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LTRDCN-2223

Implementing VXLAN In a Data Center

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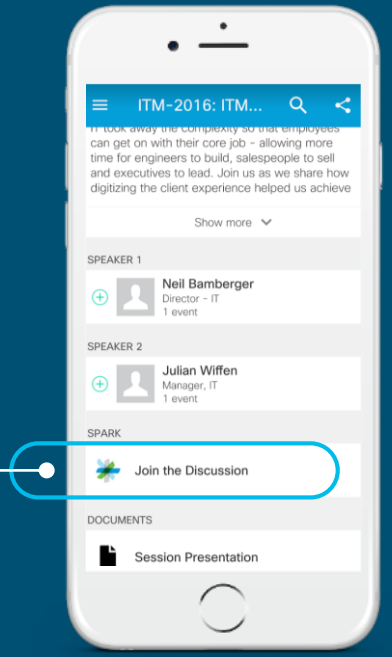

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Agenda

- VxLAN Overview
- Flood-&-Learn VXLAN
- VXLAN with MP-BGP EVPN Control Plane
- VXLAN Design Options
- MP-BGP EVPN VXLAN Configuration
- Lab Introduction

Prerequisites

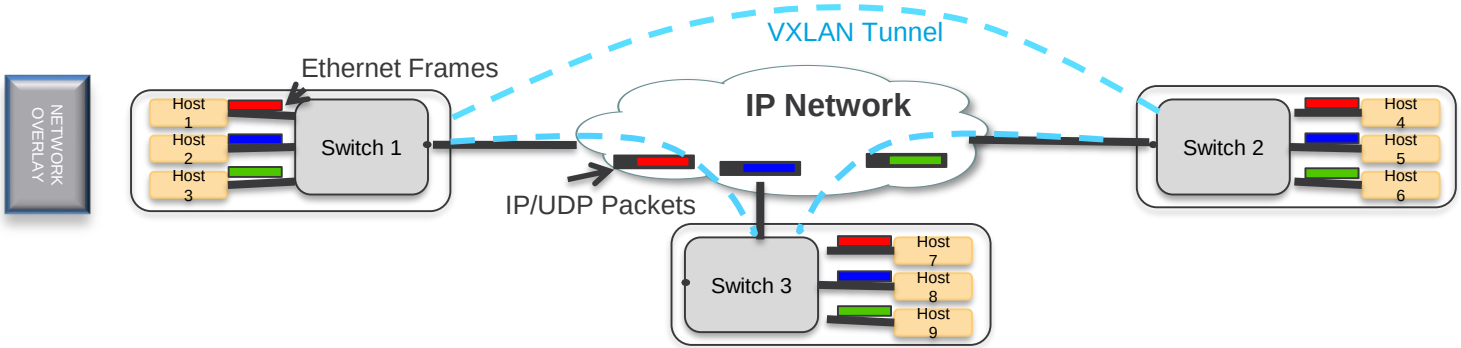
- Routing and Switching
- PIM
- MP-BGP
- NX-OS

Overlays

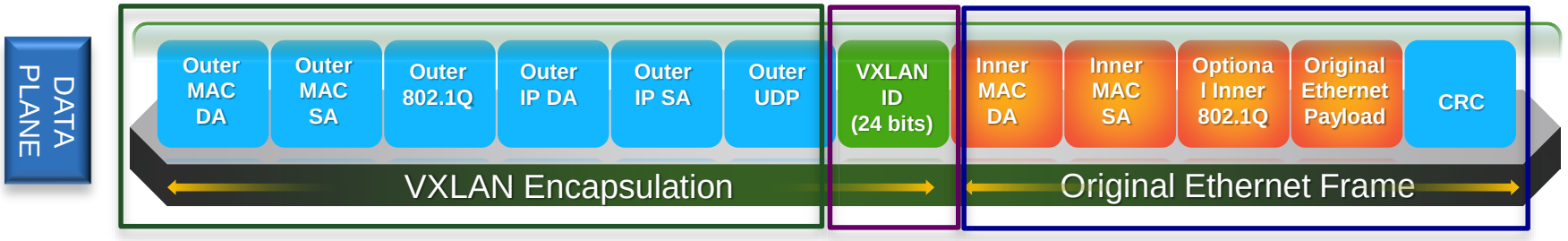
With growing adoption of virtualization in customer environments and a large number of workload mobility requirements in the data center, overlays are becoming a key technology. VXLAN is one of those overlay technologies.

Recap – What is VXLAN ?

- VXLAN is a point to multi-point tunneling mechanism to extend Layer 2 networks over an IP network



- VXLAN uses MAC in UDP encapsulation (UDP destination port 4789)



Why VXLAN?

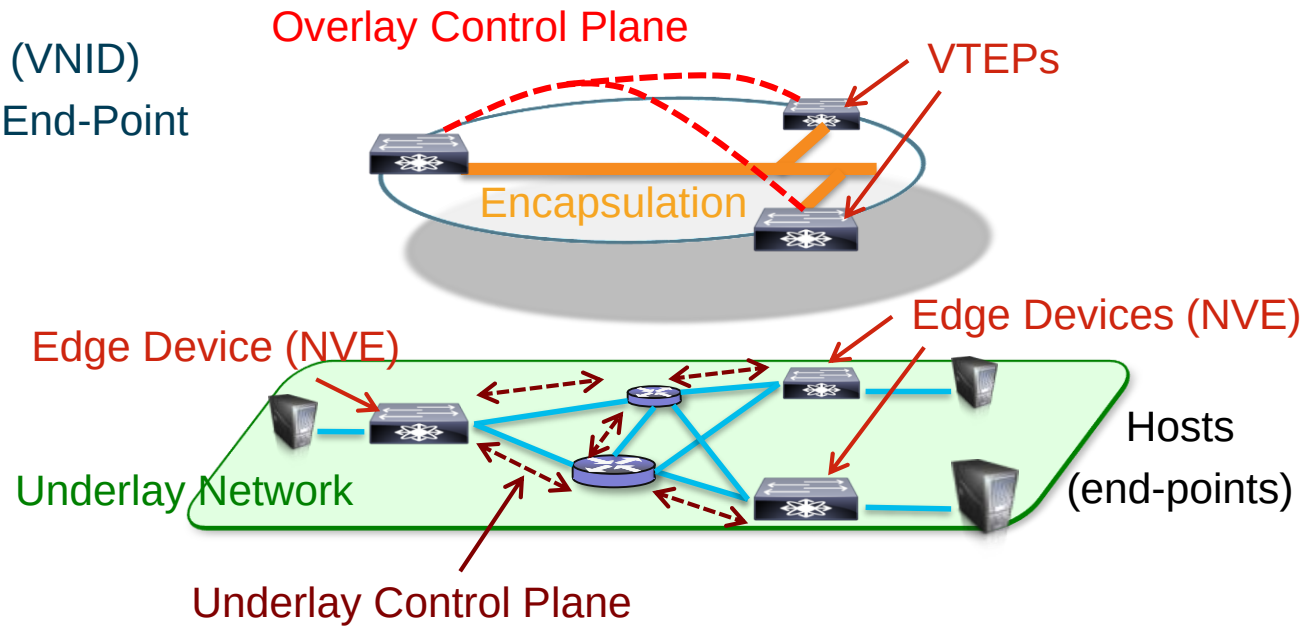
VXLAN provides a Network with Segmentation, IP Mobility, and Scale

- “Standards” based Overlay
- Leverages Layer-3 ECMP – all links forwarding
- Increased Name-Space to 16M identifier
- Segmentation and Multi-Tenancy
- Integration of Physical and Virtual

Overlay Taxonomy

Identifier = VN Identifier (VNID)

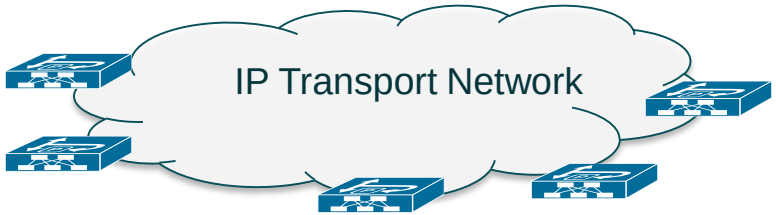
VTEP = VXLAN Tunnel End-Point



VXLAN Underlay Network – IP Routing

IP routed Network

- Flexible topologies
- Recommend a network with redundant paths using ECMP for load sharing
- Support any routing protocols --- OSFP, EIGRP, IS-IS, BGP, etc.
- All proven best practices for IP routing network apply



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Two Modes of VXLAN

Flood-and-Learn VXLAN:

- No control plane
- Data driven flood and learning
  → Ethernet in the overlay network

VXLAN EVPN:

- EVPN as control plane
- VTEPs exchange L2/L3 host and subnet reachability through EVPN control plane
  → Routing protocol for both L2 and L3 forwarding

- Limited scale
- Limited workload mobility
- Security Risk

- Increased scale and stability
- Optimized workload mobility
- Increased Security

VXLAN BUM Traffic Handling

- BUM Traffic --- Multi-destination traffic
  - Broadcast
  - Unknown Layer-2 Unicast
  - Multicast

BU**M Traffic transport mechanisms**

- Multicast replication
  - Requests the underlay network to run IP multicast
- Ingress unicast replication
  - One unicast replica per remote VTEP
  - Increase traffic load throughout the network

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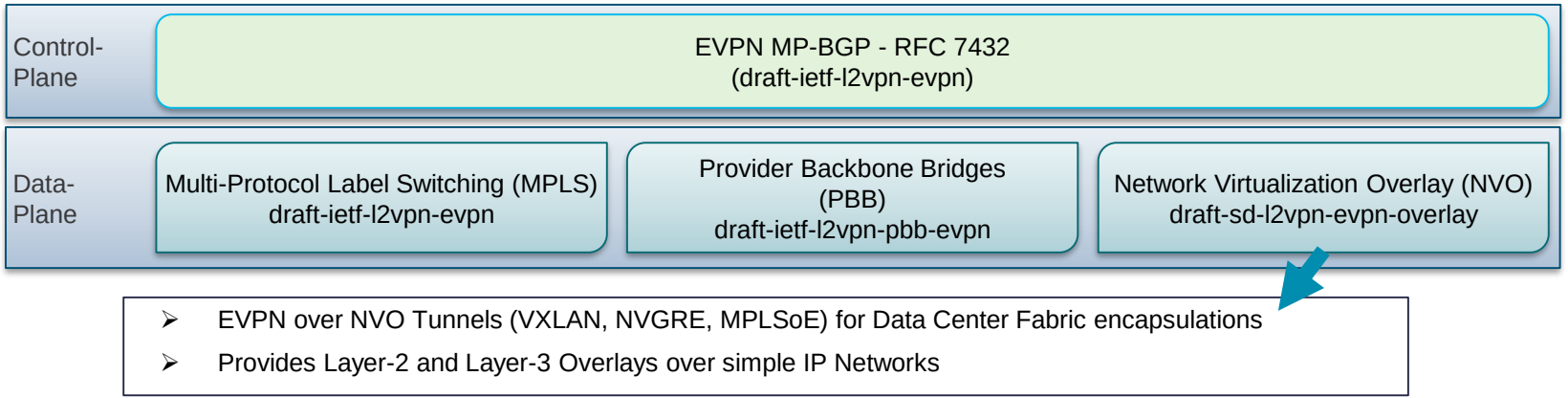
What is VXLAN/EVPN?

- Standards based Overlay (VXLAN) with Standards based Control-Plane (BGP)
- Layer-2 MAC and Layer-3 IP information distribution by Control-Plane (BGP)
- Forwarding decision based on Control-Plane (minimizes flooding)
- Integrated Routing/Bridging (IRB) for Optimized Forwarding in the Overlay



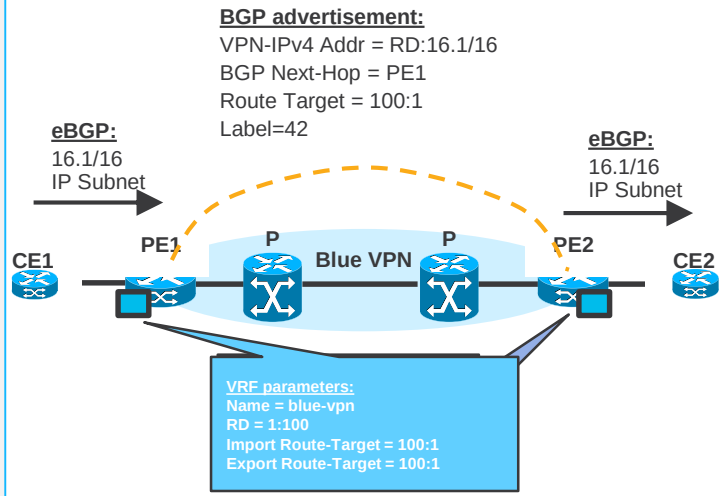
EVPN Primer --- MP-BGP Review

Virtual Routing and Forwarding (VRF)
Layer-3 segmentation for tenants' routing space

Route Distinguisher (RD):
8-byte field, VRF parameters; unique value to make VPN IP routes unique: RD + VPN IP prefix

Selective distribute VPN routes:
Route Target (RT): 8-byte field, VRF parameter, unique value to define the import/export rules for VPNv4 routes

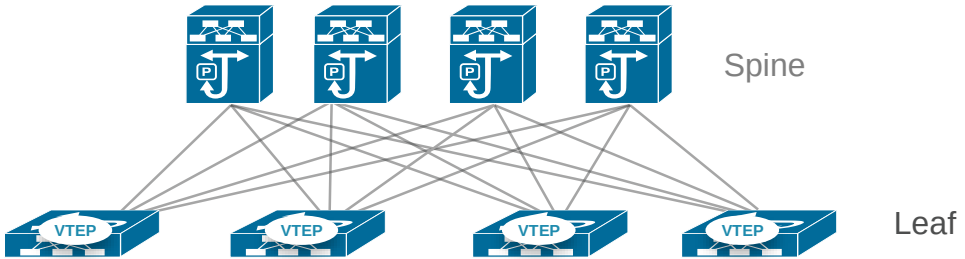
VPN Address-Family:
Distribute the MP-BGP VPN routes



EVPN Control Plane – Reachability Distribution

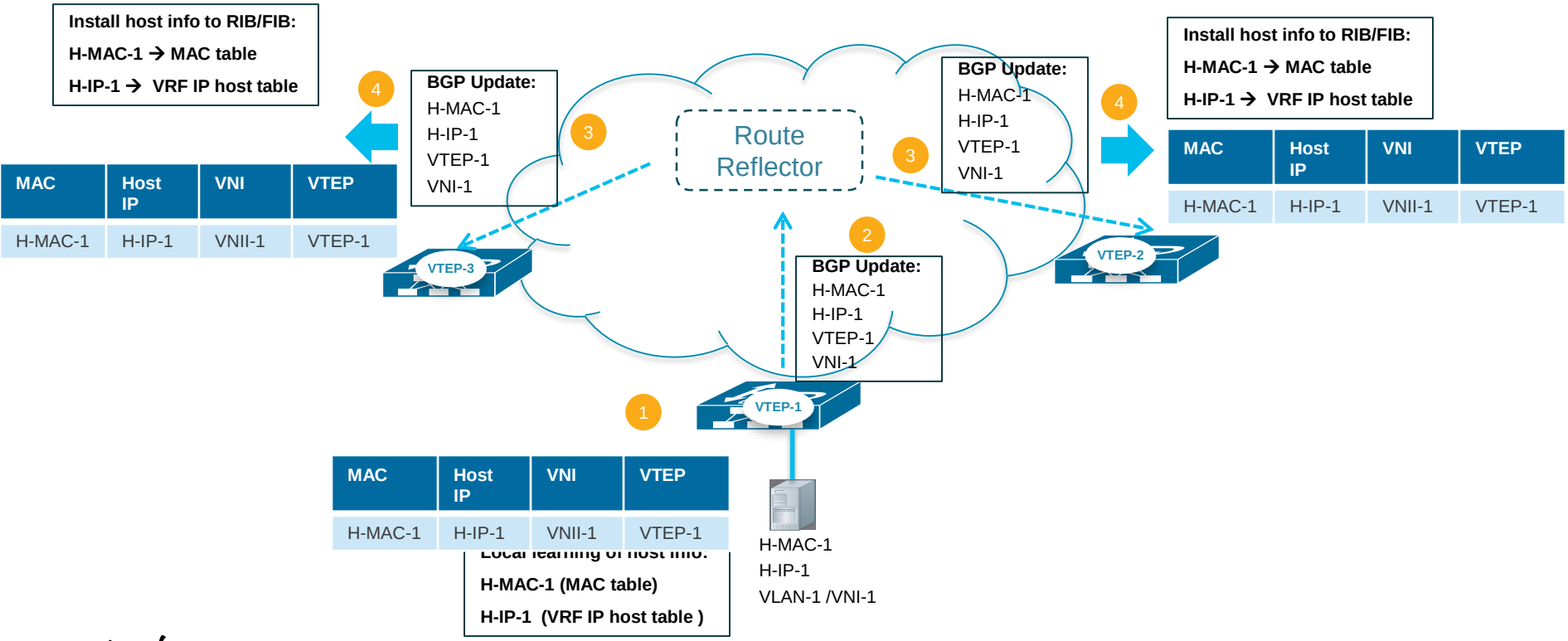
- EVPN Control Plane -- Host and Subnet Route Distribution

BGP Update
- Host-MAC
- Host-IP
- Internal IP Subnet
- External Prefixes



- Use MP-BGP with EVPN Address Family on leaf nodes to distribute internal host MAC/IP addresses, subnet routes and external reachability information
- MP-BGP enhancements to carry up to 100s of thousands of routes with reduced convergence time

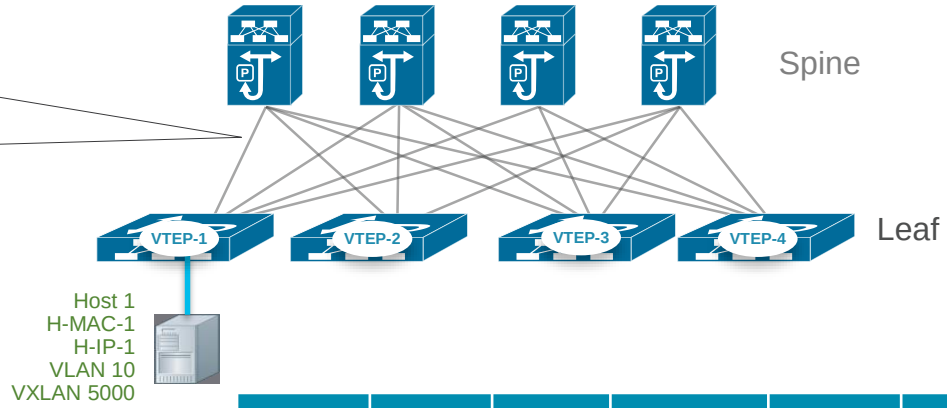
EVPN Control Plane -- Host Advertisement



EVPN Control Plane --- VM Mobility

NLRI:
- Host H-MAC-1, H-IP-1
- NVE VTEP-1
- VNI 5000

Ext. Community:
- Encapsulation: VXLAN
- Cost
- Sequence number :0



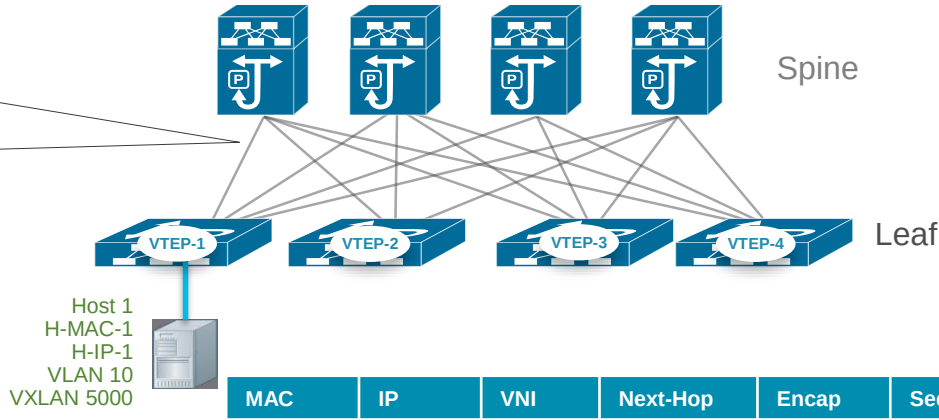
MAC	IP	VNI	Next-Hop	Encap	Seq#
H-MAC-1	H-IP-1	5000	VTEP-1	VXLAN	0

1. Host 1 attaches to VTEP-1
2. VTEP-1 detects Host1 and advertises H1 with seq #0
3. Other VTEPs learn about the host route of Host 1

EVPN Control Plane --- VM Mobility

NLRI:
- Host H-MAC-1, H-IP-1
- NVE VTEP-3
- VNI 5000

Ext. Community:
- Encapsulation: VXLAN
- Cost
- Sequence number: 1



MAC	IP	VNI	Next-Hop	Encap	Seq#
H-MAC-1	H-IP-1	5000	VTEP-3	VXLAN	1

1. Host 1 moves to VTEP-3 from VTEP-1
2. VTEP-3 detects Host 1, sends MP-BGP update for Host 1 with its own VTEP address and a new seq #1
3. Other VTEPs learn about the new route of Host 1

EVPN Control Plane --- ARP Suppression

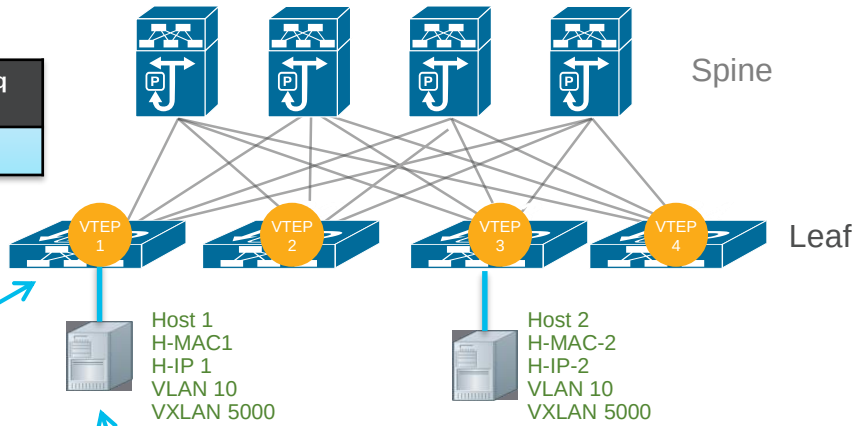
Minimize flood-&-learn behavior for host learning

MAC	IP	VNI	Next-Hop	Encap	Seq
H-MAC-2	H-IP-2	5000	VTEP-3	VXLAN	0

2

VTEP-1 receives and intercepts the ARP Request. Checks in its own host table.

- If it has a match for H-IP-2, it'll send ARP response on behave of Host-2
- If it doesn't have a match for H-IP-2, it'll forward the ARP request to remote VTEPs via multicast encap or head-end replication

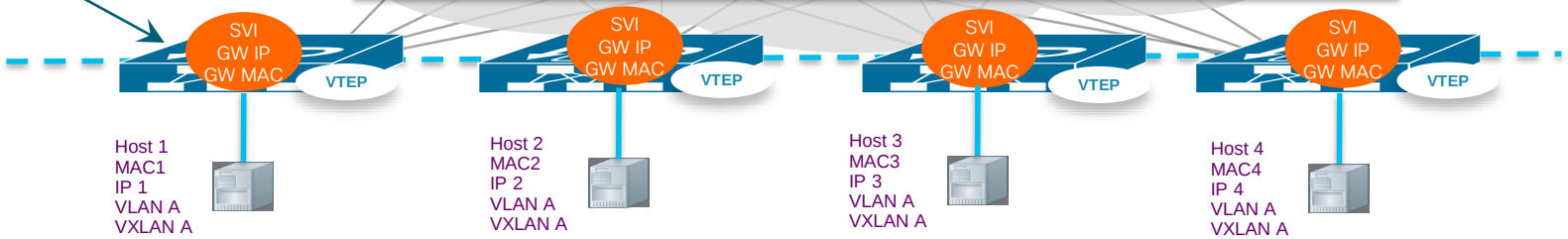


1 Host-1 sends ARP Request for H-IP-2

Distributed Anycast Gateway in MP-BGP EVPN

The same anycast gateway virtual IP address and MAC address are configured on all VTEPs in the VNI.

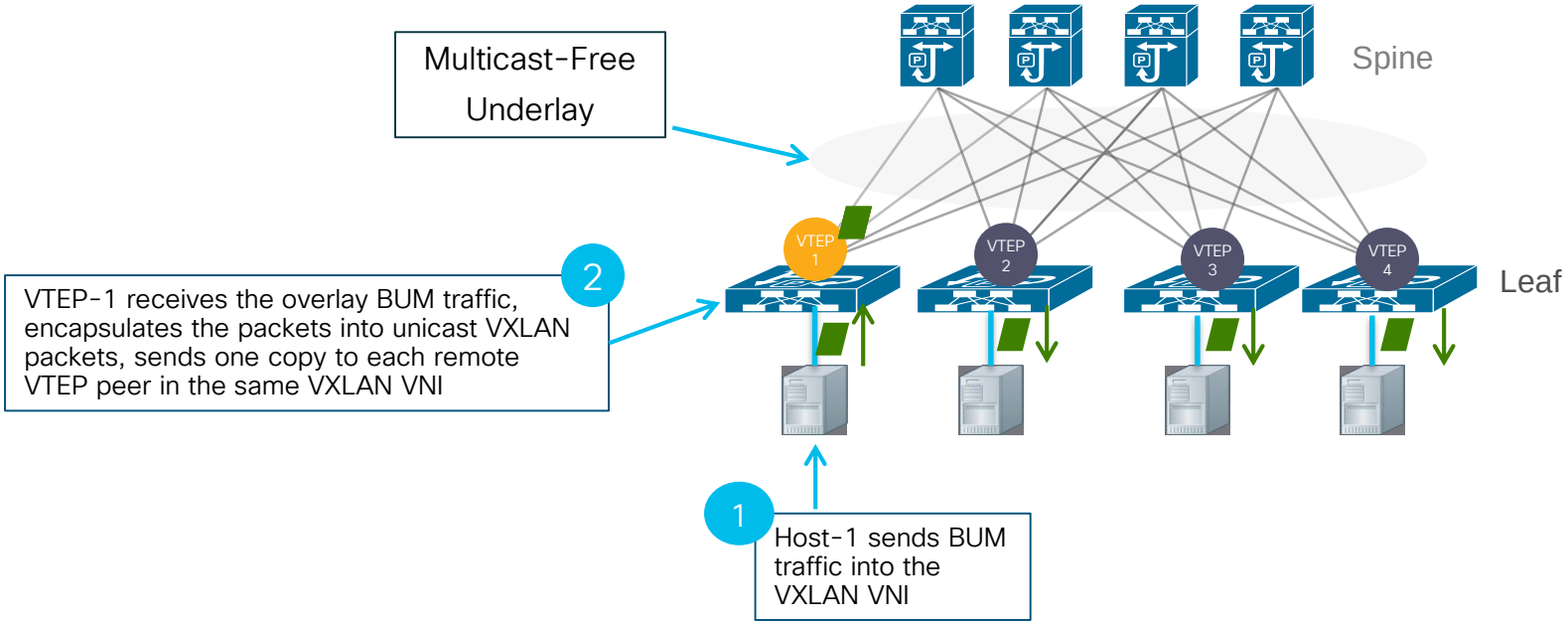
```
# VLAN to VNI mapping
vlan 200
 vn-segment 5200

# Anycast Gateway MAC, identically configured on all VTEPs
fabric forwarding anycast-gateway-mac 0002.0002.0002

# Distributed IP Anycast Gateway (SVI)
# Gateway IP address needs to be identically configured on all
VTEPs
interface vlan 200
 no shutdown
 vrf member Tenant-A
 ip address 20.0.0.1/24
 fabric forwarding mode anycast-gateway
```



EVPN Control Plane -- Head-end Replication

Head-end Replication (aka. Ingress replication):

Eliminate the need for underlay multicast to transport overlay BUM traffic



Functions of VXLAN/EVPN

Host/Network Reachability Advertisement	Advertise host/network reachability information through control protocol (MP-BGP)
VTEP Security & Authentication	Authenticate VTEPs through BGP peer authentication
Distributed Anycast Gateway	Seamless and Optimal vm-mobility
ARP Suppression	Early ARP termination Localize ARP learning process Minimize network flooding
Dynamic Ingress Replication	Unicast Alternative to Multicast underlay Dynamically discover remote peers for Ingress Replication

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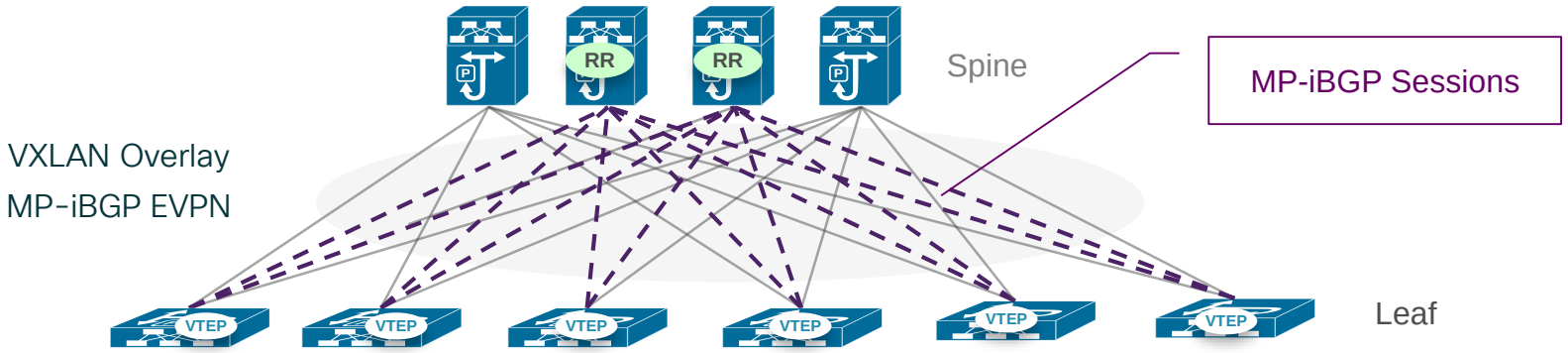
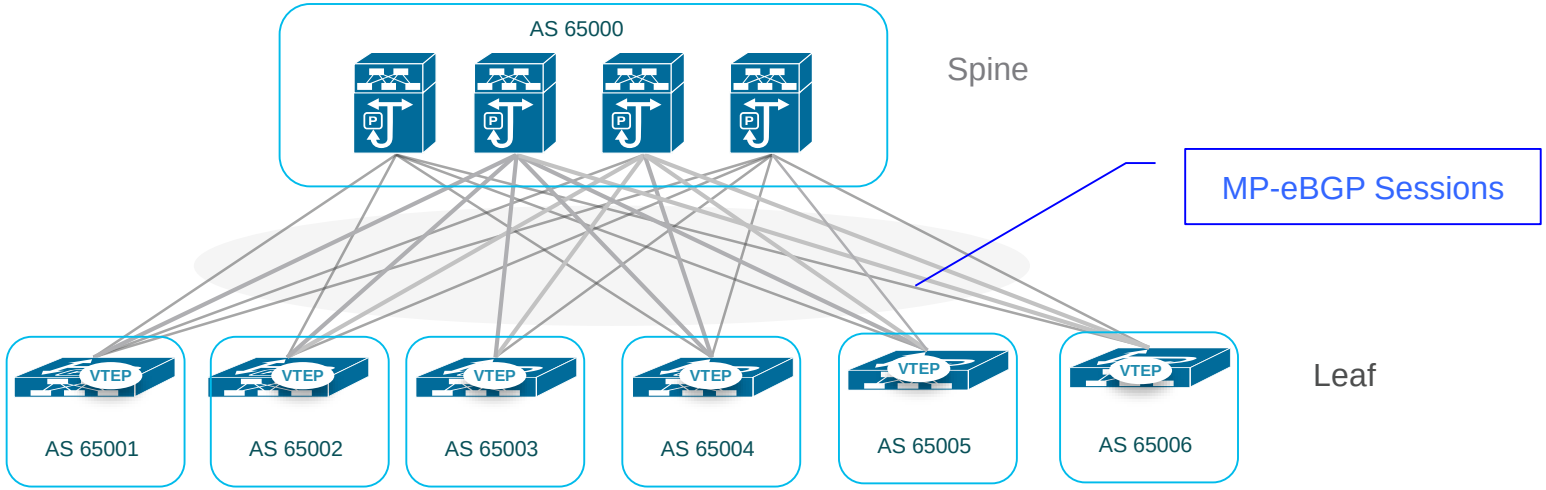
VXLAN Fabric Design with MP-iBGP EVPN



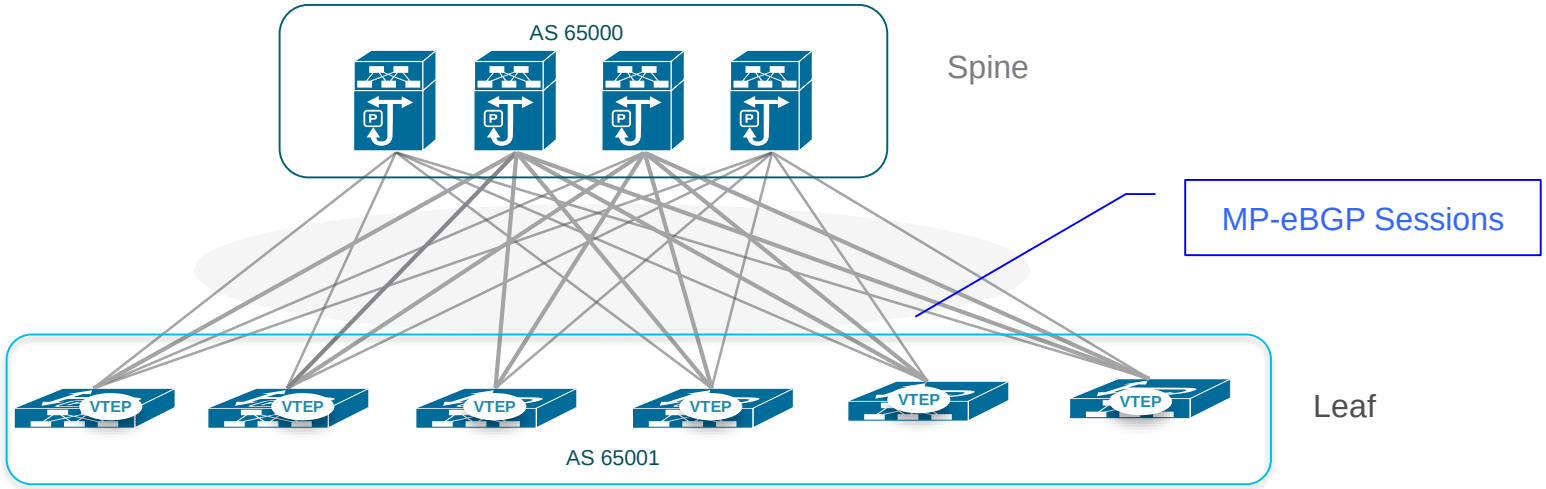
- VTEP Functions are on leaf layer
- Spine nodes are iBGP route reflector
- Spine nodes don’t need to be VTEP

VXLAN Fabric Design with MP-eBGP EVPN



- VTEP Functions are on leaf layer
- Spine nodes are MP-eBGP Peers to VTEP leafs
- Spine nodes don’t need to be VTEP
- VTEP leafs can be in the same or different BGP AS’s

VXLAN Fabric Design with MP-eBGP EVPN



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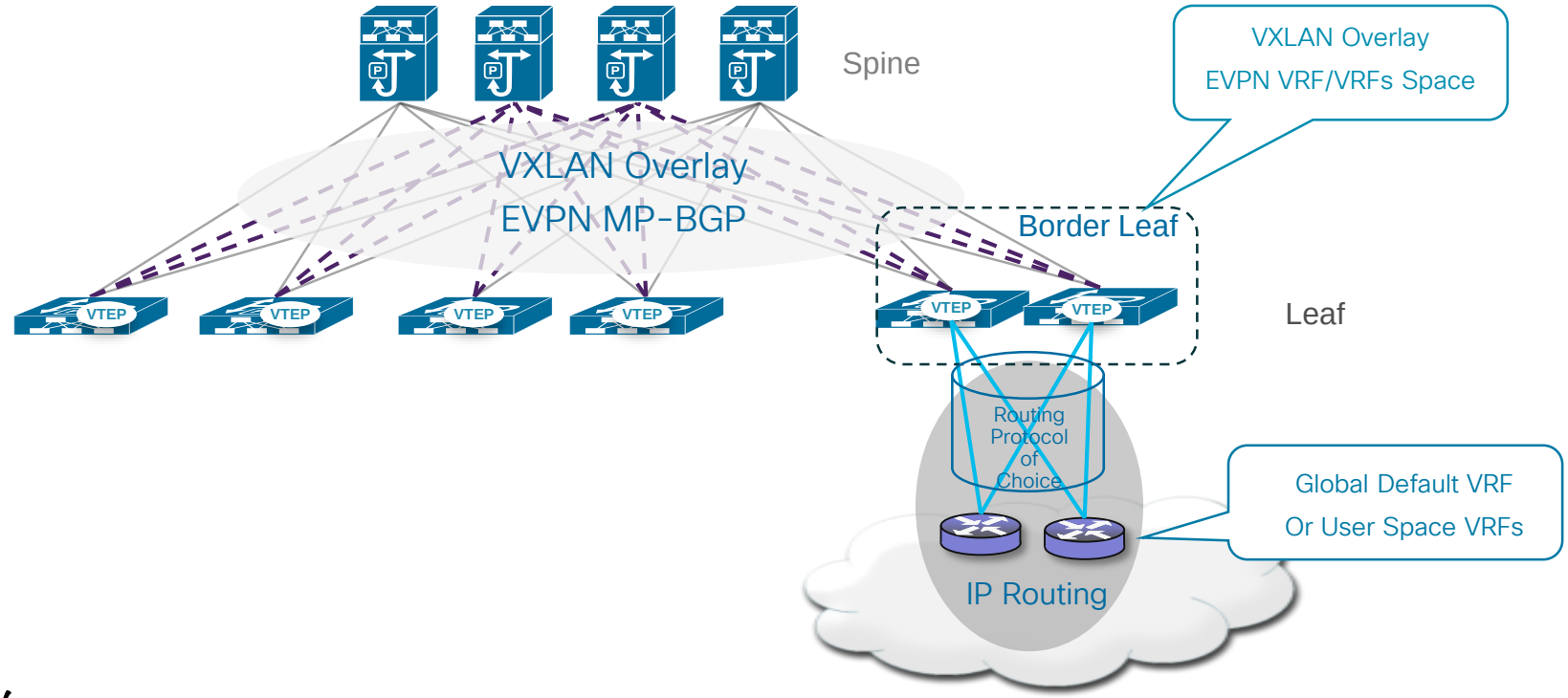
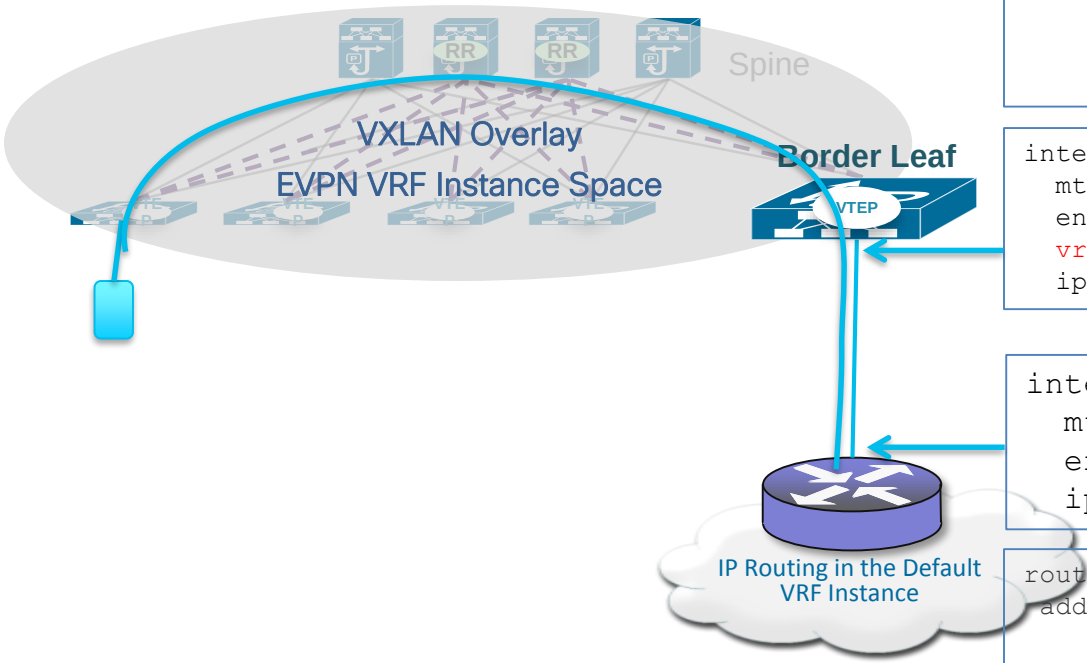
EVPN VXLAN Fabric External Routing



EVPN VXLAN External Routing with BGP Sample Configuration

FYI



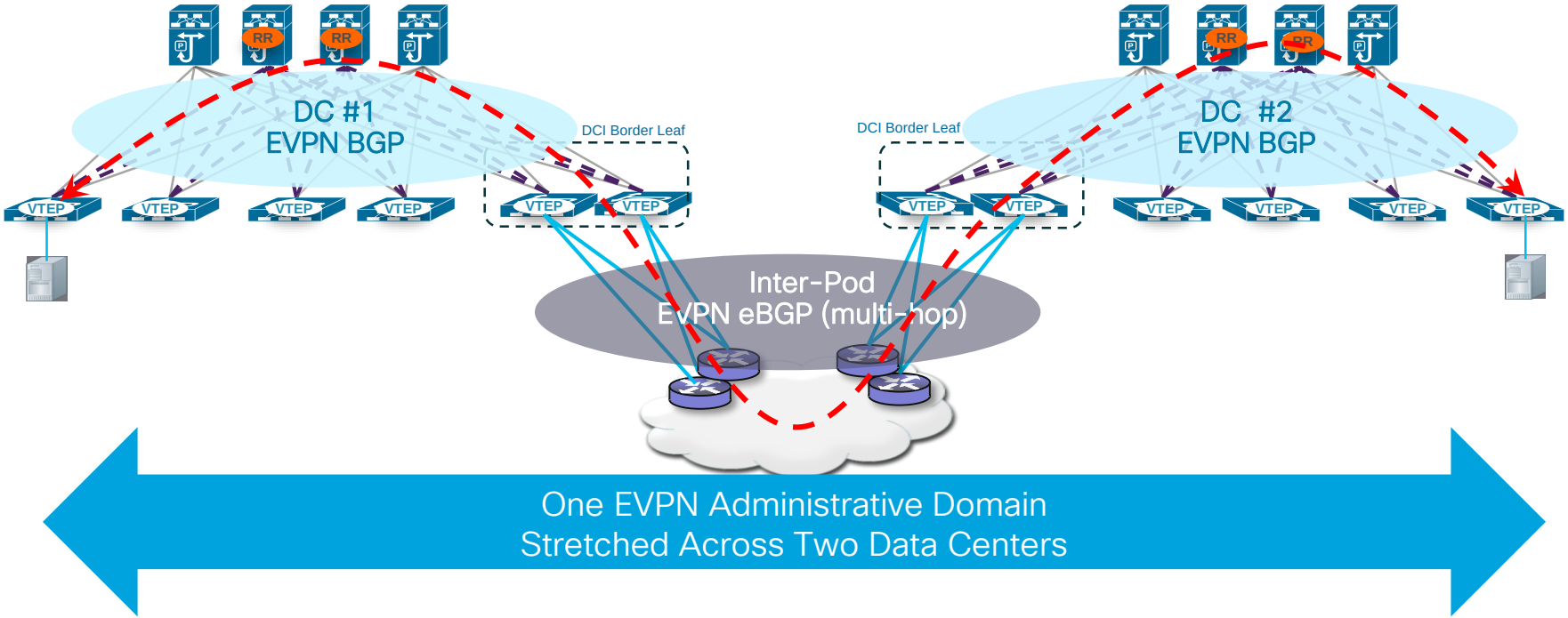

```
Router bgp 100
 vrf evpn-tenant-1
    address-family ipv4 unicast
      network 20.0.0.0/24
    neighbor 30.10.1.2 remote-as 200
      address-family ipv4 unicast
       prefix-list outbound-no-hosts out
```

```
interface Ethernet2/9.10
  mtu 9216
  encapsulation dot1q 10
  vrf member evpn-tenant-1
  ip address 30.10.1.1/30
```

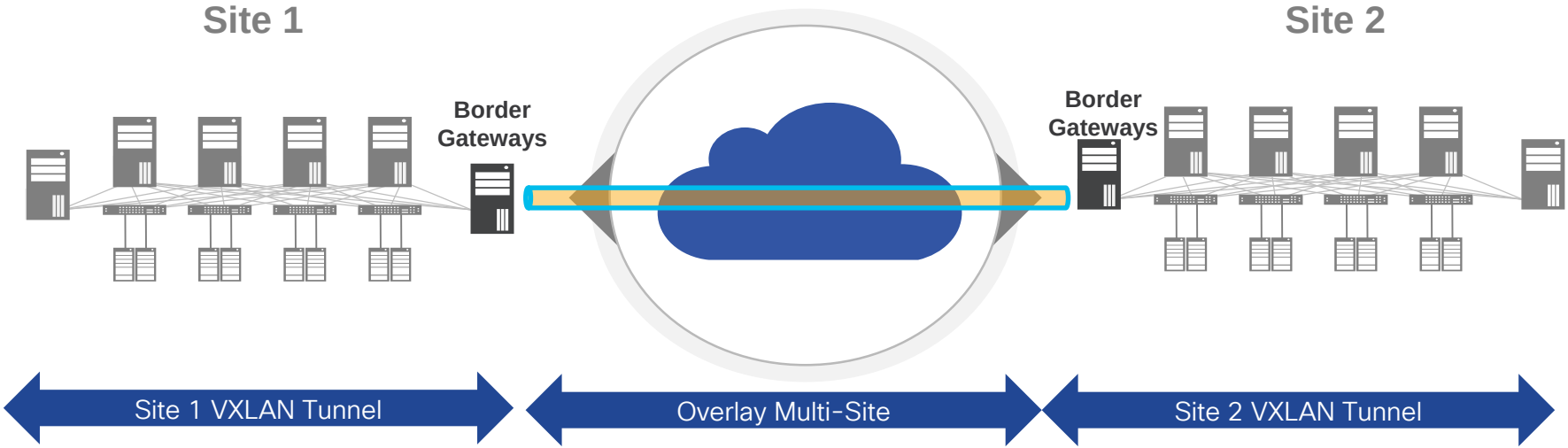
```
interface Ethernet1/50.10
  mtu 9216
  encapsulation dot1q 10
  ip address 30.10.1.2/30
```

```
router bgp 200
 address-family ipv4 unicast
    network 100.0.0.0/24
    network 100.0.1.0/24
  neighbor 30.10.1.1 remote-as 100
    address-family ipv4 unicast
```

EVPN Design for Multi-Pod



VXLAN EVPN Multi-Site



Scale through Hierarchical Forwarding

Fault Containment | Convergence independent of Network Size | Separate Admin Domains | Single Box

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FYI

Building your VTEP (VXLAN Tunnel End-Point)

```
# Features & Globals
feature bgp
feature nv overlay
nv overlay evpn

# Spine (S1)

# Leaf (V1)
interface nve1
  source-interface loopback0
  host-reachability protocol bgp
```

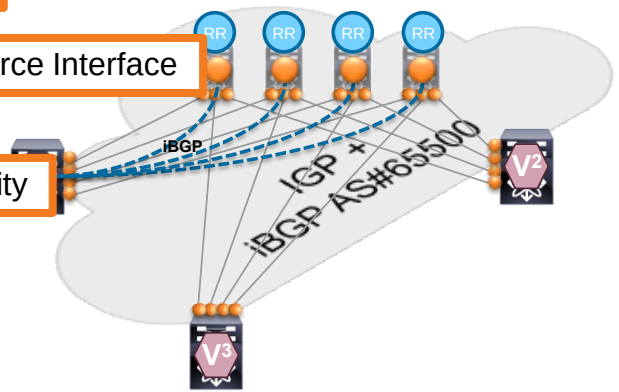
Enables VTEP (only required on Leaf or Border)

Enables EVPN Control-Plane in BGP

Configure the VTEP interface

Use a Loopback for Source Interface

Enable BGP for Host reachability



*Simplified BGP configuration; would have 4 BGP peers (RR)
IGP not shown

FYI

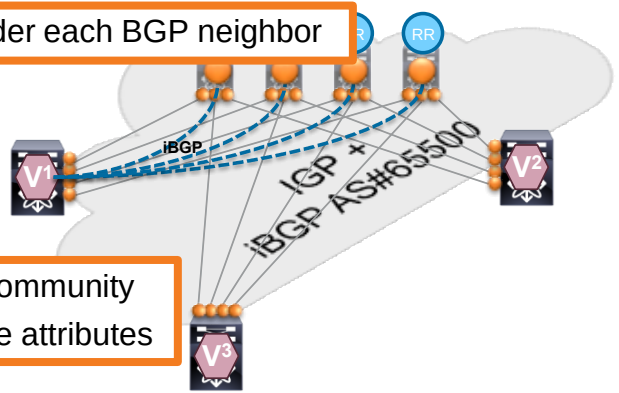
Building your EVPN MP-BGP Control-Plane

```
# Features & Globals
feature bgp
feature nv overlay
nv overlay evpn

# Spine (S1)
router bgp 65500
  router-id 10.10.10.1
  address-family ipv4 unicast
  address-family l2vpn evpn
  neighbor 10.10.10.10 remote-as 65500
    update-source loopback0
    address-family l2vpn evpn
      send-community both
      route-reflector-client

# Leaf (V1)
router bgp 65500
  router-id 10.10.10.10
  address-family ipv4 unicast
  neighbor 10.10.10.1 remote-as 65500
    update-source loopback0
    address-family l2vpn evpn
      send-community both
*
```

Enables EVPN Control-Plane in BGP

Activate L2VPN EVPN under each BGP neighbor

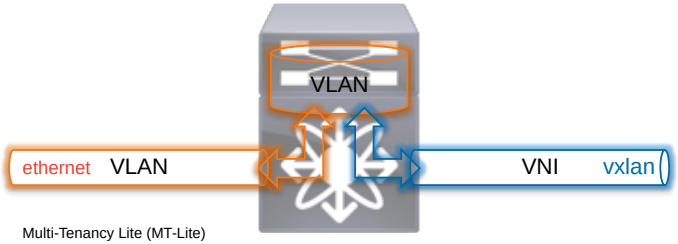
Send Extended BGP Community to distribute EVPN route attributes



FYI

Extend your VLAN to VXLAN

- VLAN to VNI configuration on a per-Switch based
- VLAN becomes “Switch Local Identifier”
- VNI becomes “Network Global Identifier”
- 4k VLAN limitation per-Switch does still apply
- 4k Network limitation has been removed
- VLAN can be port-significant. The same vlan on different ports can be mapping to different VNIs.



Multi-Tenancy Lite (MT-Lite)

```
# Features
feature vn-segment-vlan-based

# VLAN to VNI mapping (MT-Lite)
Vlan 10
 vn-segment 5010

# Activate Layer-2 VNI for EVPN
evpn
  vni 5010 l2
    rd auto
    route-target import auto
    route-target export auto

# Activate Layer-2 VNI on VTEP
interface nve1
  source-interface loopback0
  host-reachability protocol bgp
  member vni 5010
    mcast-group 239.239.239.100
    suppress-arp
```

VLAN to Layer-2 VNI mapping

Enables EVPN Control-Plane for Layer-2 Services

Alternative is to use “ingress-replication protocol bgp”

Enables Layer-2 VNI on VTEP and suppress ARP

FYI

Distributed Anycast Gateway for Extended VLANs

- All VTEPs in a VXLAN are the distributed anycast gateway for its IP subnet.
- All VTEPs in a VXLAN need to be configured with an identical anycast gateway virtual MAC address
- All VTEPs in a VXLAN need to be configured with an identical anycast gateway virtual IP address

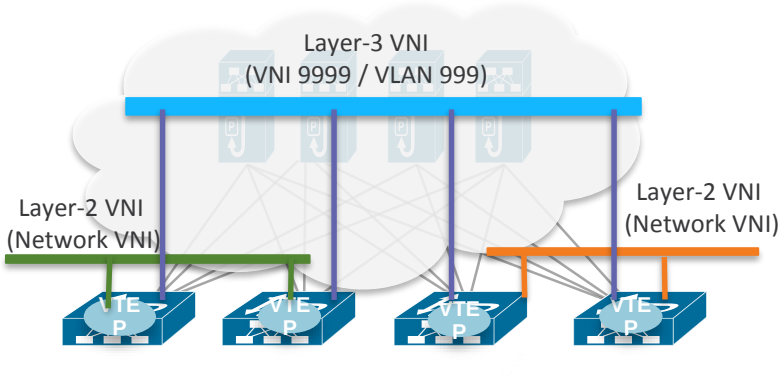
One gateway virtual MAC per VTEP

One gateway virtual IP per VLAN/VXLAN

```
# VLAN to VNI mapping
vlan 200
 vn-segment 5200

# Anycast Gateway MAC, identically configured on all
VTEPs
fabric forwarding anycast-gateway-mac 0002.0002.0002

# Distributed IP Anycast Gateway (SVI)
# Gateway IP address needs to be identically
configured on all VTEPs
interface vlan 200
 no shutdown
 vrf member Tenant-A
 ip address 20.0.0.1/24
 fabric forwarding mode anycast-gateway
```

FYI

Routing in VXLAN – Define the Resources



1:1 mapping between L3 VNI and tenant VRF

Configuration Example for VRF-A

```
# Define VLAN for VRF routing instance
Vlan 999
  vn-segment 9999

# Define SVI for VRF routing instance
interface Vlan999
  no shutdown
  mtu 9216
  vrf member VRF-A
  ip forward

# VRF configuration for "customer" VRF
vrf context VRF-A
  vni 9999
  rd auto
  address-family ipv4 unicast
    route-target both auto
    route-target both auto evpn
```

VLAN to Layer-3 VNI mapping

VLAN to Layer-3 VNI mapping

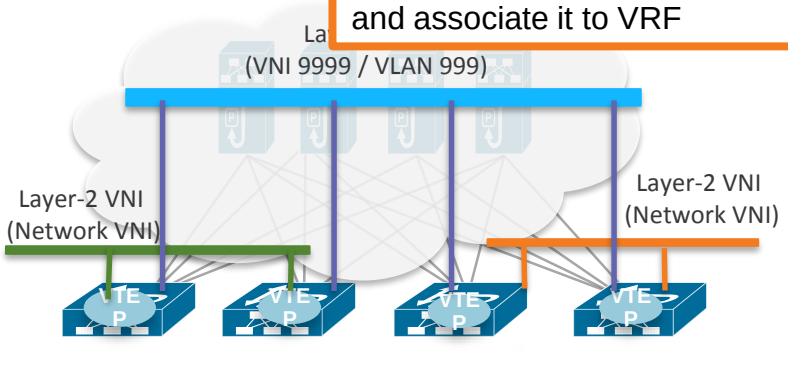
- ip forward required for prefix-based routing

VRF context definition

- VNI
- Route-Distinguisher
- Route-Targets
- IPv4 and/or IPv6

FYI

Routing in VXLAN – Configure the Routing



Enables Layer-3 VNI on VTEP and associate it to VRF

1:1 mapping between L3 VNI and tenant VRF

VRF/Tenant definition within Overlay Control-Plane

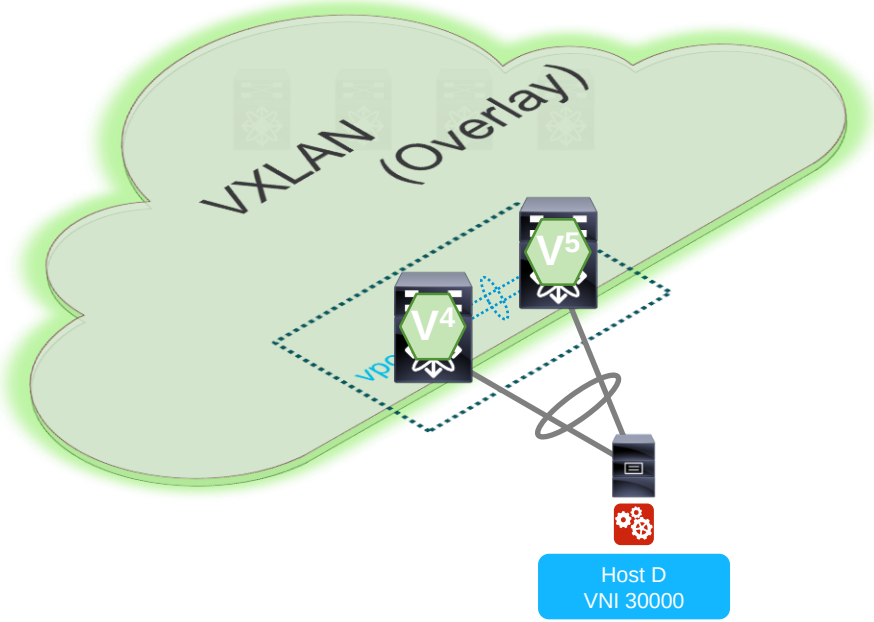
Configuration Example for VRF-A

```
# Activate Layer-3 VNI on VTEP
interface nve1
  source-interface loopback0
  host-reachability protocol bgp
  member vni 5010
    mcast-group 239.239.239.100
    suppress-arp
  member vni 9999 associate-vrf

# Route-Map for Redistribute Subnet
route-map REDIST-SUBNET permit 10
  match tag 12345

# Control-Plane configuration for VRF (Tenant)
router bgp 65500
...
  vrf VRF-A
    address-family ipv4 unicast
      advertise l2vpn evpn
      redistribute direct route-map REDIST-SUBNET
      maximum-paths ibgp 2
```

FYI

VXLAN Hardware Gateway Redundancy (vPC)

- Redundant connectivity for classic Ethernet hosts
- Extend the IP Interface (Loopback) configuration for the vPC VTEP
  - Secondary IP address (anycast) is used as the anycast VTEP address
  - Both vPC VTEP switches need to have the identical secondary IP address configured under the loopback interface



FYI

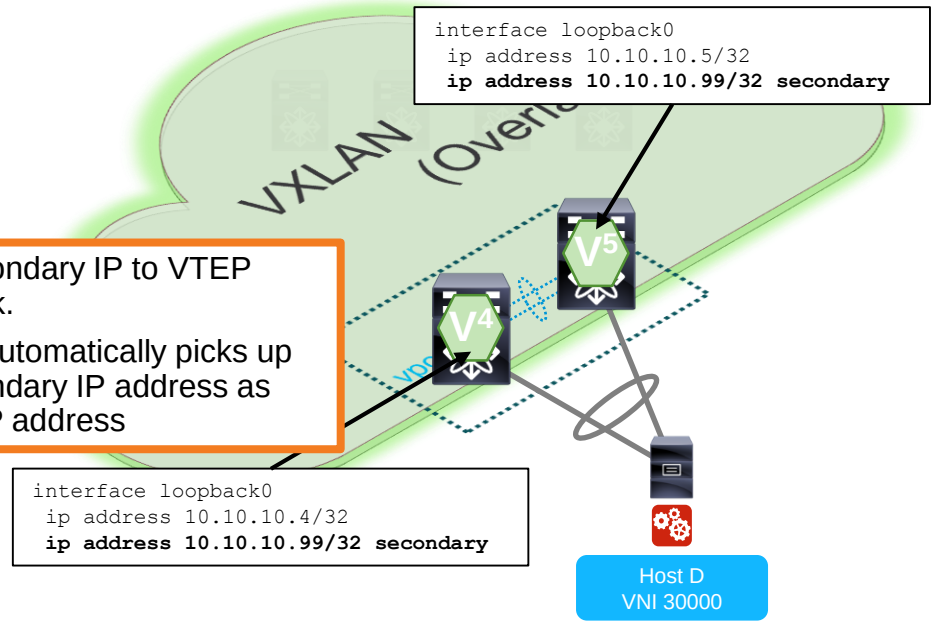
VXLAN Hardware Gateway Redundancy (vPC)

vPC VTEP Configuration Example

```
# VLAN to VNI mapping (MT-Lite)
vlan 55
 vn-segment 30000
# VTEP IP Interface; Source/Destination for all
VXLAN Encapsulated Traffic.
▪ Primary IP address is used for Orphan Hosts
▪ Secondary IP is for vPC Hosts (same IP on both
  vPC Peers)
interface loopback0
 ip address 10.10.10.5/32
 ip address 10.10.10.99/32 secondary

# VTEP configuration using Loopback as source.
interface nve1
  source-interface loopback0
  host-reachability protocol bgp
  member vni 5010
    mcast-group 239.239.239.100
    suppress-arp
  member vni 9999 associate-vrf
```

Add Secondary IP to VTEP Loopback.

VXLAN automatically picks up the secondary IP address as the VTEP address



FYI

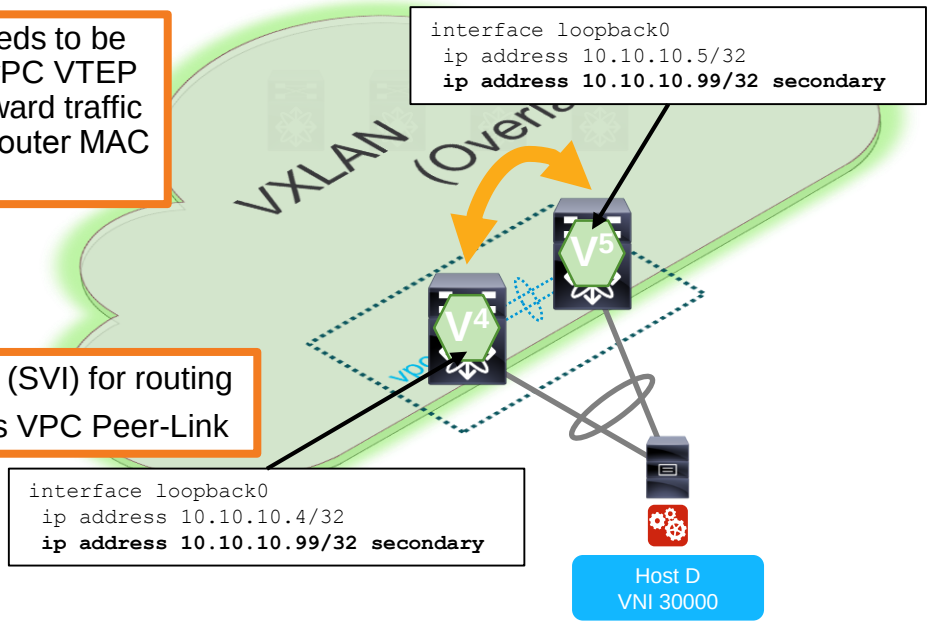
VXLAN Hardware Gateway Redundancy (vPC)

vPC VTEP Configuration Example

```
# VPC Domain Configuration
vpc domain 99
  peer-switch
  peer-keepalive destination V4-mgmt sou
  peer-gateway
  ip arp synchronize

# VPC Peer-Link
interface port-channelXX
  switchport mode trunk
  vpc peer-link

# VPC Domain Routing Adjacency
interface Vlan3999
  no shutdown
  ip address 10.254.254.1/30
  ip router ospf 1 area 0.0.0.0
  ip ospf network point-to-point
  ip pim sparse-mode
```

peer-gateway needs to be enabled so that vPC VTEP switches can forward traffic for each other's router MAC address

Routed Interface (SVI) for routing adjacency across VPC Peer-Link



FYI

eBGP EVPN Configuration (1)

Next-hop Unchange

- BGP next-hop is used as the tunnel tail end address. It shall be the advertising VTEP's address.
- Ensure the next-hop in the BGP route isn't changed during the route distribution
- eBGP changes next-hop to by default. Need to change the policy to next-hop unchanged

eBGP configuration on a spine switch

```
route-map permit-all permit 10
route-map nh-unchange permit 10
  set ip next-hop unchanged
router bgp 65000
  router-id 10.1.1.1
  address-family ipv4 unicast
  address-family l2vpn evpn
    nexthop route-map nh-unchange
    retain route-target all
  neighbor 192.167.11.2 remote-as 65001
    address-family ipv4 unicast
    address-family l2vpn evpn
      send-community extended
      route-map permit-all out
```

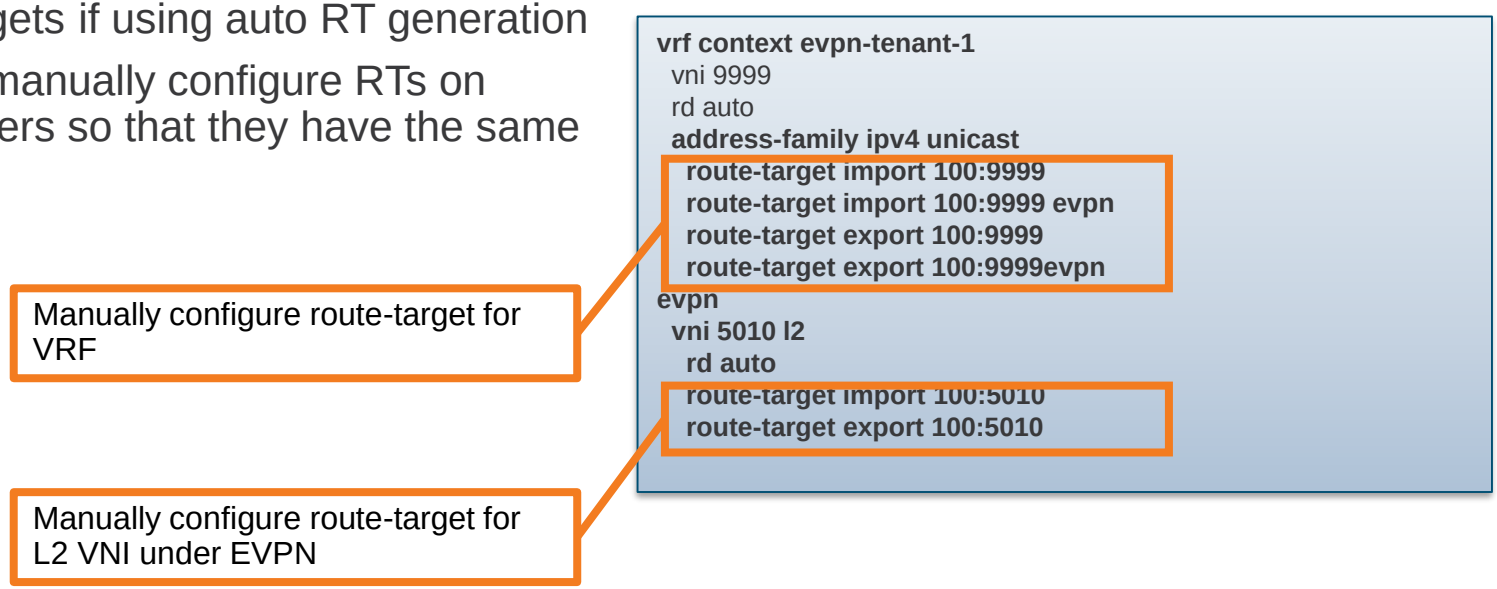
Set next-hop policy not to change the next-hop attribute

FYI

eBGP EVPN Configuration(2)

Manually configure import/export route-target

- With eBPG, VTEPs will have different route-targets if using auto RT generation
- Need to manually configure RTs on eBGP peers so that they have the same RTs



More Learning on VXLAN EVPN….

BRKDCT-3378: Building DataCenter networks with VXLAN BGP-*EVPN (Lukas Krattiger)*

BRKDCN-2304: L4-L7 Service Integration in Multi-Tenant VXLAN *EVPN* Data Center Fabrics (Matthias Wessendorf)

BRKSPG-2030: VXLAN troubleshooting and debugging in a mixed Service Provider - Data Center network (Nikolay Karpyshev, Ivan Shirshin)

BRKDCN-3505: Extending VXLAN Fabrics across geographically dispersed sites (Yves Louis)

TECDCT-2181: Deployment Considerations for Interconnecting Distributed Virtual Data Centers (Yves Louis, Victor Moreno)

LTRDCT-2224: Enhancing VXLAN/*EVPN* Fabrics with LISP (Lukas Krattiger, satish kondalam)

Agenda

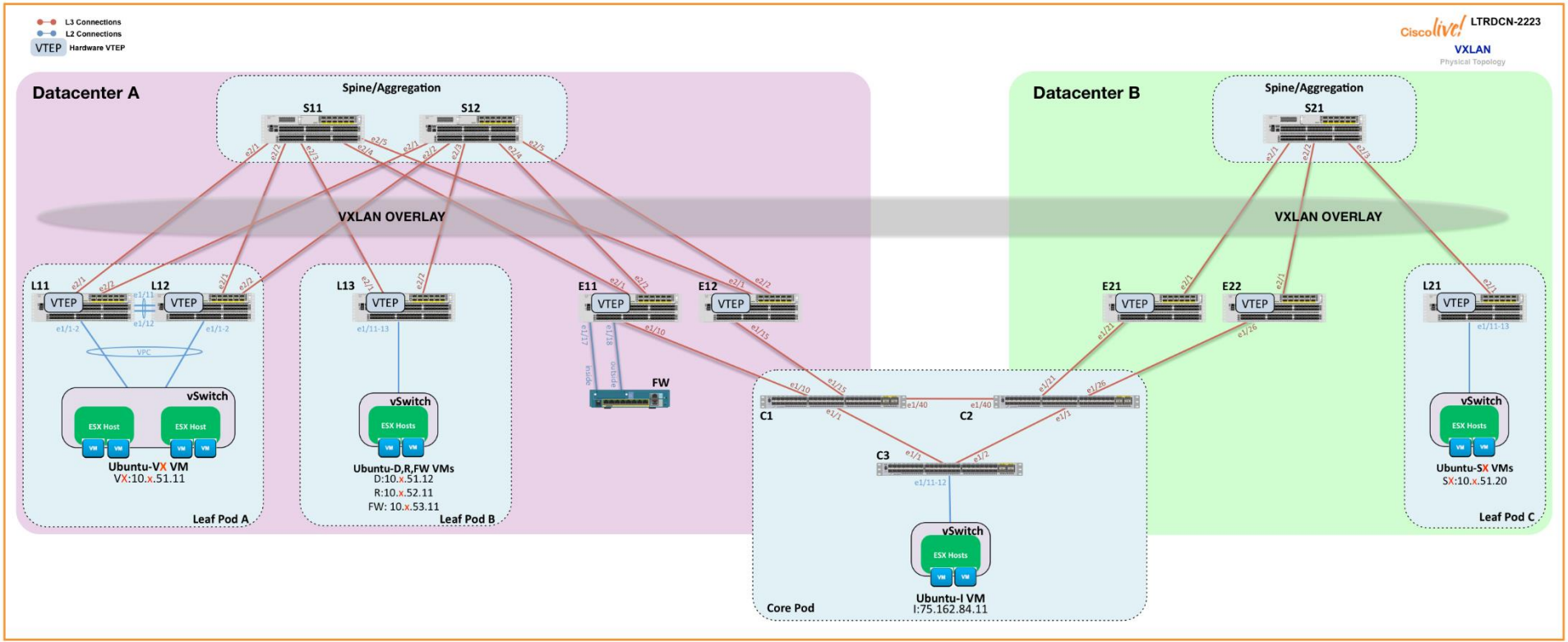
- VxLAN Overview
- Flood-&-Learn VXLAN
- VXLAN with MP-BGP EVPN Control Plane
- VXLAN Design Options
- MP-BGP EVPN VXLAN Configuration
- Lab Introduction

Lab Overview

Module Details

- **Module 1 – Network Based Overlay [DC1]**: In this module, students will configure a network based overlay with Nexus 9000 switches and use them as VTEPs. Students will also learn how to extend the anycast gateway using BGP EVPN.
- **Module 2 – FW-Security Zone [DC1]**: In this module, students will create a secure zone by placing a transparent mode FW between the VXLAN fabric and core pod.
- **Module 3 – MultiPOD [DC1 and DC2]:** In this module, students will stretch the VXLAN fabric from DC 1 to DC2 and extend VLANs from one DC to the other.

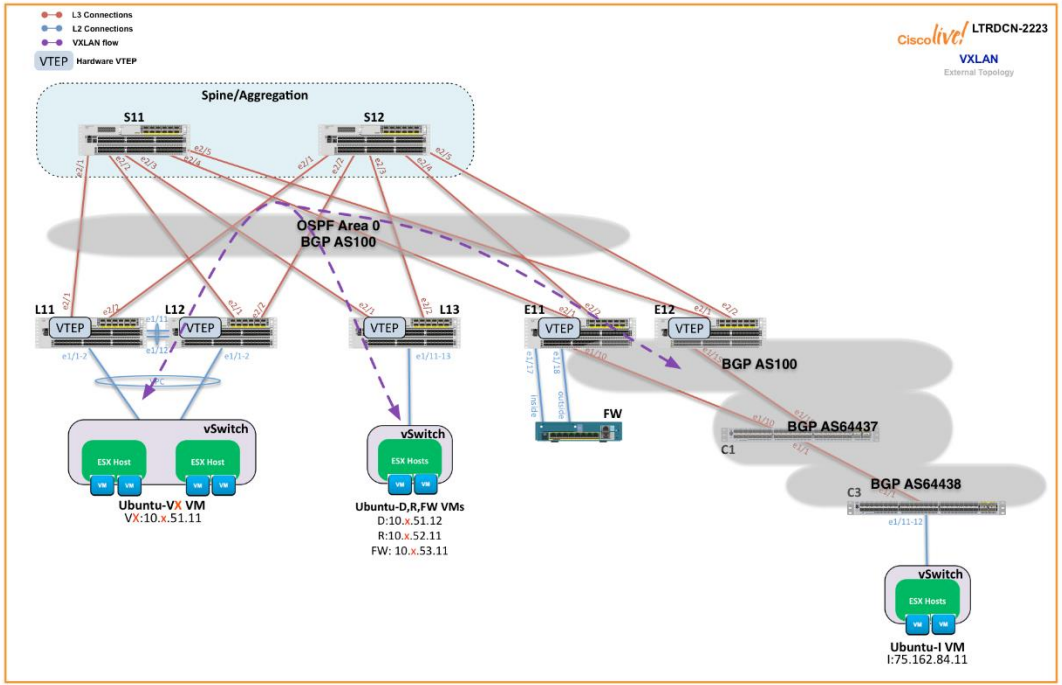
Lab Topology



Network Overview - DC1

Using BGP EVPN for Control Plane

- Using OSPF for underlay
- Using IBGP for overlay - Route Reflectors are on Spines S11 and S12
- Using VXLAN EVPN for control plane
- VXLAN Ingress Replication for the BUM Traffic
- Each student has their own VRF that will be representative of multi-tenancy.

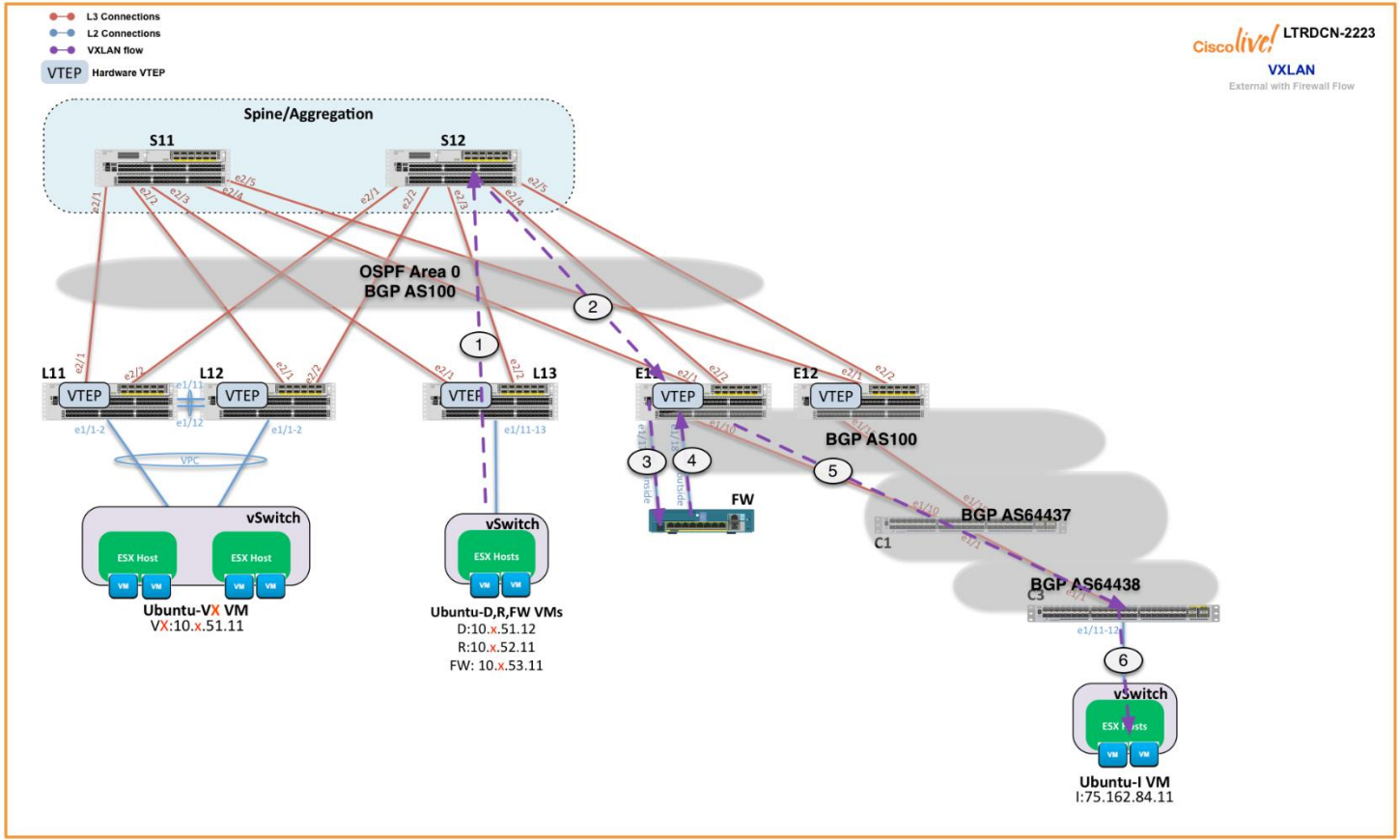


Security Module

Creating a Security Zone via VXLAN

- The Hosts in the Secured Zone are in VXLAN X53.
- Transparent FW is attached to Edge E11.
- No redundancy in this portion of the lab for simplicity.

Firewall Usecase Flow



Network Overview – DC2

Using EBGP EVPN for Underlay/Overlay

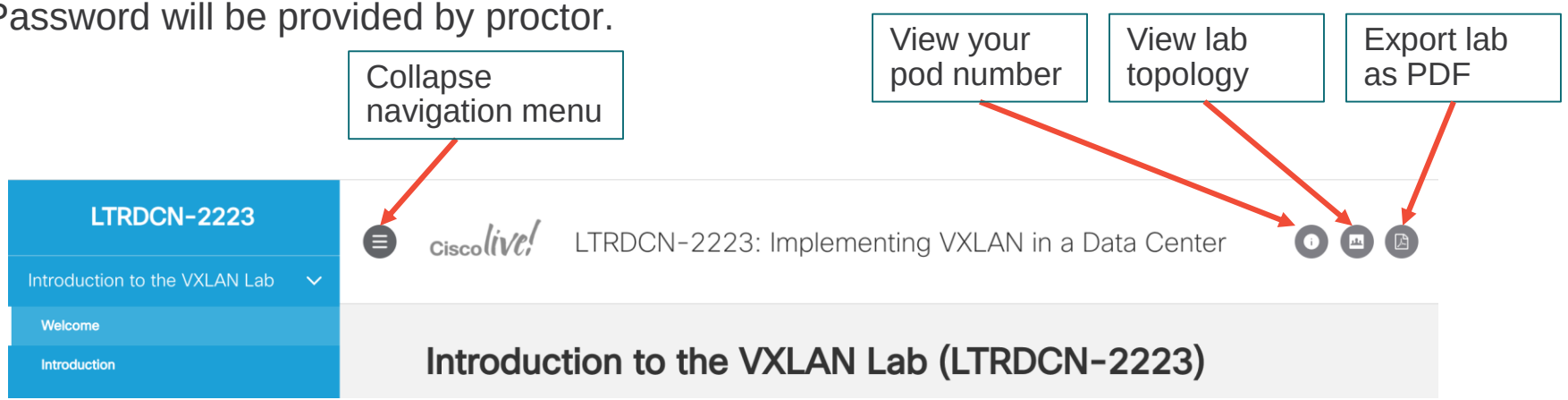
- Using EBGP for Underlay/Overlay
- Ingress Replication for the BUM Traffic.
- VLAN X51 will be stretched from DC1 to DC2.
- Each student has their own VRF that will be representative of multi-tenancy.

Manual Overview (1)

- Manual available at

  http://cs.co/ltrdcn-2223

- Password will be provided by proctor.



- Navigate either using the navigation menu on the left or the back/forward buttons at the bottom of the page.
- Only type commands that are shown in a box. Commands shown under “Configuration Sample” are not meant to be typed into the devices.

Manual Overview (2)

- Manual available at

  http://cs.co/ltrdcn-2223

- RDP Server: vxlanlab.ciscolive.com:3390
- Username: vxlan\PODxuser
- Password:

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How

1. Find this session in the Cisco Live Mobile App
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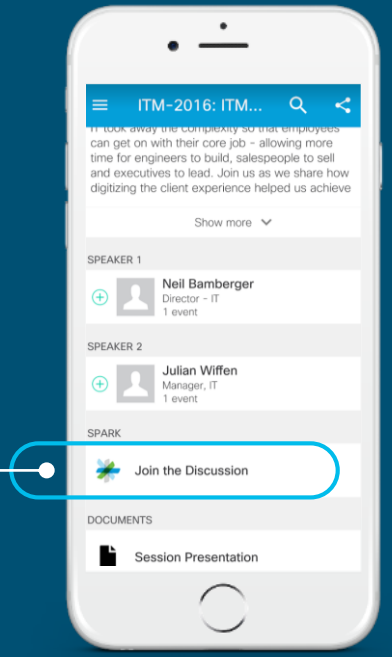

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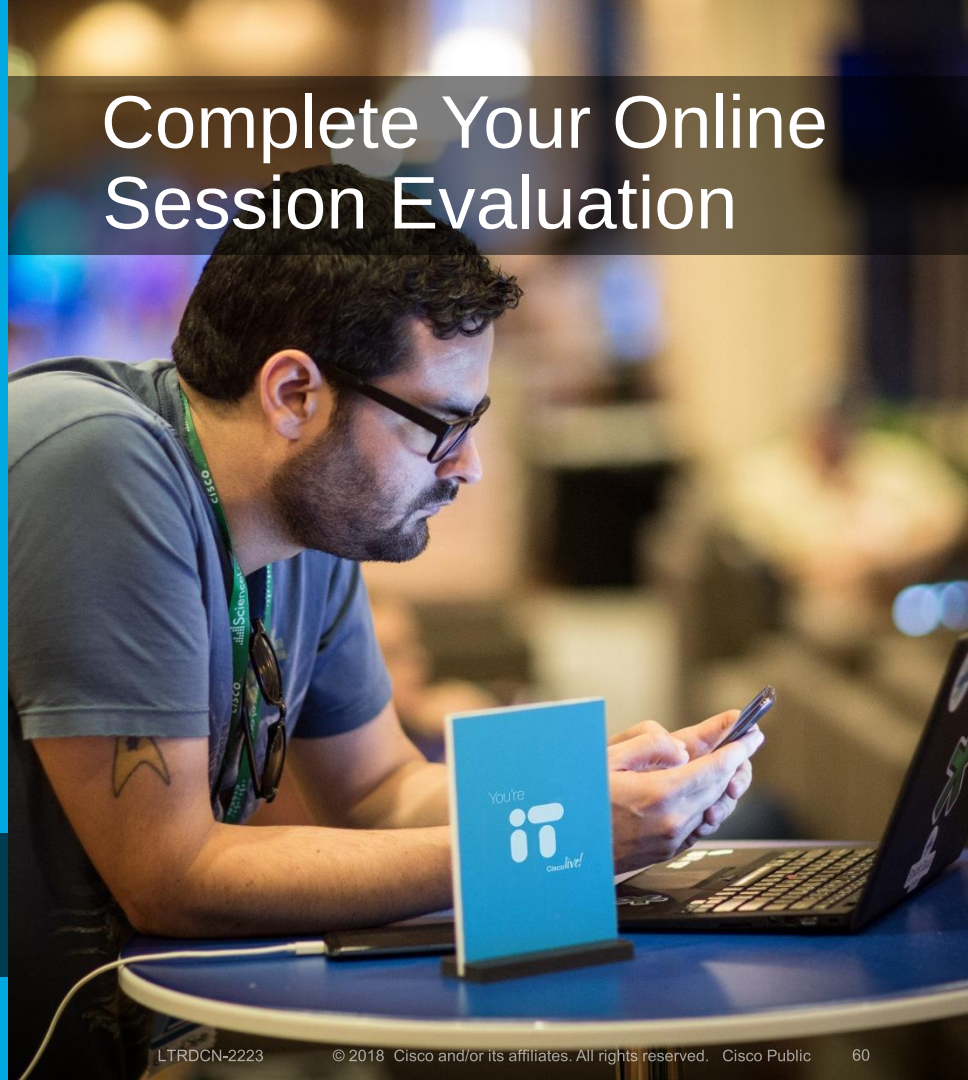

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