Deploying Carrier Ethernet Services

Kashif Islam, Solutions Architect
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Agenda

- Cisco Metro Fabric Overview
- Metro Services and Use Cases
- Metro Underlay Configuration
- IOS-XR Services Configuration Toolset
- Metro Services Configuration
- Orchestration and Management
- Summary
Cisco Metro Fabric Overview
Cisco SP Fabric Designs principals:
Simple, Scalable, Automatable

Network Location

Metro & Access

Core

Peering

Designs

Metro Fabric

Core Fabric

Peering Fabric

Building Blocks

CLOS Fabric

SR/EVPN

Automation

Telemetry and Analytics

YANG data models
Cisco Metro Fabric Building Blocks

CLOS Fabric

Industry leader: ASR9K
Dense, Scalable: NCS 5500

Segment Routing

Unified Forwarding Plane with Explicit Path Control and Traffic Engineering

BGP Based VPN

Common Control Plane for L2, L3 and IRB

Automation

Programmability and analytics with YANG data models and telemetry
BGP+SR Benefits:
Simplified Protocol and Label Stack

Unified IP/MPLS

Router

Controller/Orchestration

Apps

CLIs

BGP
T-LDP
BGP-LU
RSVP-TE
MPLS LDP
IGP
IP

Applications

BGP
T-LDP/Static
IGP/SR
IP

ACE

APIs

Provisioning NSO

Path Computation/WAN optimization XTC/WAE

EPN-M

APIs

Simplified control plane (distributed on router)
Centralized management and policy control
Compass Metro Fabric - High-Level Domain View

Access

Aggregation

Core

Aggregation

Access

ASR920/NCS4201

ASR920-12SZ-IM/NCS

ASR9000v

NCS540, NCS560, NCS50/55xx

ASR9K

ASR907 NCS4216

NCS5000

NCS5500

NCS550

ASR9K NCS6K

ODL/OSC

DDoS

EPN Manager

XRv-9000 CSR1000v

XTC

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Metro Services and Use Cases
Metro Fabric Services - Highlights

• Transport Independent => interop. with existing services
• Seamless Integration with existing L2VPN
• End-To-End and Hierarchical Services
  • Provides scale and provisioning simplification
• BGP-based services:
  • L3VPN (VPNv4/VPNv6)
  • EVPN
  • Traditional L2VPN
• Provisioning CLI and Automation
## End to End Metro Services

<table>
<thead>
<tr>
<th>Service</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3VPN</td>
<td>MP-BGP VPNv4/6</td>
</tr>
<tr>
<td>L2 P2P</td>
<td>EVPN-VPWS</td>
</tr>
<tr>
<td></td>
<td>• Multi/Single-Homed</td>
</tr>
<tr>
<td></td>
<td>• All/Single-Active</td>
</tr>
<tr>
<td></td>
<td>Legacy EoMPLS (Static PW)</td>
</tr>
<tr>
<td>L2 Multipoint</td>
<td>EVPN</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td>• All/Single-Active</td>
</tr>
<tr>
<td></td>
<td>Anycast-IRB</td>
</tr>
</tbody>
</table>
End to End Metro Services

Access - Aggregation - Core - Aggregation - Access

Distributed CO - service termination
Centralized CO - service termination
Access-To-Access - service termination

MP-BGP L3VPN
EVPN
EVPN-VPWS
Legacy EoMPLS PW
## Hierarchical Metro Services

<table>
<thead>
<tr>
<th>Service</th>
<th>Technology in Access/Aggregation</th>
<th>Technology in Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3VPN</td>
<td>EVPN-VPWS</td>
<td>MP-BGP VPNv4/6 (IRB/PWHE)</td>
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<tr>
<td></td>
<td>• Multi/Single-Homed</td>
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<tr>
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<td>• All/Single-Active</td>
<td></td>
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<tr>
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<td>Anycast-Static-PW</td>
<td></td>
</tr>
<tr>
<td>L2 P2P</td>
<td>Not-Required</td>
<td></td>
</tr>
<tr>
<td>L2 Multipoint</td>
<td>EVPN-VPWS</td>
<td>EVPN</td>
</tr>
<tr>
<td></td>
<td>• Multi/Single-Homed</td>
<td>• Multi/Single-Homed</td>
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<tr>
<td></td>
<td>• All/Single-Active</td>
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<tr>
<td></td>
<td>Anycast-Static-PW</td>
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</tr>
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<td>L2/L3 Multipoint</td>
<td>EVPN-VPWS</td>
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<td>• Multi/Single-Homed</td>
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<td></td>
<td>• All/Single-Active</td>
<td>• All-Active (Anycast-IRB)</td>
</tr>
<tr>
<td></td>
<td>Anycast-Static-PW</td>
<td>• Single-Active (PWHE)</td>
</tr>
</tbody>
</table>
Metro Fabric Underlay Configuration
Cisco Metro Fabric Building Blocks

CLOS Fabric
- Industry leader: ASR9K
- Dense, Scalable: NCS 5500

Segment Routing
- Unified Forwarding Plane with Explicit Path Control and Traffic Engineering

BGP Based VPN
- Common Control Plane for L2, L3 and IRB

Automation
- Programmability and analytics with YANG data models and telemetry
Segment Routing Configuration Basics

- Configured with the IGP Routing Protocols – ISIS and OSPF
- Requires: Enabling SR and configuring Prefix SID
- Prefix SID
  - **Globally Significant** → SR Global Block (SRGB)
  - SRGB advertised with router capabilities TLV
  - Configured as an **absolute value or an index**
    - Advertised as globally unique index
      - E.g. index 1 → SID is 16,000 + 1 = 16,001
- Adjacency SID
  - **Locally significant**
  - Automatically allocated for each adjacency
  - Always encoded as an absolute value
IS-IS Configuration – Example

```
router isis 1
  address-family ipv4 unicast
    metric-style wide
    segment-routing mpls
  !
  address-family ipv6 unicast
    metric-style wide
    segment-routing mpls
  !
  interface Loopback0
    passive
    address-family ipv4 unicast
      prefix-sid index 1
      !
    address-family ipv6 unicast
      prefix-sid absolute 20001
      !
```

Wide metrics

enable SR IPv4 control plane and SR MPLS data plane on all ipv4 interfaces in this IS-IS instance

Wide metrics

enable SR IPv6 control plane and SR MPLS data plane on all ipv6 interfaces in this IS-IS instance

Ipv4 Prefix-SID value for loopback0
(Index translate to 16001 absolute value)

Ipv6 Prefix-SID value for loopback0
OSPF Configuration Example

```
router ospf 1
  router-id 1.1.1.1
  segment-routing mpls

area 0
  interface Loopback0
    passive enable
    prefix-sid absolute 16001

```

- Enable SR on all areas
- Prefix-SID for loopback0
EVPN Flavors

- EVPN provides an evolution of Ethernet services
  - BGP control-plane for Ethernet Segment and MAC distribution and learning over MPLS core
  - Same principles and operational experience of IP VPNs
- BGP control plane provides a familiar, consistent and flexible configuration interface
- Multi-vendor solutions for P2P and MP services
EVPN control plane with BGP

- New BGP NLRI to advertise MACs and IPs for next hop resolution
  - AFI=25 (L2VPN) SAFI=70 (EVPN)
- IPv4 and IPv6 support
- Control over MAC learning
- ECMP for multihomed CEs
- Inherent BGP scalability and hierarchy

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<th>Field</th>
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<td>Route Distinguisher</td>
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<td>Ethernet Segment Identifier or ESI</td>
<td>10</td>
</tr>
<tr>
<td>Ethernet Tag ID</td>
<td>4</td>
</tr>
<tr>
<td>MAC Address Length</td>
<td>1</td>
</tr>
<tr>
<td>MAC Address</td>
<td>6</td>
</tr>
<tr>
<td>IP Address Length</td>
<td>1</td>
</tr>
<tr>
<td>IP Address</td>
<td>0 or 4 or 16</td>
</tr>
<tr>
<td>MPLS Label 1</td>
<td>3</td>
</tr>
<tr>
<td>MPLS Label 2</td>
<td>0 or 3</td>
</tr>
</tbody>
</table>
EVPN Planes Of Operation

Control plane for Overlay
- L2 P2P
- L2 P2MP
- IRB
- EVPN BGP AFI

Data plane for Overlay
- Label (L2/L3 VPN)
- PBB (MAC in MAC)
- VXLAN (MAC in UDP)

Control plane for Underlay
- SR/IGP
- LDP
- TE

Underlay Data plane
- IP/MPLS Transport
EVPN - Components

**EVPN Instance (EVI)**

- EVI spans all PEs participating in an EVPN
- MAC-VRF: A VRF table for MACs on a PE
- Encompass one or more bridge-domains, depending on service interface type
  - Port-based
  - VLAN-based (shown above)
  - VLAN-bundling
  - VLAN aware bundling (NEW)

**Ethernet Segment**

- Represents a ‘site’ connected to one or more PEs
- Uniquely identified by a 10-byte global Ethernet Segment Identifier (ESI)
- Could be a single device or an entire network
  - Single-Homed Device (SHD)
  - Multi-Homed Device (MHD)
  - Single-Homed Network (SHN)
  - Multi-Homed Network (MHN)

**BGP Routes**

- EVVPN and PBB-EVPN define a single new BGP NLRI used to carry all EVPN routes
- NLRI has a new SAFI (70)
- Routes serve control plane purposes, including:
  - MAC / IP address reachability
  - MAC mass withdrawal
  - Split-Horizon label adv.
  - Aliasing
  - Multicast endpoint discovery
  - Redundancy group discovery
  - Designated forwarder election

**BGP Route Attributes**

- New BGP extended communities defined
- Expand information carried in BGP routes, including:
  - MAC address moves
  - C-MAC flush notification
  - Redundancy mode
  - MAC / IP bindings of a GW
  - Split-horizon label encoding
BGP Control Plane for EVPN

```bash
router bgp 65001
bgp router-id 6.1.1.1

address-family l2vpn evpn

neighbor 6.1.1.10
remote-as 65001
update-source Loopback0
address-family l2vpn evpn

Enable EVPN Address Family

Enable a neighbor with new EVPN AF

EVPN neighbor verification and EVPN routes receive
```

RP/0/0/CPU0:R1# sh bgp l2vpn evpn summary
BGP router identifier 6.1.1.1, local AS number 65001

<table>
<thead>
<tr>
<th>Process</th>
<th>RcvTblVer</th>
<th>bRIB/RIB</th>
<th>LabelVer</th>
<th>ImportVer</th>
<th>SendTblVer</th>
<th>StandbyVer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaker</td>
<td>8</td>
<td>8</td>
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<td>8</td>
<td>8</td>
<td>0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Neighbor</th>
<th>Spk</th>
<th>AS</th>
<th>MsgRcvd</th>
<th>MsgSent</th>
<th>TblVer</th>
<th>InQ</th>
<th>OutQ</th>
<th>Up/Down</th>
<th>St/PfxRcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1.1.10</td>
<td>0</td>
<td>65001</td>
<td>5744</td>
<td>5743</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>3d23h</td>
<td>1</td>
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</table>
IOS-XR Service Configuration Toolset
Anatomy of a Metro Ethernet Service

Frame Classification
- Ethernet Flow Points
- Intelligent Layer 2 Sub-interfaces

Frame Forwarding
- Bridge Domain, Bridged Virtual Interface
- Local Connect, Ethernet over MPLS (EoMPLS), Virtual Private LAN Service (VPLS), Ethernet VPN (EVPN)

Forwarding
- Frame Manipulation
- VLAN Tag Rewrite
Ethernet Flow Point

- EVC Infrastructure introduces the concept of an EFP interface r/s/module/port.<sub-intf no.> *l2transport*

  <match criteria commands> (VLAN tags, MAC, Ether type)
  <rewrite commands> (VLAN tags pop/push/translation)
  <feature commands> (QoS, ACL etc)
EFP Flexible Tag Classification

The Longest Match Rule and the default option

• Longest match for VLAN tag provides configuration flexibility
Traffic Forwarding Through an EFP

Traffic Manipulation
- Flexible VLAN Tag Manipulation
  - Push, Pop, Translate
- Any combination up to 2 VLANS
  - 1 to 1, 1 to 2, 2 to 1 or 2 to 2
- Uses “rewrite” keyword
- Symmetric Application

Point to Point Forwarding
- MEF defined E-LINE services
- Allows 2 sites to be connected via EFPs
- Two Primary Mechanisms
  - Local Connect
  - EoMPLS

Multipoint Forwarding
- E-LAN, E-TREE services
- Allows 2+ sites to connected via EFPs
- MAC based Forwarding
- Bridge-Domain, BVI
- VPLS, H-VPLS
- EVPN, PBB-EVPN

Configured under “l2vpn” CLI
Bringing Everything Together
IOS-XR Flexible Ethernet SW Infrastructure

- EFP (Ethernet Flow Point) or sub-interface
- Flexible VLAN tag classification
- Flexible VLAN tag rewrite
- Flexible Ethertype (.1Q, QinQ, .1ad)

Flexible service mapping and multiplexing
L2 and L3, P2P and MP services concurrently on the same port
Metro Fabric Services Configuration
# Metro Fabric Services Configuration

<table>
<thead>
<tr>
<th>Service</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point to Point</td>
<td>• EoMPLS</td>
</tr>
<tr>
<td></td>
<td>• EVVPN VPW (Single Homed and Multi Homed)</td>
</tr>
<tr>
<td>Multi Point (L2/L3 services)</td>
<td>• VPLS</td>
</tr>
<tr>
<td></td>
<td>• MP Switching</td>
</tr>
<tr>
<td></td>
<td>• EVVPN</td>
</tr>
<tr>
<td></td>
<td>• PBB-EVPN</td>
</tr>
</tbody>
</table>

**Metro Fabric Services Configuration**

- **Access**
  - **AG**
  - **PE**
  - **CO**
  - **A**

- **Aggregation**
  - **AG**
  - **PE**
  - **CO**

- **Core**
  - **PE**
  - **CO**

- **Aggregation**
  - **AG**
  - **PE**
  - **CO**

- **Access**
  - **AG**
  - **PE**
  - **CO**
  - **A**

**service termination**

- Distributed CO
- Centralized CO
- Access-To-Access
Point to Point Services Configuration

EoMPLS and EVPN-VPWS

interface gig 0/0/0/4.1 l2transport
encapsulation dot1q 100
rewrite ingress tag pop 1 symmetric
l2vpn
xconnect group CISCO
  p2p EoMPLS_VPWS
  interface Gig 0/0/0/4.1
  neighbor 1.1.1.1 pw-id 100

interface gig 0/0/0/4.1 l2transport
encapsulation dot1q 100
rewrite ingress tag pop 1 symmetric
l2vpn
xconnect group CISCO
  p2p EVPN_VPWS
  interface Gig 0/0/0/4.1
  neighbor evpn evi 100 target 10 source 10
```
12vpn
  bridge group CISCO
  bridge-domain BD1
  interface TenGigE0/0/0/0.1
  interface TenGigE0/0/0/1.1
  routed interface bvi 20 ➔ BVI
  neighbor 11.1.1.1 pw-id 20
  vfi CISCO-VFI
    neighbor 1.1.1.1 pw-id 21
    neighbor 22.2.2.2 pw-id 21

Interface bvi 20 ➔ BVI
  ipv4 address 1.1.1.1 255.255.255.0
```
Multipoint Services Configuration Example with EVPN IRB

```
evpn
 evi 100
 bgp
  route-target import 65001:100
  route-target export 65001:100
!
adVERTISE-MAC

interface BVI100
 host-routing
 vrf Tenant
 ipv4 address 30.10.12.1 255.255.255.0
 mac-address 1000.1000.1001

l2vpn
 bridge group bg100
 bridge-domain bd100
 interface Bundle-Ether100.1
 routed interface BVI100
 evi 100
```
Dual Homed CE Configuration Example with EVPN

- Ethernet Segment (ES) is a set of links that connect one tenant site to one of more PEs.
- Should be unique (10 Octets) for each segment (a segment can a pair of links from a dual-homed Host)

```plaintext
evpn
  interface Bundle-Ether100
  ethernet-segment
    identifier type 0 11.11.11.11.11.11.11.11.11
  bgp route-target 1111.1111.1111
```
PBB-EVPN Configuration Example

PE1

interface Bundle-Ether1.777 l2transport
  encapsulation dot1q 777

l2vpn
  bridge group gr1
    bridge-domain bd1
      interface Bundle-Ether1.777
        pbb edge i-sid 256 core-bridge core_bd1

  bridge group gr2
    bridge-domain core_bd1
      pbb core
        evpn evi 1000

router bgp 64
  bgp router-id 1.100.100.100
  address-family l2vpn evpn
  !
  neighbor 2.100.100.100
    remote-as 64
    update-source Loopback0
    address-family l2vpn evpn

Note: MPLS / LDP configuration required on core-facing interfaces (not shown)
Services Orchestration and Management
Deployment model: Existing vs NSO
NSO Main Features

**Applications**
- REST, NETCONF, Java, Python, Erlang, CLI, Web UI

**Engineers**
- Service Manager
- Device Manager
- Network Element Drivers (NEDs)

**Network Apps**
- VNFM
- Controller Apps
- EMS and NMS

**Physical Networks**

**Virtual Networks**

**Logical Networks**
- VNFM
- Controller Apps
- EMS and NMS

**Service Models**
- Structured representations of:
  - Service instances
  - Network configuration and state

**Data Models**
- Mapping service operations to network configuration changes
- Transactional integrity
- Multiprotocol and multivendor support

**NETCONF, REST, SNMP, CLI, etc**
NSO Network Element Driver (NED)

- Management support for devices - major bottleneck
- NSO uses Network Element Drivers (NED) to Communicate to any management interface
- Built in NED support for:
  - Cisco IOS
  - Cisco IOS XR
- NED packages available for many other multivendor products
Services Automation Framework

Service Orchestrator (NSO)

WAE

XTC

Config Management (NSO)

"Service Abstraction" Service models & orchestration

"Network Abstraction" Path computation, Network model

"Device Abstraction" Controllers, Protocols, NED's

"Protocols" South-bound network protocols

"Network" Equipment and Devices

SNMP CLI NetFlow

BGP-LS PCEP

CLI NETCONF/ YANG

Segment Routing

Segment Routing
In Conclusion ...
In Conclusion …

- Cisco Metro Fabric Provides a reference design for Metro Services Deployment
- Point to Point and Multipoint services
- Flexible, versatile Configuration toolset
- Underlay Configuration using ISIS/OSPF for SR and BGP for EVPN
- Various flavors of EVPN – EVPN VPWS, EVPN IRB – and EoMPLS/VPLS
- Services Orchestration and Management framework
- Summary
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