# Design, Deployment, and Management of ~~Next-Generation~~ Network Fabrics

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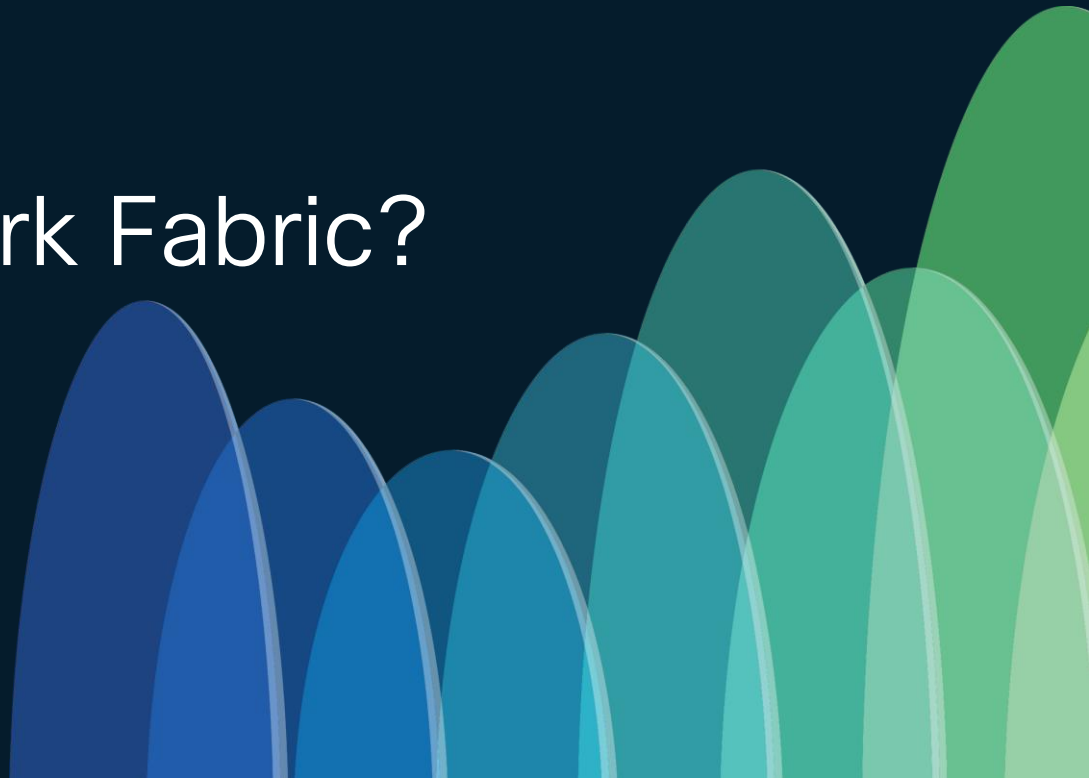
BRKSPG-2227

# Agenda

- What is a Network Fabric and why would I need one?
- How do I design a Network Fabric?
- How do I deploy a Network Fabric?
- How do I manage a Network Fabric?
- Resources and Conclusions

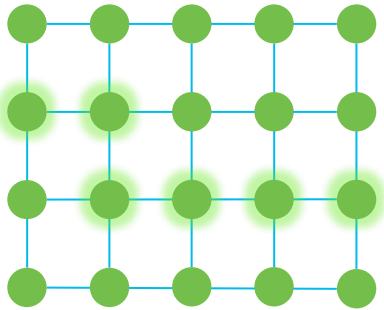
# What is a Network Fabric?



# Let’s start with what is a fabric?

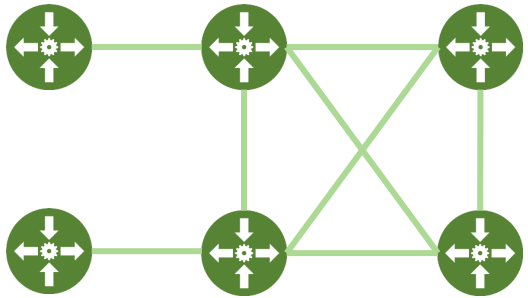
Fabric = Structure

*The arrangement of physical components in relation to each other and the interconnections that complete a structure*



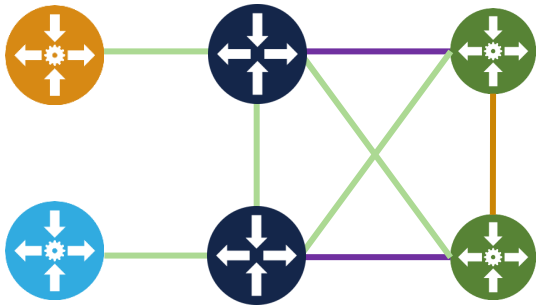
# What is a network fabric?

*The systematic arrangement of network nodes in relation to each other and the interconnections that complete the network*



# What is a network fabric?

*Nodes and interconnects in the fabric also have defined purpose, or a role*



”Internet” services PE
(Full GRT, uRPF, etc.)

VPN business services PE
(HQoS, L2VPN, L3VPN)

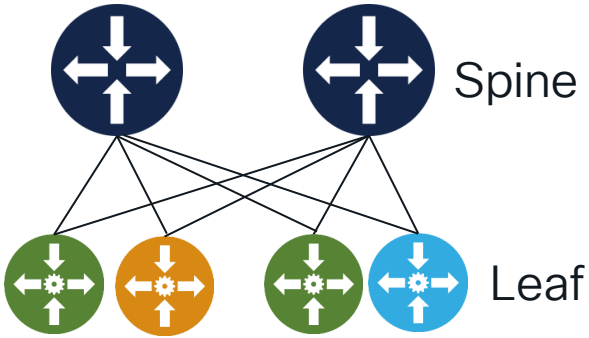
Spine/agg/P

Defined roles have benefits

# Network Fabric Examples

## Spine and Leaf (Clos)

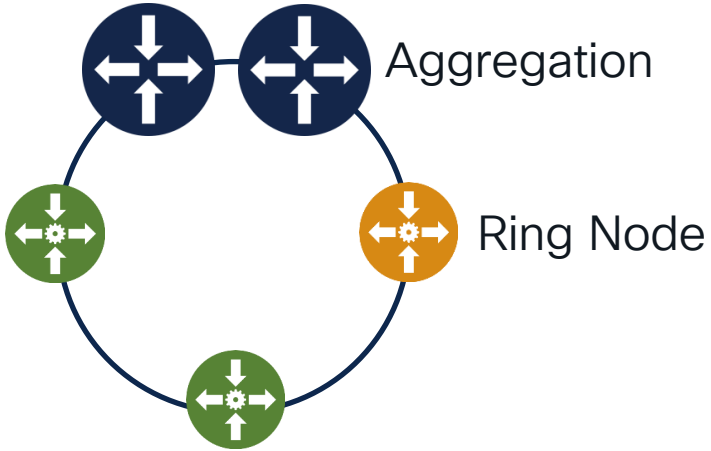
Common for aggregation / datacenter




What most think of as a “fabric”

## Aggregation Ring

Common topology for access / backhaul




Also a fabric!

# Network Fabric properties

- Can be thought of as a design process as much as a physical design
- Sets of routers managed as groups by role / properties
  - “Cattle” versus “Pet” design philosophy
- Devices and interconnects have specific “roles”

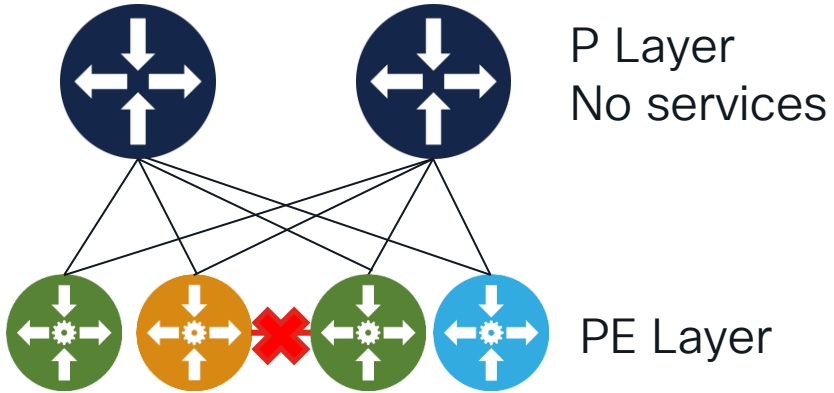
# Network Fabric properties

- Scale-out models are supported depending on the fabric design, but not required
- Non–blocking or oversubscribed based on requirements
- Standards-based control and forwarding plane.  Not a cluster of nodes using proprietary interconnects and forwarding
- Distributed control plane augmented as needed by controllers

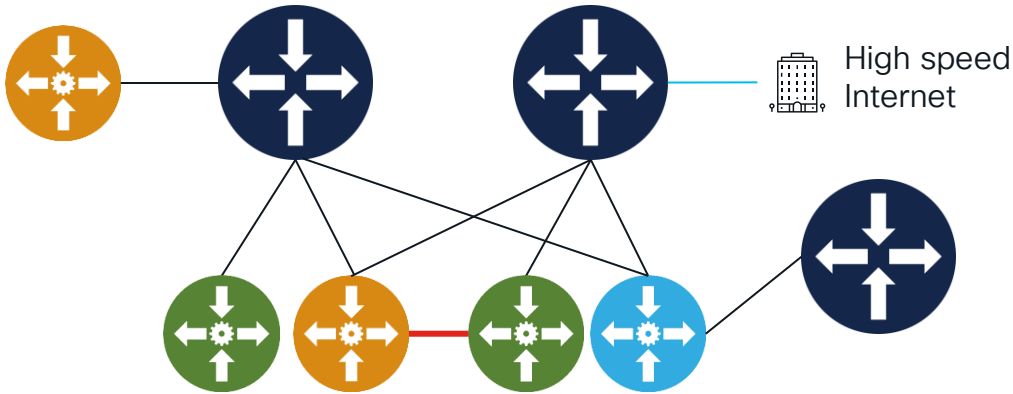
# Why build a network fabric?

# How have we been building networks?

Some networks utilize rigorous discipline in structure and service termination

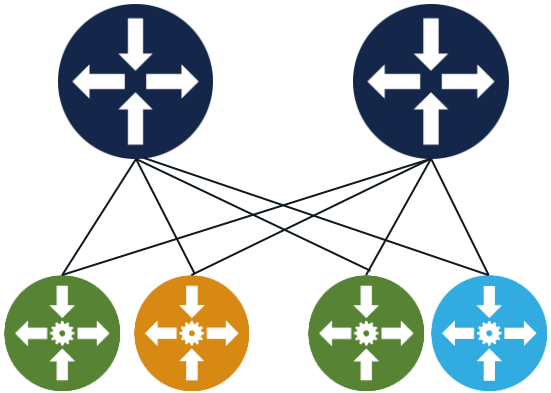



Many (Most?) networks are built organically based on network and service requirements

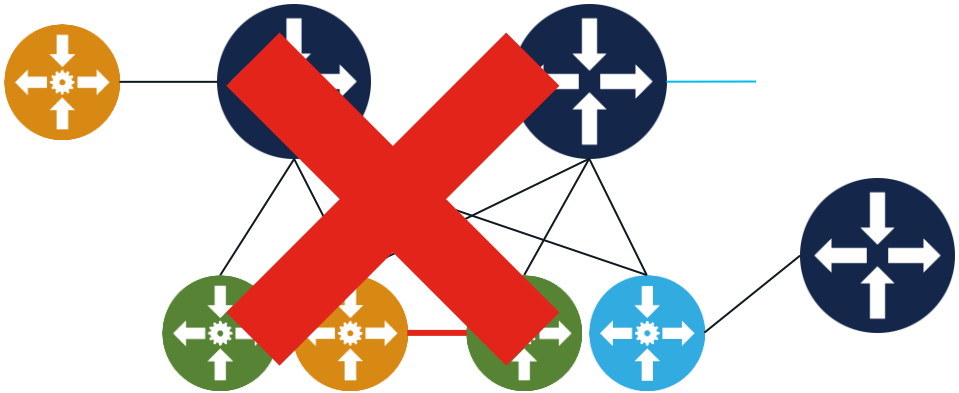


# Which network is easier to build and operate?

Fabric

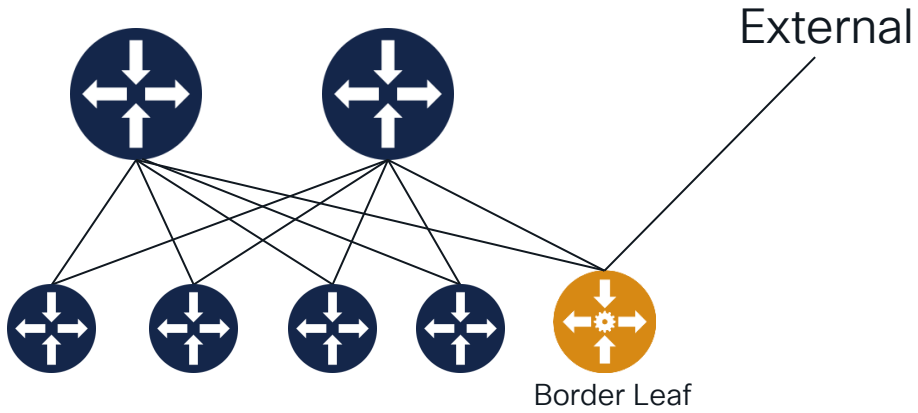


Organic Network



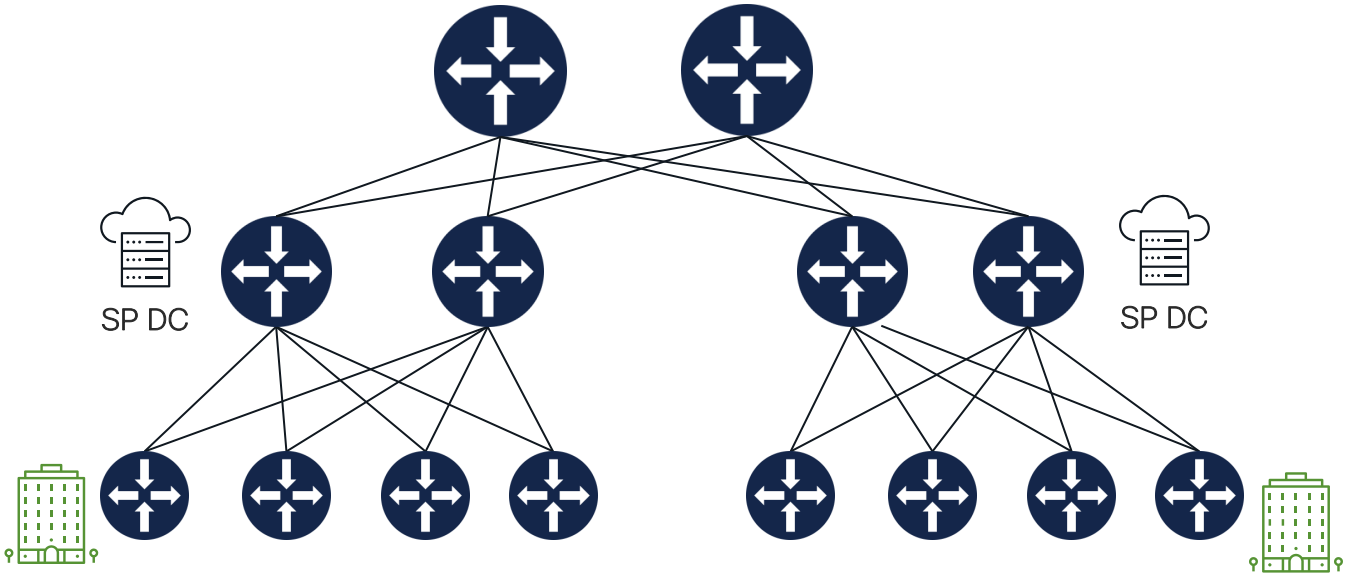
# Datacenter fabric drivers

- Any to any connectivity
- East-west traffic patterns
- Resiliency
- Efficient and effective load balancing
- Deterministic behavior

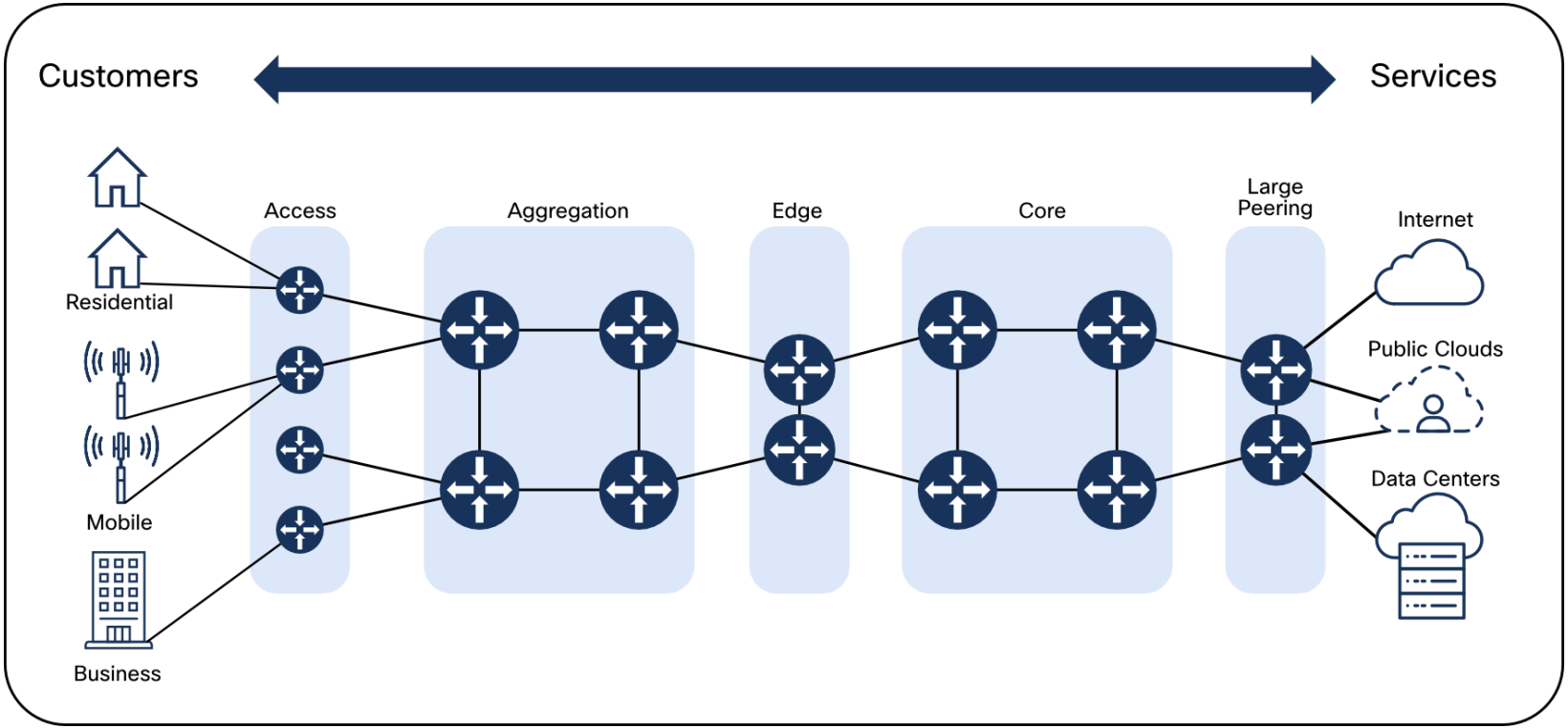


# Service provider fabric drivers

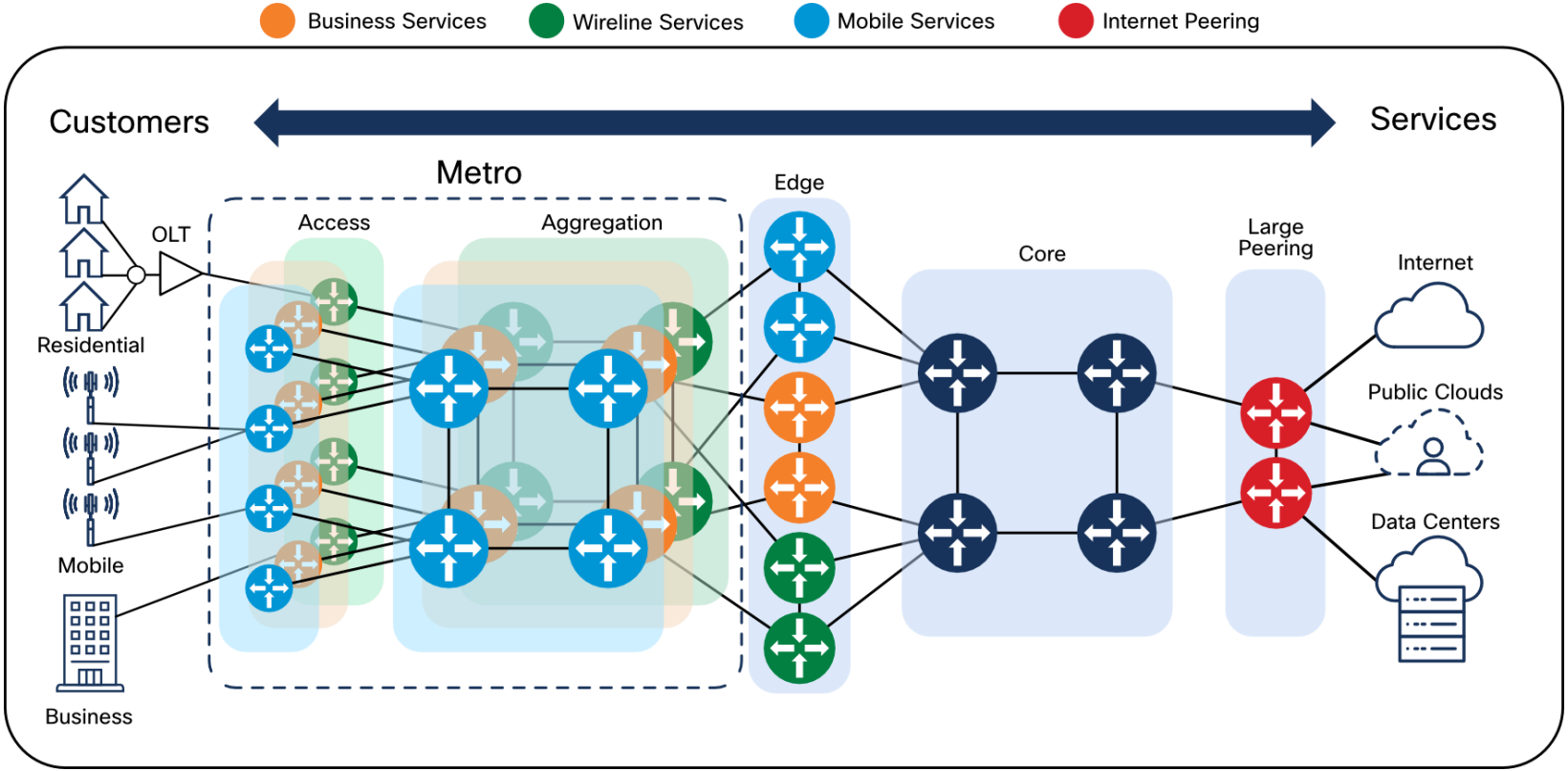
- Any to any connectivity
- Resiliency
- Efficient and effective load balancing
- Deterministic behavior



# Traditional SP network design



# Traditional “Metro” service networks



# Network Fabric pros and cons

## Pros

+ Structured network design and deployment
+ Build out fabric scale on-demand as needed
+ Any to any connectivity

## Cons

- In a design with fixed devices, more devices to manage
- Higher distributed control-plane scale

# How do I design a network fabric?

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# Key Network Requirements

- Resiliency – Adaptive to failures without service loss
- Scalability – Modern networks need to connect almost unlimited numbers of endpoints
- Security – Against internal and external threats
- Flexibility – Easily deploy new services where needed

# Initial design questions

- What services do I need to carry today and in the future?
- SLAs required for network services and infrastructure?
- Network migration and co-existence with legacy networks?
- Capacity planning?  Where is traffic entering and exiting my network?
- Observability and management?

# What services do I need to carry?

Mobile

## Tighter SLA and stringent network requirements

- Resiliency
- Fast failover
- Timing

Residential

## Mixed SLA

- Higher Bandwidth best effort traffic
- Lower bandwidth voice traffic, latency and loss sensitive
- Lower bandwidth video traffic, loss but not latency sensitive

Enterprise

## Mixed SLAs depending on service type

- Resiliency is sometimes very important
- Fast failover can be very important

# Infrastructure requirements

This is the standard set of features and scale required to satisfy network needs based on a modern design

- Control-plane protocols and methodology
- Network timing requirements
- IP address planning

# Infrastructure Design – Hardware

- Modern routers are meant to fulfill many different use cases
- Floating edge may be the norm in future networks
  - Hardware is selected based on bandwidth and port configurations, not feature sets (see Agile Services Networking)
  - Made easier with network simplification

# Infrastructure Design – IP Addressing

- IPv4 addresses are monetary commodity in 2024
- You CAN build an all IPv6 underlay infrastructure today
  - Meta moved to all IPv6 recently [1]
- IPv6-only underlay networks are a reality with SRv6 and technologies like 4PE
- IPv6 link-local vs. interface addresses
  - Link-local works like IPv4 unnumbered but most still use interface addresses to aid in troubleshooting

[1] https://youtu.be/lKYw7JlyAQQ

# Migration and Interoperability

- Very few greenfield networks are built today
- Have an eye on interop and migration without sacrificing network fabric design goals
- Need to be diligent in completing a design or migration

# Cisco Recommended Design

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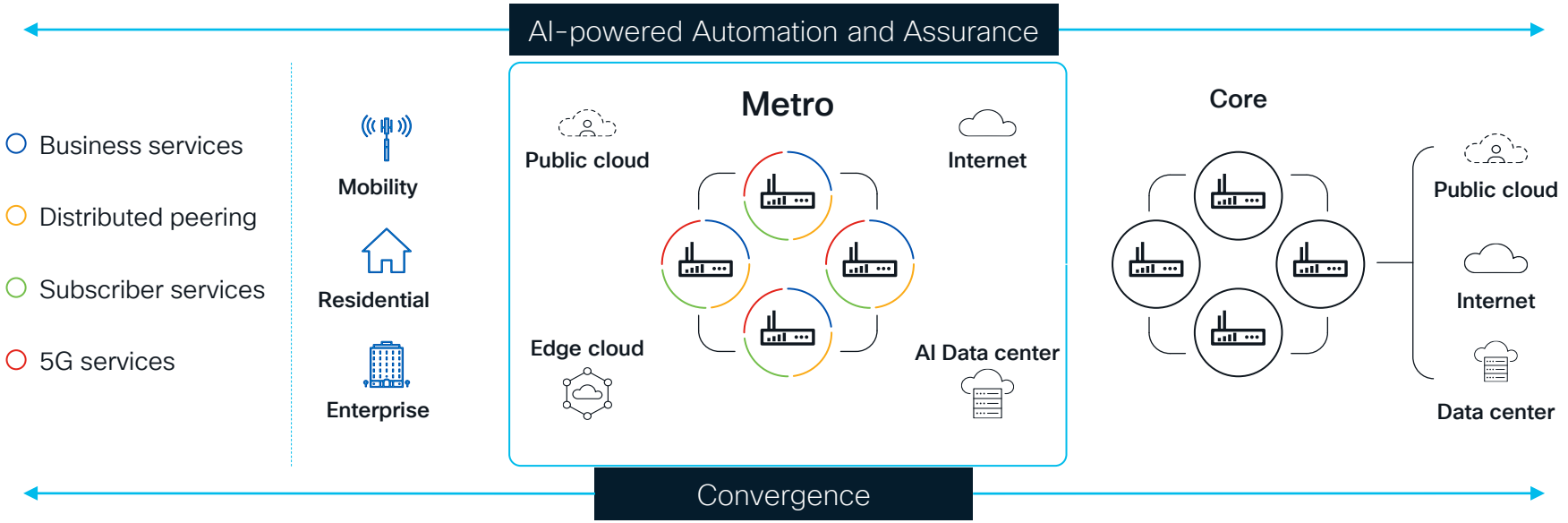
# Keep it simple

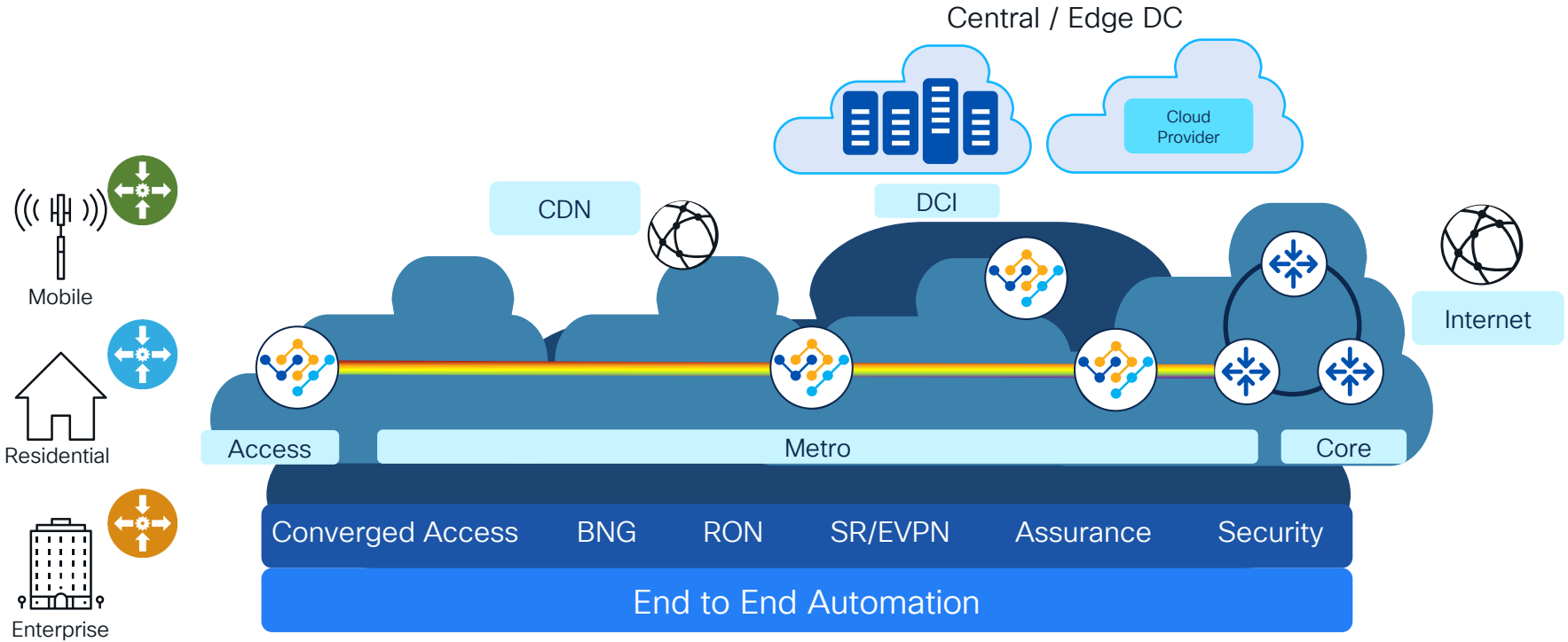
*Simplification is key to building networks that are easy to build and operate*

# Cisco Agile Services Networking

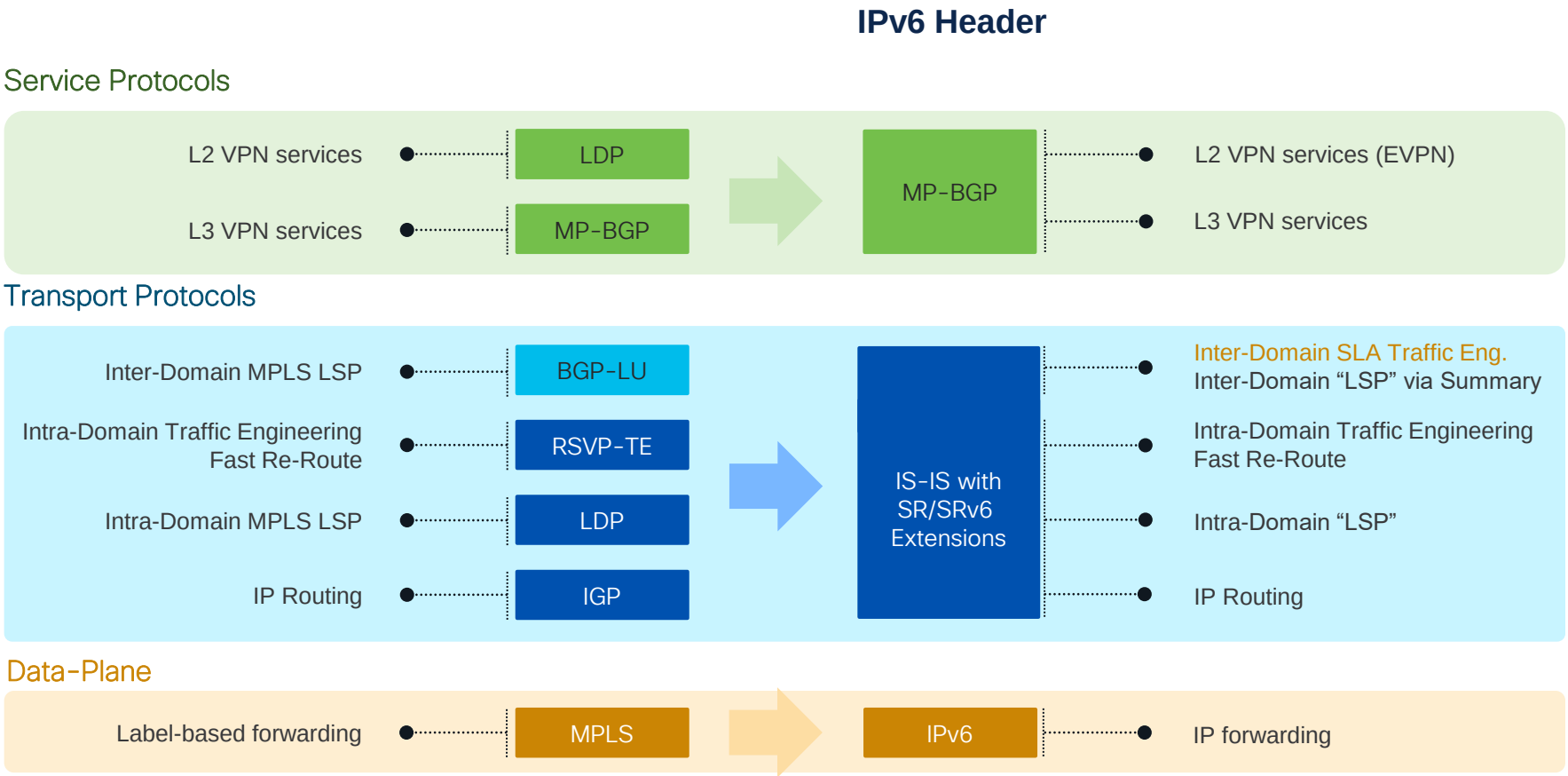



| Better performance | Simplified networking | Efficient transport | Increased resilience |
|---|---|---|---|

# Converged networks are simpler networks



# Network Control Plane Evolution



# Agile Metro network fabric elements

- Baseline packet transport based on SR with MPLS and IPv6 data planes
- Cisco Edge Fabric for scalable edge services termination
- Next-generation subscriber services using Cloud Network BNG and Cisco Routed PON
- Distributed network protection using Cisco DDoS Edge Protection
- End-to-End automation and assurance using Cisco Network Automation

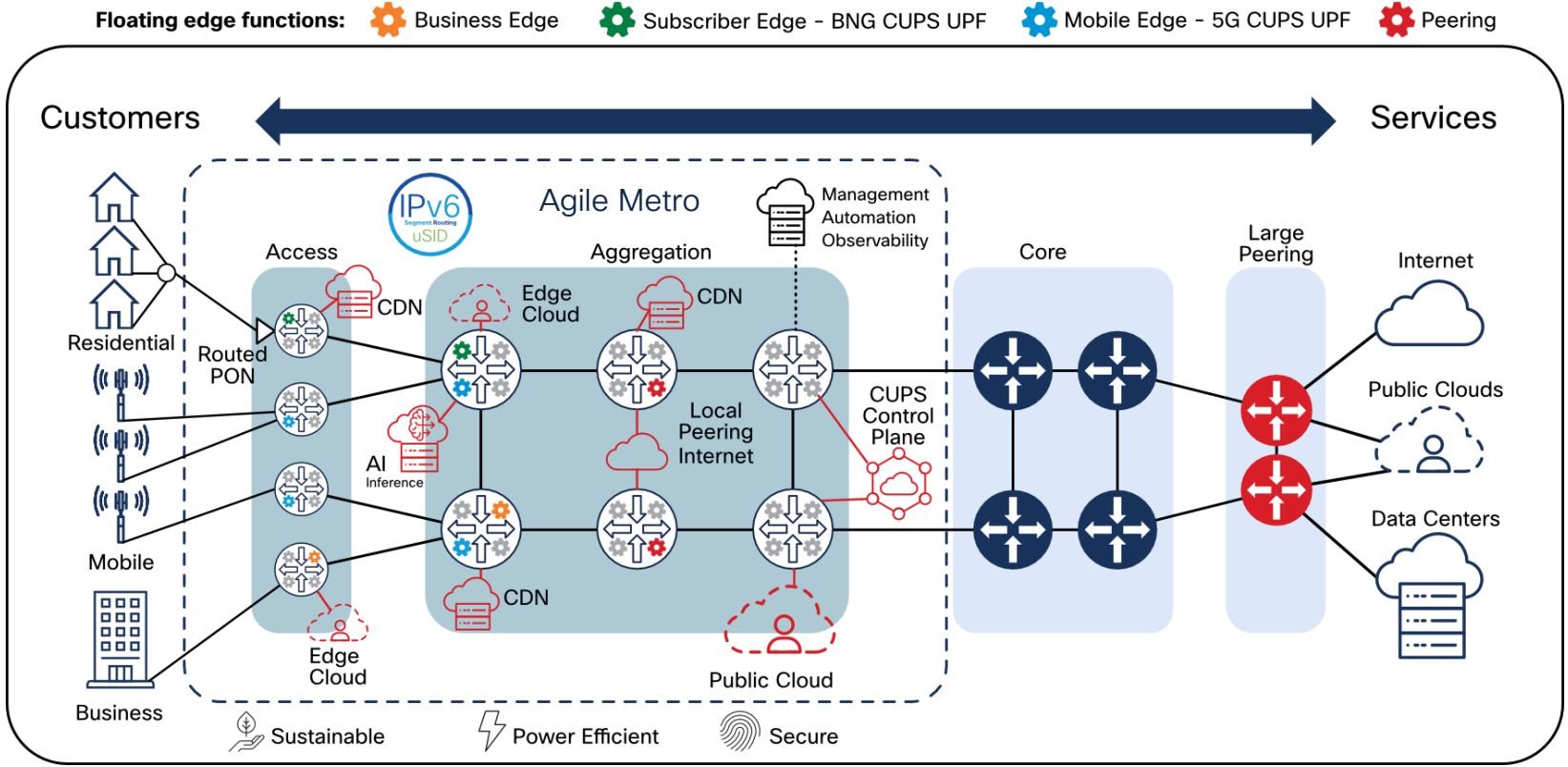
# Agile Networking Fabric – Basic features

Baseline necessities for most network operators must be included

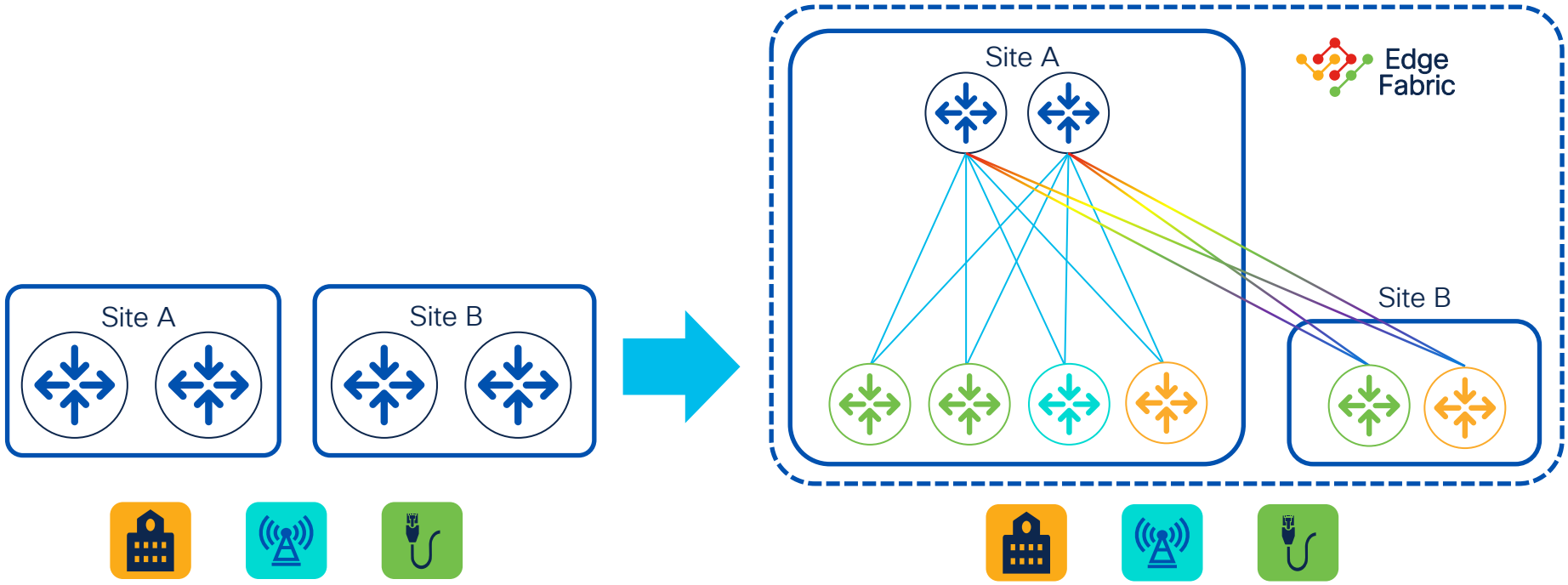
- Topology independence with any-to-any connectivity
- Simplified control and forwarding plane
- Simplified services control plane
- Any service at any place in the network
- End-to-end network timing
- Service level assurance
- Device level automation
- Device and distributed network **visibility**
- Device and distributed network **security**

# Cisco's Vision – Evolving Metro networks

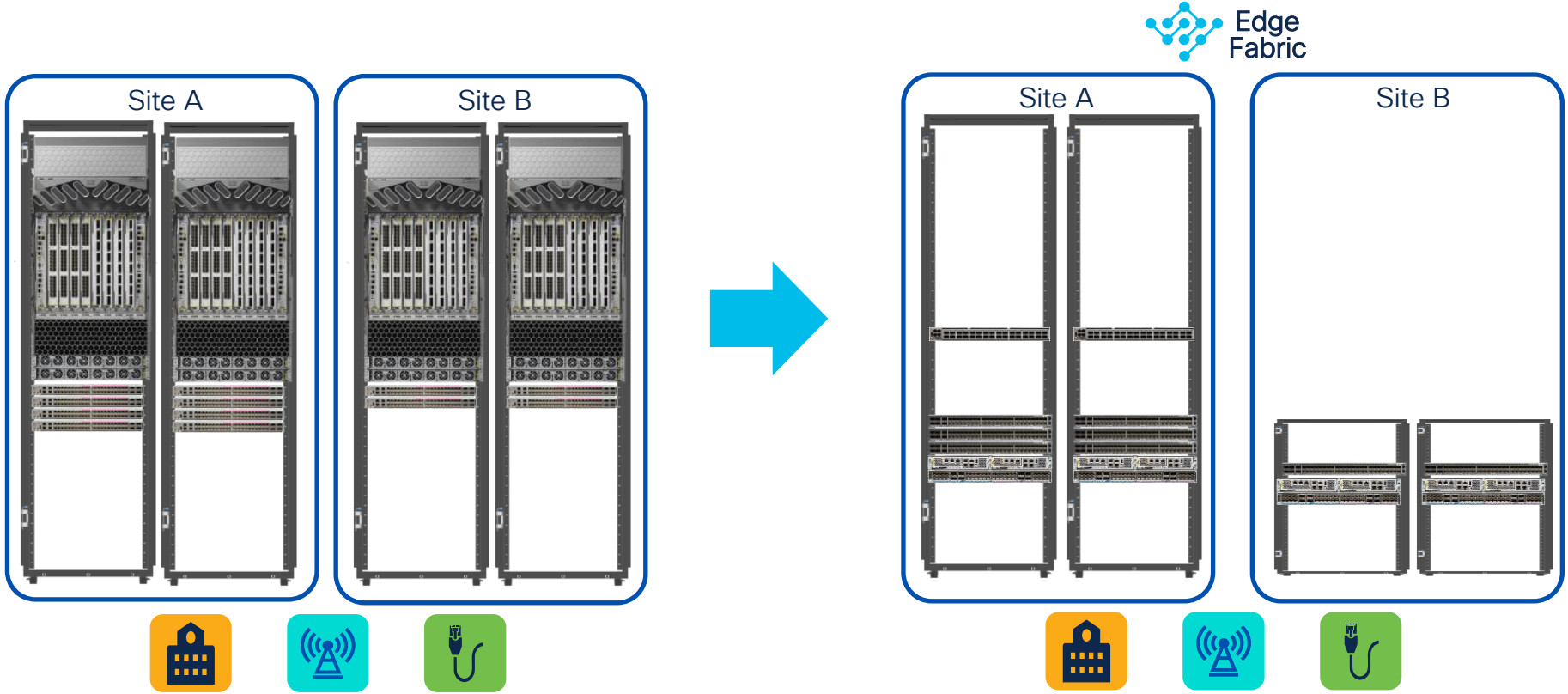
## Fully converged, distributed network architecture



# Agile Metro network use case – Edge Fabric



# Network Use Case – Agile Metro Edge Fabric

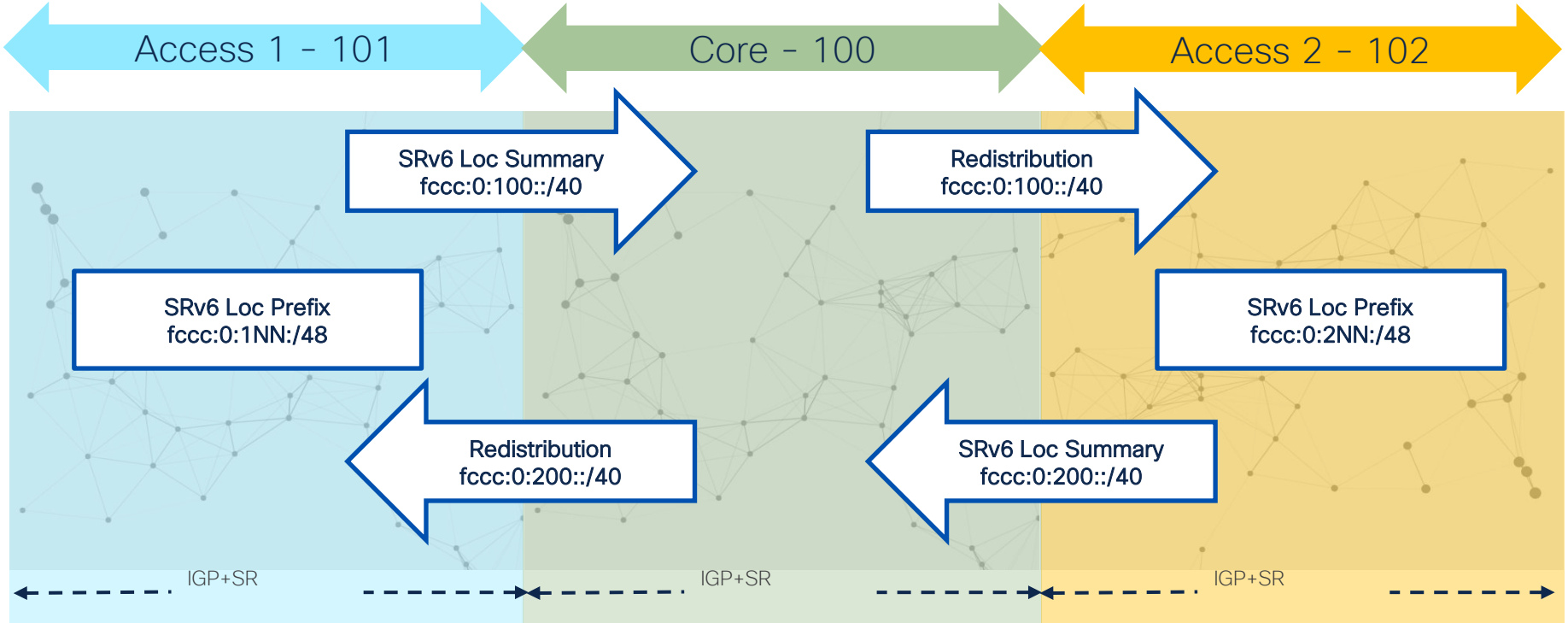


# Network Fabric Underlay – SRv6 uSID

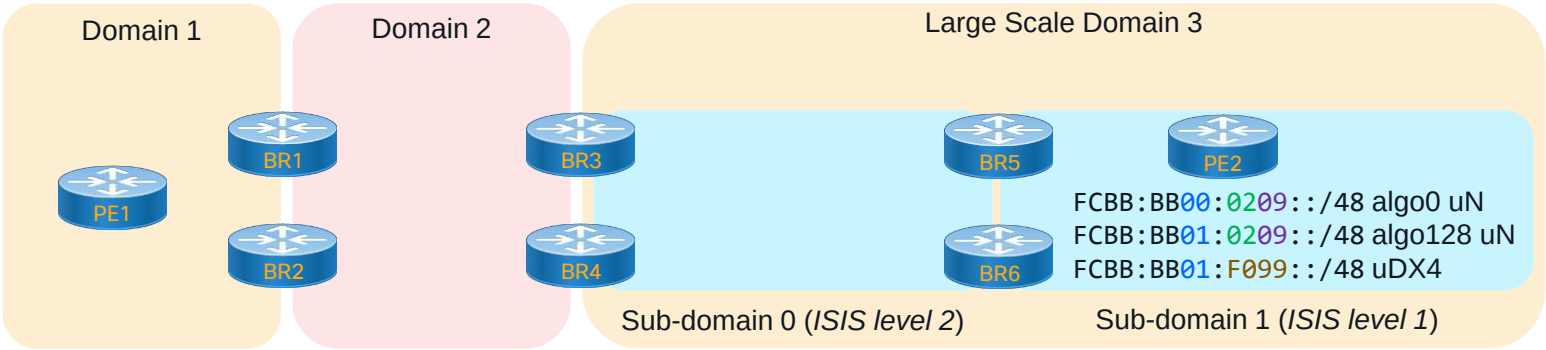
Segment Routing IPv6 makes networking simpler. It's just IP routing!


- Maximum scale
- Simple and efficient
- Services rich
- Operational simplicity
- Seamless deployment

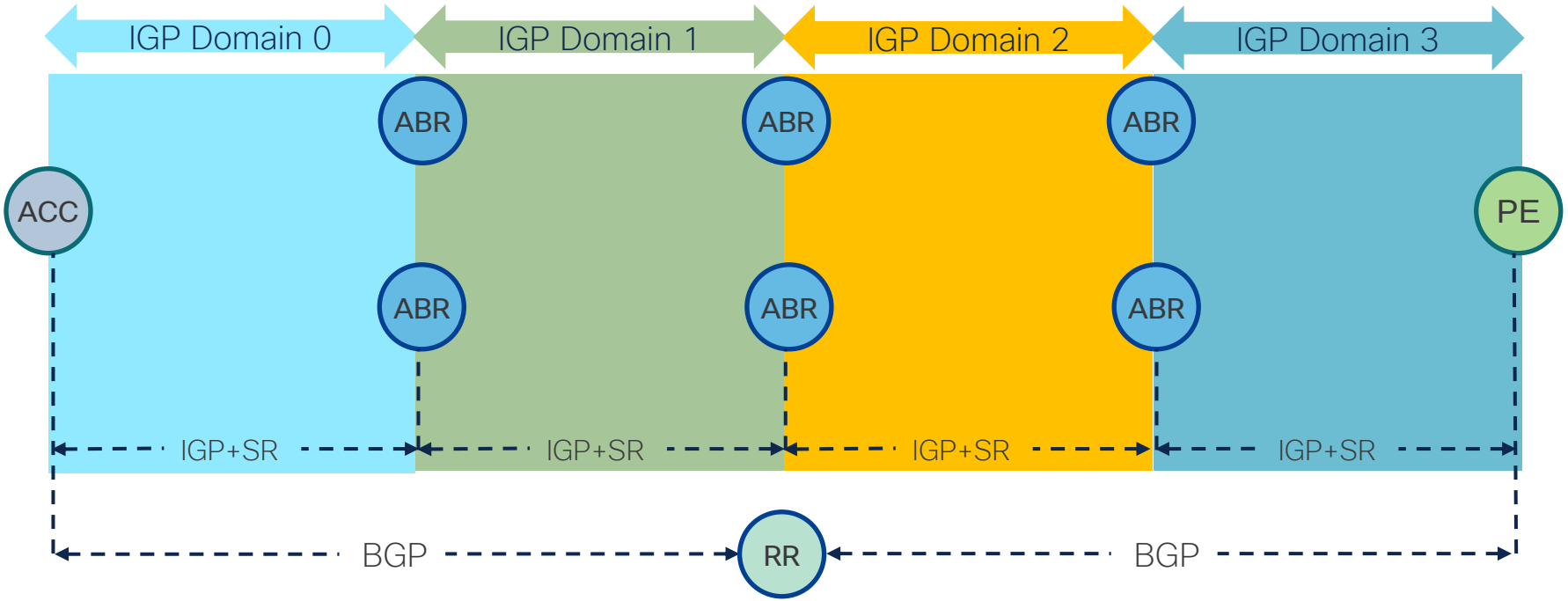
# SRv6 scaling using uSID



# SRv6 multi-domain summarization with Flex Algo

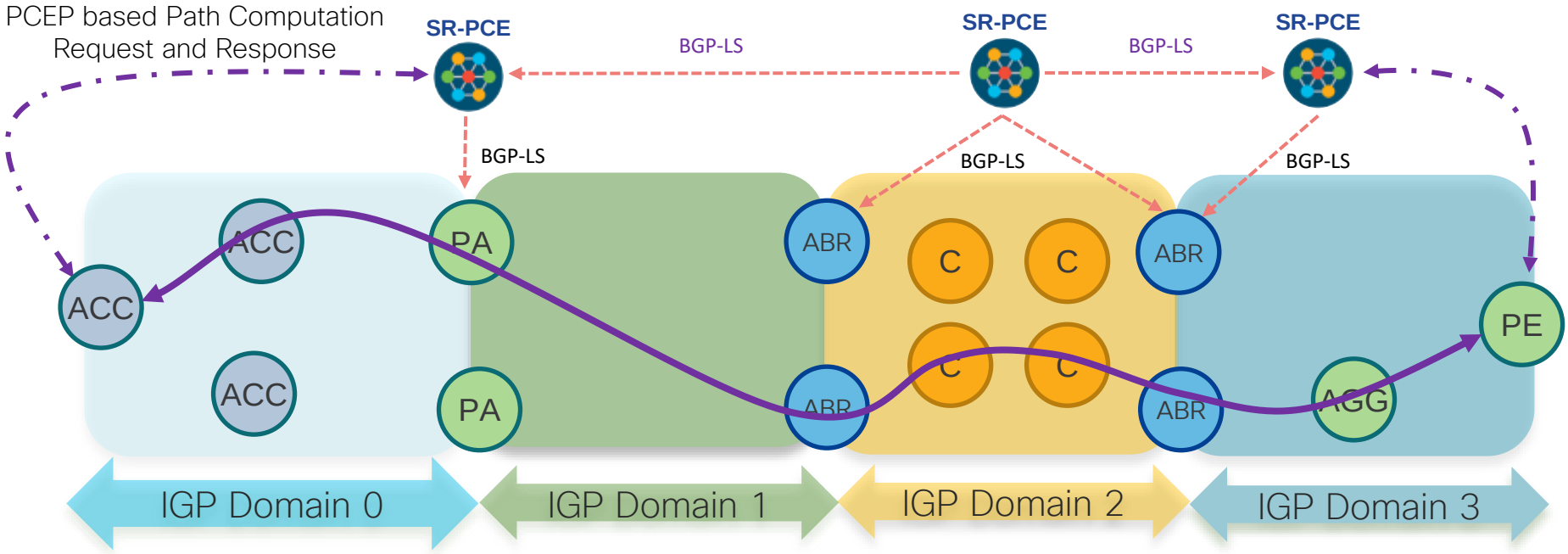


# Large scale segmented networks



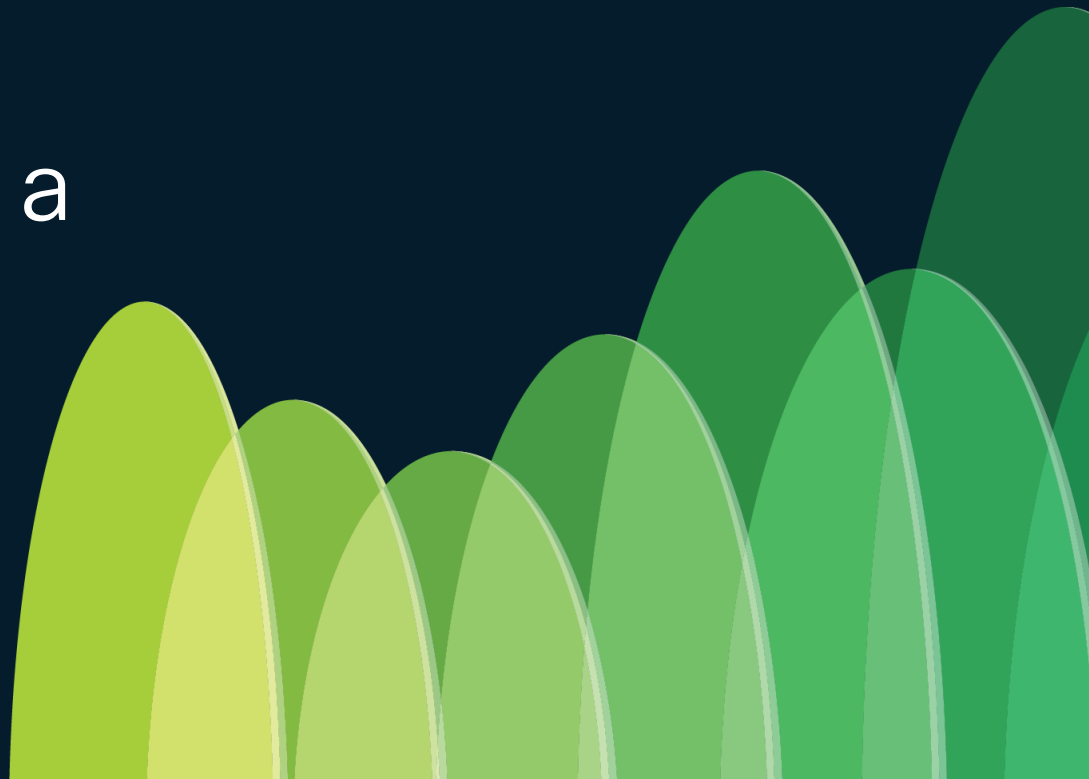

- BGP runs on endpoint service nodes only
- Interior ABRs and nodes in each domain are BGP free

# Controller Based Architecture for Advanced TE




- End to End SLAs maintained
- Support advanced TE use cases

# How do I deploy a network fabric?



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# Network fabric definition

- Fabrics are meant to be declarative in nature and based on a network design model
- Automation can help with defining how the fabric is built and how nodes are interconnected
- Service endpoints should be part of the overall network model

# Network fabric device roles

- Most devices in a network share a common purpose
  - Core, Service PE, Peering
- Have a common set of deployment guidelines for each role
- Device roles and grouping are not new
  - Leverage them to enact change
  - Heuristics can drive automated device role mapping
- The current state of a role is intent based
  - ”All peering routers must have this ACL, or this SW version”

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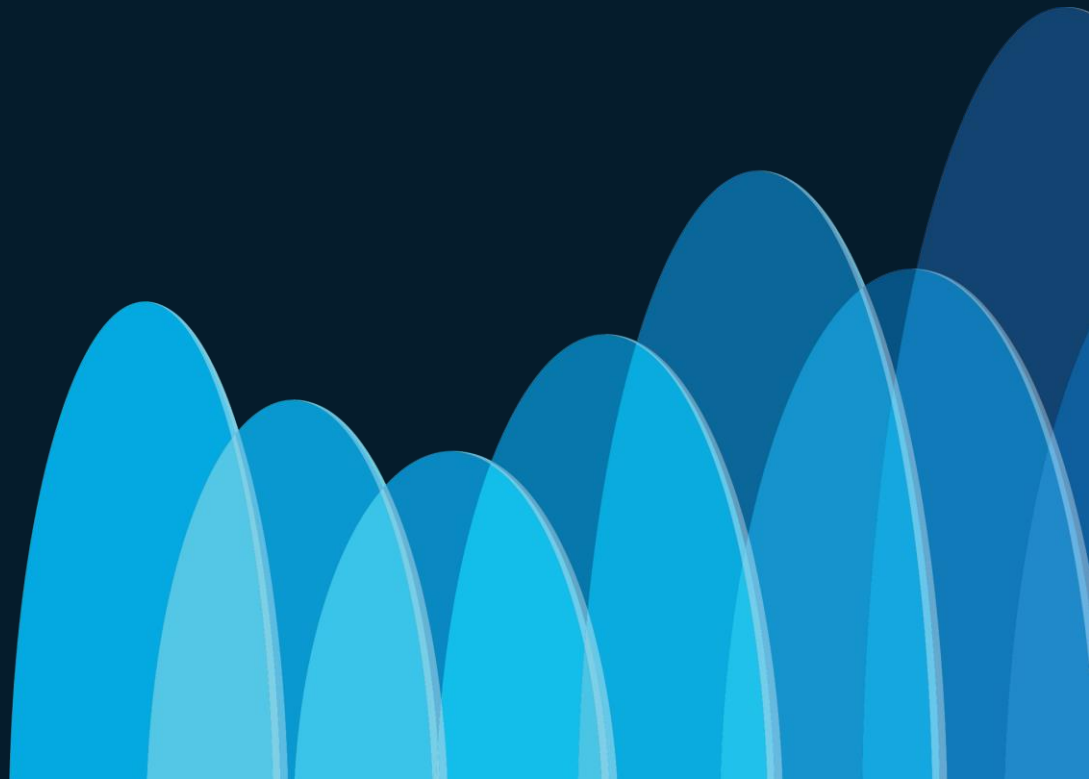
# Automated deployment

- ZTP can help play a critical role in minimizing configuration errors and consistency across the fabric
- ZTP has been widely used in higher volume networks and datacenter, extend that to the rest of the network
- Device key may be the management MAC, serial number which is used as a database lookup for the device role containing other properties
- Interconnects and other intent driven properties can be dynamically created in the model during onboarding

# Example: Fabric and Role Definition

```
fabrics fabric-id fab1
 fabric-description "Example Fabric"
 fabric-tags        "cisco"
 fabric-template-id fab1-base-template
 device-role device-role-name xr-leaf-l2vpn device-model N540-24Z8Q2C-M
  topology-role     leaf
  role-templates role-template-id leaf-l2vpn-bgp-1
   role-template-variables name BGP_ASN
   !
   role-template-variables name BGP_ROUTER_ID
   !
  !
  role-templates role-template-id leaf-l2vpn-isis-v1
   role-template-variables name BGP_LS_INSTANCE_ID
   !
   role-template-variables name ISIS_NET
   !
   role-template-variables name SR_SID_INDEX_ALGO_0
   !
   role-template-variables name SR_SID_ABS_ALGO_128
   !
  !
  interface-template interface-template-id fab1-interface-template
  interface-template interface-template-variables name MTU
  !
  interface-template interface-template-variables name PTP_PROFILE
  target-os-version 7.11.2
 !
!
```

# How do I manage a network fabric



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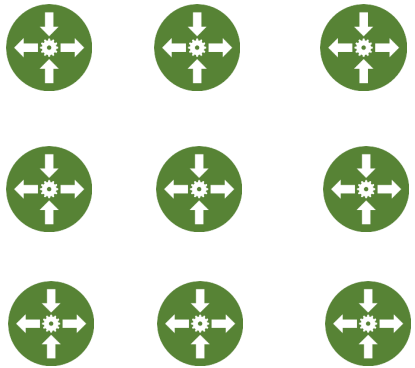
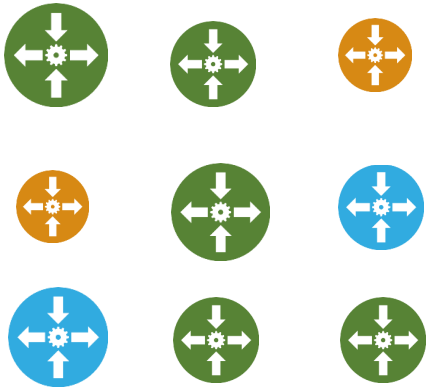
# Are networks homogenous? Not typically



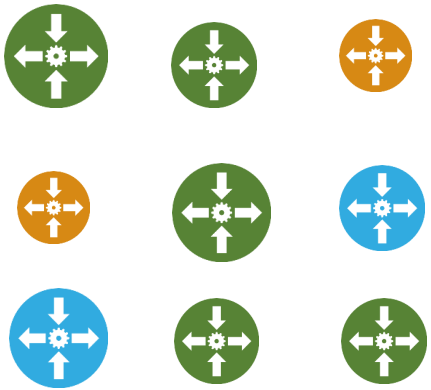
Ideal



Reality

Multi-vendor is the norm in most service provider networks

# Are networks homogenous?  Not typically

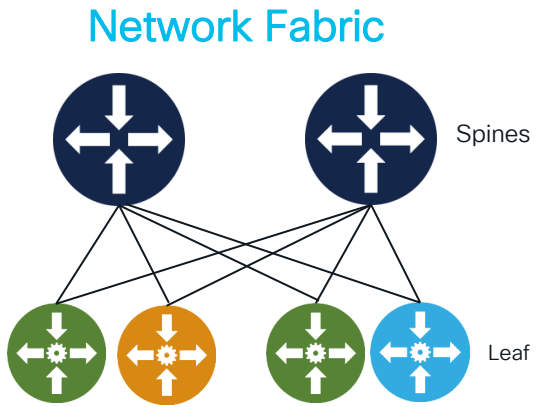


Question:  How do we manage homogenous networks?
Answer:  Standard device and controller models, standard open APIs

# Network Fabric Management

## How can we better automate a network fabric?

- Treat the network fabric as a single collection of nodes with reduced management points
- Examples:  Aggregation of alarms, balancing of services across multiple nodes without user interaction, automated insertion/onboarding of nodes into the fabric



# Edge and network fabric management

| | |
|---|---|
| Fabric Definition | Fabric attributes, device roles, config templates |
| Fabric and Device Commissioning | ZTP and manual device onboarding, new leaf discovery |
| Operations | Software lifecycle management, fabric health and performance, aggregated fault/alarm data, inventory |
| Advanced | Intelligent service placement, service level end to end visibility, coordinated maintenance |

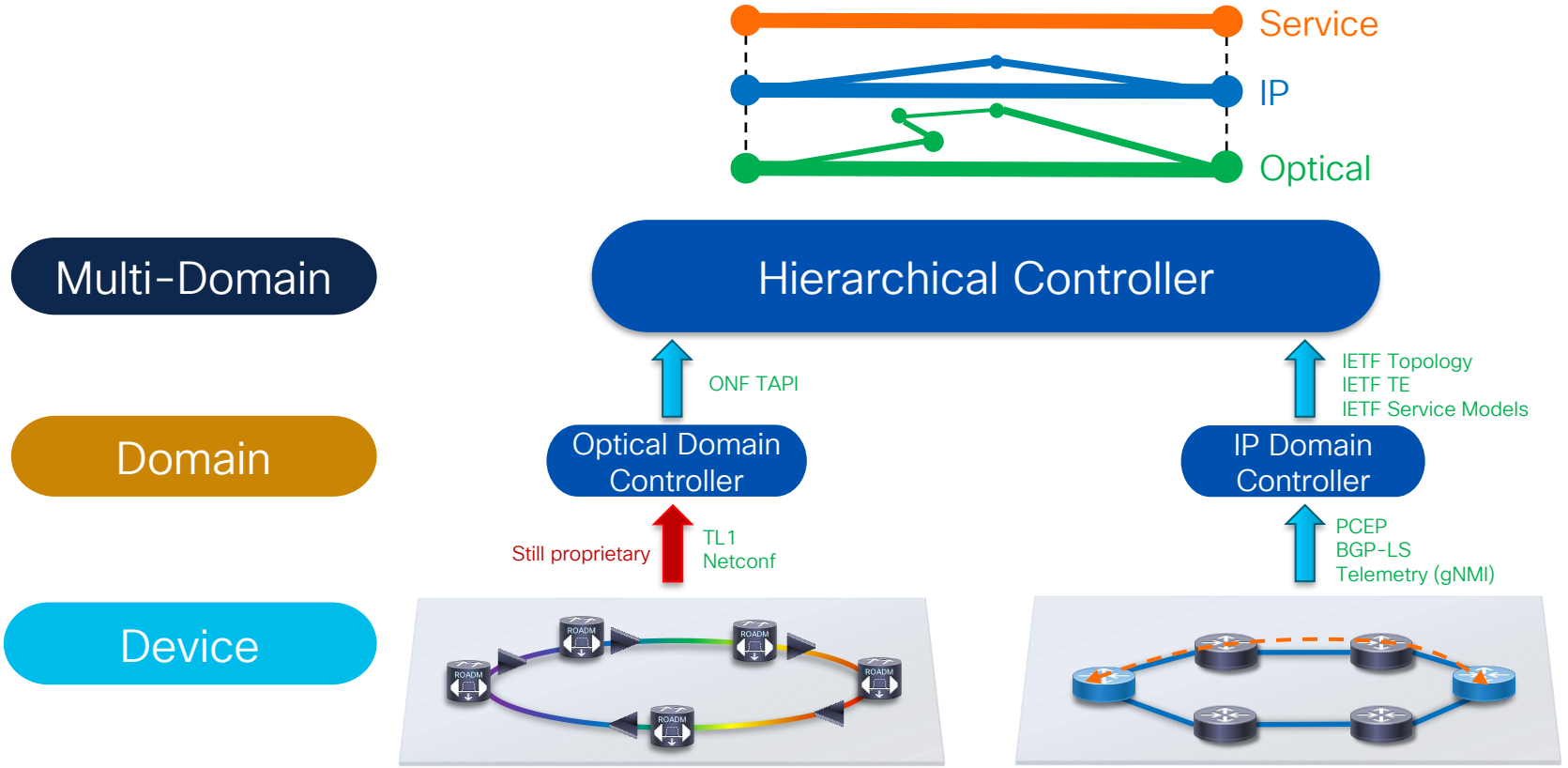
# Standardized models for open management

- OpenConfig has become the de facto standard for device-level management.  IETF device models are not widely used outside ietf-interfaces
- Models controllers use for exposing northbound data are primarily IETF models
- Models used for service provisioning are IETF (L2NM, L3NM, etc.)
- SNMP MIBs can be thought of as a model and many networks still rely on standard MIBs

# Standard model examples

- openconfig-platform for inventory data
- openconfig-interfaces for interface configuration and telemetry
- IETF L2NM for L2VPN service provisioning between upper layer management system and downstream network controller

# Model driven management



# Standardized RPCs for device and OS management

- NETCONF is still the most widely supported API driven method for device management
- There is a lot of work going on in the IETF currently around network management and operations
- NMOP working group covers many areas network management and operations
- Renewed interest in IETF on Network Management with IAB NEMOPS (Next Era of Network Management Operations) workshop and followups
- As an operator get involved ☺

# Standardized RPCs for device and OS management

- OpenConfig has introduced a number of device-level RPCs based on gRPC
- gNMI is well known and is used for device configuration and telemetry
- gNOI (gRPC Network Operations Interface) is used to perform different device and OS management functions
  - Reboot, manage files, install certificates
- gNSI (gRPC Network Security Interface) is used to perform device security functions

# Infrastructure and service assurance

**Infrastructure assurance** – Monitors the underlay network performance and availability

- Hop by hop loss, latency, jitter
- Performance data and impact
- Next-hop forwarding validation

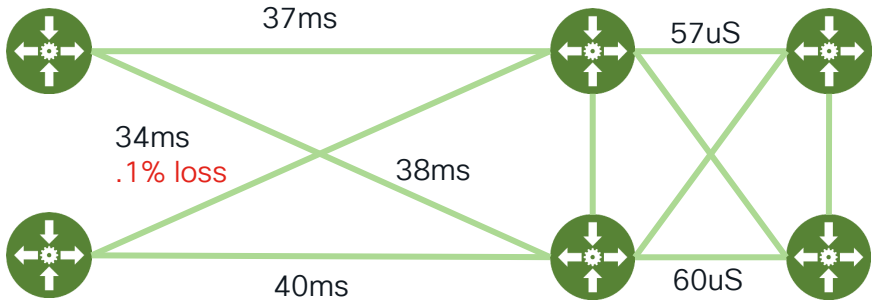
**Service assurance** – Monitors the service layer performance

- End to end liveness
- End to end loss, latency, jitter

- **Correlation between the two is key in overall network assurance**

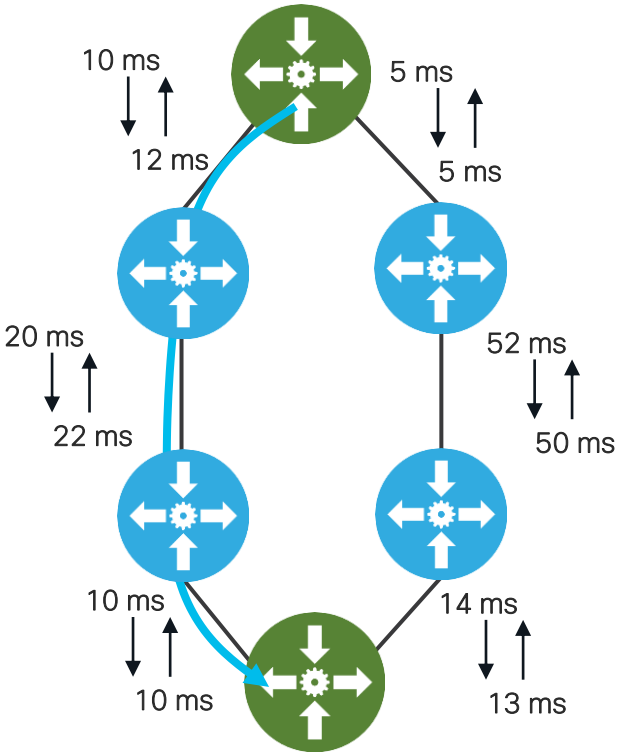
# The fabric is a great source of assurance data

- Latency
- Loss
- Traffic statistics (matrix and per-interface)

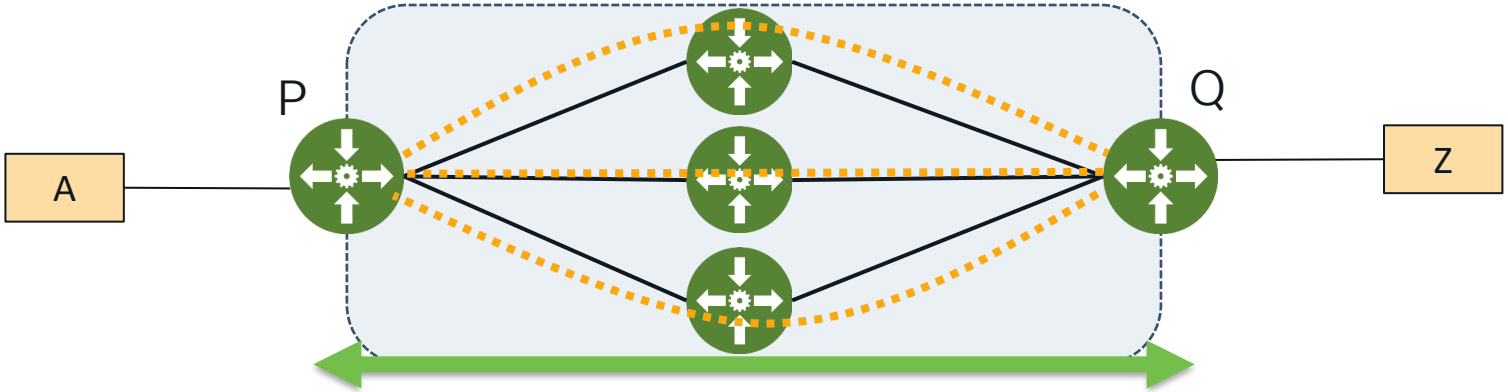


# Segment Routing Performance Measurement

- Dynamic measurement of latency, loss, and liveness
- Built into IOS-XR
- Standards-based probes (STAMP)
- Flexible endpoints
  - Link, IP endpoints, SR-TE Policy, external sensors supporting STAMP / loopback

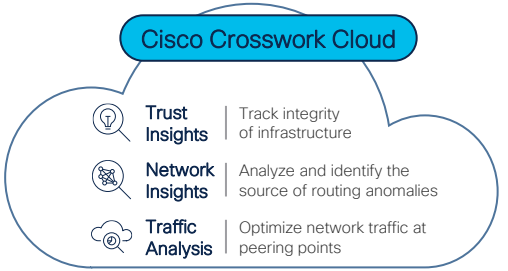


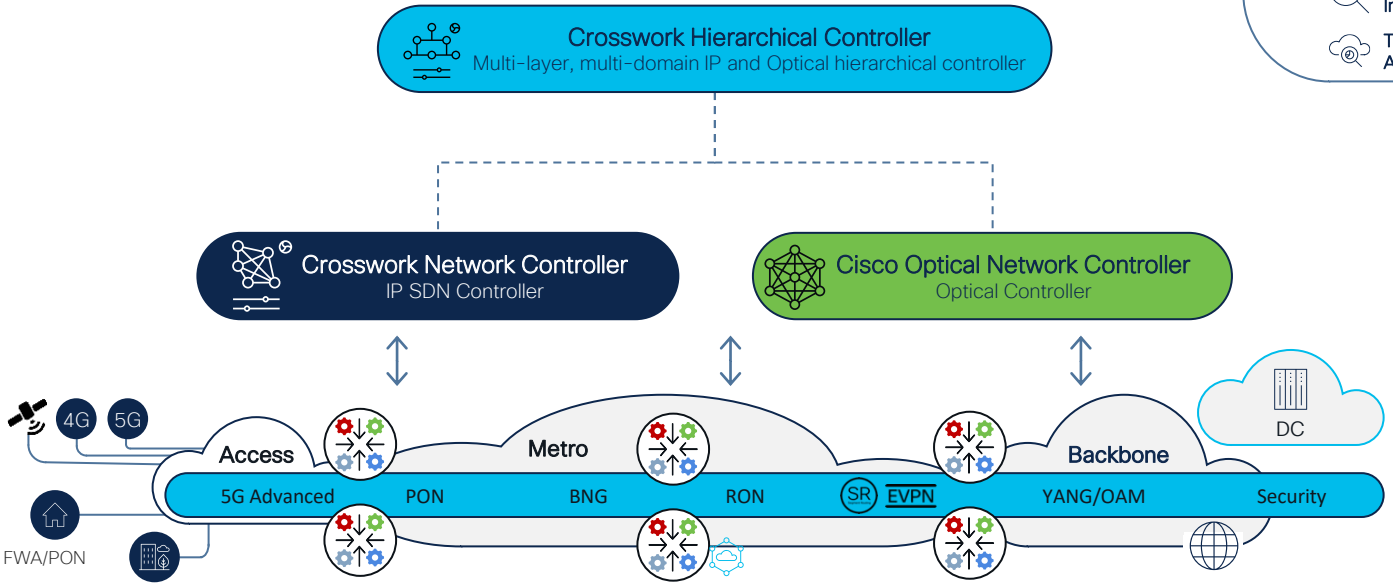
# Integrated Performance Measurement
## SLA Measurement from Any Edge to Any Edge, across ECMP

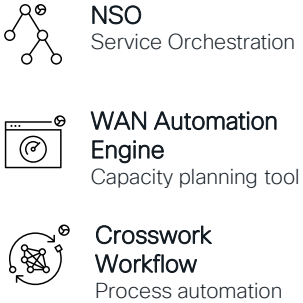



- Active probing from any P to any Q via, any ECMP path
- Continuous forwarding path monitoring
- Analytics
  - Correlation of probe measurement and routing data

# Controller Based Automation

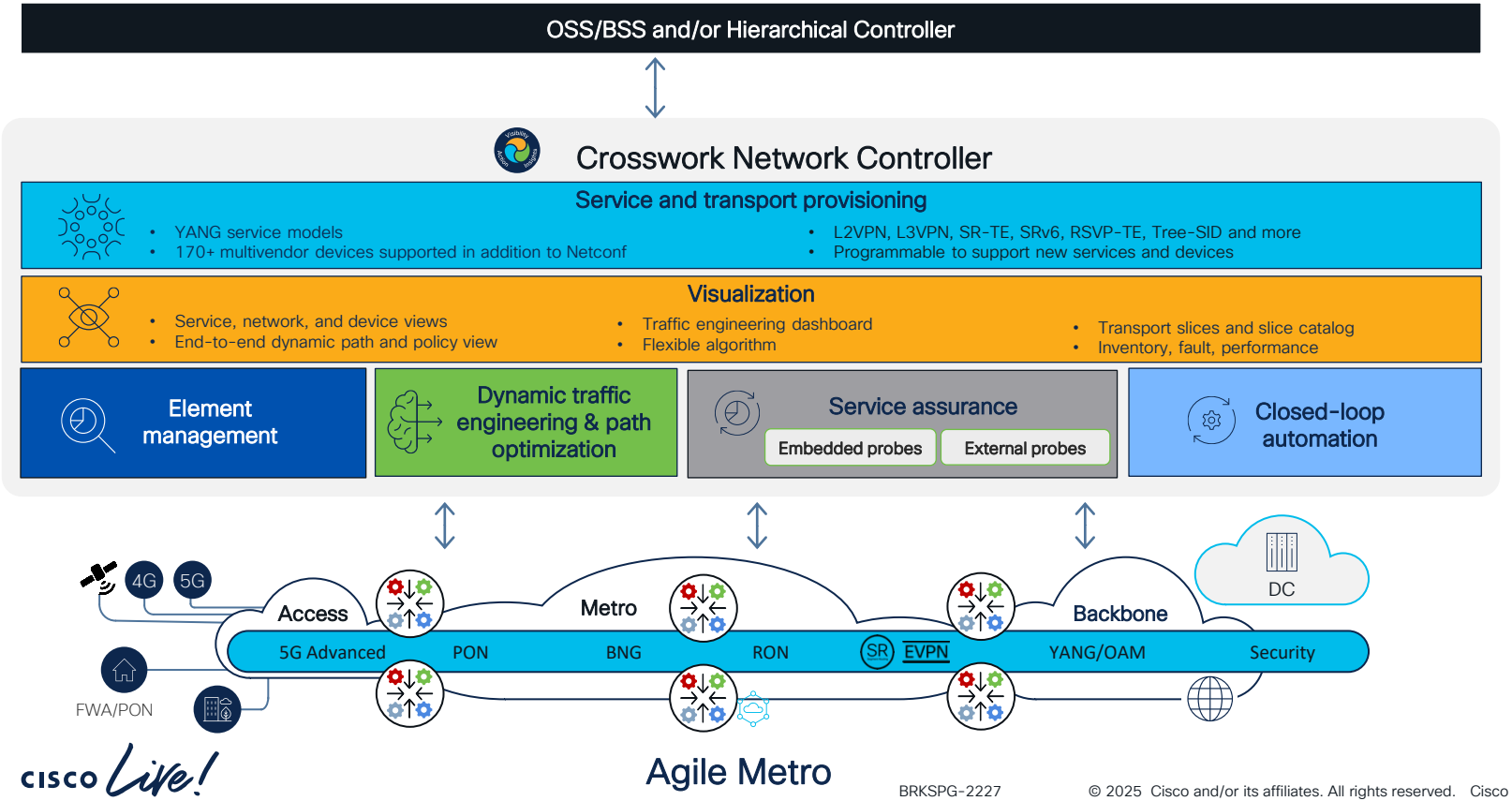



Follows principles of RFC 8453/ACTN Framework
Endorsed by major Service Provider

# CNC: Service and device management for network fabrics




Agile Metro

# End-to-end multi-layer Automation

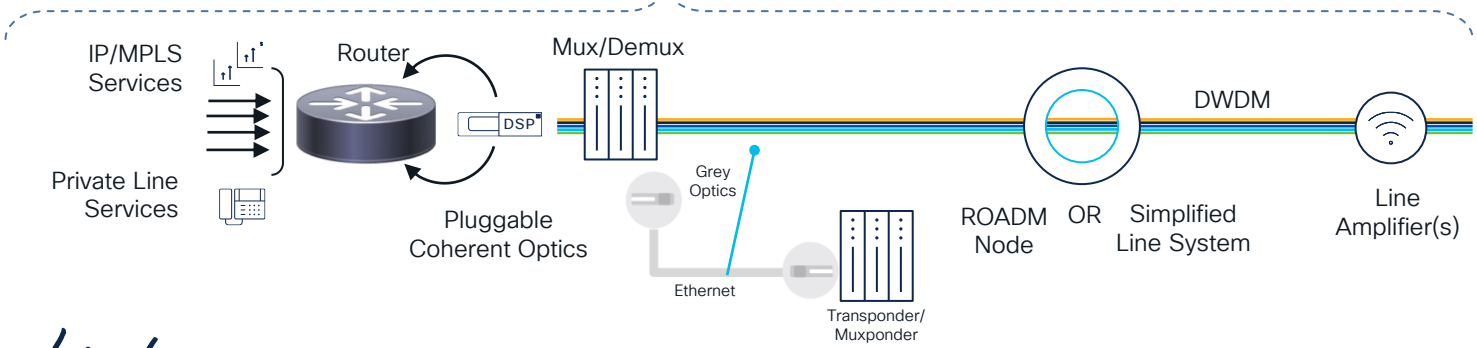
## Comprehensive integrated multi-layer controller (HCO-CNC-ONC) solution

Integrated IP and Optical Services Orchestration

and

Lifecycle Management

| | | |
|---|---|---|
| Automation Layer | | Hierarchical Controller (Sedona NetFusion)<br>Unified IP and Optical Network Controller (Crosswork + Sedona) |
| Service Layer | EVPN | Ultra scalable services (BGP-based)<br>EVPN VPWS for private line emulation |
| Transport Layer | SR Segment Routing | Sub-50ms failover for node, link or SRLG<br>Traffic-Engineering at mass scale, including circuit-style performance monitoring (delay, loss, liveness) |
| Photonic Layer | DSP | Simple point-to-point photonic path engineering |

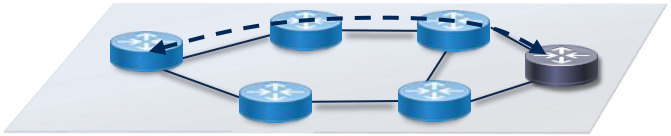


# End to end network fabric assurance

Combining data and analytics from every layer of the network for enhanced end to end assurance

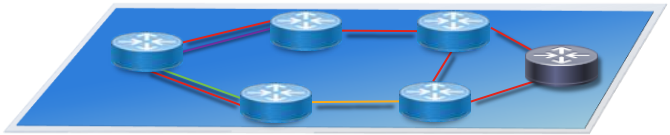

Service Layer Network

Cisco/Provider Connectivity Assurance Sensors
SR and IP Performance Measurement



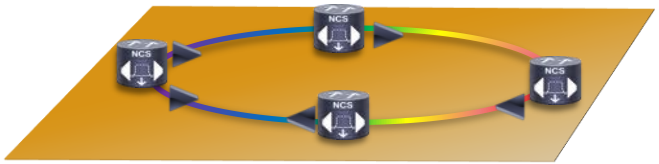
Segment Routing Underlay Network

Cisco Provider Connectivity Assurance
SR and IP Performance Measurement
SRv6 Integrated Performance Measurement



Routed Optical Networking Layer

Cisco Network Controller
Crosswork Hierarchical Controller




Optical Layer

Cisco Optical Network Controller
Crosswork Hierarchical Controller

# Conclusions and Resources

# Additional information

- Cisco Agile Services Networking - https://www.cisco.com/site/us/en/solutions/service-provider/networking/agile-services/index.html
- Cisco Validated - https://www.cisco.com/c/en/us/solutions/design-zone/service-provider.html
- XRDocs design - https://xrdocs.io/design

# Webex App

## Questions?

Use the Webex app to chat with the speaker after the session

## How

1. Find this session in the Cisco Events mobile app
2. Click “Join the Discussion”
3. Install the Webex app or go directly to the Webex space
4. Enter messages/questions in the Webex space

## Webex spaces will be moderated by the speaker until February 28, 2025.

# Fill Out Your Session Surveys


Participants who fill out a minimum of 4 session surveys and the overall event survey will get a unique Cisco Live t-shirt.

(from 11:30 on Thursday, while supplies last)

All surveys can be taken in the Cisco Events mobile app or by logging in to the Session Catalog and clicking the ‘Participant Dashboard’

Content Catalog

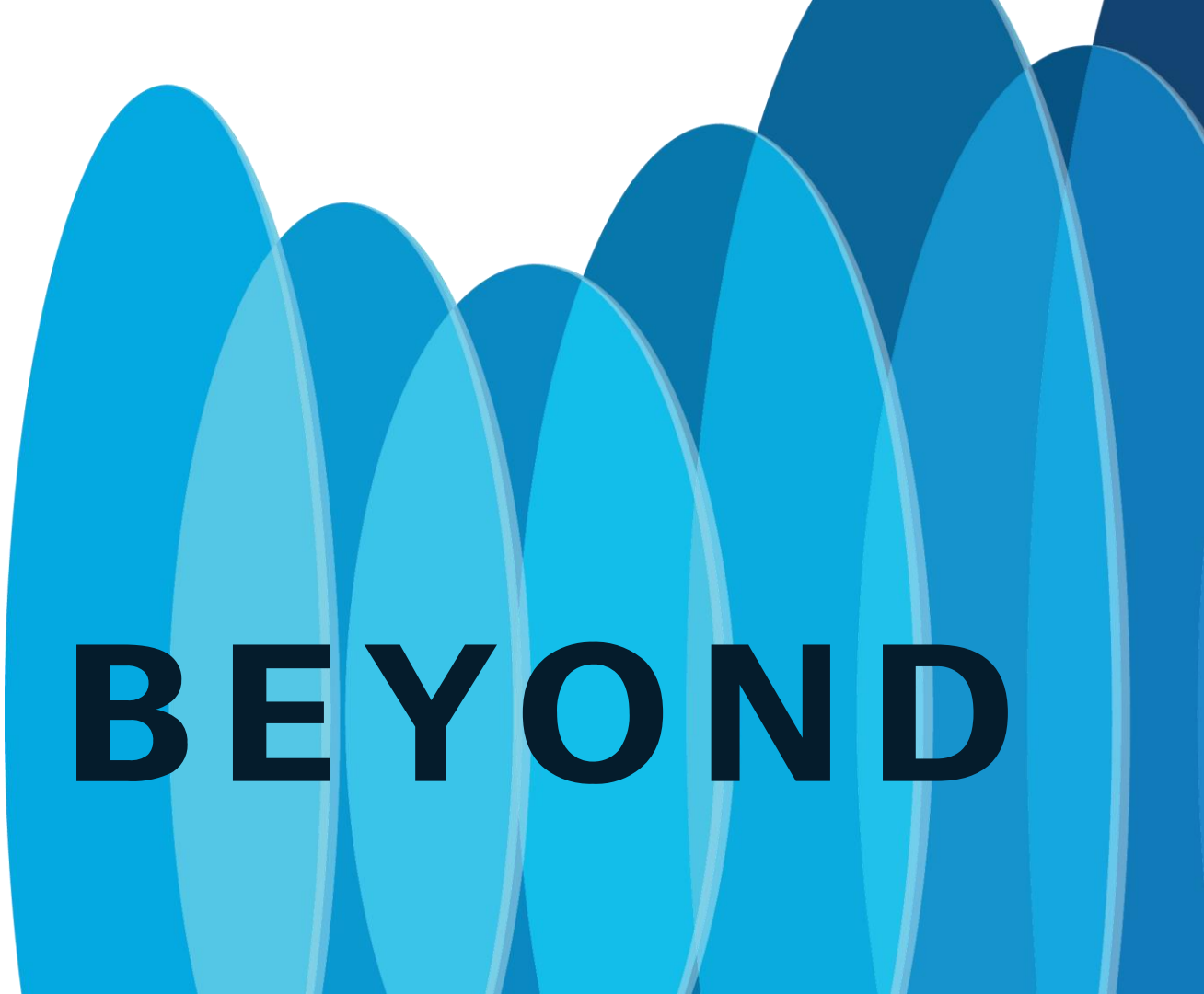
# Continue your education

- Visit the Cisco Showcase for related demos
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at ciscolive.com/on-demand. Sessions from this event will be available from March 3.

# Thank you

cisco Live!

cisco Live!



# GO BEYOND