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The bridge to possible

Building transport grade packet-based networks with Routed Optical Networking

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Technical Solutions Architects

BRKOPT-2016

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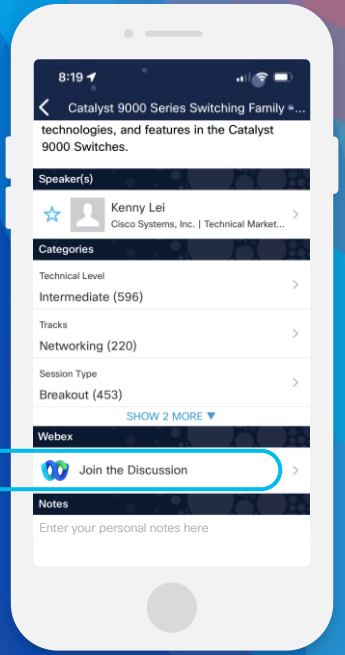

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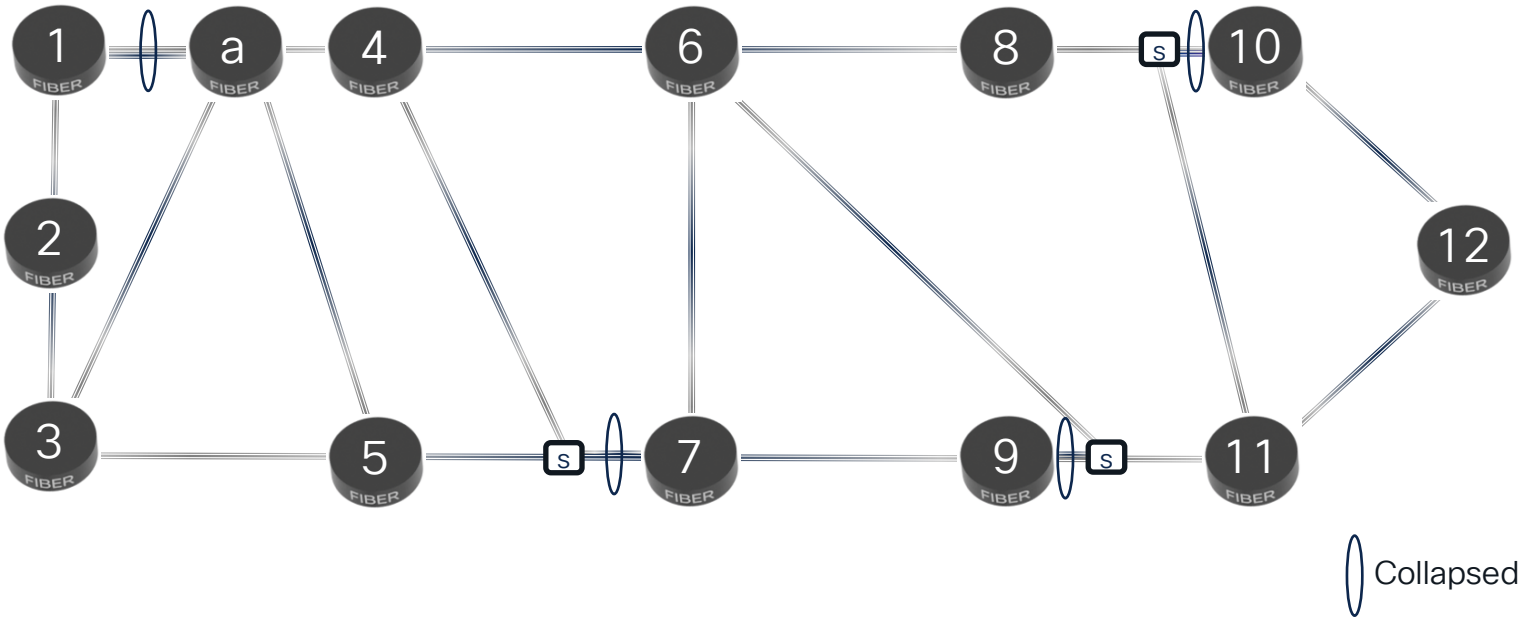
Agenda

- Today's Networking Layers
- Complexity of Multiple Control Planes
- Advantages of Routing Control Plane
- Unified Control Plane (incl sub 50ms restoration)
- Customer Outcomes with Summary

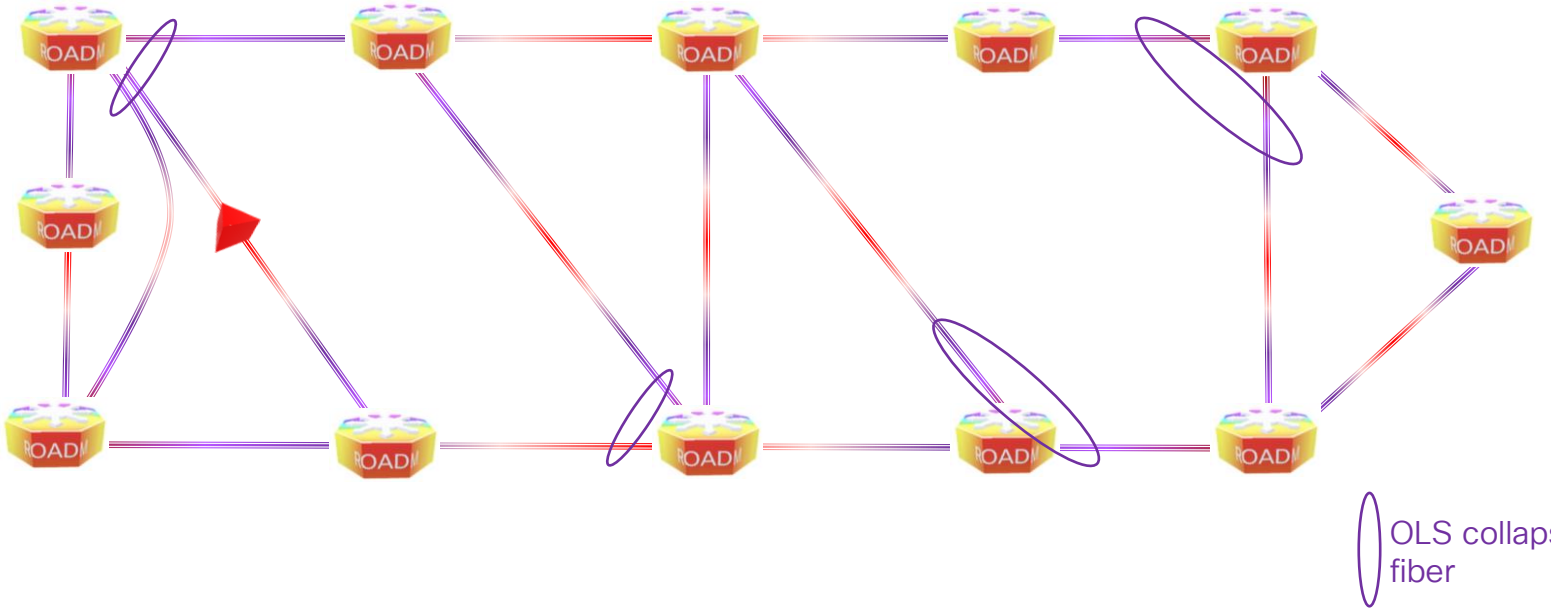
Today's Networking Layers

Multilayer Topologies… Fiber Layout

this is the Logical Fiber Topology

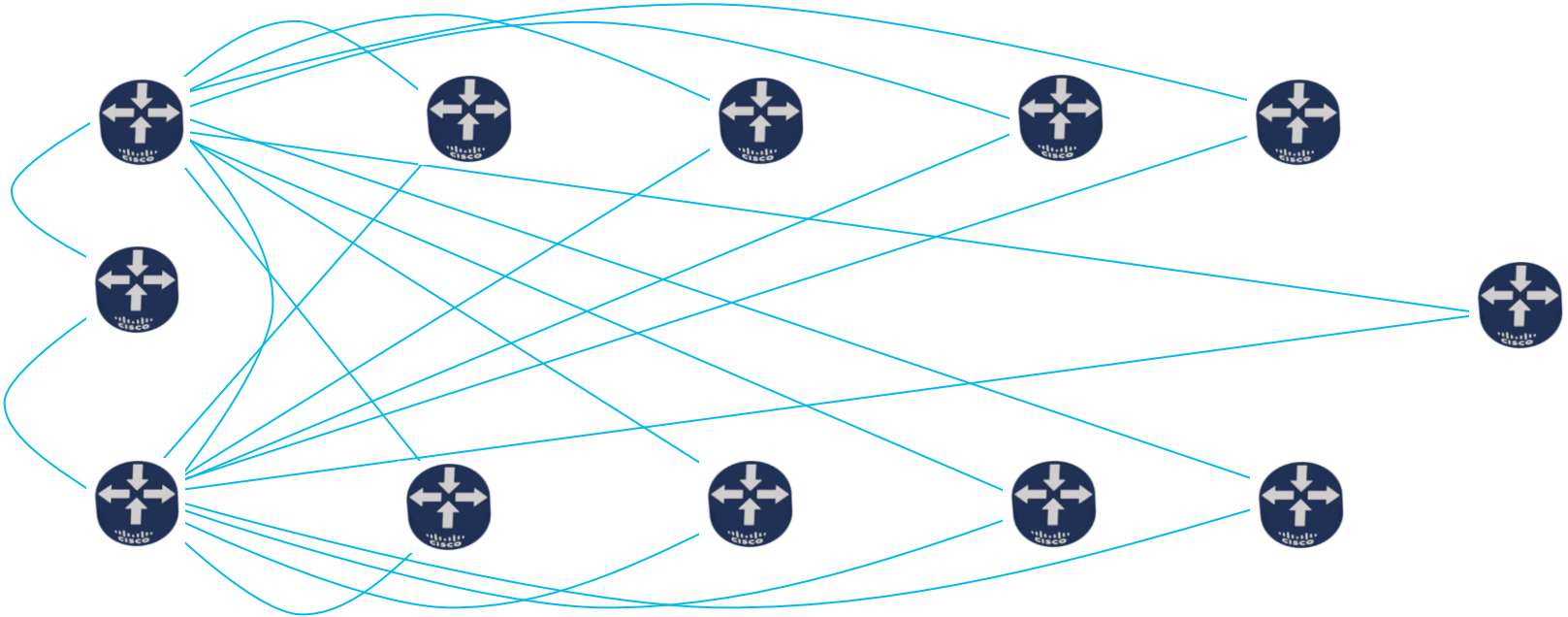


Multilayer Topologies… OLS Layout



Multilayer Topologies… Router Adjacencies

Hub-and-Spoke Logical Topology



Complexity of Multiple Control Planes

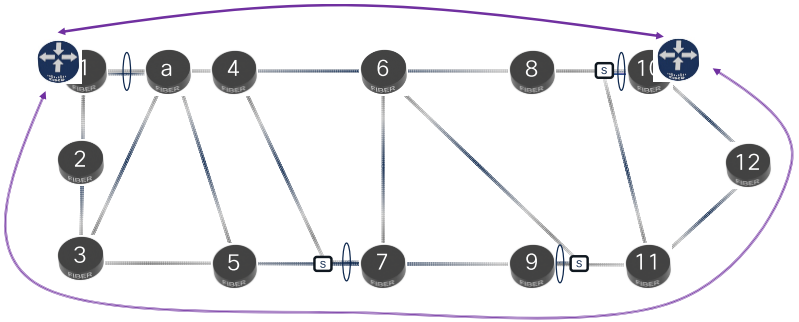
Multilayer Topologies… All Layers

Logical for all Layers

Mapping Services with Disparate Transponders…

Use Fiber Topology to ensure route diversity of 1:1 Service

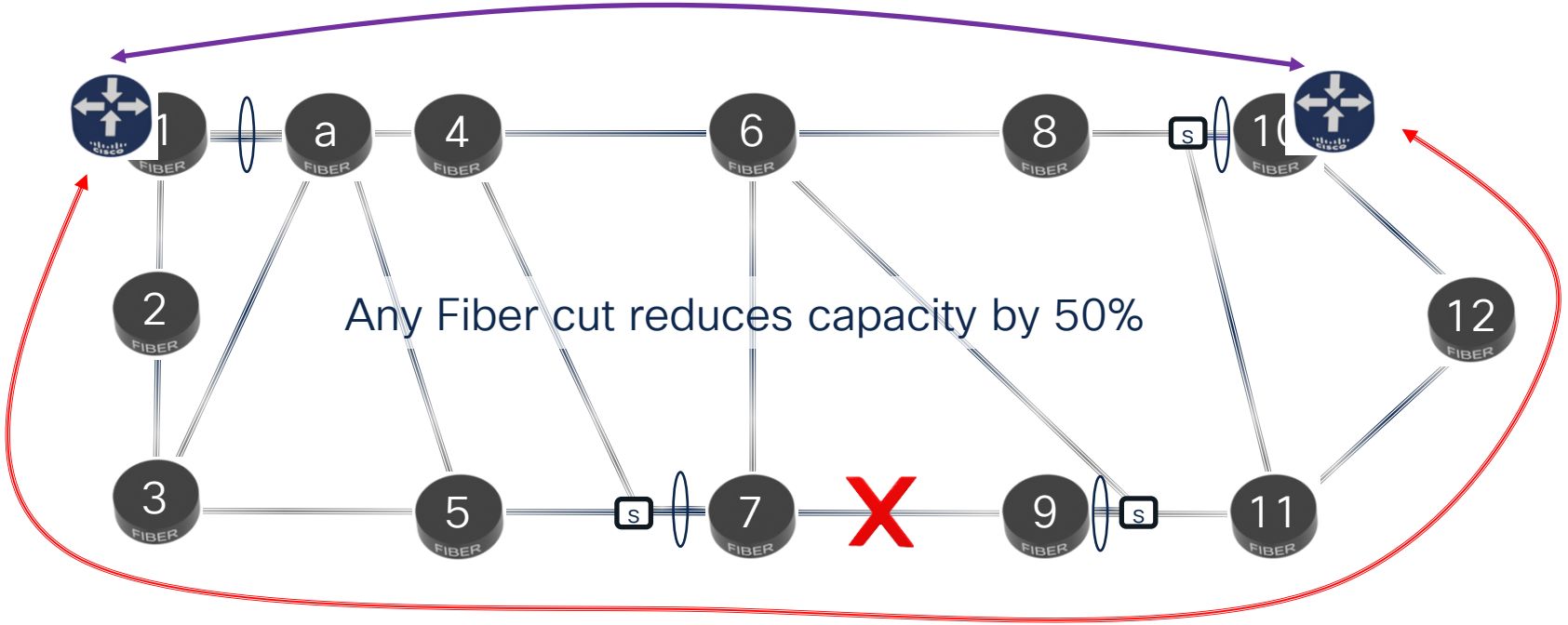
- Hub-and-Spoke topology R1-R10
  - must determine valid paths for all Router Connections
- None of the middle paths are useable due to fiber collapses



- These are static Optical Circuits supporting IP Services –
  - constant line rate regardless of needed Capacity
  - no optical restoration or switching
- Fiber, OLS, and Router Diversities (SRLG's) must be determined/ designed between each router

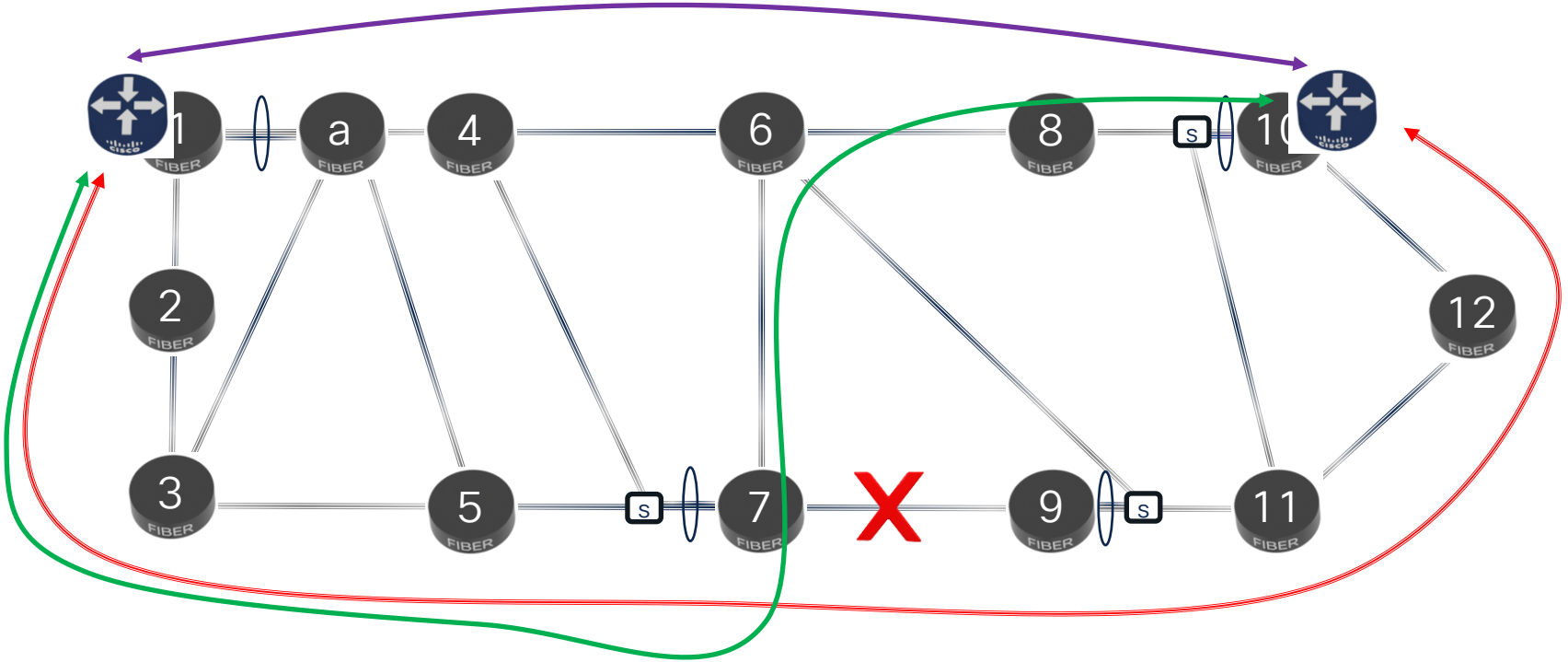
Mapping Services with Disparate Transponders…

Use Fiber Topology to ensure route diversity of 1:1 Service



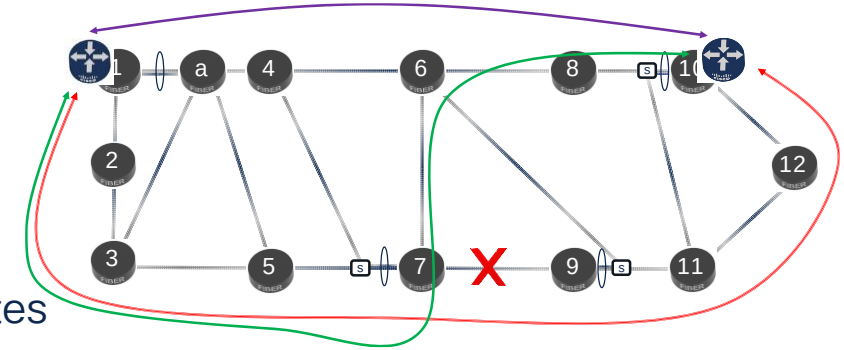
Mapping Services with Disparate Transponders…

Overcome with Optical Restoration 1+1+R



Mapping Services with Disparate Transponders…

Overcome with Optical Restoration 1+1+R



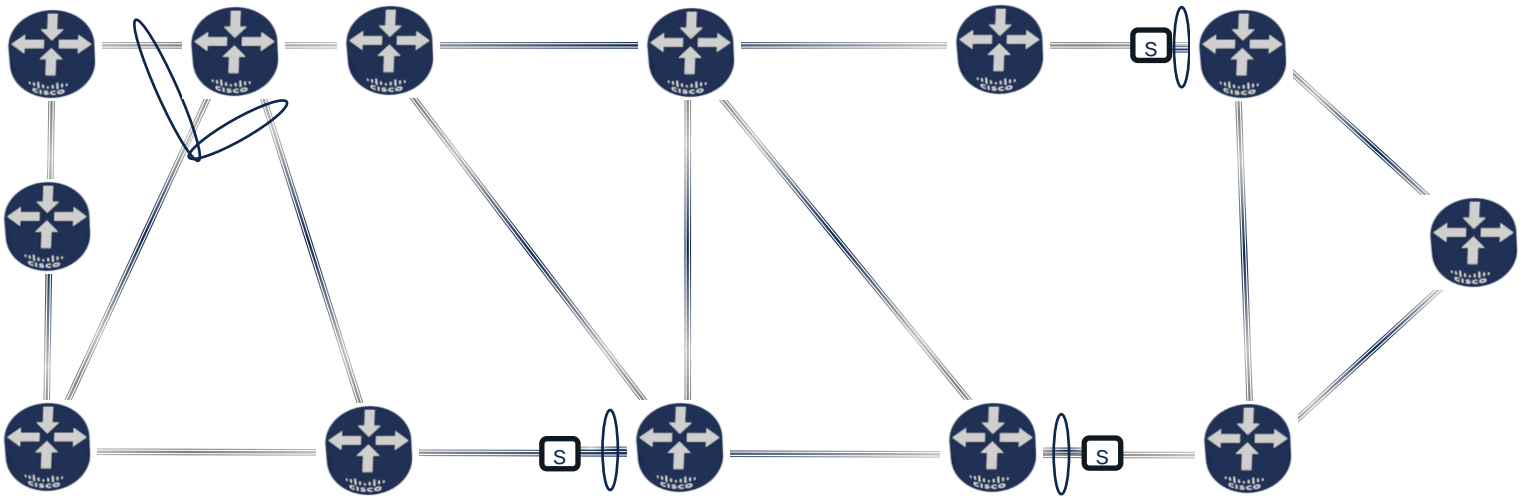
- Failover is easy –
  - just re-route during fault events
- No coordination with the IP Layer
  - Optical Restoration can restore within minutes
- …but this path has partial overlap with the first path so it must be reverted – how do you keep track of the “home” paths for each?
- Optical Reversion is Hard – auto or manual reversion options
  - generally, auto just reverts after set time (WTR)
  - preferably would be scheduled event(s) in coordination with the IP Layer
  - usually, multiple circuits will revert without coordination with each other

Network Protection Schemes

Optical Protection Schemes				IP Protection
None – 1:1	1+1	1+1+R	PSM	
"Easily" done	< 50ms Electrical Switching (OTN)	N-x Optical Paths available for restoration	Fast Optical Switching	IP Protection is as fast as Optical Switching
Diverse Hardware and Paths	Diverse Paths could have diverse HW	No additional Optical Trunk (2)	Minimal Additional Hardware	All Paths are useable
<50% Link Utilization	+1 Optical Trunk/Card/HW	Requires Omni-directional, CDC HW	Loss of Light Switching prone to problems	Less Hardware
No or little IP Layer Interaction	Failback is not coordinated with IP Layer	Failback is not coordinated with IP Layer	Failback is not coordinated with IP Layer	New Skillset within IP
	Only 2-paths for redundancy	Multi-path support if available	Only 2-paths for redundancy	
	Additional Power, real estate, and costs			

RON Topology… all Layers are the same

Router Layout – Physical = Logical



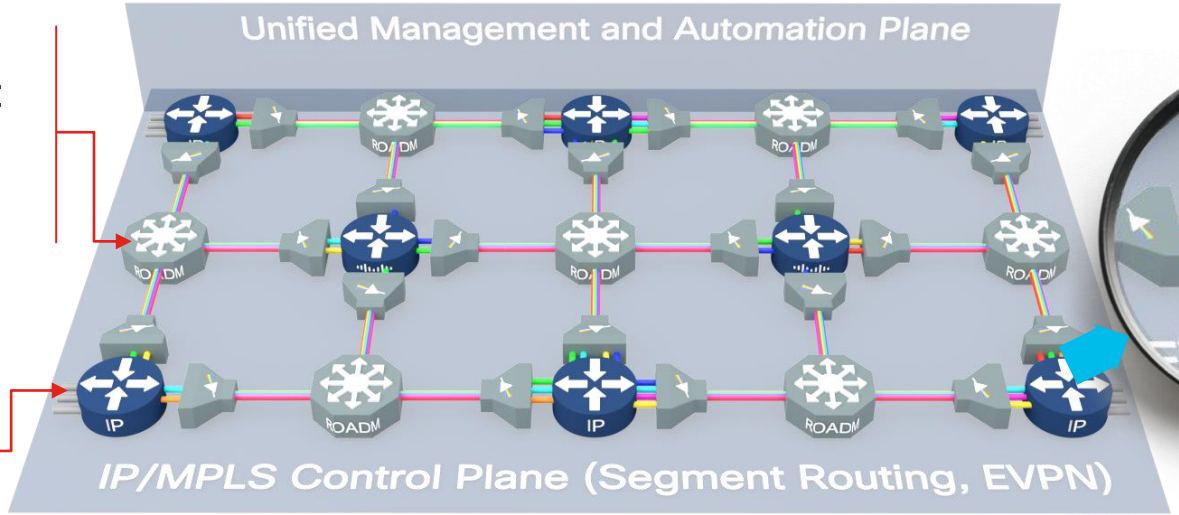
Advantages of Routing Control Plane

A Single Control Plane?

400ZR/ZR+
QSFP-DD DCO
Pluggable Optics

75GHz min. width DWDM: ROADM, FOADM or Terminals

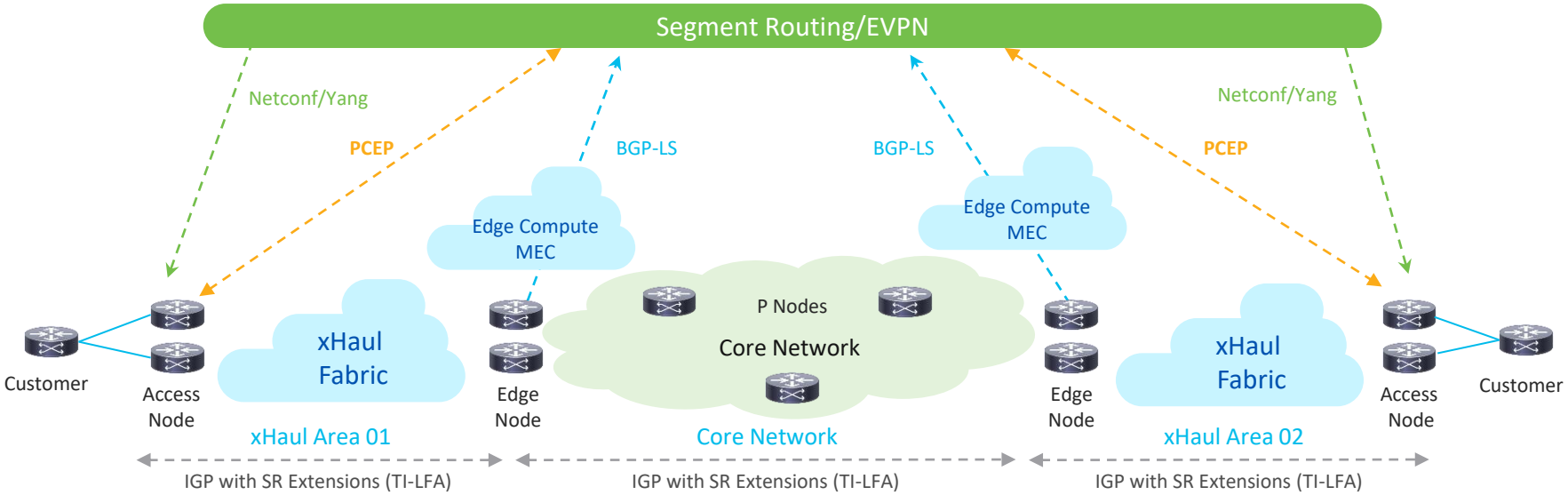
L3 VPN
L2 VPN
L1 PLE*



400GE Capable Router: Modular, Fixed (from 1RU)

*PLE: Private Line Emulation

A Single IP/MPLS Control Plane



Why Segment Routing?

01

Optimized Traffic Delivery

- Complete control over forwarding path
- Ingress router “forces the path”
- Transit routers only need to know how to get to a segment, not the full per-path
- Segments are topology or services-based

02

Network Simplification

- Reduce of protocols as IGP takes over
- Better network asset utilization
- Minimal Control Plane Pressure
  Migrations do not disrupt data plane

03

Network Resiliency

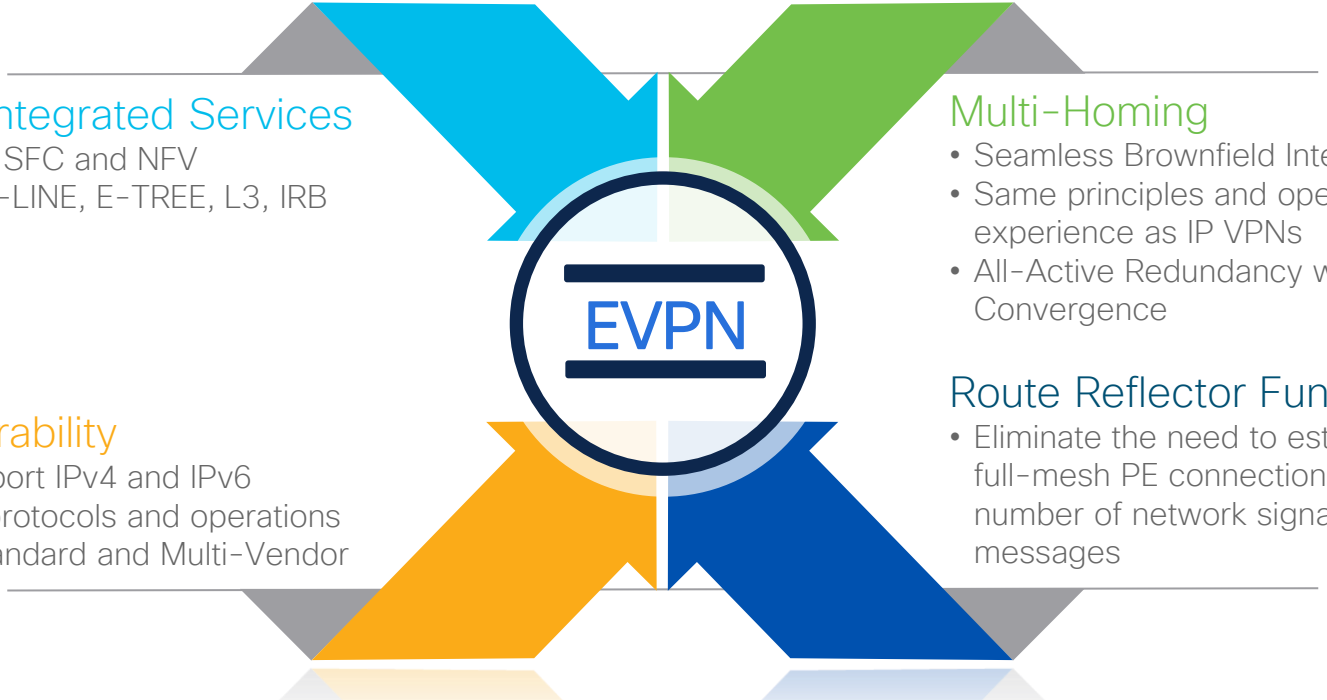
- FRR over ANY topology (LFA/RFLA)
- Sub-50msec convergence
- Minimize network congestion

04

SDN – App-Eng Routing

- Can integrate with SDN Controllers for optimal path selection
- Balance between distributed intelligence and centralized optimization

Why EVPN?



Deliver Integrated Services

- Stateless SFC and NFV
- E-LAN, E-LINE, E-TREE, L3, IRB Services
- Multicast

Multi-Homing

- Seamless Brownfield Integration
- Same principles and operational experience as IP VPNs
- All-Active Redundancy with Fast Convergence

Interoperability

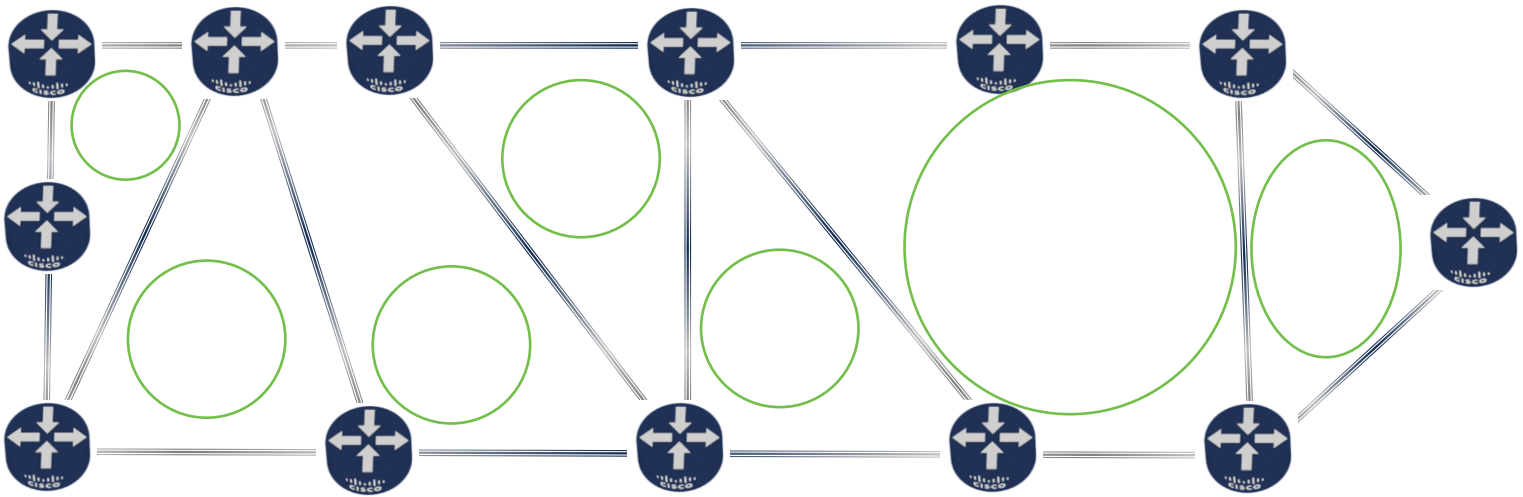
- Fully support IPv4 and IPv6
- Simplify protocols and operations
- Open-Standard and Multi-Vendor

Route Reflector Function

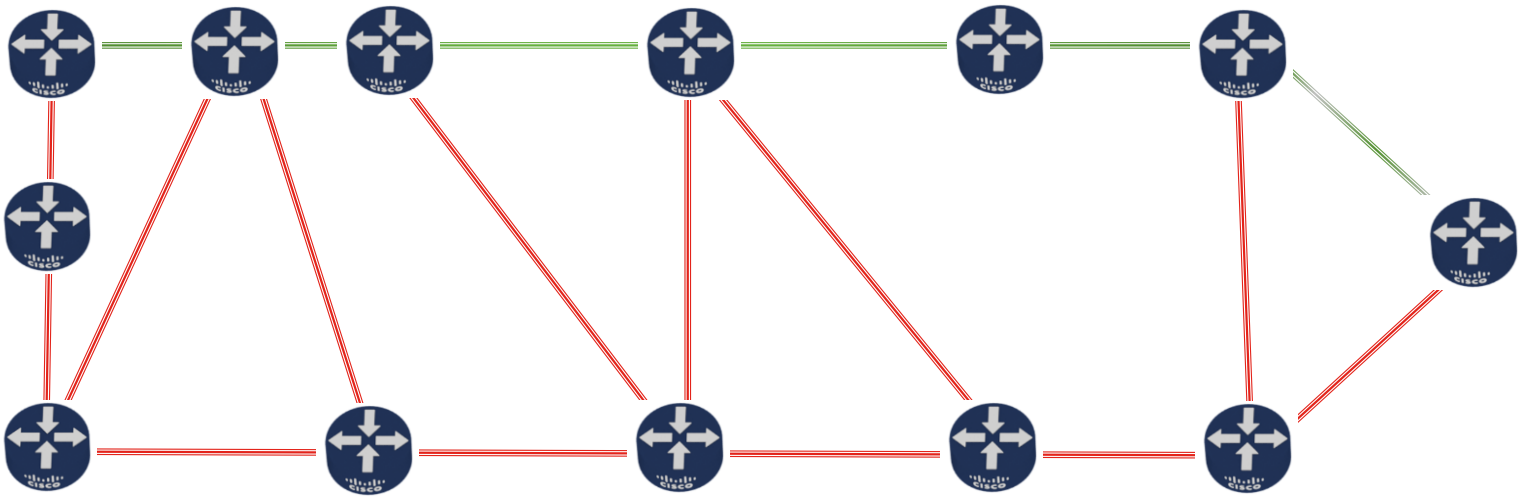
- Eliminate the need to establish full-mesh PE connections Reduce number of network signaling messages

Fast, Resilient, Flexible Unified Services

Let us consider



Utilization we see...



A case against G.8032 Ethernet Rings

Smaller size – reconvergence suffers as the ring grows

Short L2 rings, star mesh not supported

Cascaded rings – physical disruption to stop unexplained behavior

Some locations on the ring do not have the best path to destination

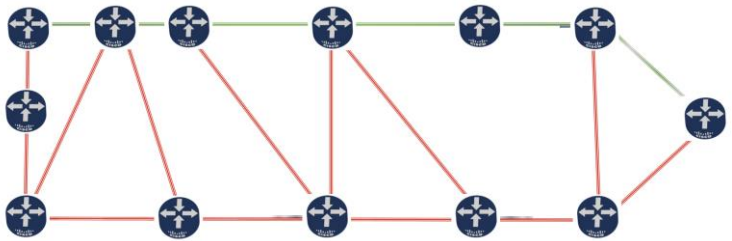
No multi-failure resiliency

Optical restoration is not faster than IP

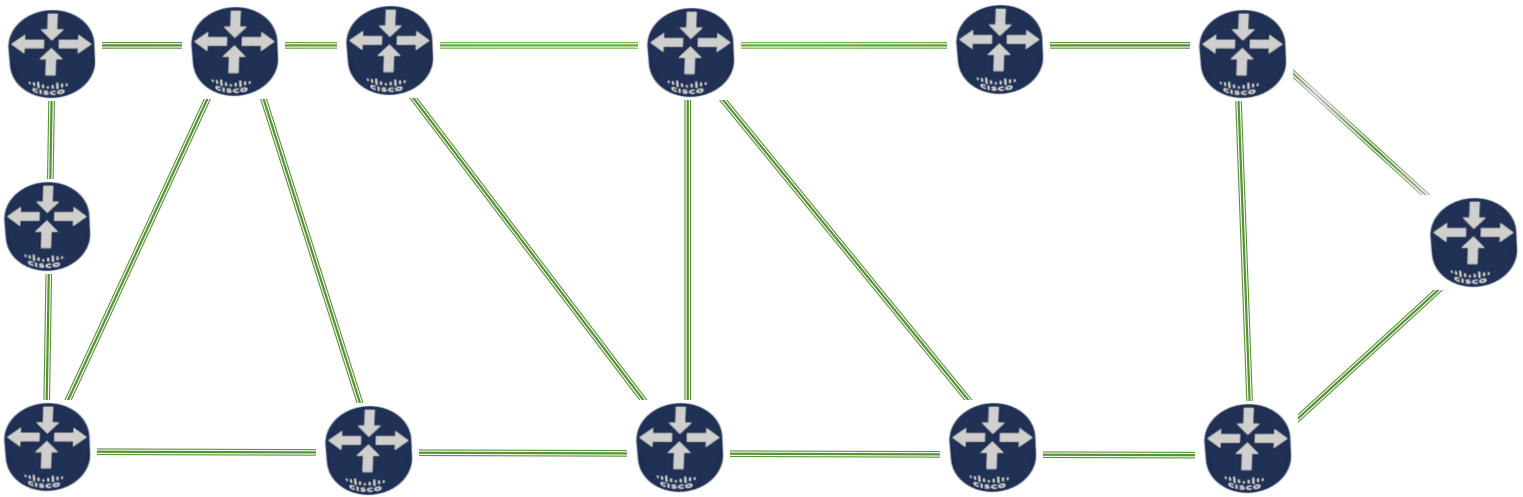
No traffic prioritization and engineering

No security for the control plane

No measurable latency advantage (fiber latency = 5 µs/km)



Utilization we would like to see...



IP Compared to L2 Rings

Using ALL available paths (resilience = # of Fiber paths)

Any-to-Any connectivity = Aggregating traffic from any site onto the optical link and/or offloading traffic directly into any other site

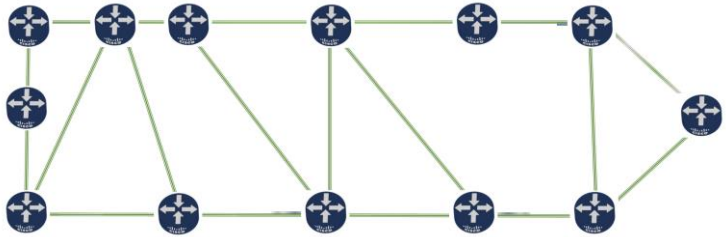
Optical Fiber Path = Routing Topology

Easy & flexible integration and placement of new Platforms, like Far Edge compute, cloud native BNG

Built-in Fast-Convergence/Protection mechanisms (IP-FRR/TI-LFA)

L3 Control Plane as Single Control Plane vs. IP/MPLS + Optical GMPLS + WSON/SSON

Network Slicing through Segment Routing - Low Latency path, Disjoint Path, Highest BW path



G.8032 vs IP Compared

Reference Slide

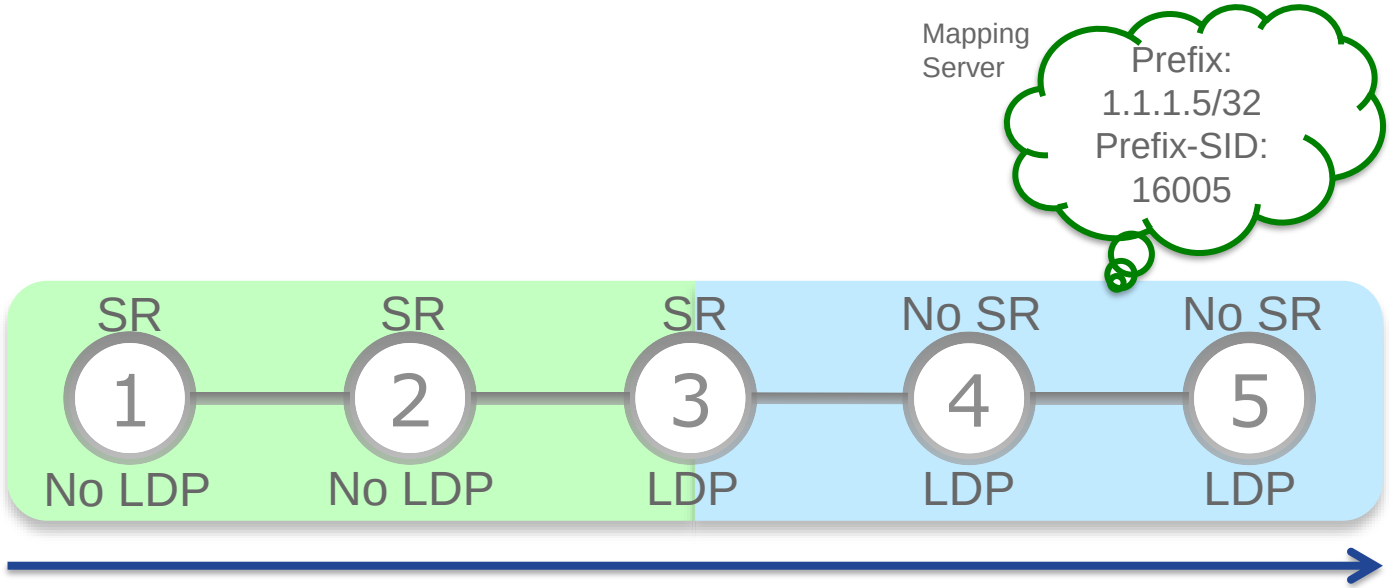
	VLAN-Based Solutions	EVPN-SR
Scale	• Large, flat L2 architectures don't scale • VLAN tag stacking is not a manageable solution	• Will scale to thousands of nodes per domain • 20-bit labels yield virtually limitless tunnels and services • 10's of thousands of LSPs
Operations	• Understanding switching path will be very difficult since there is no control-plane state for services or tunnels	• Traffic routing will be deterministic based on dynamic or explicit path selection via control plane • Switching paths are easily traced using MPLS OAM toolkit
Automation	• Requires EMS or manual configuration and assignment (which will be error-prone and complex to manage)	• EVPN dynamically learns remote endpoints • Programmatically define the path for the packet at the source node
Optimization	• Traffic engineering with VLAN-based switching is very difficult if not impossible	• Native ECMP allows efficient use of network resources – no configuration required
Flexibility	• VLAN-based solutions constrained to logical hub-and-spoke or ring architectures	• Any arbitrary topology can be supported with same resiliency and scale

Unified Control Plane Benefits

Interop with Existing MPLS

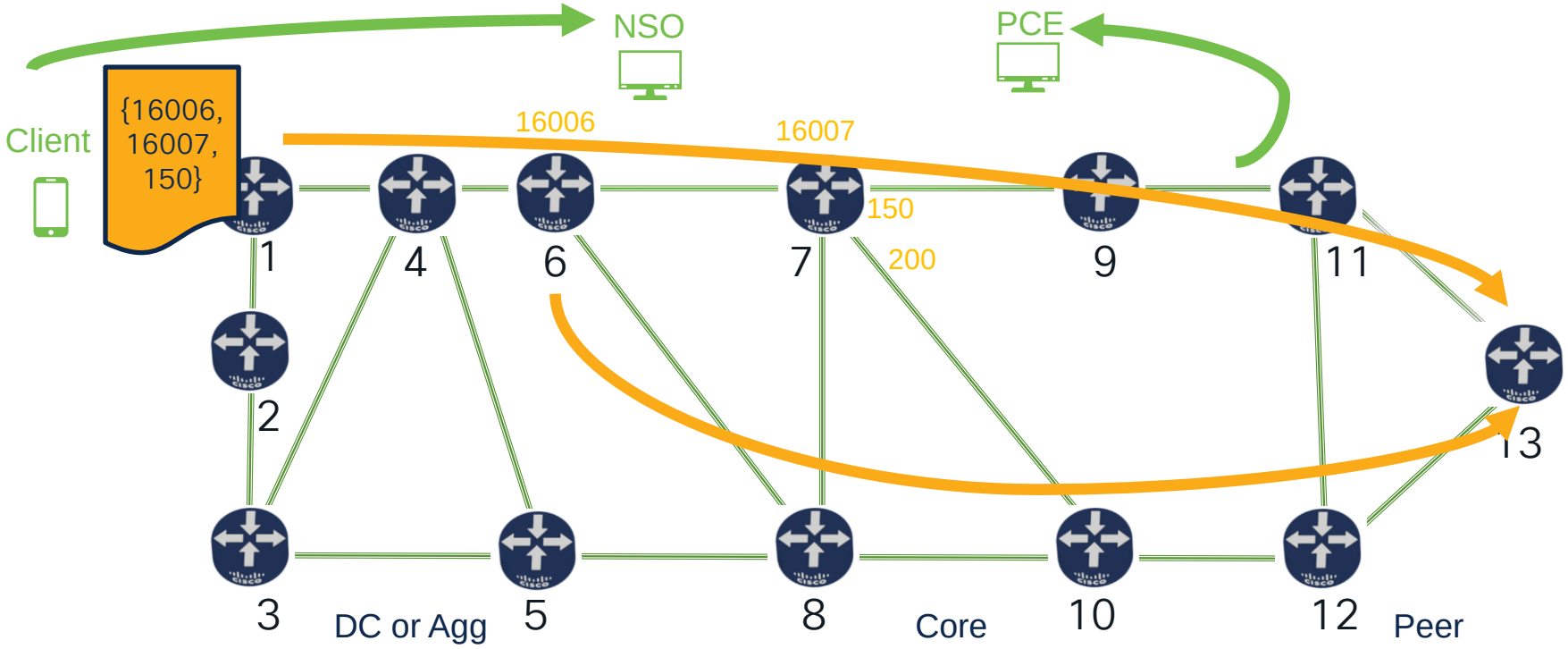
SR LDP

Let’s dispense with this (labels and mapping servers)



Multipath – any available path

ECMP/UECMP to use the totality of the network



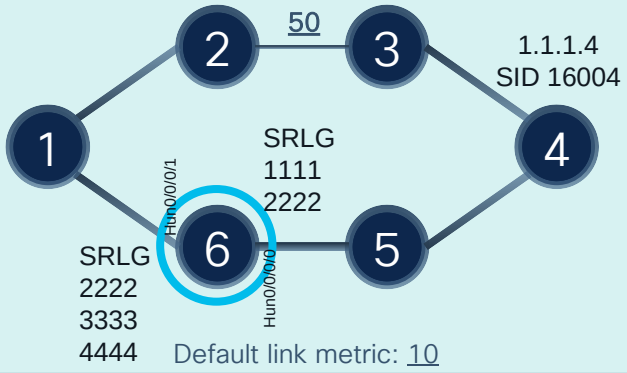
SRLG (Fate Sharing)

Shared Risk Link Groups (SRLGs) are identified by a number

Links with the same SRLG id share a common risk (e.g. same fiber conduit)

On Node6:

```
srlg
 interface Hun0/0/0/0
  10 value 1111
  20 value 2222
 !
 interface Hun0/0/0/1
  10 value 2222
  20 value 3333
  30 value 4444
 !
!
```



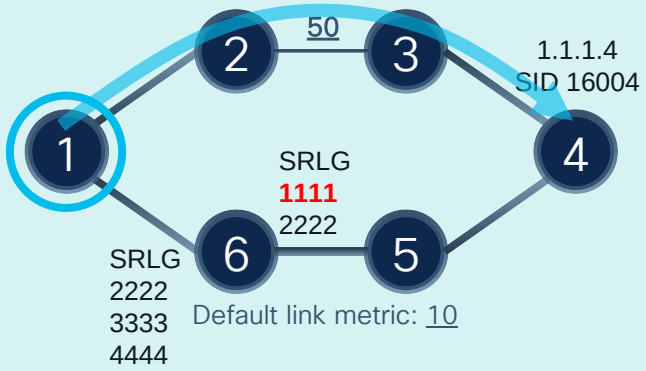
SRLG (Fate Sharing)

SRTE can compute paths that excludes links that have specific SRLGs

On Node1:

```
segment-routing
  traffic-eng
    policy POLICY1
      color 20 end-point ipv4 1.1.1.4
      candidate-paths
        preference 100
          dynamic
            metric type igp
          constraints
           srlg
            exclude 1111
```

Don't use links with SRLG 1111



TI-LFA sub 50ms restoration on any topology

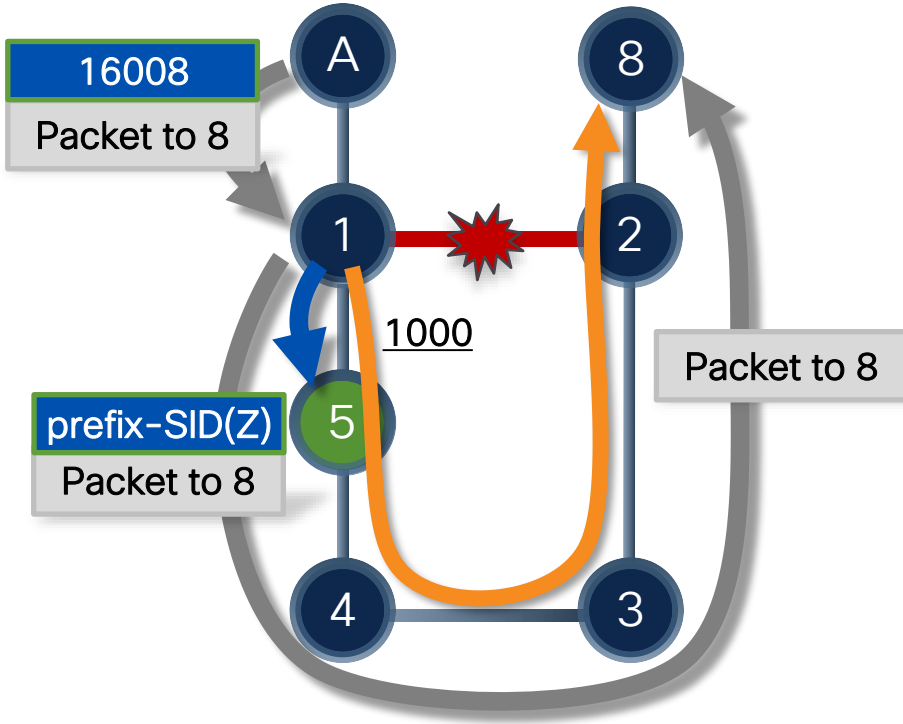
Simple to operate and understand

Automatically computed by the IGP

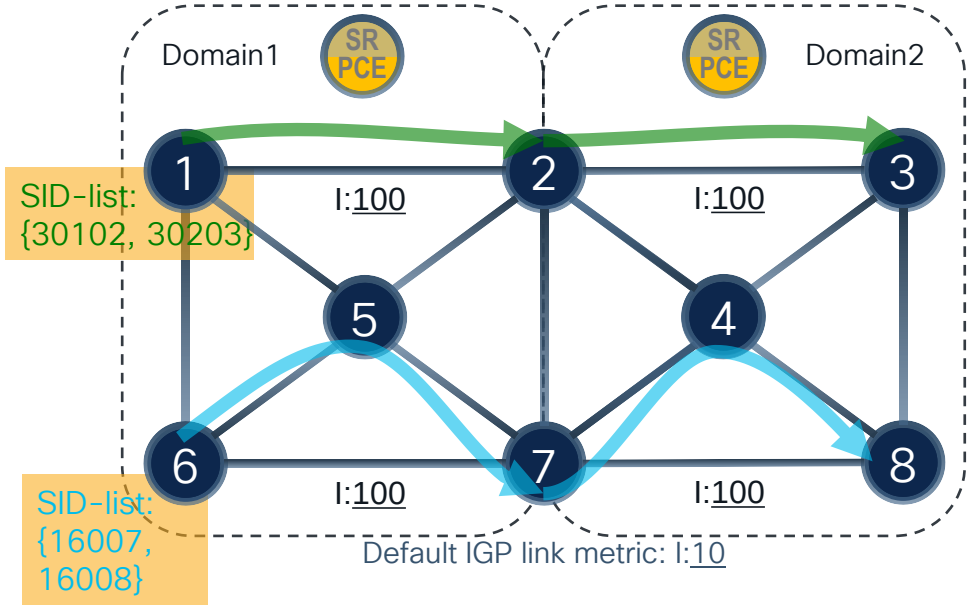
One configuration line only

Prevents transient congestion and suboptimal routing

Leverages the post-convergence path, planned to carry the traffic



Service Disjointness



Node1

```
segment-routing
 traffic-eng
  policy POLICY1
   color 20 end-point ipv4 1.1.1.3
    candidate-paths
     preference 100
      dynamic
       pcep
       metric type igp
       constraints
        association group 1 type node
```

Node6

```
segment-routing
 traffic-eng
  policy POLICY2
   color 20 end-point ipv4 1.1.1.8
    candidate-paths
     preference 100
      dynamic
       pcep
       metric type igp
       constraints
        association group 1 type node
```

Two dynamic paths between two different pairs of (head-end, end-point) must be disjoint from each other

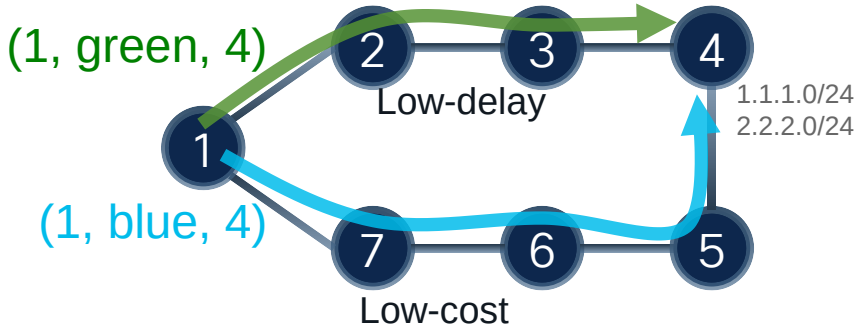
SR Traffic Engineering

Each SR Policy has a color to indicate a certain treatment (SLA, policy)

Each SR Policy triplet (Headend, Color, Endpoint) is unique

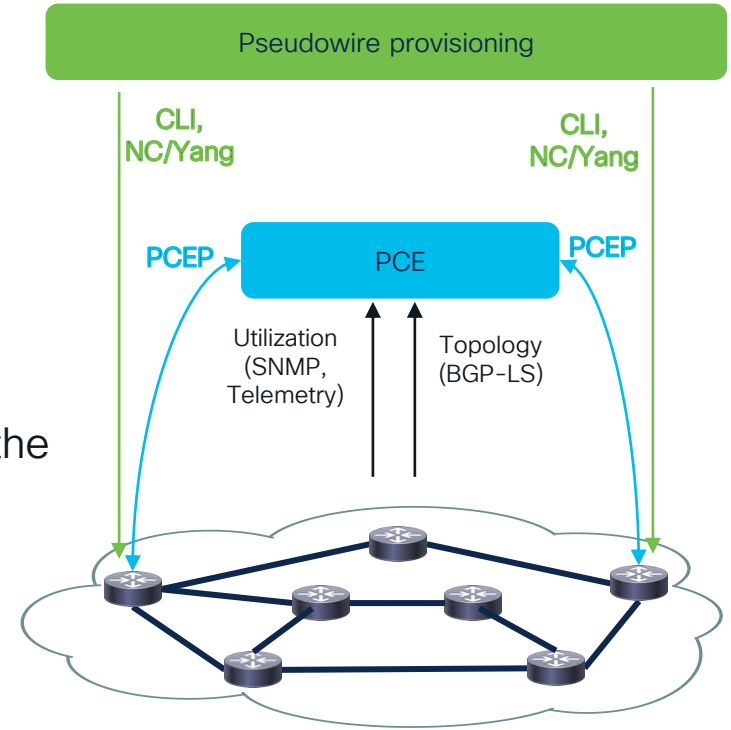
Example:

- Low-cost="blue", Low-delay="green"
- steer traffic to 1.1.1.0/24 via Node4 into Low-cost SR Policy (1, blue, 4)
- steer traffic to 2.2.2.0/24 via Node4 into Low-delay SR Policy (1, green, 4)

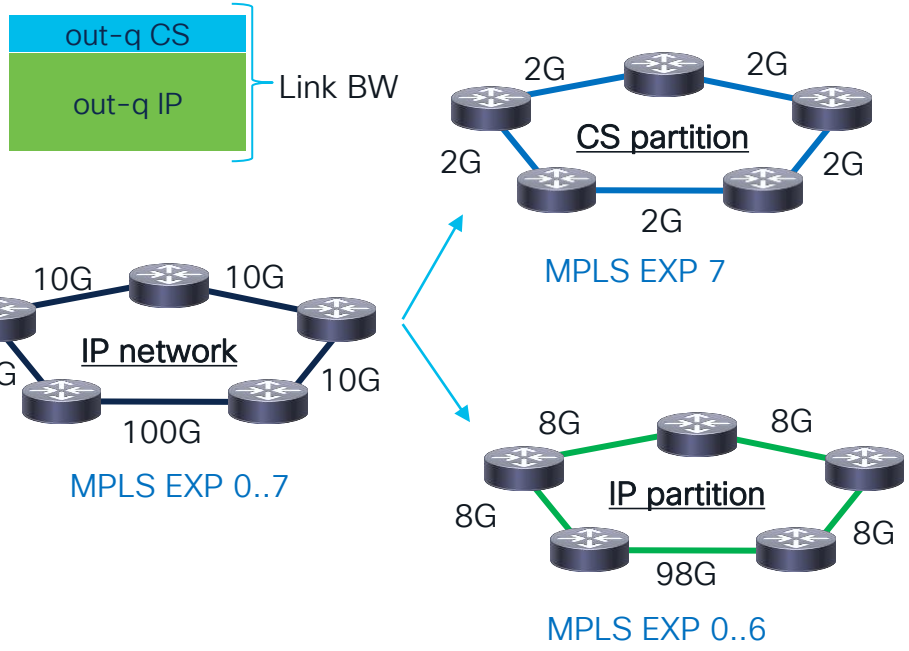


Circuit-style Segment Routing

- Pseudowire has a distinct bandwidth requirement assigned
- Pseudowire is mapped to a SR policy
- Headend routing requests a path via PCEP from a central PCE
  - Bandwidth
  - Path constraints
- The path is encoded via a list of adjacency SIDs in the packet header
- The central PCE maintains a real time view of
  - The network topology (BGP-LS)
  - All path/bandwidth requests (PCEP)



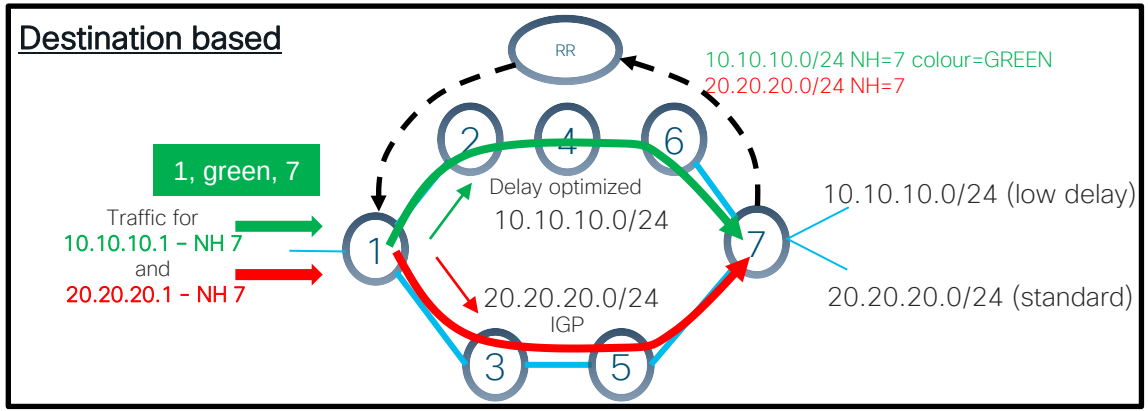
Partitioning the network for circuit-style Services

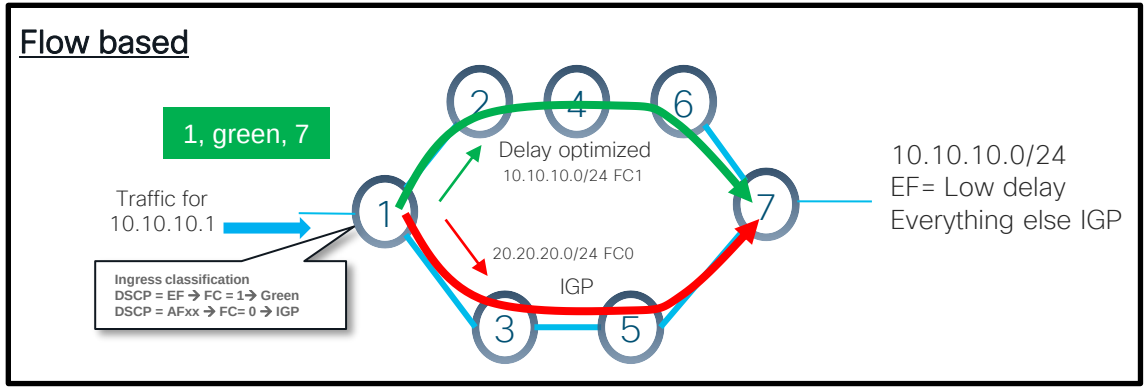


- To allow Circuit Style services, the network is partition
  - CS partition
  - IP partition
- Allocate one MPLS-EXP to the circuit-style partition
- QoS configuration (MQC) isolates circuit traffic from IP traffic

SR – Service Aware Traffic Steering

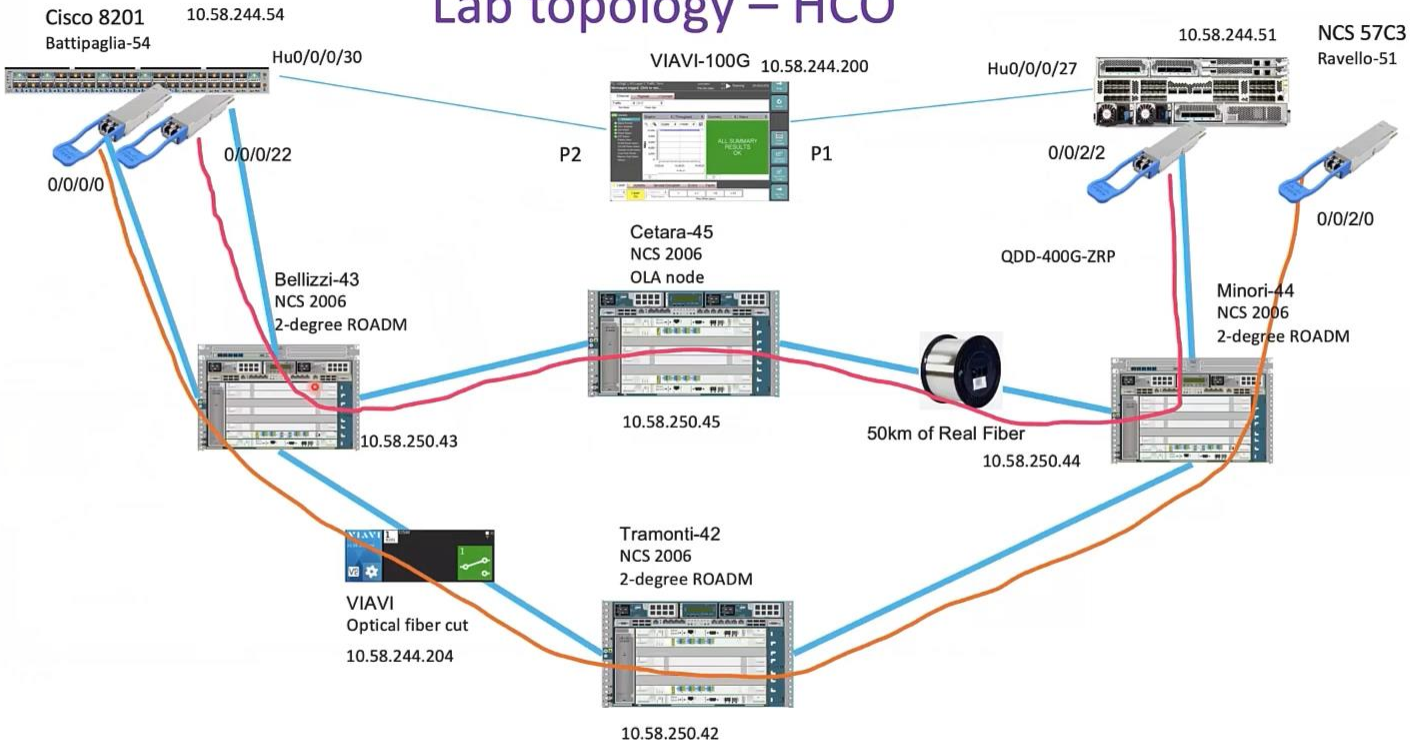
- ✓ Mechanism on source router to steer traffic
- ✓ By default traffic uses IGP path
- ✓ Can steer traffic into a SR policy or specific Flex-algos
- ✓ Destination TS : destination only
- ✓ Flow based TS : destination + QoS criteria





Demo Time!

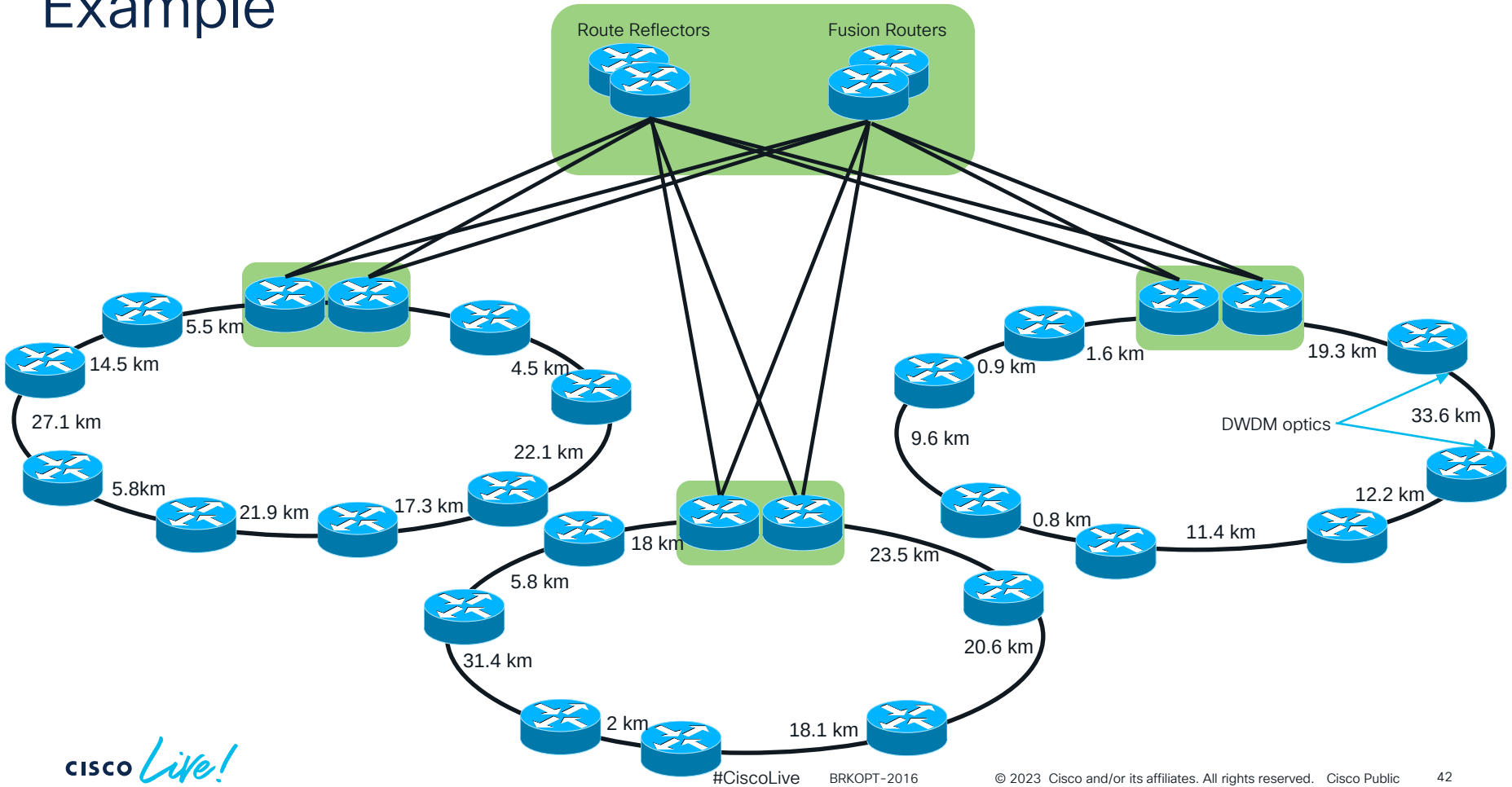
Lab topology – HCO




```
RP/0/RP1/CPU0:Ravello-51#sh mpls forwarding labels 15154
Fri Dec 23 12:58:57.149 CET
Local  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface                    Switched
------ ----------- ----------------- ------------ --------------- ------------
15154  Pop         SRLB (idx 154)    FH0/0/2/0    17.51.54.54     0
RP/0/RP1/CPU0:Ravello-51#
```

Customer Outcomes

Example



Benefits and Challenges

Technical

- Reduce cost to scale to high speeds (10/100GE)
- Reduce transport power requirements
- Manage one network, not two
- Network-wide Automation with OpenConfig

Business

- Technical design
- Organizational
- Commercial

Final thoughts

- IP Restoration/Protection has enhanced capabilities
  - These capabilities are inherent to IP – nothing new here!
  - No interaction between Optical and IP Protection schemes

- Driving towards simpler Networks
  - Single Topology of Fiber = OLS = Routing Topology
  - Reduced Hardware
  - Easier to automate vs. coordinate across multiple-layers

Fill out your session surveys!

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These points help you get on the leaderboard and increase your chances of winning daily and grand prizes

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- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
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The bridge to possible

Thank you


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