



We're ready.
Are you?

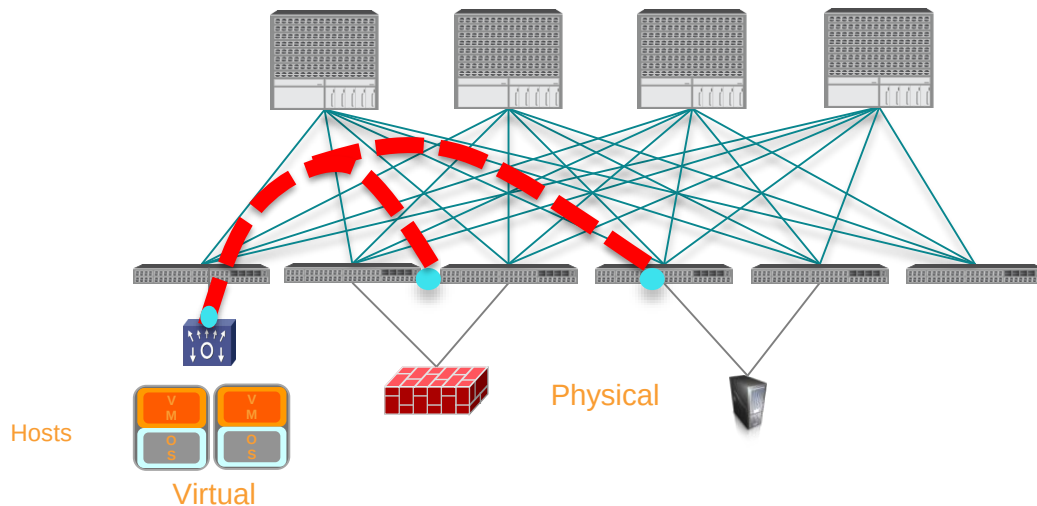
Introduction to LISP and VXLAN - Scalable Technology Overlays for Switching

Victor Moreno - Distinguished Engineer

Agenda

- Overlays and Switching Fabrics
- VXLAN encapsulation
- The EVPN Control Plane
- The LISP Control Plane
- Deployment Considerations
- Conclusion

Flexible Switching Fabrics



Mobility
Segmentation + Policy
Scale
Automated & Programmable
Full Cross Sectional BW
L2 + L3 Connectivity
Physical + Virtual

Use VXLAN to Create Overlay Networks on Switching Fabrics

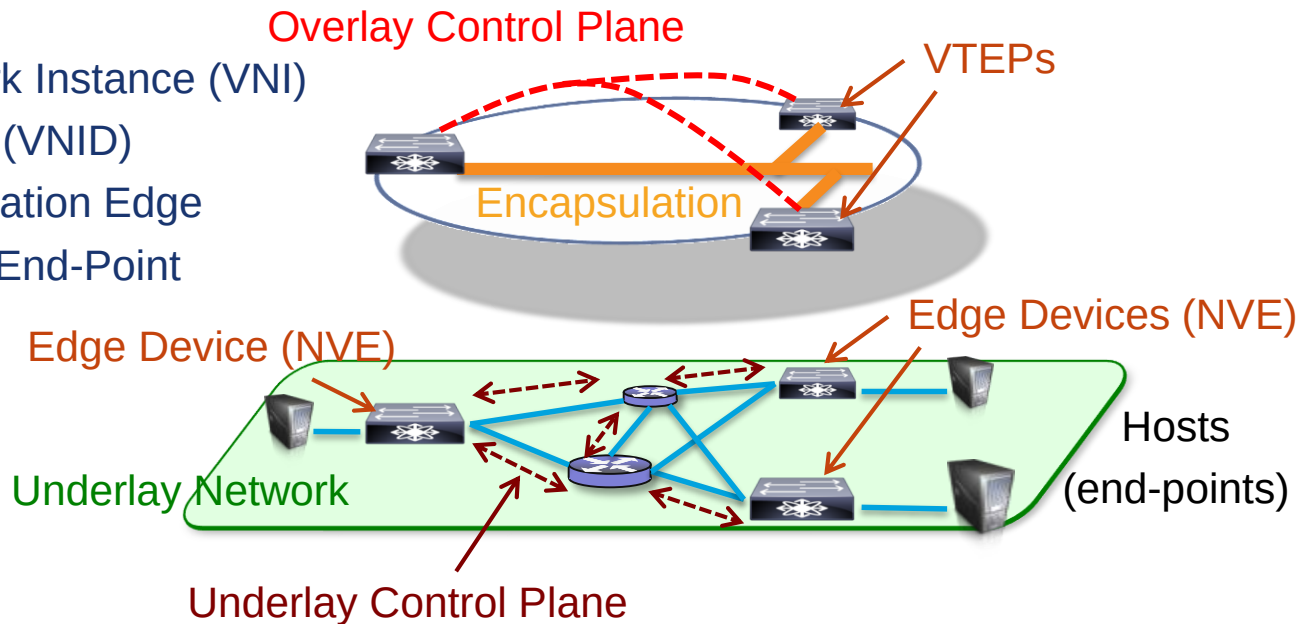
Overlay Taxonomy

Service = Virtual Network Instance (VNI)

Identifier = VN Identifier (VNID)

NVE = Network Virtualisation Edge

VTEP = VXLAN Tunnel End-Point



VXLAN Fundamentals

VXLAN is an Overlay Encapsulation

Data Plane Learning

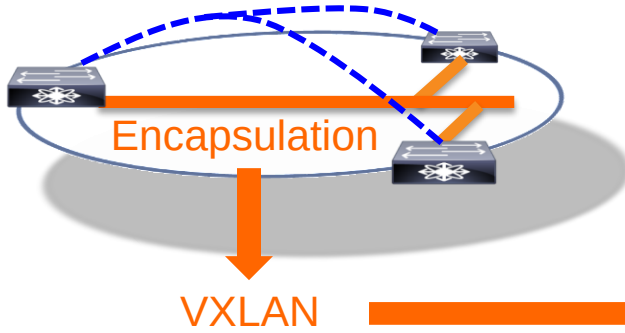
Flood and Learn over a multdestination distribution tree joined by all edge devices

Protocol Learning

Advertise hosts in a protocol amongst edge devices



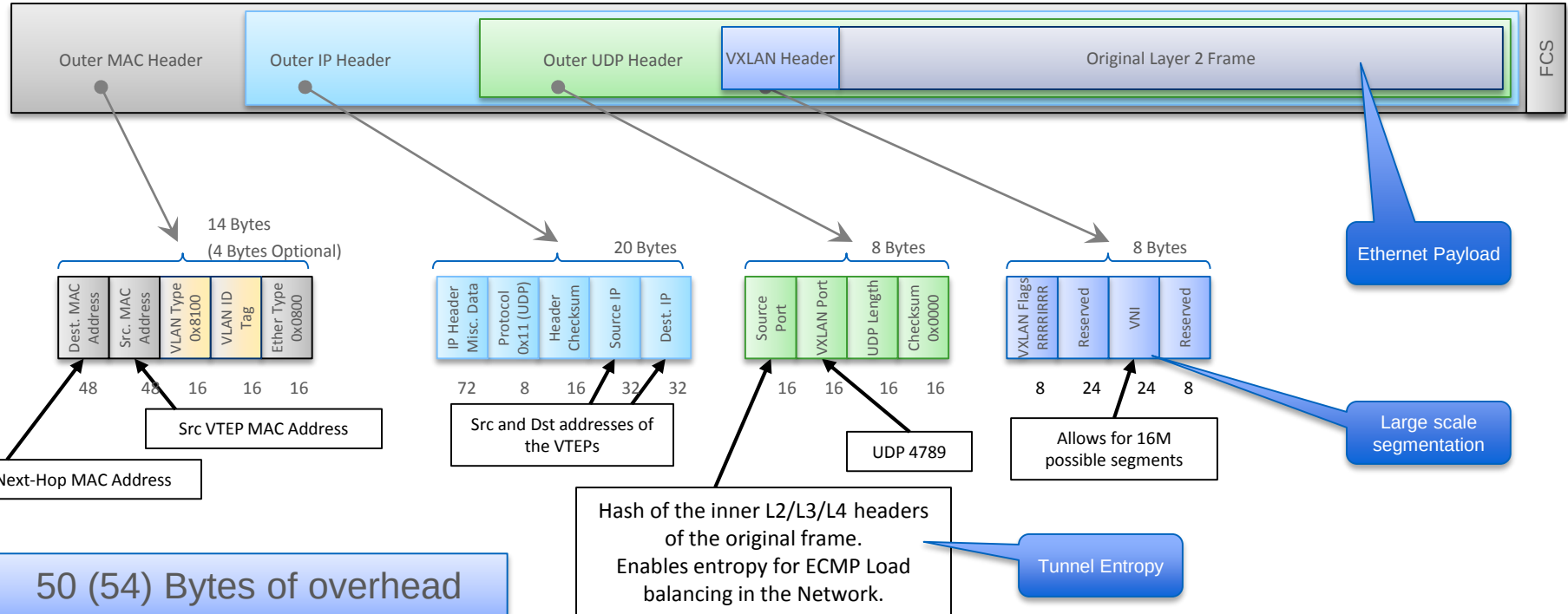
Overlay Control Plane



VXLAN

VXLAN Packet Structure

Ethernet in IP with a Shim for Scalable Segmentation

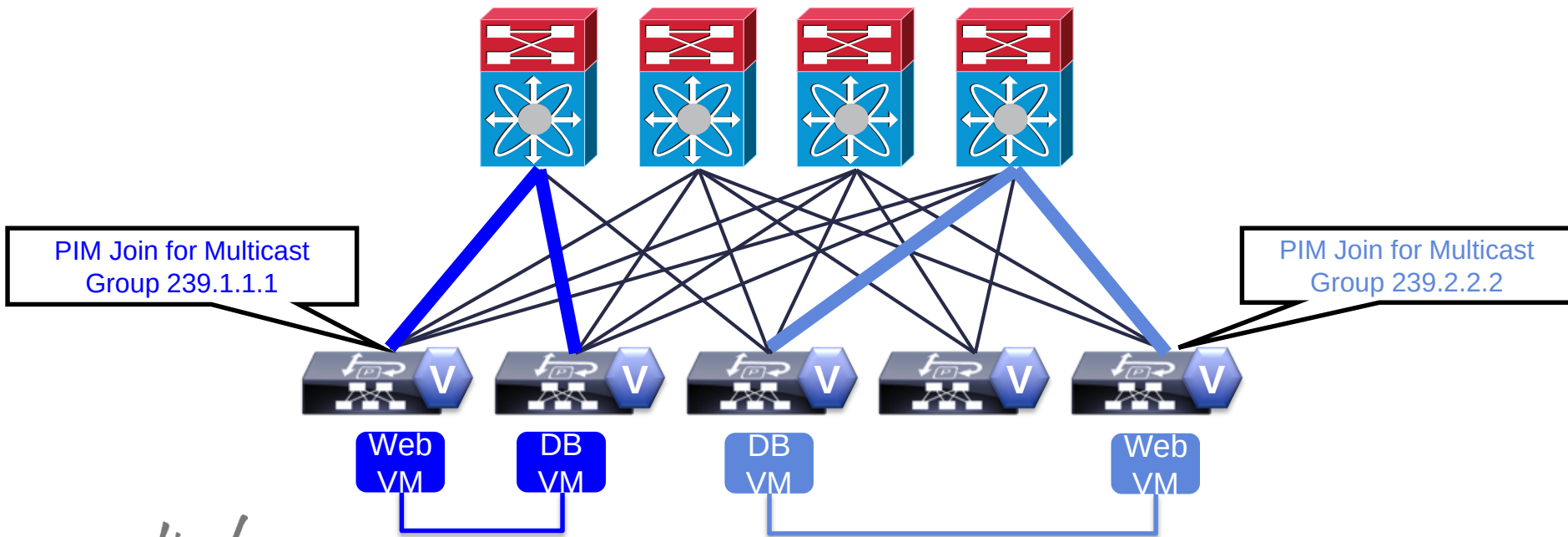


50 (54) Bytes of overhead

CiscoLive!

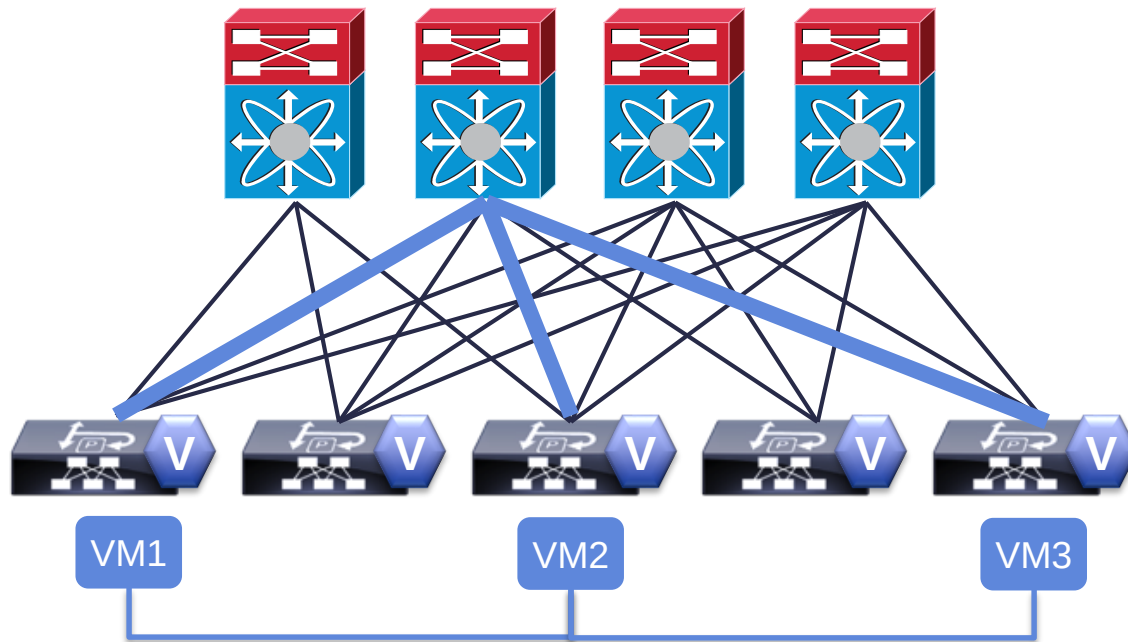
Data Plane Learning

Dedicated Multicast Distribution Tree per VNI



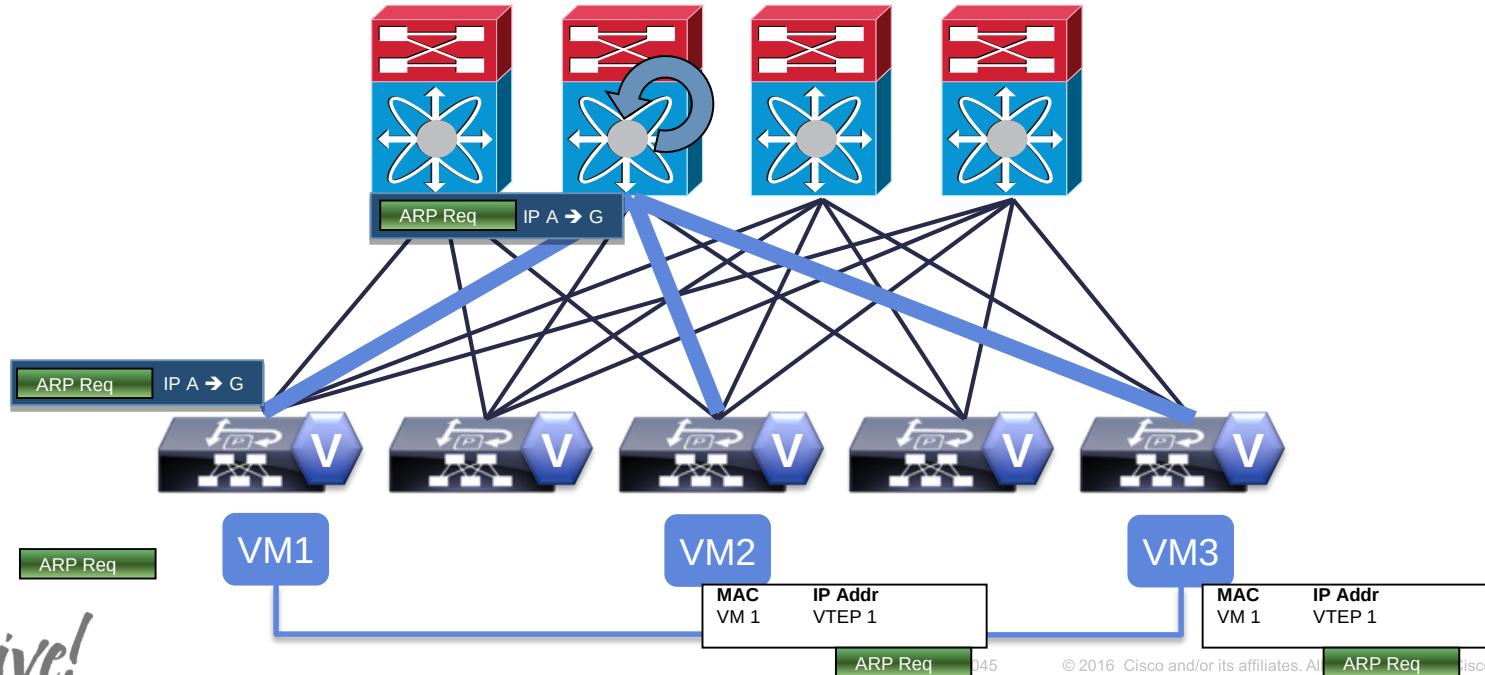
Data Plane Learning

Dedicated Multicast Distribution Tree per VNI



Data Plane Learning

Learning on Broadcast Source - ARP Request Example



Learning on Unicast Source - ARP Response Example



VXLAN Evolution

Multicast Independent

- Head-end replication enables unicast-only mode
- Control Plane provides dynamic VTEP discovery

Protocol Learning prevents floods

- Workload MAC addresses learnt by VXLAN NVEs
- Advertise L2/L3 address-to-VTEP association information in a protocol

External Connectivity

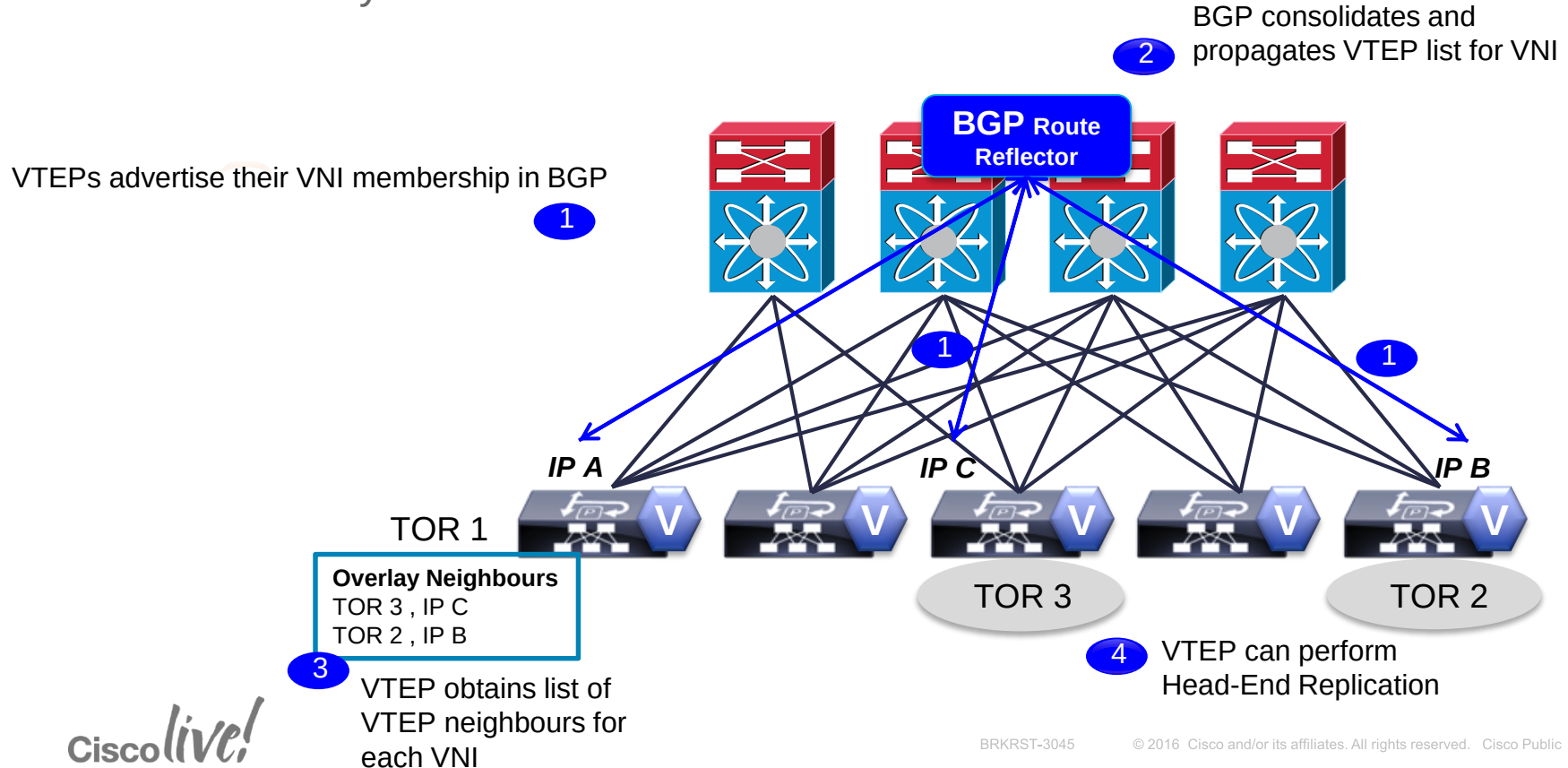
- VXLAN HW Gateways to other encaps/networks
- VXLAN HW Gateway redundancy
- Enable hybrid overlays

IP Services

- VXLAN Routing
- Distributed IP Gateways

VXLAN Evolution: Using a Control Protocol

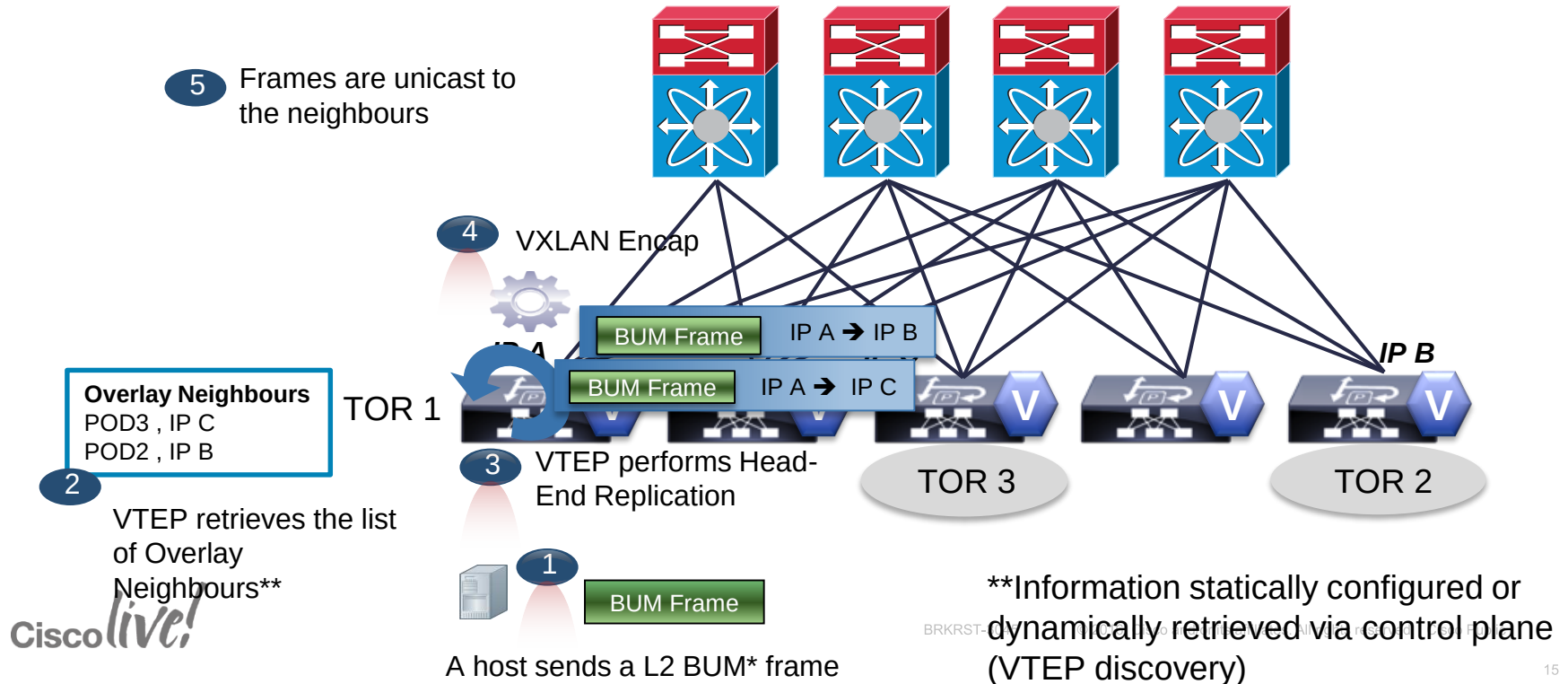
VTEP Discovery



VXLAN Data Plane Learning in Unicast Mode

Head-end Replication

*Broadcast, Unknown Unicast or Multicast



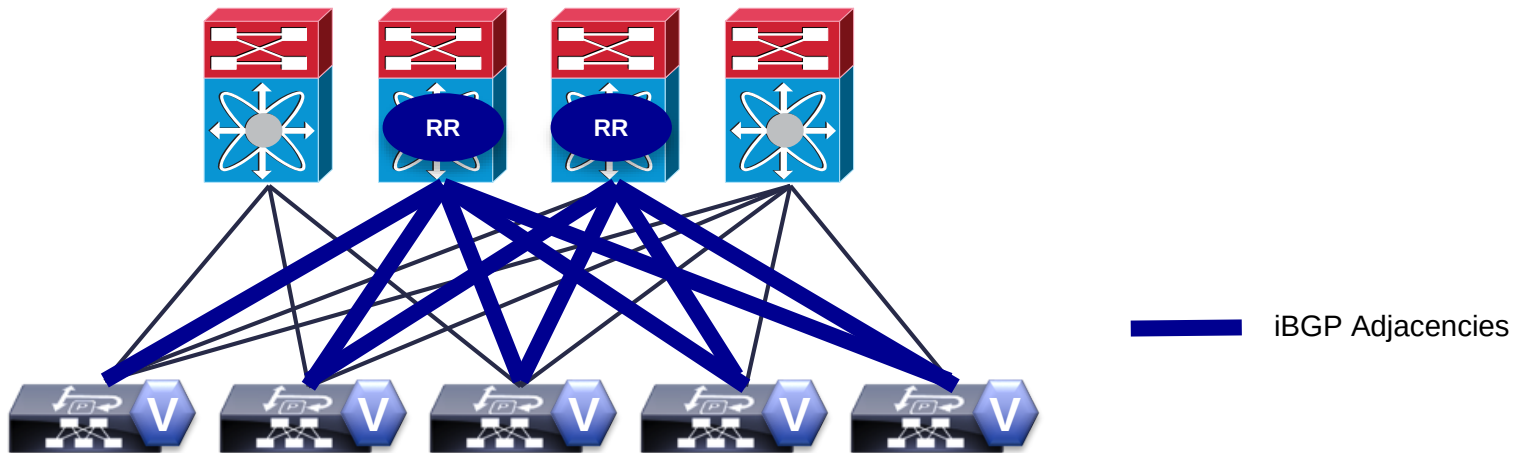
Agenda

- Overlays and Switching Fabrics
- VXLAN encapsulation
- The EVPN Control Plane
- The LISP Control Plane
- Deployment Considerations
- Conclusion

BGP EVPN Control Plane for VXLAN

Host and Subnet Route Distribution

Route-Reflectors deployed for scaling purposes



- Host Route Distribution decoupled from the Underlay protocol
- Use MP-BGP on the leaf nodes to distribute internal host/subnet routes and external reachability information

BGP EVPN Control Plane

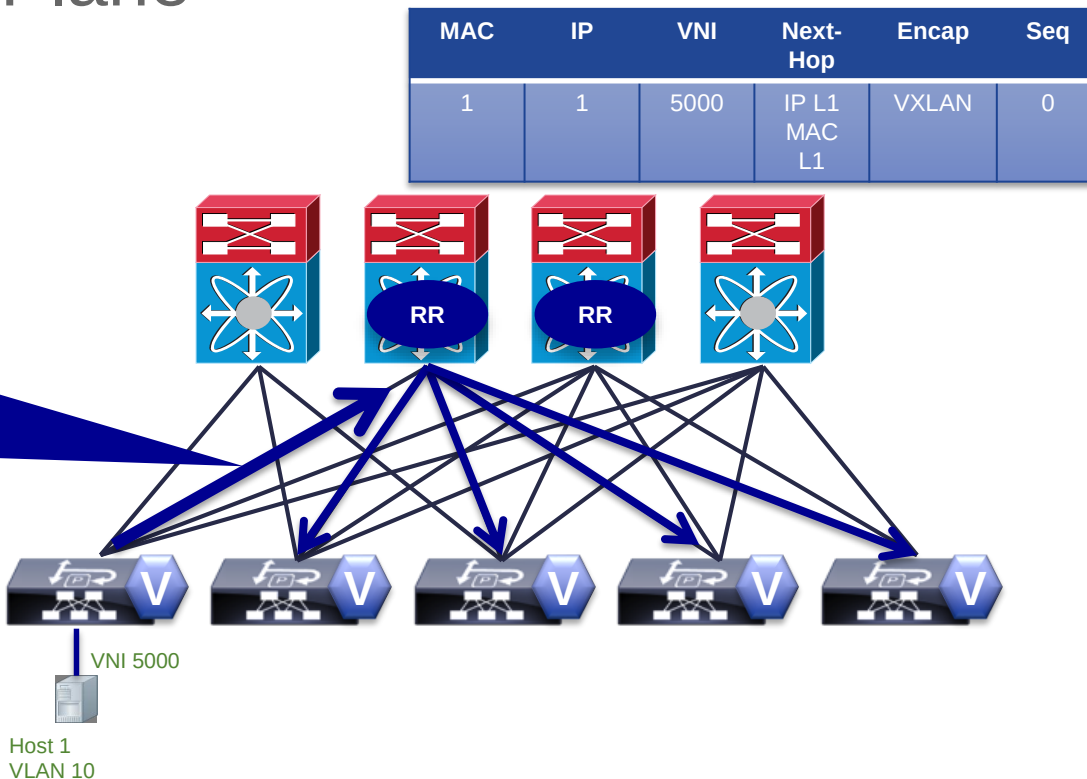
Host Advertisement

NLRI:

Host MAC1, IP1
NVE IP L1/MAC L1
VNI 5000

Ext.Community:

Encapsulation: VXLAN, NVGRE
Sequence 0



1. Host Attaches
2. Attachment NVE advertises host's MAC (+IP) through BGP RR
3. Choice of encapsulation is also advertised

BGP EVPN Control Plane

Host Moves

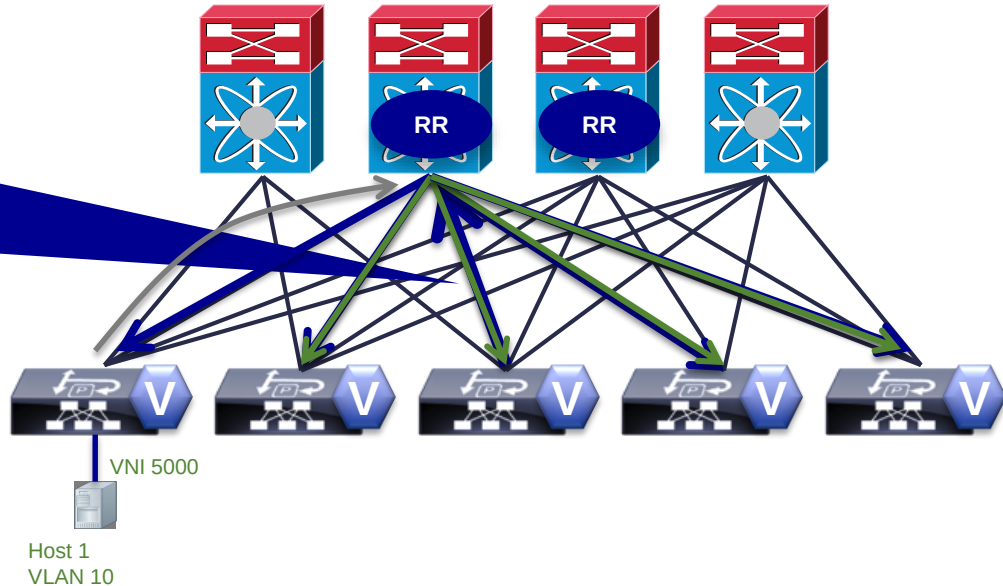
NLRI:

Host MAC1, IP1
NVE IP L3/MAC L3
VNI 5000

Ext.Community:

Encapsulation: VXLAN, NVGRE
Sequence 1

MAC	IP	VNI	Next-Hop	Encap	Seq
1	1	5000	IP L3 MAC L3	VXLAN	1

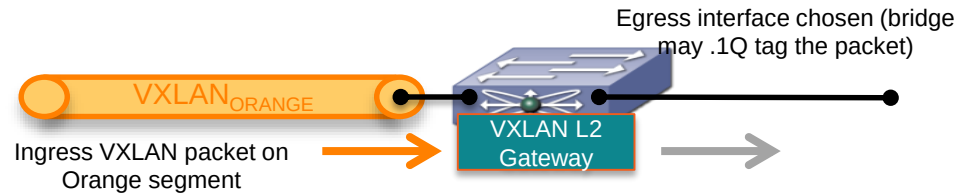


1. Host Moves to NVE3
2. NVE3 detects Host1 and advertises H1 with seq#1
3. NVE1 sees more recent route and withdraws its advertisement

VXLAN L2 and L3 Gateways

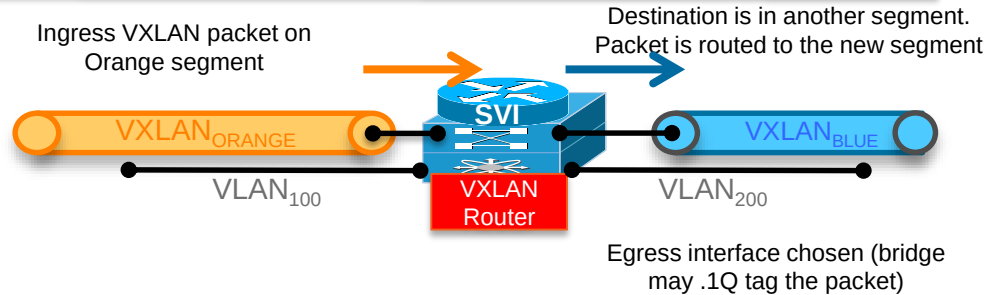
Connecting VXLAN to the broader network

L2 Gateway: VXLAN to VLAN Bridging



L3 Gateway: VXLAN to X Routing

- VXLAN
- VLAN

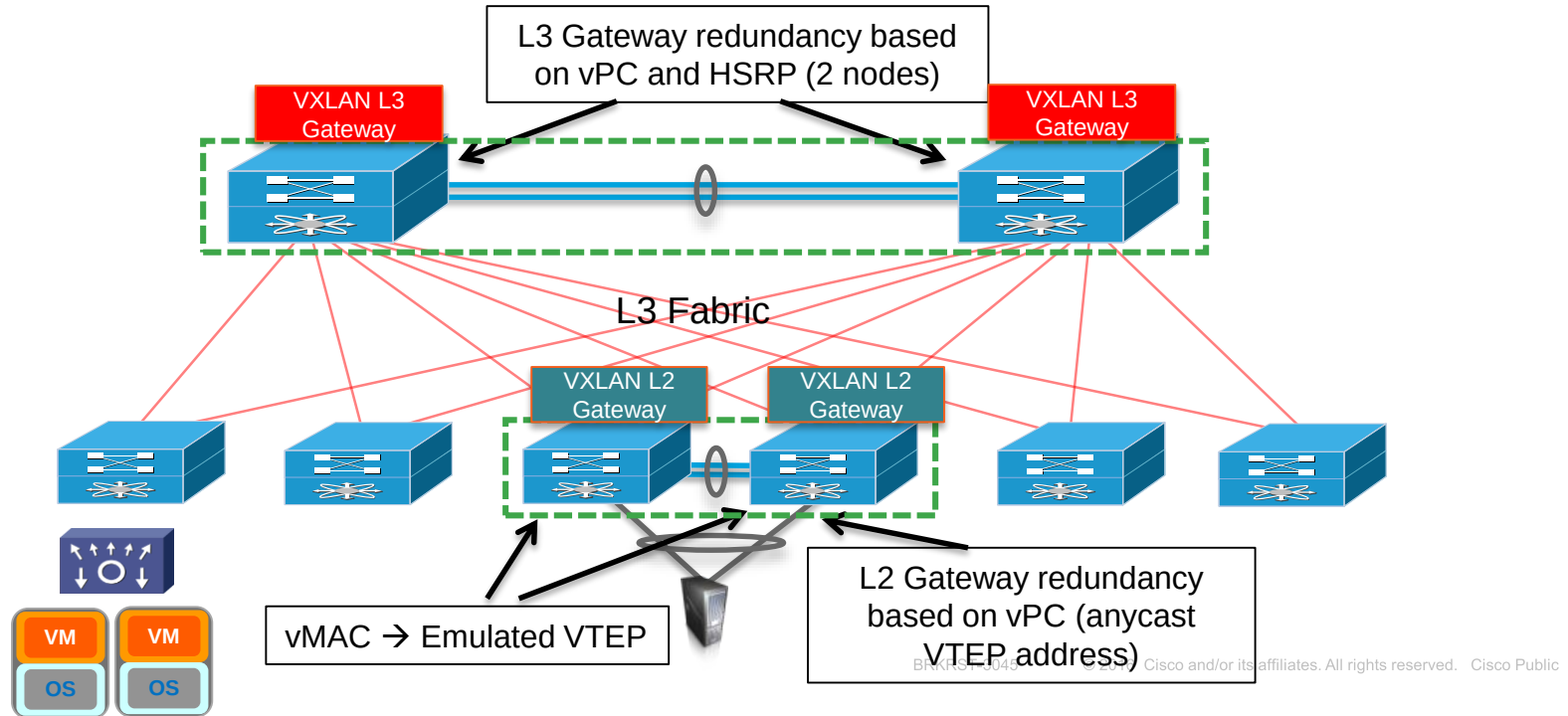


	N1KV	N7K w/F3 LC	Nexus 3K	N5K/6K	N9K	CSR 1000V	ASR1K/ASR 9K
L2 Gateway	VXGW on 1110	Yes	Yes	Yes	Yes	N/A	Yes
L3 Gateway	CSR 1000V	Yes	No	Yes	Yes	Yes	Yes

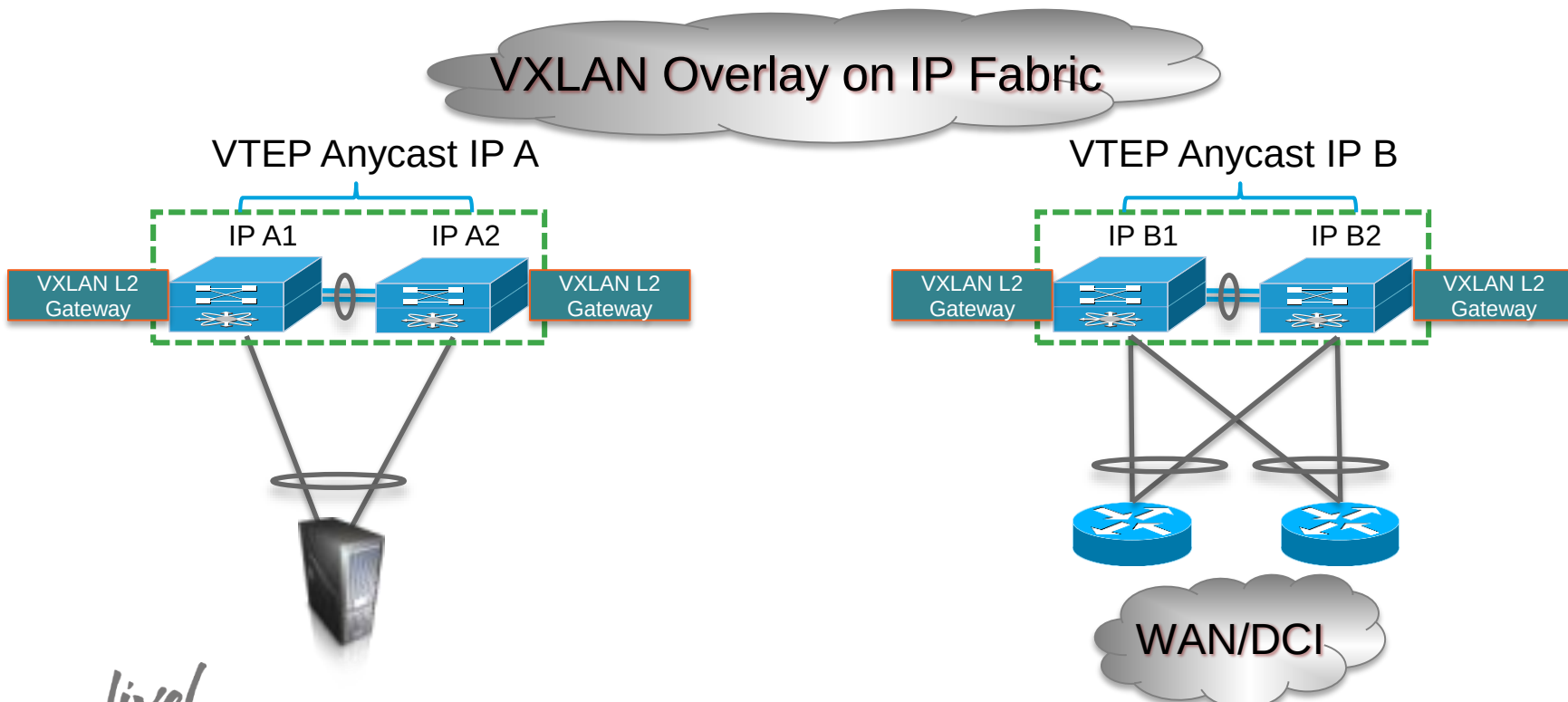
VTEP Redundancy in a VXLAN Fabric

vPC provides MAC state synchronisation and HSRP peering

Redundant VTEPs share anycast VTEP IP address in the underlay



HW VTEP Redundancy – L2 Gateway

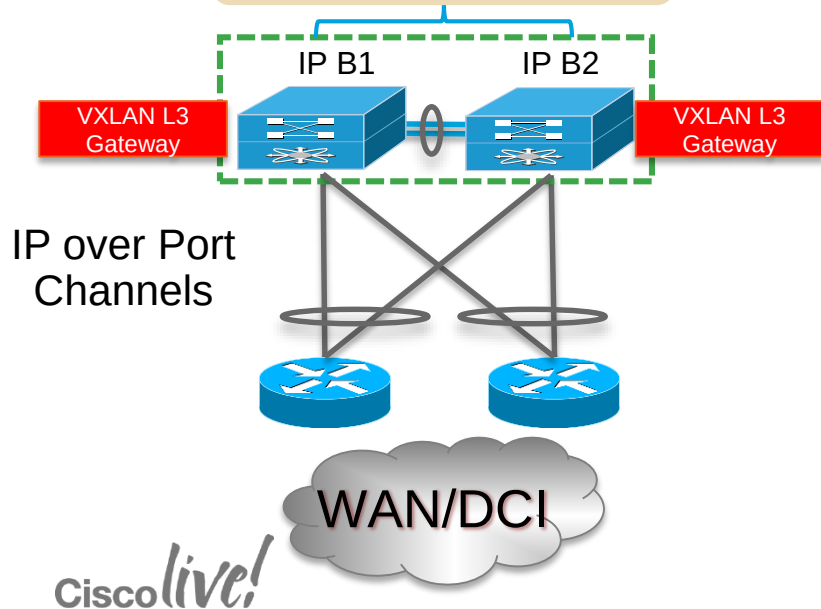


HW VTEP Redundancy – L3 Gateway

L2 VXLAN Overlay

Overlay: HSRP VIP

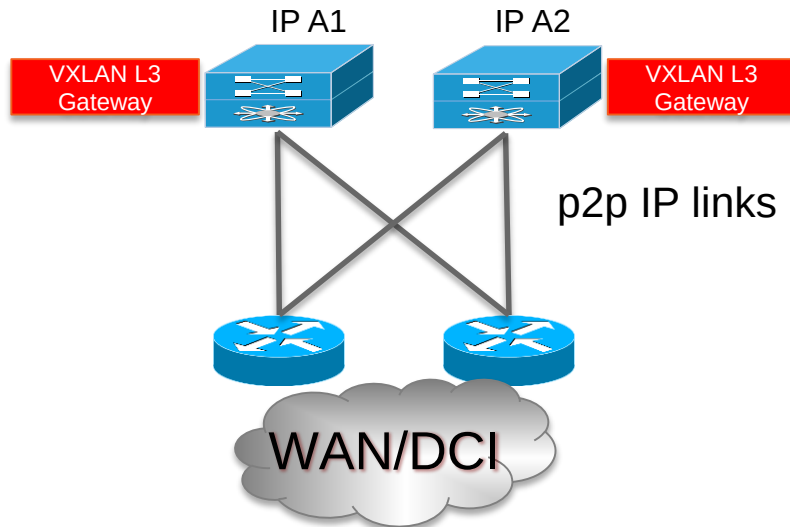
Underlay: VTEP Anycast IP B



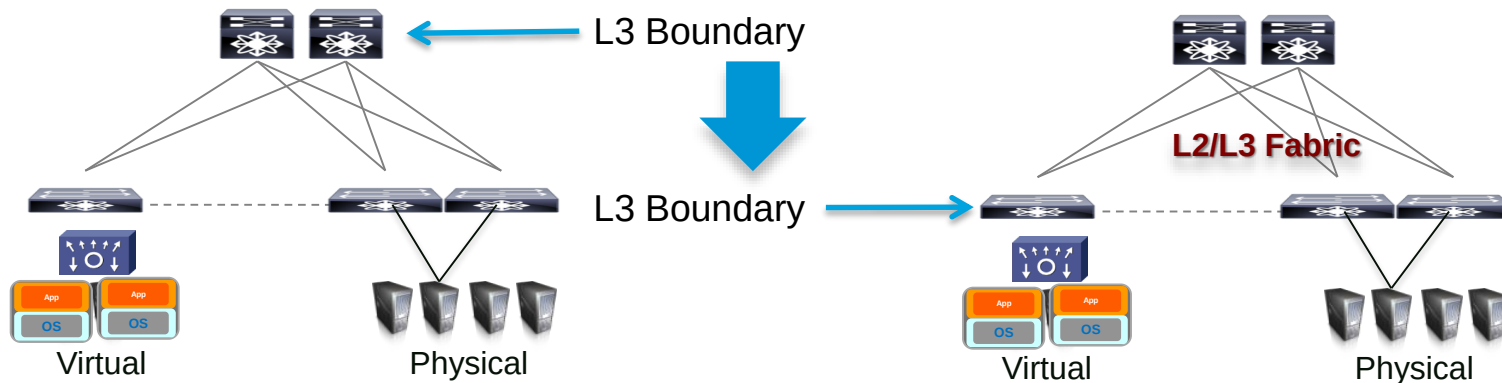
L3 VXLAN Overlay

Overlay: No HSRP

Underlay: Independent VTEPs



Distributed Gateway Function in L3 Overlays



Traditional L2 - centralised L2/L3 boundary

- Always bridge, route only at an aggregation point
- Large amounts of state converge
- Scale problem for large# of L2 segments
- Traditional L2 and L2 overlays

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L2/L3 fabric (or overlay)

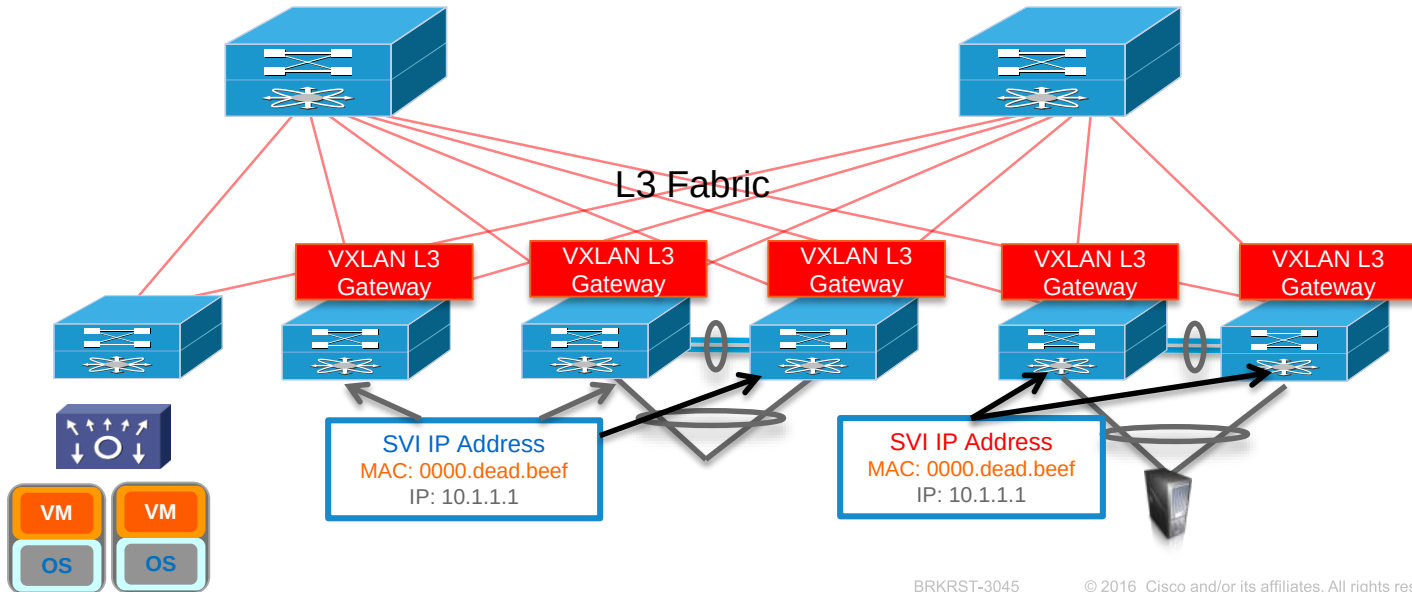
- Always route (at the leaves), bridge when necessary
- Distribute and disaggregate necessary state
- Optimal scalability
- Enhanced forwarding and L3 overlays

BRKRST-3045

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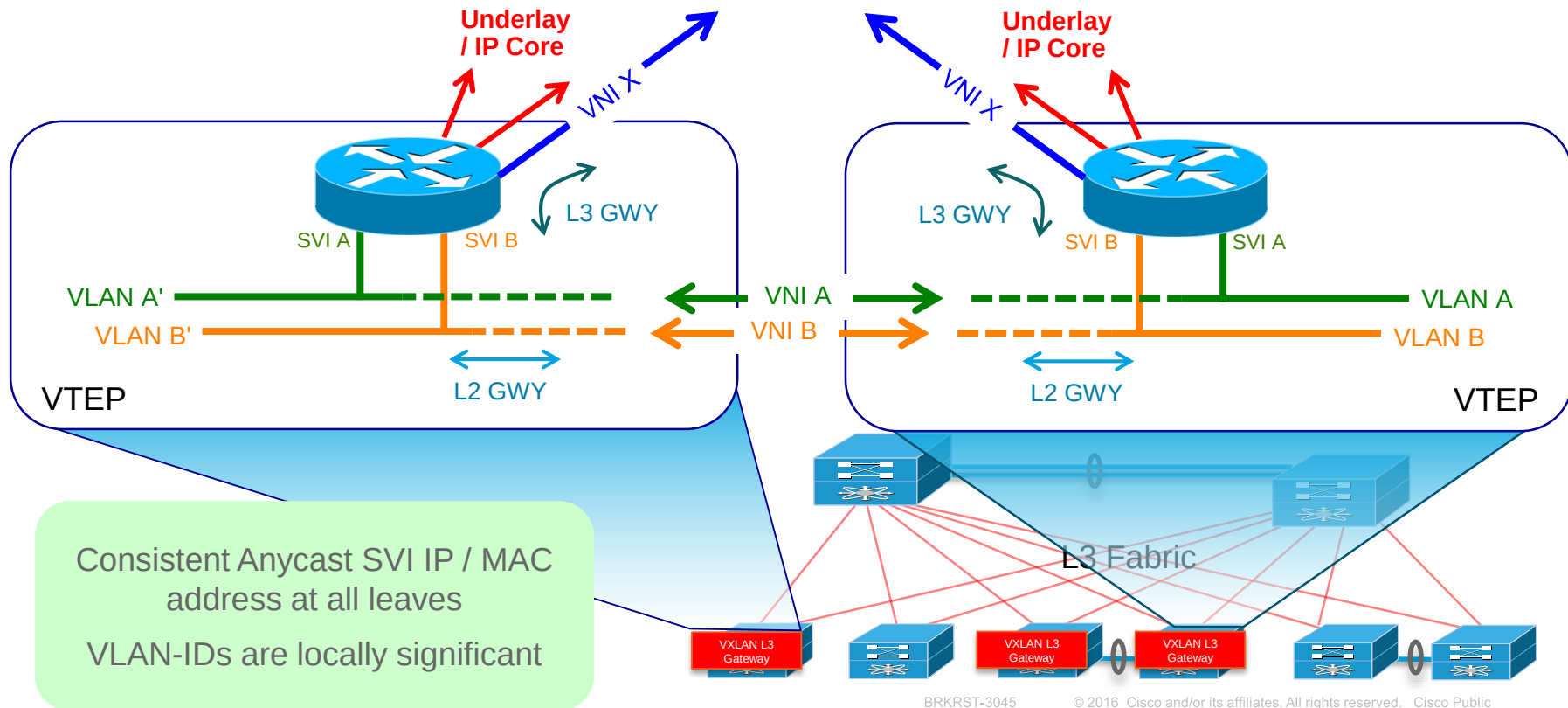
Distributed IP Anycast Gateway

The same “Anycast” SVI IP/MAC is used at all VTEPs/ToRs
A host will always find its SVI anywhere it moves



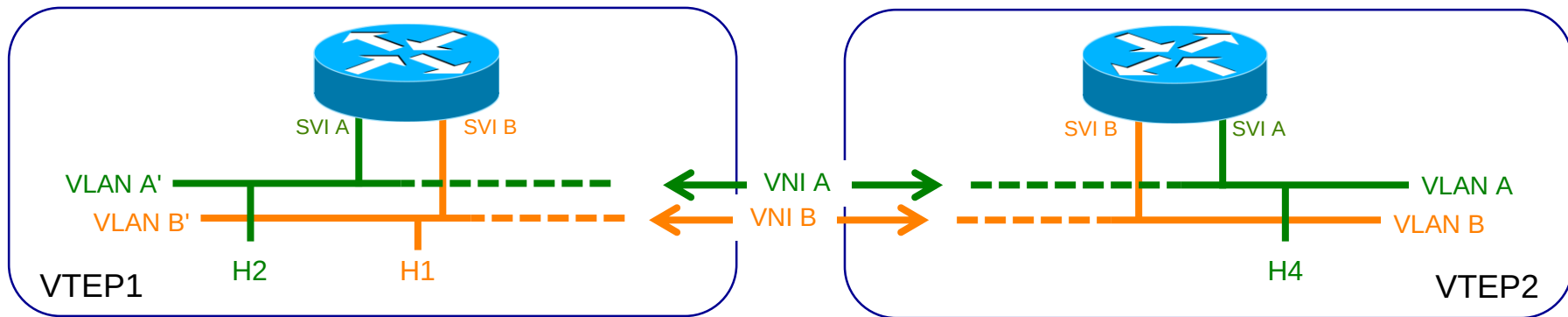
Distributed IP Anycast Gateway

Detailed View



Bridged Traffic in VXLAN EVPN

802.1Q Tagged Traffic to VNI Mapping

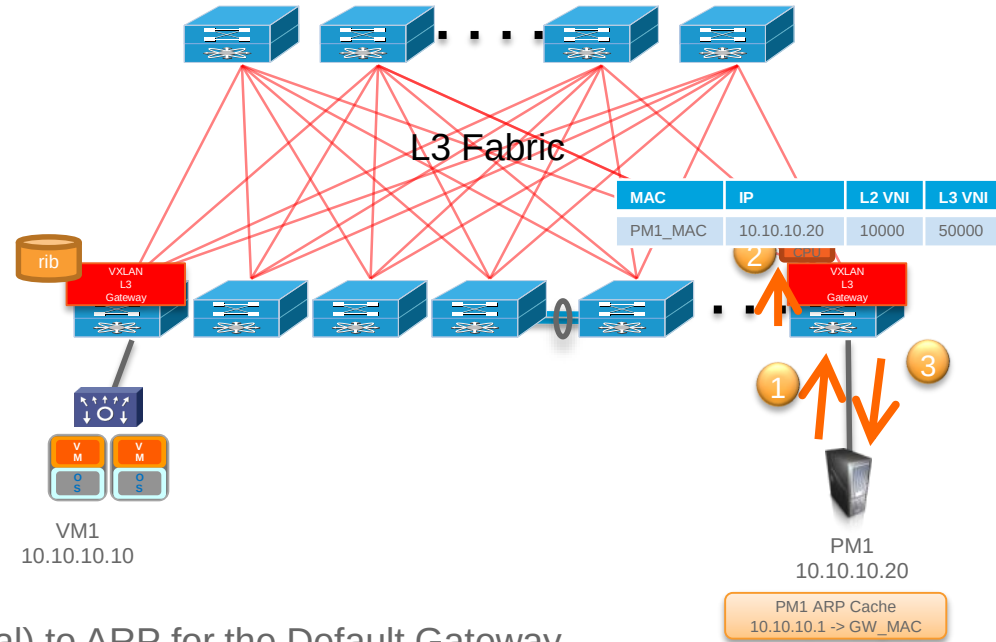


- VLANs are stretched over L2 VNIs
- VLANs (VLAN A) mapped to VNI (VNI A) at each VTEP: $\text{VLAN A}' \leftrightarrow \text{VNI A} \leftrightarrow \text{VLAN A}$
- Bridged traffic forwarded over the L2 VNIs

Distributed IP Anycast Gateway

Packet-Walk – IP Forwarding within the Same Subnet aka Bridging (ARP)

1. PM1 sends an ARP request for Default Gateway –10.10.10.1
2. The ARP request is suppressed at TOR and punted to the Supervisor, where MAC and IP is learned and distributed
3. TOR response with Gateway MAC to PM1

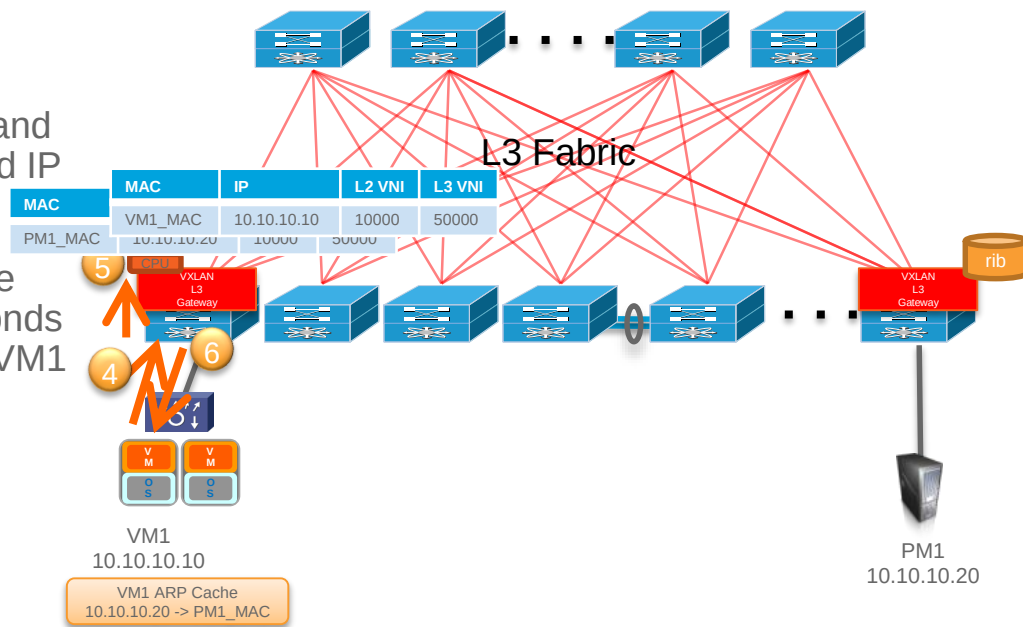


Standard behaviour of End-Host (virtual or physical) to ARP for the Default Gateway

Distributed IP Anycast Gateway

Packet-Walk – IP Forwarding within the Same Subnet aka Bridging (ARP)

4. VM1 sends an ARP request for PM1 – 10.10.10.20
5. The ARP request is suppressed at TOR and punted to the Supervisor, where MAC and IP is learned and distributed
6. Assuming PM1 is known and a valid route does exist in the Unicast RIB, TOR responds to ARP with PM1 MAC as Source MAC. VM1 can build its ARP cache

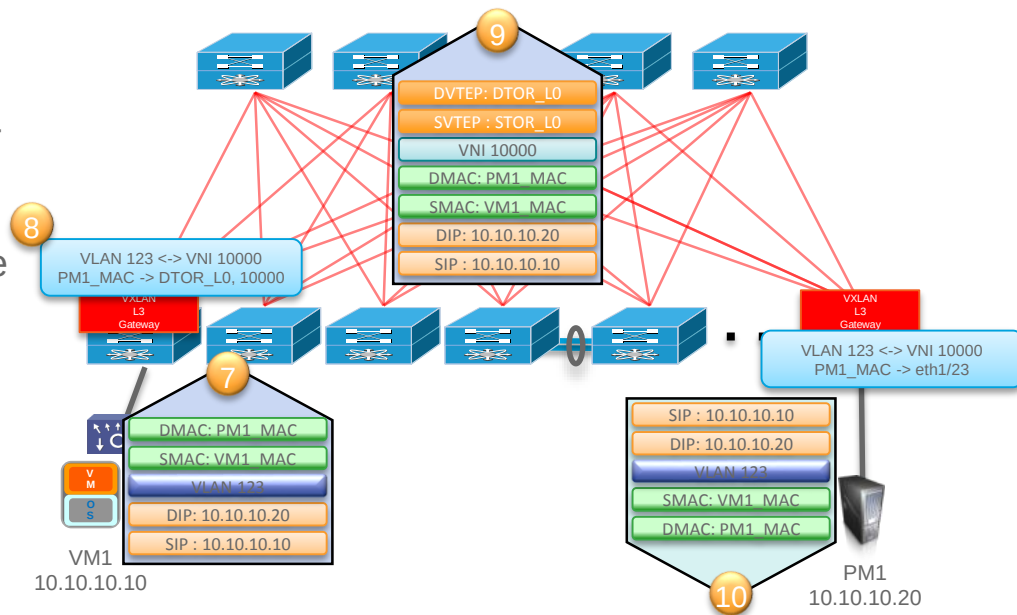


If there is Unicast RIB miss on TOR, ARP request will be forwarded to all ports except the original sending port (ARP snooping). ARP response will be punted to Supervisor of destination TOR for Unicast RIB population (learn) and subsequently forwarded to source TOR. BRKRST-3045

Distributed IP Anycast Gateway

Packet-Walk – IP Forwarding within the Same Subnet aka Bridging (Data Packet)

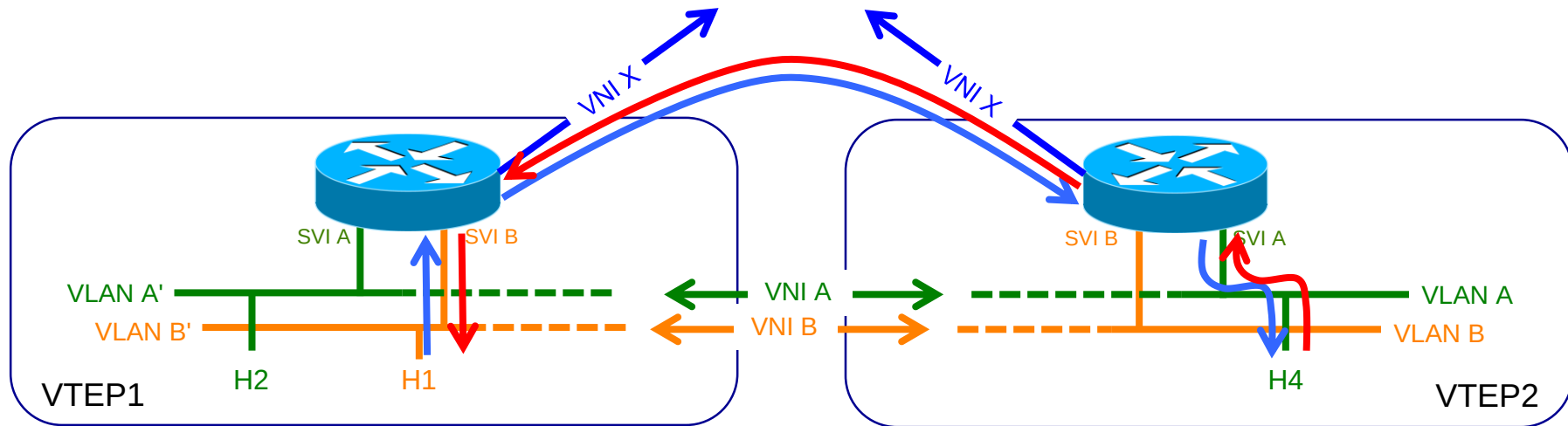
7. VM1 generates a data packet with PM1_MAC as destination MAC
8. TOR receives the packet and performs Layer-2 lookup for the destination
9. TOR adds VXLAN-Header information (Destination VTEP, VNI, etc) and forwards the packet across the Layer-3 fabric, picking one of the equal cost paths available via the multiple Spines
10. The destination TOR receives the packet, strips off the VXLAN header and performs lookup and forwarding toward PM1



In case of VM1 is not known to PM1, PM1 would ARP for VM1. Destination TOR would Proxy for VM1. No Silent-Host discovery problem.

Distributed Routing with EVPN

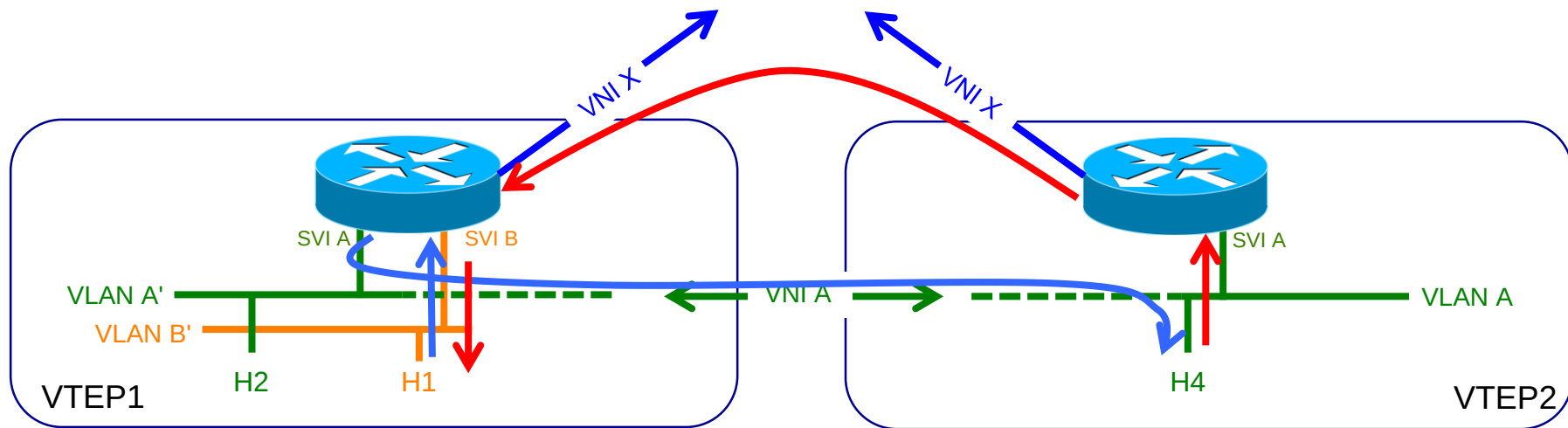
Routed Traffic to VNI Mapping



- A common VNI (VNI X) is provisioned amongst the different VTEPs to carry routed traffic
- Routed traffic between VTEPs will be encapsulated in VNI X
- Standard longest prefix match routing takes place:
 - Host routes for all known remote hosts are installed at every VTEP → Forward over VNI X
 - Local hosts are covered by directly connected prefix, a host route will not be present

Distributed IP Anycast Gateway with EVPN

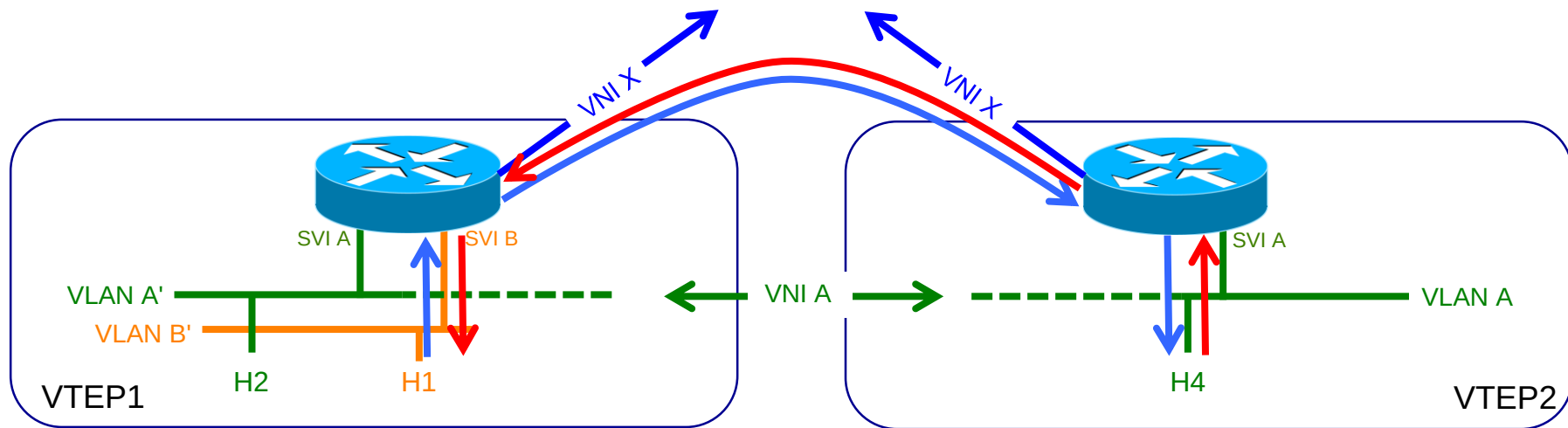
Packet Flow – Unknown Host (H4) in remote Subnet



- H1 → H4
 - Routed via **SVI B** (VTEP1) to **VLAN A** (VTEP1) → Bridged over **VNI A** (as unknown unicast flood)
- H4 → H1
 - Routed via **SVI A** (VTEP2) → **VNI X** → **SVI B** (VTEP1) → **VLAN B'** (as **H1** is known based on response)
- Standard longest prefix match routing: As long as H4 is not learnt by VTEP1, the only path to H4 is the locally connected subnet (VLAN A')

Distributed IP Anycast Gateway with EVPN

Packet Flow – unknown Host (H1) in remote Subnet

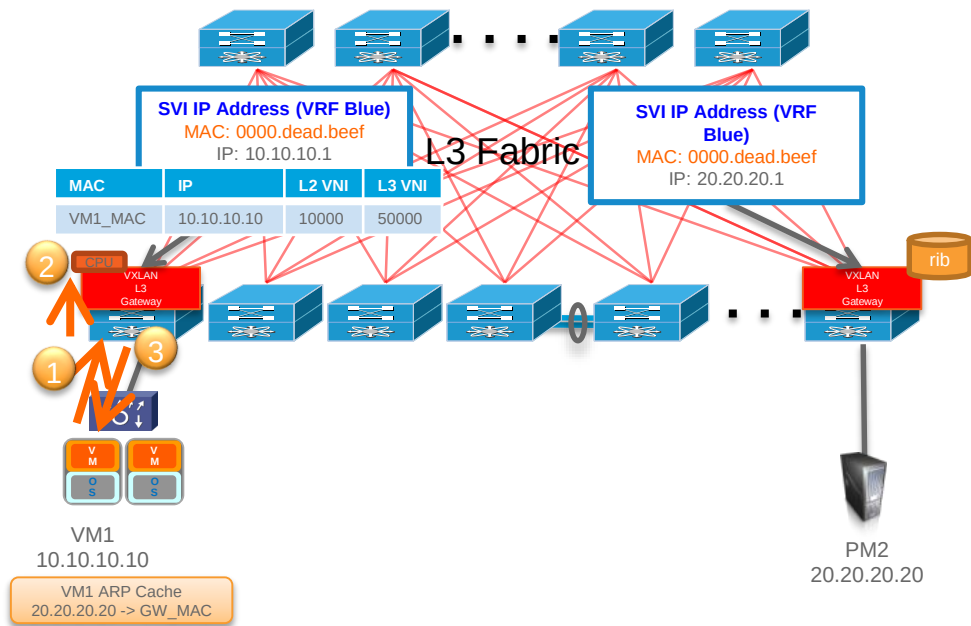


- H4 → H1
 - Routed via SVI A (VTEP2) to VLAN B (VTEP1) → Routed over VNI X (as destination Subnet known)
- H1 → H4
 - Routed via SVI B (VTEP1) → VNI X → SVI A (VTEP2) → VLAN A' (as H1 is known based on response)

Distributed IP Anycast Gateway

Packet-Walk – IP Forwarding within the Different Subnet aka Routing (ARP)

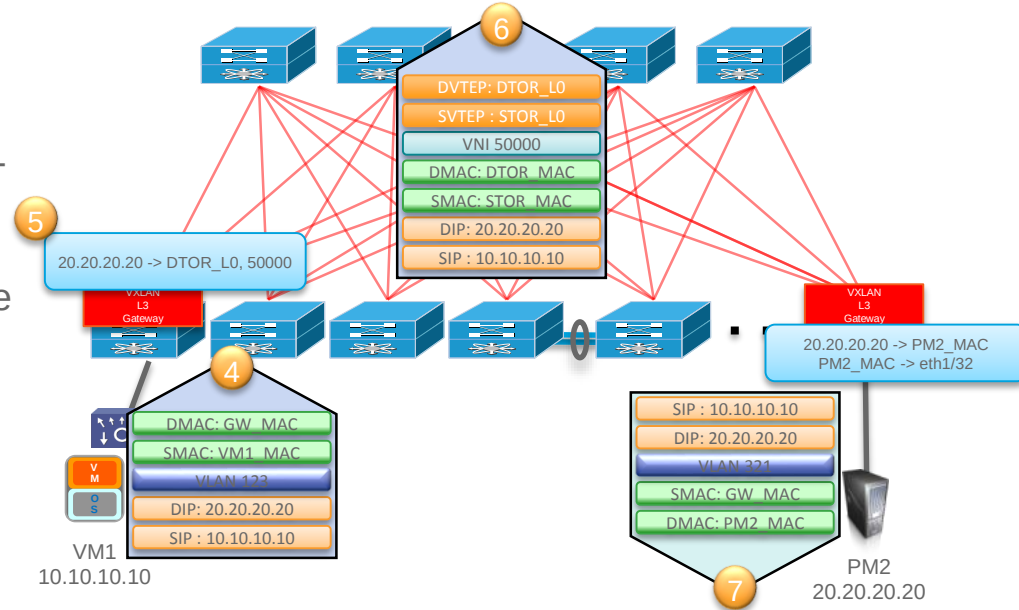
1. VM1 sends ARP request for Default Gateway –10.10.10.1
2. The ARP request will be received at TOR and punted to the Supervisor, where MAC and IP is learned and distributed
3. TOR acts as regular Default Gateway and sends ARP response with GW MAC to VM1



Distributed IP Anycast Gateway

Packet-Walk – IP Forwarding within the Different Subnet aka Routing (Data Packet)

4. VM1 generates a data packet destined to PM2 IP (20.20.20.20) with GW_MAC as destination MAC
5. TOR receives the packet and performs Layer-3 lookup for the destination (known)
6. TOR adds VXLAN-Header information (Destination VTEP, VNI, etc) and forwards the packet across the Layer-3 fabric, picking one of the equal cost paths available via the multiple Spines
7. The destination TOR receives the packet, strips off the VXLAN header and performs lookup and forwarding toward PM2



BGP-EVPN Configuration Summary



```
feature nv overlay
feature vn-segment-vlan-based
feature bgp
nv overlay vpn
```

Enable

```
interface nve1
no shutdown
source-interface loopback1
host-reachability protocol bgp
member vni 6000
  suppress-arp
  mcast-group 235.1.1.1
member vni 39000 associate-vrf
```

VXLAN

```
vlan 3002
  vn-segment 6000
evpn
  vni 6000 12
    rd auto
    route-target import auto
    route-target export auto
```

L2 VNIs

```
vlan 555
  vn-segment 39000
interface vlan 555
no shutdown
vrf member customer1
```

L3 VNIs

```
fabric forwarding anycast-gateway-mac 0002.0002.0002
```

```
interface vlan 3002
no shutdown
vrf member customer1
ip address 10.10.10.1/24
fabric forwarding mode anycast-gateway
```

Distributed Gateway

```
vrf context customer1
vni 39000
rd auto
address-family ipv4 unicast
  route-target both auto
  route-target both auto evpn
```

Tenant VRF with EVPN

```
router bgp 65000
address-family ipv4 unicast
address-family l2vpn evpn
neighbor x.x.x.x remote-as 65000
update-source loopback1
address-family ipv4 unicast
address-family l2vpn evpn
  send-community extended
```

iBGP Configuration

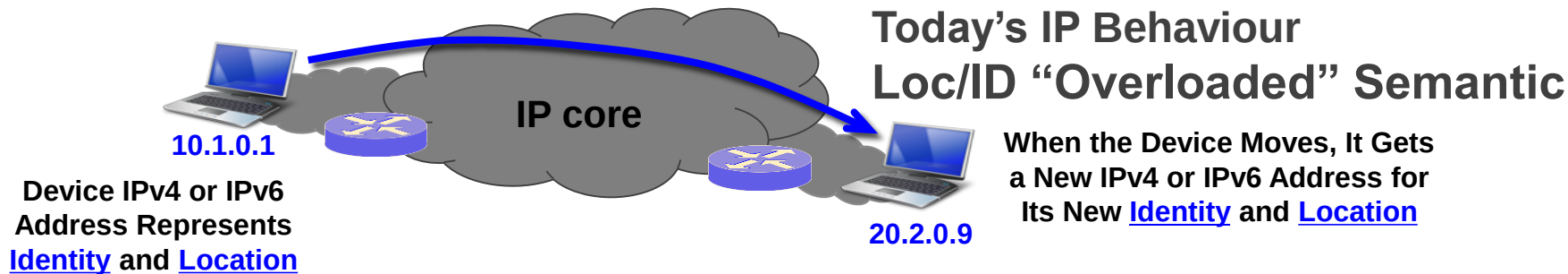
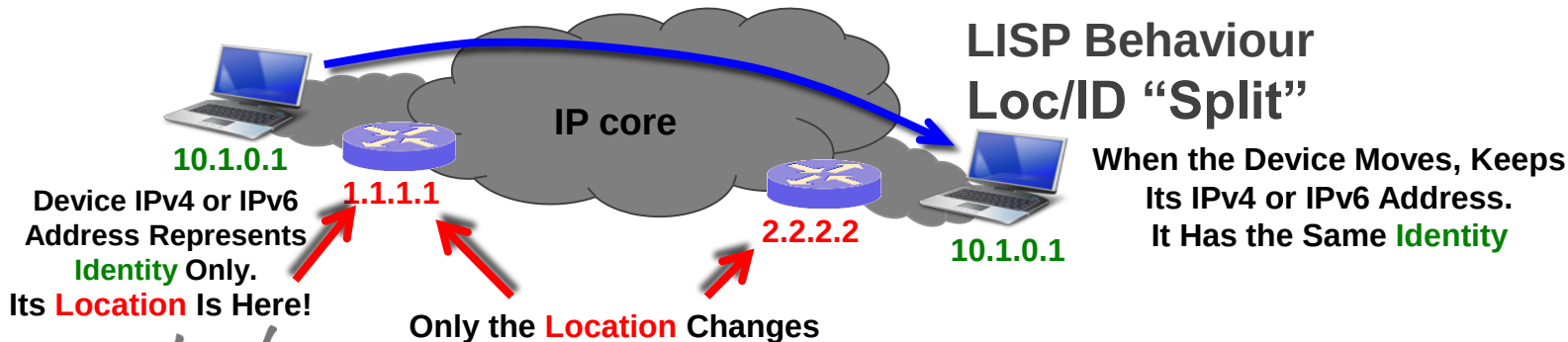
```
vrf customer1
  address-family ipv4 unicast
    advertise l2vpn evpn
  redistribute direct route-map bar
```

Agenda

- Overlays and Switching Fabrics
- VXLAN encapsulation
- The EVPN Control Plane
- The LISP Control Plane
- Deployment Considerations
- Conclusion

Location Identity Separation Protocol

- What do we mean by “Location” and “Identity”



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LISP Operations

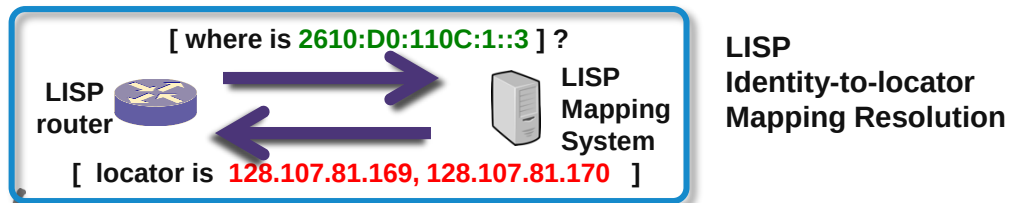
LISP :: Mapping Resolution “Level of Indirection”

- LISP “Level of Indirection” is analogous to a DNS lookup

- DNS resolves IP addresses for URL Answering the “WHO IS” question

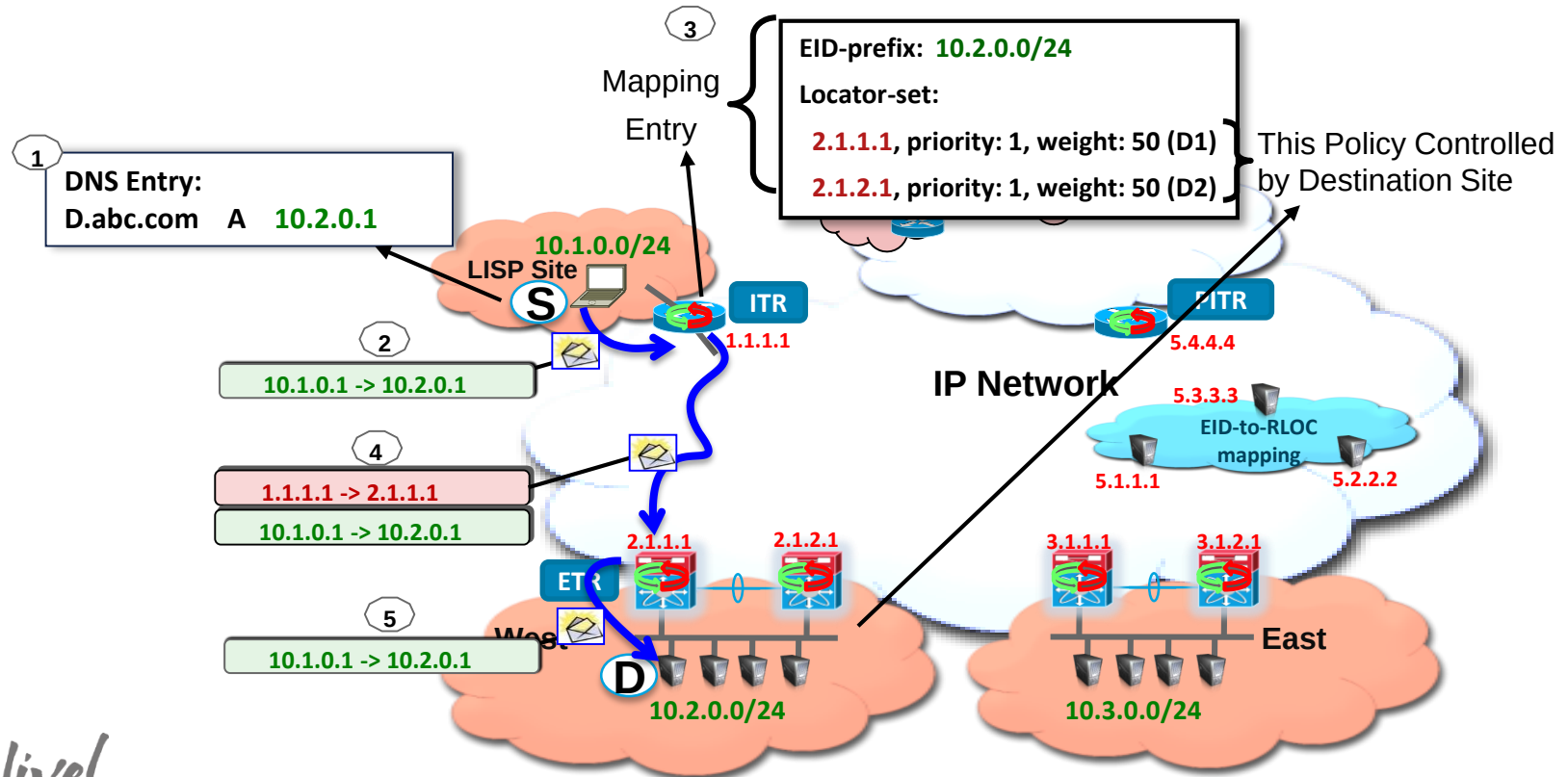


- LISP resolves locators for queried identities Answering the “WHERE IS” question



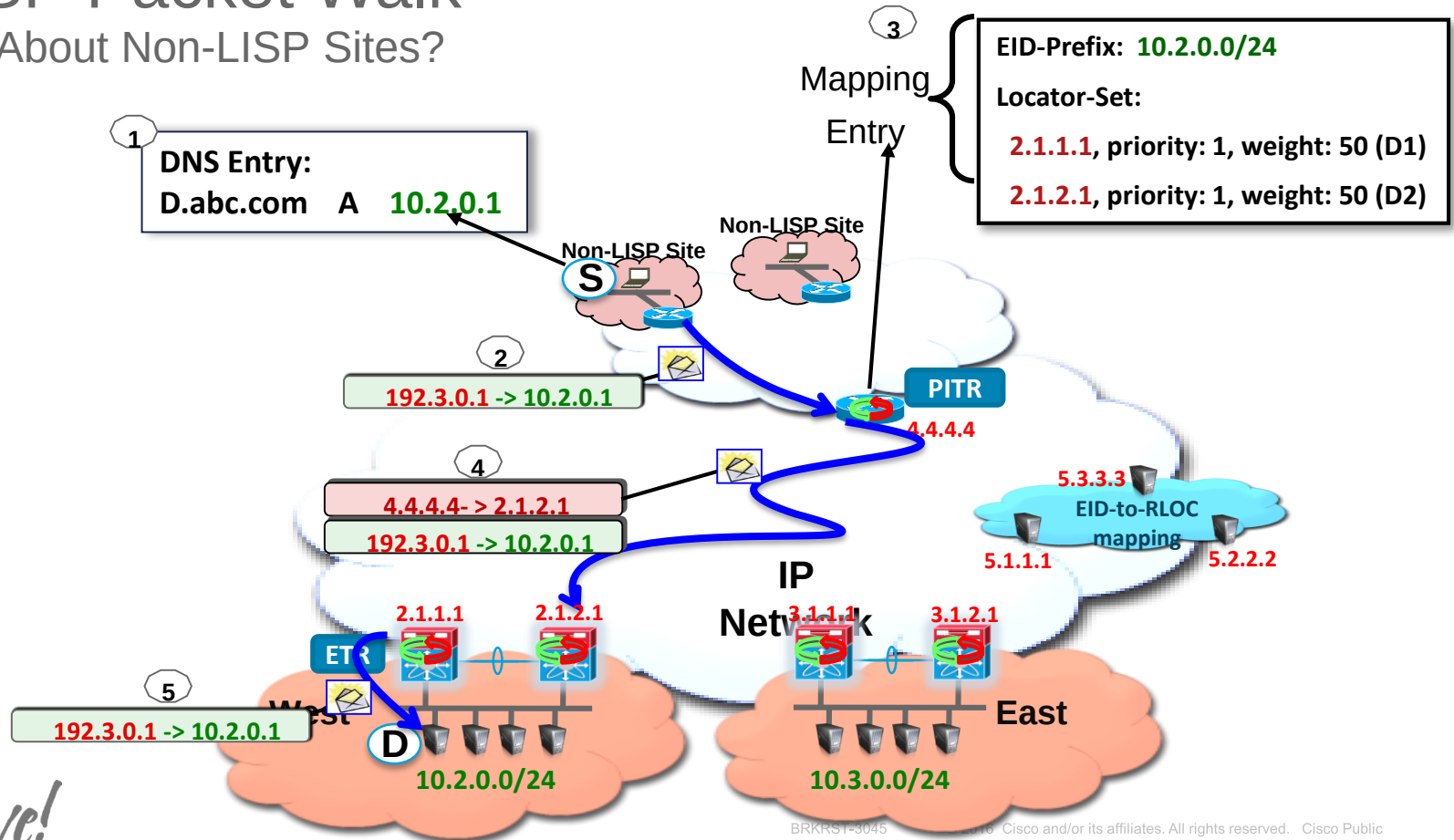
A LISP Packet Walk

- How Does LISP Operate?



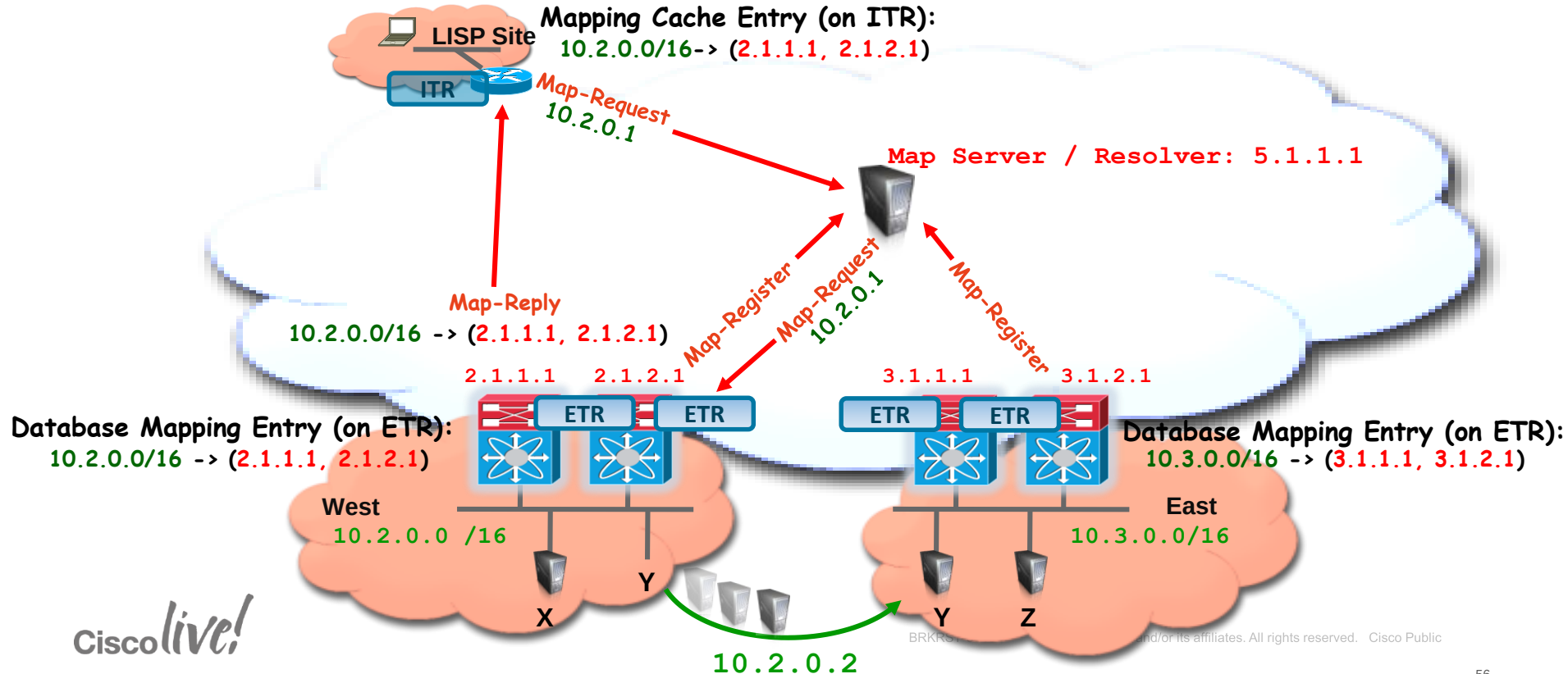
A LISP Packet Walk

- How About Non-LISP Sites?



LISP Mapping Database

- The Basics – Registration and Resolution



Basic LISP Configuration

Border Routers Between Backbones

```
ip lisp proxy-itr  
ip lisp ITR map-resolver 5.3.3.3
```

Branch Routers

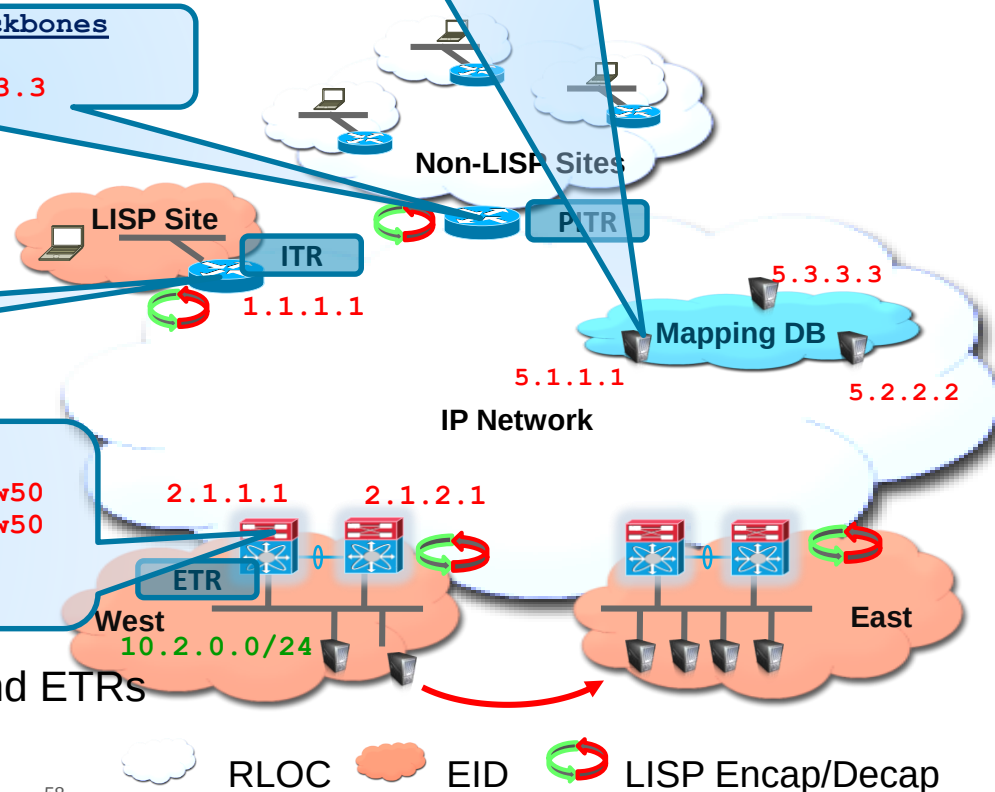
```
ip lisp itr-etr  
ip lisp ITR map-resolver 5.3.3.3
```

DC Aggregation Routers

```
ip lisp itr-etr  
ip lisp database-mapping 10.2.0.0/24 2.1.1.1 p1 w50  
ip lisp database-mapping 10.2.0.0/24 2.1.2.1 p1 w50  
ip lisp ETR map-server 5.1.1.1 key s3cr3t  
ip lisp ETR map-server 5.2.2.2 key s3cr3t
```

Servers

```
ip lisp map-resolver  
ip lisp map-server  
lisp site west  
authentication-key 0 s3cr3t  
eid-prefix 10.2.0.0/24
```



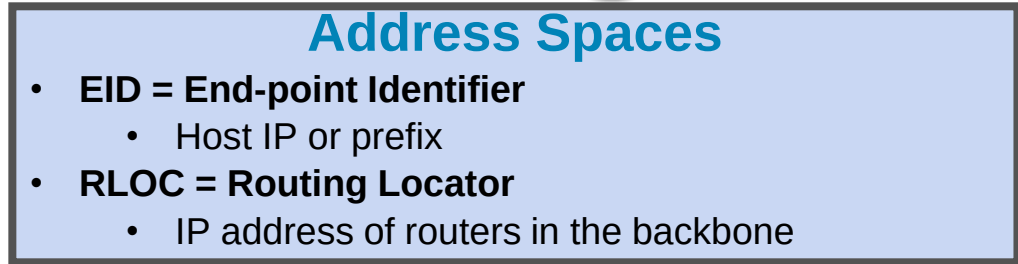
Usually Devices Will Be Configured as ITRs and ETRs
to Handle Traffic in Both Directions;
We Illustrate Only One Direction for Simplicity

- What are the Different Components Involved?

- What are the Different Components Involved?

- **Tunnel Routers - xTRs**

- Edge devices encaps/decap
- Ingress/Egress Tunnel Routers (ITR/ETR)
- **Proxy Tunnel Routers - PxTR**
 - Coexistence between LISP and non-LISP sites
 - Ingress/Egress: PITR, PETR
- **EID to RLOC Mapping DB**
 - RLOC to EID mappings
 - Servers and Resolvers

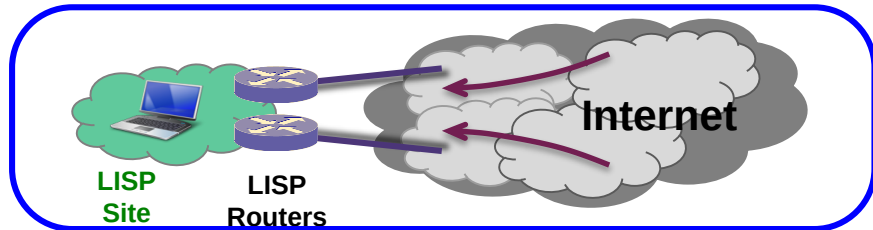


Address Spaces

- **EID = End-point Identifier**
 - Host IP or prefix
- **RLOC = Routing Locator**
 - IP address of routers in the backbone

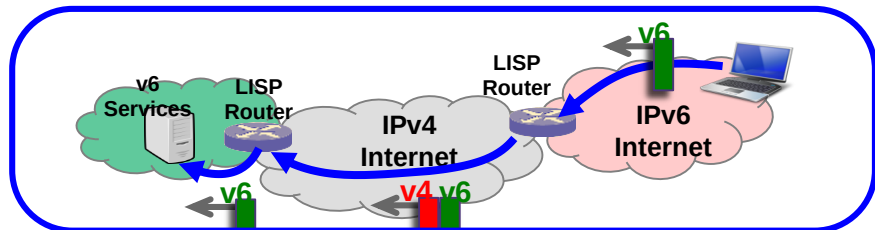
LISP Use Cases

Efficient Multi-Homing



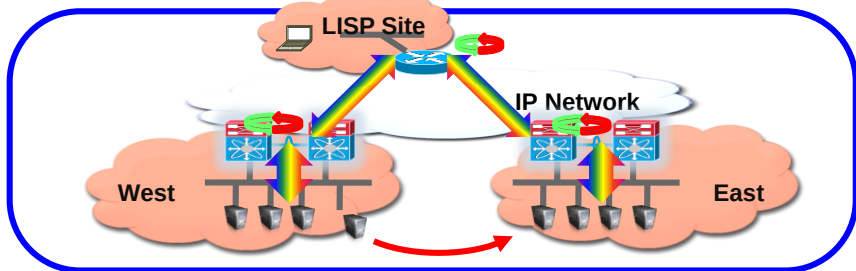
- IP Portability
- Ingress Traffic Engineering without BGP

IPv6 Transition Support



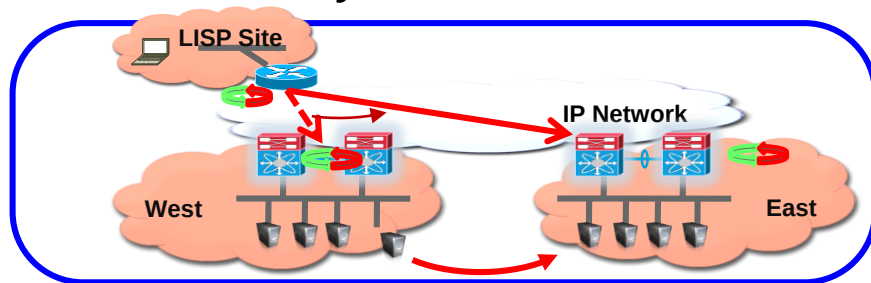
- v6-over-v4, v6-over-v6
- v4-over-v6, v4-over-v4

Multi-Tenancy and VPNs



- Reduced CapEx/OpEx
- Large scale Segmentation

Host-Mobility



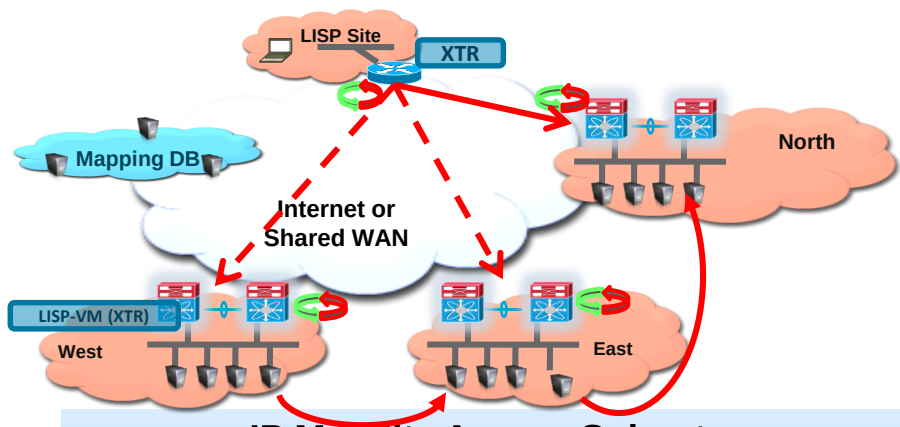
- Cloud / Layer 3 VM moves
- Segmentation

BRKRST-3045

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Host-Mobility Scenarios

Moves Without LAN Extension



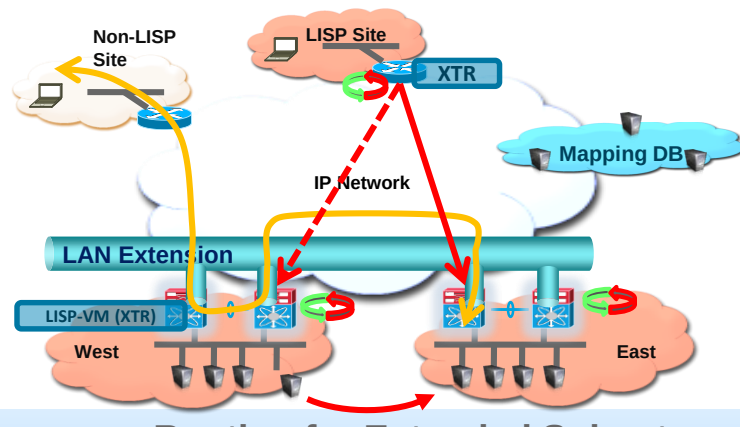
IP Mobility Across Subnets

Disaster Recovery

Cloud Bursting

Application Members in One Location

Moves With LAN Extension



Routing for Extended Subnets

Active-Active Data Centres

Distributed Clusters

Application Members Distributed
(Broadcasts across sites)

- Monitor the Source of Received Traffic

- the new xTR checks the source of received traffic
- configured dynamic-EIDs define which prefixes may roam

```
lisp dynamic-eid roamer
  database-mapping 10.2.0.0/24 <RLOC-C> p1 w50
  database-mapping 10.2.0.0/24 <RLOC-D> p1 w50
  map-server 5.1.1.1 key abcd
interface vlan 100
  lisp mobility roamer
```

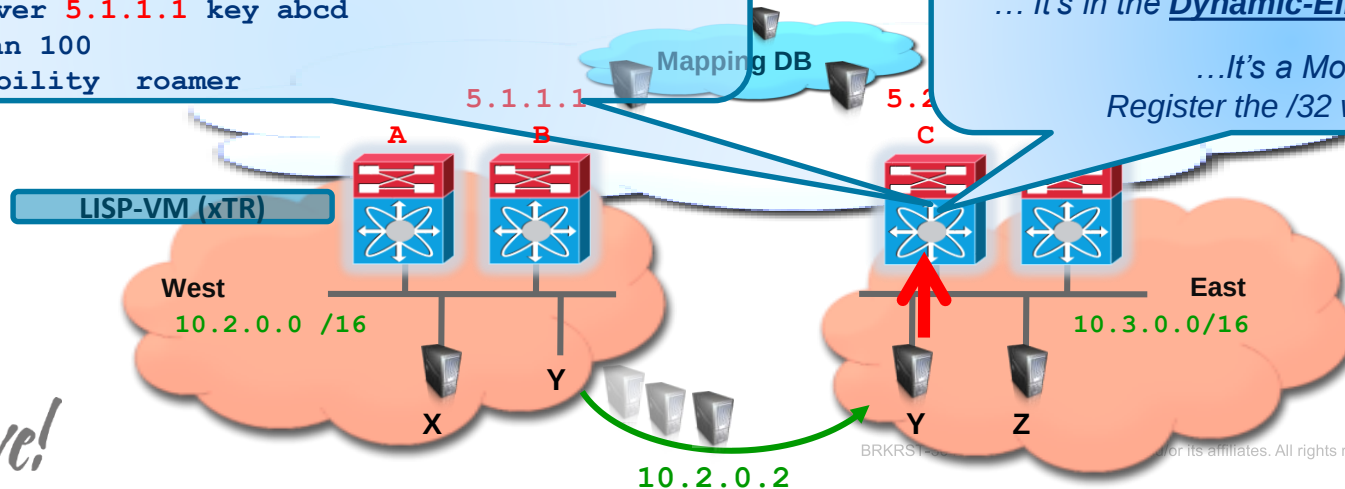
Received a Packet ...

... It's from a "New" Host

... It's in the **Dynamic-EID** Allowed Range

...It's a Move!

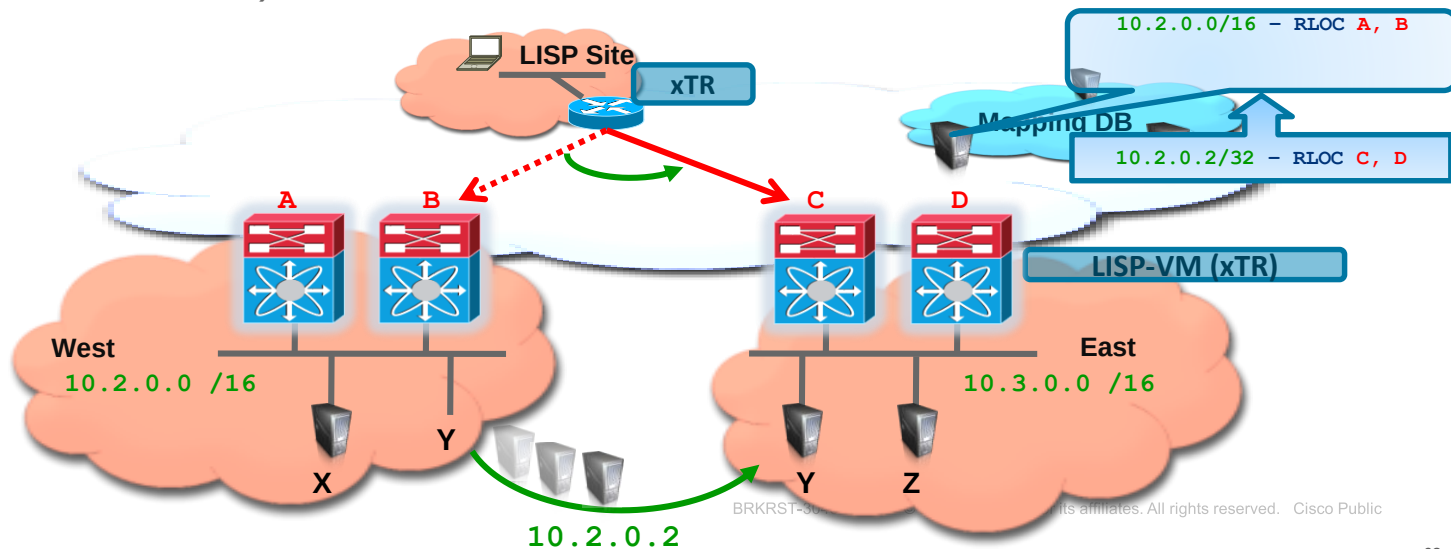
Register the /32 with LISP



LISP Host-Mobility – Traffic Redirection

- Update Location Mappings for the Host System Wide

- When a host move is detected, updates are triggered:
 - The host-to-location mapping in the Database is updated to reflect the new location
 - The old ETR is notified of the move
 - ITRs are notified to update their Map-caches
- Ingress routers (ITRs or PITRs) now send traffic to the new location

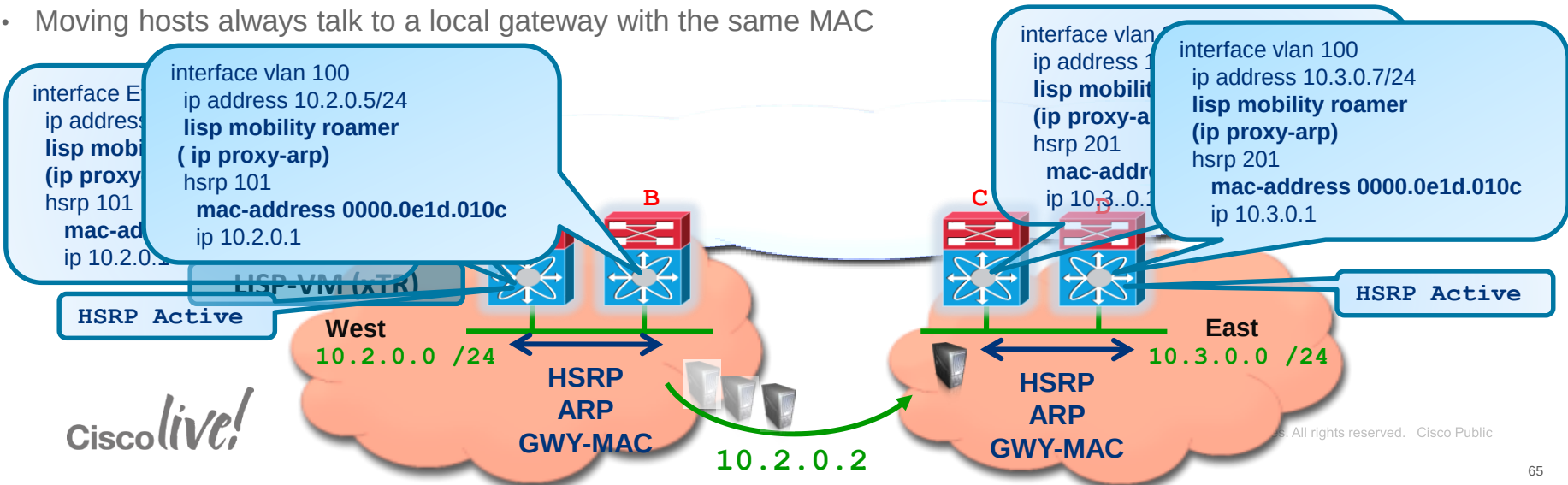


Host Mobility without LAN extensions

LISP Host-Mobility – First Hop Routing

- No LAN Extension

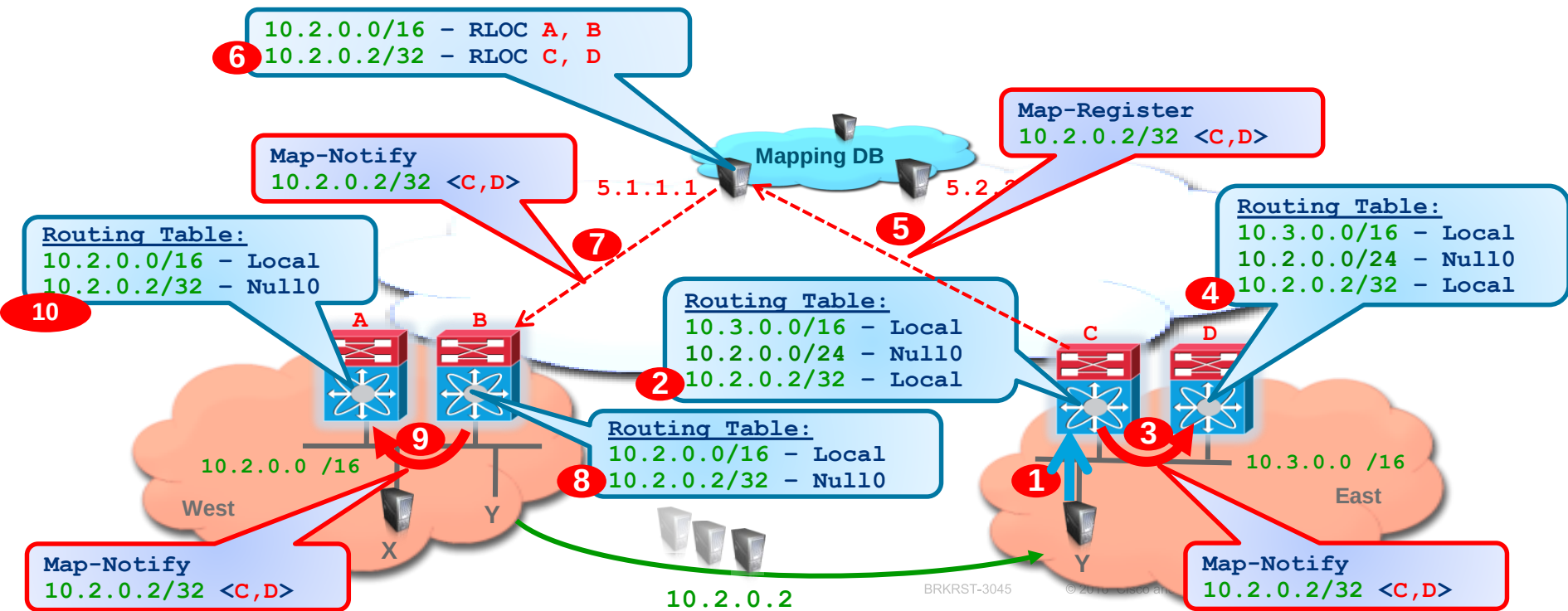
- SVI (Interface VLAN x) and HSRP configured as usual
 - Consistent GWY-MAC configured across all dynamic subnets
- The lisp mobility <dyn-eid-map> command enables proxy-arp functionality on the SVI
 - The LISP-VM router services first hop routing requests for both local and roaming subnets
- Moving hosts always talk to a local gateway with the same MAC



Host-Mobility and Multi-homing

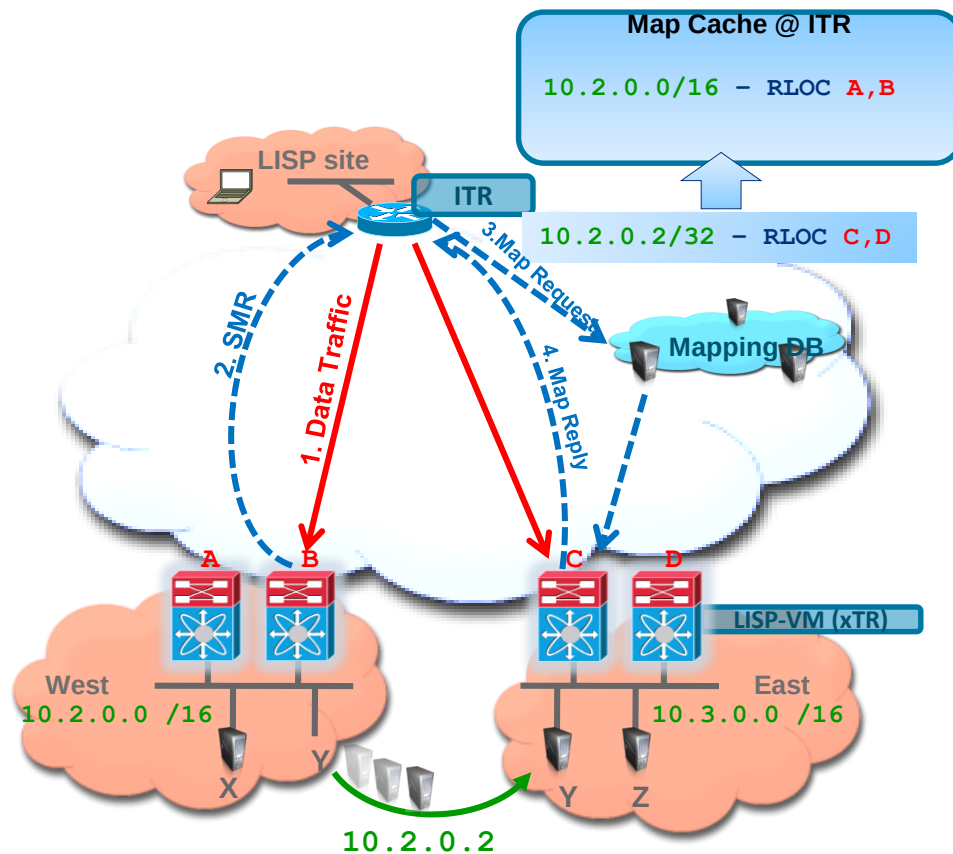
- ETR Updates – Across LISP Sites

Null0 host routes indicate the host is “away”



Refreshing the Map Caches

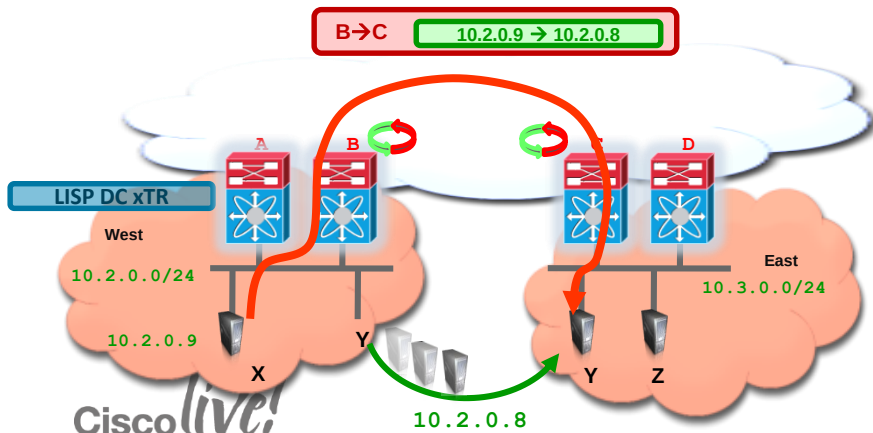
1. ITRs and PITRs with cached mappings continue to send traffic to the old locators
 1. The old xTR knows the host has moved (Null0 route)
 2. Old xTR sends Solicit Map Request (SMR) messages to any encapsulators sending traffic to the moved host
 3. The ITR then initiates a new map request process
 4. An updated map-reply is issued from the new location
 5. The ITR Map Cache is updated
- Traffic is now re-directed
 - SMRs are an important integrity measure to avoid unsolicited map responses and spoofing



On-subnet Server-Server Traffic

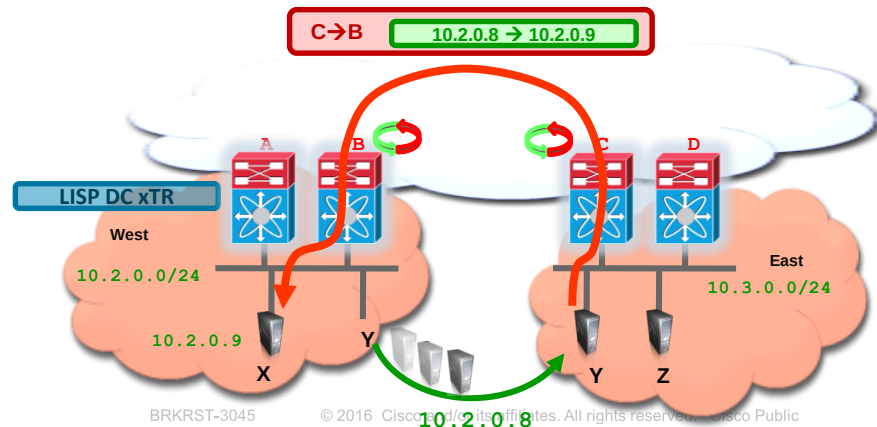
West-to-East

- X ARPs for Y, /32 Null0 entry for Y triggers proxy-ARP on West xTRs to ensure traffic is steered there
 - Note: entry for Y in X ARP cache is cleared by GARP message originated by West XTRs
- Traffic to Y is **LISP encapsulated**



East-to-West

- Y ARPs for X, /24 Null0 entry for the 'home subnet' triggers proxy-ARP on East DC xTRs to ensure traffic is steered there
 - Note: assumption is that ARP cache on Y is refreshed after the move
- Traffic to X is **LISP encapsulated**

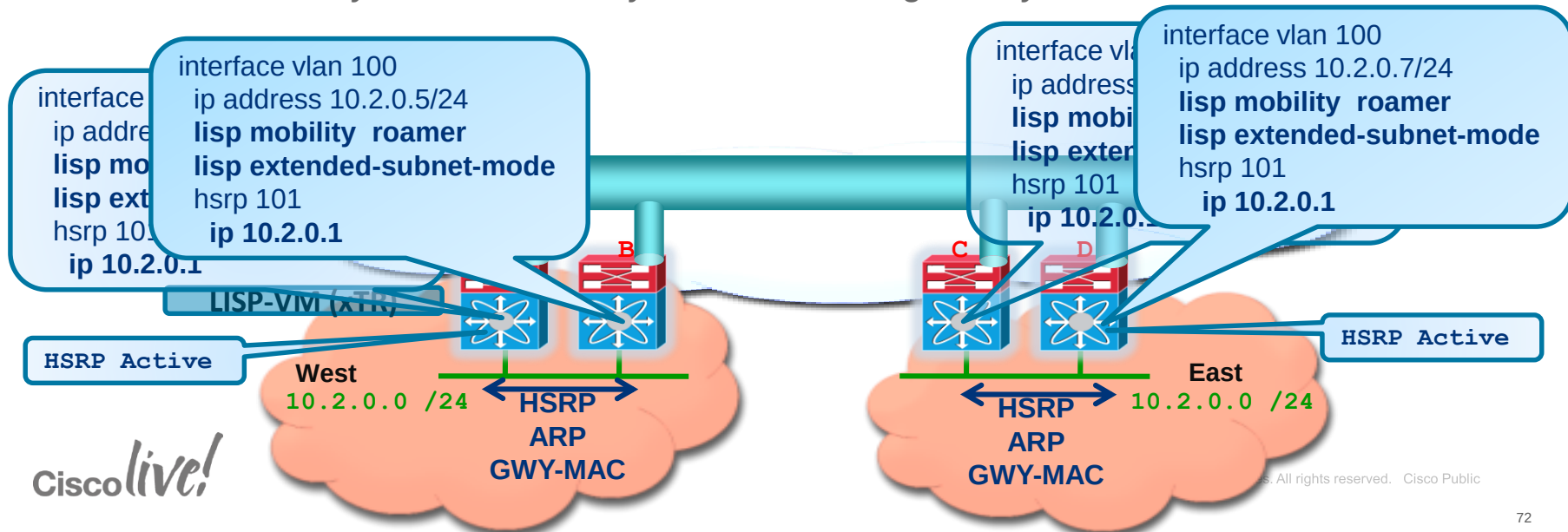


Host Mobility in Extended Subnets

LISP Host-Mobility – First Hop Routing

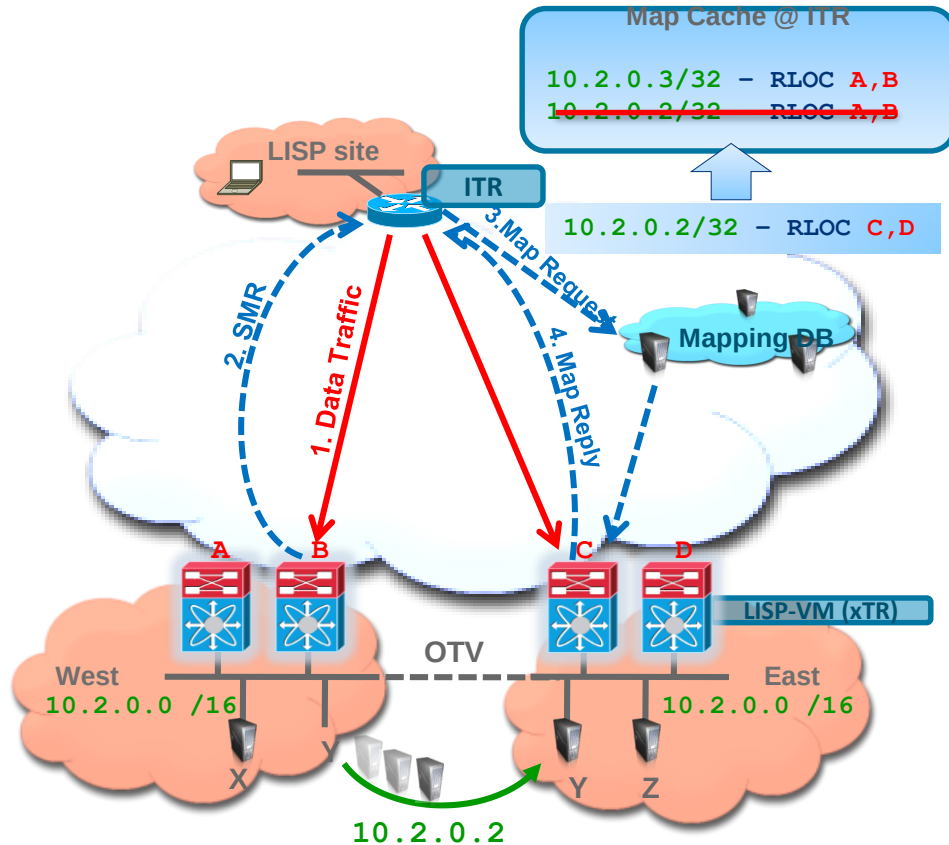
- With Extended Subnets

- Consistent GWY-IP and GWY-MAC configured across all sites
 - Consistent HSRP group number across sites → consistent GWY-MAC
- Servers can move anywhere and always talk to a local gateway with the same IP/MAC



Refreshing the Map Caches

1. ITRs and PITRs with cached mappings continue to send traffic to the old locators
 1. The old xTR knows the host has moved (Null0 route)
 2. Old xTR sends Solicit Map Request (SMR) messages to any encapsulators sending traffic to the moved host
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- Traffic is now re-directed
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LISP VM-Mobility Configuration



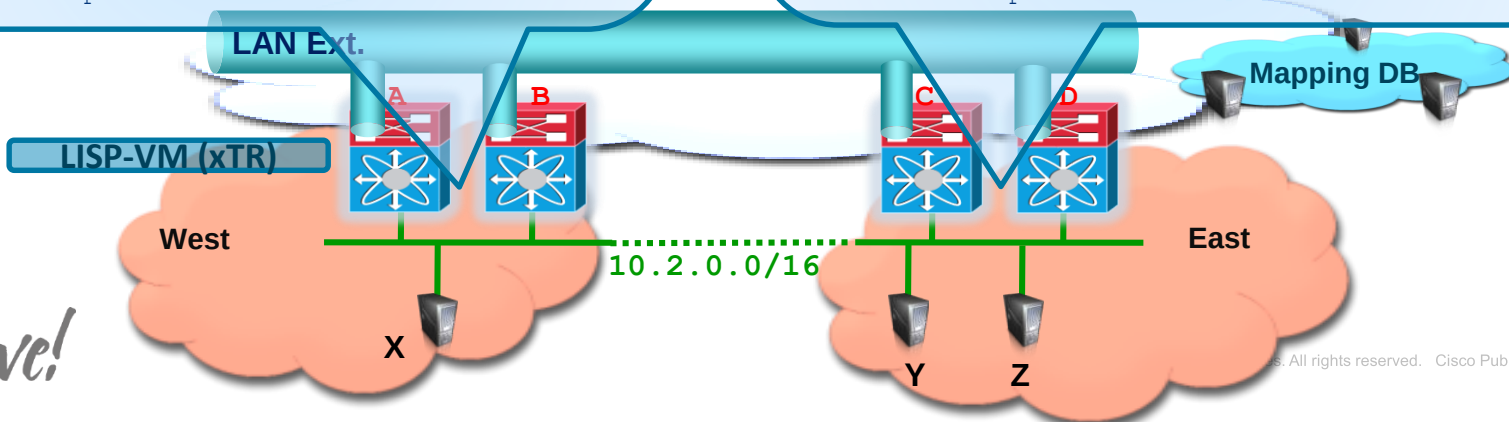
- With Extended Subnets → “extended-subnet-mode”

```
ip lisp ITR-ETR
ip lisp database-mapping 10.2.0.0/16 <RLOC-A>
ip lisp database-mapping 10.2.0.0/16 <RLOC-B>
```

```
lisp dynamic-eid roamer
  database-mapping 10.2.0.0/24 <RLOC-A> ...
  database-mapping 10.2.0.0/24 <RLOC-B>
  map-server 1.1.1.1 key abcd
  map-server 2.2.2.1 key abcd
  map-notify-group 239.10.10.10
interface vlan 100
  ip address 10.2.0.10 /16
  lisp mobility roamer
  lisp extended-subnet-mode
  hsrp 101
    ip 10.2.0.1
```

```
ip lisp ITR-ETR
ip lisp database-mapping 10.3.0.0/16 <RLOC-C>
ip lisp database-mapping 10.3.0.0/16 <RLOC-D>
```

```
lisp dynamic-eid roamer
  database-mapping 10.2.0.0/24 <RLOC-C>
  database-mapping 10.2.0.0/24 <RLOC-D>
  map-server 1.1.1.1 key abcd
  map-server 2.2.2.1 key abcd
  map-notify-group 239.10.10.10
interface vlan 100
  ip address 10.2.0.11 /16
  lisp mobility roamer
  lisp extended-subnet-mode
  hsrp 101
    ip 10.2.0.1
```

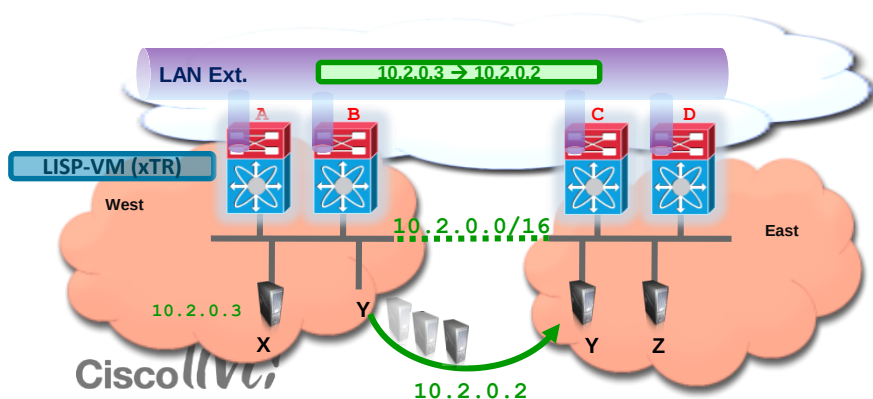


On-subnet Server-Server Traffic

- On Subnet Traffic Across L3 Boundaries

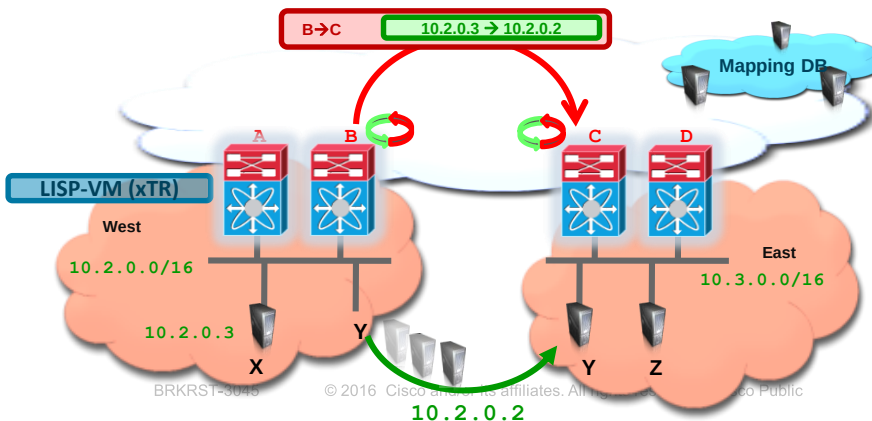
With LAN Extension

- Live moves and cluster member dispersion
- Traffic between X & Y uses the LAN Extension
- Link-local-multicast handled by the LAN Extension



Without LAN Extensions

- Cold moves, no application dispersion
- X- Y traffic is sent to the LISP-VM router & LISP encapsulated
- Need LAN extensions for link-local multicast traffic



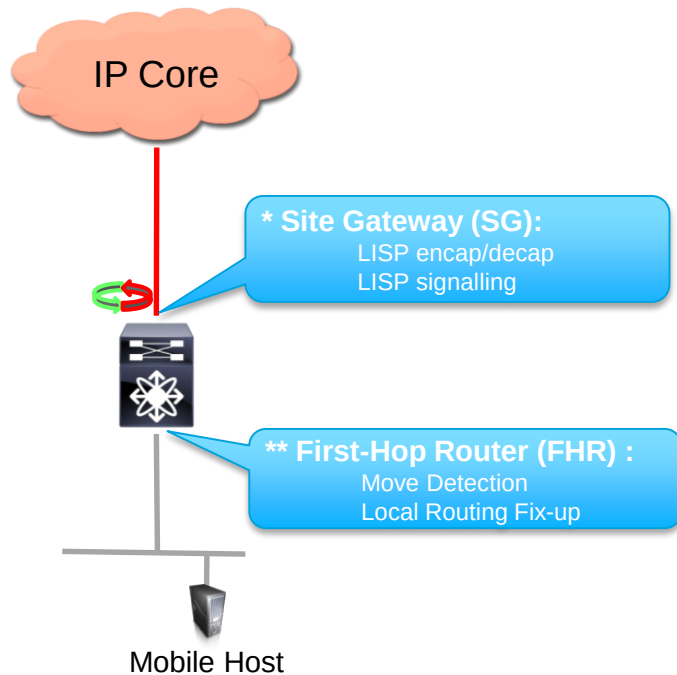
Dissection of LISP Mobility Functionality

Modular Functionality: Fixed Menu or a-la-carte

1. Overlay Control Plane (Signalling) *
2. Overlay Data Plane (Encap-decap) *
3. Mobility detection **
4. First hop routing fix-ups **

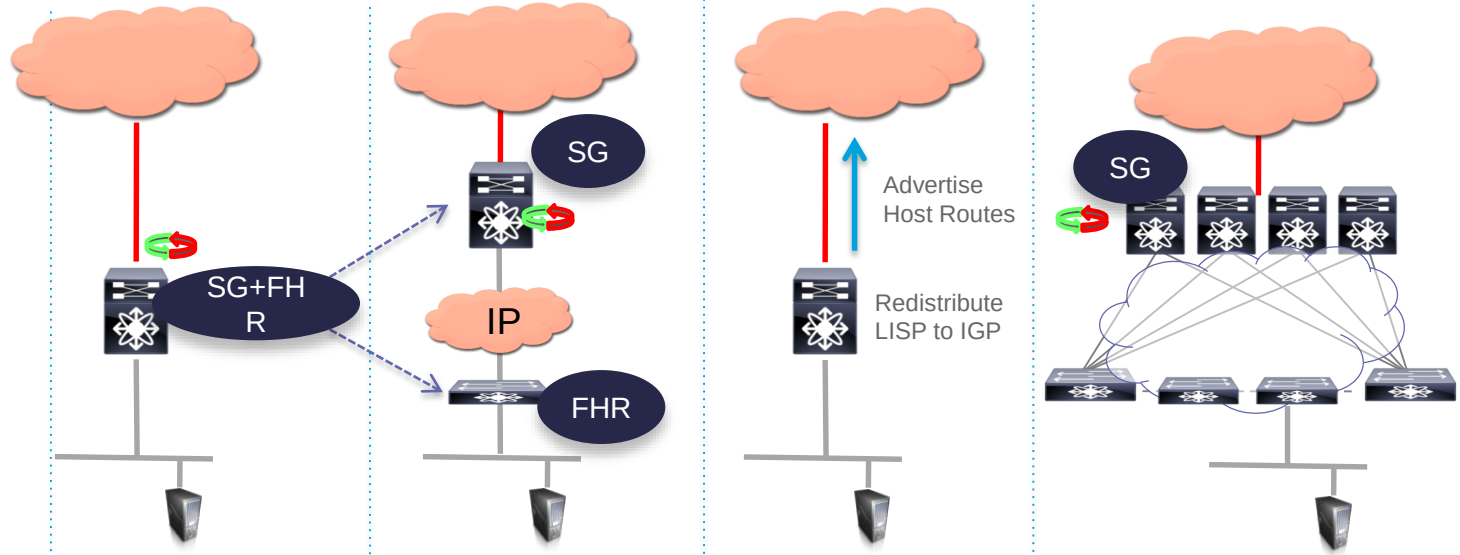
Menu of functionality:

- Consume some or all
- May be distributed over multiple hops



LISP Mobility Consumption Models

Modular Functionality: Fixed Menu or a-la-carte



Single-Hop (SH)

Multi-Hop (MH)

IGP Assist (SH or MH)

Fabric Integrated

SG: Encap/decap

✓

✓

X

✓

SG: LISP Signalling

✓

✓

✓

✓

FHR: Move Detection

✓

✓

✓

X

FHR: Local Routing Fix-up

✓

✓

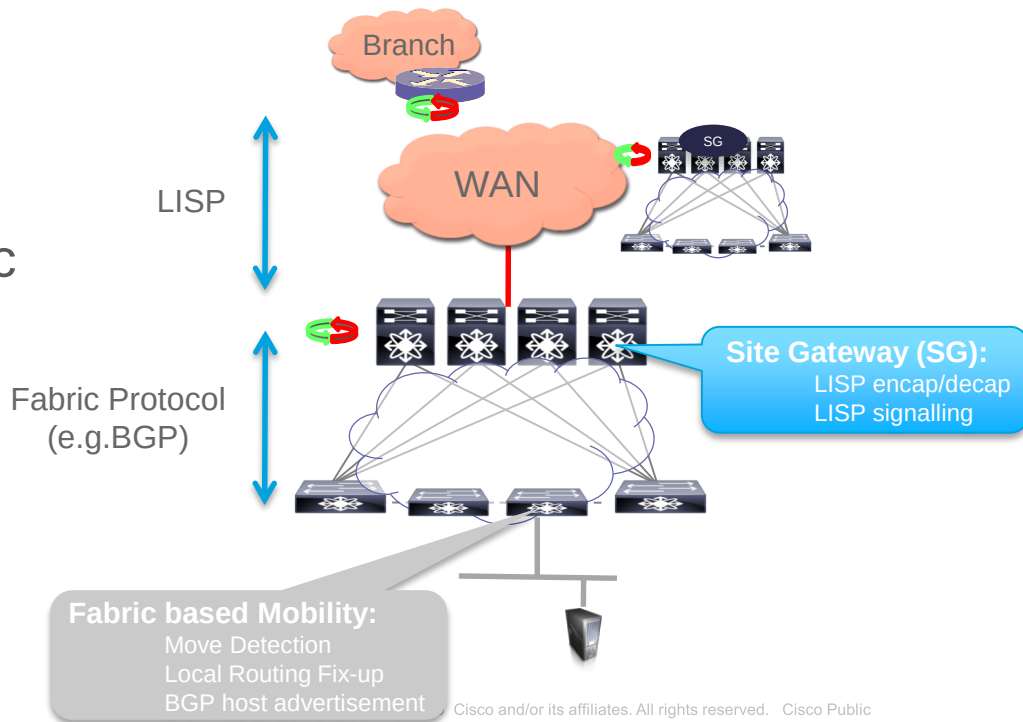
✓

X

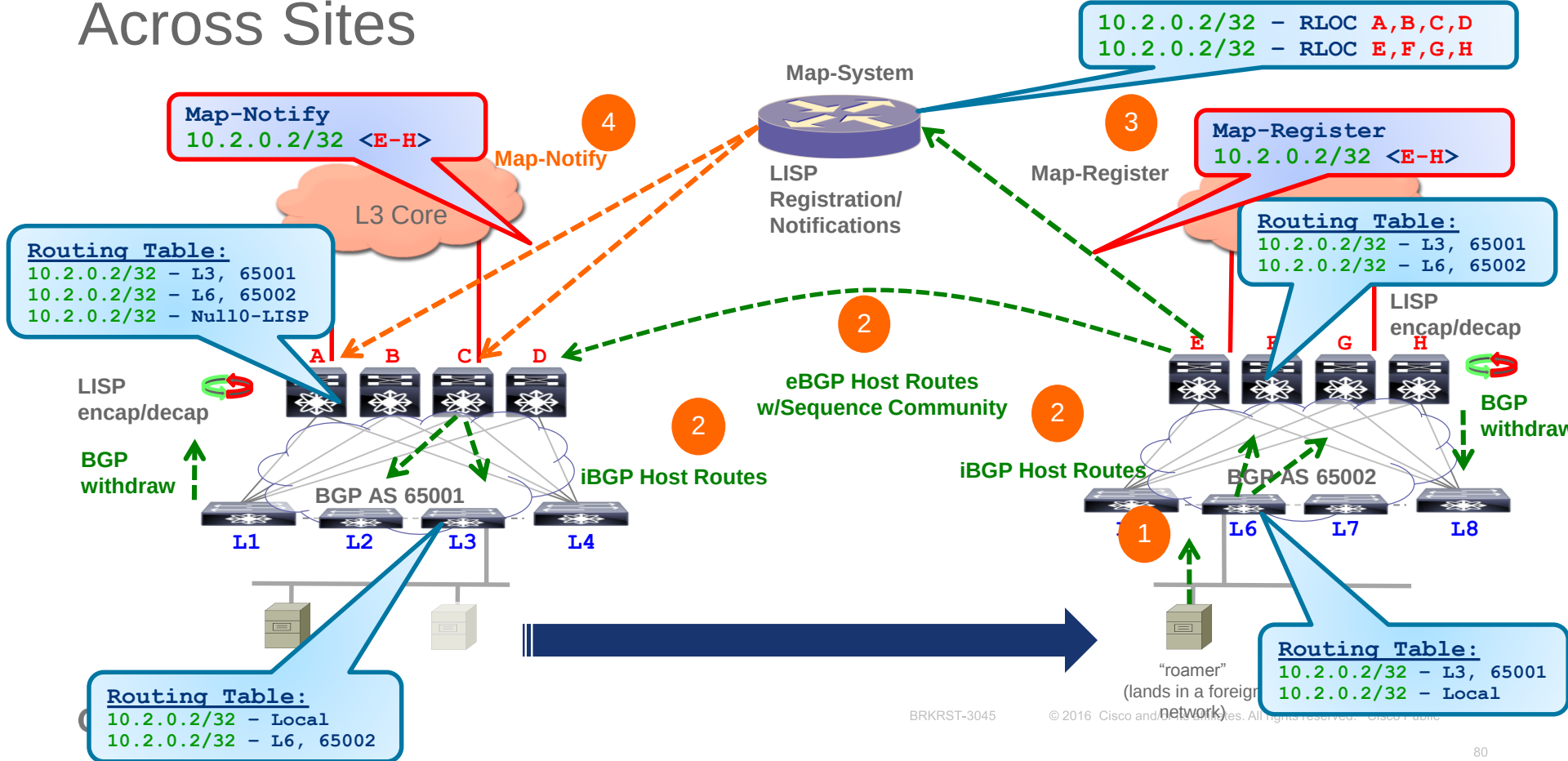
LISP – Standalone Fabric Integration

- Benefits:
 - Ingress Routing Optimisation
 - Edge Router Scale
 - WAN/Multi-homing
- Host detection done by the fabric
- LISP mobility triggered by reception of host routes
- MP-BGP to LISP handoff
 - VXLAN EVPN (Standalone)
 - VPNv4

Cisco *live!*



LISP Fabric Integration - Host Mobility Signalling Across Sites



LISP Fabric Integration

Fabric Host Route Distribution @ SG

LISP Infrastructure

```
vrf context UNDERLAY-RLOC-VRF
ip lisp itr-etr
ip lisp itr map-resolver <MR-address>
ip lisp etr map-server <MS-address> key <registration-key>
```

Tenant Mobility

```
vrf context TENANT-A-VRF
ip lisp itr-etr
ip lisp locator-vrf UNDERLAY-RLOC-VRF
lisp instance-id <lisp-segment-id>
lisp dynamic-eid <mobility-group-name>
    database-mapping dyn-eid-prefix <RLOC1> p1 w50
    database-mapping dyn-eid-prefix <RLOC2> p1 w50
register-route-notifications tag <route-tag>
```

Register hosts with LISP

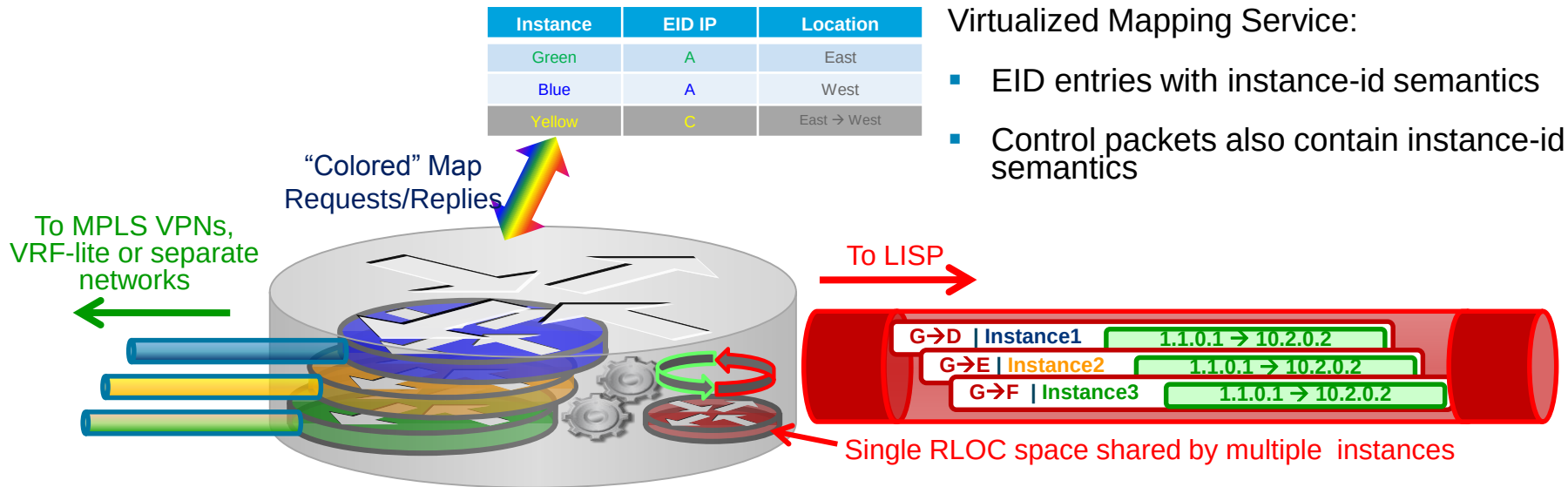
SG Interface

```
interface ethernet 2/4
ip address x.x.x.x
no shutdown
```

Multi-tenancy/Segmentation in LISP



- LISP Multi-tenancy



Virtualized Mapping Service:

- EID entries with instance-id semantics
- Control packets also contain instance-id semantics

Virtualized Map Cache (xTRs):

- Mappings cached in different VRFs per instance-id
- Interoperable with other VRF features/solutions

“Colored” Traffic:

- Instance-ID tag in LISP data header
- Instance-ID encoded in LISP control packets

LISP Extensibility

- LISP Canonical Address Family (LCAF)
- Extensible encoding allows inclusion of metadata in the control plane (without having to get IETF workgroup approval each time it changes)
- Attributes can be added to extend EIDs or RLOCs. For example:
 - Instance IDs for segmentation are encoded in LCAF as part of the EID
 - Another example are geo-coordinates as part of the RLOC
 - MAC addresses are easily implemented using LCAF
 - SGTs could be registered as part of the RLOC for an EID

Summary

- BGP is a full featured routing protocol. It has been extended to support overlay location management
- LISP is a Directory Service.
- Both mechanisms are currently implemented to interoperate cleanly
- Operators may prefer one over the other or the combination
- Cisco is committed to deliver end-to-end solutions in both areas

Q & A

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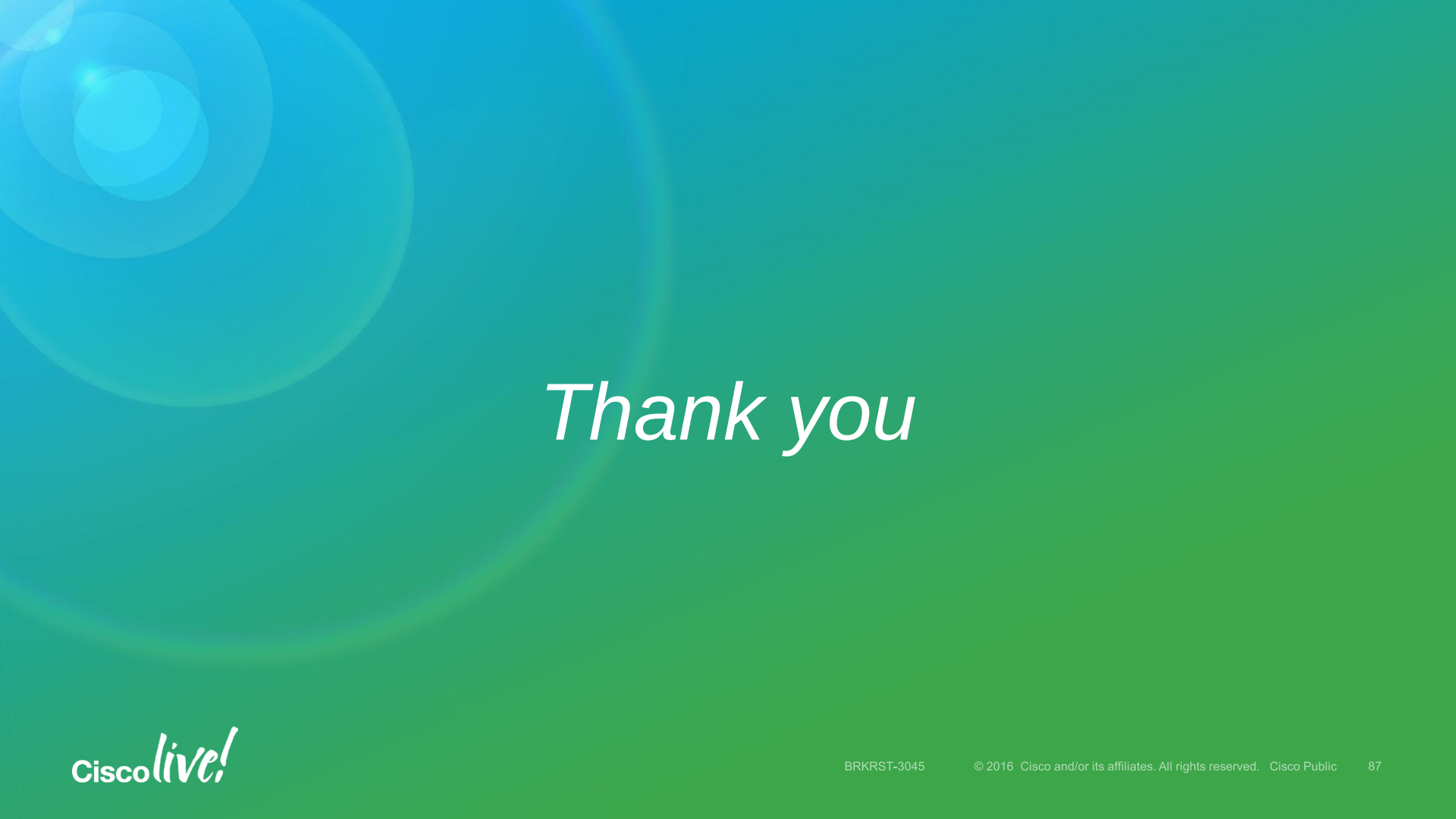
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