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Introduction to VXLAN The future path of your datacenter

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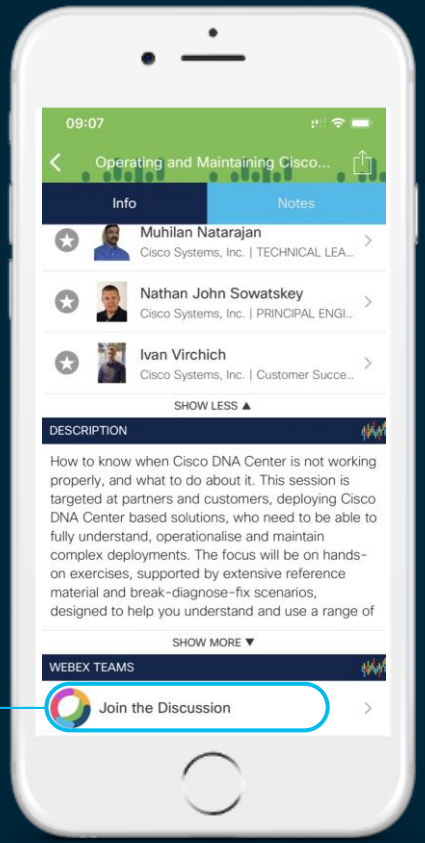


A few things..

- Prerequisites
  - Good understanding of Unicast Routing Protocols – OSPF/ISIS
  - Knowledge of Multi protocol BGP (MP-BGP)
  - Basics of Multicast forwarding and PIM
- Use Cisco WebEx Teams for Questions
- Watch out for the hidden slides ☺

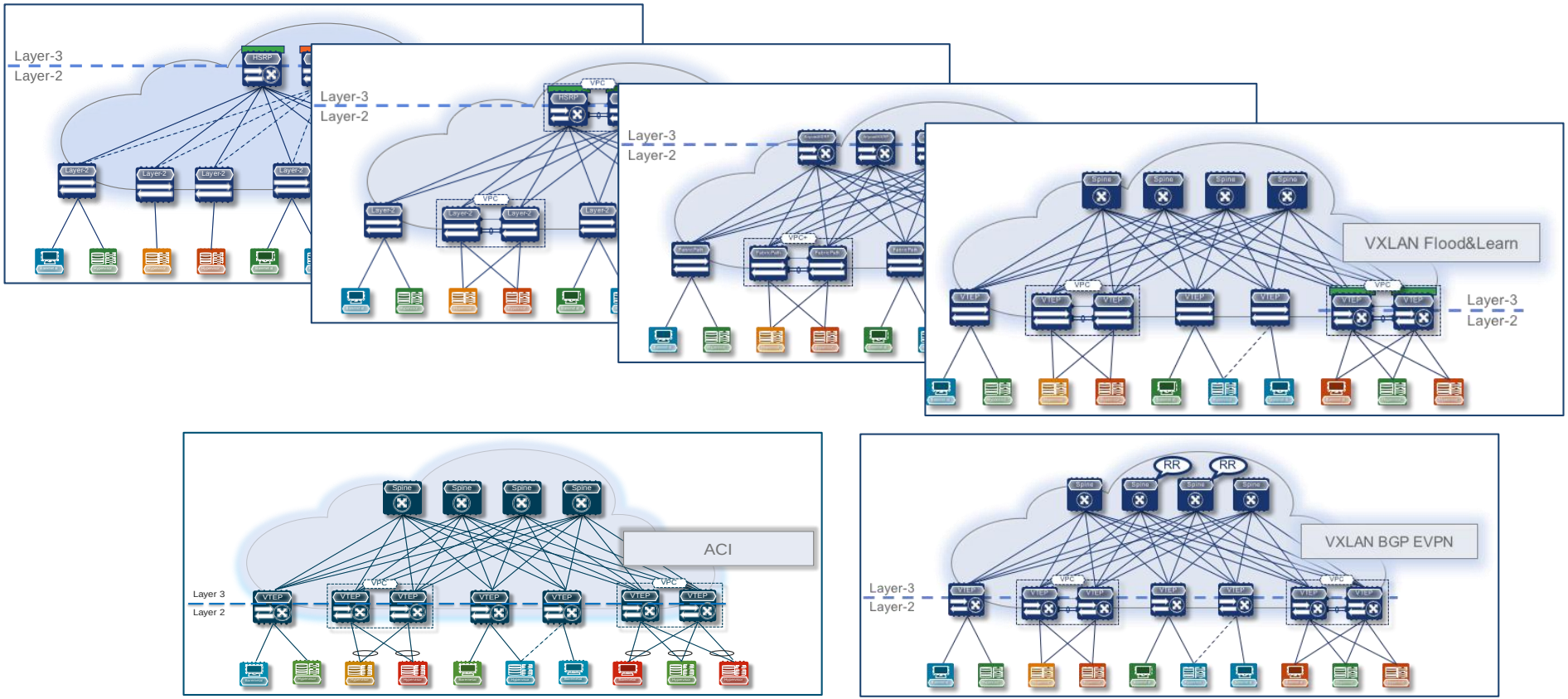
Session Objective

- A short overview on Data Center Evolution
- Introduction to Overlays and VXLAN
- Understanding how MP-BGP is used as a control plane
- Packet Walk with VXLAN
- Design options and additional use cases

Agenda

- Data Center evolution
- Overlay Taxonomy
- VXLAN with MP-BGP EVPN Control Plane
- Packet Walk
- VXLAN Design Options
- Use cases

Data Center “Fabric” Journey

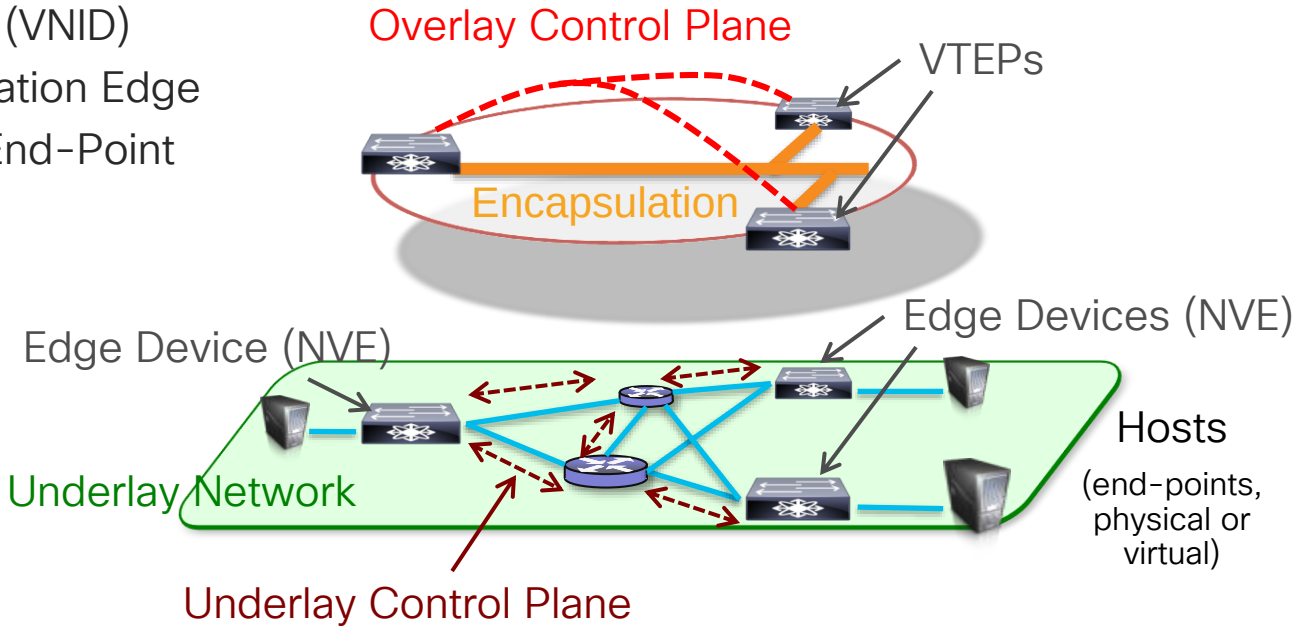


Why VXLAN Overlay

Customer Needs	VXLAN Delivered
Any workload anywhere – VLANs limited by L3 boundaries	Any Workload anywhere- across Layer 3 boundaries
VM Mobility	Seamless VM Mobility
Scale above 4k Segments (VLAN limitation)	Scale up to 16M segments
Efficient use of bandwidth	Leverages ECMP for optimal path usage over the transport network
Secure Multi-tenancy	Traffic & Address Isolation

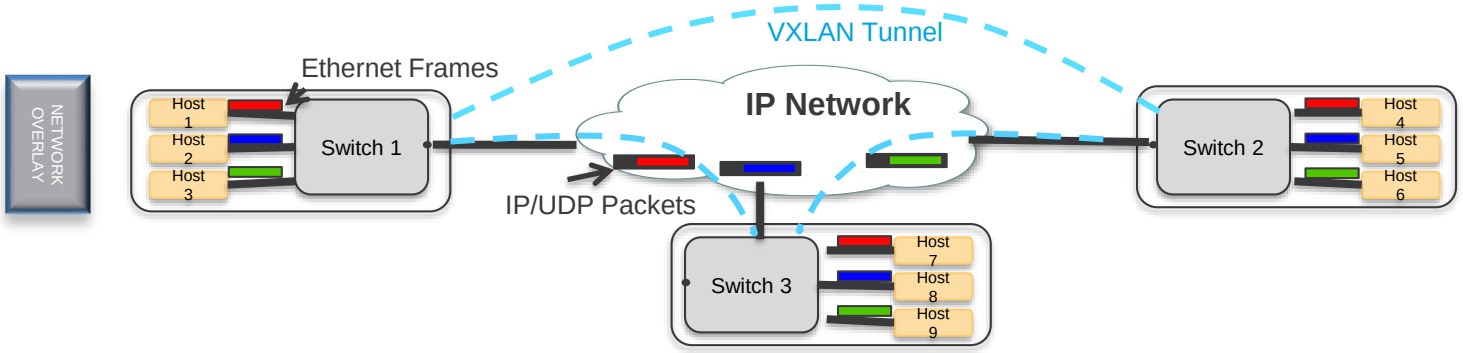
Overlay Taxonomy

Identifier = VN Identifier (VNID)
NVE = Network Virtualisation Edge
VTEP = VXLAN Tunnel End-Point

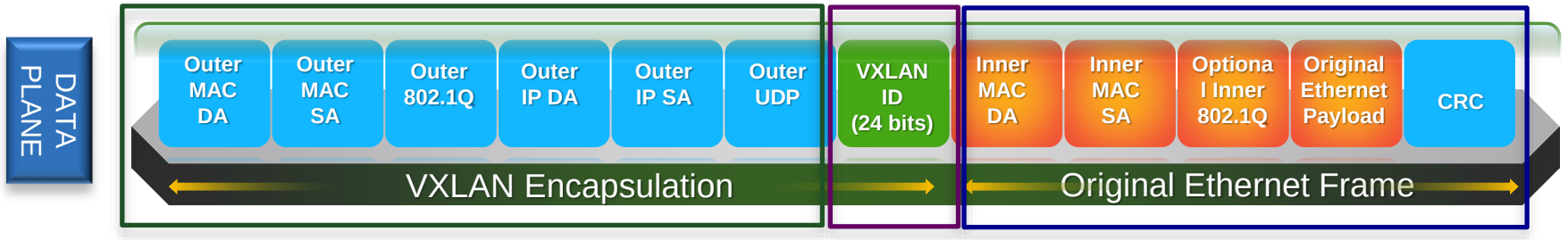


VXLAN Packet

- VXLAN is 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)

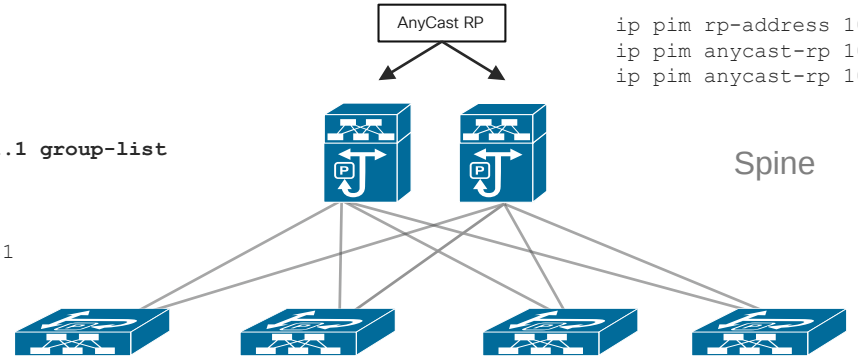


Lets Build a VXLAN Fabric

VXLAN Fabric – Creating the underlay network

IP routed Network

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




```
ip pim rp-address 10.237.1.1 group-list 224.0.0.0/4
ip pim anycast-rp 10.237.1.1 10.255.255.101
ip pim anycast-rp 10.237.1.1 10.255.255.102
```

```
ip pim rp-address 10.237.1.1 group-list
224.0.0.0/4

interface Ethernet1/49
  ip address 192.168.1.0/31
  mtu 9216
  ip pim sparse-mode
```

```
router ospf 1
interface Ethernet1/50
  mtu 9216
  ip address 192.168.1.10/31
  ip router ospf 1 area 0.0.0.0
```

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
- Centralized Gateway
- Security Risk

- Increased scale and stability
- Optimized workload mobility
- Distributed Anycast Gateway
- Increased Security

VXLAN BUM Traffic Handling

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

BUM 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

VXLAN with BGP EVPN Control Plane

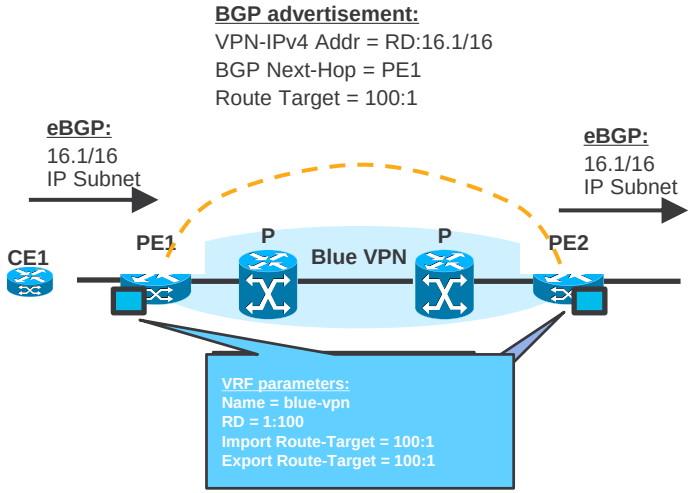
EVPN Primer --- MP-BGP Review

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

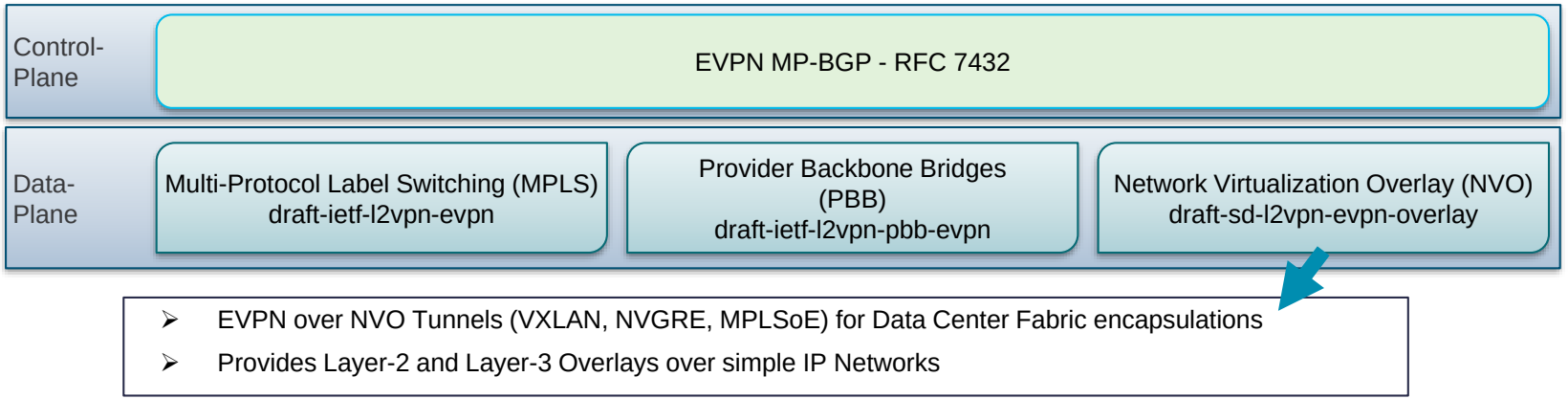
Selective distribute VPN routes:
Route Target (RT): 8-byte field, VRF parameter, unique value to define the import/export rules for VPNv4 routes

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



What is VXLAN/EVPN?

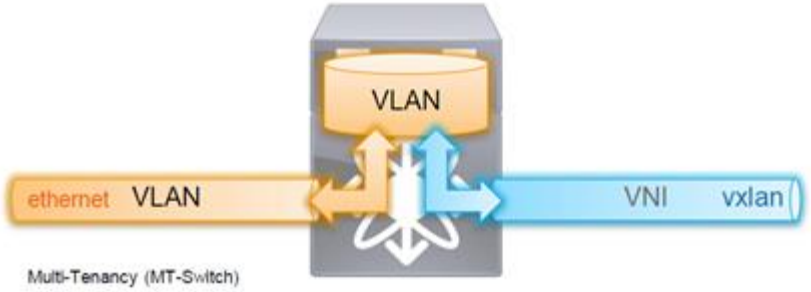
- Standards based Overlay (VXLAN) with Standards based Control-Plane (BGP)
- Layer-2 MAC and Layer-3 IP information distribution by Control-Plane (BGP)
- Forwarding decision based on Control-Plane (minimizes flooding)
- Integrated Routing/Bridging (IRB) for Optimized Forwarding in the Overlay



Layer 2 Multi-tenancy

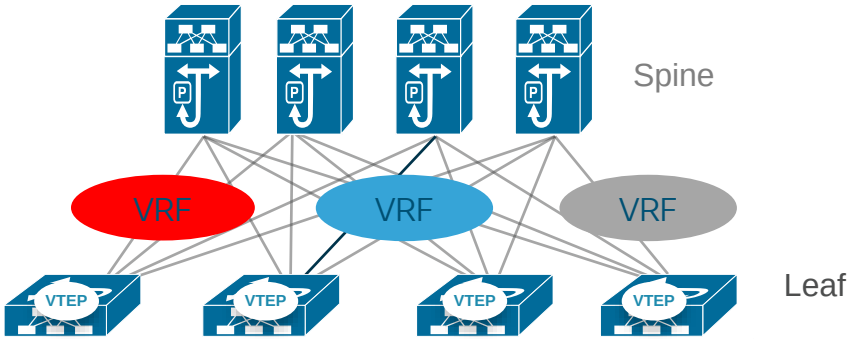
Switch level multi-tenancy

- VLAN to Segment ID mapping (4K vlans per switch)
- With VLAN we can achieve per port significance



Layer 3 Multi-tenancy

Tenants or VRF for L3 logical separation

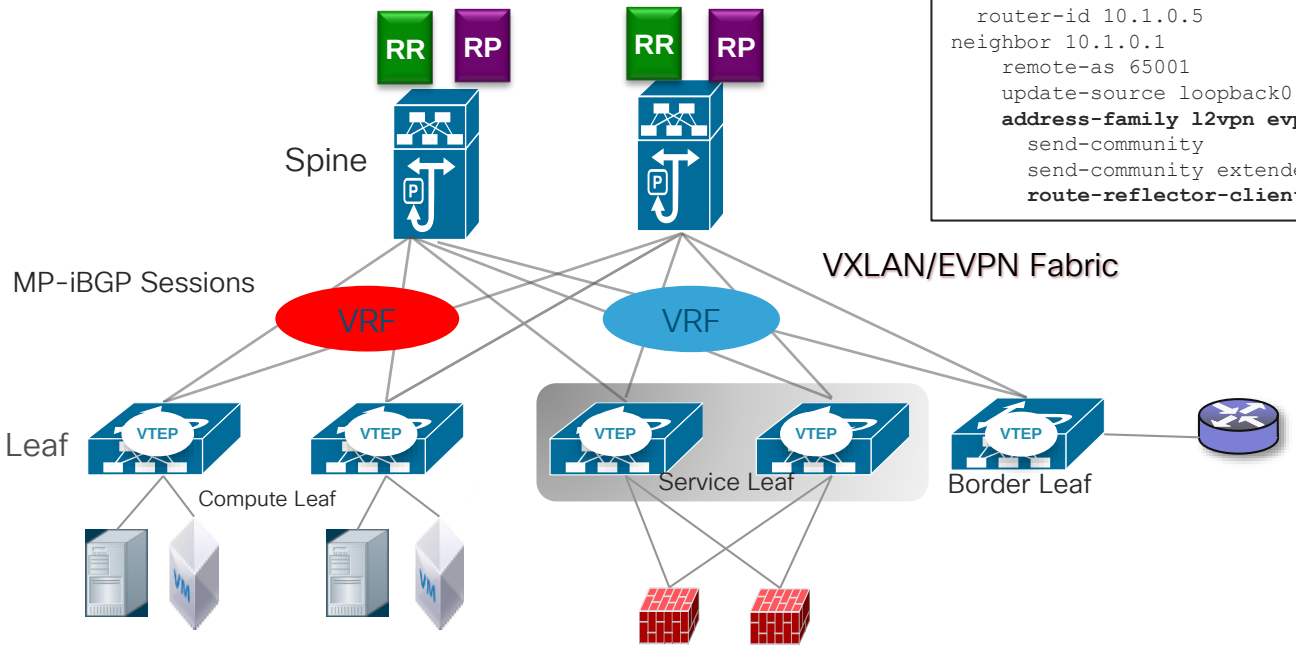


EVPN based VXLAN Fabric

RR EVPN Route Reflector

RP Rendezvous Point (Underlay)

```
! leaf bgp config
router bgp 65001
  router-id 10.1.0.4
  neighbor 10.1.0.5
    remote-as 65001
    update-source loopback0
    address-family l2vpn evpn
      send-community
      send-community extended
  vrf VRF-RED
    address-family ipv4 unicast
      advertise l2vpn evpn
    address-family ipv6 unicast
      advertise l2vpn evpn
  vrf VRF-BLUE
    address-family ipv4 unicast
      advertise l2vpn evpn
    address-family ipv6 unicast
      advertise l2vpn evpn
```

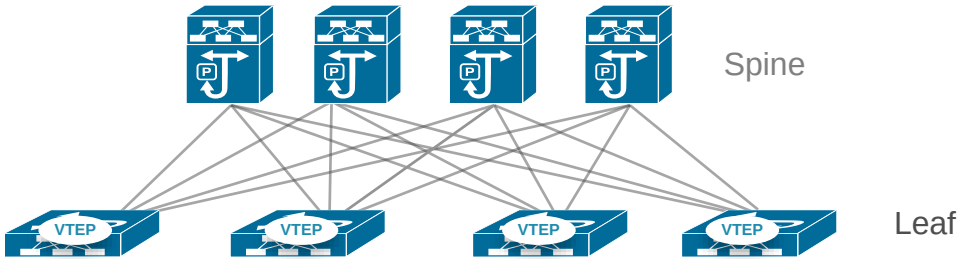



```
! spine bgp config

router bgp 65001
  router-id 10.1.0.5
neighbor 10.1.0.1
    remote-as 65001
    update-source loopback0
    address-family l2vpn evpn
      send-community
      send-community extended
      route-reflector-client
```

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

Configuration Snippet

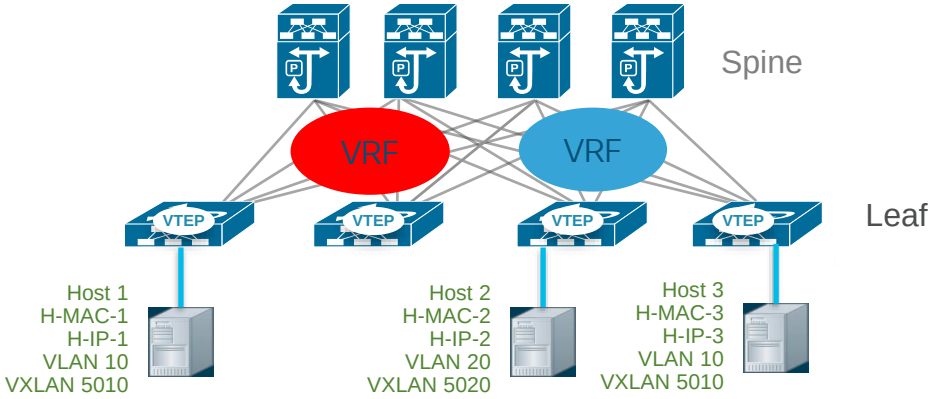
```
Vlan 10
 vn-segment 5010
Vlan 20
 vn-segment 5020

Vlan 1000
 !Layer 3 VNI
 vn-segment 9999
Vlan 2000
 !Layer 3 VNI
 vn-segment 9998

interface Vlan10
  no shutdown
  vrf member VRF-RED
  ip address 192.168.10.254/24 tag 12345
  ipv6 address 2001::1/64 tag 12345
  fabric forwarding mode anycast-gateway

interface Vlan20
  no shutdown
  vrf member VRF-BLUE
  ip address 192.168.20.254/24 tag 12345
  ipv6 address 2002::1/64 tag 12345
  fabric forwarding mode anycast-gateway

interface nve1
  source-interface loopback0
  host-reachability protocol bgp
  member vni 5010
    mcast-group 239.1.1.1
  member vni 5020
    mcast-group 239.1.1.1
  member vni 9999 associate-vrf
  member vni 9998 associate-vrf
```

Layer 2 VNI

Layer 3 VNI

Map L2VNI to NVE

Associate L3VNI to NVE



Layer 3 VNI

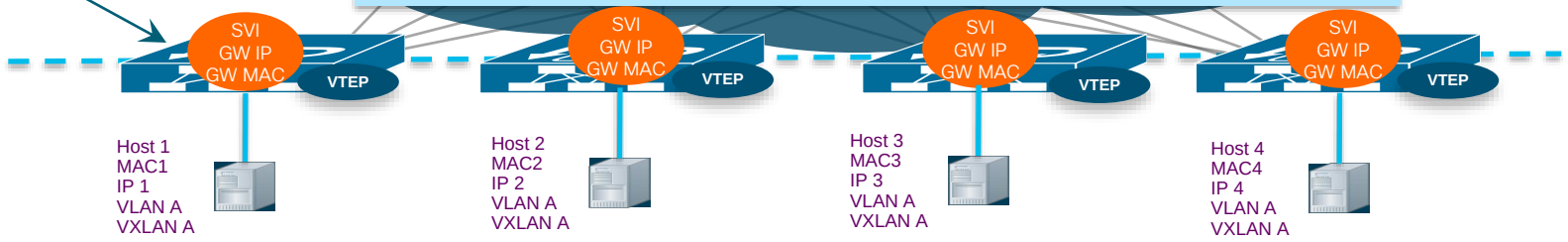
```
vrf context VRF-RED
  vni 9999
  rd auto
  address-family ipv4 unicast
    route-target both auto
    route-target both auto evpn
evpn
  vni 5010 l2
    rd auto
    route-target both auto
```

```
vrf context VRF-BLUE
  vni 9998
  rd auto
  address-family ipv4 unicast
    route-target both auto
    route-target both auto evpn
evpn
  vni 5020 l2
    rd auto
    route-target both auto
```

Distributed Anycast Gateway in MP-BGP EVPN

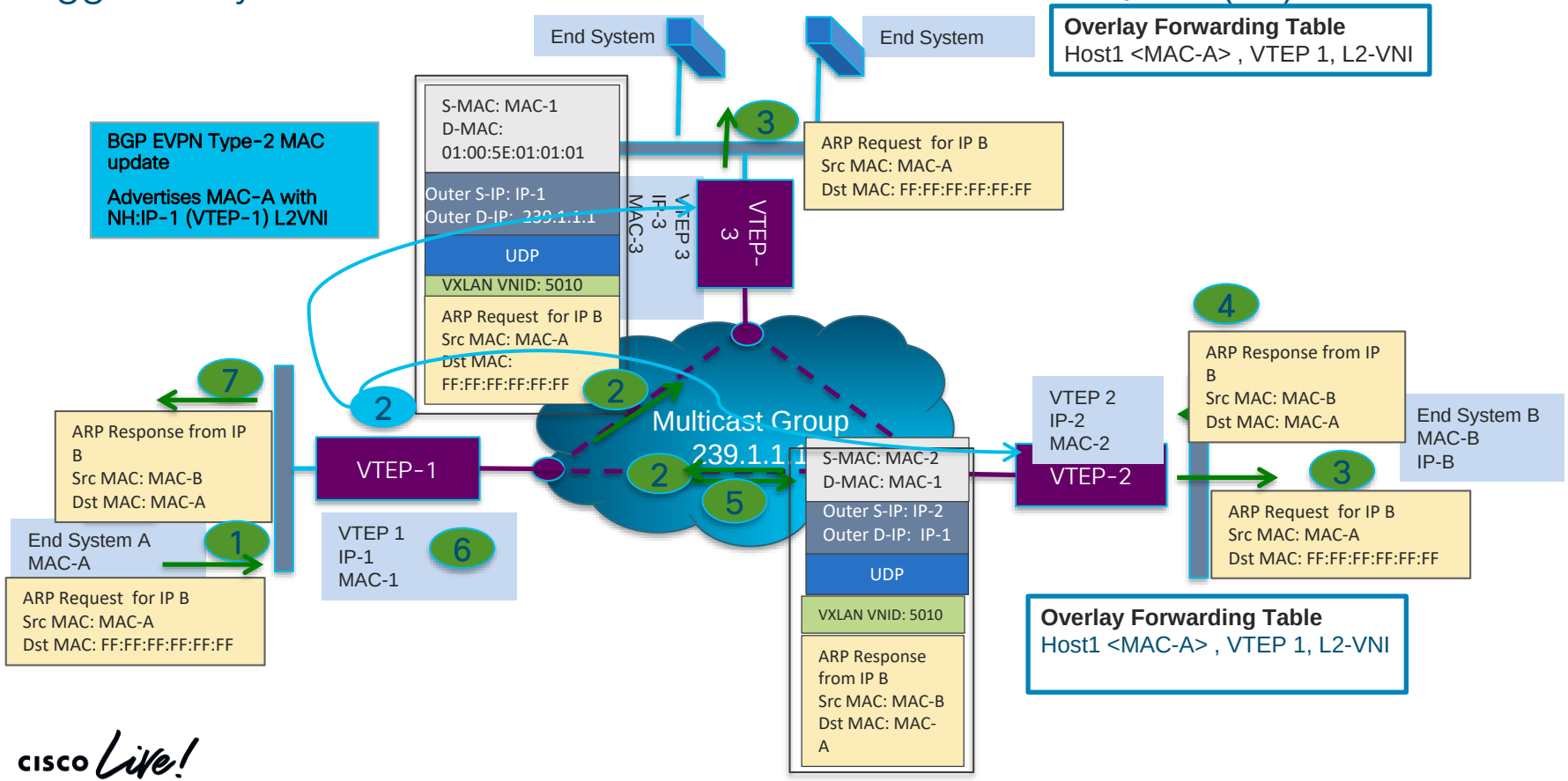
The same anycast gateway virtual IP address and MAC address are configured on all VTEPs in the VNI.

```
# VLAN to VNI mapping
vlan 20
 vn-segment 5020

# 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 20
 no shutdown
 vrf member VRF-BLUE
 ip address 192.168.20.254/24
 ipv6 address 2002::1/64
 fabric forwarding mode anycast-gateway
```



EVPN Peer and Endpoint(Host) Discovery

Triggered by Host Communication across the same VLAN/VNI (L2)



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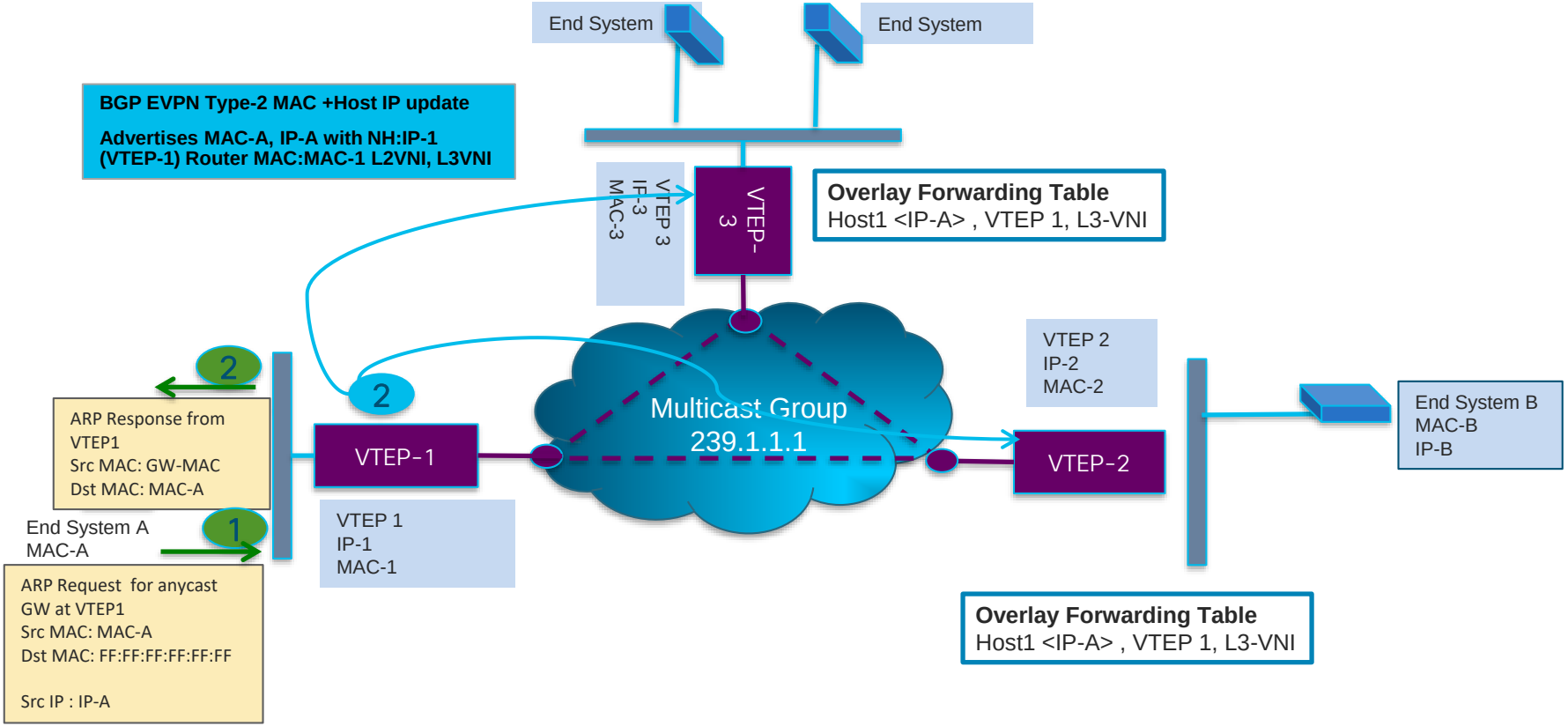
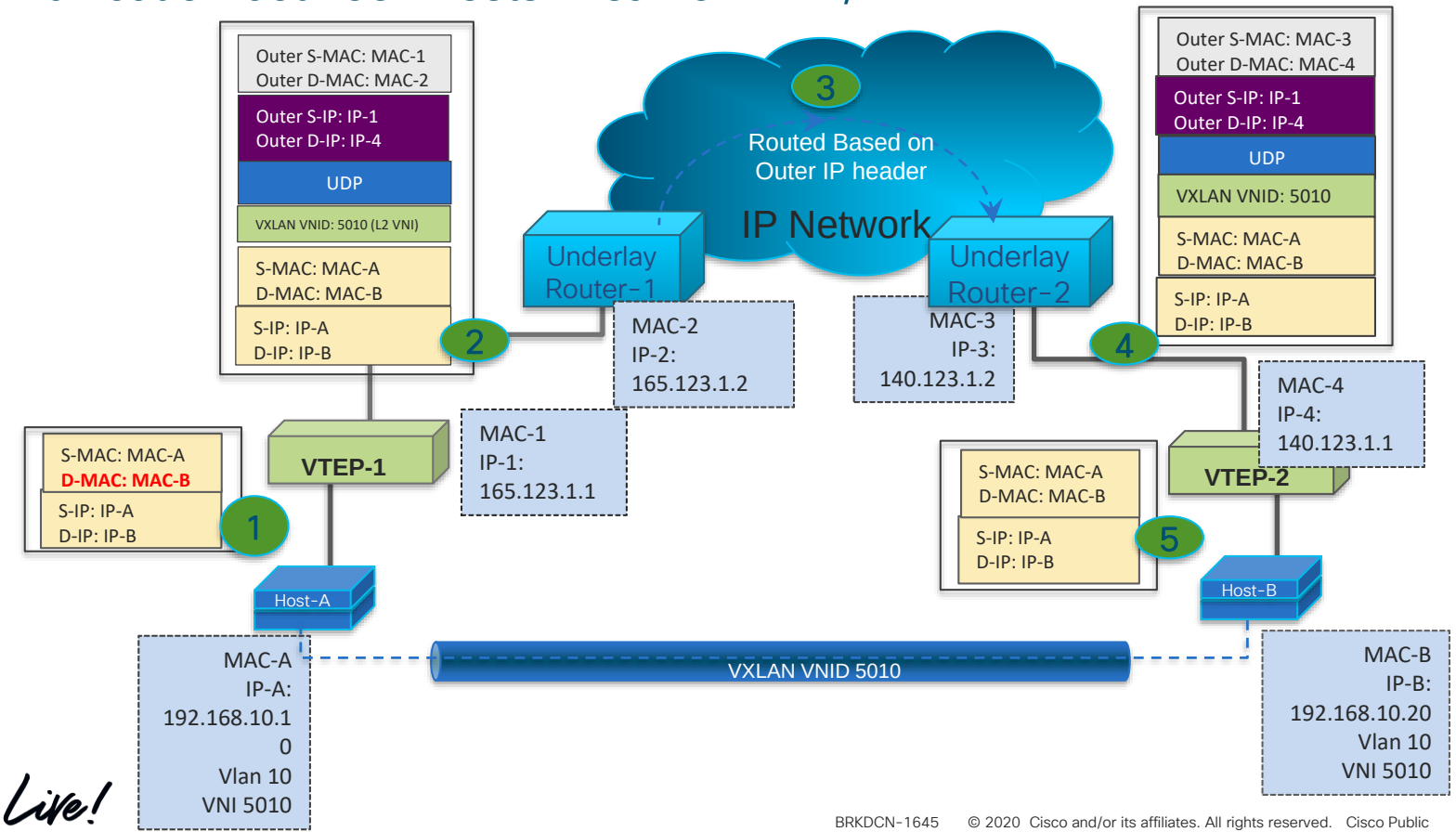
EVPN Peer and Endpoint(Host) Discovery

Triggered by Host Communication between VLAN/VNI (L3)



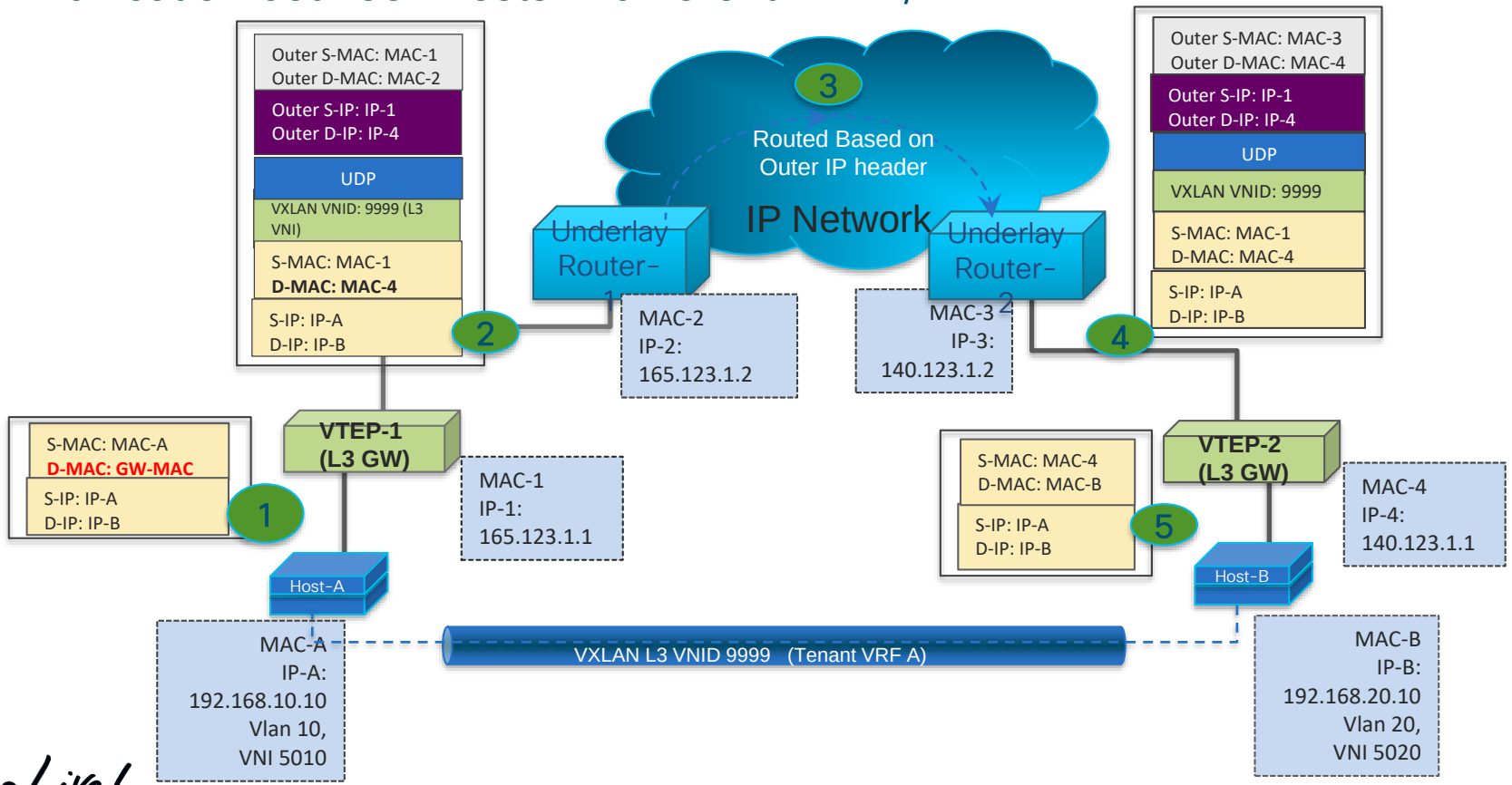
Packet Walk

Communication between hosts in same VLAN/VNI



Packet Walk

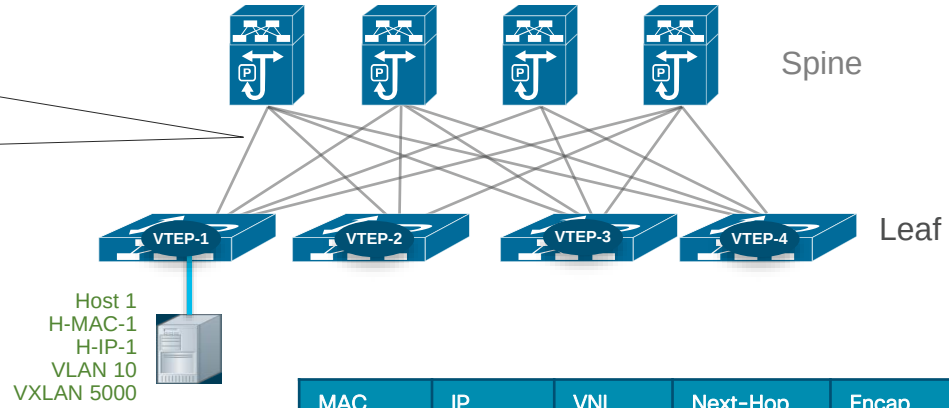
Communication between hosts in different VLAN/VNI



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



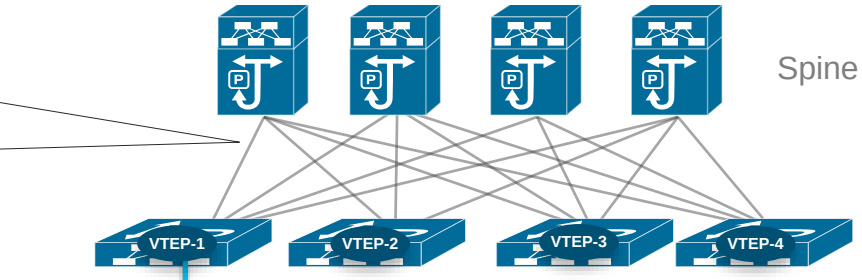
MAC	IP	VNI	Next-Hop	Encap	Seq#
H-MAC-1	H-IP-1	5000	VTEP-1	VXLAN	0

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 from VTEP 3 with a higher sequence number and prefer that update

EVPN Control Plane --- ARP Suppression

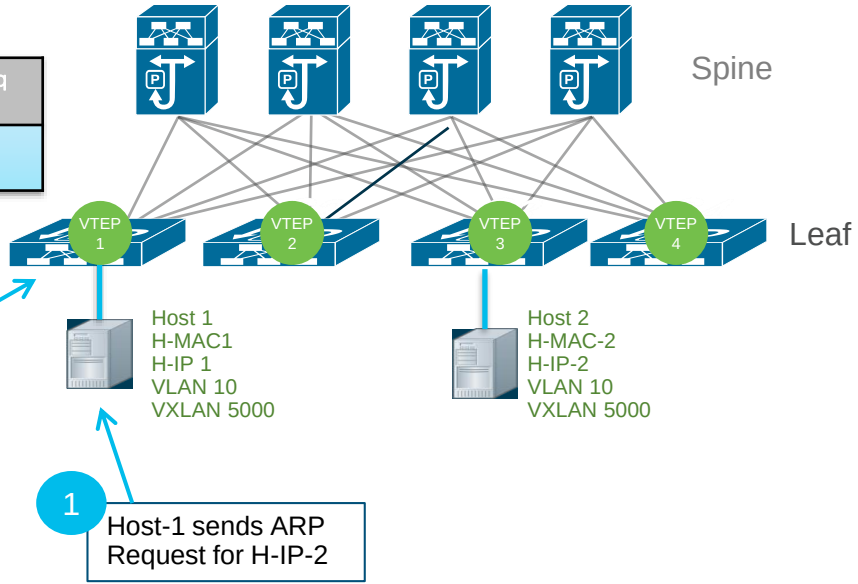
Minimize flood-&-learn behavior for host learning

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 an 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

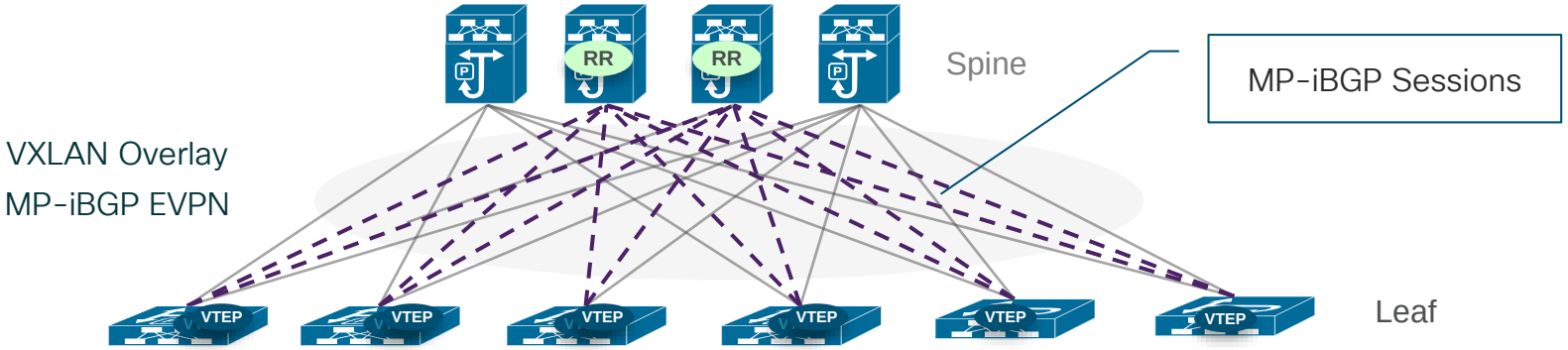


Functions of VXLAN/EVPN

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

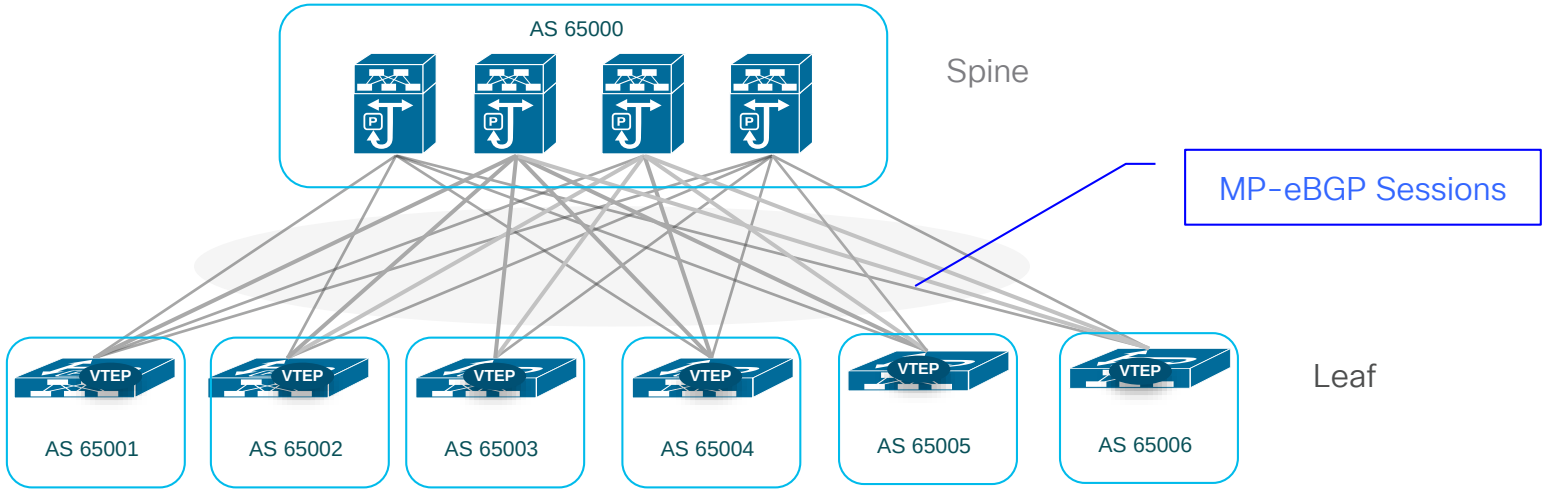
Design Options and Use case

VXLAN Fabric Design with MP-iBGP EVPN



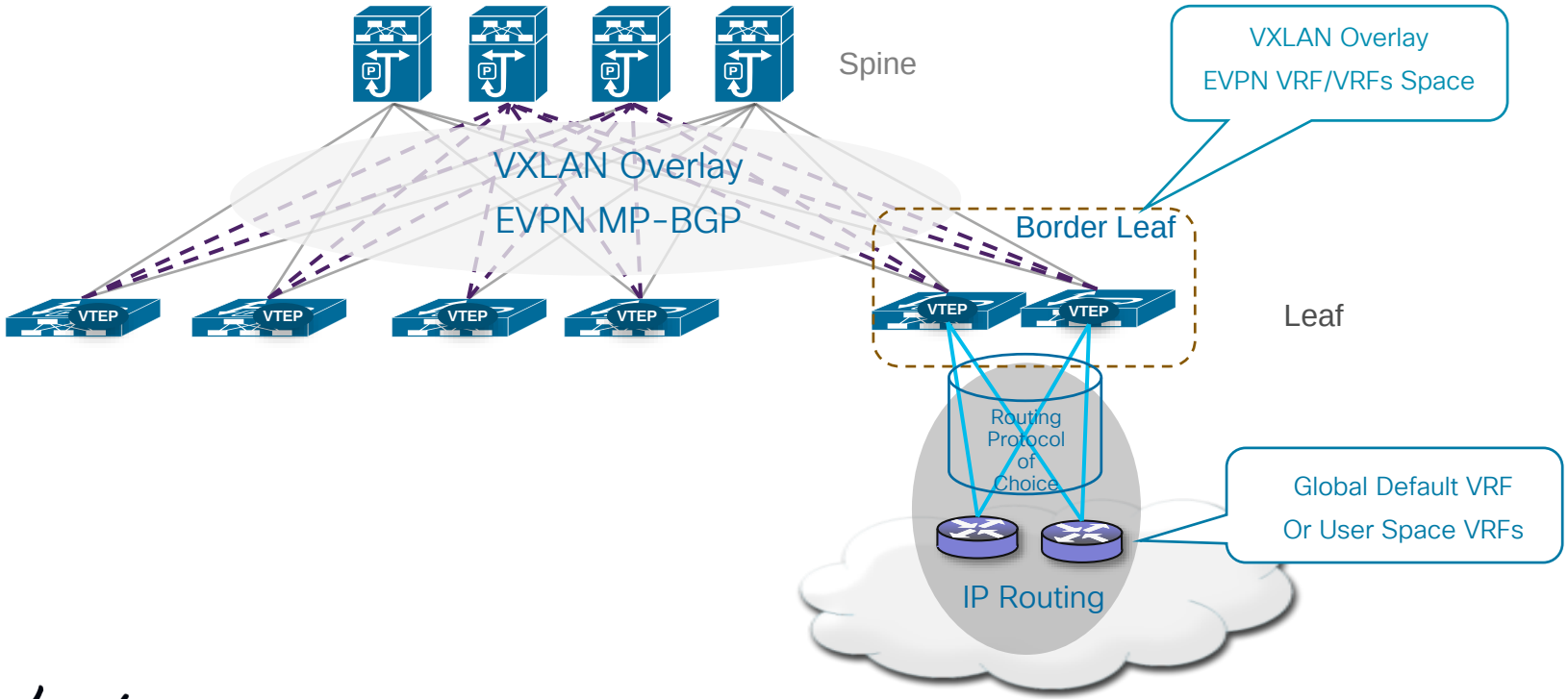
- VTEP Functions are on leaf layer
- Spine nodes are iBGP route reflector
- Spine nodes don’t need to be VTEP

VXLAN Fabric Design with MP-eBGP EVPN

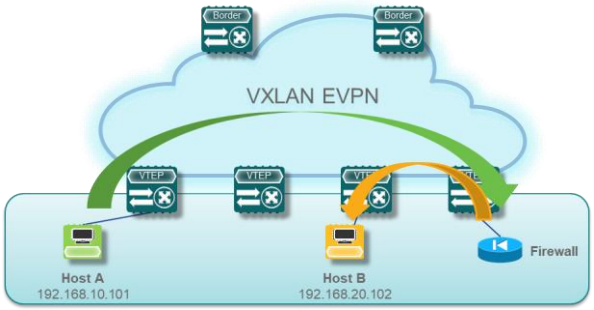


- VTEP Functions are on leaf layer
- Spine nodes are MP-eBGP Peers to VTEP leafs
- Spine nodes don't need to be VTEP
- VTEP leafs can be in the same or different BGP AS's

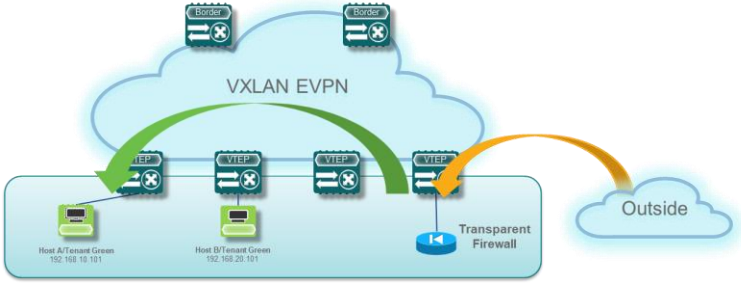
VXLAN Fabric – External Routing



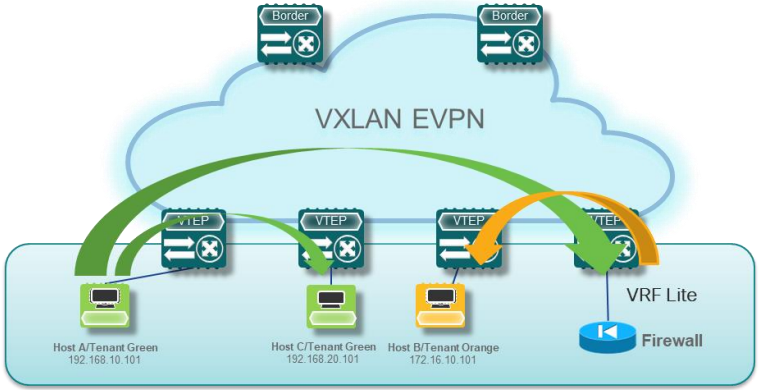
VXLAN Fabric – Service Insertion



Firewall as a default gateway : Centralized Gateway- Firewall bottleneck



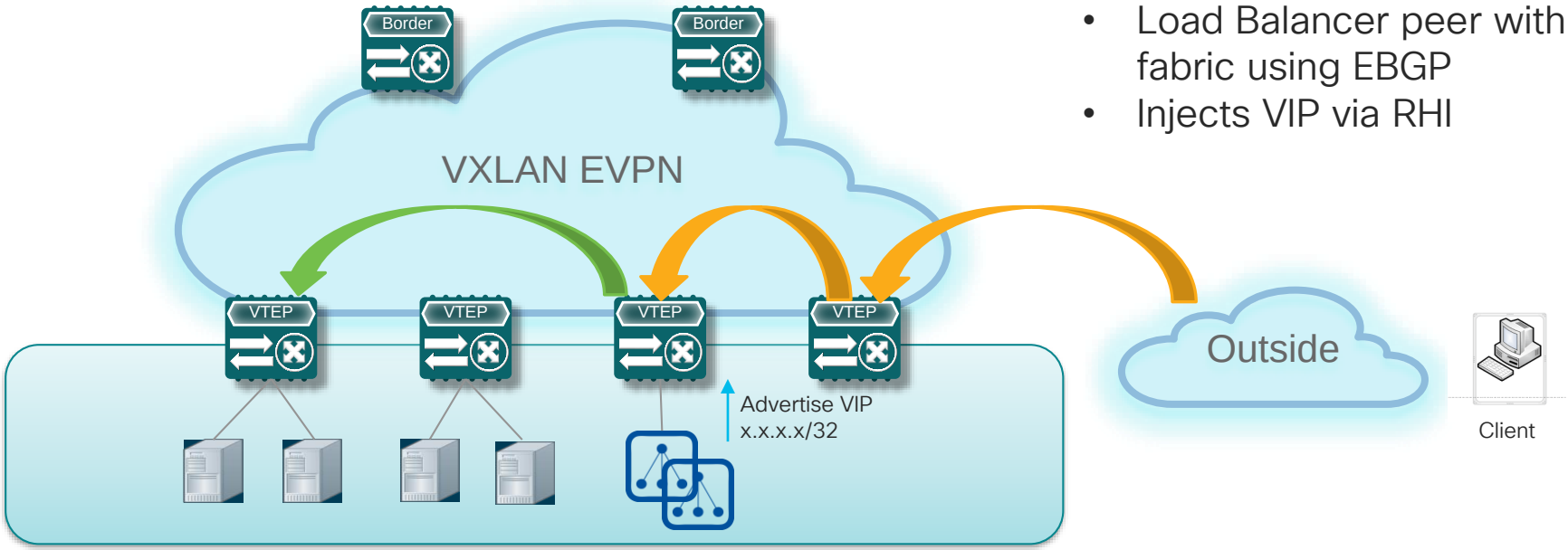
Transparent Firewall : Inspect and then bridge Traffic between “dirty” VLAN and “clean” VLAN



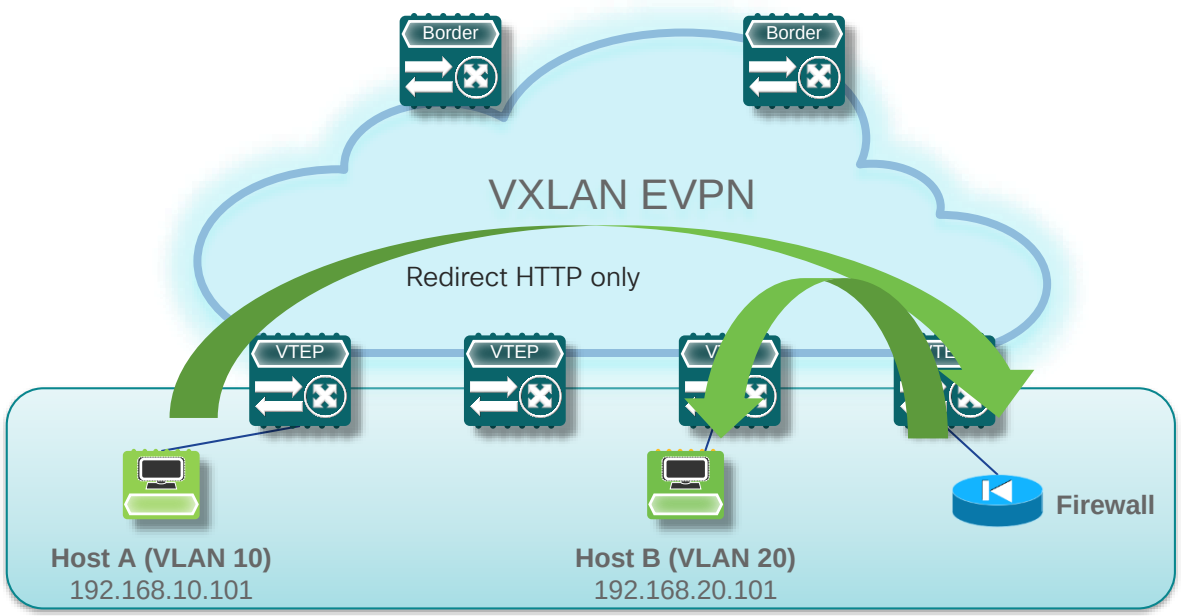
Tenant Edge Firewall: Traffic between Tenants/VRFs routed via the firewall

VXLAN Fabric – Service Insertion

- Load Balancer Integration
- Load Balancer peer with fabric using EBGP
- Injects VIP via RHI



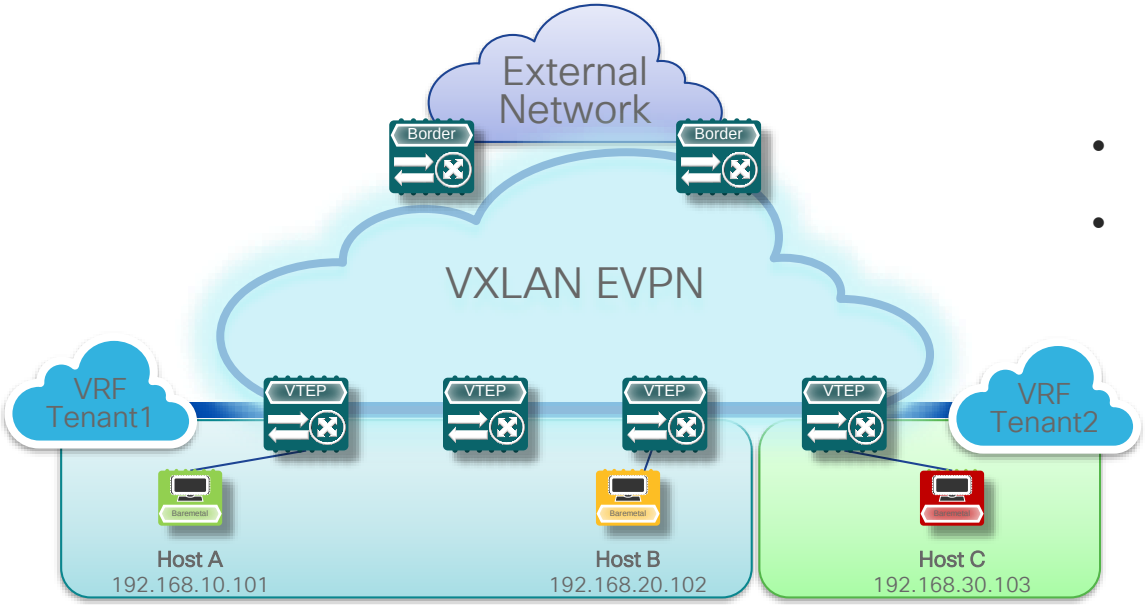
VXLAN Fabric – Selective Traffic Redirection



- Leverages Policy Based Redirect
- Inter VLAN traffic bypass default routing lookup and redirected
- Service Redirection to Load Balancers, Firewalls etc.

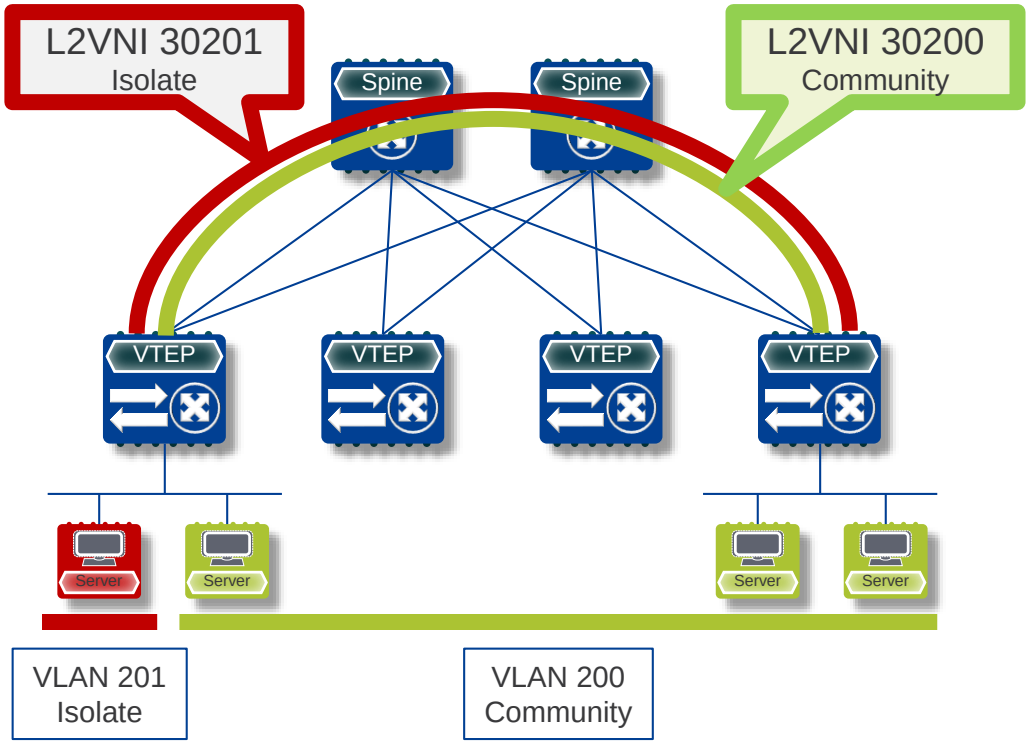
VXLAN Fabric – Centralized Route Leaking

Extranet Support



- Use Cases – Shared Services, External Connectivity
- VRF to VRF or VRF to Default
- Centralize Location for leaking routes

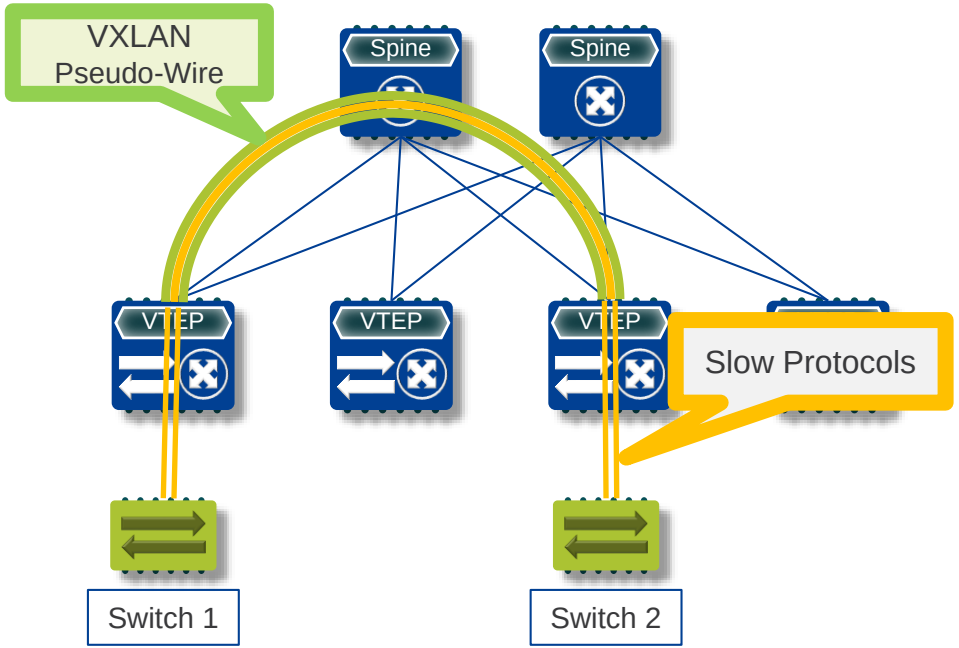
VXLAN Fabric – Private VLAN over VXLAN



Private VLAN with VXLAN

- Extending Private VLAN over VXLAN
- Sub-VLAN Segmentation
- Availability of 2nd VLAN Modes
  - Community VLAN across VXLAN
  - Promiscuous VLAN across VXLAN
  - Isolate VLAN localized but extended across VXLAN

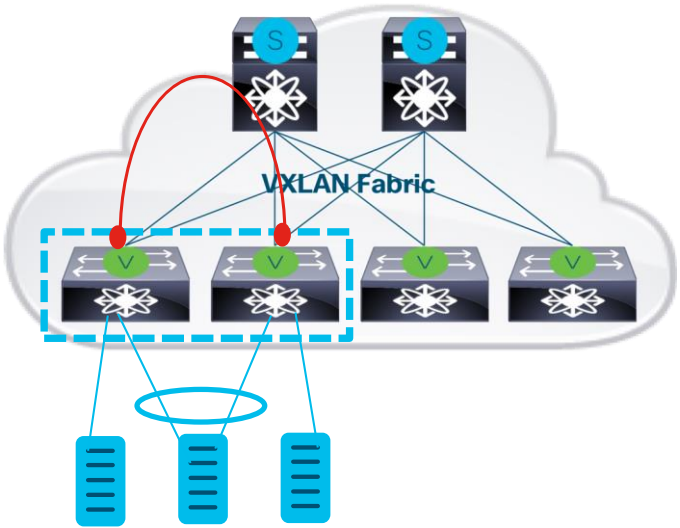
VXLAN Fabric – VXLAN Pseudo wire(Xconnect)



VXLAN Pseudo-Wire

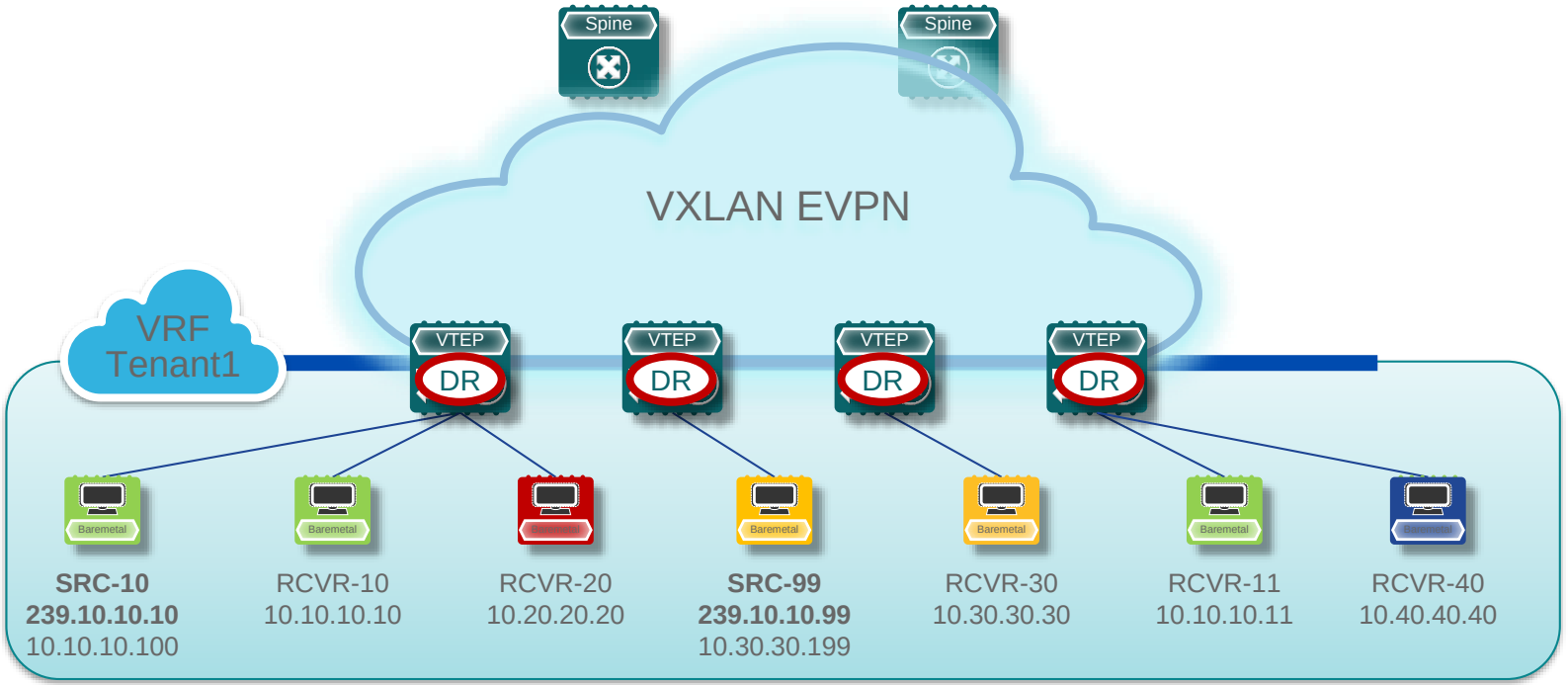
- Cross-Connect (X-Connect) concept
  - Point-2-Point
- Enables Protocol Tunneling for
  - STP, CDP, LLDP, PAGP, LACP, BFD

Peerlink-Less VPC

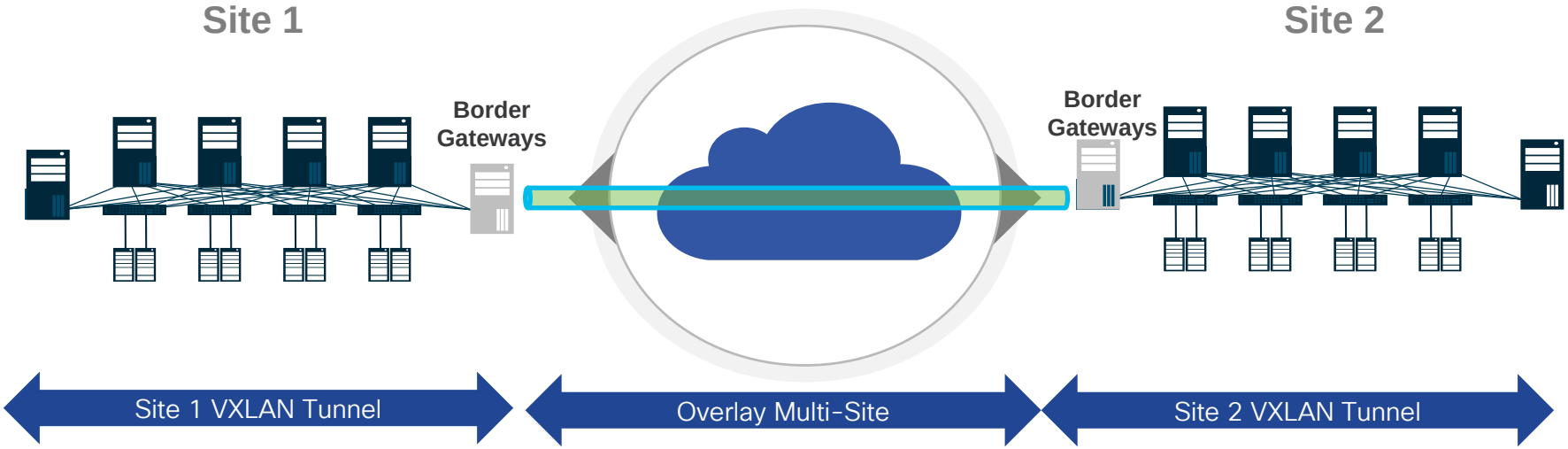


- Enhanced dual-homing solution without wasting physical ports
- Preserve traditional vPC characteristics

VXLAN Fabric – Tenant Routed Multicast



VXLAN EVPN Multi-Site



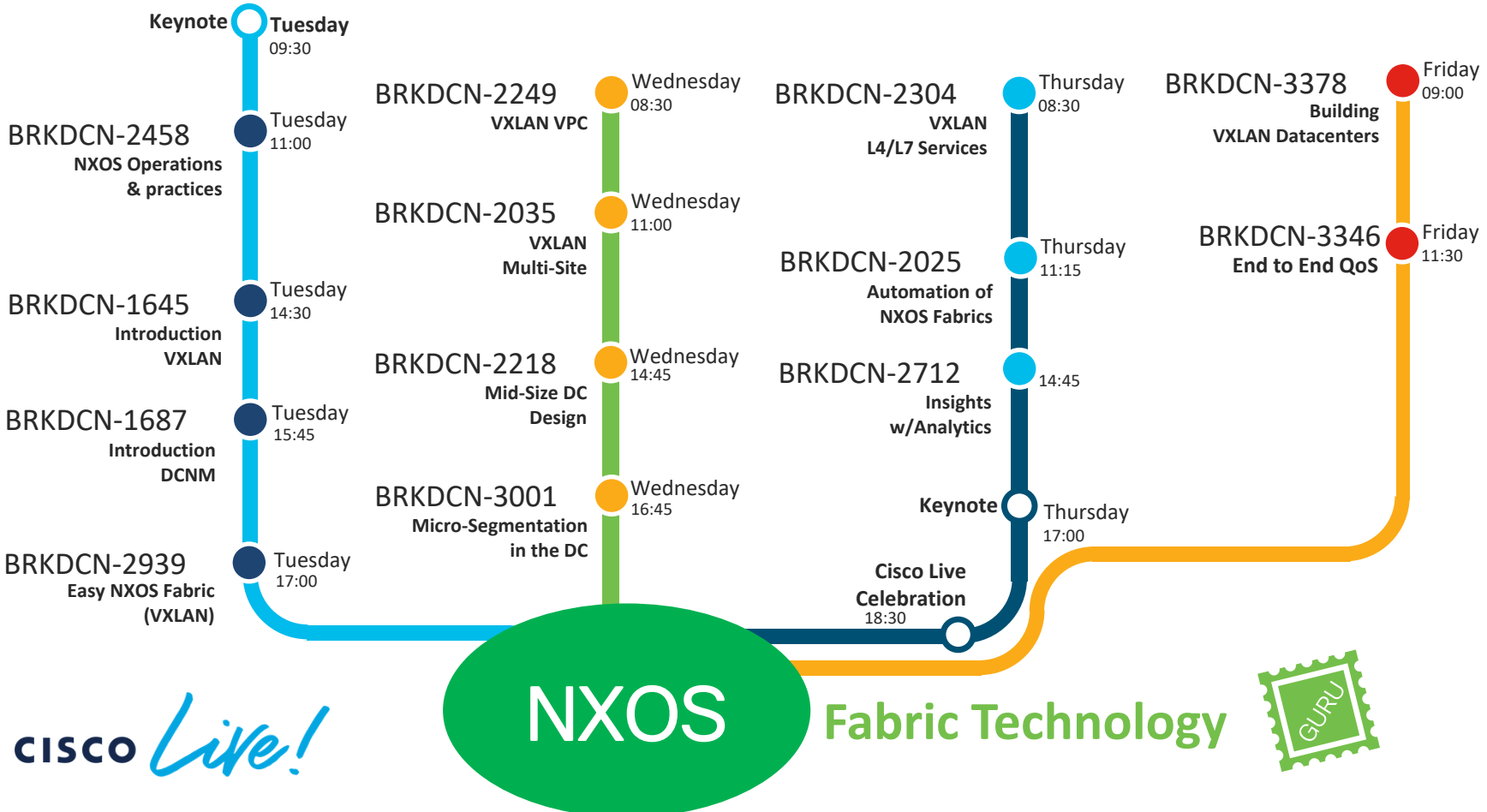
Scale through Hierarchical Forwarding

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

Summary

Summary

- VXLAN enables scalable Data Center fabrics
- BGP EVPN with VXLAN provides a robust control plane enabling multi-tenancy, VM mobility , optimizing traffic forwarding
- Seamless integration with service nodes such as Firewalls and Load balancers and ability to provide shared services
- Fabric can cater to multicast traffic in the overlay
- VXLAN as a DCI with Multi-Site


Keynote
Tuesday
09:30
BRKDCN-2458
NXOS Operations & practices
Tuesday
11:00
BRKDCN-1645
Introduction VXLAN
Tuesday
14:30
BRKDCN-1687
Introduction DCNM
Tuesday
15:45
BRKDCN-2939
Easy NXOS Fabric (VXLAN)
Tuesday
17:00
BRKDCN-2249
VXLAN VPC
Wednesday
08:30
BRKDCN-2035
VXLAN Multi-Site
Wednesday
11:00
BRKDCN-2218
Mid-Size DC Design
Wednesday
14:45
BRKDCN-3001
Micro-Segmentation in the DC
Wednesday
16:45
BRKDCN-2304
VXLAN L4/L7 Services
Thursday
08:30
BRKDCN-2025
Automation of NXOS Fabrics
Thursday
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BRKDCN-2712
Insights w/Analytics
14:45
Keynote
Thursday
17:00
Cisco Live Celebration
18:30
BRKDCN-3378
Building VXLAN Datacenters
Friday
09:00
BRKDCN-3346
End to End QoS
Friday
11:30
NXOS
Fabric Technology
GURU
CISCO Live!

Building your VTEP (VXLAN Tunnel End-Point)

FYI

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

# Spine (S1)

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

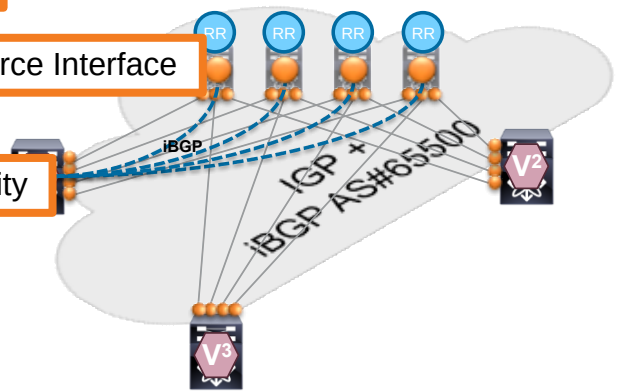
Enables VTEP (only required on Leaf or Border)

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

Building your EVPN MP-BGP Control-Plane

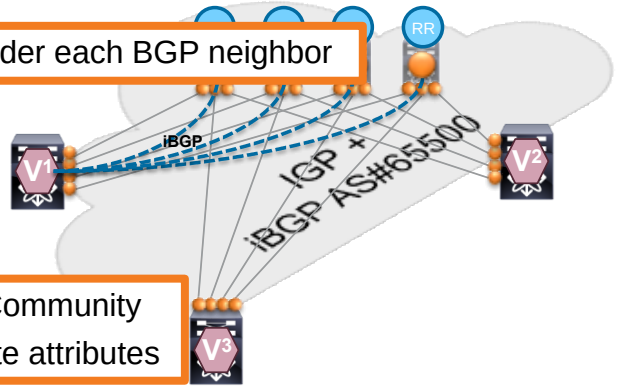
FYI

```
# 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 10.10.10.0/24 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

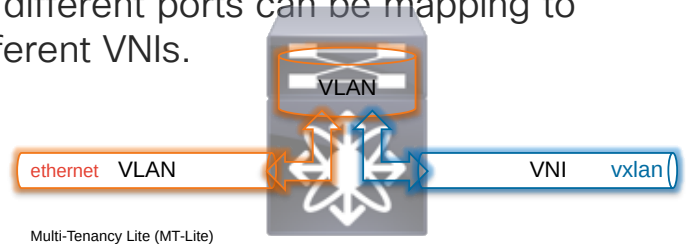
Send Extended BGP Community to distribute EVPN route attributes



Extend your VLAN to VXLAN

FYI

- 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.




```
# 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

Distributed Anycast Gateway for Extended V

FYI

- 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

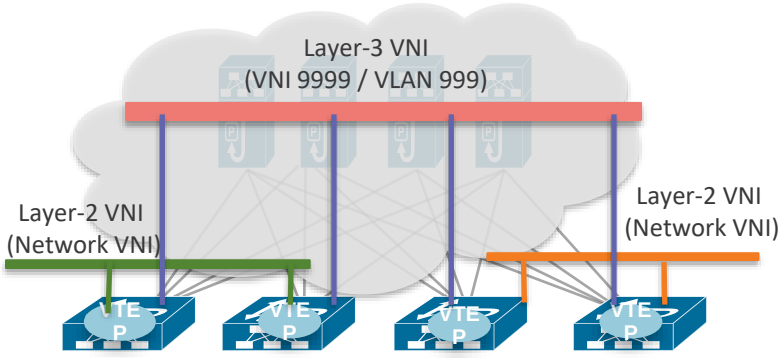
One gateway virtual MAC per VTEP

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 VRF-A
 ip address 20.0.0.1/24
 fabric forwarding mode anycast-gateway
```

Routing in VXLAN – Define the Resources

FYI



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

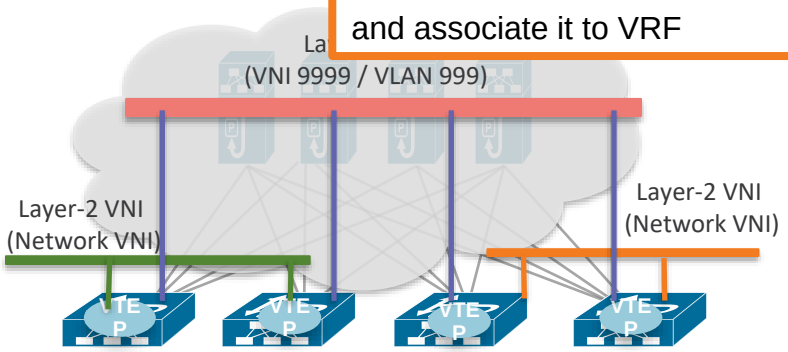
- ip forward required for prefix-based routing

VRF context definition

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

Routing in VXLAN – Configure the Routing

FYI



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

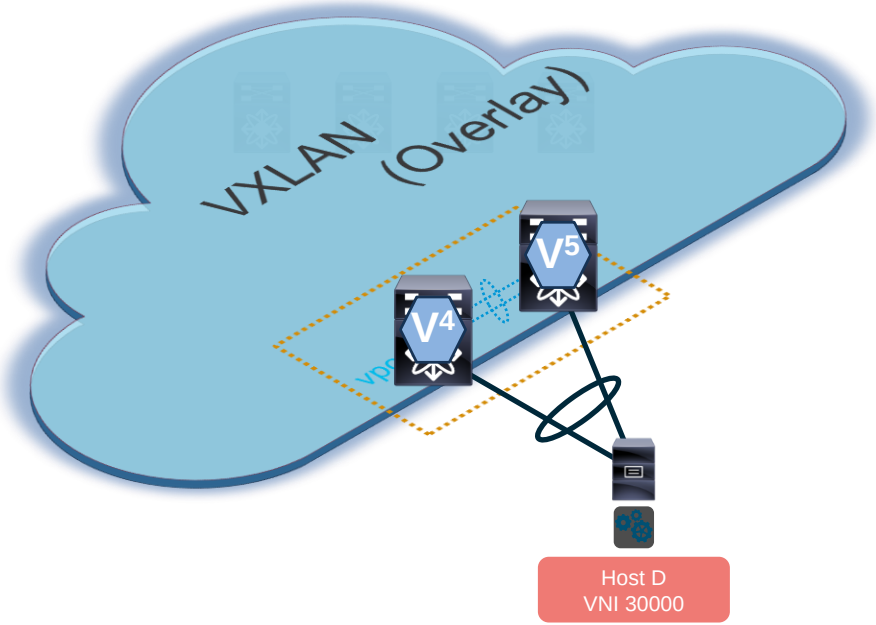
Configuration Example for VRF-A

```
# 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
```

VXLAN Hardware Gateway Redundancy (vPC)

FYI

- 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



VXLAN Hardware Gateway Redundancy (vPC)

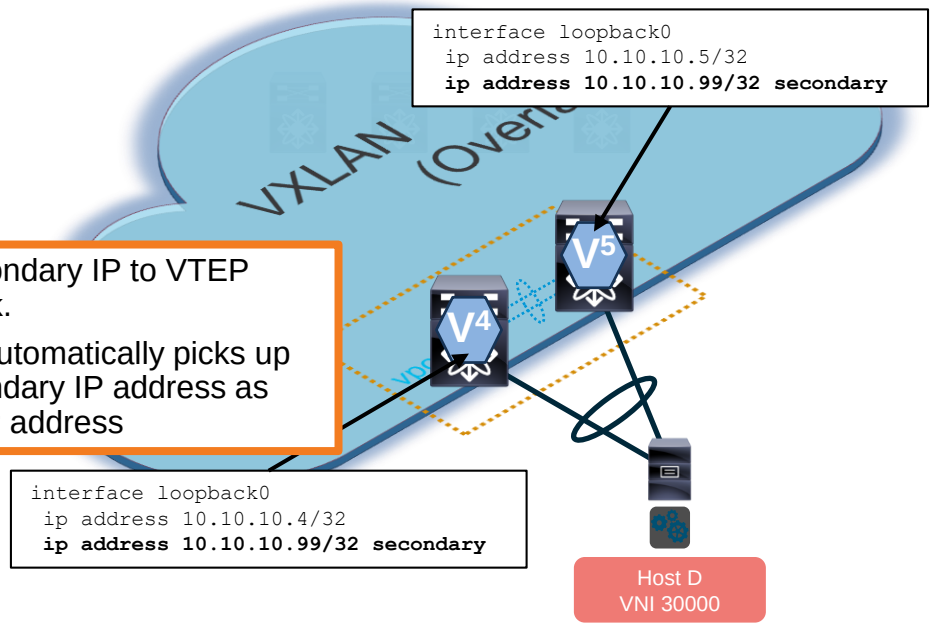
FYI

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



VXLAN Hardware Gateway Redundancy (vPC)

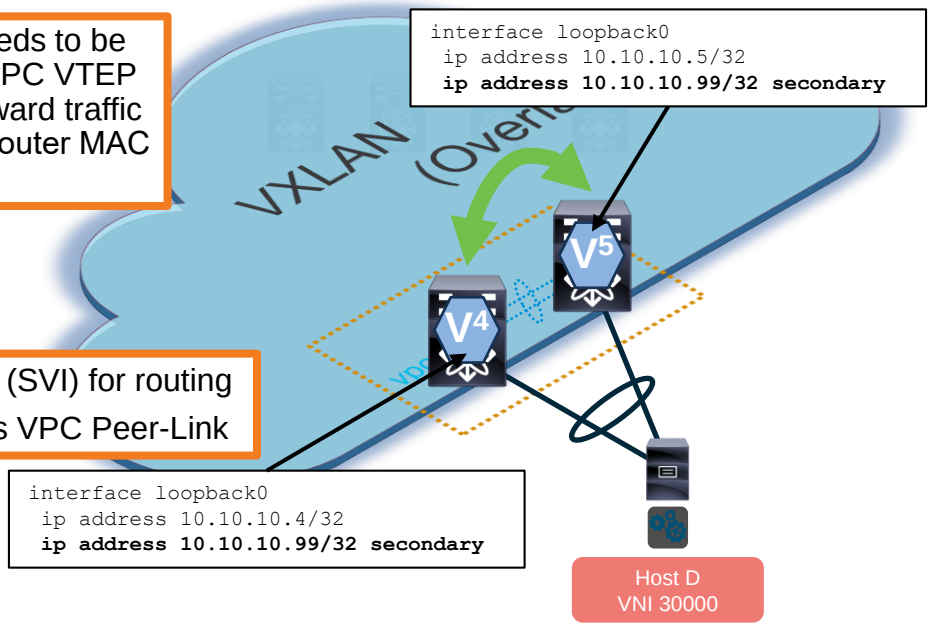
FYI

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



eBGP EVPN Configuration (1)

FYI

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 by default. Need to change the policy to next-hop unchanged

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

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
```

eBGP EVPN Configuration(2)

FYI

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

Manually configure route-target for VRF

Manually configure route-target for L2 VNI under EVPN

```
vrf context evpn-tenant-1
  vni 9999
  rd auto
  address-family ipv4 unicast
    route-target import 100:9999
    route-target import 100:9999 evpn
    route-target export 100:9999
    route-target export 100:9999 evpn
evpn
  vni 5010 l2
    rd auto
    route-target import 100:5010
    route-target export 100:5010
```

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