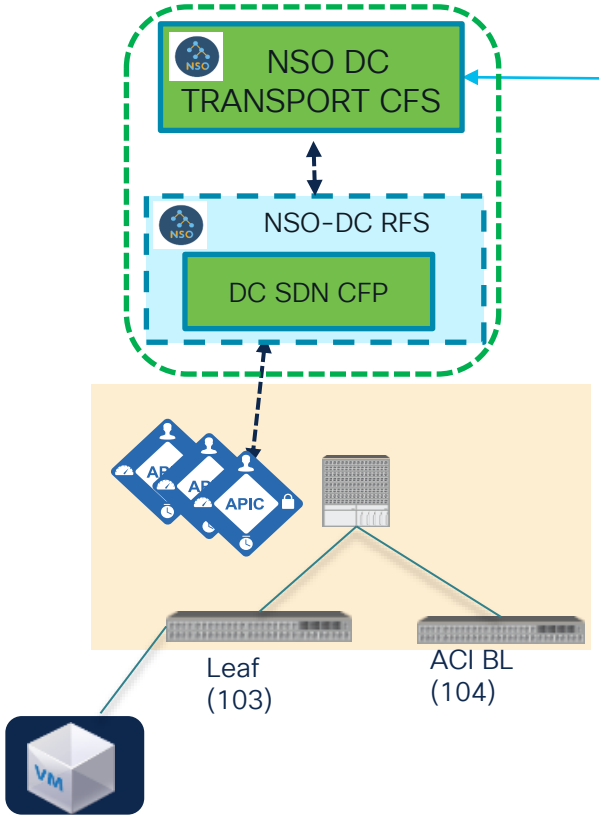
Enable Overlay L3VPN Tenant Service on DC Router and SR-MPLS



- Tenant – L3VPN
  - VRF
  - PE-Attributes
    - RT Value- Import/Export
  - DC Transport- Interconnect

Configure DCT – DC– L3OUT

Associate SR l3out EPG linked to SR MPLS Infra l3out with valid contract



- **L3 Out Security Service**
  - Associate to L3Out Routing Service
  - Contract association to External EPG

Transport SDN Automation

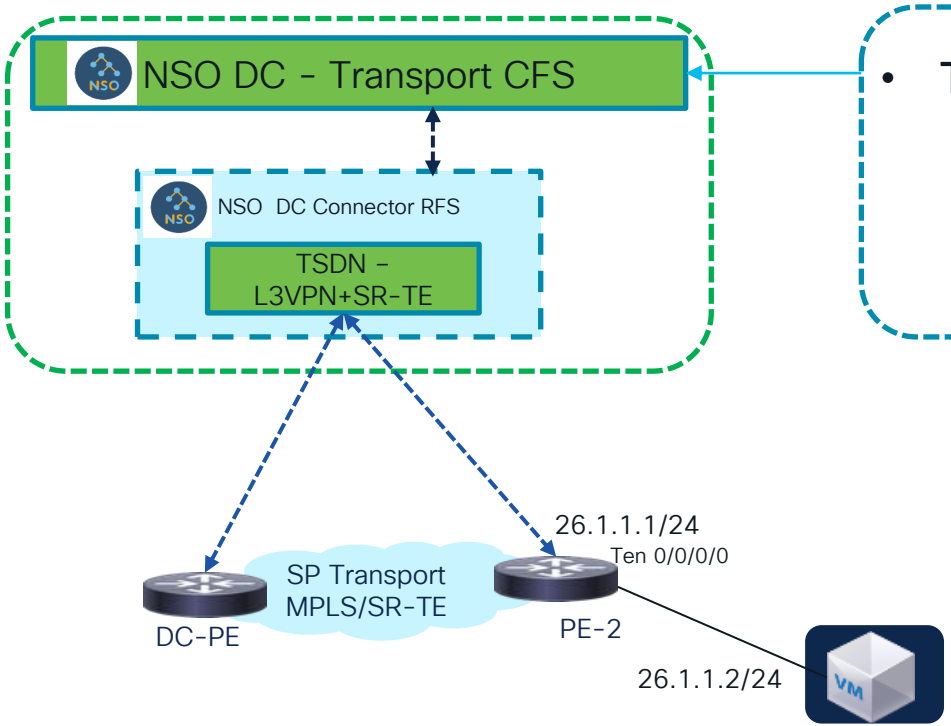
The NSO, part of Transport SDN Automation Solution, shall instantiate L3/L2 VPN, IETF-TE services (examples only) running over SR-TE

NSO Function Packs

- VPN Service Function Packs (example of L2/L3 VPN)
  - VRF, Interfaces, BGP vpnv4/6 , EVPN-ELAN/ETREE
  - Route-policy / autoroute
- IETF-TE Function Packs (example of RSVP-TE)
  - P2P Dynamic and Explicit Path
  - Local and PCE Computation
- SR-TE Core Function Pack – PCC Init based
  - ODN SR Policy
  - SR Policy (dynamic or explicit)
  - SRv6 TE

TSDN – L3VPN and SR-TE ODN

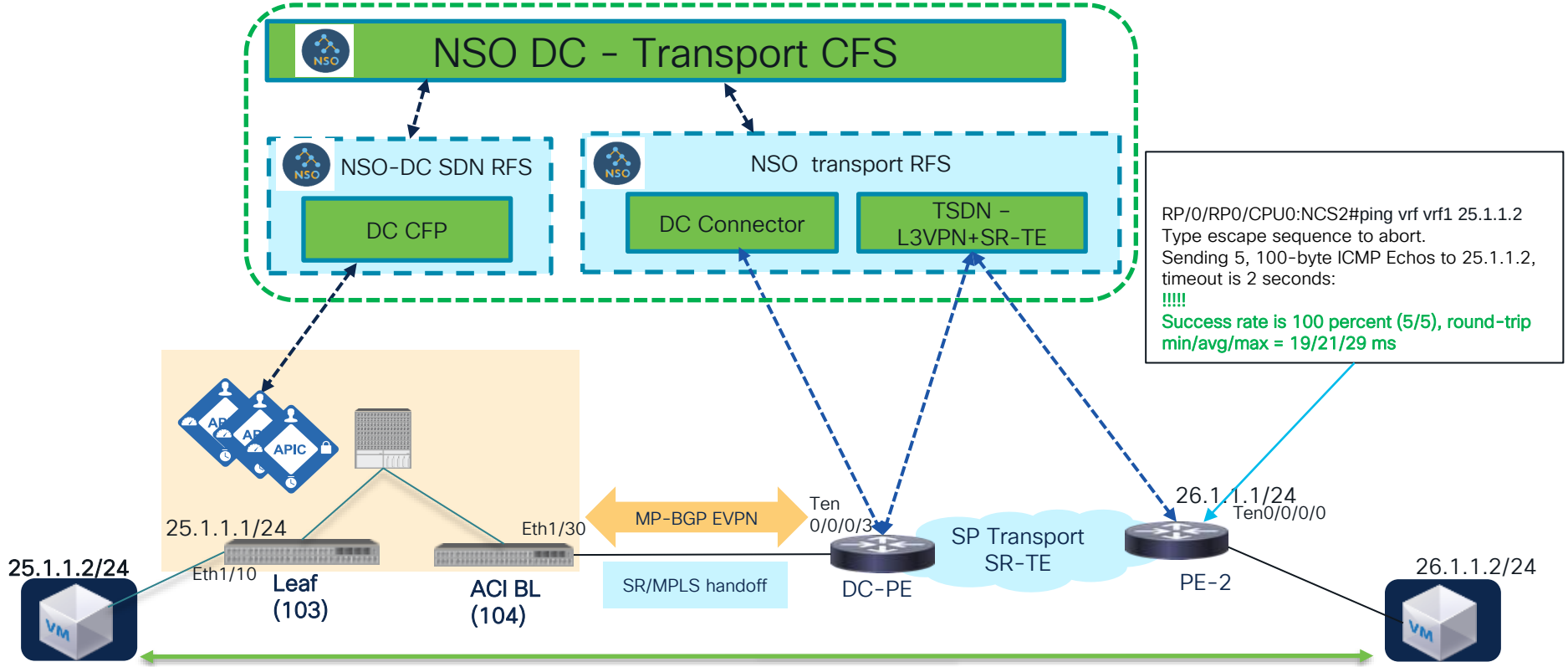
SR-TE ODN color-1000 associate to L3VPN Service



- **TSDN FP Service**
  - SR-TE ODN Template Color -1000
  - L3VPN
  - Endpoints – DC –PE and PE-2

Test Connectivity from PE2- to App Server

Validation of Tenant L3out Data Plane



Summary

Deploy NSO for cross-domain automation and use DC domain controllers like ACI and NDFC for automation and operations within DC

Core Function pack (CFPs) are a great way to deploy NSO since it's TAC/BU supported and evolves with solution

NSO DC SDN CFP is ready for cross-domain Telco cloud deployments with key use-cases support – DC automation, IP handoff and SR/MPLS handoff and 5G network slicing

LSA support for scale, and separation between DC and transport domain

Reach out to Cisco Representative - CX, Sales and partners for education and roadmap

References

- Check out reference slides for more details
- Network slice demo with sample workflow automation tool
- ACI NSO CFP Solution guide
- ACI NSO CFP user guide
- ACI to SR/MPLS handoff design guide
- ACI to SR/MPLS whitepaper

Related sessions

- BRKSPG-2034 Automate Operations Across Service Lifecycle with Cisco SDN Controller
- PSOSPG-2009 Multi Layer, Multi Vendor Automation with Cisco's Hierarchical Controller

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Reference slides

Supported topologies

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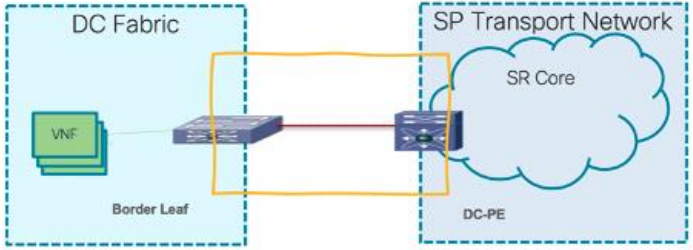

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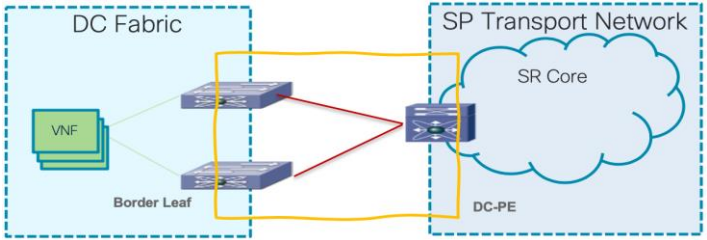

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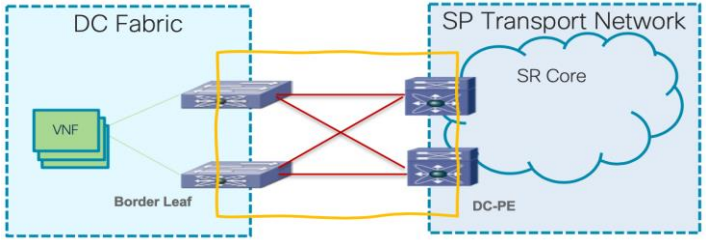

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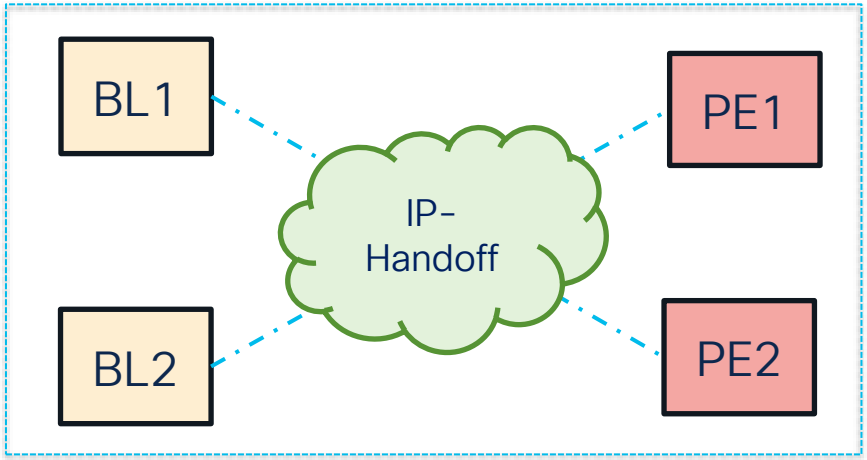

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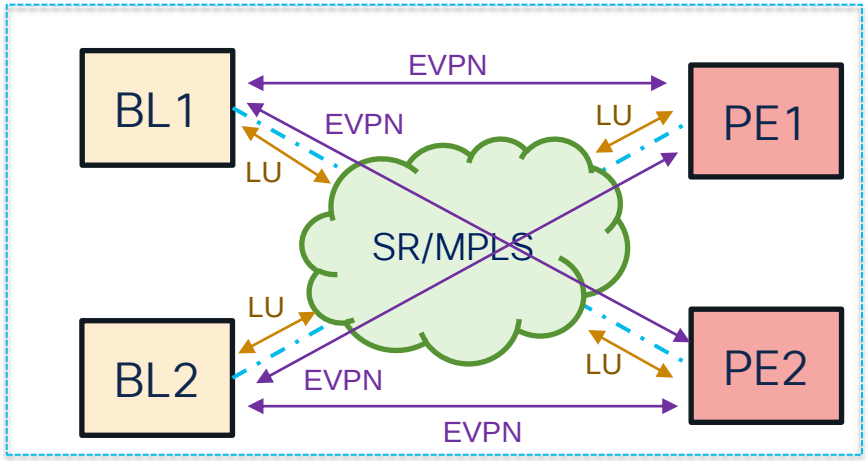
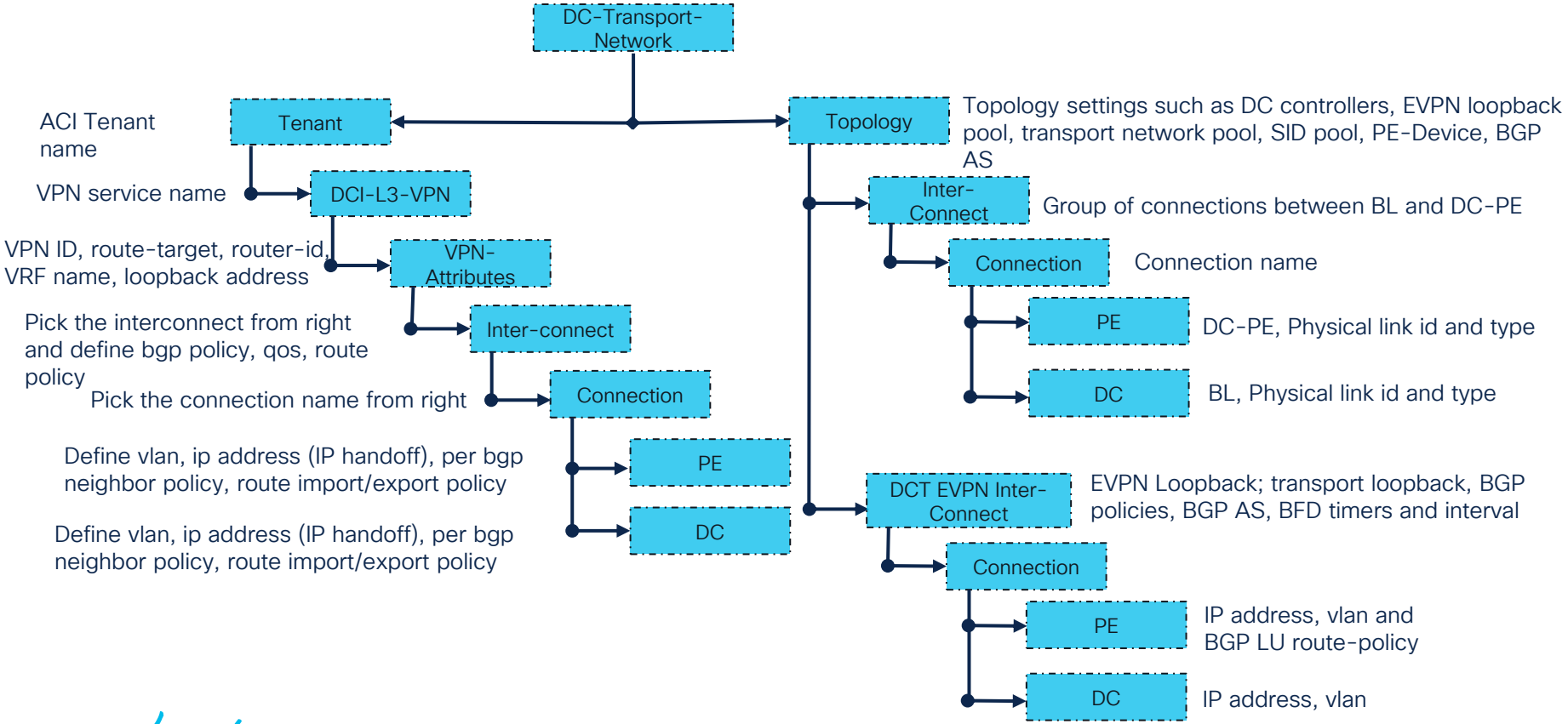


Cross-domain model hierarchy



Service/modules for cross-domain orchestration

Module	Use-case
dct-l3-vpn	VPN service configuration between ACI fabric and DC-PE.
dct-evpn-interconnect	SR MPLS configuration for an interconnect between data-center and the provider network.

Network resource management for IP handoff

NSO allows automatic allocation and management of following network resources for IP handoff.

Resource name	Name in model	Usage
VLAN ID	dci-vlan-pool	VLAN id configuration for link between ACI BL and DC-PE
Router IDs	router-id-pool	Router ID for ACI BL
IPv4/v6 address	Intercon-pool	IPv4/v6 address configuration for link between ACI BL and DC-PE

Network resource management for SR/MPLS handoff

NSO allows automatic allocation and management of following network resources for SR/MPLS handoff.

Resource name	Name in model	Usage
VLAN ID	dci-vlan-pool	VLAN id configuration for link between ACI BL and DC-PE
Router IDs	router-id-pool	Router ID configuration on ACI BL
IP address	Intercon-pool	IP address configuration for link between ACI BL and DC-PE
Route target	route-target-pool	BGP route-target configuration for VRF/VPN
Segment ID	sid-pool	Label index for SR configuration
EVPN control plane loopback	evpn-lo-ip-pool	Control plane loopback allocation for ACI BL.
Transport loopback	tr-lo-ip-pool	Transport loopback allocation for ACI BL

Operation status of Resource management

NSO can manage network resources across multiple fabrics and DC-PEs.

```
admin@ncs# show resource-pools
NAME                ID                                                          ERROR  ID
-------------------------------------------------------------------------------------------
dct-vlan-pool
route-target-pool   DC-PE-Network-Tenant-sevt-11-sevt-vrf-11-DC-Inter-Connect  -      121
                    SEVT-DC-PE-Network-vEPC-VRF5-SEVT-DC-Inter-Connect          -      122
sid-pool            APIC-NSO-202                                                -      101
                    APIC-TME-101                                                -      102

NAME              ID                                          ERROR  SUBNET        FROM
-------------------------------------------------------------------------------------------
evpn-lo-ip-pool   APIC-NSO-202                                -      20.1.1.1/32   20.1.1.0/24
                  APIC-TME-101                                -      20.1.1.2/32   20.1.1.0/24
intercon-pool     DC-PE-Network-DC-Inter-Connect-con01        -      22.1.1.0/30   22.1.1.0/24
                  SEVT-DC-PE-Network-SEVT-DC-Inter-Connect-con01  -  22.1.1.4/30   22.1.1.0/24
router-id-pool
tr-lo-ip-pool     APIC-NSO-202                                -      11.1.1.1/32   11.1.1.0/24
                  APIC-TME-101                                -      11.1.1.2/32   11.1.1.0/24
```

Fabric-1

Fabric-2

SR/MPLS Handoff Payload

Resource pool configuration for ACI and DC-PE

```
resource-pools ip-address-pool evpn-lo-ip-pool
 subnet 20.1.1.0 24
!
resource-pools ip-address-pool intercon-pool
 subnet 22.1.1.0 24
!
resource-pools ip-address-pool router-id-pool
 subnet 10.10.10.0 24
!
resource-pools ip-address-pool tr-lo-ip-pool

 subnet 11.1.1.0 24
!
```

Topology settings of ACI and DC-PE

```
dc-transport-network SEVT-DC-PE-Network
 topology topology-settings sr-global-block start 16001
 topology topology-settings sr-global-block end 23000
 topology topology-settings route-target-auto-base 200
 topology topology-settings dc-attributes sid-pool sid-pool
 topology topology-settings dc-attributes route-target-pool route-target-pool
 topology topology-settings dc-attributes transport-loopback-ip-pool tr-lo-ip-pool
 topology topology-settings dc-attributes evpn-loopback-ip-pool evpn-lo-ip-pool
 topology topology-settings dc-attributes dc-controller APIC-TME
```

BGP configuration on ACI and DC-PE

```
topology topology-settings dc-attributes dc-controller APIC-TME
  bgp-as 65000
  border-leaf 101
   router-id 101.101.101.101
 !
 topology topology-settings pe-attributes pe-device DC-PE
  bgp-as           100
  evpn-loopback-id 0
  evpn-loopback-ip 1.1.1.1
!
```

Topology interconnection for port information

```
 topology interconnect SEVT-DC-Inter-Connect
  traffic-handoff sr-hand-off
  dc-controller   APIC-TME
  connection con01
   dc-end border-leaf 101
   dc-end port port-config-service-name SEVT-L3out-Port
   dc-end port interface    1/29
   pe-end pe-device DC-PE
   pe-end port if-type GigabitEthernet
   pe-end port if-id 0/0/0/4
```

SR/MPLS Handoff Payload

Underlay SR/MPLS configuration on ACI and DC-PE

```
topology dct-evpn-interconnect SEVT-DC-Inter-Connect
  deploy true
  evpn-settings ipv4-subnet-policy ip-address-pool
intercon-pool
  dc-attributes bgp-lu peer-control defaultValue
  dc-attributes bgp-lu weight 10
  pe-attributes pe-device DC-PE
  !
  connection con01
   dc-end
   pe-end
```

Route-map configuration

```
dc-controller APIC-TME
 dc-route-policy VRF-route-pol
  tenant vEPC
  rules-set match-rules Match-Rules
   route-destination-ip 10.10.10.0/24
    aggregate yes
   rules-set set-rules Set-Rules
   metric name 4
   nh-address 10.1.1.1
```

```
route-policy DC-PE-Route-Pol
   match-and-set-group Set-Rules
    order  0
    action permit
    match-rules Match-Rules

 dc-route-policy rpl-ten11
  tenant Tenant-sevt-11
  rules-set match-rules matchrule1
   route-destination-ip 11.0.0.0/8
    aggregate yes
   !
  !
  rules-set set-rules rule1
   metric name 2
   nh-address 0.0.0.0
  !
  route-policy outbound-rmap
   match-and-set-group rule1
    order  0
    action permit
    match-rules matchrule1
    !
```

SR/MPLS Handoff Payload

SR MPLS VRF configuration on both ACI and DC PE

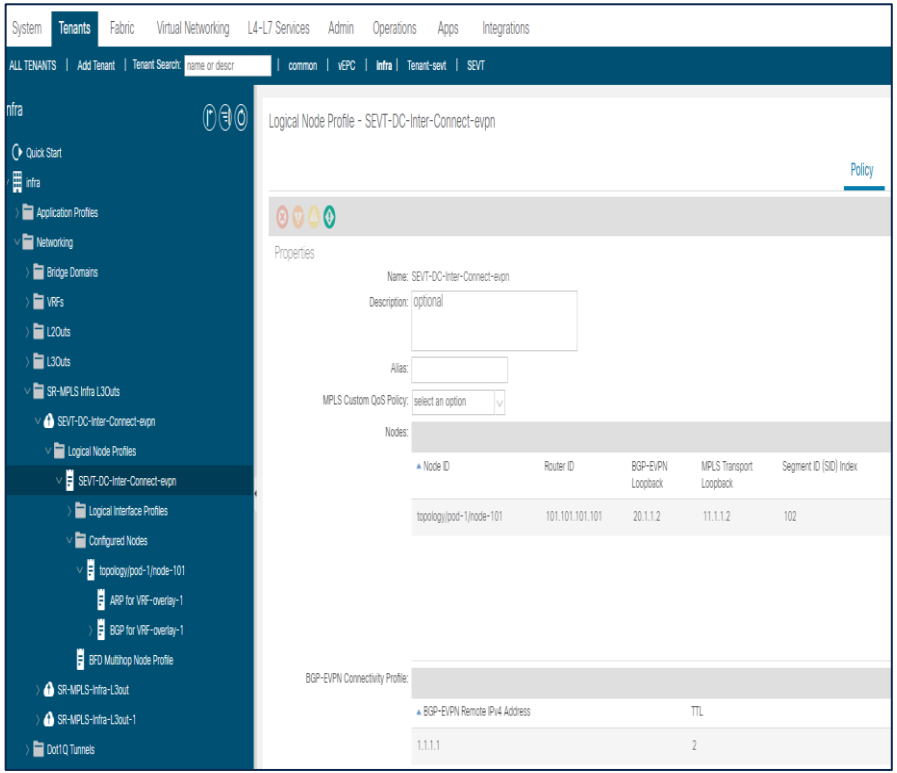
```
tenant vEPC
  dct-l3-vpn VRF5
   deploy false
   type   sr-mpls
   address-family ipv4
   !
   pe-attributes address-family ipv4
    vpn-target 100:120
     rt-type import
    !
    vpn-target 120:115
     rt-type import
    !
   pe-attributes pe-device DC-PE
    address-family ipv4
     redistribute-connected
     redistribute-static
    !
interconnect SEVT-DC-Inter-Connect
    dc-attributes import-route-policy DC-PE-Route-Pol
    dc-attributes export-route-policy outbound-rmap
```

External EPG configuration for SR/MPLS handoff

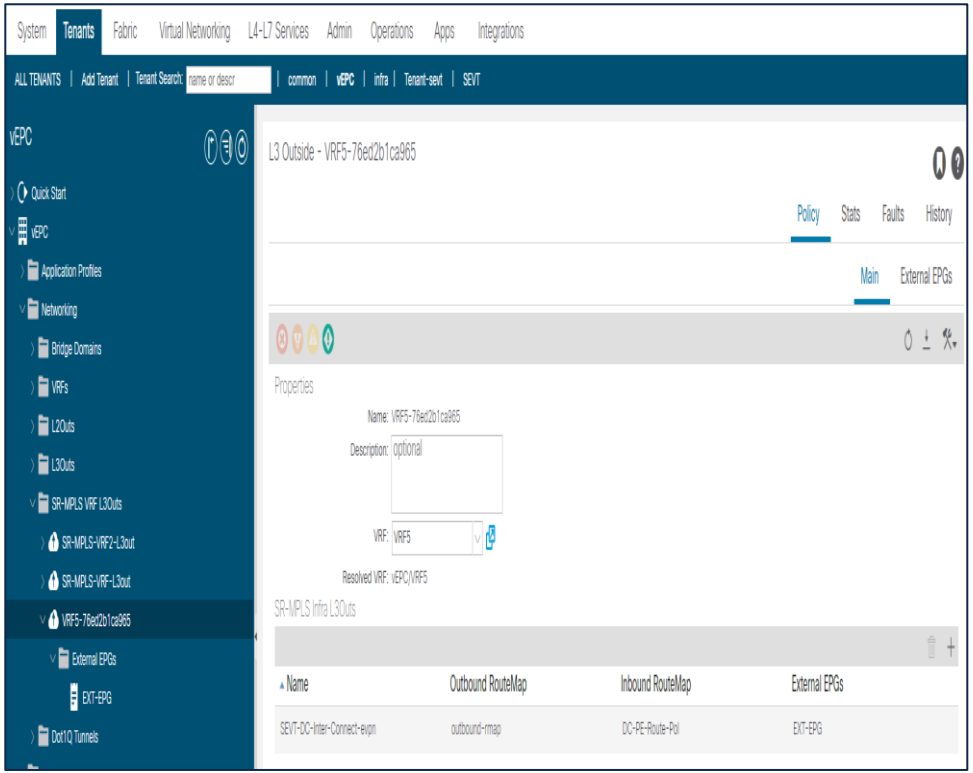
```
dc-controller APIC-TME
!
 l3out-security-service VRF5-76ed2b1ca965
  l3out-routing-service SEVT-DC-Inter-Connect-evpn
  l3out-type sr-mpls-vrf-l3out
  tenant              vEPC
  border-leaf 101
   external-epg EXT-EPG
    prefix 0.0.0.0/0
    !
    contract NSO-contract
     type consumed
    !
```

SR/MPLS configuration on APIC controller

SR/MPLS infra L3out



SR/MPLS VRF L3out



SR/MPLS configuration on DC-PE

VRF-Configuration

```
vrf VRF5
 address-family ipv4 unicast
  import route-target
   100:120
   120:115
   200:122 stitching
  !
  export route-target
   200:122 stitching
!
interface Loopback0
 ipv4 address 10.10.10.10 255.255.255.255
!

interface GigabitEthernet0/0/0/4
 description xDomain inter-connect interface
 ipv4 address 22.1.1.6 255.255.255.252
!
router bgp 100
 bgp router-id 10.10.10.10
 mpls activate
  interface GigabitEthernet0/0/0/4
 !
```

BGP LU, EVPN and VPN configuration

```
neighbor 20.1.1.2
  remote-as 65000
  bfd multiplier 3
  bfd minimum-interval 250
  ebgp-multihop 2
  update-source Loopback0
  address-family l2vpn evpn
   import stitching-rt re-originate
   route-policy PASS_ALL in
   route-policy PASS_ALL out
   advertise vpnv4 unicast re-originated stitching-rt
   advertise vpnv6 unicast re-originated stitching-rt
  !
 neighbor 22.1.1.5
  remote-as 65000
  address-family ipv4 labeled-unicast
   route-policy PASS_ALL in
   route-policy PASS_ALL out
  !
  vrf VRF5
  rd auto
  address-family ipv4 unicast
   redistribute connected
   redistribute static
```

IP Handoff Payload

```
dc-transport-network SEVT-IP-Handoff
 topology topology-settings pe-attributes pe-device DC-PE
  bgp-as 600
 !
 topology interconnect interconnect-1
  dc-controller APIC-TME
  bfd interval 50
  bfd multiplier 3
  bgp-password  $8$dtuq/YuDYuBBlNo1MsjtEwVuzxfwDkVz2LM9ZDPpuKc=
  connection connection-1
   dc-end border-leaf 101
   dc-end port port-config-service-name SEVT-L3out-Port
   dc-end port interface     1/29
   pe-end pe-device DC-PE
   pe-end port if-type TenGigE
   pe-end port if-id 0/0/0/0
  !
 !
 interconnect interconnect-1
    dc-attributes bgp local-as 500
    pe-attributes bgp as-override true
    pe-attributes bgp allow-as-in 3
    pe-attributes bgp site-of-origin 10:14
    connection connection-1
     dc-end ipv4-address 120.0.0.1/24
     dc-end vlan id 3001
     pe-end ipv4-address 120.0.0.2/24
     pe-end vlan id 3001
```

```
tenant vEPC
  dct-l3-vpn SEVT-VPN
   vrf VRF1
   dc-attributes dc-controller APIC-TME
    border-leaf 101
     router-id 101.101.101.101
    !
   !
   pe-attributes vpn-id 100:100
   pe-attributes address-family ipv4
    vpn-target 100:100
     rt-type both
    !
   !
   pe-attributes pe-device DC-PE
    router-id 201.201.201.201
    address-family ipv4
     redistribute-connected
     redistribute-static
    !
    static ipv4-prefix 0.0.0.0/0
     next-hop 120.0.0.1
     !
```

DC orchestration

Services/modules for DC configuration

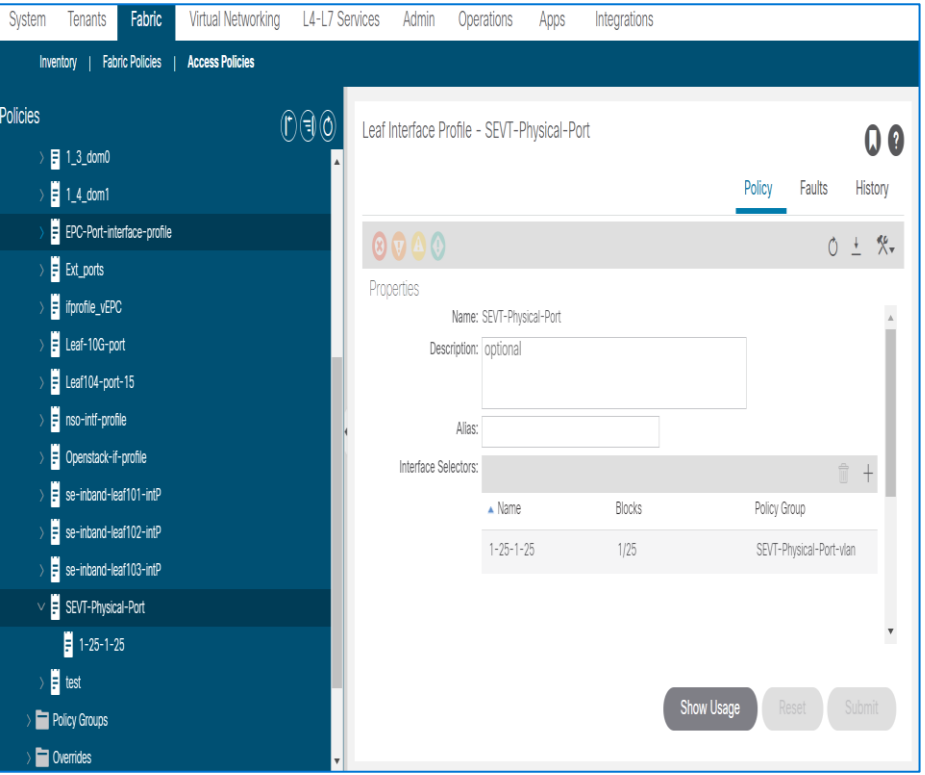
Module	Use-case
route-reflector-service	Route reflector configuration of ACI Fabric
qos-default-policy	Default fabric level QOS configuration
dc-route-policy	Route-map, match and set rules
port-configs	Port configuration - Access Policies, Interface policy group, Interface profile, switch profile, vlan-pool, port-range, access-port, vPC, PC
l3out-routing-service	L3out configuration over routed port, routed sub-interface, SVI, vPC. BGP, static route and BFD configuration. Attaching routing and QOS policies on L3out.
l3out-security-service	External EPG, contract configuration of L3out
service-graph	Create Service Graph and attach PBR
tenant-service	Tenant, AP, EPG, BD, VRF, Contracts, Filters, Qos policy
custom-template	Apply custom config

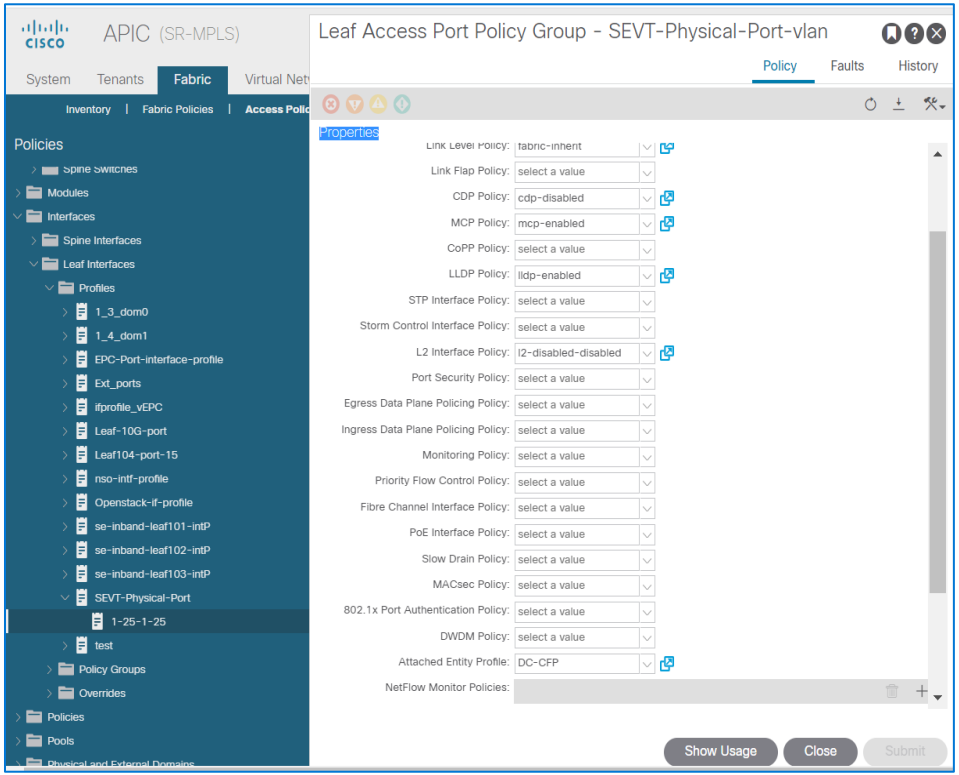
ACI Port configuration using DC CFP

Interface policies, Profiles, VLAN Pool, Policy group, AEP, Switch profile, domains are automatically created in the background

```
admin@ncs(config)# dc-controller APIC-TME port-configs port-config SEVT-Physical-Port leafs from-leaf 101 to-leaf 102
admin@ncs(config-port-config-SEVT-Physical-Port)# policies cdp enabled lldp enabled ?
Possible completions:
  fabric           -
  l2               -
  l2-port-security -
  lacp             - PortChannel Member Policies
  lacp-lag         -
  mcp              - Mis-cabling Protocol Interface Policy
  qos-dpp          -
  qos-pfc          -
  storm-control    -
  stp              - Spanning Tree Interface
  <cr>             -
admin@ncs(config-port-config-SEVT-Physical-Port)# policies cdp enabled lldp enabled
admin@ncs(config-port-config-SEVT-Physical-Port)# interfaces interface-id 1/25
admin@ncs(config-interface-id-1/25)# vlan-pool 500 600
```

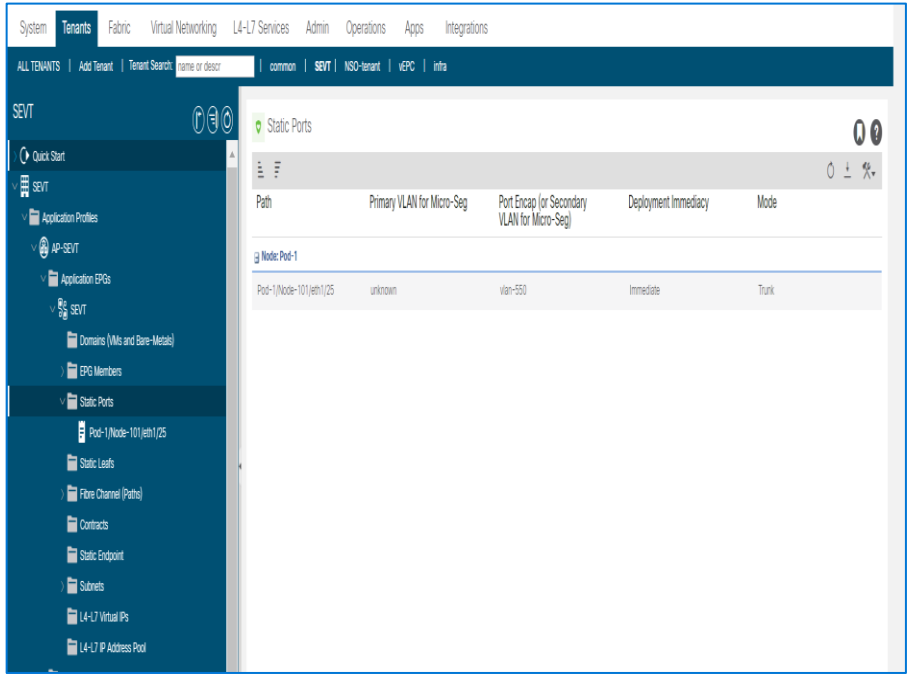
Port configurations pushed on ACI

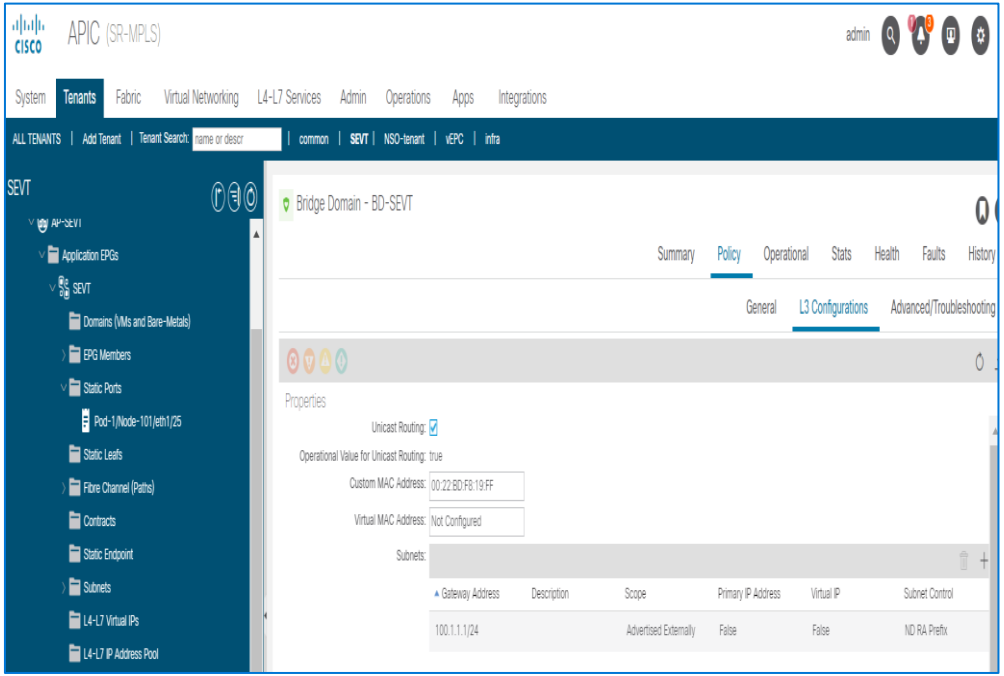




Creating EPG in ACI

```
admin@ncs(config)# dc-controller APIC-TME tenant-service SEVT application-profile AP-SEVT epg SEVT bridge-domain BD-SEVT
admin@ncs(config-epg-SEVT)# port-config SEVT-Physical-Port leaf-id 101 interface-id 1/25 vlan 550
admin@ncs(config-port-config-SEVT-Physical-Port)# bridge-domain BD-SEVT bd-subnet 100.1.1.1/24 scope public
admin@ncs(config-bd-subnet-100.1.1.1/24)# commit dry-run
```





Brownfield

Auto-populate NSO with existing objects

- Enable Auto-population of existing object into NSO. This would help in showing existing object in both CLI and GUI.

```
admin@ncs> request dc-actions sync-fabric-auto-population fabric APIC-TME
success true
detail Sync up DC fabric: APIC-TME
 Sync DC Internal Device: APIC-TME
 Sync Successful for DC Internal Device
 Sync fabric Successful
[ok][2020-10-12 15:25:47]
admin@ncs>
```

- Check below example to see all existing Tenants into APIC

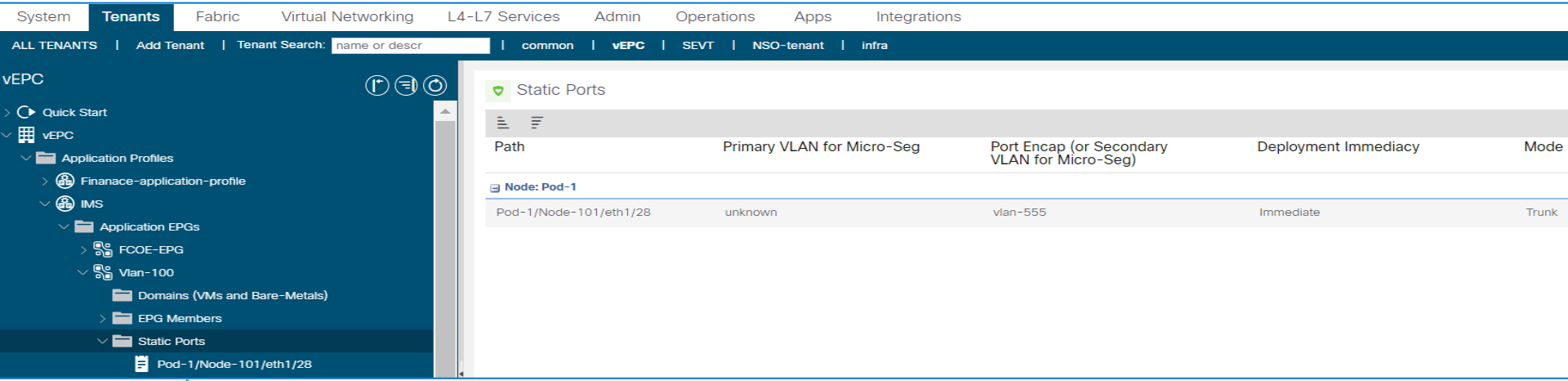
```
admin@ncs(config)# dc-controller APIC-TME tenant-service ?
Possible completions:
  <Specify tenant name as Service>      NSO-tenant                                SEVT
  vEPC                                  Maxis                                     Maxis_Engineering
  Maxis_IT                              SG-App                                    SR-MPLS
  common                                infra                                     mgmt
  prj_477ba1e574ea4a99be83fc6f95688892  prj_bb71332946a4426c810a26576d0ef2e1
```

Add a port into existing EPG

Use apic-port-service instead of Port-config service

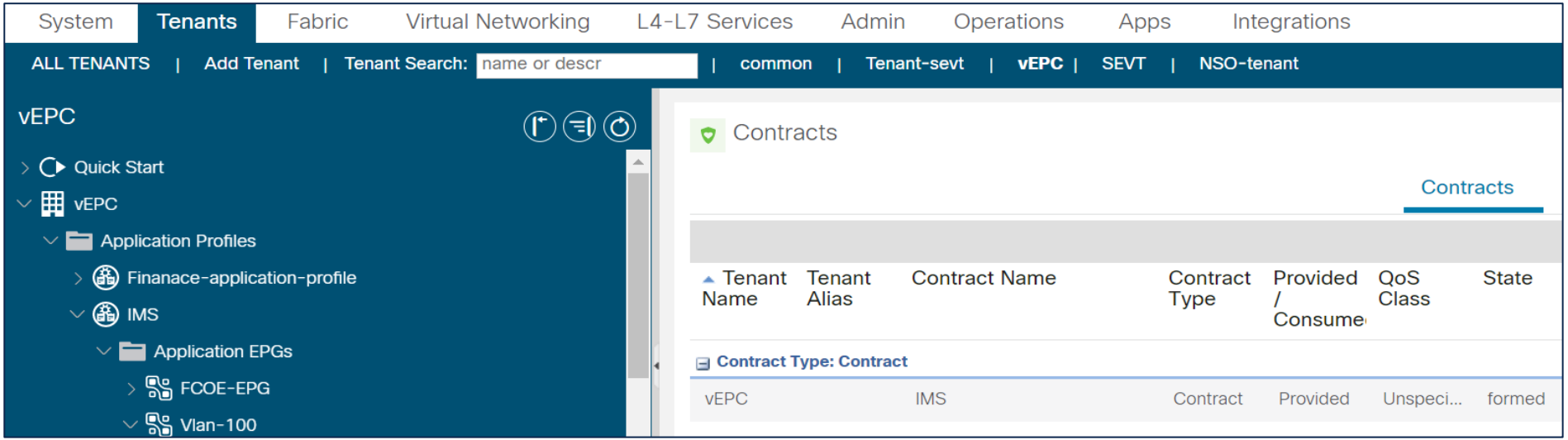
```
admin@ncs(config)# dc-controller APIC-TME tenant-service vEPC application-profile IMS epg Vlan-100
admin@ncs(config-epg-Vlan-100)# ?
Possible completions:
  apic-port-service           - Attach APIC Brownfield port-service, VPC, Direct PC
```

```
admin@ncs(config)# dc-controller APIC-TME tenant-service vEPC application-profile IMS epg Vlan-100
admin@ncs(config-epg-Vlan-100)# apic-port-service topology/pod-1/paths-101/pathep-[eth1/28] vlan 555
```



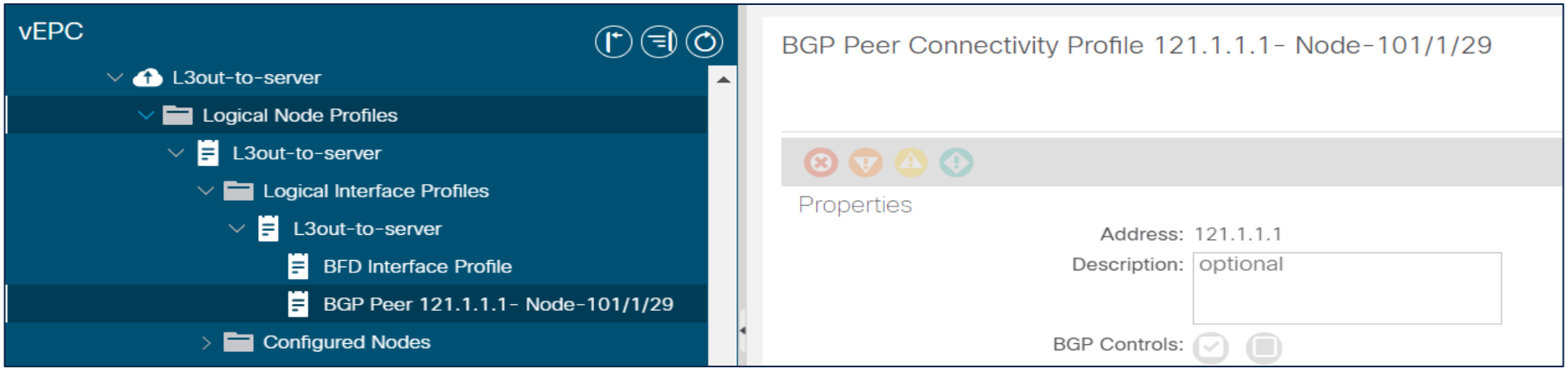
Configure contract in the existing EPG

```
admin@ncs(config)# dc-controller APIC-TME tenant-service vEPC application-profile IMS epg Vlan-100
admin@ncs(config-epg-Vlan-100)# epg-contract ?
Possible completions:
  Gi-LAN-PGW-Internet  Gi-Lan-tcp-opt  IMS                    NSO-contract   PGW-IP-MPLS
  QOS-contract        all-permit       contract-with-filter   route-leaking  service-chaining
admin@ncs(config-epg-Vlan-100)# epg-contract IMS type provided
```



Add existing port into L3out

```
admin@ncs# show running-config dc-controller APIC-TME l3out-routing-service
dc-controller APIC-TME
 l3out-routing-service L3out-to-server
  tenant      vEPC
  vrf-name    VRF4
  enable-bfd bfd_50_3
  border-leaf 101
   router-id 101.101.101.101
   loopback  no
   routing bgp 121.1.1.1
    source-interface external-connection Connection-1
    remote-as 100
   !
   external-connection Connection-1
    interface-profile L3out-to-server
    type routed-interface apic-port-service leaf-host-path topology/pod-1/paths-101/pathep-[eth1/29]
    type routed-interface ip-addresses ipv4-primary 121.1.1.1/24
```



When brownfield configuration is different than CFP default

By default DC CFP configures ACI VRF in enforced mode

VRF in ACI should always be configured in enforced mode. This configuration is must to enable contract for communication between two EPGs in this VRF. This mode is also required for PBR. DC CFP uses this configuration, by default.

```
admin@ncs-cfs% commit dry-run
cli {
    local-node {
        data  dc-controller APIC-1 {
                  tenant-service NSO-tenant {
              +       vrf VRF1 {
              +       }
               }
lsa-node {
        name data-center-rfs-1
        data  devices {
                  device APIC-1 {
                      config {
                          apic {
                              fvTenant NSO-tenant {
                                  fvCtx VRF1 {
              +                       pcEnfPref enforced; *** ------> Core FP templates is configuring VRF in  "enforced“ mode,  If user intents
to override this value to "unenforced", we need to use custom template
```

Steps to change default CFP behavior

Below is the example to change VRF mode using custom template. Links in these steps may change for different versions :

1. Download **custom-templates.tar.gz**
2. Copy custom-templates.tar.gz to ***/var/opt/ncs/packages*** directory for system installation (For local install, copy it under /packages folder of NSO running directory).
3. Go to ***/var/opt/ncs/packages*** and extract custom-templates.tar.gz.
4. Delete custom-templates.tar.gz.

NAMING CONVENTION:
Name of custom templates must start with either "ct-" or "CT-"
The device name variable in config templates must be either ***"DEVICE_NAME"*** or ***"DEVICE"***.

Refer :
NSO Development Guide - Chapter : Templates
NSO User Guide – Chapter Device Manager – Device Templates

Custom template to change VRF mode from default

Create Device template as below. Custom templates must be created with file name as "ct-" or "CT-"

```
    admin@ncs(config)# devices template ct-vrf-unenforced
 ned-id cisco-apicdc-gen-3.8
  config
   apic fvTenant ($TENANT}
    fvCtx {$VRF}
     pcEnfPref unenforced
    !
   !
  !
 !
!
```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