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3 Steps to Design Cisco SD-WAN On-Prem

Andraz Piletic, Consulting Engineer / Instructor
Prashant Tripathi, Global Technical Solutions Architect

BRKRST-2559

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Barcelona | January 27-31, 2020

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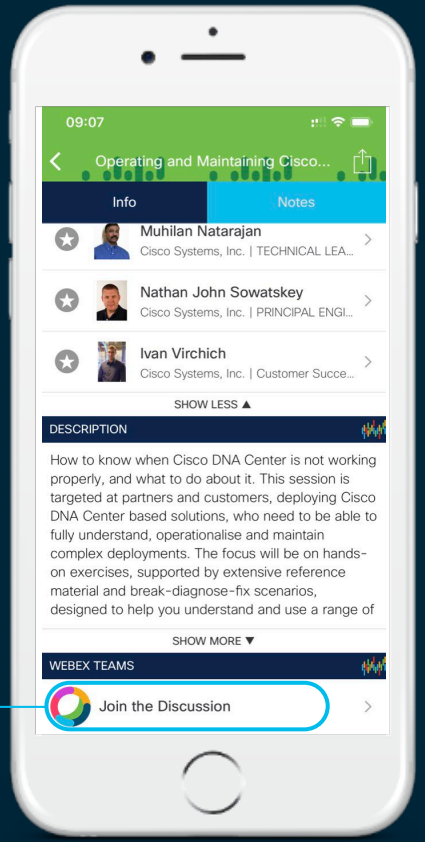


Agenda

- Designing controllers connectivity
- Deployment requirements
- Managing SA/VA
- Certificate Authority Options
- Zero Touch Provisioning
- vManage Cluster
- Designing high availability and scale

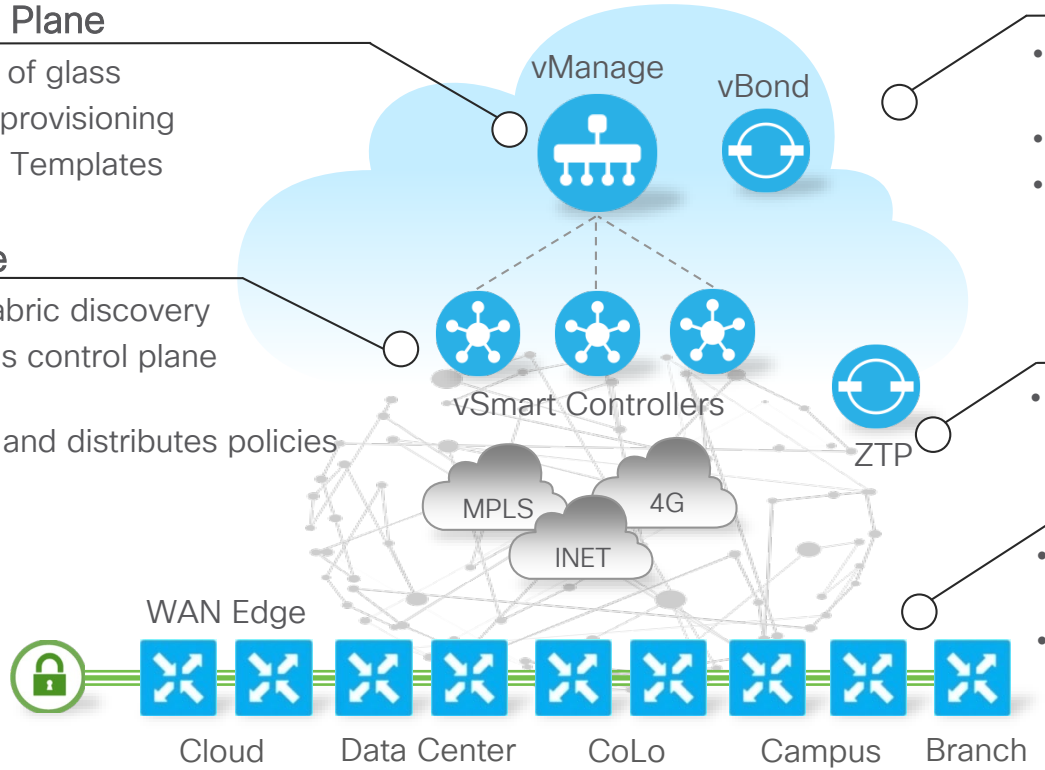
Architecture

Management Plane

- Single pane of glass
- Centralized provisioning
- Policies and Templates

Control Plane

- Facilitates fabric discovery
- Disseminates control plane information
- Implements and distributes policies



Orchestrator

- Orchestrates control and management plane
- First point of authentication
- Facilitates NAT traversal

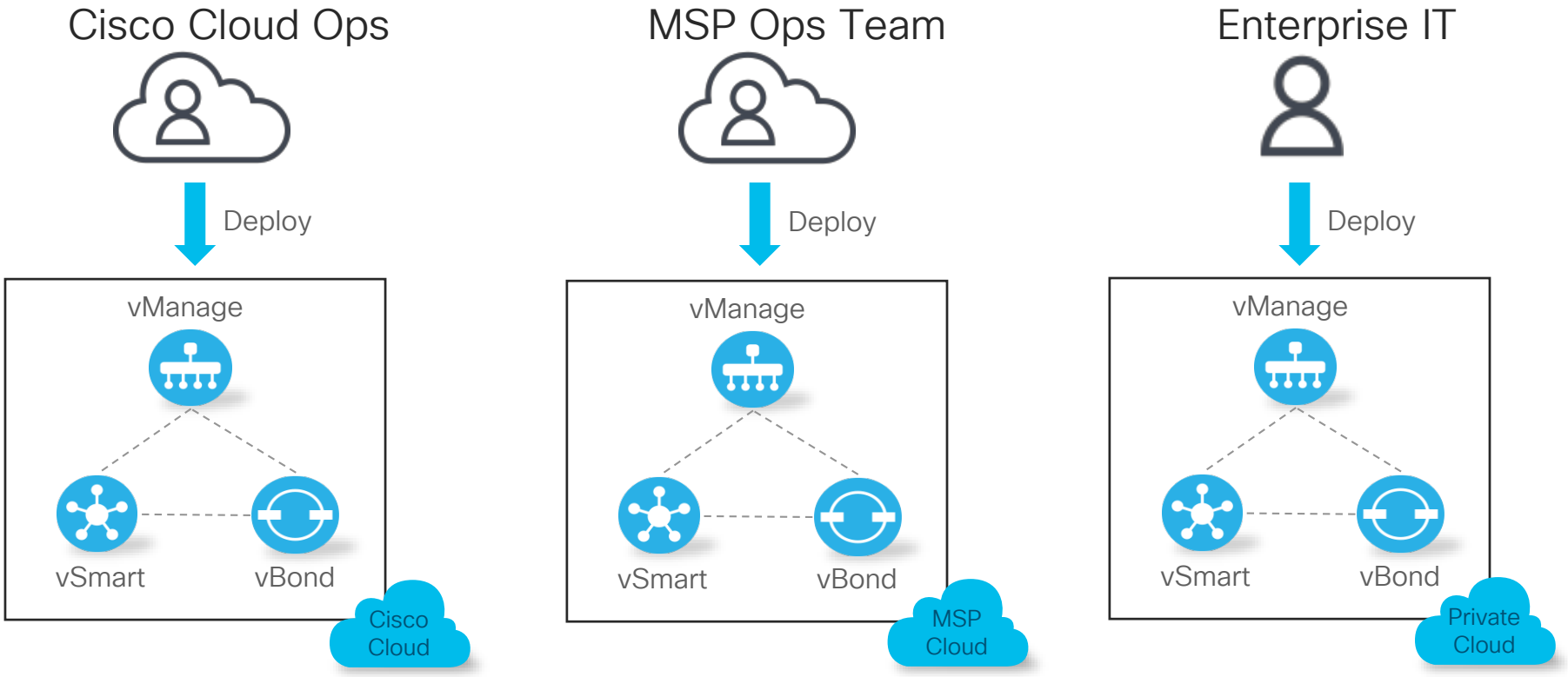
Zero Touch Provisioning

- Facilitates device onboarding

Data Plane

- Diversity of Physical or Virtual appliances
- Builds IPsec tunnels and exchanges user traffic

Controllers Deployment Options



Colors, Address Assignments, and Connectivity

On-Prem Design Consideration

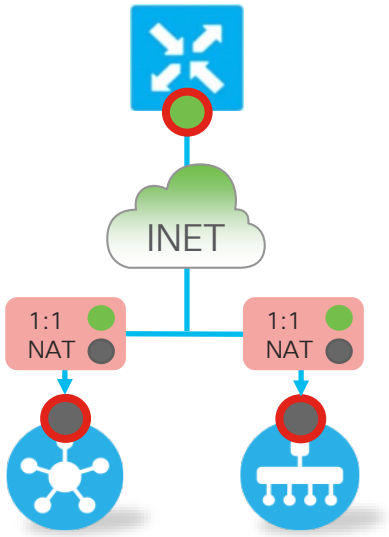
- How to connect WAN Edge devices to controllers?
  - Internet
  - MPLS
  - Multiple Transports
- Should I use private IPs, NAT, public IPs?
- What transport colors should I assign to my controllers?
- Where to place controllers in on-prem environment?

Transport Colors

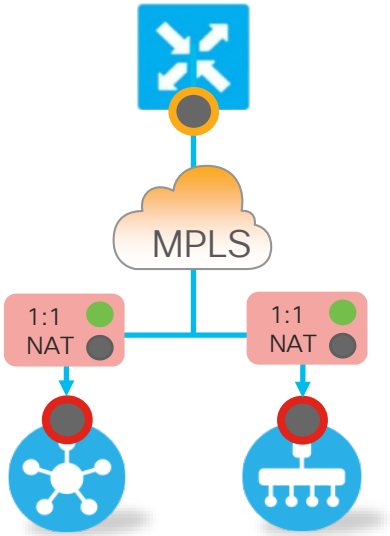
- Color attribute is used to identify:
  - Individual WAN transport tunnel – TLOC Interface
  - Underlay network attachment
- The specific color is categorized as Private or Public
  - Private Colors [mpls, private1-6, metro-ethernet]
  - All other colors are public [default, red, blue,..., public-internet,...]
- Private vs Public color is highly significant
- Color setting applies to:
  - WAN Edge to Controller Communication
  - WAN Edge to WAN Edge Communication

Transport Colors and Control Connections

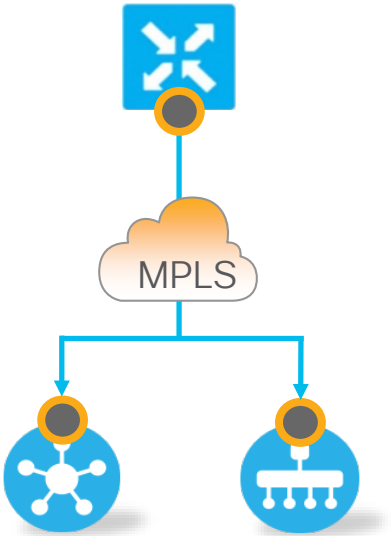
Local Color: Public
Controller Color: Public
Use: Public IP



Local Color: Private
Controller Color: Public
Use: Public IP

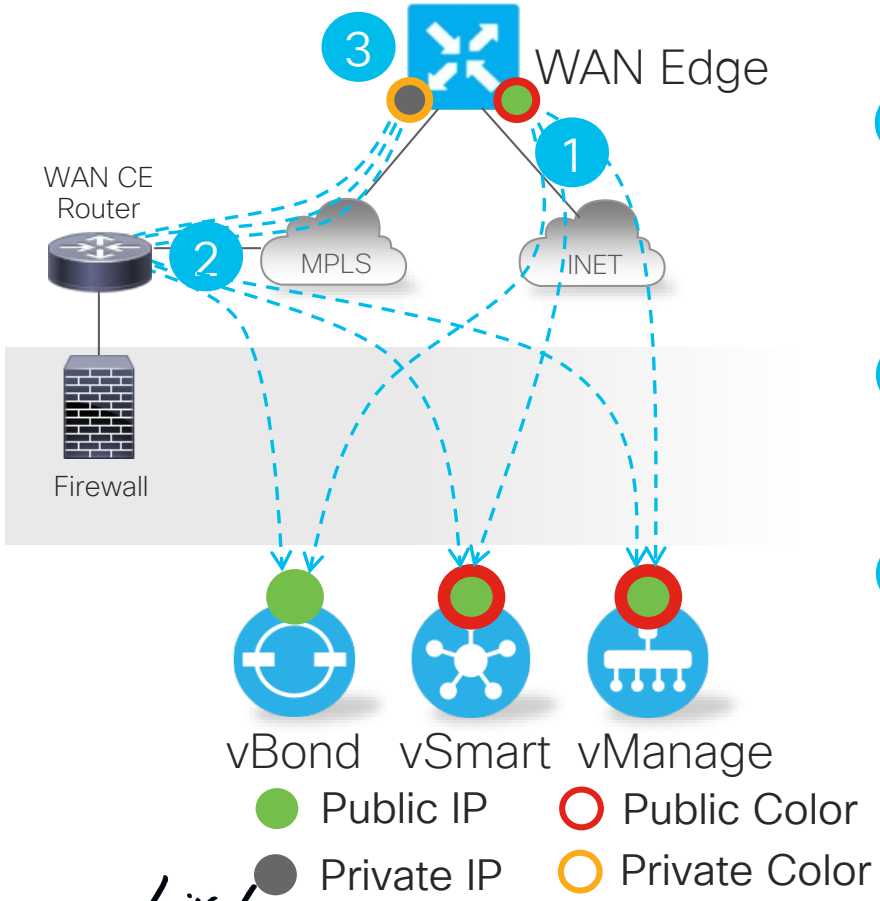


Local Color: Private
Controller Color: Private
Use: Private IP



Public IP
Private IP
Public Color
Private Color

Option A) Assigning Public IPs to Controllers

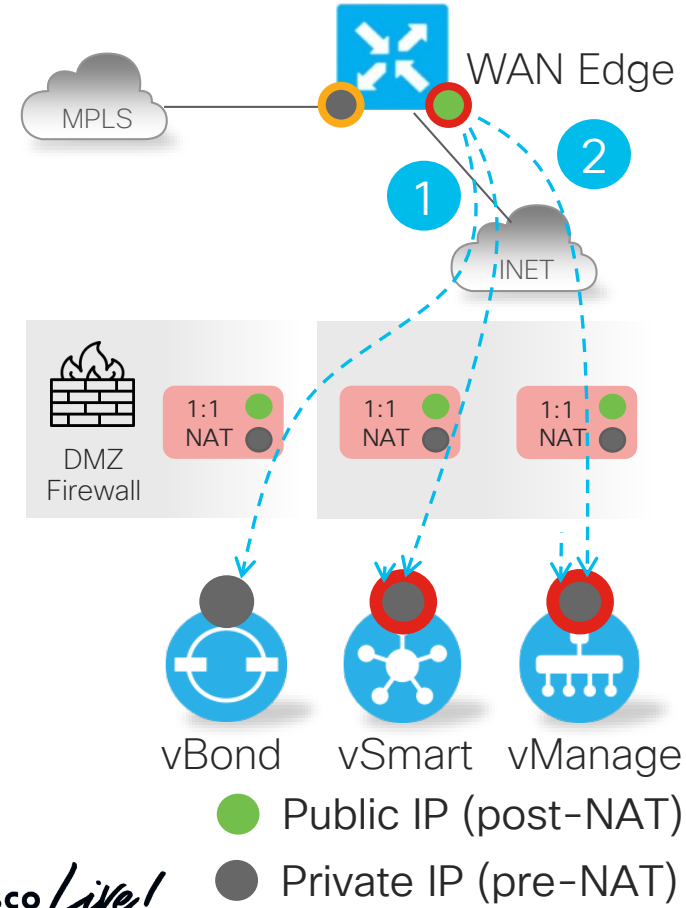


1 WAN Edge points to the vBond public IP and learns about vManage and vSmart public IPs

2 Optionally advertise controllers' public IPs also into private transport.

3 WAN Edge establishes control connections also via private transport using same controllers' public IPs

Option B) Assigning NATed Public IPs to Controllers

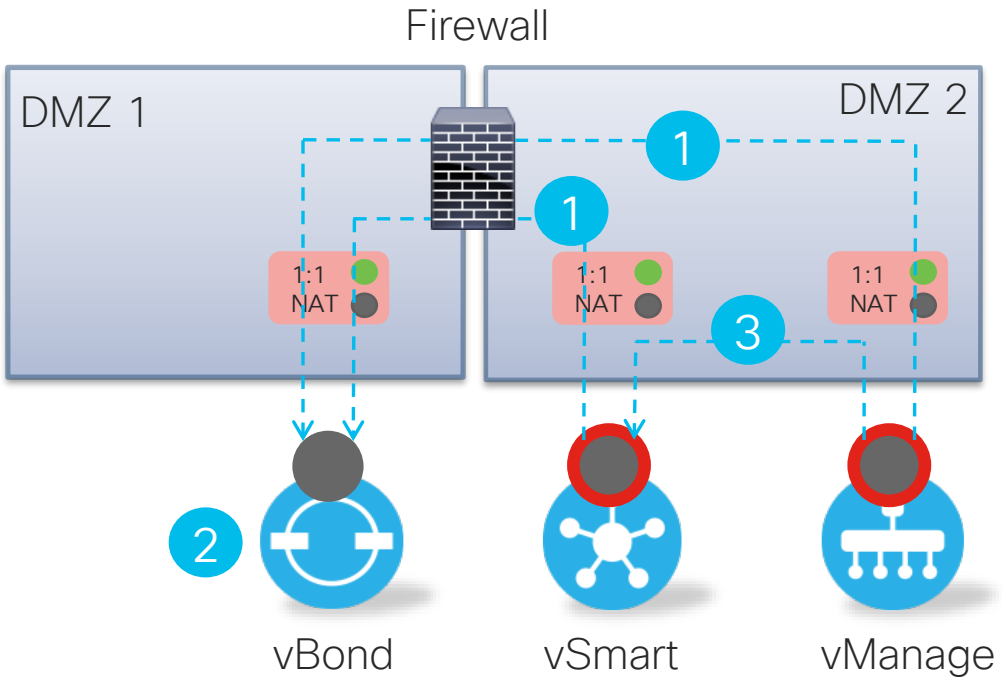


1 WAN Edge points to the vBond FQDN that resolves to NATed IP.

2 WAN Edge communicates with vSmart and vManage NATed public IP over the Internet only.

- Same design option as used in cloud-hosted scenario.

Option B) Assigning NATed Public IPs to Controllers



1 vSmart and vManage point to the vBond NATed public IP.

2 vBond learns interface private and NATed IP address of vSmart and vManage.

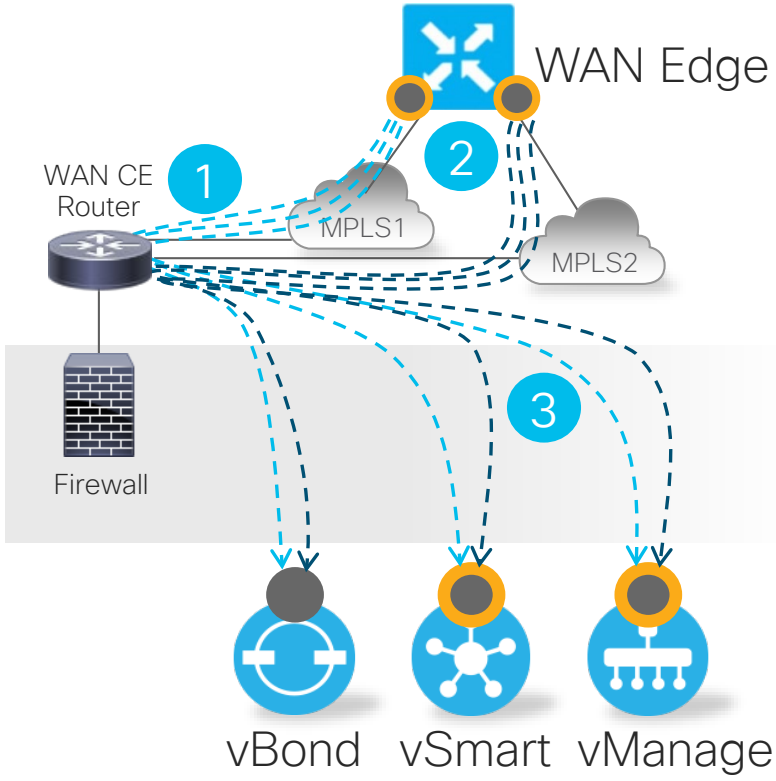
3 vSmart and vManage use private IPs for communication

- Same Site-ID must be used

Public IP (post-NAT) Public Color

Private IP (pre-NAT)

Option C) Assigning Private IPs to Controllers



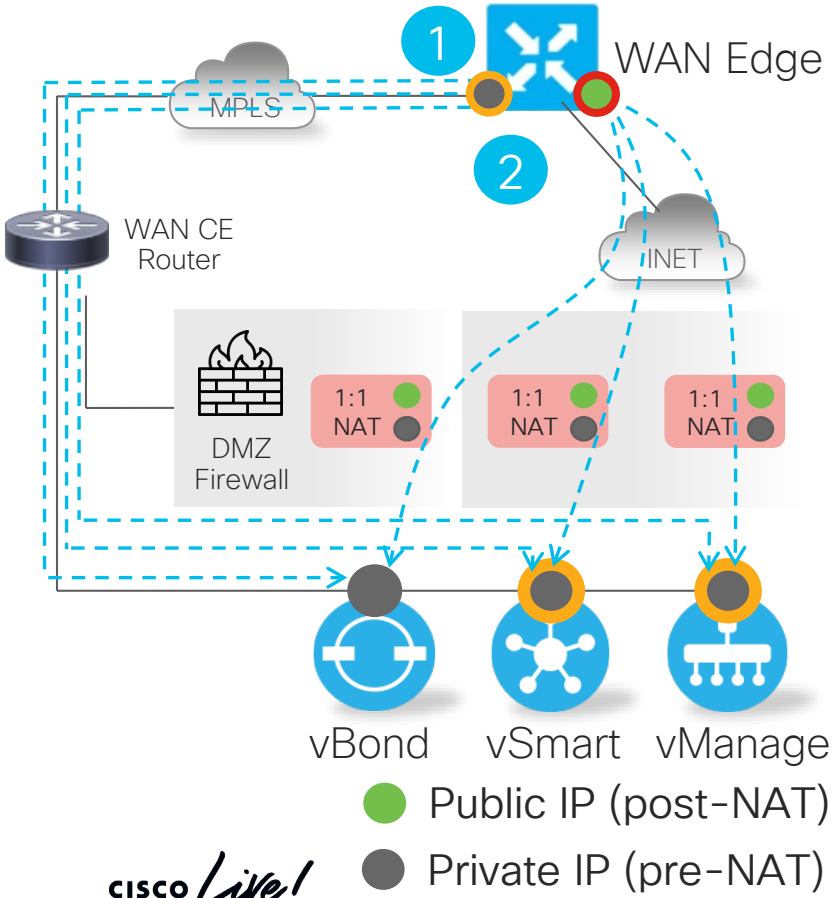
1 Controllers' private IPs are advertised across private transports.

2 WAN Edge points to the vBond private IP address.

- vBond private IP address is reachable through all private transports.

3 WAN Edge communicates with vSmart and vManage by connecting to their private IP address.

Option D) Assigning NATed Public IPs to Controllers



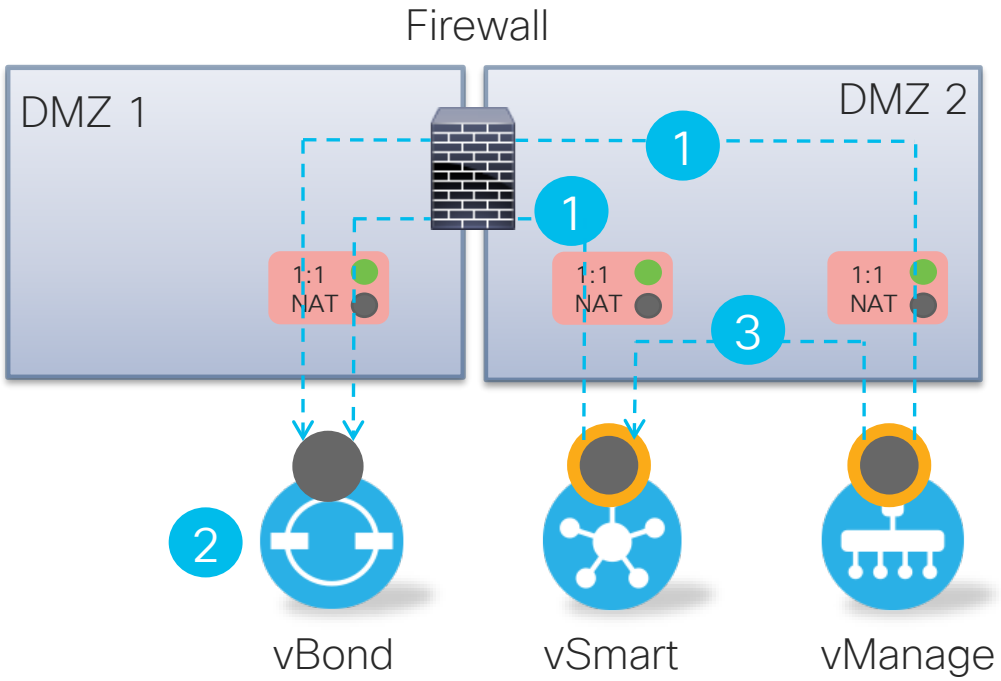
1 WAN Edge points to the vBond FQDN that resolves both public and private IP.

	Private IP	Public IP
MPLS	✓	✗
Internet	✗	✓

2 WAN Edge communicates with vSmart and vManage NATed public IP over Internet and use private IPs over MPLS

- Private color to private color uses private IP, public color to public color uses public IP.

Option D) Assigning NATed Public IPs to Controllers



1 vSmart and vManage point to the vBond NATed public IP.

2 vBond learns interface private and NATed IP address of vSmart and vManage.

3 vSmart and vManage use private IPs for communication

- vSmart and vManage use private color (non-default).

Public IP (post-NAT) Private Color

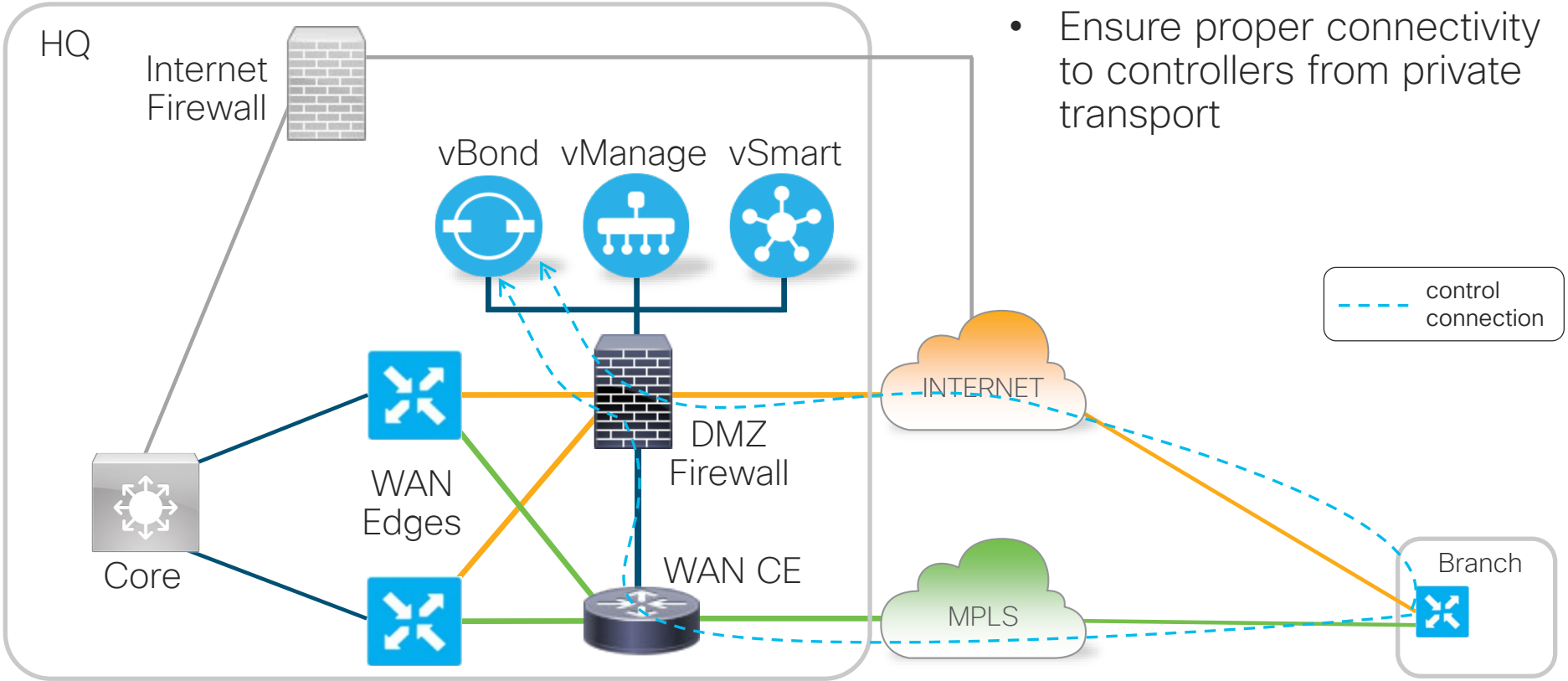
Private IP (pre-NAT)

Review of Design Options

Option	Controller's IPs	Behind NAT	Color Type	Reachable from INET	Reachable from MPLS
A	Public	No	Public	Yes	Only if advertised
B	Private	Yes	Public	Yes (NAT)	No
C	Private	No	Private	No	Yes
D	Private	Yes	Private	Yes (NAT)	Yes

- Prefer designs with control connections over multiple transports for better resiliency
- Option A) is the cleanest/simplest

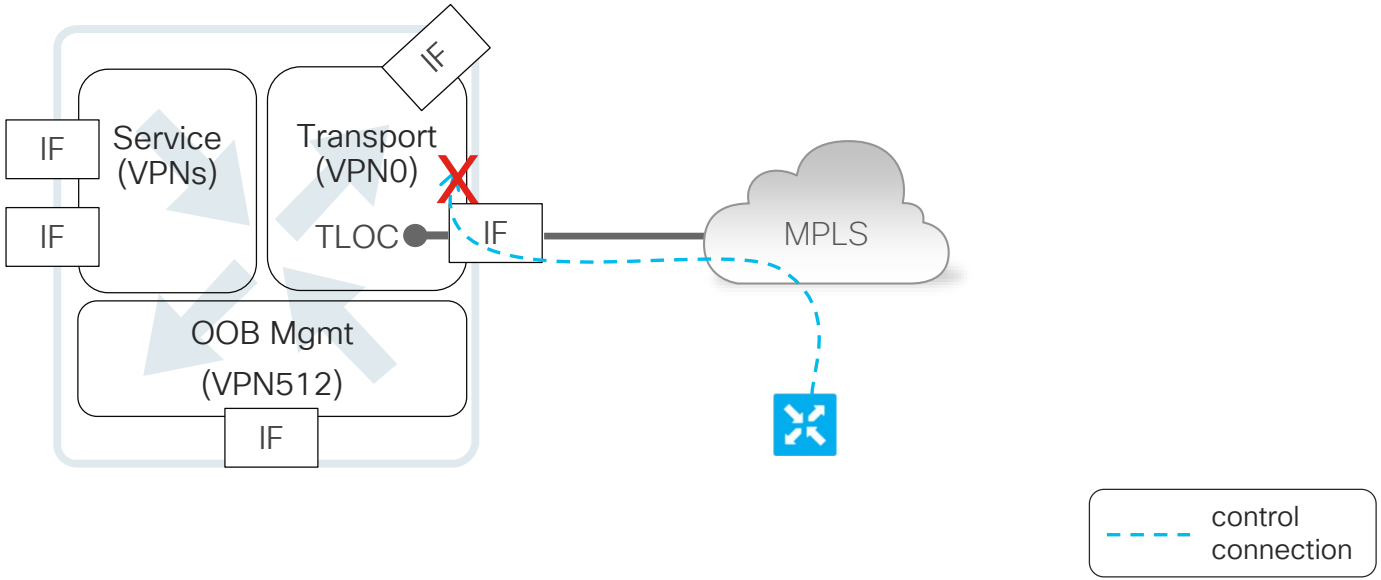
Controllers Placement in On-Prem Environment



- Ensure proper connectivity to controllers from private transport

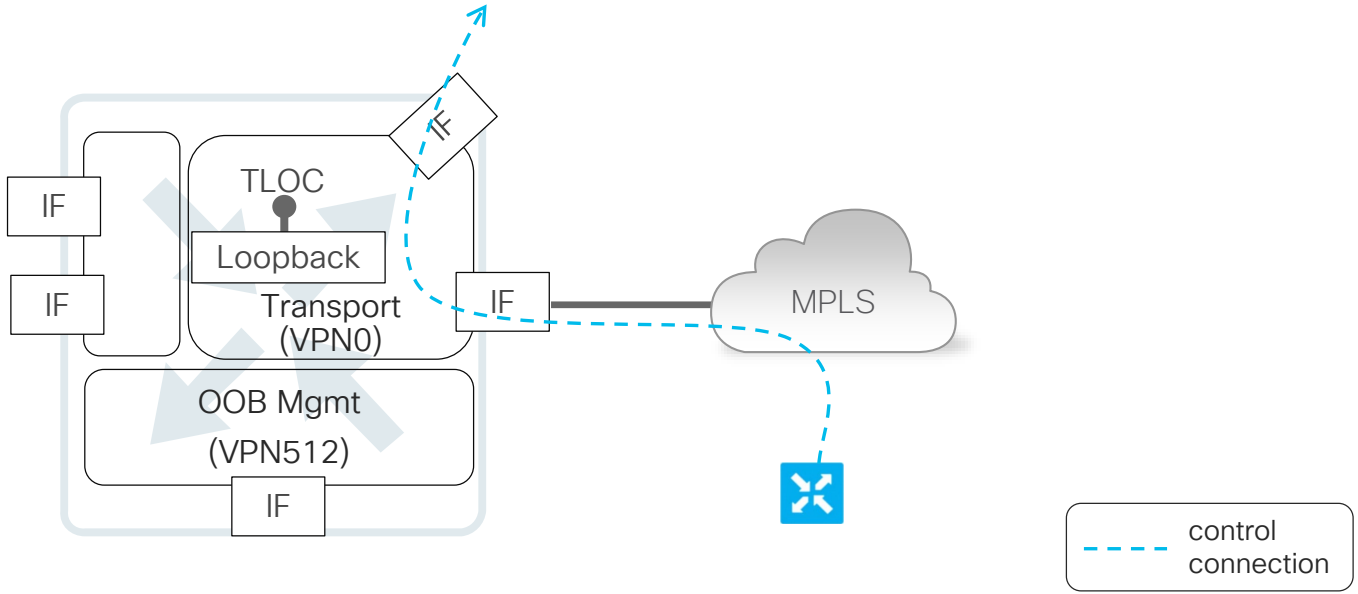
Using Loopback for TLOC Termination

- Problem: TLOC configuration on WAN interface locks down the interface – control connections are not routed through.

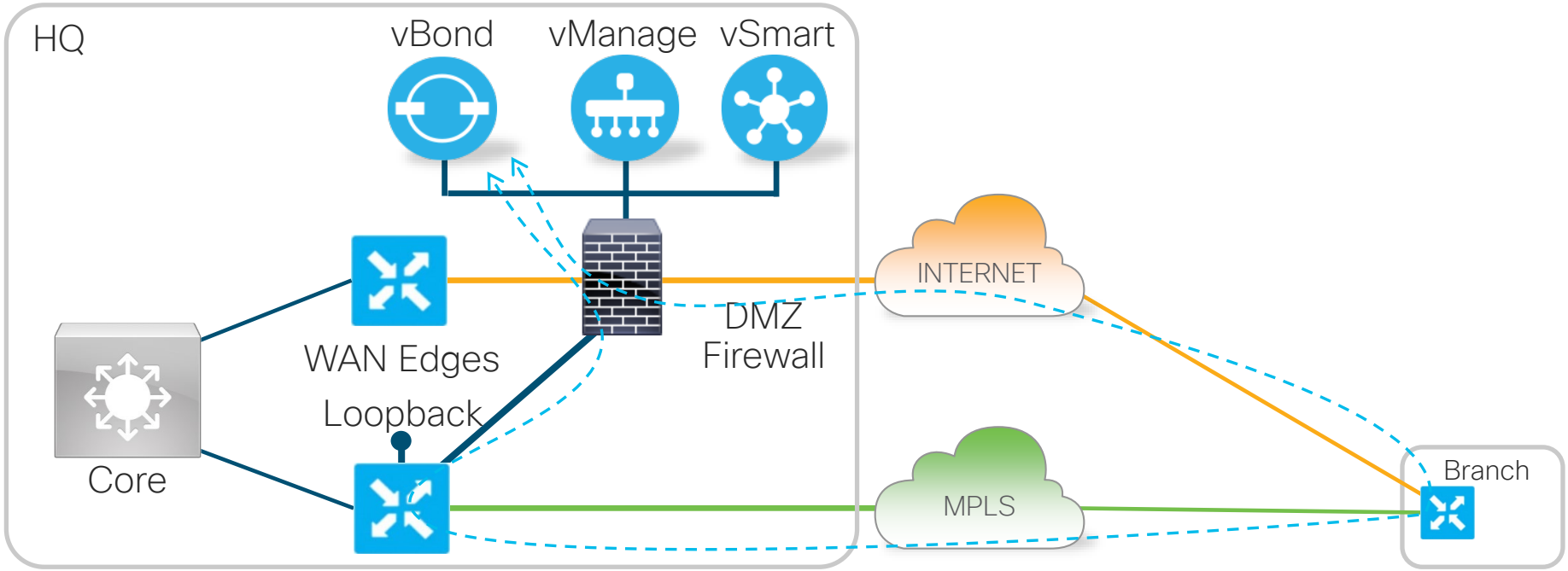


Using Loopback for TLOC Termination

- Problem: TLOC configuration on WAN interface locks down the interface – control connections are not passed through
- Solution: Configure TLOC interface on loopback



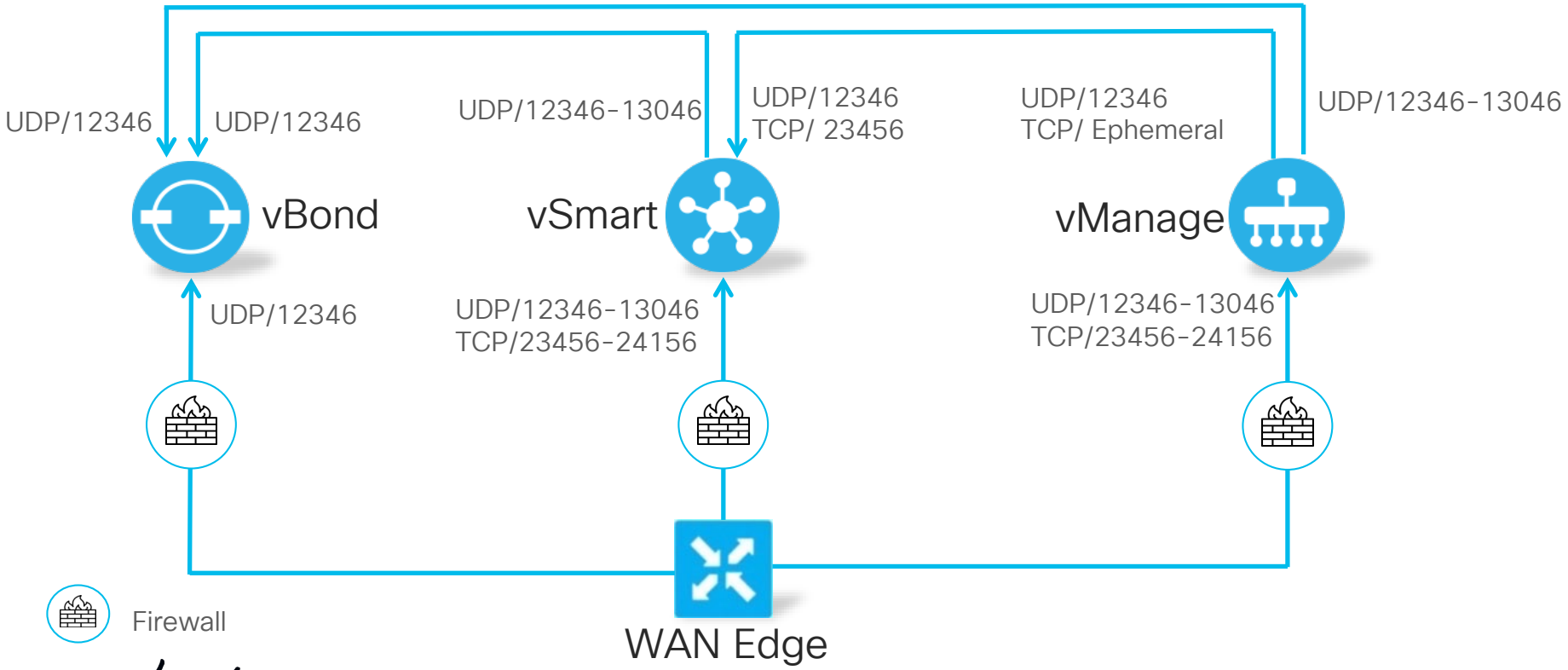
Connecting Controllers Without WAN CE Router



- Configure TLOC on Loopback to allow control connections passing through the WAN Edge towards controllers.

control connection

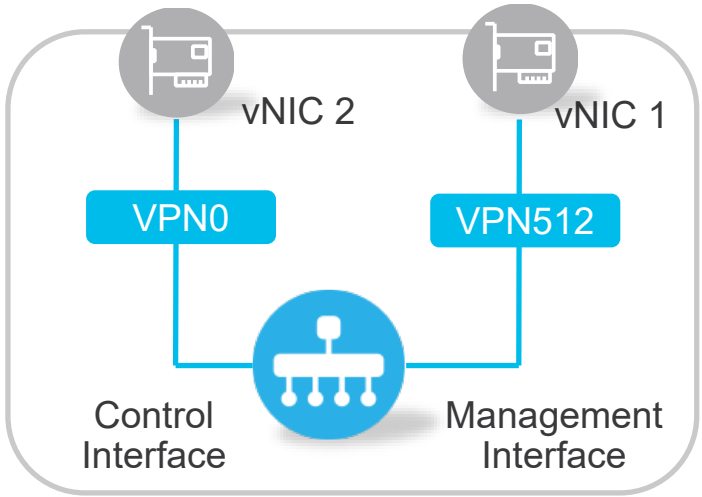
Firewall Rules for On-Prem Controllers



Deployment Requirements

Controllers' Requirements

- All controllers are deployed as virtual machines
- Supported Hypervisors in on-prem deployment
  - KVM
  - VMware ESXi (5.5 – 6.5)
- SSD-based storage required for all controllers
- One underlay (VPN0) interface is supported on each controller, optional additional interface for out-of-band management (VPN512)



Verifying vManage System Requirements

Devices	vCPUs	RAM	OS Volume	Database Volume	Bandwidth	vNICs
1-250	16	32 GB	20 GB	500 GB, 1500 IOPS	25 Mbps	2
251-1000	32	64 GB	20 GB	1 TB, 3072 IOPS	100 Mbps	2
1000+	32	64 GB	20 GB	1 TB, 3072 IOPS	150 Mbps	3*

- Private lab setup for learning purposes will work with less resources.
- * vManage Cluster requires dedicated interface for message bus.

Verifying vBond System Requirements

Devices	vCPUs	RAM	OS Volume	Bandwidth	vNICs
1-50	2	4 GB	10 GB	1 Mbps	2
51-250	2	4 GB	10 GB	2 Mbps	2
251-1000	2	4 GB	10 GB	5 Mbps	2
1001+	4	8 GB	10 GB	10 Mbps	2

- vBond is installed using vEdgeCloud OVA.
- OVA is preconfigured with four vCPUs.

Verifying vSmart System Requirements

Devices	vCPUs	RAM	OS Volume	Bandwidth	vNICs
1-50	2	4 GB	16 GB	2 Mbps	2
51-250	4	6 GB	16 GB	5 Mbps	2
251-1000	4	16 GB	16 GB	7 Mbps	2
1001+	8	16 GB	16 GB	10 Mbps	2

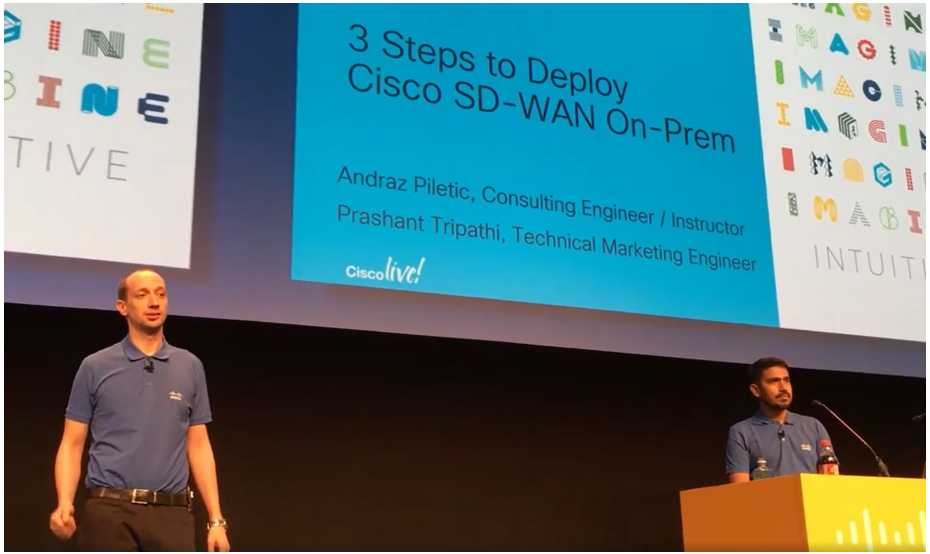
- vSmart controller can run also as container instance in vContainer

Performing Controller Installation

- Detailed step by step procedure covered at CiscoLive San Diego & Barcelona 2019:

BRKRST-2559 - 3 Steps to **Deploy** Cisco SD-WAN On-Prem

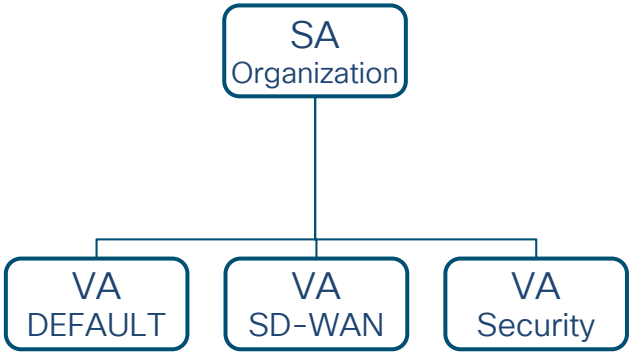
- Recordings and slides are available in the Cisco Live On-Demand Library



Managing Smart Account & Virtual Accounts

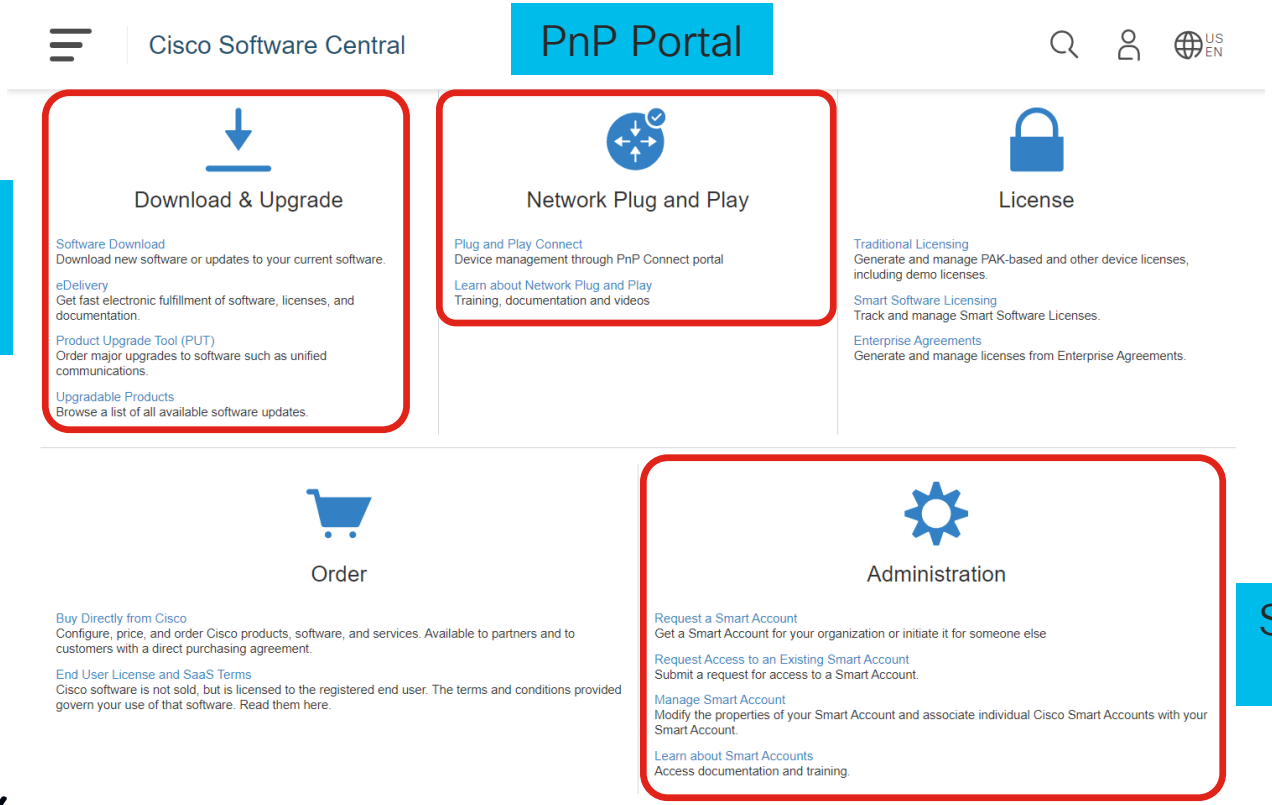
Cisco Smart and Virtual Accounts

- Smart Account (SA) – central repository where you can view, store, and manage licenses across the entire organization.
- Virtual Account (VA) – subaccount to organize and manage licenses based company needs.
  - Created and maintained by the customer
  - Individual SD-WAN overlay is mapped to a single VA
- Recommendation: create dedicated VA for SD-WAN needs
- Find SA Admin to accept PnP Agreement



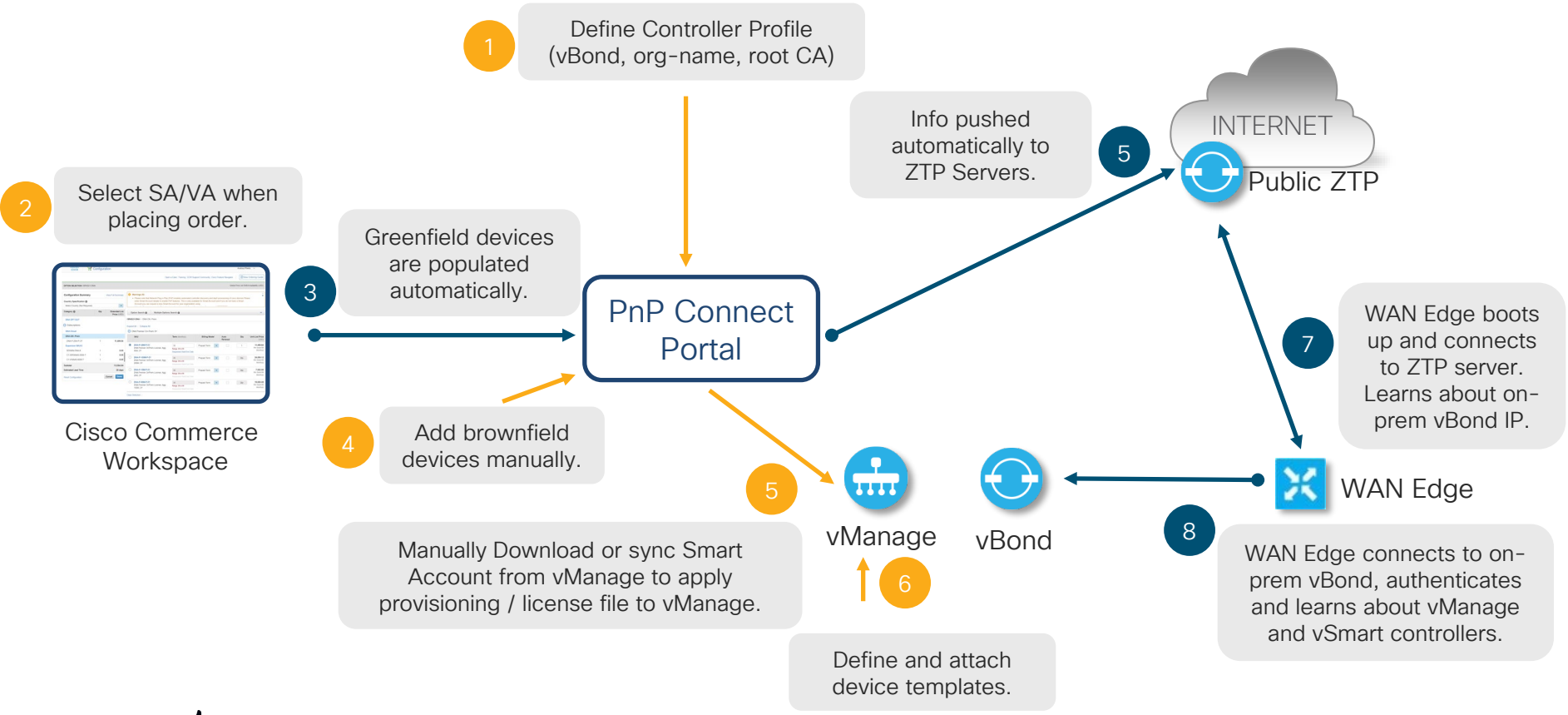
Cisco Software Central – software.cisco.com

Obtain SD-WAN Software

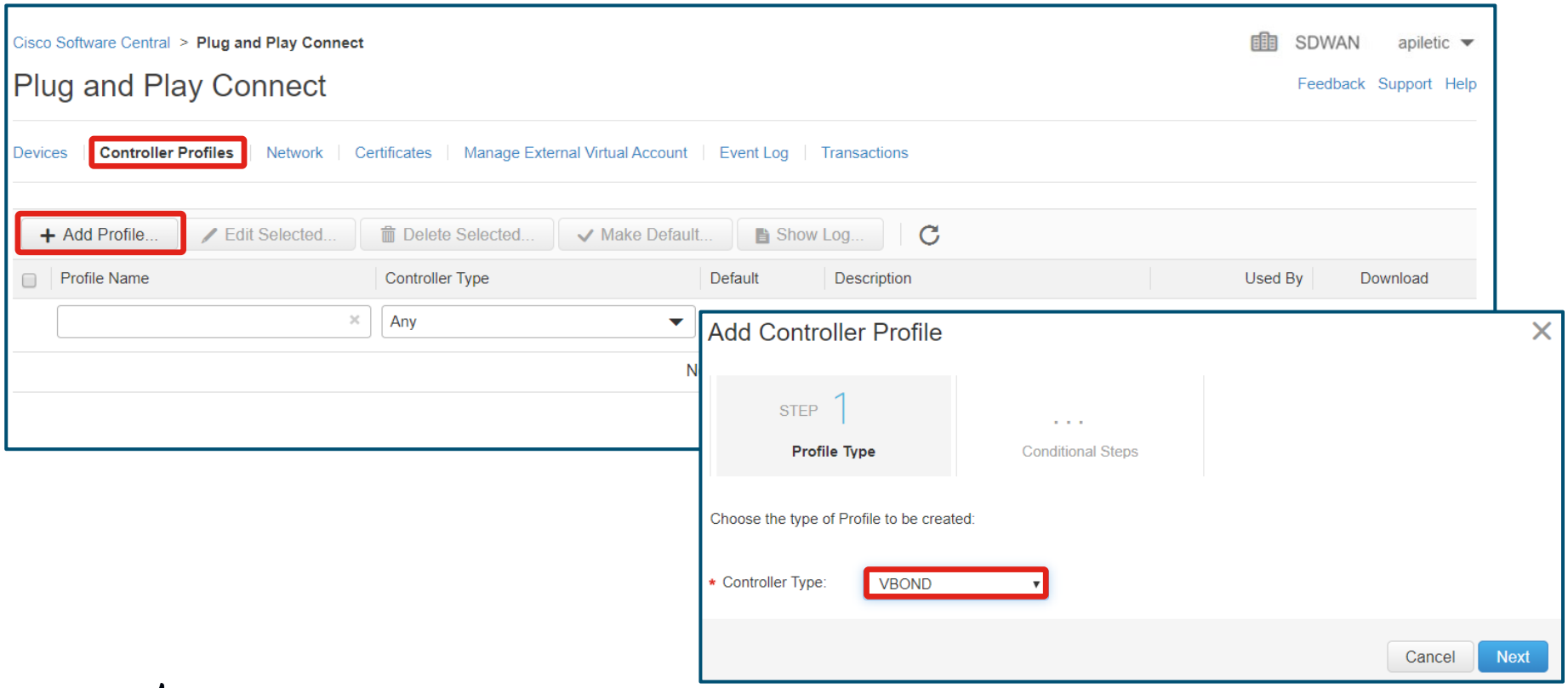


Smart Account Management

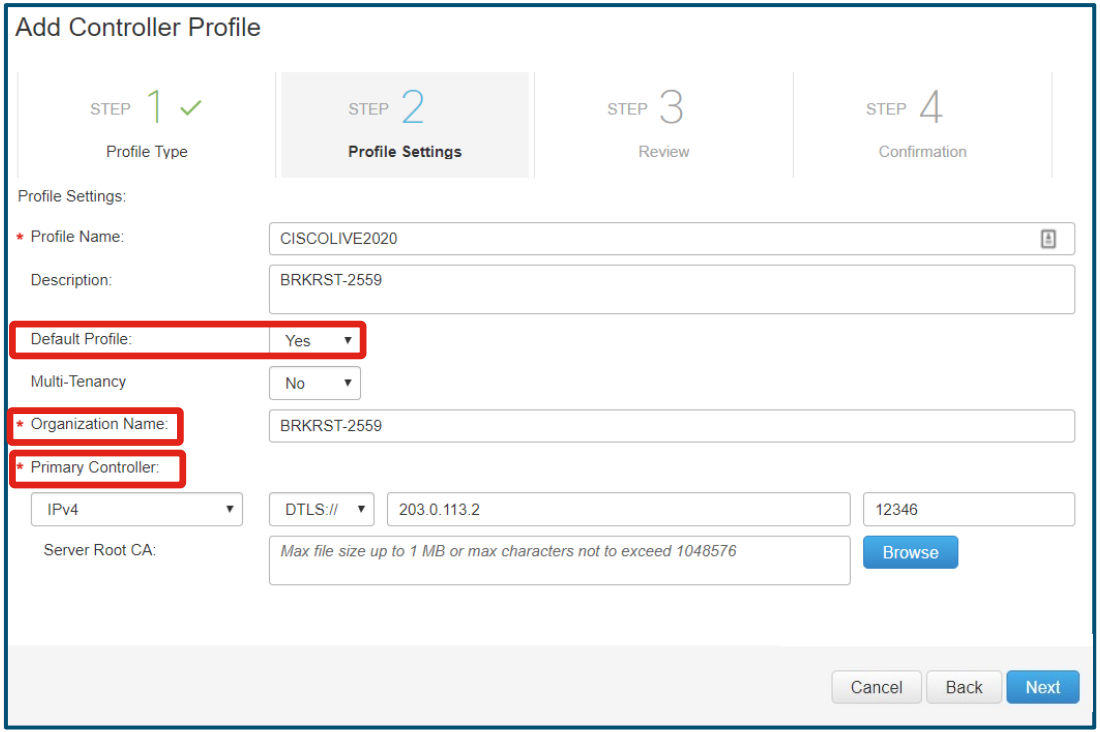
Workflow Overview



Defining Controller Profile



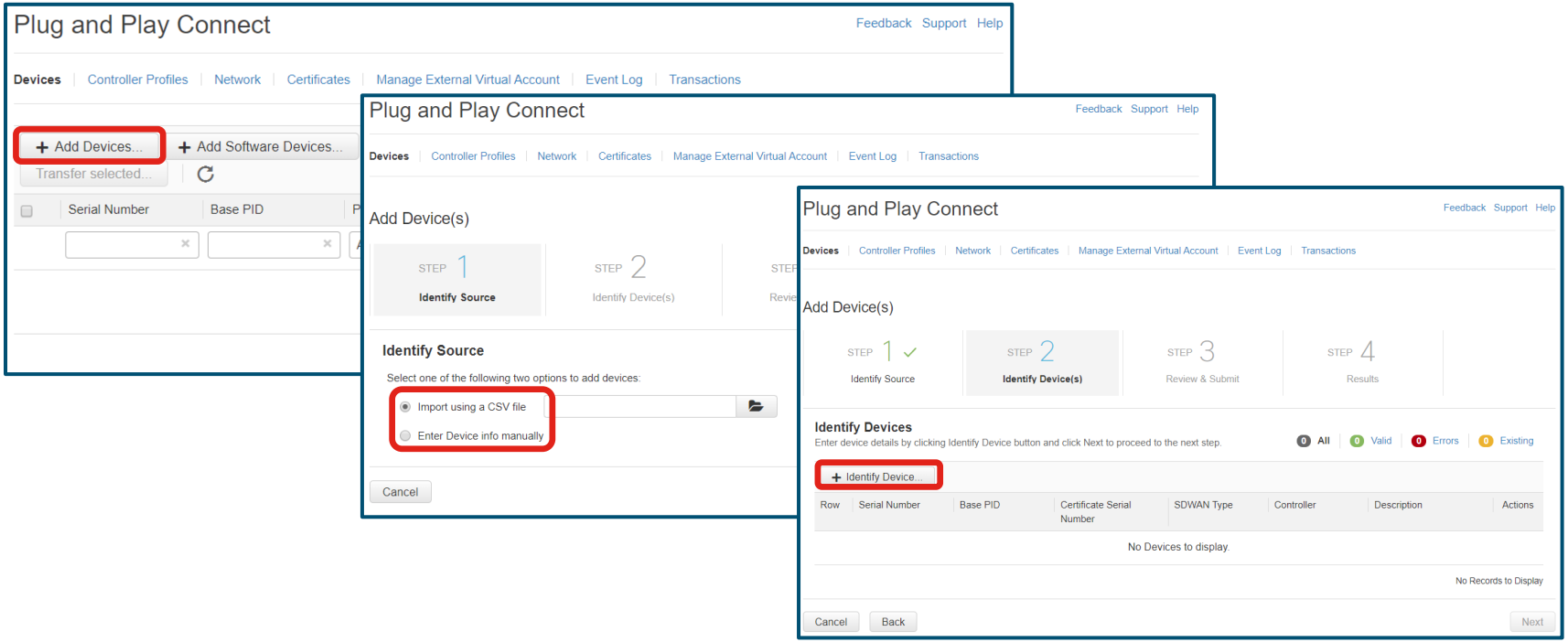
Controller Profile Details



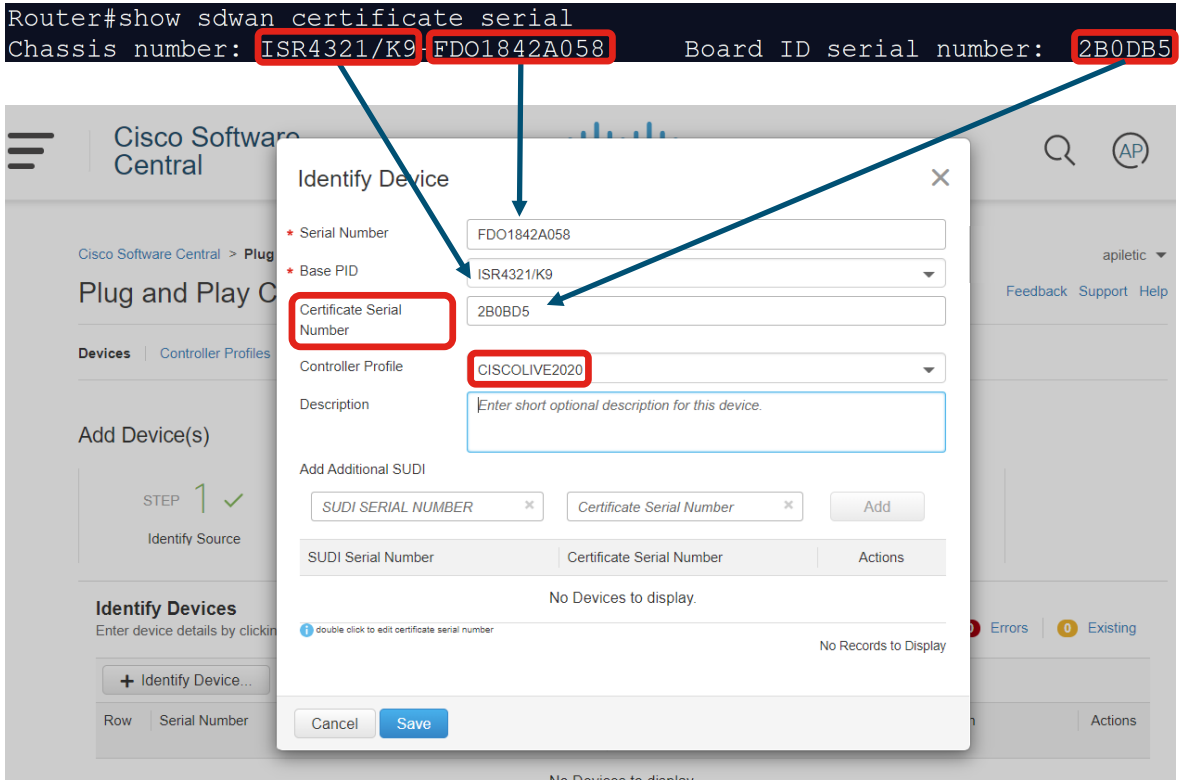
- Defined Organizational Name must match on all SD-WAN components.
- First profile must be marked as default

- Specify Domain or IP of on-prem vBond controller.
- Optionally upload Enterprise Root CA.

Adding Brownfield Devices to PnP Portal

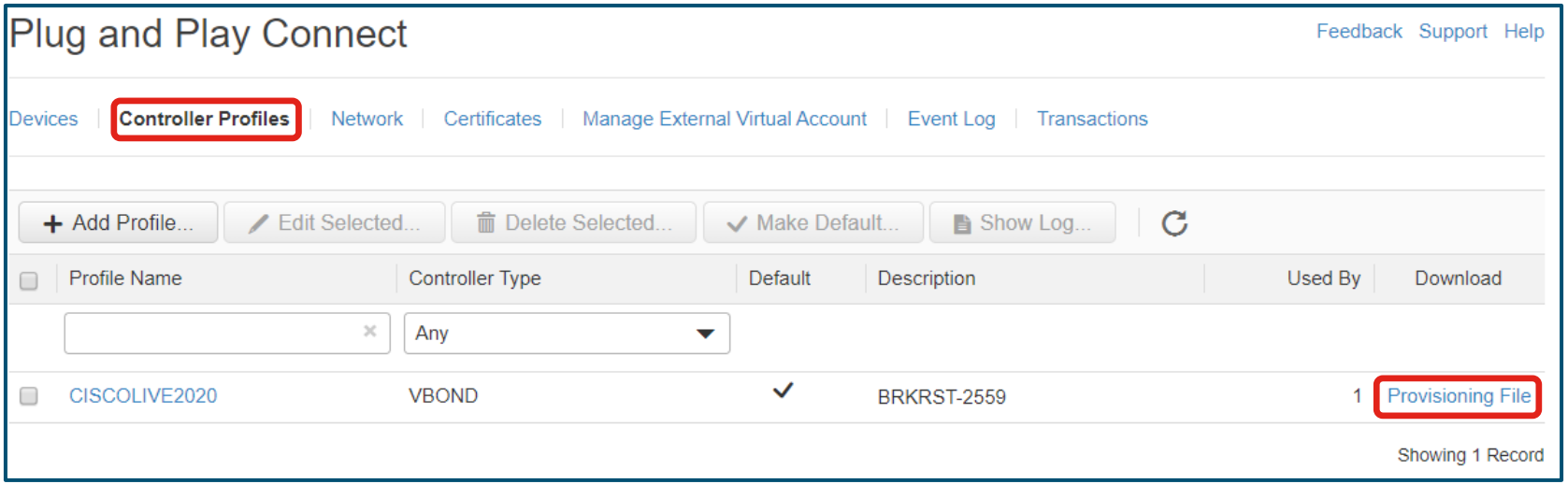


Adding Brownfield Devices to PnP Portal (Cont.)



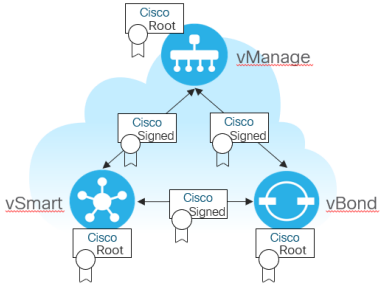
- Certificate Serial Number is required field for SD-WAN deployments
- On IOS-XE platforms running 16.6.1 or more use: **show crypto pki certificates**

Obtaining License / Provisioning File

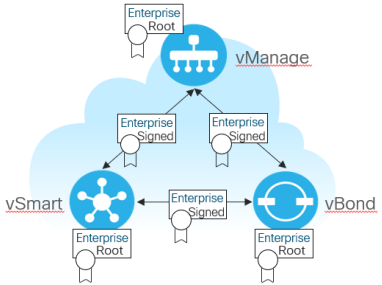


Certificate Authorities

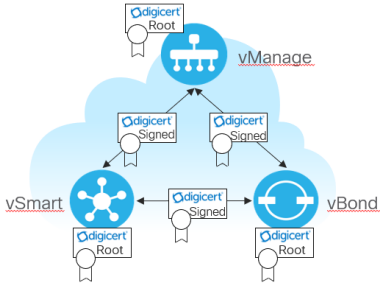
Certificate Authority Options



- Cisco PKI can be used for on-prem controllers deployment.
- CSRs can be automatically signed using configured Smart account and internet connectivity from vManage.
- Manual signing is supported via PnP portal.

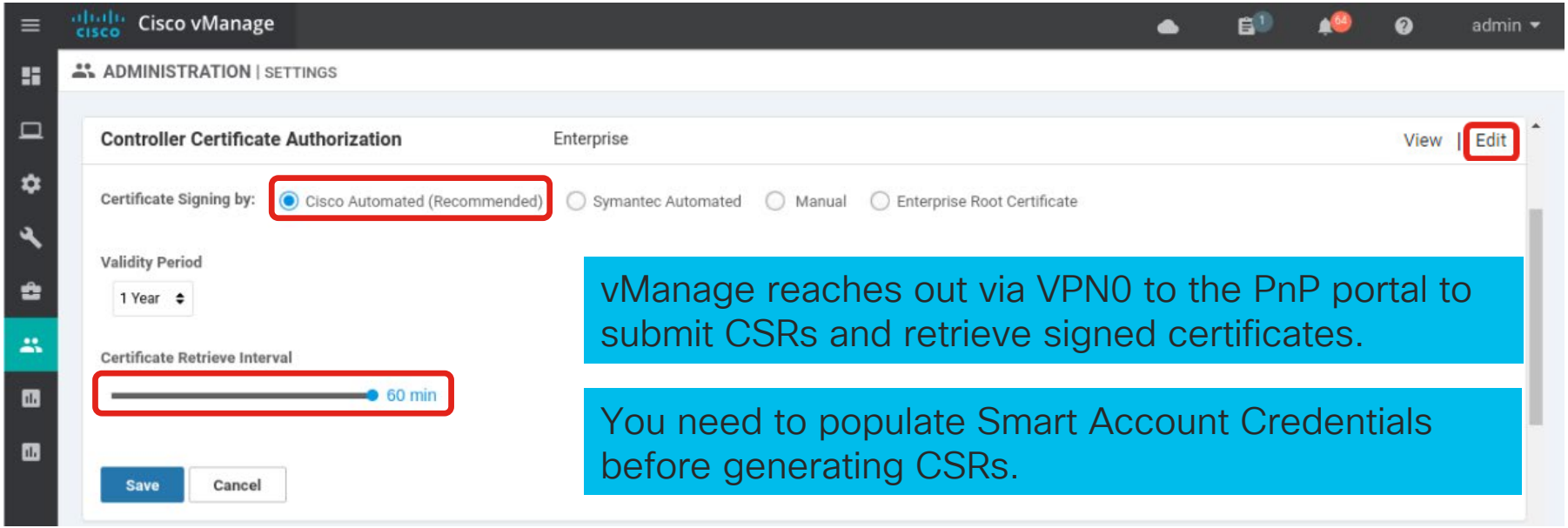


- Enterprise certificates can be used for on-prem controllers deployment.
- Need to install root certificate chain and sign all CSRs manually.



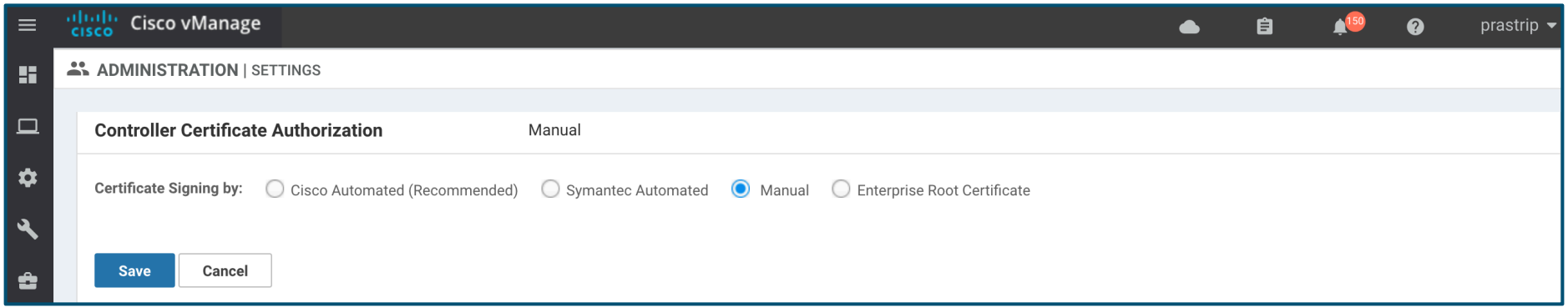
- DigiCert certificates can also be used also in on-prem deployment.
- Need to contact CloudOps for approval.
- Root certificate is preinstalled in the software.

Utilizing Cisco PKI



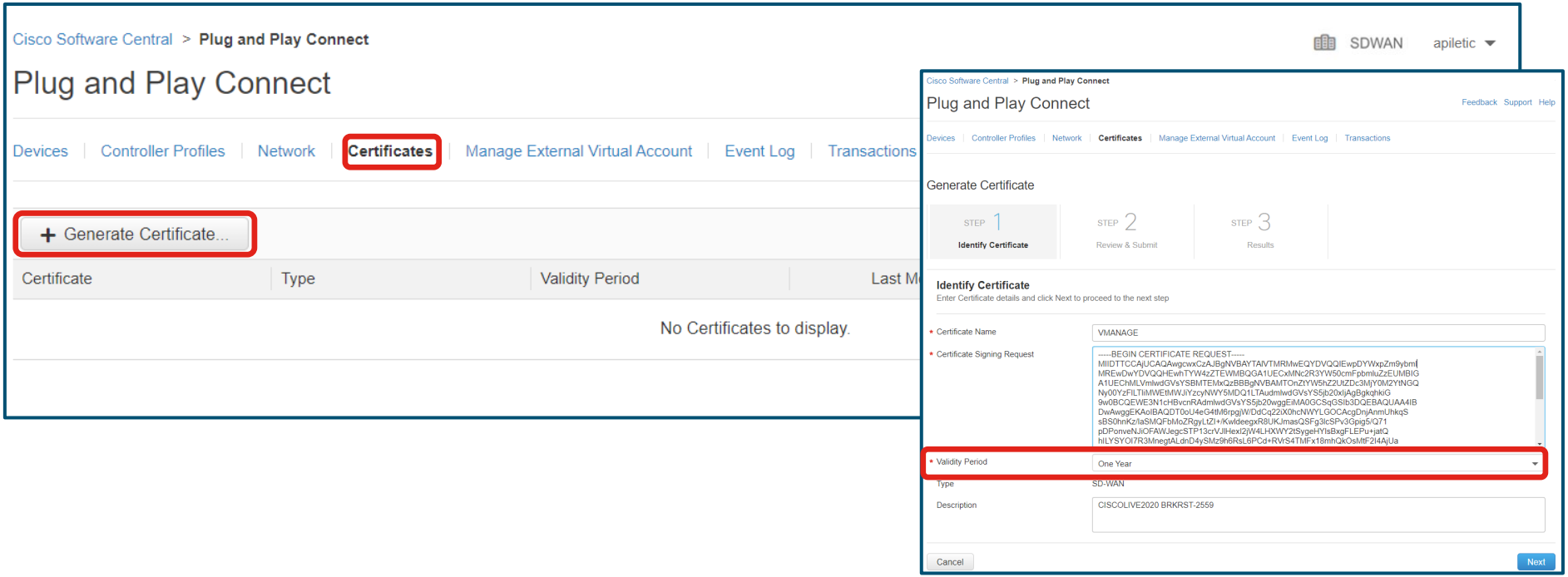
- Cisco PKI is supported since 19.1 software release

Utilizing Cisco PKI – Manual Method

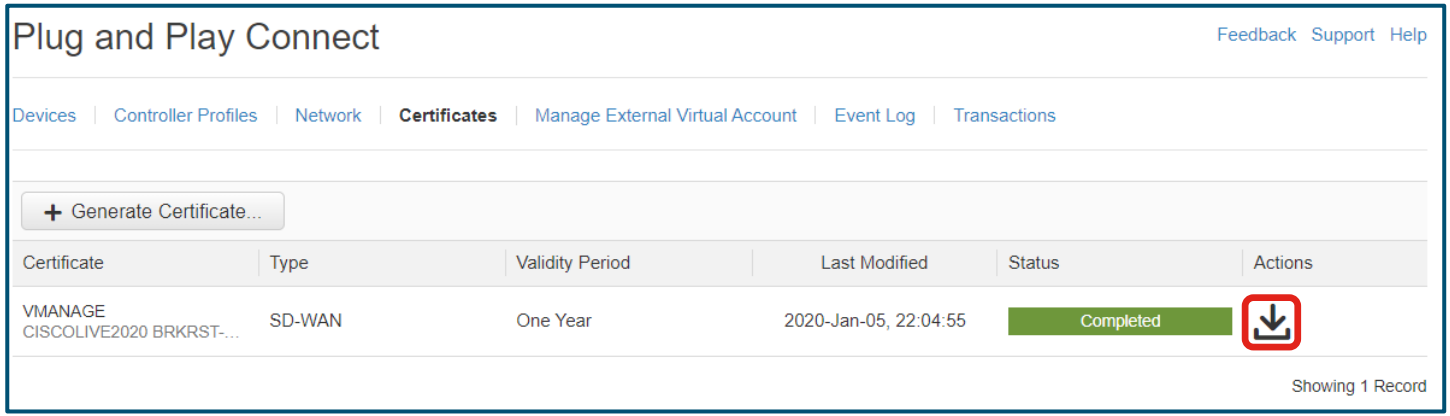


- For environments where vManage cannot connect to the PnP portal
- Manually generate CSRs for all controllers and submit them to the PnP Portal

Manually Submiting CSR to Cisco PKI



Utilizing Cisco PKI – Downloading Signed Cert

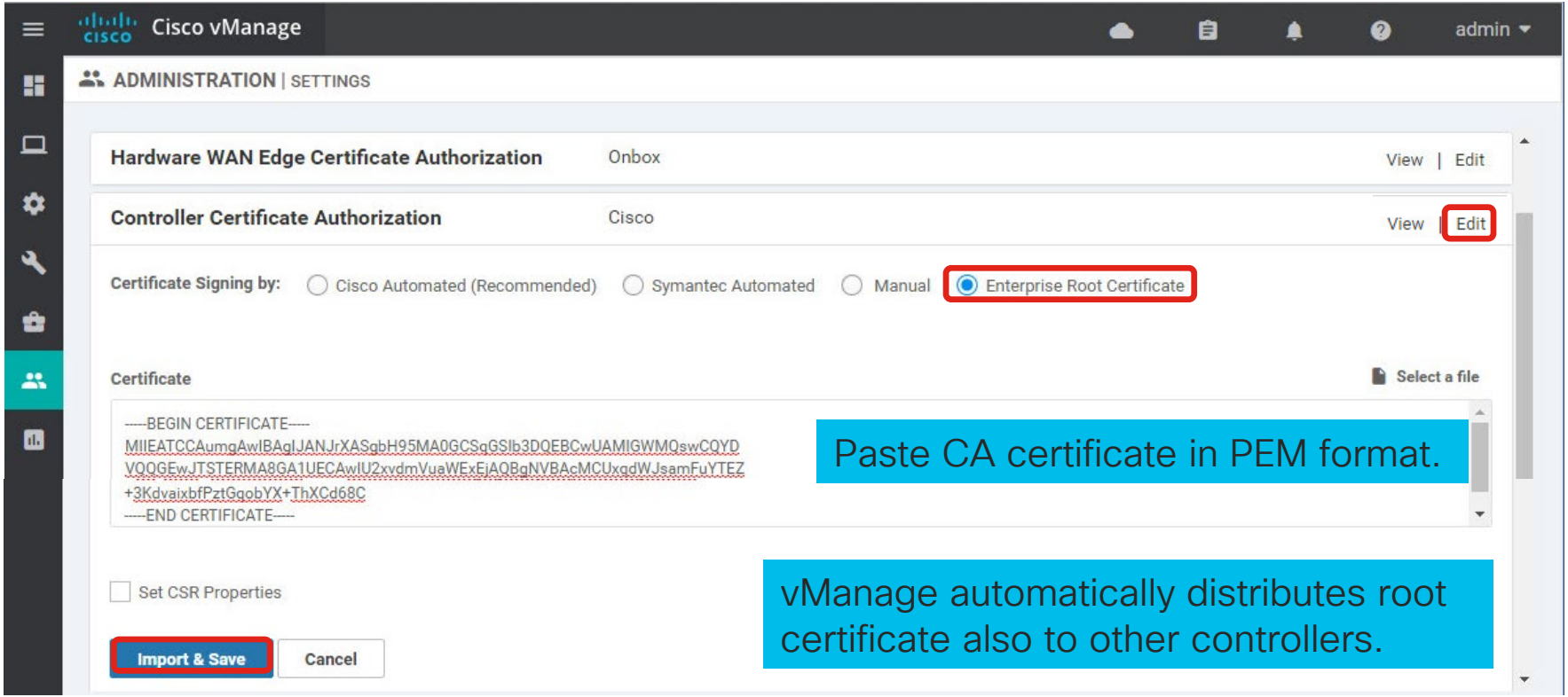


- When approaching expiration date, make sure new CSRs are generate and new certificates obtained and installed.

Using Enterprise CA

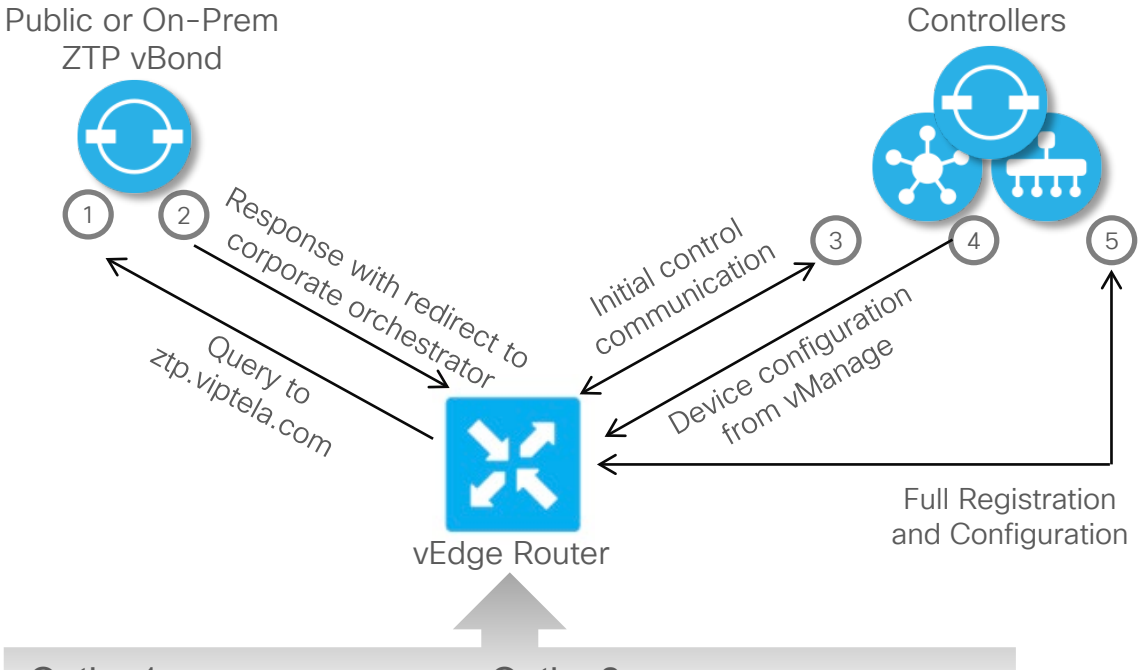
- Customer‘s existing CA infrastructure:
  - Microsoft CA is commonly used within enterprise environments.
- Convenient CA setups for lab testing and PoCs:
  - XCA
  - TinyCA
  - OpenSSL
    - The OpenSSL library is part of most Linux distributions by default.
    - Can be used for simple certificate generation, signing CSRs, etc.
- If using subordinate servers, make sure you export/import the full root-ca chain.

Utilizing Enterprise CA



Zero Touch Provisioning

Zero Touch Provisioning – vEdge HW Appliance



Option1:
- DHCP on WAN interface
- DNS to resolve ztp.viptela.com

Option2:
- Discover local addressing via ARP
- Google DNS: resolve ztp.viptela.com

- Public ZTP vBond can redirect to cloud hosted or On-Prem controllers.
- New devices are linked to organization using the Smart Account when placing order.
- Additional devices can be associated with the customer using the PnP Connect portal
- ZTP for vEdges can be deployed also On-Prem

Configuring On-Prem ZTP vBond Server

Dedicated vBond server can act as a ZTP server. Required steps:

1. Activate the ZTP role.

```
vBondZTP(config)# system vbond ip-address local ztp-server
```

2. Obtain a signed certificate by a trusted CA (Symantec / Digicert).
3. Define and upload the whitelist file.
4. Configure a local DNS server to resolve ztp.viptela.com with ZTP vBond IP.
5. Define device templates.

Obtaining Signed Certificate by Trusted CA

```
vBondZTP# request csr upload /home/admin/ztp.csr
Uploading CSR via VPN 0
Enter organization-unit name                  : ZTPvBond
Re-enter organization-unit name               : ZTPvBond
Generating private/public pair and CSR for this vbond device
Generating CSR for this vbond device    .........[DONE]
Copying ... /home/admin/ztp.csr via VPN 0
CSR upload successful
```

- Generate and submit CSR to Symantec Certificate Enrollment portal

Obtaining Signed Certificate by Trusted CA (Cont.)

```
vBondZTP# request certificate install /home/admin/ztp.pem
Installing certificate via VPN 0
Copying ... /home/admin/ztp.pem via VPN 0
Successfully installed the certificate
```

```
vBondZTP# show certificate installed
    Data:
        Version: 3 (0x2) Serial Number: 6f:3a:61:cd:a8:de:3e:b1:b9
    Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=US, O=Symantec Corporation, OU=Symantec Trust Network,
        CN=Symantec Class 3 Secure Server CA - G4
        Validity
            Not Before: Nov 29 00:00:00 2019 GMT
            Not After : Nov 30 23:59:59 2020 GMT
        Subject: C=US, ST=California, L=San Jose, O=vIPtela Inc,
        OU=ZTPvBond, CN=vbond-088b7cc2-a905-2f4ee1729bf9-0.viptela.com
```

Uploading The ZTP Whitelist Chassis File

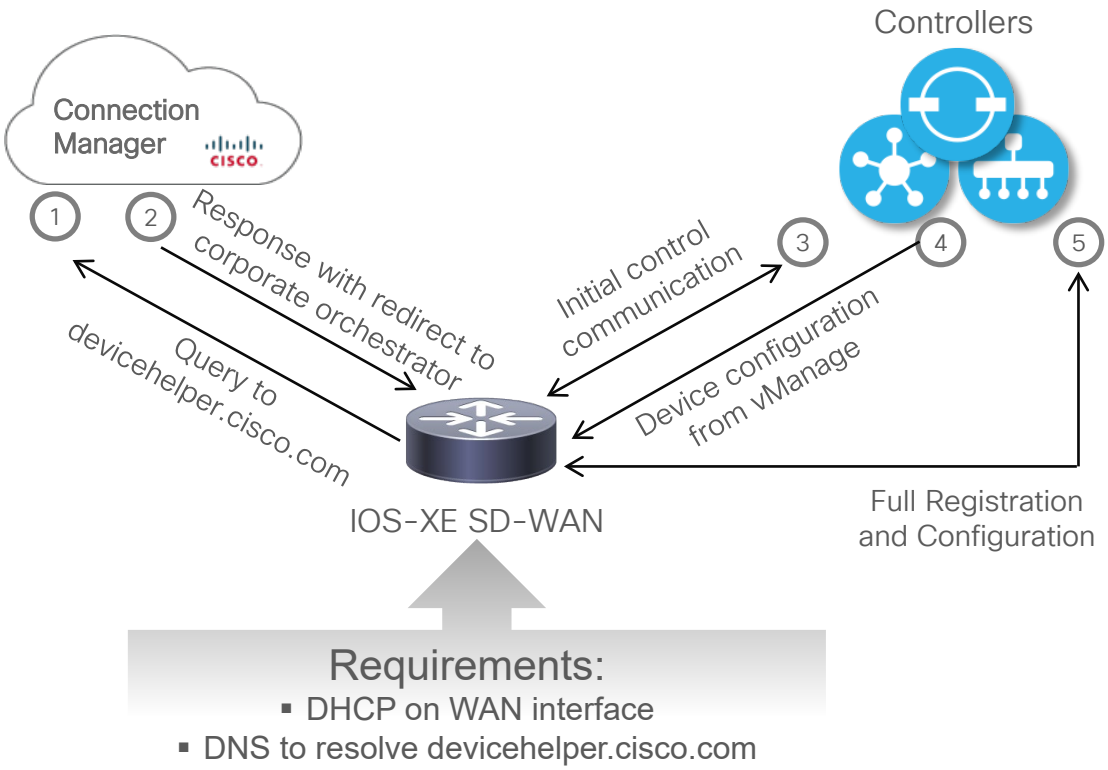
```
vBondZTP# vshell
vBondZTP~$ cat ztp-chassis-file
12345,6789,valid,10.0.0.22,12346,CLEUR 2020 BRKRST - 2559,/home/admin/ca.crt

vBondZTP# request device-upload chassis-file /home/admin/ztp-chassis-file
Uploading chassis numbers via VPN 0
Copying ... /home/admin/ztp-chassis-file via VPN 0
Successfully loaded the chassis numbers file to the database.
Uploading the serial numbers to the vedge-list ...
Uploading serial numbers via VPN 0
Copying ... /home/admin/ztp-chassis-file via VPN 0
Successfully loaded the vEdge serial numbers
```

Define and verify chassis file

Apply chassis file

```
vBondZTP# show ztp entries
       CHASSIS  SERIAL                                VBOND  ORGANIZATION                ROOT CERT
INDEX  NUMBER   NUMBER  VALIDITY  VBOND IP   PORT    NAME                        PATH
-------------------------------------------------------------------------------------------------
1      12345    6789    valid     10.0.0.22  12346   CLEUR 2020 BRKRST - 2559    /home/admin/ca.crt
```

Zero Touch Provisioning – WAN Edge Appliance



- The PnP Connection Manager can redirect to cloud-hosted or On-Prem controllers.
- New devices are linked to organization using the Smart Account when placing order.
- Additional devices can be associated with the customer using the PnP Connect portal
- No on-prem ZTP server support for IOS-XE SDWAN devices at the moment.

ZTP – Bootstraping With Configuration File

```
<… output omitted …>
#cloud-boothook
  system
   personality           vedge
   device-model          vedge-ISR-4321
   host-name             WanEdge
   system-ip             10.255.255.121
   site-id               21
   organization-name     "CLEUR 2020 BRKRST - 2559"
   console-baud-rate     9600
   vbond 203.0.113.3 port 12346
   !
   !
interface GigabitEthernet0/0/0
   no shutdown
   ip address 198.0.51.10 255.255.255.0
  exit
  !
ip route 0.0.0.0 0.0.0.0 198.0.51.1
<… output omitted …>
```

- Upon bootup, the router searches bootflash: or usbflash: for filename ciscosdwan.cfg.
- The config file with interface configuration, Root CA, Organization Name, vBond information, is fed into the PnP process.
- Supported only on SD-WAN IOS-XE (since 16.10).

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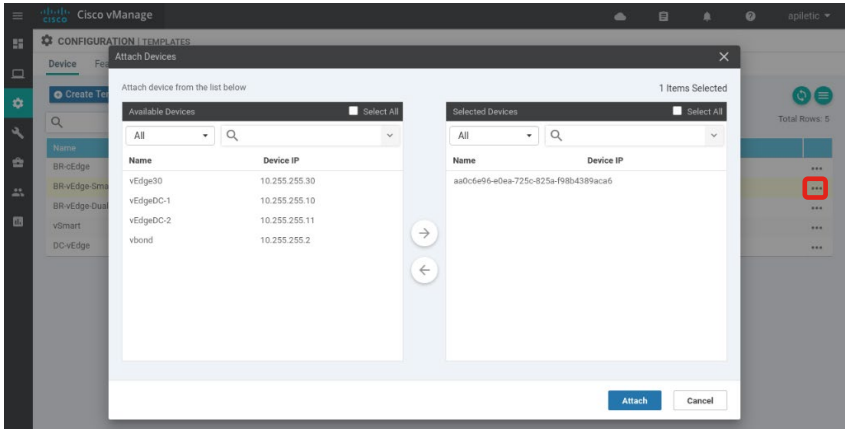
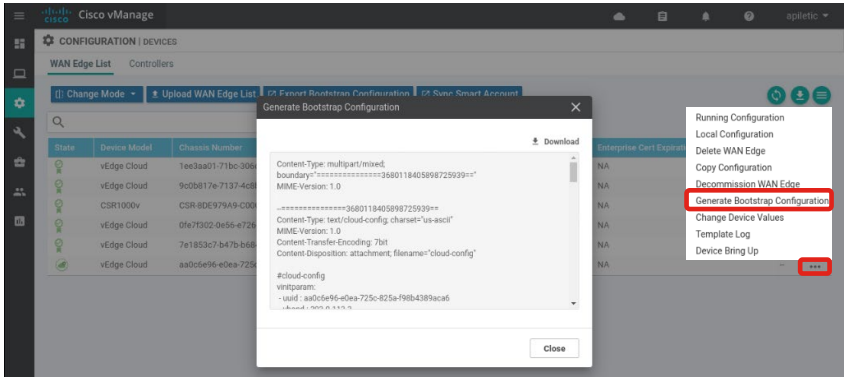
Generating Bootstrap Configuration File

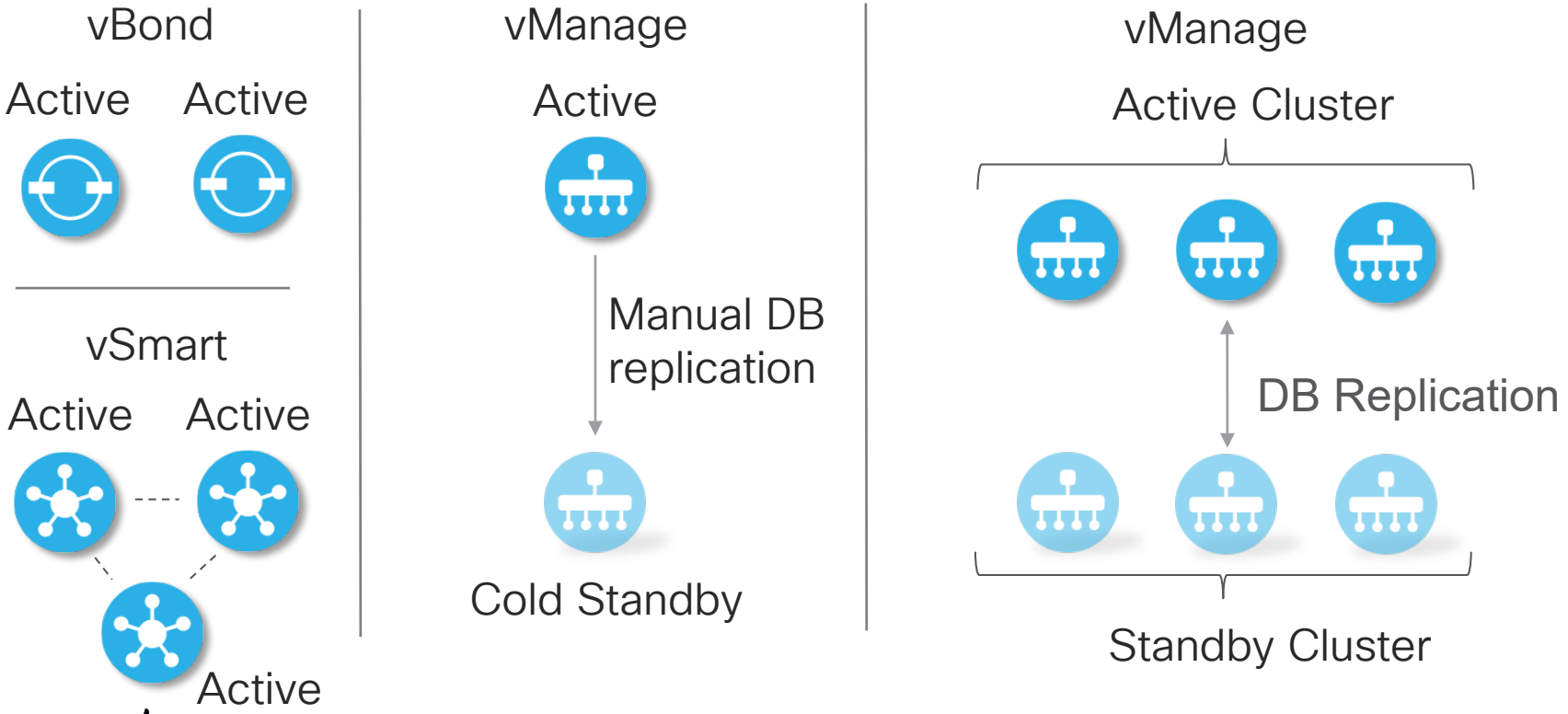
- Attach template to device placeholder
- Specify device specific variable values
- Generate bootstrap config
- Store it on bootflash: or usbflash: as ciscosdwan.cfg





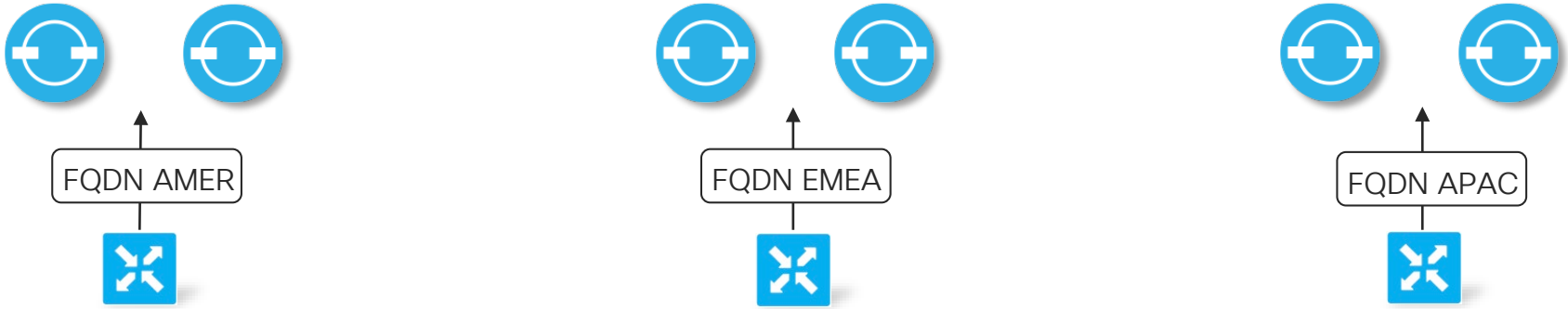
Designing for High Availability and Scale

Controllers High Availability Overview



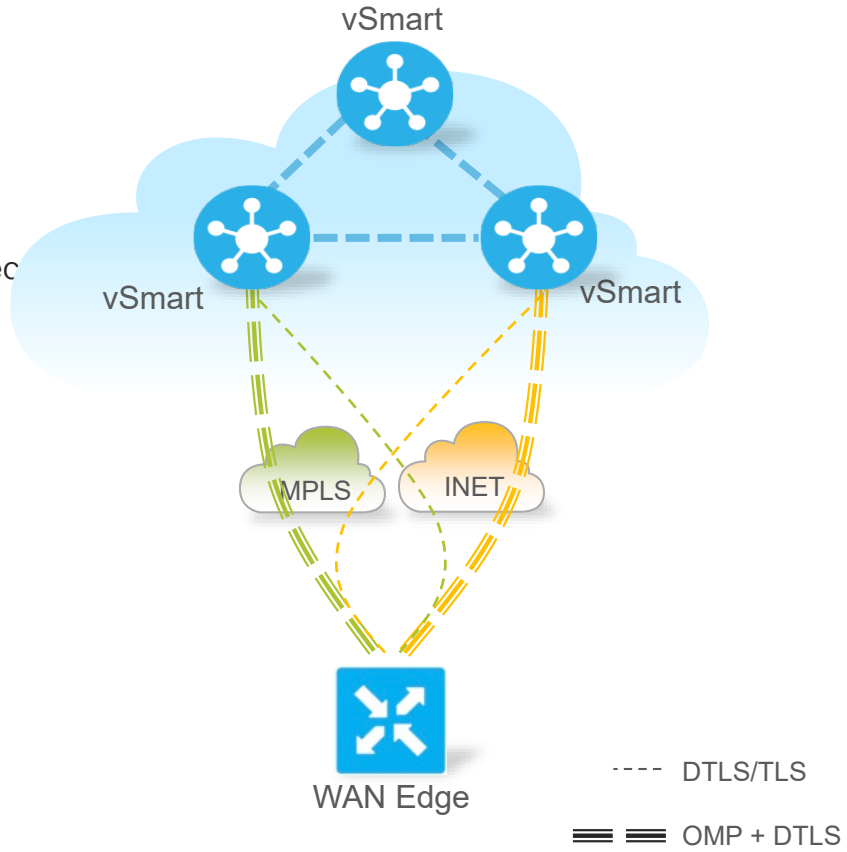
vBond High Availability and Scale

- Default behavior: WAN Edge tries to resolve and connect to all known vBond IPs on all WAN interfaces. Connection is transient.
- Scale approach:
  - Configure regional domain name to point to specific regional vBond pair
  - Rely on DNS A records or define manual host entry

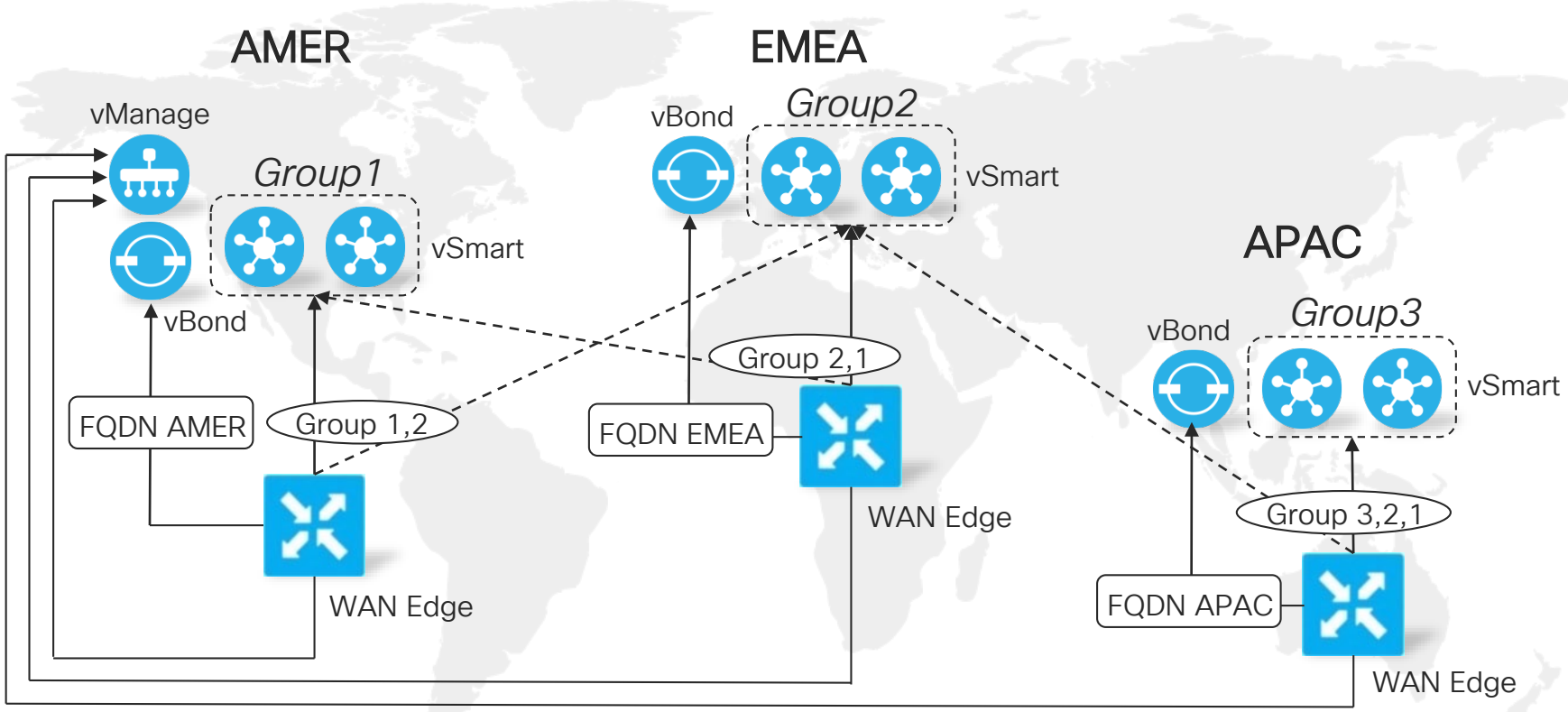


vSmart High Availability and Scale

- Default behavior:
  - WAN Edge connects up to two vSmarts on each transport
  - Example: WAN Edge with two transports == 2 control connec
  - No control over vSmart preference
- Scaling approach:
  - Leverage controller groups and affinity values

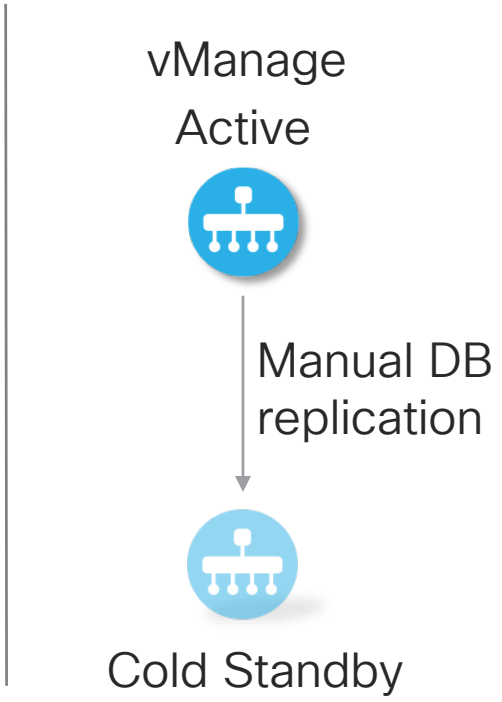


Controller Groups



Standalone vManage – Disaster Recovery

- Prerequisites:
  - Same SW version
  - Signed certificate on standby vManage
  - Synchronized clock
  - Reachable vBond
  - Disabled tunnel-interface on standby vManage



Managing Backup of Active vManage Controller

- Manually creating vManage backup

```
vmanage# request nms configuration-db backup path /home/admin/db_backup
Starting backup of configuration-db
Creating staging directory for backup.
config-db backup logs are available in /var/log/nms/neo4j-backup.log file
Successfully saved database to /home/admin/db_backup.tar.gz
```

- Transporting backup to external location

```
vmanage# vshell
vmanage:~$ scp db_backup.tar.gz admin@192.168.0.100:/home/admin
admin@192.168.0.100's password:
db_backup.tar.gz                              100%  703KB 351.3KB/s   00:02
```

- Caveat: configuration-db does not include local users and repository
- Tip: utilize a script to automate regular backups and exports

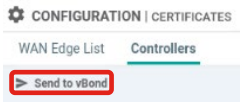
Activating Standby vManage Controller

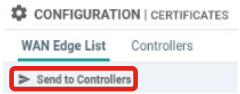
- Import backup to standby vManage

```
Standby-vManage# request nms configuration-db restore /home/admin/db_backup.tar.gz
Configuration database is running in a standalone mode
Importing database...Successfully restored database
```

- Check all services are running using `#request nms all status`
- Under *Configuration>Certificates>Controllers* edit existing vBond entries by retyping mgmt IPs and credentials.
- Bring up vManage tunnel-interface
- Send the updated device list to vBond controllers
- Under *Configuration>Certificates>WAN Edge List*

  select *Send to Controllers*
- Invalidate failed vManage controller





Taking VM Level Snapshots

- Taking VM level snapshots for vManage controller is heavily recommended
  - Quick recovery
  - Rollback on controller upgrades
- Similar method is used by Cisco for Cloud hosted environment
  - Daily snapshots kept for 10 day
- Snapshots do not preclude the need for configuration database backups

Designing vManage Cluster with High Availability

vManage Cluster

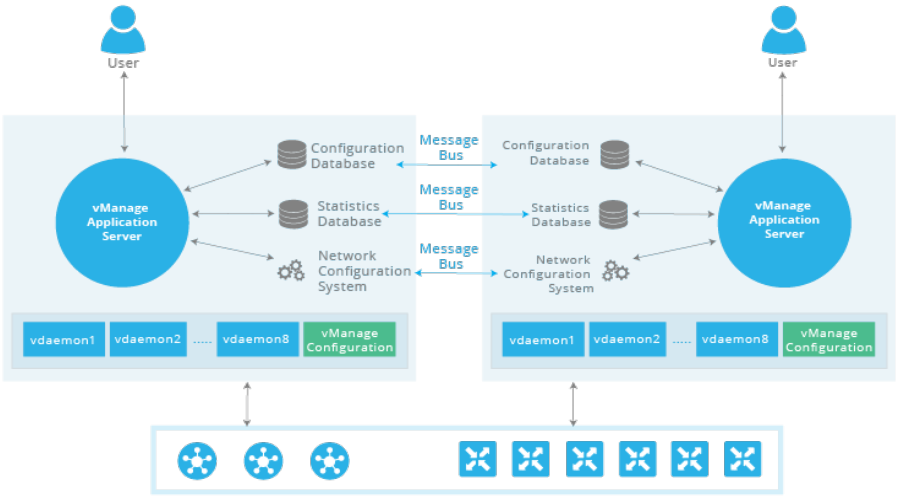
- Why cluster:
  - Managing large number of devices
  - Distributing NMS service load
  - Providing HA and redundancy for FT

vManage Cluster

- Main vManage services:
  - Application Server (GUI)
  - Statistics DB (statistics, logs, alarms, events)
  - Configuration DB (policies, templates, certificates)
  - Messaging Server (used by cluster)

Understanding the vManage Cluster

- Dedicated interface in VPN0 is used for synchronization (10G recommended)
- Required latency below 5ms (same DC)
- Databases run on odd number of members – quorum required
- Control connections are by default load-balanced between all members
- By default all services run on all members in a cluster



vManage Cluster Design – Basic Deployment

- 3 nodes, all services run on all nodes
- In case of single node failure:
  - Remaining nodes can support up to 4000 devices.
  - Configuration and statistics DBs are replicated, no data is lost

	vManage 1	vManage 2	vManage 3
Application Server	✓	✓	✓
Statistics Database	✓	✓	✓
Configuration Database	✓	✓	✓
Messaging Server	✓	✓	✓
Control Connections	✓	✓	✓

vManage Cluster Design – Increasing Stats DB Performance and Scale

- When improved performance and scale of Statistics DB is required
- Configuration DB redundancy is not provided
- Failure of first node will prevent management until recovery
- In case of other node failure, cluster can support up to 6000 devices

	vManage 1	vManage 2	vManage 3	vManage 4
Application Server	✓	✓	✓	✓
Statistics Database		✓	✓	✓
Configuration Database	✓			
Messaging Server	✓			
Control Connections	✓	✓	✓	✓

vManage Cluster Design – Large Deployment

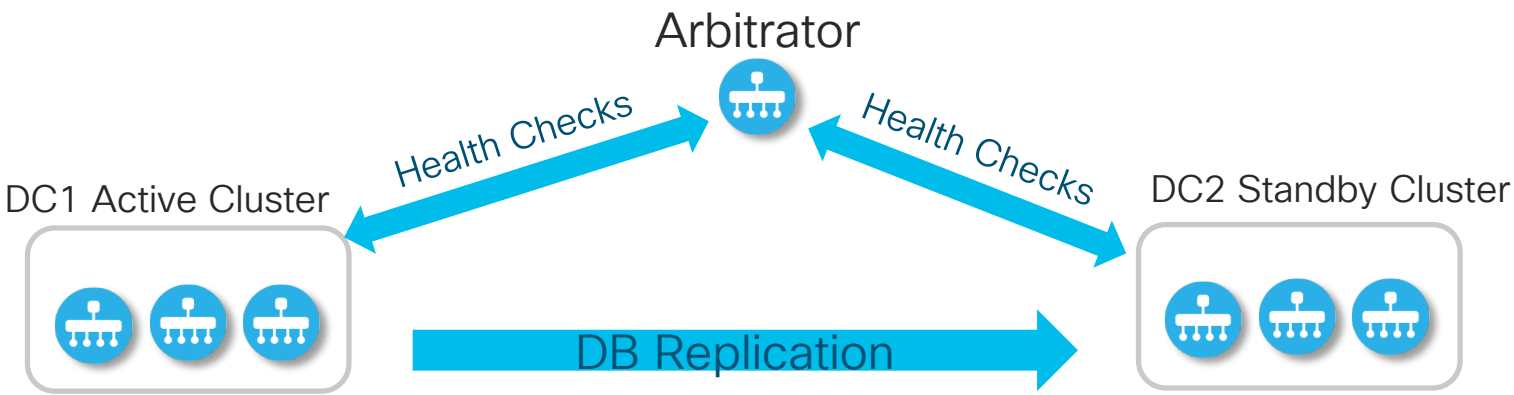
- Improved performance with redundancy
- Nodes 1-3 host everything except Statistics DB. In single node failure scenario can support up to 4000 devices.
- Nodes 4-6 host Statistics DB and no control connections for max performance.

	vManage 1	vManage 2	vManage 3	vManage 4	vManage 5	vManage 6
Application Server	✓	✓	✓	✓	✓	✓
Statistics DB				✓	✓	✓
Configuration DB	✓	✓	✓			
Messaging Server	✓	✓	✓			
Control Conn	✓	✓	✓			

vManage Cluster Disaster Recovery

vManage Cluster Disaster Recovery

- Problem: Cluster nodes must be part of same DC due to low latency requirements. Single cluster does not fulfill DR requirements. Need for automatic failover.
- Solution: Primary cluster, standby cluster, and arbitrator instance, which performs automatic failover in case of failure



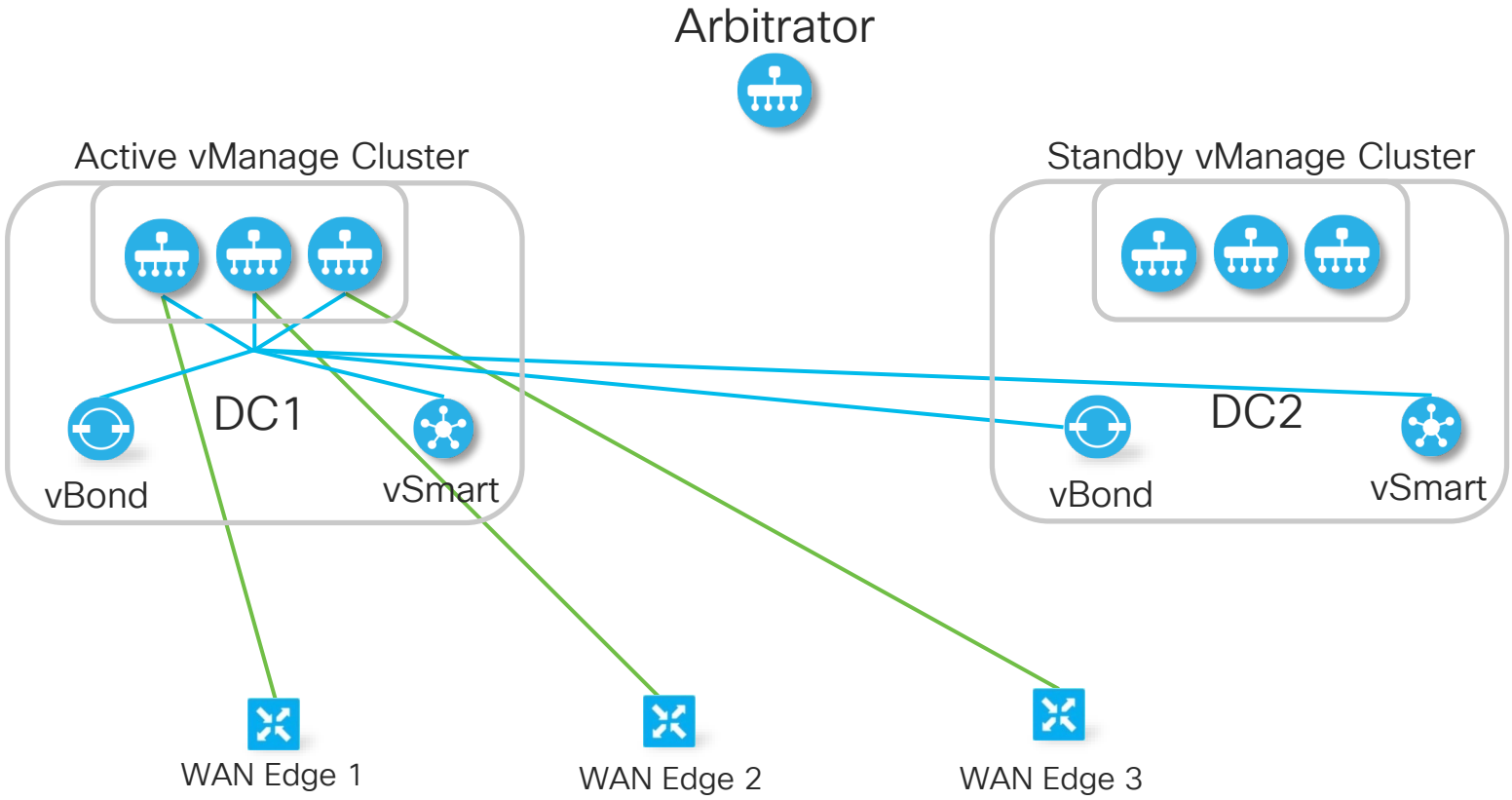
Understanding DR Arbitrator

- Installed as dedicated vManage instance (low resource profile).
- Tracks health state of the cluster.
- Prevents split-brain scenarios.

- Triggers activation of standby cluster in case of disaster (all nodes down).
  - No configuration changes is needed on WAN edge devices.

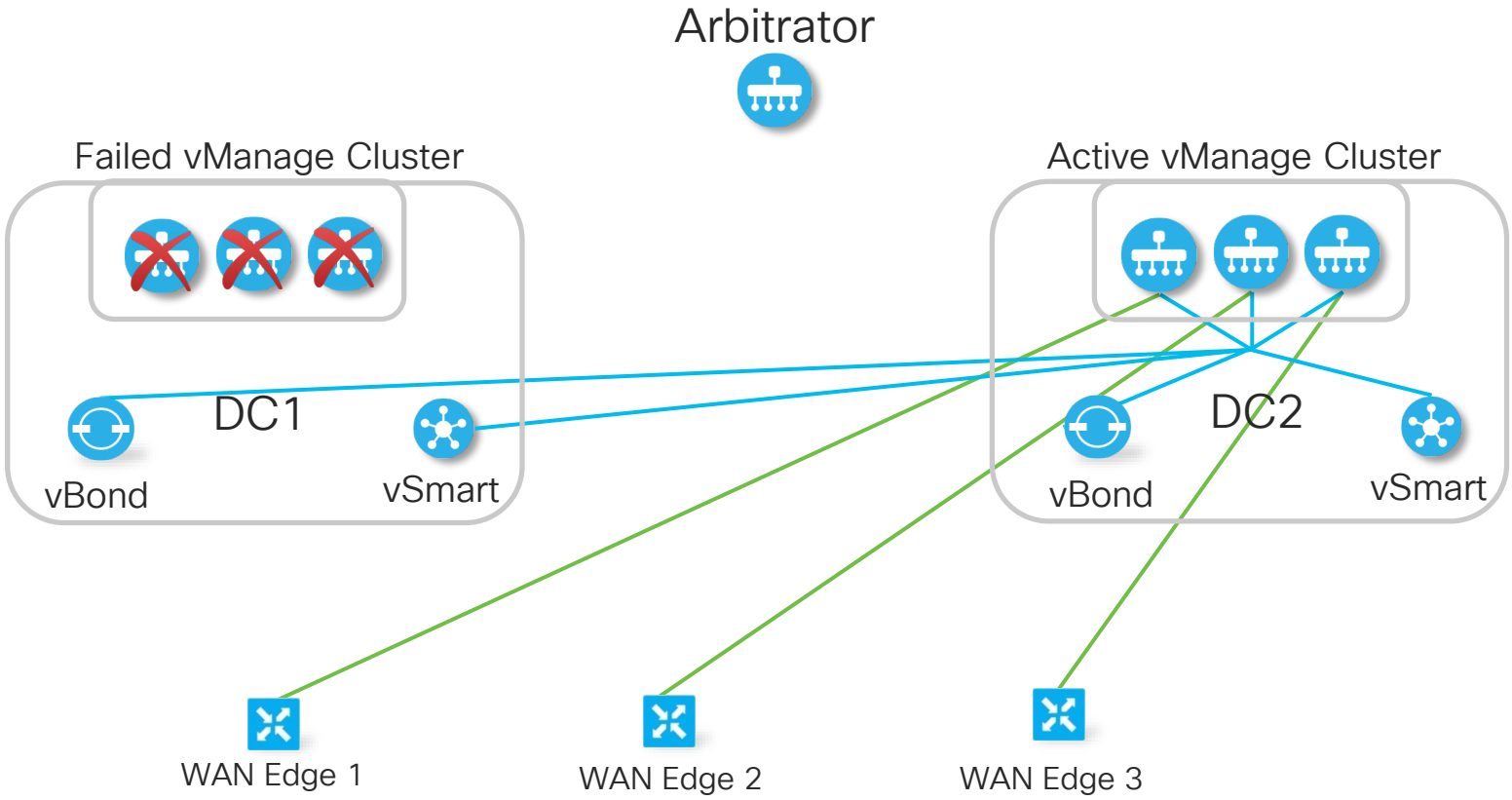
- Arbitrator and cluster members need IP connectivity over enterprise network.

Primary vManage Cluster Active



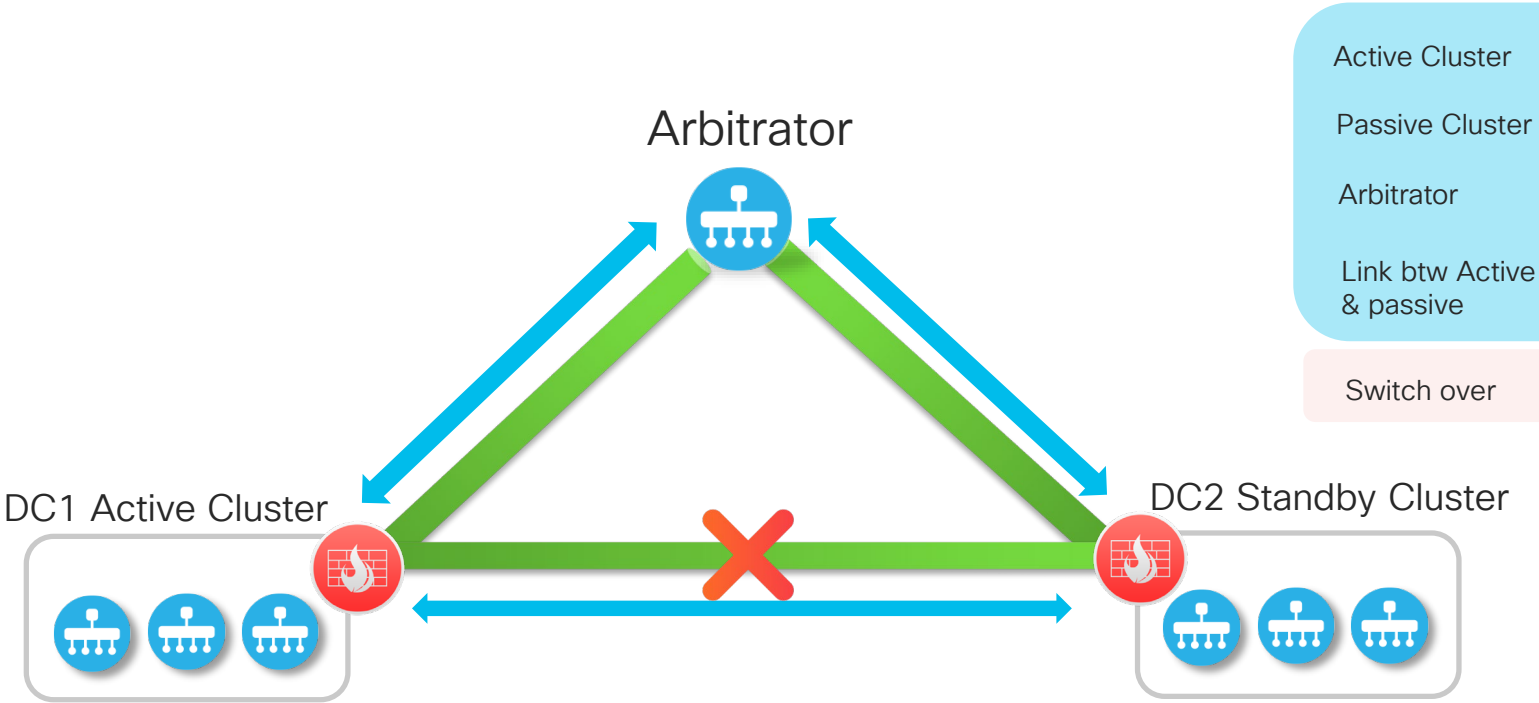
* Control connections between WAN Edges and vBonds/vSmarts not shown

Secondary vManage Cluster Active After Failover

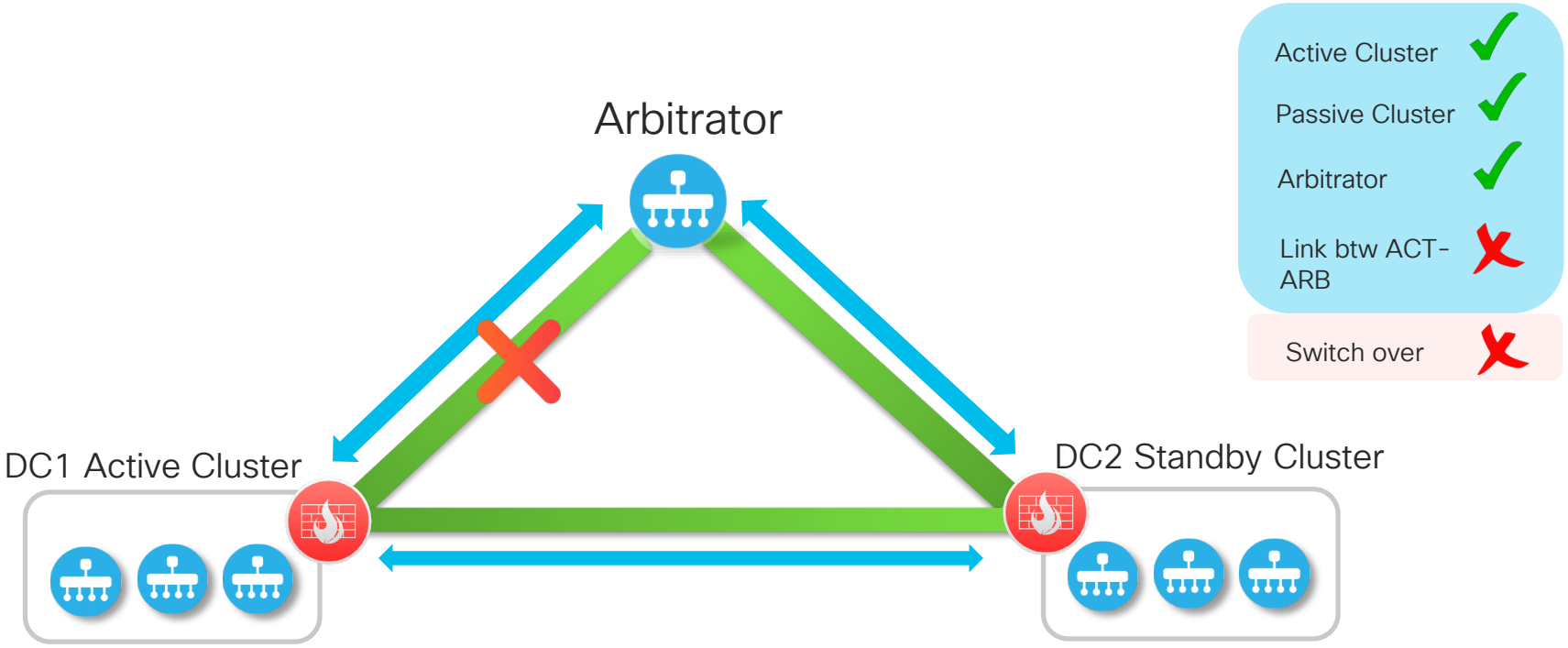


* Control connections between WAN Edges and vBonds/vSmarts not shown

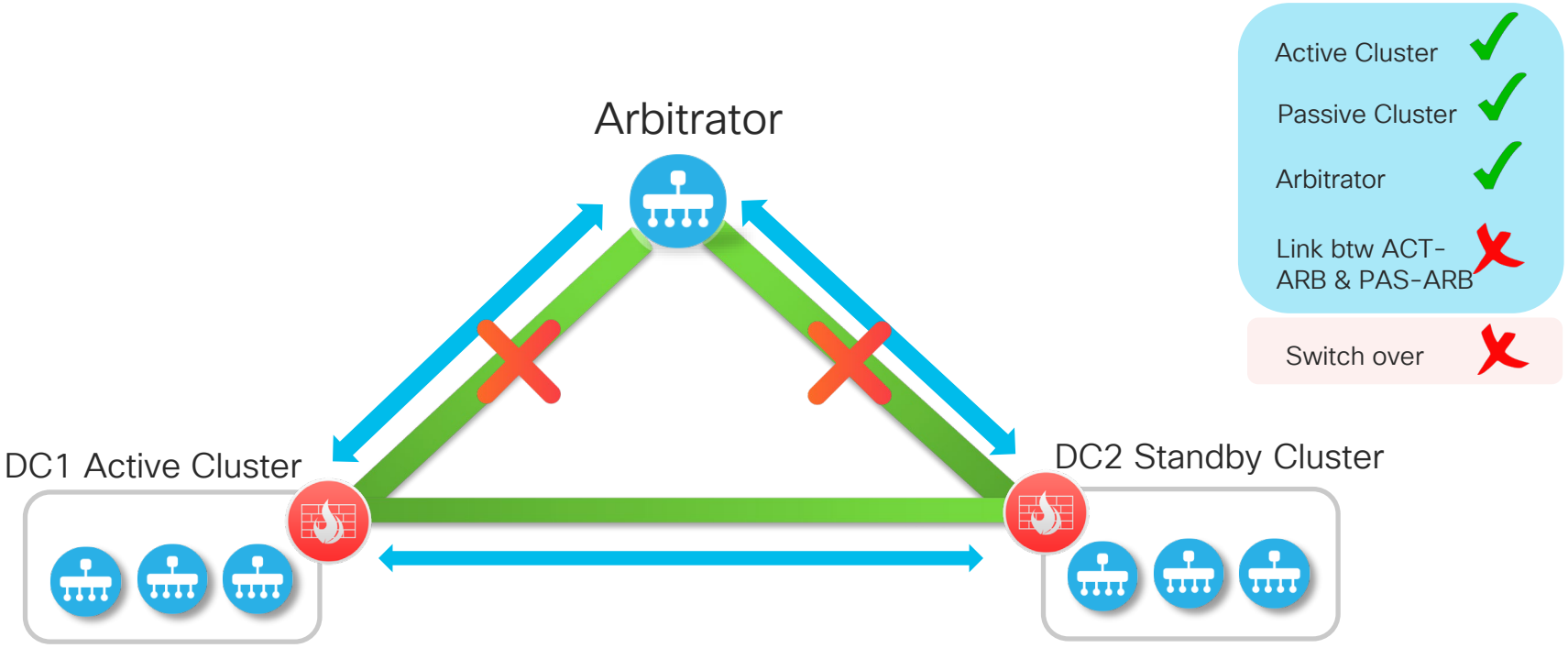
Scenario A) Failed DCI Link Between Clusters



Scenario 2) Failed Connectivity With Arbitrator



Scenario 3) Failed Connectivity With Arbitrator or Failed Arbitrator



Next Steps

- Documentation:

Cisco Documentation

https://sdwan-docs.cisco.com

- Cisco Live On-Demand Library

BRKRST-2559

- Webex Teams room

- SD-WAN Guides (CVDs)

Design Guide, Deployment Guide

vManage Cluster White paper

- SD-WAN TechNotes

Disaster Recovery

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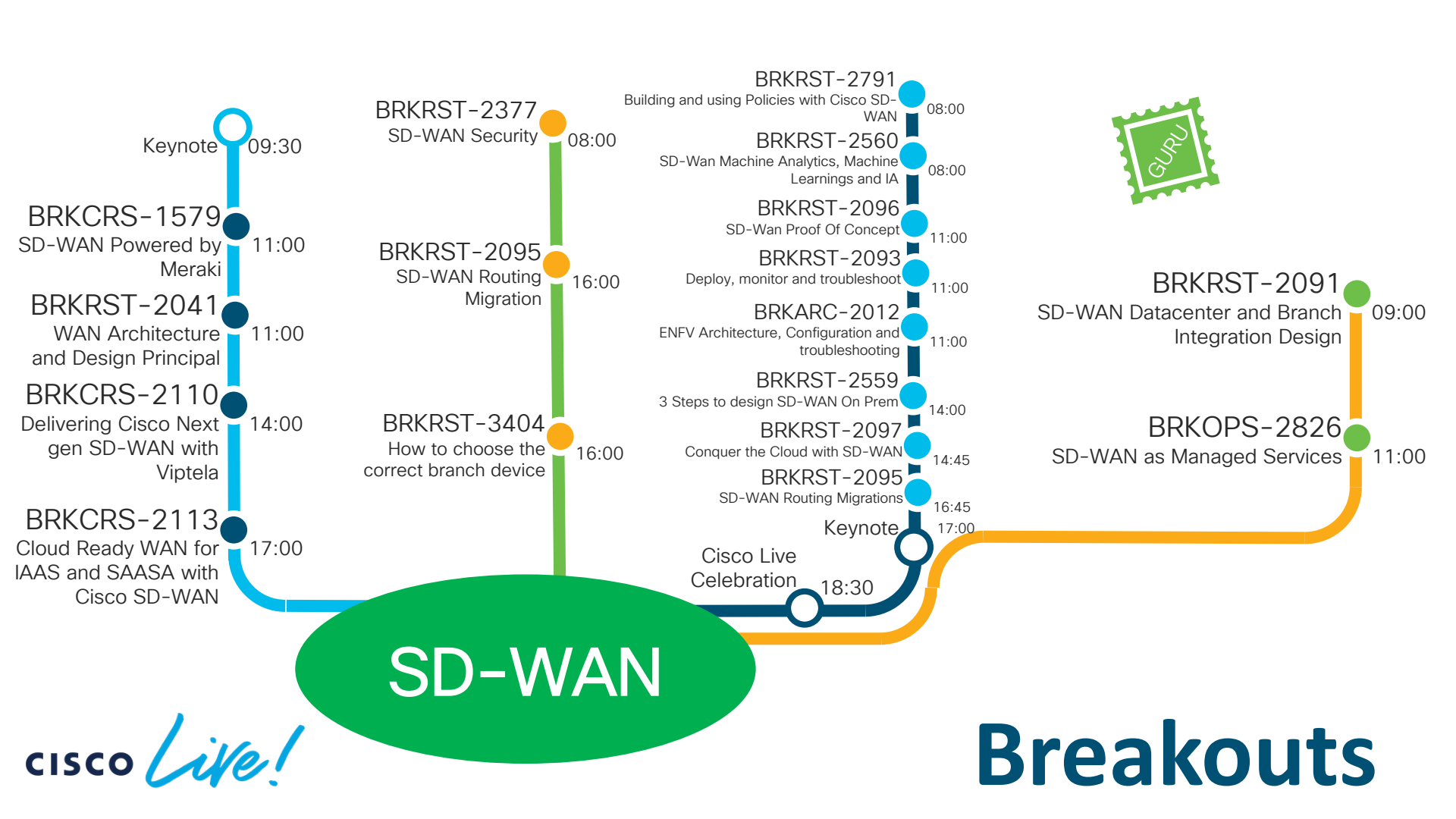
Keynote 09:30
BRKCRS-1579
SD-WAN Powered by Meraki
11:00
BRKRST-2041
WAN Architecture and Design Principal
11:00
BRKCRS-2110
Delivering Cisco Next gen SD-WAN with Viptela
14:00
BRKCRS-2113
Cloud Ready WAN for IAAS and SAASA with Cisco SD-WAN
17:00
BRKRST-2377
SD-WAN Security
08:00
BRKRST-2095
SD-WAN 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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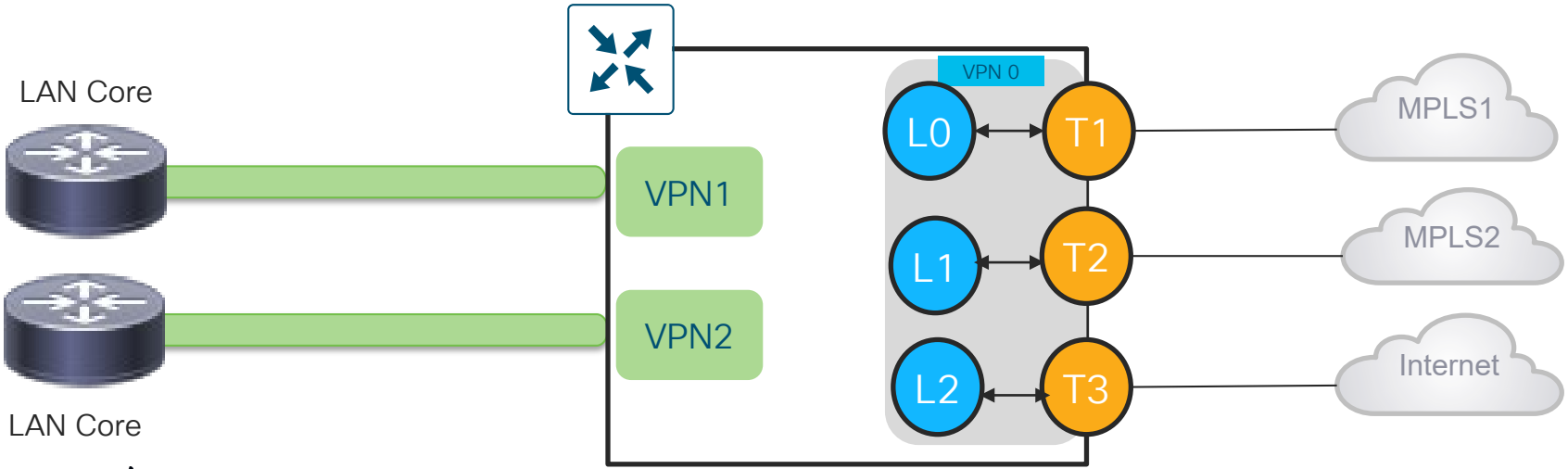
You make **possible**

Loopback Interface – Bind mode

- In case of bind mode, each loopback is bound to a physical interface
- Traffic destinated to loopback will be carried to and from mapped physical interface
- This can be used when customers have connected subnets on transport side, and can use loopback to form control connections and data tunnels.



Loopback Interface – Unbind Mode

- In case of unbind mode, loopback interface is not bound to any physical interface
- Traffic destinated to loopback can go through any physical interface (Based on hash lookup)
- This can be used when there are multiple transports available to same provider