Possibilities

#CiscoLive

Cisco SD-WAN: Planning your Deployment and Lessons Learned.

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DGTL-BRKENT-2191

Agenda

- Introduction
- SD-WAN Foundational Review
- BFD & App Aware Routing
- Planning your SD-WAN Deployment
- Lessons Learned the Hard Way
- Conclusion

SD-WAN Fundamentals

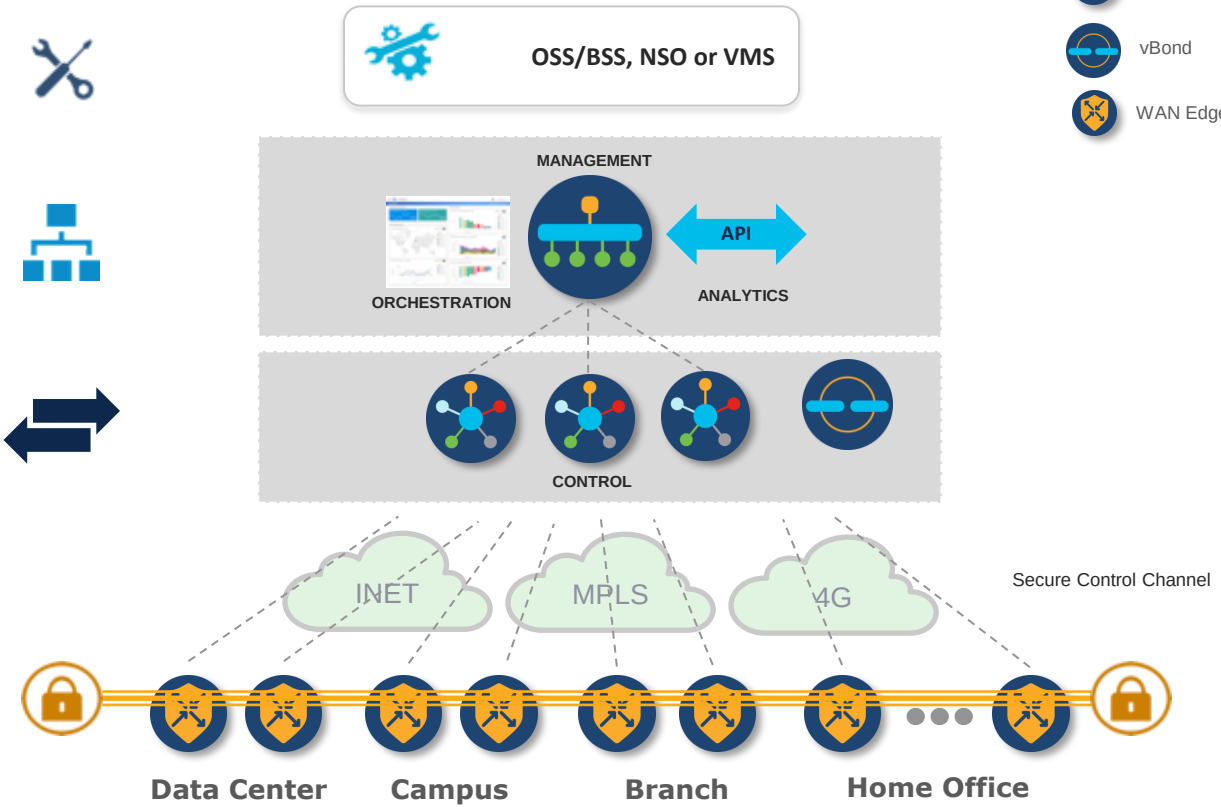
Cisco SDWAN

Orchestration Plane

Management Plane
(Multi-tenant or Dedicated)

Control Plane
(Containers or VMs)

Data Plane
(Physical or Virtual)



Solution Elements Functional Roles

vBond orchestrator
- Primary authenticator for all SDWAN components
- Facilitates discovery of the control elements by the wEdge routers
- Notifies wEdges of their public IP, if behind NAT.

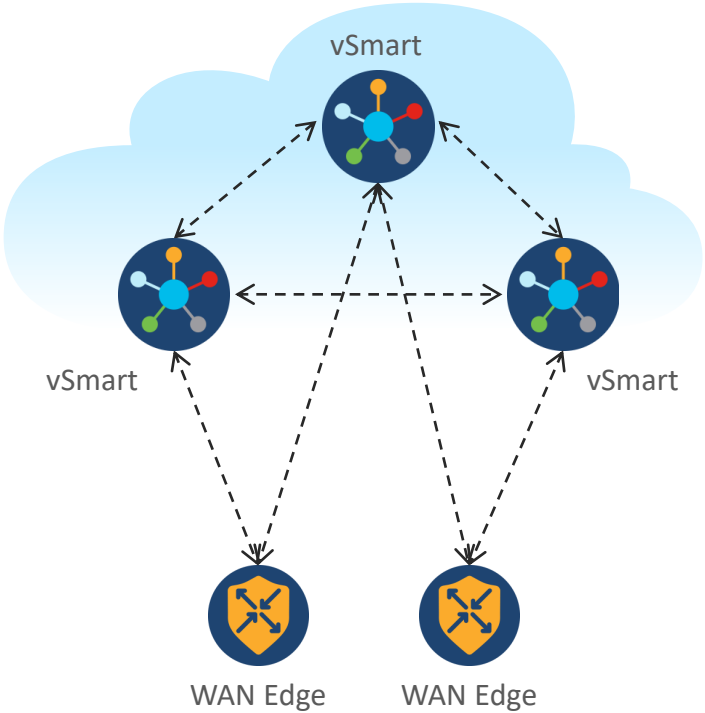
vManage is the network management system, a single pane of glass, for the entire SD-WAN fabric

vSmart controllers:
- Distribute reachability and security information between the WAN Edge routers
- Distribute data and app-route policies from vManage to wEdges. Enforce control policies.
- Perform best-path calculation for non ECMP routes and advertise best route to the wEdges (second best too, if configured)

WAN Edge routers sit at the perimeter of an SD-WAN site and provide connectivity across the fabric. wEdge routers handle the transmission of data traffic.

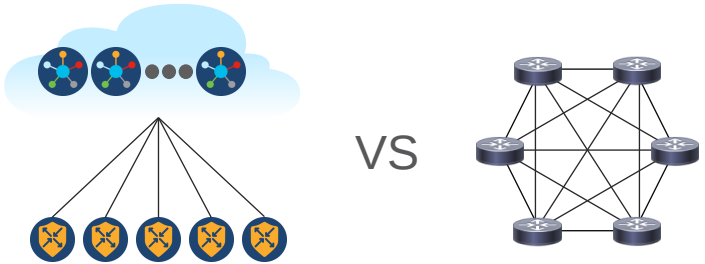
WAN Edge routers are offered as pre-integrated appliance or as a software-only virtual machine for ESXi, KVM, AWS and Microsoft Azure platforms.

Overlay Management Protocol (OMP)
Unified Control Plane

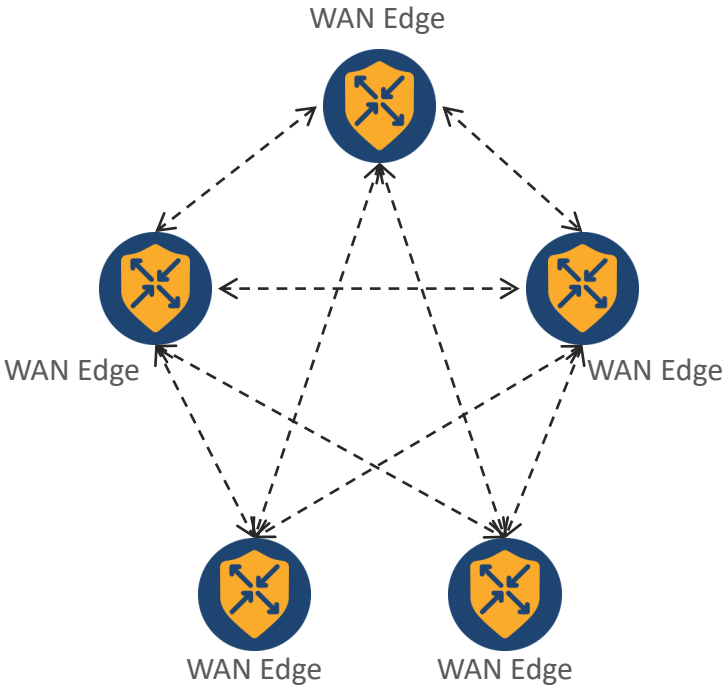


Note: wEdge routers need not connect to all vSmart Controllers

- TCP based extensible control plane protocol
- Runs between WAN Edge routers and vSmart controllers and between the vSmart controllers
  - Inside TLS/DTLS connections
- Advertises control plane context
- Dramatically lowers control plane complexity and raises overall solution scale

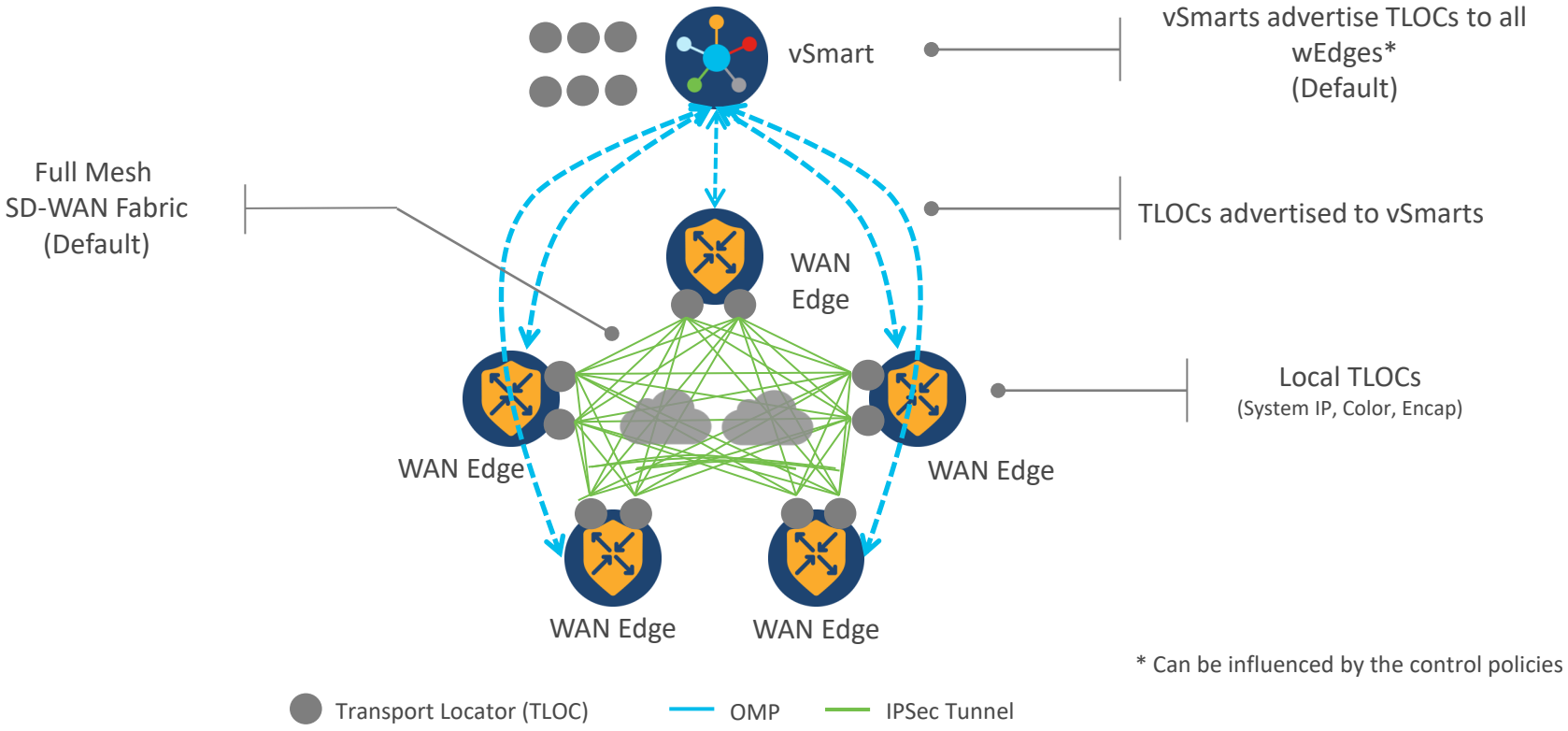


Bidirectional Forwarding Detection (BFD)

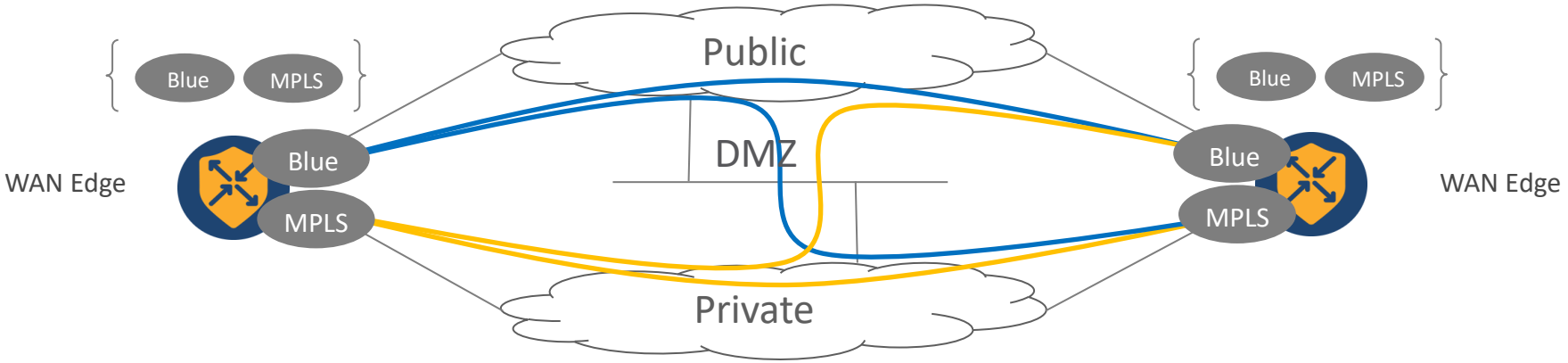


- Path liveliness and quality measurement detection protocol
  - Up/Down, loss/latency/jitter, IPSec tunnel MTU
- Runs between all WAN Edge routers in the topology
  - Inside IPSec tunnels
  - Operates in echo mode
  - Automatically invoked at IPSec tunnel establishment
  - Cannot be disabled
- Uses hello (up/down) interval, poll (app-aware) interval and multiplier for detection
  - Fully customizable per-WAN Edge, per-color

Transport Locators (TLOCs)



Transport Colors



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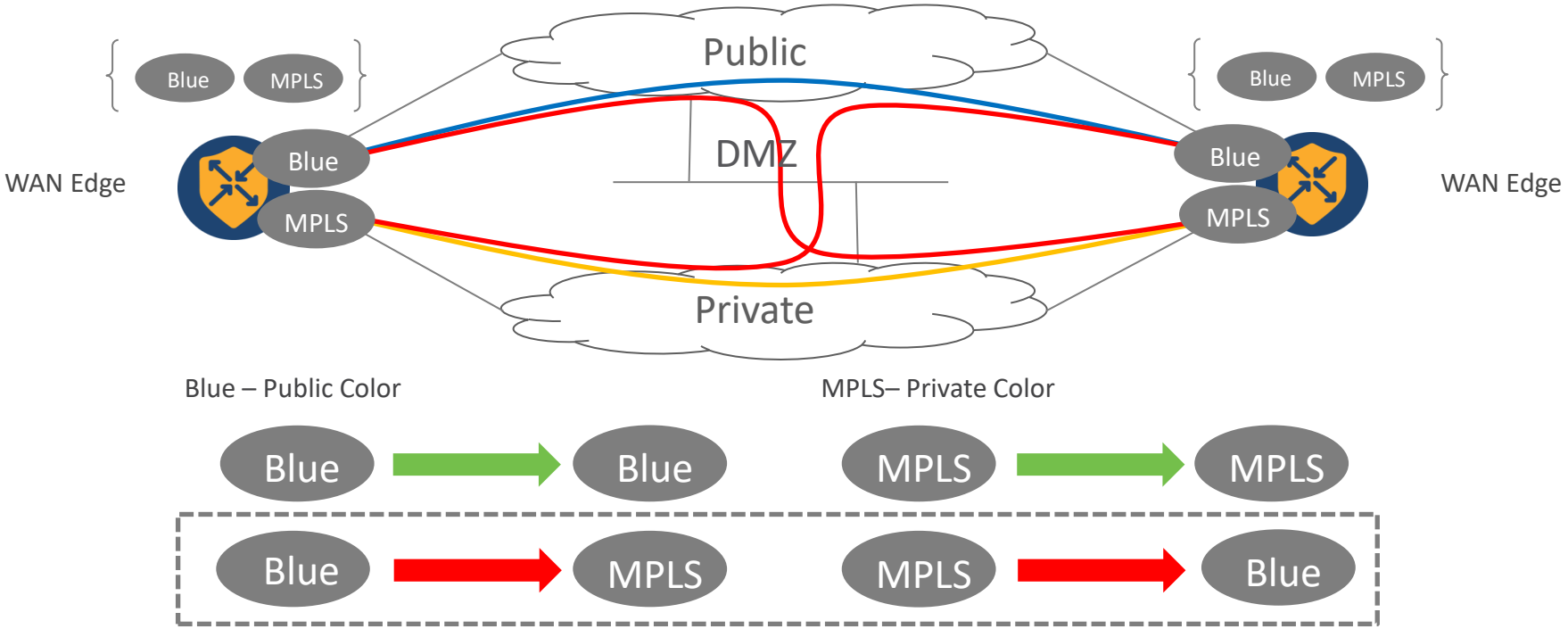
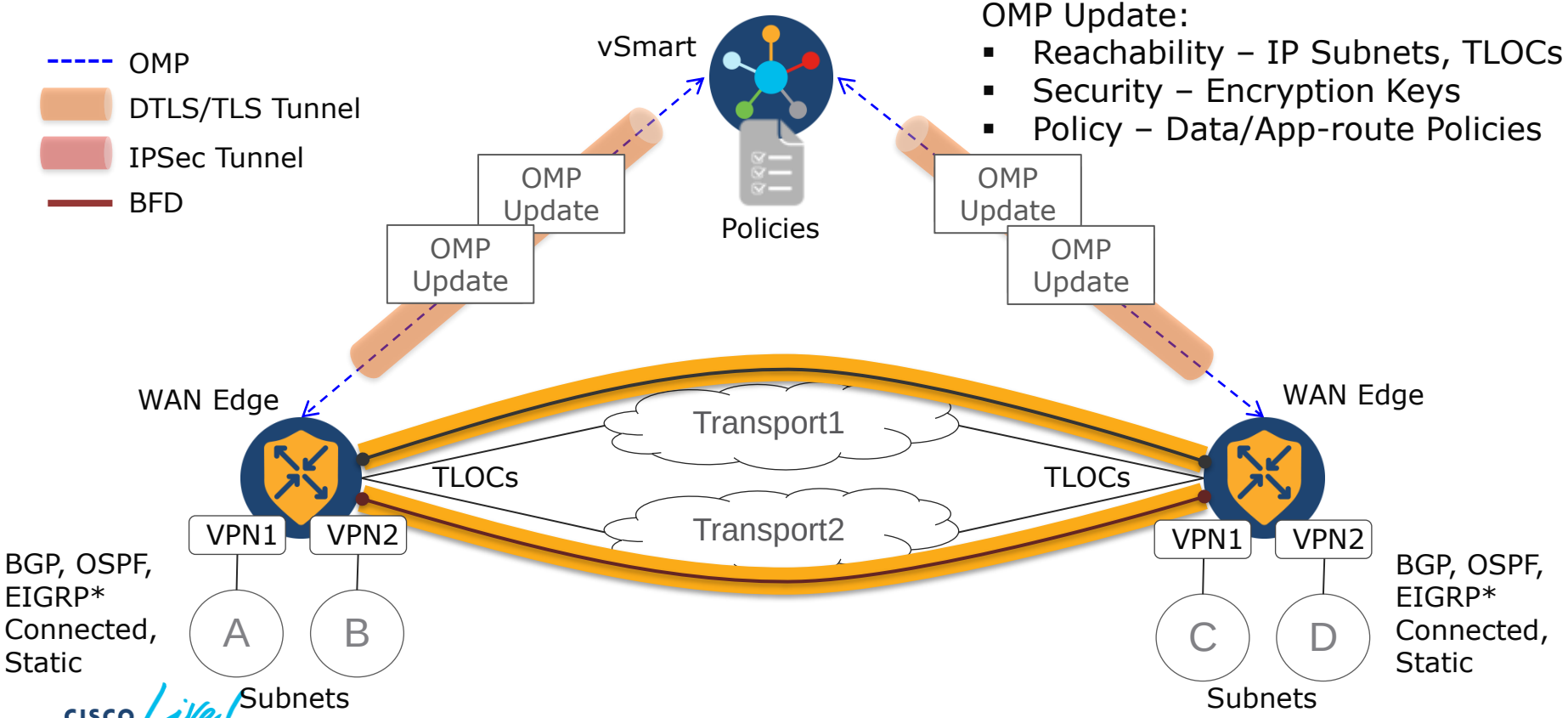
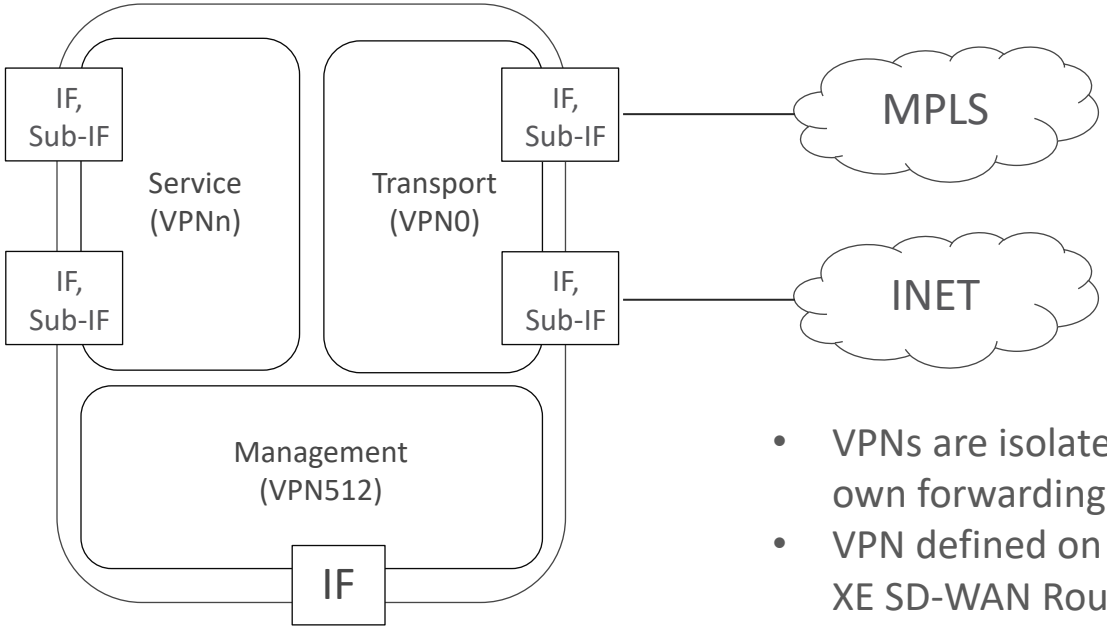


Fabric Operation
Fabric Walk-Through

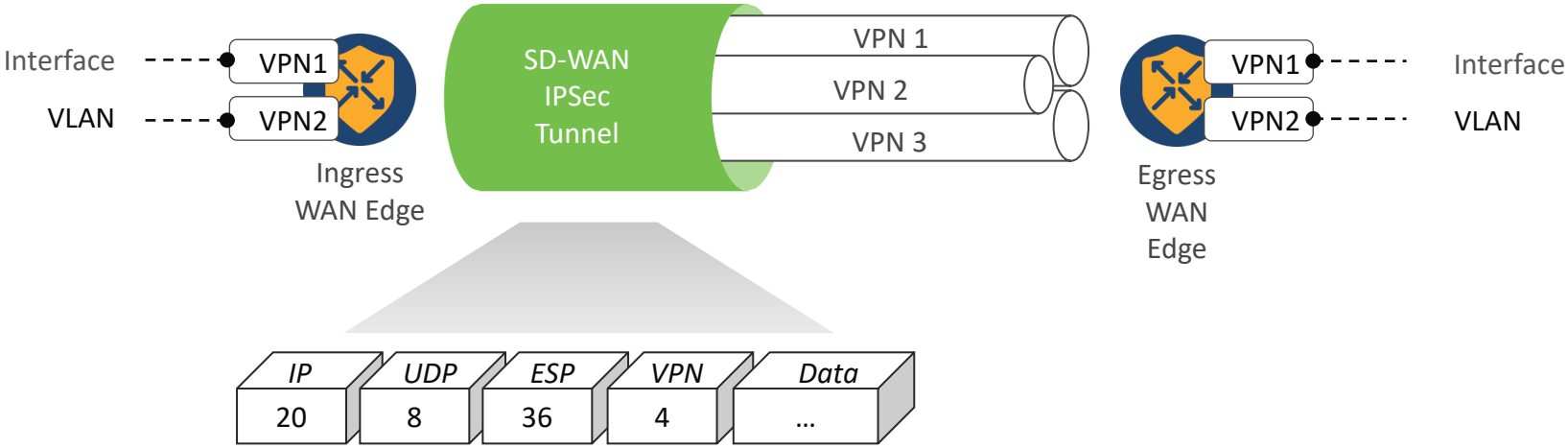


Cisco SD-WAN VPNs
WAN Edge Router Security Zones



- VPNs are isolated from each other, each VPN has its own forwarding table
- VPN defined on vEdge Routers, VRF defined on IOS-XE SD-WAN Routers
- Reachability within VPN is advertised by the OMP

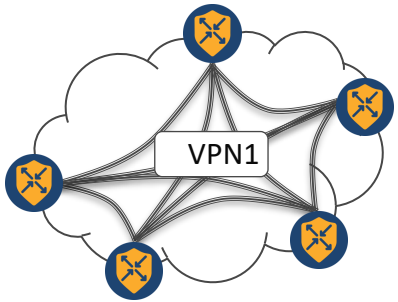
End-to-End Segmentation



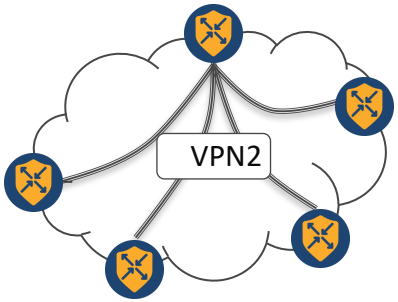
- Segment connectivity across fabric w/o reliance on underlay transport
- WAN Edge routers maintain per-VPN routing table
- Labels are used to identify VPN for destination route lookup
- Interfaces and sub-interfaces (802.1Q tags) are mapped into VPNs

Flexible VPN Topologies

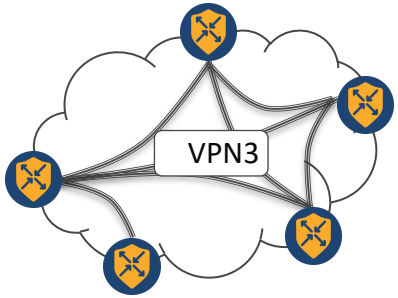
Full-Mesh



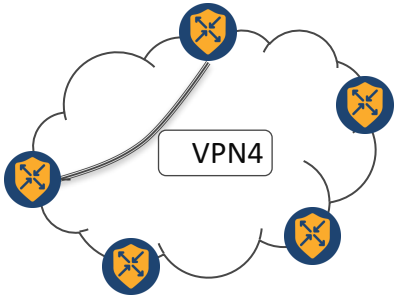
Hub-and-Spoke



Partial Mesh

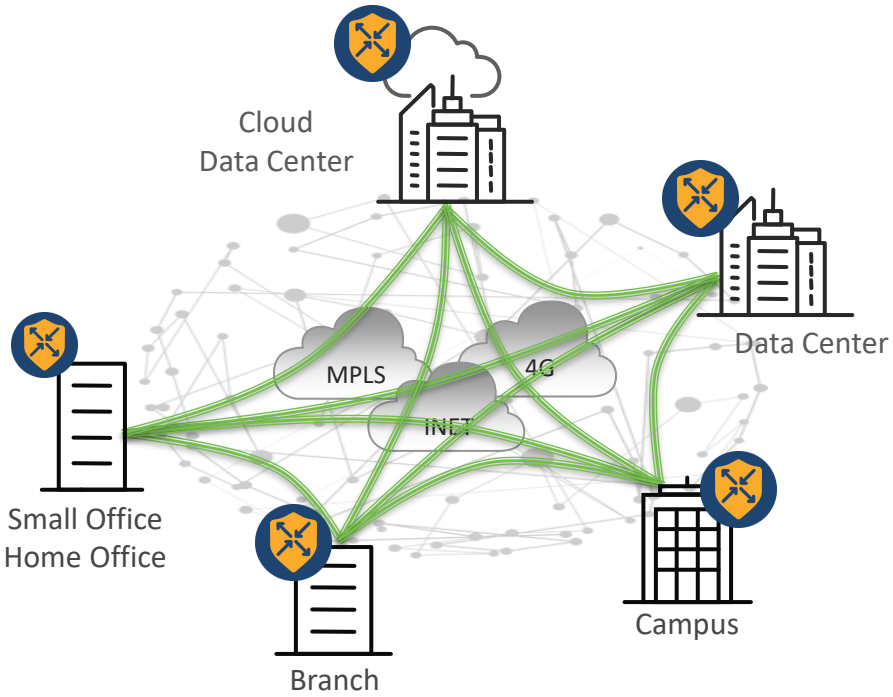


Point-to-Point



- Each VPN can have it's own topology
  - Full-mesh, hub-and-spoke, partial-mesh, point-to-point, etc…
- VPN topology can be influenced by leveraging control policies
  - Filtering TLOCs or modifying next-hop TLOC attribute for OMP routes
- Applications can benefit from shortest path, e.g. voice takes full-mesh topology
- Security compliance can benefit from controlled connectivity topology, e.g. PCI data takes hub-and-spoke topology

Application Visibility and Recognition



Deep Packet Inspection

- ✓ App Firewall
- ✓ Traffic prioritization
- ✓ Transport selection

OMP Routes Advertised

Three Major Types of Routes

1. OMP Routes
   - Prefixes learnt from site-local (i.e. service side)
   - Like prefixes of BGP
2. TLOCs
   - Ties OMP route to physical location (i.e. wEdge)
   - Like next-hop of BGP
3. Network-Service Routes
   - Ties OMP route to an advertised network service

OMP Routes

Routes learnt from a site-local network

Route Types:

- Connected (Direct)
- Static
- BGP
- OSPF
- EIGRP*

Some Attributes:

- TLOC: System-IP of route originator + color
- Site-id: Site identifier of route
- VPN-id: VPN identifier of route
- Tag: optional transitive path attribute
- Preference: Degree of preference for a route
- Originator ID: Originator of route
- Origin: Protocol + metric

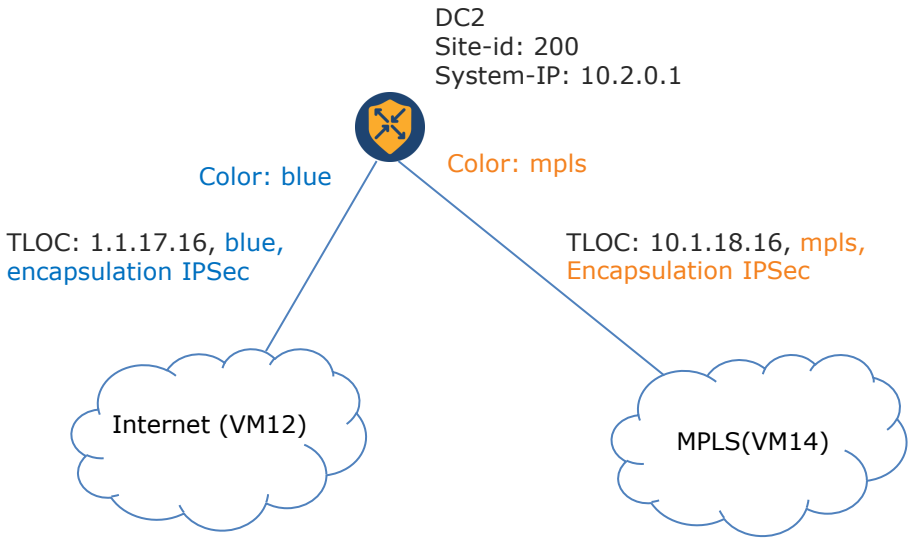
```
BR2-VEDGE# show omp routes 10.2.0.0/24 detail

---------------------------------------------------
omp route entries for vpn 10 route 10.2.0.0/24
---------------------------------------------------
             RECEIVED FROM:
peer             12.12.12.12
path-id          30
label            1002
status           C,I,R
loss-reason      not set
lost-to-peer     not set
lost-to-path-id  not set
    Attributes:
     originator       10.2.0.1
     type             installed
     tloc             10.2.0.1, mpls, ipsec
     ultimate-tloc    not set
     domain-id        not set
     overlay-id        1
     site-id          200
     preference       not set
     tag              not set
     origin-proto     connected
     origin-metric    0
     as-path          not set
     unknown-attr-len not set
```

TLOC Route

Routes connecting locations to physical network

Attributes:

- TLOC private
- TLOC public
- Weight
- Preference
- Color
- Tag
- Site-id
- Encap type



OMP Service Route Attributes

Routes of network-services connected to WAN Edge routers

Attributes:

- VPN id
- Service-id:
  - FW, IDS, IDP or generic net-svc
- Label
- Originator-id
- TLOC
- Path-id

```
vSmart-1# show omp services service netsvc1 received
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Stg -> staged
Inv -> invalid

ADDRESS                                                  PATH
FAMILY   VPN    SERVICE  ORIGINATOR  FROM PEER        ID     LABEL    STATUS
---------------------------------------------------------------------------
ipv4     10     netsvc1  10.1.0.1    10.1.0.1         66     1005     C,I,R
                                     10.1.0.1         68     1005     C,I,R
                                     22.22.22.22      42     1005     C,R
                                     22.22.22.22      74     1005     C,R
         10     netsvc1  10.1.0.2    10.1.0.2         66     1005     C,I,R
                                     10.1.0.2         68     1005     C,I,R
                                     22.22.22.22      25     1005     C,R
                                     22.22.22.22      96     1005     C,R
```

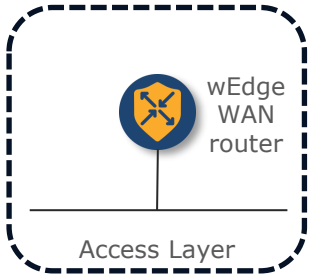
Policy Driven WAN Infrastructure

Policy Augmented Dynamic Routing

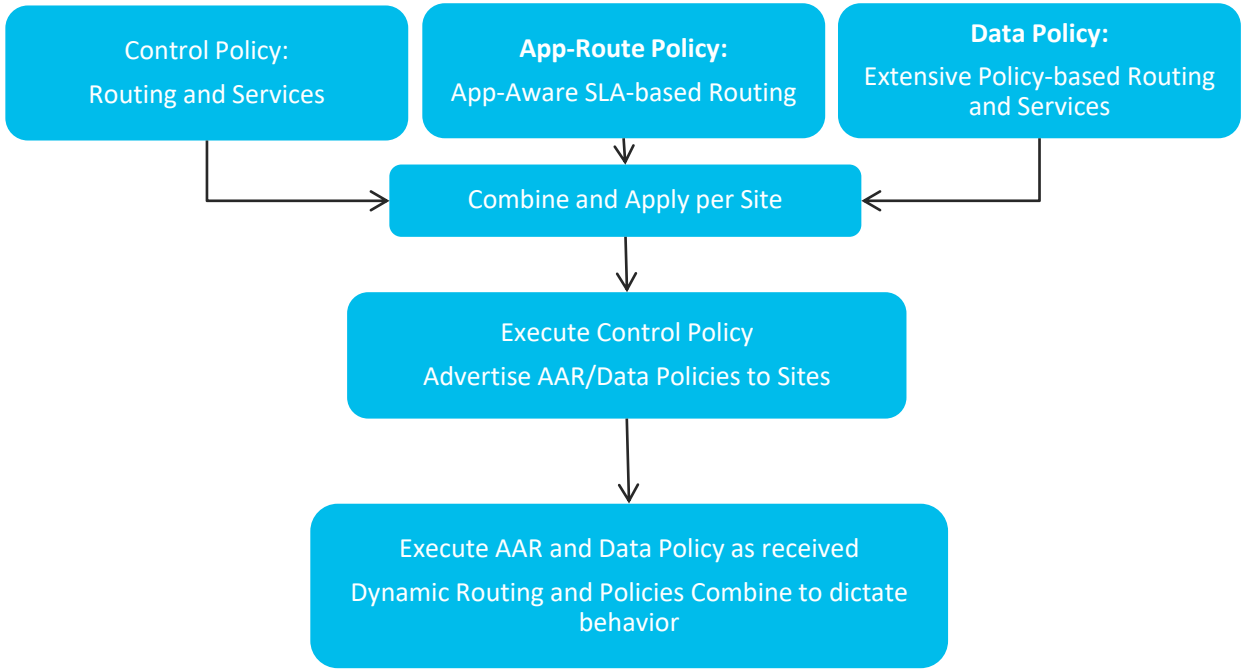
1 vManage GUI – Policy Orchestration

2 vSmart controller – Policy Enforcement/Advertisement

3



Branch/DC



Centralized (vSmart) Policy Architecture

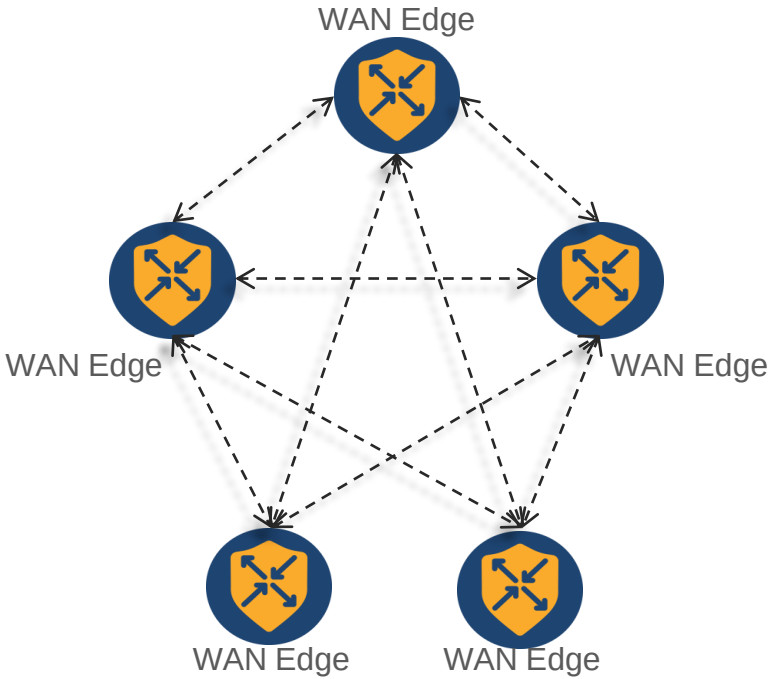
- vSmart Policies consist of these building blocks:
  - Lists used for defining targets of policy application or matching
  - Policies controlling aspects of control and forwarding
    - **Control Policy**
    - Application Aware Policy
    - **Data Policy**
    - cflowd-template
    - vpn-membership-policy
  - Policy Application to control towards what a policy is applied
    - Site-oriented and defined by a site-list

Local (WAN Edge) Policy Architecture

- Routing Policies are traditional routing policies
- Attaches to BGP, OSPF, or EIGRP locally on the WAN Edge
- Used in the traditional sense for controlling BGP and OSPF
  - Information exchange
  - Attributes
  - Path Selection
- Quality of Service
  - Match via ACL to set DSCP
  - DSCP Re-write Rule
  - WAN Class-maps and queuing

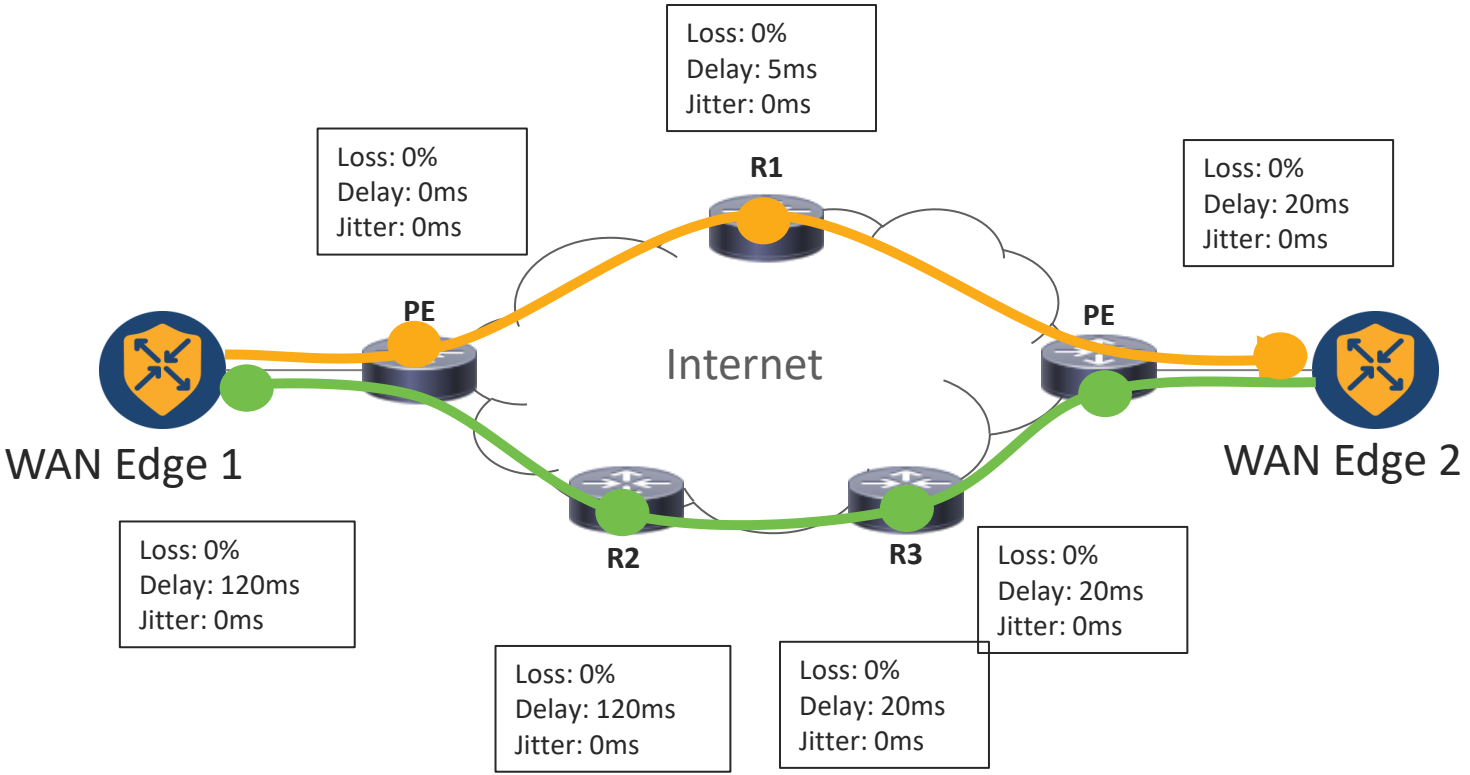
BFD & App Aware Routing

Data Plane Liveliness and Quality



- Bidirectional Forwarding Detection (BFD)
- Path liveliness and quality measurement
  - Up/Down, loss/latency/jitter, IPSec tunnel MTU
- Runs between all WAN Edge routers in the topology
  - Inside SD-WAN tunnels
  - Negotiated – Higher value wins
  - Across all transports
  - Operates in echo mode
  - Automatically invoked at SD-WAN tunnel establishment
  - Cannot be disabled
- Uses hello (up/down) interval, poll (app-aware) interval and multiplier for detection
  - Fully customizable per-WAN Edge, per-transport

BFD Quality Measurement Operations



PMTUD Operations

IPSec Header: 54 Bytes
MPLS Label: 4 Bytes

Scenario 1:
Min MTU: 522 Bytes
Max MTU: 1446 Bytes

Scenario 2:
Min MTU: 984 Bytes
Max MTU: 1446 Bytes

Scenario 3:
Min MTU: 984 Bytes
Max MTU: 1215 Bytes

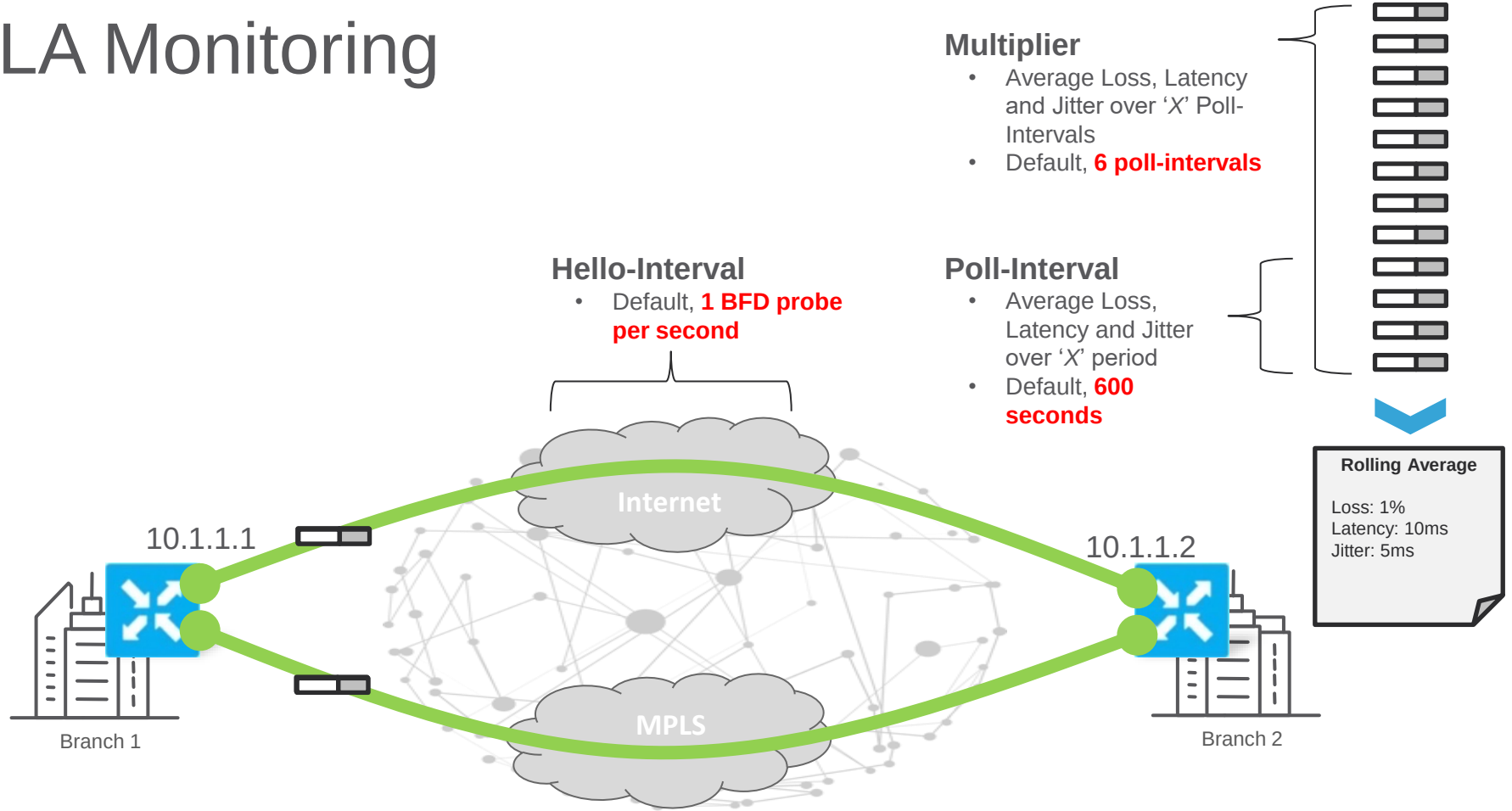
* Discovery can take up to 20 minutes. Discovery runs again when there is a tunnel flap or change in MTU on local interface.

SLA Monitoring

Multiplier
- Average Loss, Latency and Jitter over '*X*' Poll-Intervals
- Default, **6 poll-intervals**

Hello-Interval
- Default, **1 BFD probe per second**

Poll-Interval
- Average Loss, Latency and Jitter over '*X*' period
- Default, **600 seconds**



Real World Example

SLA Defined:
Latency: 100ms
Loss: 0%
Jitter: 0ms

Poll-Interval
- **60 seconds**

Multiplier
- **3 poll-intervals**

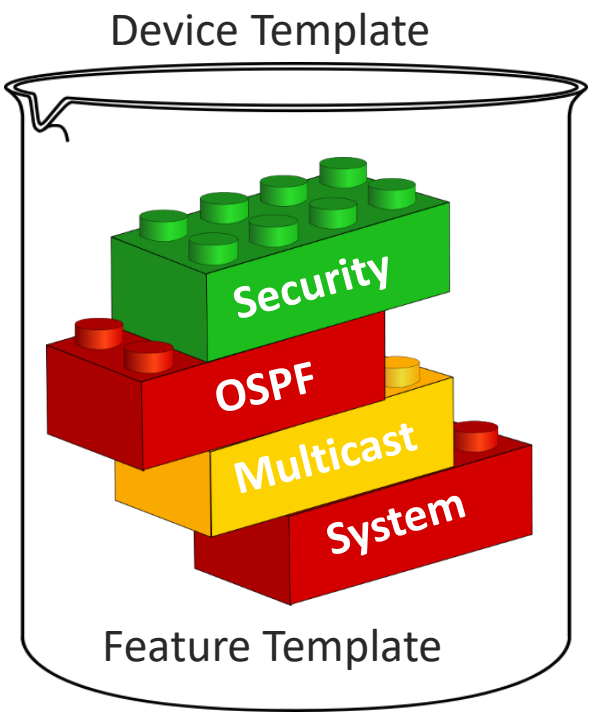
Interval Number:	Latency:	Rolling Average
Poll-Interval 1:	5ms	5ms
Poll-Interval 2:	10ms	~8ms
Poll-Interval 3:	295ms	~103ms
Poll-Interval 4:	0ms	~102ms
Poll-Interval 5:	0ms	~98ms

Planning your SD-WAN Deployment

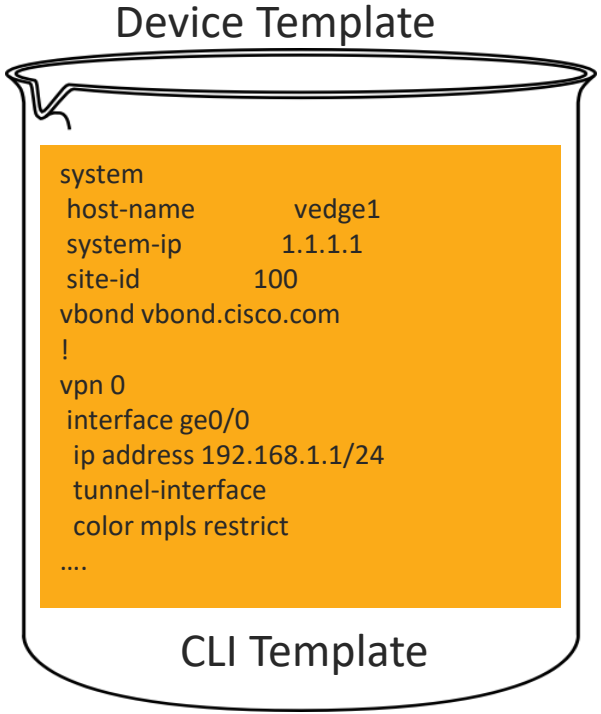
Templates

Device Templates

Device templates contain a devices complete configuration. You can create device templates by consolidating individual feature templates or by using a CLI template. You cannot mix and match CLI and feature templates. A device template is specific to the type of device, you may use the same device template if the device type is the same.



OR

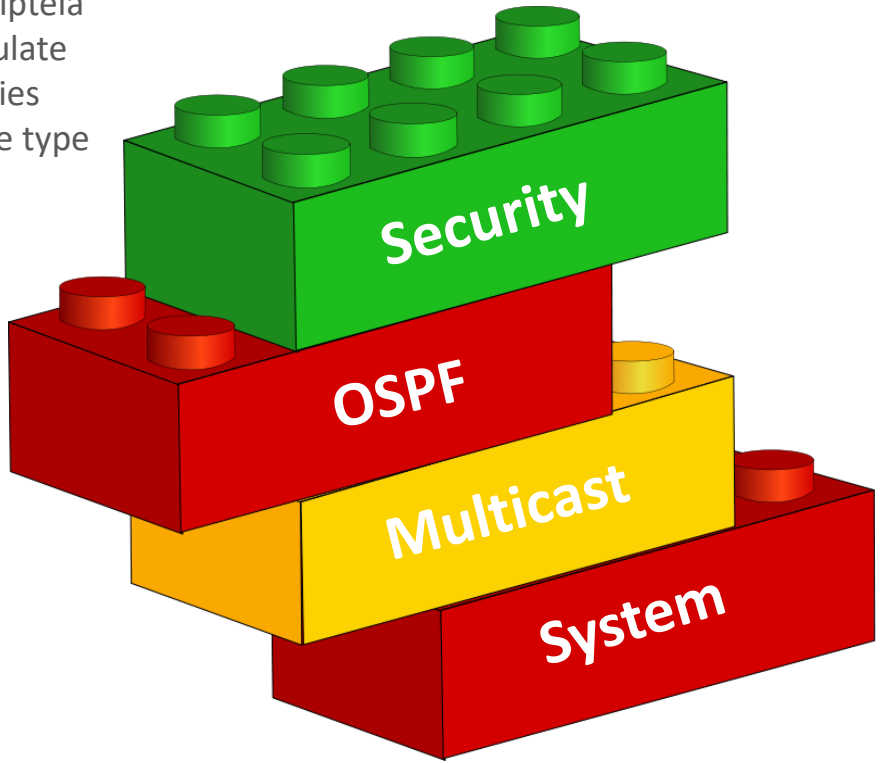


Feature Templates

Feature templates are the building blocks for a device's configuration. For each feature that you can enable on a Viptela device, vManage provides you an easy to use form to populate with the required variables. Since device configuration varies depending on the device type feature templates are device type specific. Some common features templates are:

- Security
- Multicast
- Routing protocol configuration
- SNMP
- DHCP
- …

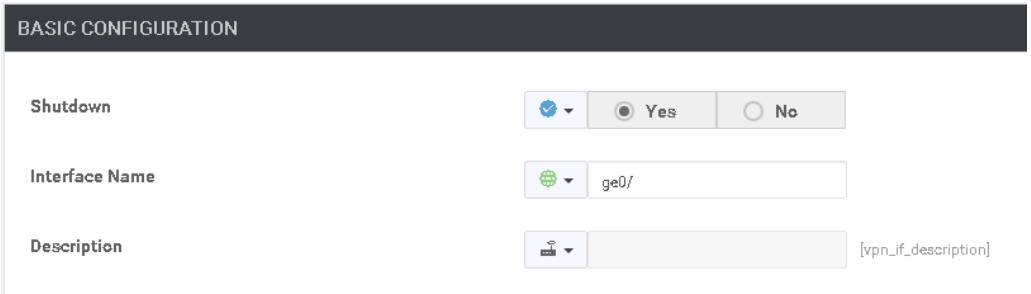
Some features are mandatory for device operation



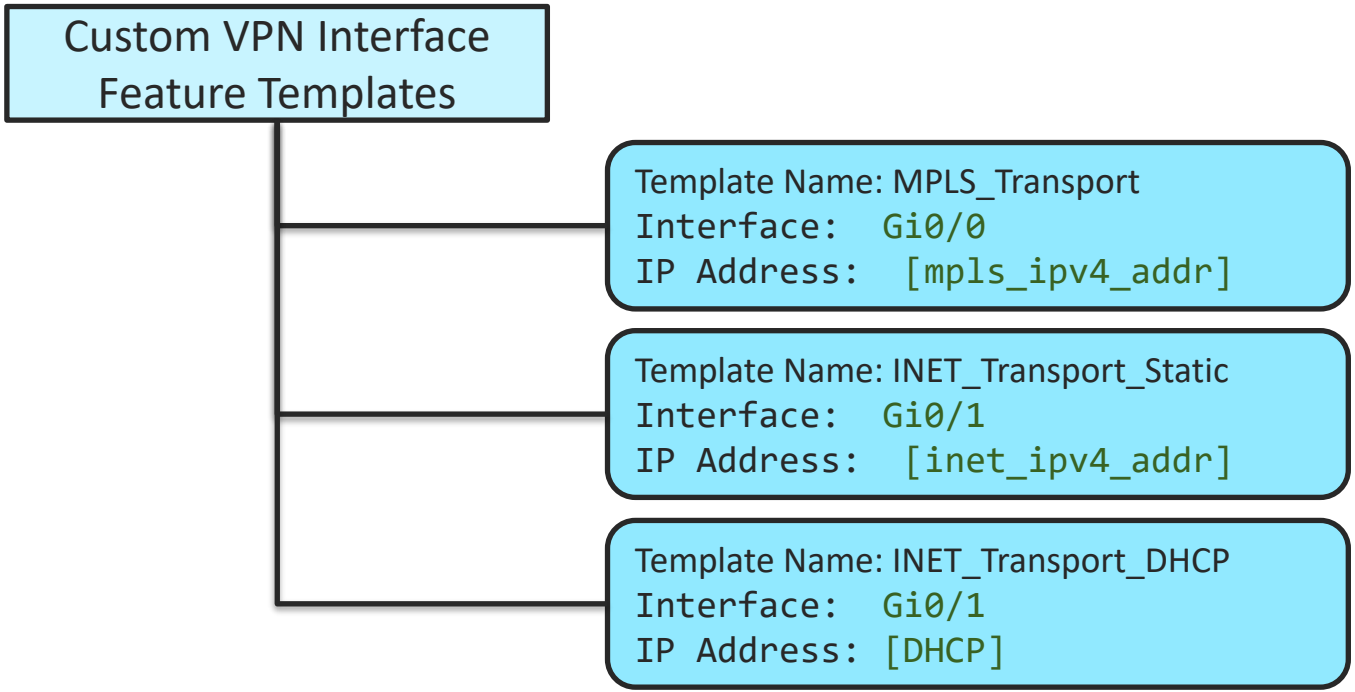
Feature Template Values

Three main values for most template settings

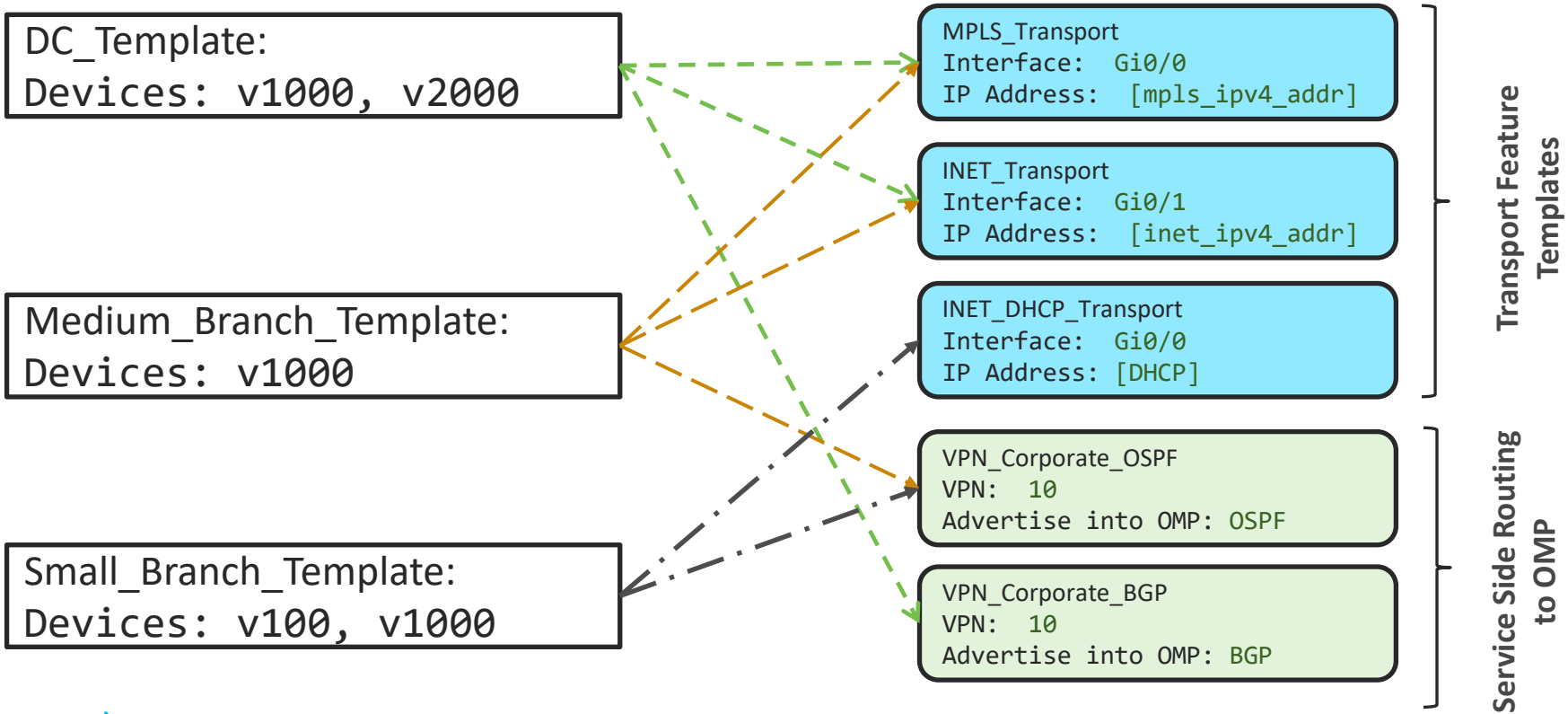
- **Default** – Values set by default in the environment. These cannot be changed
- **Global** – Values set to the same value for all devices associated to this feature template
- **Device Specific** – Value is set via a variable. The value for that variable is defined at the time the device template is associated to a device



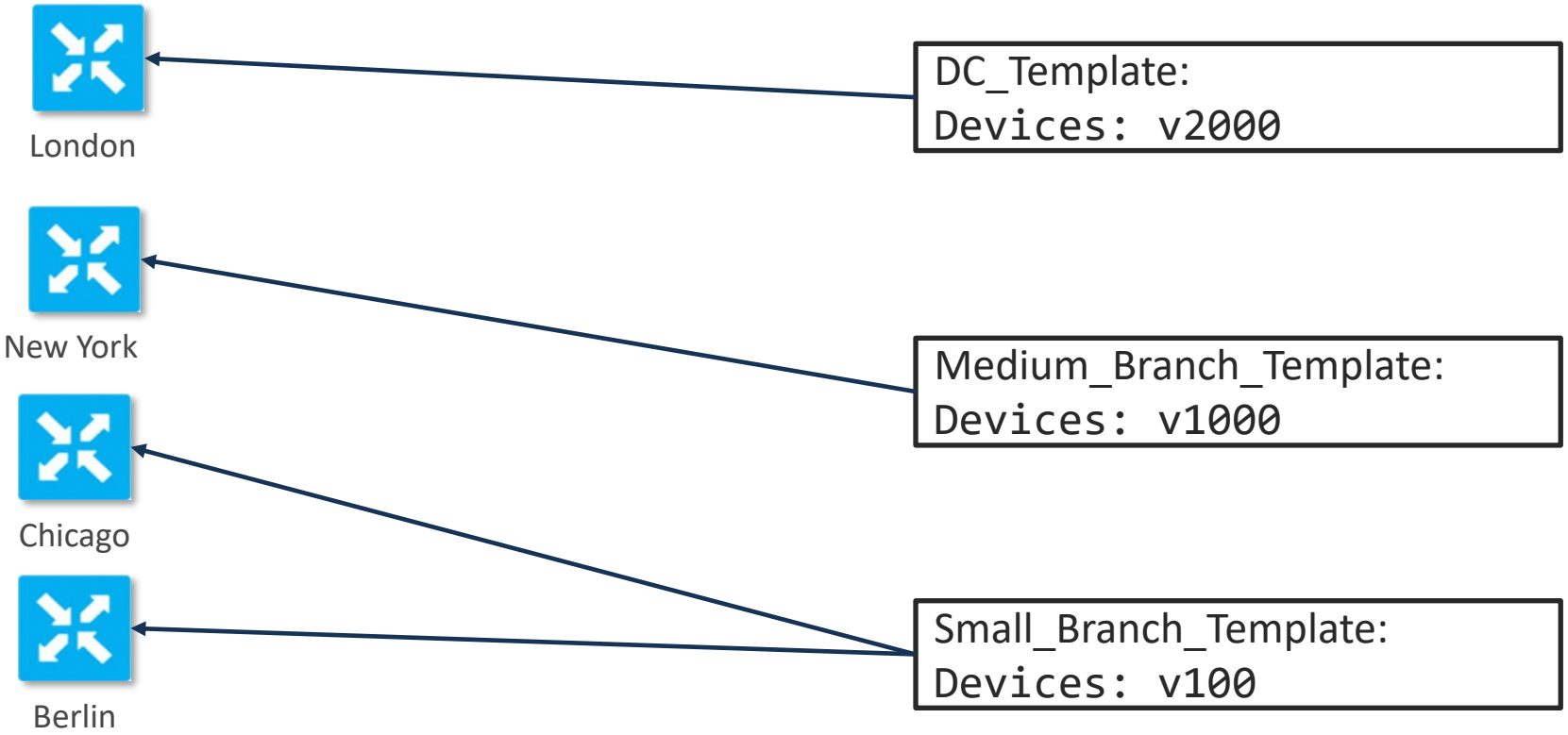
Sample VPN Interface Feature Template



Device Template Components



Device Template Components



Methods to Control Feature Template Sprawl

MPLS_Trans_Gi0
Interface: Gi0/0
IP Address: [mpls_ipv4_addr]

INET_Trans_Static_Gi0
Interface: Gi0/0
IP Address: [inet_ipv4_addr]

INET_Trans_DHCP_Gi0
Interface: Gi0/0
IP Address: [DHCP]

MPLS_Trans_Gi1
Interface: Gi0/1
IP Address: [mpls_ipv4_addr]

INET_Trans_Static_Gi1
Interface: Gi0/1
IP Address: [inet_ipv4_addr]

INET_ Trans_ DHCP_Gi1
Interface: Gi0/1
IP Address: [DHCP]

MPLS_Trans_Gi2
Interface: Gi0/2
IP Address: [mpls_ipv4_addr]

INET_Trans_Static_Gi2
Interface: Gi0/2
IP Address: [inet_ipv4_addr]

INET_ Trans_ DHCP_Gi1
Interface: Gi0/1
IP Address: [DHCP]

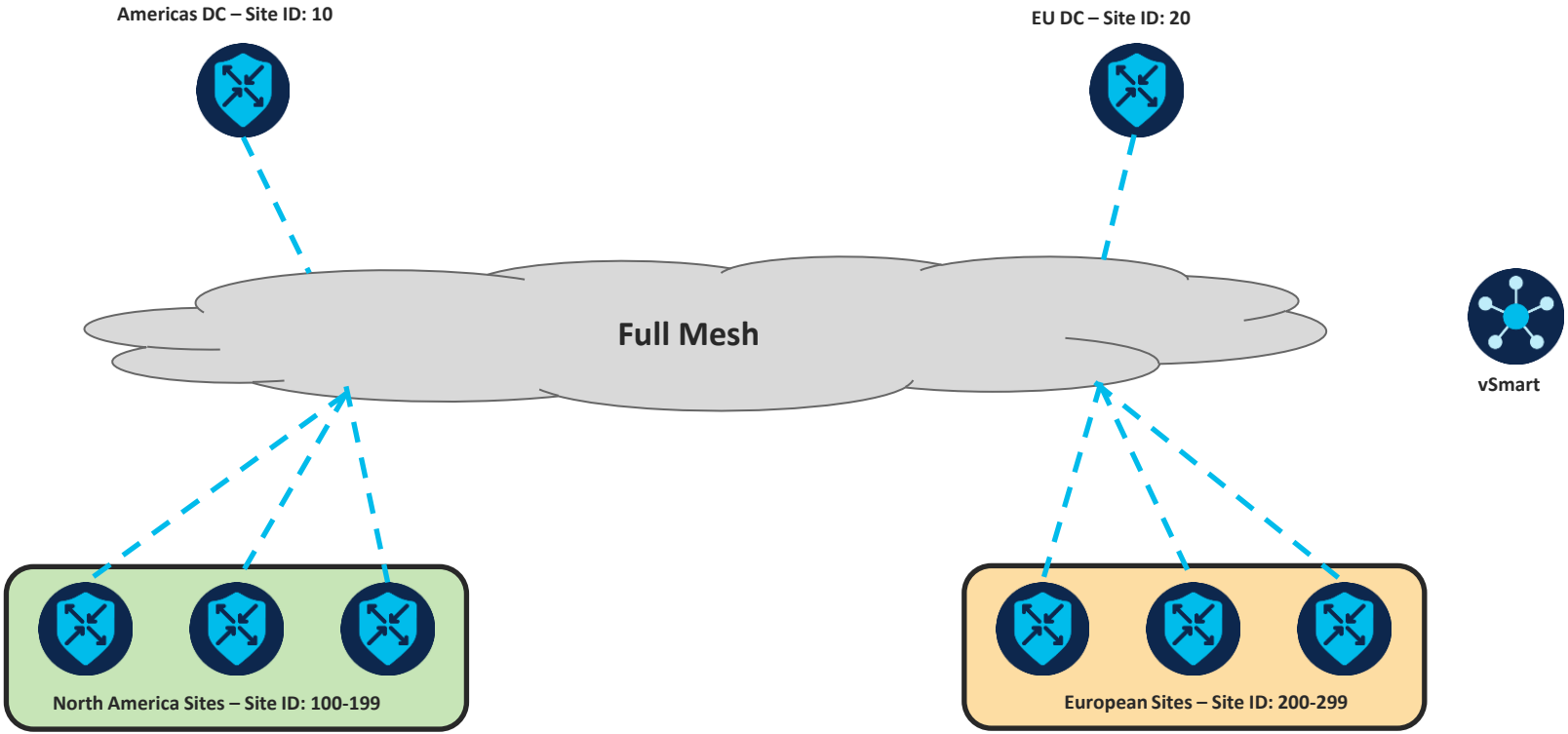
MPLS_Transport
Interface: [mpls_int]
IP Address: [mpls_ipv4_addr]

INET_Trans_Static
Interface: [inet_int]
IP Address: [inet_ipv4_addr]

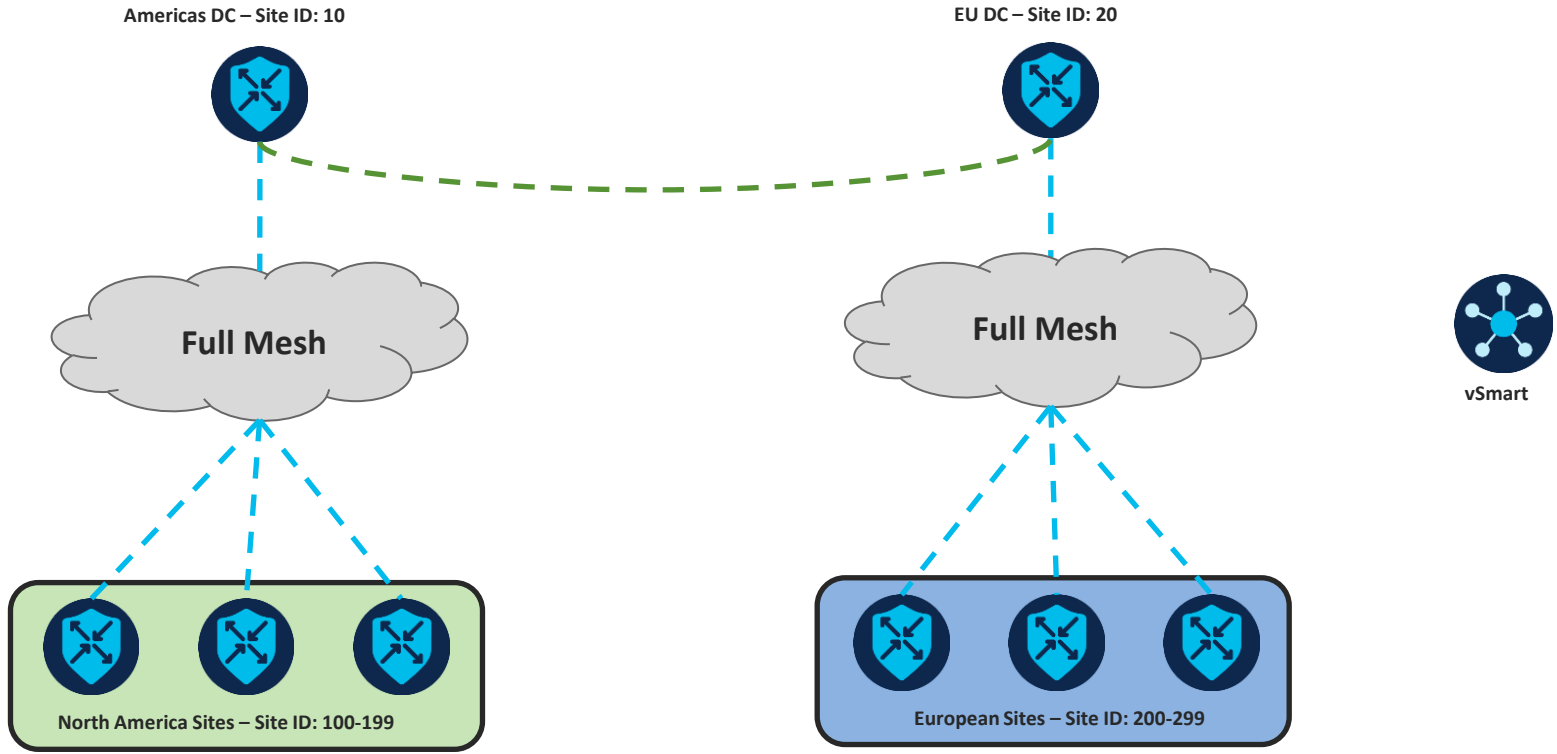
INET_ Trans_ DHCP
Interface: [inet_int]
IP Address: [DHCP]

Site ID Design

Site ID Concepts



Site ID Design – Regional Mesh



Site ID Design – Regional Mesh Policy

```
 control-policy EU-SITES
    sequence 1
     match tloc
      site-list NA-BRANCH-SITES
     !
     action reject
     !
sequence 11
     match tloc
      tloc-list NA-DC-TLOC
     !
     action reject
     !
default-action accept
 !
 control-policy EU-DC-SET-NEXT-HOP
    sequence 1
     match route
      site-list NA-BRANCH-SITES
      prefix-list _AnyIpv4PrefixList
     !
     action accept
      set
       tloc-list NA-DC-TLOC
      !
  default-action accept
 !
```

```
 control-policy NA-SITES
    sequence 1
     match tloc
      site-list EU-BRANCH-SITES
     !
     action reject
     !
    sequence 11
     match tloc
      tloc-list EU-DC-TLOC
     !
     action reject
     !
default-action accept
 !
  control-policy NA-DC-SET-NEXT-HOP
    sequence 1
     match route
      site-list EU-BRANCH-SITES
      prefix-list _AnyIpv4PrefixList
     !
     action accept
      set
       tloc-list EU-DC-TLOC
      !
default-action accept
!
```

```
lists
  site-list EU-BRANCH-SITES
   site-id 200-299
  !
  site-list EU-DATACENTER
   site-id 20
  !
  site-list NA-BRANCH-SITES
   site-id 100-199
  !
  site-list NA-DATACENTER
   site-id 10
  !
  tloc-list EU-DC-TLOC
   tloc 1.1.1.5 color default encap ipsec
  !
  tloc-list NA-DC-TLOC
   tloc 1.1.1.4 color default encap ipsec
  !
  prefix-list _AnyIpv4PrefixList
   ip-prefix 0.0.0.0/0 le 32
  !
viptela-policy:apply-policy
 site-list EU-BRANCH-SITES
  control-policy EU-SITES out
 !
 site-list NA-DATACENTER
  control-policy NA-DC-SET-NEXT-HOP out
 !
 site-list EU-DATACENTER
  control-policy EU-DC-SET-NEXT-HOP out
 !
 site-list NA-BRANCH-SITES
  control-policy NA-SITES out
 !
```

Lessons Learned the Hard Way

Route Advertisement Limit

- vSmart will only select 16 best routes to advertise to remote sites
- Limit Scenarios
  - Horizontal Scaling
  - Multiple transports in multiple data centers advertising core prefix's
    - Multiple MPLS Carriers
    - Multiple Internet Providers
    - Point to Point Links
  - Regional Internet Egress points advertising a default route

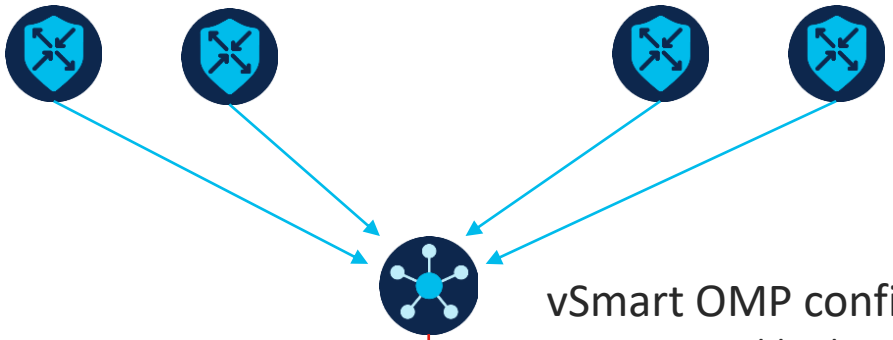
Route Advertisement Limit

- Scenario
  - 2 Data Centers advertising 10.0.0.0/8
  - 4Transports per Data Center
    - 4 Routes advertised per hub device
  - Horizontal Scaling in each DC required due to number of spoke sites

Route Advertisement Limit: Standard DC Prior to Horizontal Scaling

All DC's advertise 10.0.0.0/8 across 4 paths

16 total paths to vSmart



vSmart OMP configuration

send-backup-paths

send-path-limit 16

Branch vEdge receives 16 paths

Installs 4

4 Links

Route Advertisement: Standard Behavior

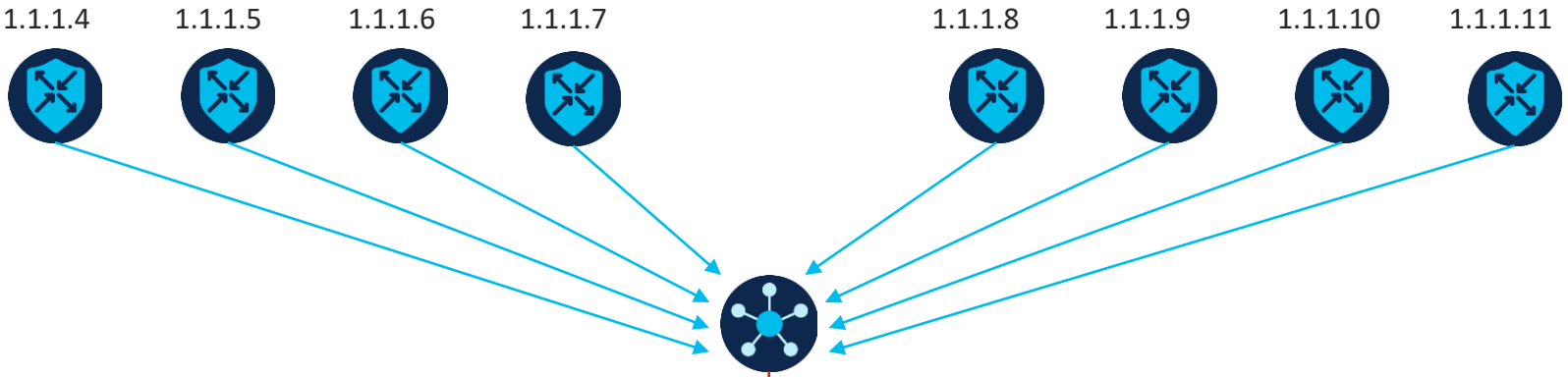
```
vEdge-1# show omp routes
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                     PATH                      ATTRIBUTE
VPN     PREFIX              FROM PEER       ID      LABEL     STATUS    TYPE       TLOC IP          COLOR            ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8          1.1.1.3         33      1003      C,I,R     installed  1.1.1.4          biz-internet     ipsec  -
                            1.1.1.3         34      1003      C,I,R     installed  1.1.1.4          public-internet  ipsec  -
                            1.1.1.3         35      1003      C,I,R     installed  1.1.1.4          red              ipsec  -
                            1.1.1.3         36      1003      C,I,R     installed  1.1.1.4          blue             ipsec  -
                            1.1.1.3         37      1003      C,R       installed  1.1.1.5          biz-internet     ipsec  -
                            1.1.1.3         38      1003      C,R       installed  1.1.1.5          public-internet  ipsec  -
                            1.1.1.3         39      1003      C,R       installed  1.1.1.5          red              ipsec  -
                            1.1.1.3         40      1003      C,R       installed  1.1.1.5          blue             ipsec  -
                            1.1.1.3         41      1003      C,R       installed  1.1.1.6          biz-internet     ipsec  -
                            1.1.1.3         42      1003      C,R       installed  1.1.1.6          public-internet  ipsec  -
                            1.1.1.3         43      1003      C,R       installed  1.1.1.6          red              ipsec  -
                            1.1.1.3         44      1003      C,R       installed  1.1.1.6          blue             ipsec  -
                            1.1.1.3         45      1003      C,R       installed  1.1.1.7          biz-internet     ipsec  -
                            1.1.1.3         46      1003      C,R       installed  1.1.1.7          public-internet  ipsec  -
                            1.1.1.3         47      1003      C,R       installed  1.1.1.7          red              ipsec  -
                            1.1.1.3         48      1003      C,R       installed  1.1.1.7          blue             ipsec  -
```

Set TLOC at Remote Site

Route Advertisement: Standard Behavior

```
vEdge-1# show omp routes
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                     PATH                    ATTRIBUTE
VPN     PREFIX          FROM PEER    ID      LABEL   STATUS  TYPE       TLOC IP      COLOR            ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8      1.1.1.3      33      1003    C,I,R   installed  1.1.1.4      biz-internet     ipsec  -
                        1.1.1.3      34      1003    C,I,R   installed  1.1.1.4      public-internet  ipsec  -
                        1.1.1.3      35      1003    C,I,R   installed  1.1.1.4      red              ipsec  -
                        1.1.1.3      36      1003    C,I,R   installed  1.1.1.4      blue             ipsec  -
                        1.1.1.3      37      1003    C,R     installed  1.1.1.5      biz-internet     ipsec  -
                        1.1.1.3      38      1003    C,R     installed  1.1.1.5      public-internet  ipsec  -
                        1.1.1.3      39      1003    C,R     installed  1.1.1.5      red              ipsec  -
                        1.1.1.3      40      1003    C,R     installed  1.1.1.5      blue             ipsec  -
                        1.1.1.3      41      1003    C,R     installed  1.1.1.6      biz-internet     ipsec  -
                        1.1.1.3      42      1003    C,R     installed  1.1.1.6      public-internet  ipsec  -
                        1.1.1.3      43      1003    C,R     installed  1.1.1.6      red              ipsec  -
                        1.1.1.3      44      1003    C,R     installed  1.1.1.6      blue             ipsec  -
                        1.1.1.3      45      1003    C,R     installed  1.1.1.7      biz-internet     ipsec  -
                        1.1.1.3      46      1003    C,R     installed  1.1.1.7      public-internet  ipsec  -
                        1.1.1.3      47      1003    C,R     installed  1.1.1.7      red              ipsec  -
                        1.1.1.3      48      1003    C,R     installed  1.1.1.7      blue             ipsec  -
```

Route Advertisement Limit: Set TLOC at Spoke Site



All DC's advertise 10.0.0.0/8 across 4 paths

32 total paths to vSmart

Match: All Routes
Action: Accept
Set TLOC 1.1.1.8

1.1.1.13

4 Links

Route Advertisement: Set TLOC at Spoke Site

```
vEdge-1# show omp routes vpn 10
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                     PATH                                ATTRIBUTE
VPN     PREFIX          FROM PEER    ID     LABEL   STATUS   TYPE        TLOC IP     COLOR           ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8      1.1.1.3      174    1003    C,I,R    installed   1.1.1.8     biz-internet    ipsec  -
                        1.1.1.3      175    1003    C,I,R    installed   1.1.1.8     public-internet ipsec  -
                        1.1.1.3      176    1003    C,I,R    installed   1.1.1.8     red             ipsec  -
                        1.1.1.3      177    1003    C,I,R    installed   1.1.1.8     blue            ipsec  -
```

Route Advertisement:
Set TLOC at Spoke Site – DC Router Down

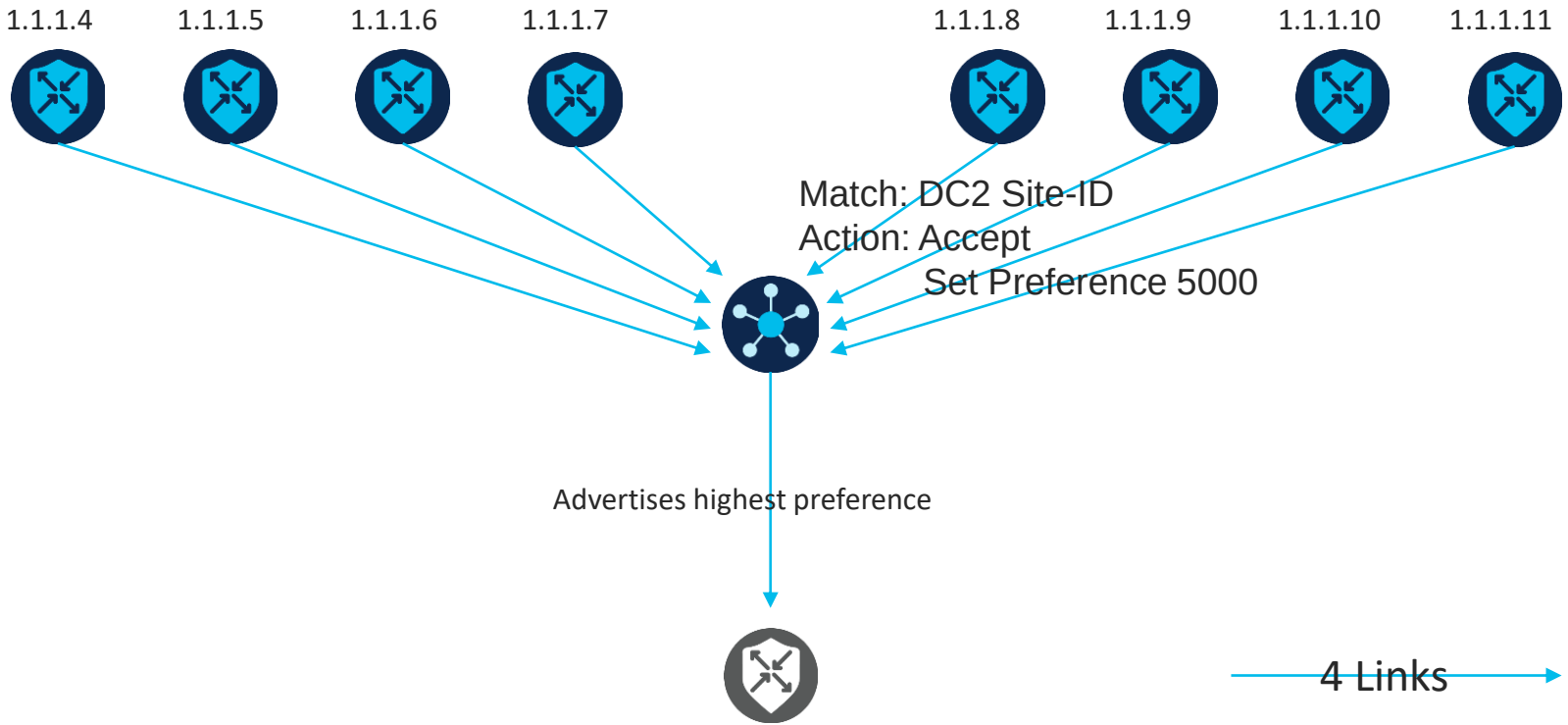
```
vEdge-1# show omp routes vpn 10
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                      PATH                    ATTRIBUTE
VPN     PREFIX          FROM PEER     ID      LABEL   STATUS  TYPE       TLOC IP      COLOR           ENCAP  PREFERENCE
-----------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8      1.1.1.3       174     1003    Inv,U   installed  1.1.1.8      biz-internet    ipsec  -
                        1.1.1.3       175     1003    Inv,U   installed  1.1.1.8      public-internet ipsec  -
                        1.1.1.3       176     1003    Inv,U   installed  1.1.1.8      red             ipsec  -
                        1.1.1.3       177     1003    Inv,U   installed  1.1.1.8      blue            ipsec  -
```

Set Policy Inbound from Data Center

Route Advertisement: Standard Behavior

```
vEdge-1# show omp routes
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                     PATH                    ATTRIBUTE
VPN     PREFIX          FROM PEER    ID      LABEL   STATUS  TYPE       TLOC IP      COLOR            ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8      1.1.1.3      33      1003    C,I,R   installed  1.1.1.4      biz-internet     ipsec  -
                        1.1.1.3      34      1003    C,I,R   installed  1.1.1.4      public-internet  ipsec  -
                        1.1.1.3      35      1003    C,I,R   installed  1.1.1.4      red              ipsec  -
                        1.1.1.3      36      1003    C,I,R   installed  1.1.1.4      blue             ipsec  -
                        1.1.1.3      37      1003    C,R     installed  1.1.1.5      biz-internet     ipsec  -
                        1.1.1.3      38      1003    C,R     installed  1.1.1.5      public-internet  ipsec  -
                        1.1.1.3      39      1003    C,R     installed  1.1.1.5      red              ipsec  -
                        1.1.1.3      40      1003    C,R     installed  1.1.1.5      blue             ipsec  -
                        1.1.1.3      41      1003    C,R     installed  1.1.1.6      biz-internet     ipsec  -
                        1.1.1.3      42      1003    C,R     installed  1.1.1.6      public-internet  ipsec  -
                        1.1.1.3      43      1003    C,R     installed  1.1.1.6      red              ipsec  -
                        1.1.1.3      44      1003    C,R     installed  1.1.1.6      blue             ipsec  -
                        1.1.1.3      45      1003    C,R     installed  1.1.1.7      biz-internet     ipsec  -
                        1.1.1.3      46      1003    C,R     installed  1.1.1.7      public-internet  ipsec  -
                        1.1.1.3      47      1003    C,R     installed  1.1.1.7      red              ipsec  -
                        1.1.1.3      48      1003    C,R     installed  1.1.1.7      blue             ipsec  -
```

Route Advertisement Limit: Inbound Policy from DC



Route Advertisement: Set DC Preference Inbound

```
vEdge-1# show omp routes vpn 10
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                      PATH                  ATTRIBUTE
VPN     PREFIX              FROM PEER ID    LABEL  STATUS   TYPE       TLOC IP  COLOR            ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8          1.1.1.3   226   1003   C,I,R    installed  1.1.1.9  biz-internet     ipsec  5000
                            1.1.1.3   227   1003   C,I,R    installed  1.1.1.9  public-internet  ipsec  5000
                            1.1.1.3   228   1003   C,I,R    installed  1.1.1.9  red              ipsec  5000
                            1.1.1.3   229   1003   C,I,R    installed  1.1.1.9  blue             ipsec  5000
                            1.1.1.3   230   1003   C,R      installed  1.1.1.10 biz-internet     ipsec  5000
                            1.1.1.3   231   1003   C,R      installed  1.1.1.10 public-internet  ipsec  5000
                            1.1.1.3   232   1003   C,R      installed  1.1.1.10 red              ipsec  5000
                            1.1.1.3   233   1003   C,R      installed  1.1.1.10 blue             ipsec  5000
                            1.1.1.3   234   1003   C,R      installed  1.1.1.11 biz-internet     ipsec  5000
                            1.1.1.3   235   1003   C,R      installed  1.1.1.11 public-internet  ipsec  5000
                            1.1.1.3   236   1003   C,R      installed  1.1.1.11 red              ipsec  5000
                            1.1.1.3   237   1003   C,R      installed  1.1.1.11 blue             ipsec  5000
                            1.1.1.3   238   1003   C,R      installed  1.1.1.12 biz-internet     ipsec  5000
                            1.1.1.3   239   1003   C,R      installed  1.1.1.12 public-internet  ipsec  5000
                            1.1.1.3   240   1003   C,R      installed  1.1.1.12 red              ipsec  5000
                            1.1.1.3   241   1003   C,R      installed  1.1.1.12 blue             ipsec  5000
```

Route Advertisement:
Set DC Preference Inbound – DC Router Down

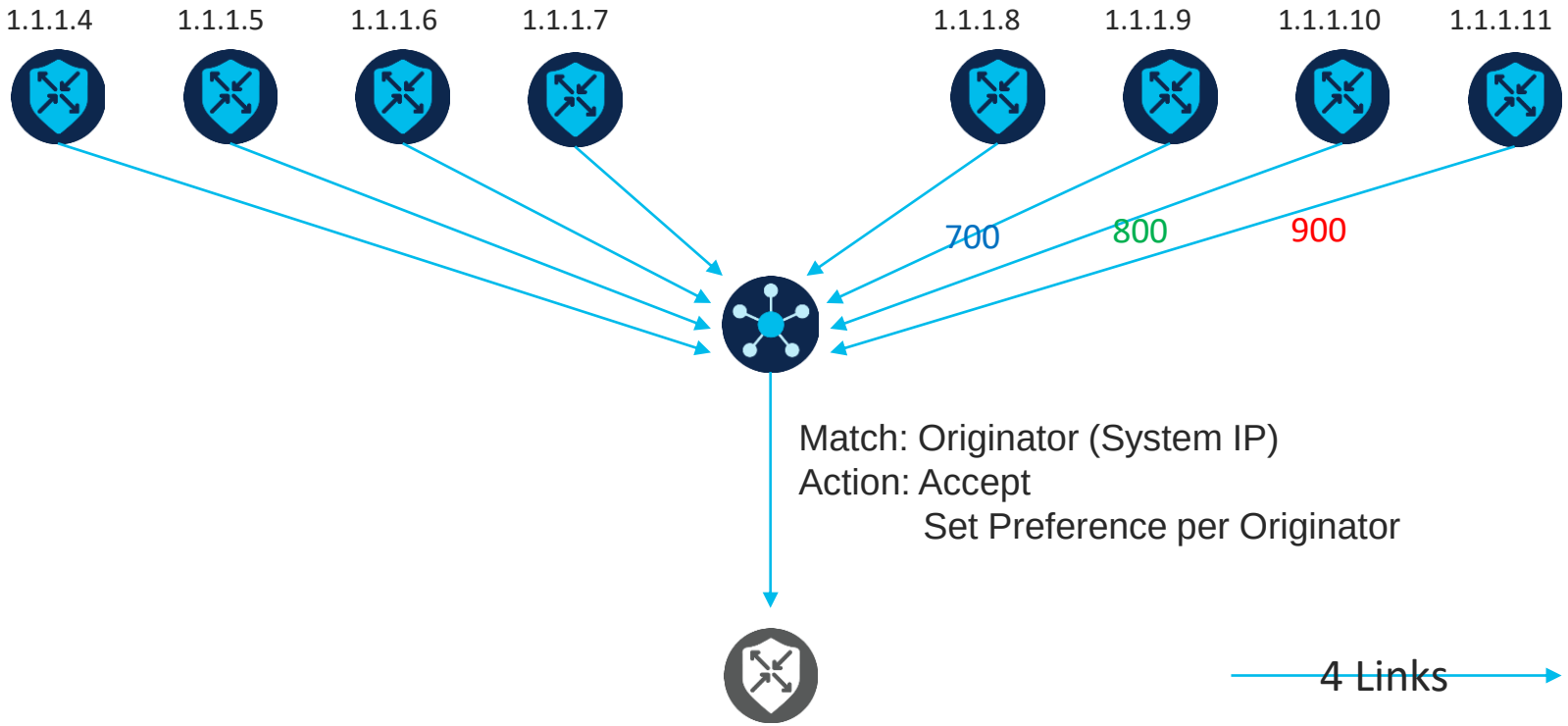
```
vEdge-1# show omp routes vpn 10
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                     PATH                    ATTRIBUTE
VPN     PREFIX              FROM PEER       ID      LABEL   STATUS  TYPE        TLOC IP         COLOR           ENCAP  PREFERENCE
-----------------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8          1.1.1.3         226     1003    Inv,U   installed   1.1.1.9         biz-internet    ipsec  5000
                            1.1.1.3         227     1003    Inv,U   installed   1.1.1.9         public-internet ipsec  5000
                            1.1.1.3         228     1003    Inv,U   installed   1.1.1.9         red             ipsec  5000
                            1.1.1.3         229     1003    Inv,U   installed   1.1.1.9         blue            ipsec  5000
                            1.1.1.3         230     1003    C,I,R   installed   1.1.1.10        biz-internet    ipsec  5000
                            1.1.1.3         231     1003    C,I,R   installed   1.1.1.10        public-internet ipsec  5000
                            1.1.1.3         232     1003    C,I,R   installed   1.1.1.10        red             ipsec  5000
                            1.1.1.3         233     1003    C,I,R   installed   1.1.1.10        blue            ipsec  5000
                            1.1.1.3         234     1003    C,R     installed   1.1.1.11        biz-internet    ipsec  5000
                            1.1.1.3         235     1003    C,R     installed   1.1.1.11        public-internet ipsec  5000
                            1.1.1.3         236     1003    C,R     installed   1.1.1.11        red             ipsec  5000
                            1.1.1.3         237     1003    C,R     installed   1.1.1.11        blue            ipsec  5000
                            1.1.1.3         238     1003    C,R     installed   1.1.1.12        biz-internet    ipsec  5000
                            1.1.1.3         239     1003    C,R     installed   1.1.1.12        public-internet ipsec  5000
                            1.1.1.3         240     1003    C,R     installed   1.1.1.12        red             ipsec  5000
                            1.1.1.3         241     1003    C,R     installed   1.1.1.12        blue            ipsec  5000
```

Set Preference Outbound to Remote

Route Advertisement: Standard Behavior

```
vEdge-1# show omp routes
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                     PATH                      ATTRIBUTE
VPN     PREFIX          FROM PEER    ID      LABEL   STATUS    TYPE       TLOC IP      COLOR            ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8      1.1.1.3      33      1003    C,I,R     installed  1.1.1.4      biz-internet     ipsec  -
                        1.1.1.3      34      1003    C,I,R     installed  1.1.1.4      public-internet  ipsec  -
                        1.1.1.3      35      1003    C,I,R     installed  1.1.1.4      red              ipsec  -
                        1.1.1.3      36      1003    C,I,R     installed  1.1.1.4      blue             ipsec  -
                        1.1.1.3      37      1003    C,R       installed  1.1.1.5      biz-internet     ipsec  -
                        1.1.1.3      38      1003    C,R       installed  1.1.1.5      public-internet  ipsec  -
                        1.1.1.3      39      1003    C,R       installed  1.1.1.5      red              ipsec  -
                        1.1.1.3      40      1003    C,R       installed  1.1.1.5      blue             ipsec  -
                        1.1.1.3      41      1003    C,R       installed  1.1.1.6      biz-internet     ipsec  -
                        1.1.1.3      42      1003    C,R       installed  1.1.1.6      public-internet  ipsec  -
                        1.1.1.3      43      1003    C,R       installed  1.1.1.6      red              ipsec  -
                        1.1.1.3      44      1003    C,R       installed  1.1.1.6      blue             ipsec  -
                        1.1.1.3      45      1003    C,R       installed  1.1.1.7      biz-internet     ipsec  -
                        1.1.1.3      46      1003    C,R       installed  1.1.1.7      public-internet  ipsec  -
                        1.1.1.3      47      1003    C,R       installed  1.1.1.7      red              ipsec  -
                        1.1.1.3      48      1003    C,R       installed  1.1.1.7      blue             ipsec  -
```

Route Advertisement: Match Originator and Set Preference



Route Advertisement: Match Originator and Set Preference

```
vEdge-1# show omp routes vpn 10
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                      PATH                        ATTRIBUTE
VPN     PREFIX              FROM PEER ID    LABEL  STATUS       TYPE        TLOC IP     COLOR            ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8          1.1.1.3   230   1003   R            installed   1.1.1.10    biz-internet     ipsec  800
                            1.1.1.3   231   1003   R            installed   1.1.1.10    public-internet  ipsec  800
                            1.1.1.3   232   1003   R            installed   1.1.1.10    red              ipsec  800
                            1.1.1.3   233   1003   R            installed   1.1.1.10    blue             ipsec  800
                            1.1.1.3   234   1003   C,I,R        installed   1.1.1.11    biz-internet     ipsec  900
                            1.1.1.3   235   1003   C,I,R        installed   1.1.1.11    public-internet  ipsec  900
                            1.1.1.3   236   1003   C,I,R        installed   1.1.1.11    red              ipsec  900
                            1.1.1.3   237   1003   C,I,R        installed   1.1.1.11    blue             ipsec  900
                            1.1.1.3   246   1003   R            installed   1.1.1.9     blue             ipsec  700
                            1.1.1.3   247   1003   R            installed   1.1.1.9     biz-internet     ipsec  700
                            1.1.1.3   248   1003   R            installed   1.1.1.9     red              ipsec  700
                            1.1.1.3   249   1003   R            installed   1.1.1.9     public-internet  ipsec  700
```

Route Advertisement:
Match Originator and Set Preference – DC Down

```
vEdge-1# show omp routes vpn 10
Code:
C   -> chosen
I   -> installed
Red -> redistributed
Rej -> rejected
L   -> looped
R   -> resolved
S   -> stale
Ext -> extranet
Inv -> invalid
Stg -> staged
U   -> TLOC unresolved

                                      PATH                    ATTRIBUTE
VPN     PREFIX              FROM PEER ID     LABEL  STATUS    TYPE       TLOC IP     COLOR            ENCAP  PREFERENCE
-------------------------------------------------------------------------------------------------------------------------
10      10.0.0.0/8          1.1.1.3   230    1003   C,I,R     installed  1.1.1.10    biz-internet     ipsec  800
                            1.1.1.3   231    1003   C,I,R     installed  1.1.1.10    public-internet  ipsec  800
                            1.1.1.3   232    1003   C,I,R     installed  1.1.1.10    red              ipsec  800
                            1.1.1.3   233    1003   C,I,R     installed  1.1.1.10    blue             ipsec  800
                            1.1.1.3   234    1003   Inv,U     installed  1.1.1.11    biz-internet     ipsec  900
                            1.1.1.3   235    1003   Inv,U     installed  1.1.1.11    public-internet  ipsec  900
                            1.1.1.3   236    1003   Inv,U     installed  1.1.1.11    red              ipsec  900
                            1.1.1.3   237    1003   Inv,U     installed  1.1.1.11    blue             ipsec  900
                            1.1.1.3   246    1003   R         installed  1.1.1.9     blue             ipsec  700
                            1.1.1.3   247    1003   R         installed  1.1.1.9     biz-internet     ipsec  700
                            1.1.1.3   248    1003   R         installed  1.1.1.9     red              ipsec  700
                            1.1.1.3   249    1003   R         installed  1.1.1.9     public-internet  ipsec  700
```

Hub and Spoke Routing

- Routing Table Considerations
  - Default route
  - Summarization
  - Direct Internet Access***
- Setting TLOC List
  - Specific Routes
  - Site-List matching

Thank you

Possibilities

#CiscoLive