FUTUREWEI
Technologies

SRv6 Deployment Strategies

Mike McBride

IETF SRv6OPS WG

Operational aspects of deploying and managing SRv6 networks. Mission includes:

Being a forum for network operators to discuss operational matters in SRv6 networks.

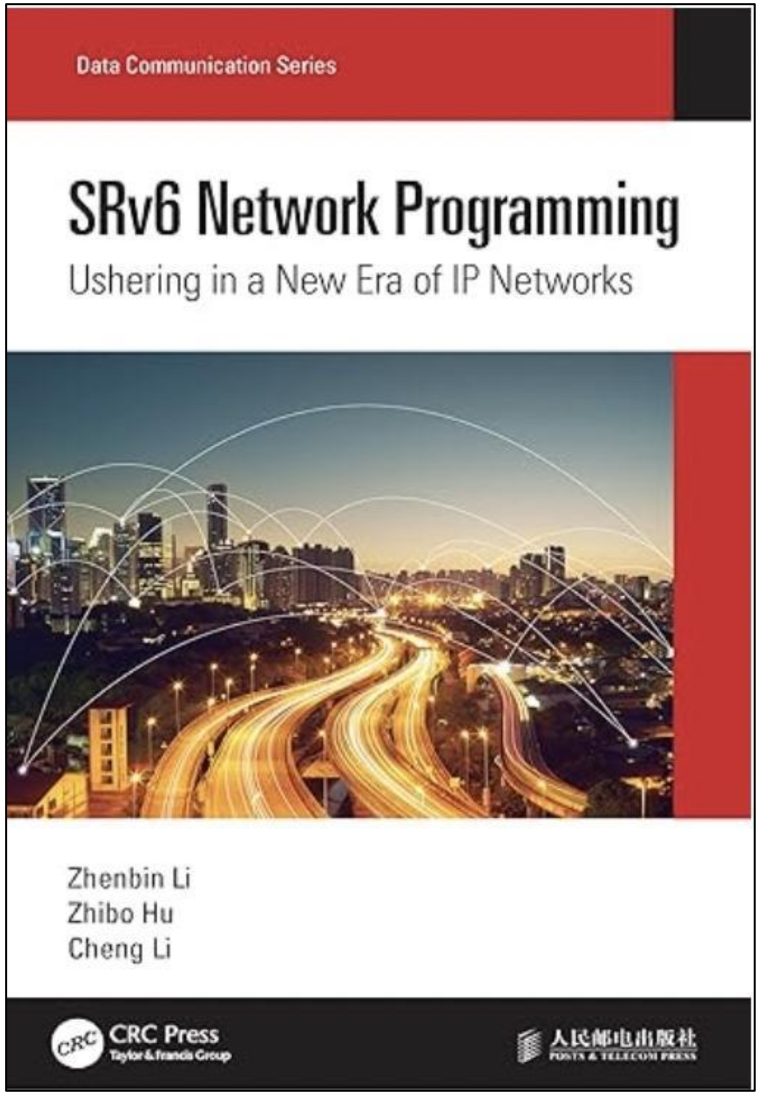
Identifying and addressing operational challenges encountered during SRv6 deployments. Additionally, developing operational guidelines to ensure secure, reliable, efficient, and scalable SRv6 network operations.

draft-liu-srv6ops-problem-summary
SRv6 Deployment and Operation Problem Summary

draft-mcbride-srv6ops-srv6-deployment
SRv6 Deployment Options

draft-liu-srv6ops-sid-address-assignment
IPv6 Address Assignment for SRv6

SRv6 Deployment Resources



Data Communication Series

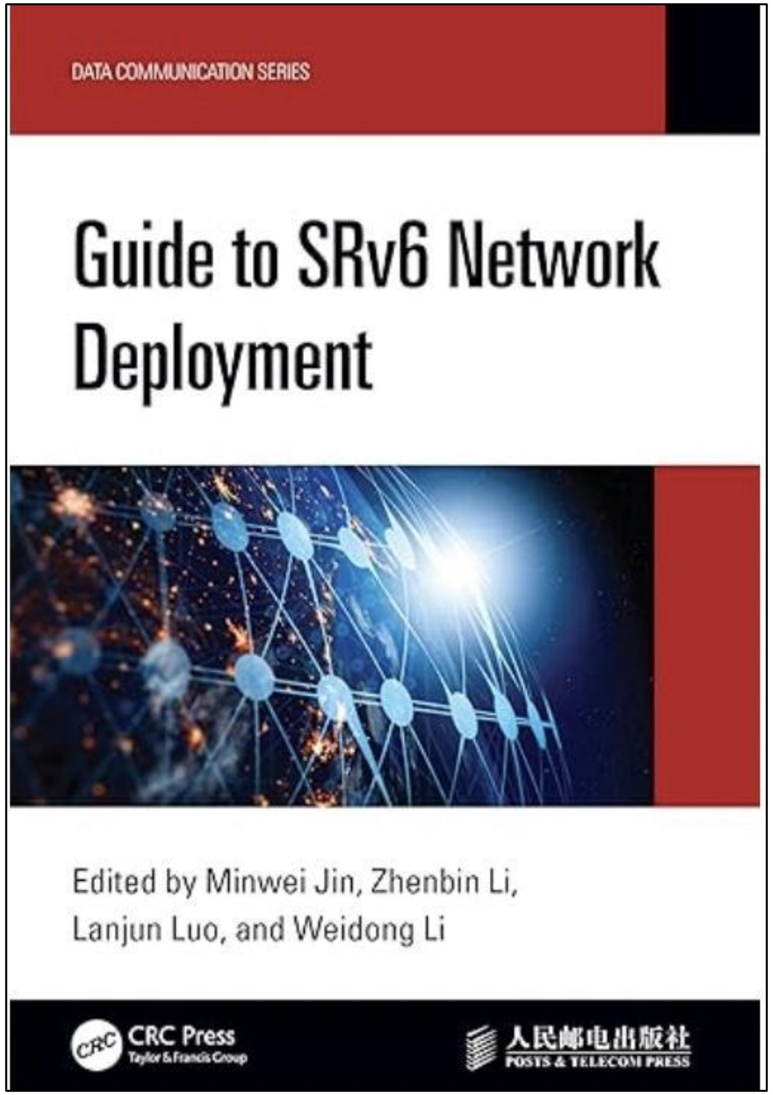
SRv6 Network Programming

Ushering in a New Era of IP Networks

Zhenbin Li
Zhibo Hu
Cheng Li

CRC Press
Taylor & Francis Group

人民邮电出版社
POSTS & TELECOM PRESS



DATA COMMUNICATION SERIES

Guide to SRv6 Network Deployment

Edited by Minwei Jin, Zhenbin Li,
Lanjun Luo, and Weidong Li

CRC Press
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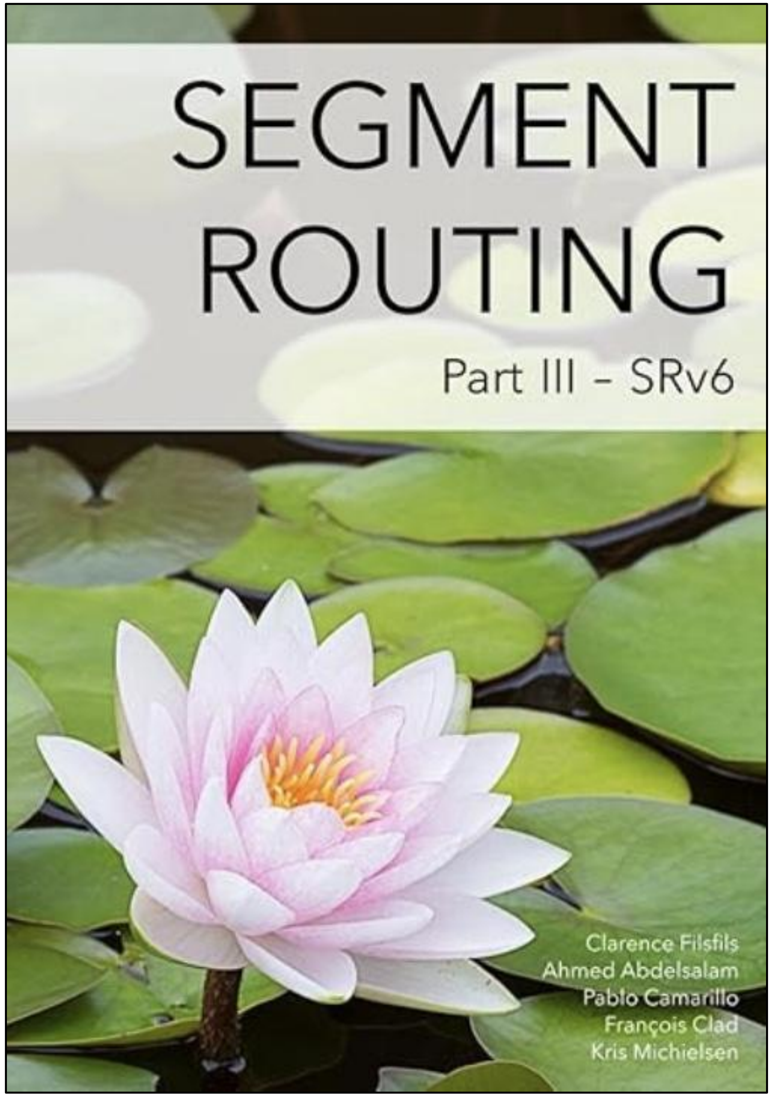


SEGMENT ROUTING

Part III – SRv6

Clarence Filsfils
Ahmed Abdelsalam
Pablo Camarillo
François Clad
Kris Michielsen

IP Network Protocol Evolution

	IP	MPLS	Segment Routing (SR)
	Reachability	Connectivity & Services	Simplification & Programming
	1980~	*1997~Now*	*2015~Future*
Service	Internet	VoIP, IPTV, VPN	Cloud, 4K, 5G, IoT
Management	Command line	CLI & NMS	SDN, Telemetry
Protocol	IPv4	MPLS, LDP/RSVP-TE VLL, VPLS, L3VPN	IPv6, SR/SRv6, EVPN
	Best-effort	Peer-to-peer	Global Optimal Path

What is Segment Routing?

SR is a source-based routing technology that simplifies traffic engineering by encoding the path directly into the packet header. How It Works:

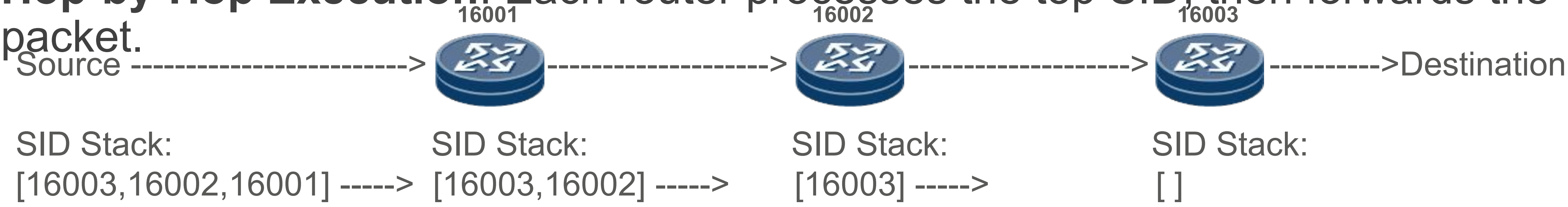
Segments: Path is divided into segments (instructions like nodes/links/services).

Segment IDs (SIDs): Each segment has a unique identifier:

1. **Node SID**: Forward to a specific router.
2. **Adjacency SID**: Use a specific link.
3. **Service SID**: Apply a service (e.g., firewall, NAT).

Source Routing: Ingress node pushes an ordered list of SIDs into the packet header.

Hop-by-Hop Execution: Each router processes the top SID, then forwards the packet.



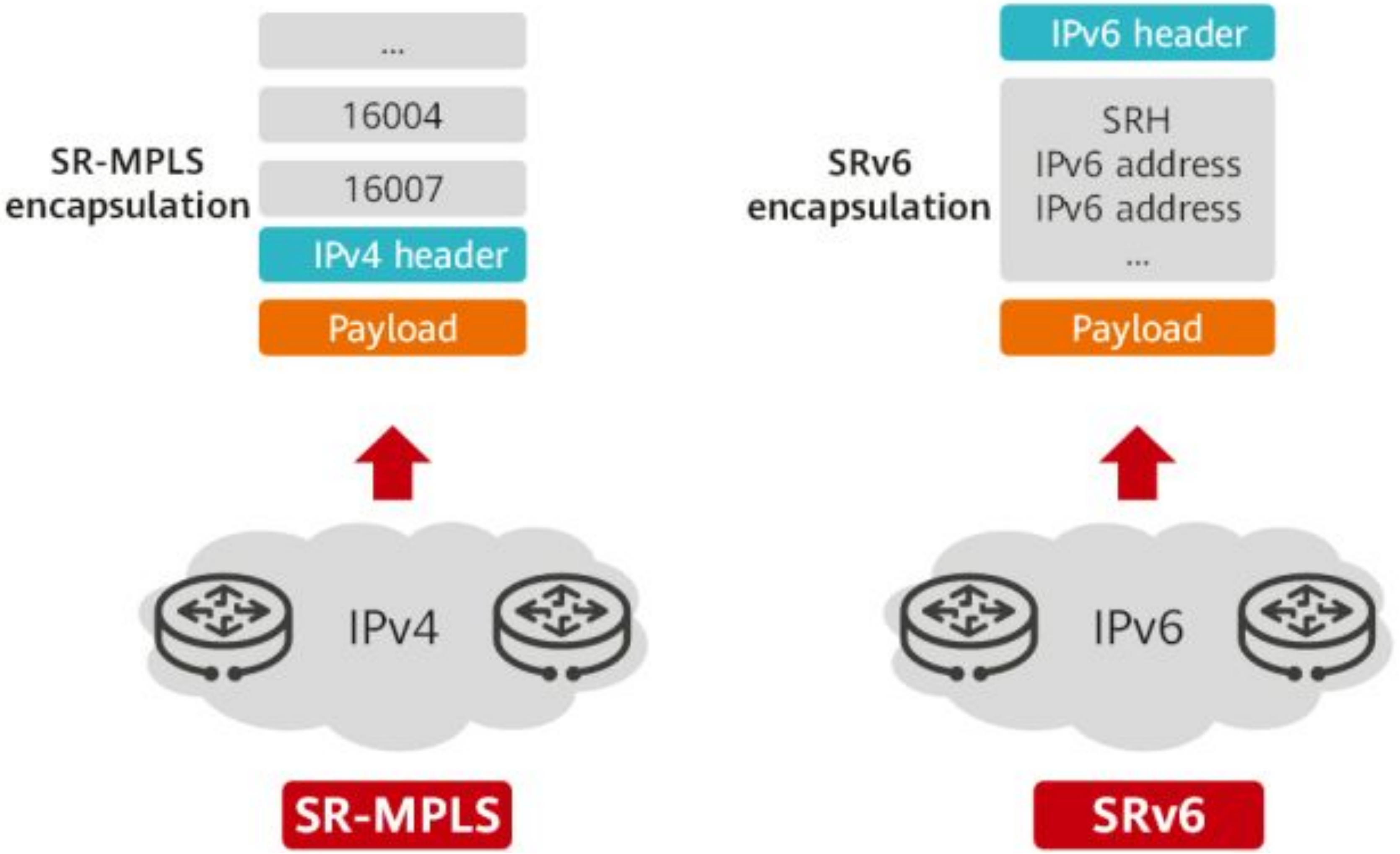
SID Stack:
[16003,16002,16001] ----->

SID Stack:
[16003,16002] ----->

SID Stack:
[16003] ----->

SID Stack:
[ ]

SR Data Planes



SR-MPLS encapsulation

...

16004

16007

IPv4 header

Payload

IPv4

SR-MPLS

SRv6 encapsulation

IPv6 header

SRH
IPv6 address
IPv6 address
...

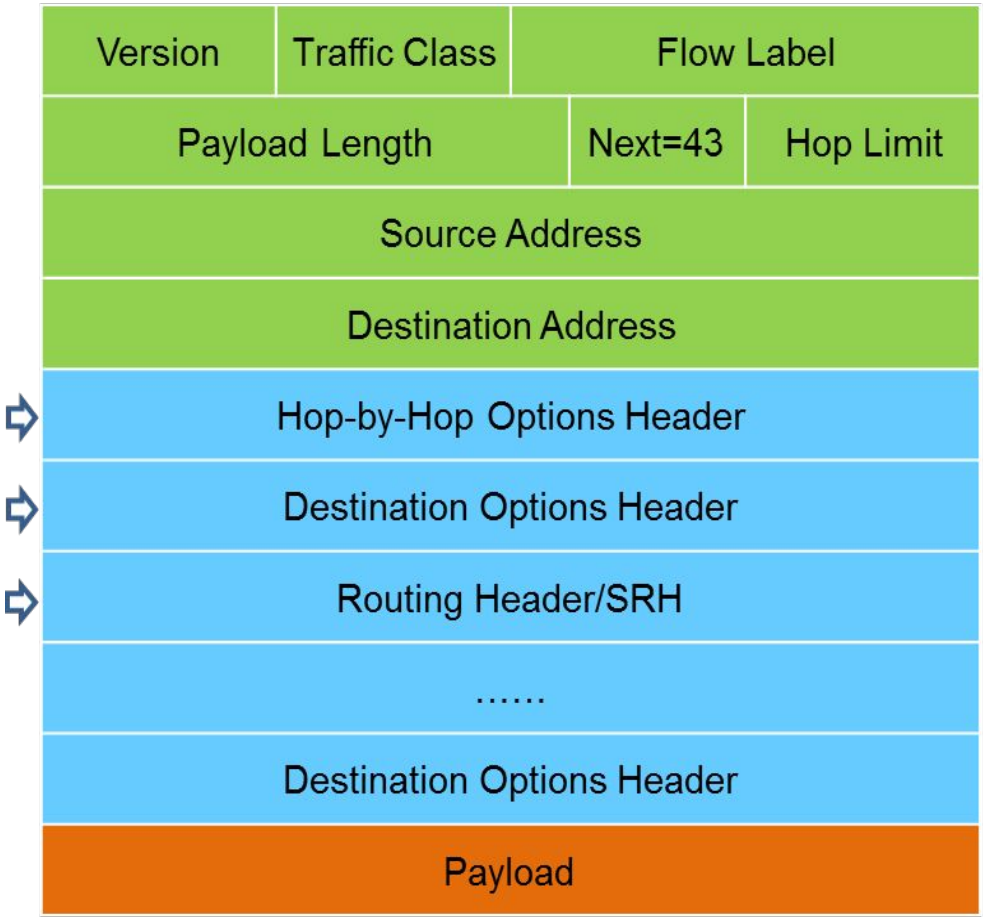
Payload

IPv6

SRv6

IPv6 EH – the foundation of SRv6

IPv6 Extension Headers



Version | Traffic Class | Flow Label

Payload Length | Next=43 | Hop Limit

Source Address

Destination Address

Hop-by-Hop Options Header

Destination Options Header

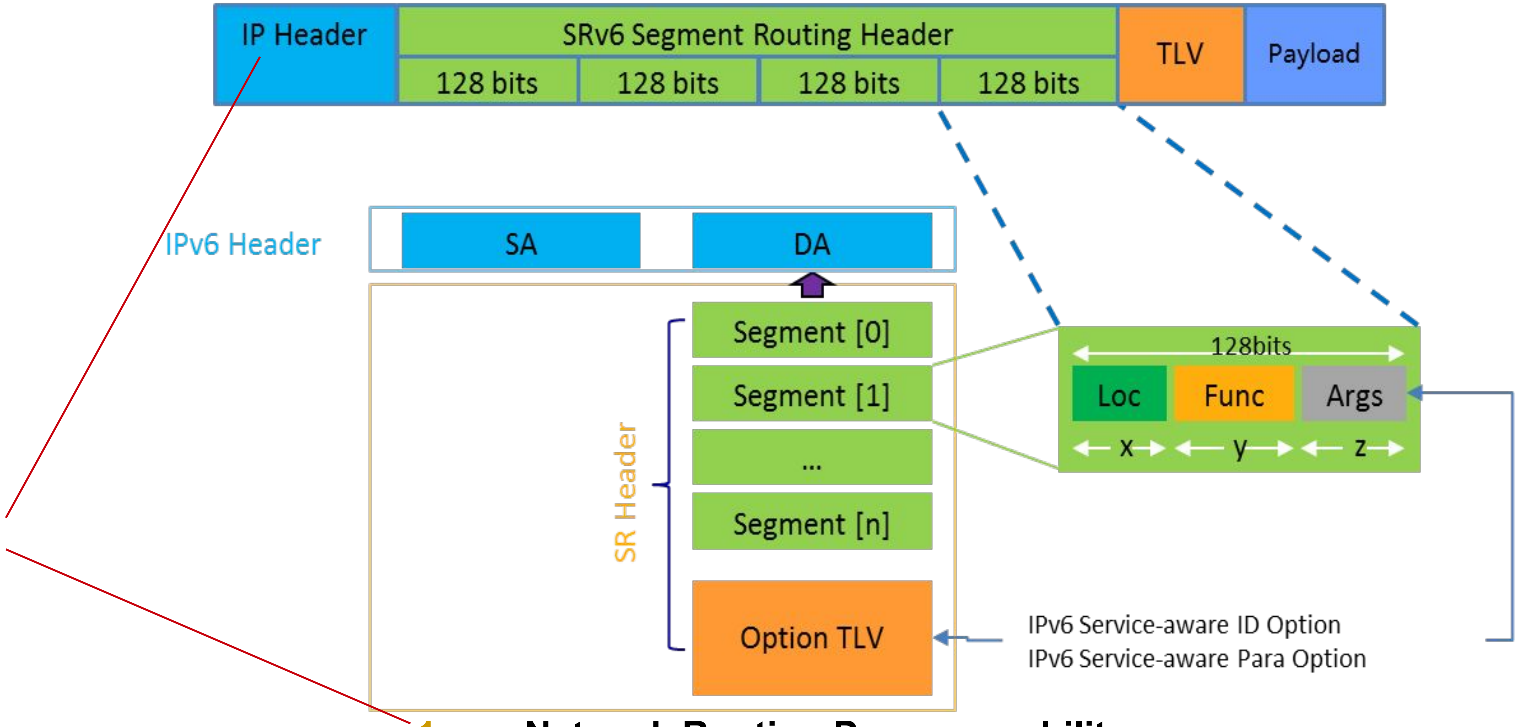
Routing Header/SRH

……

Destination Options Header

Payload

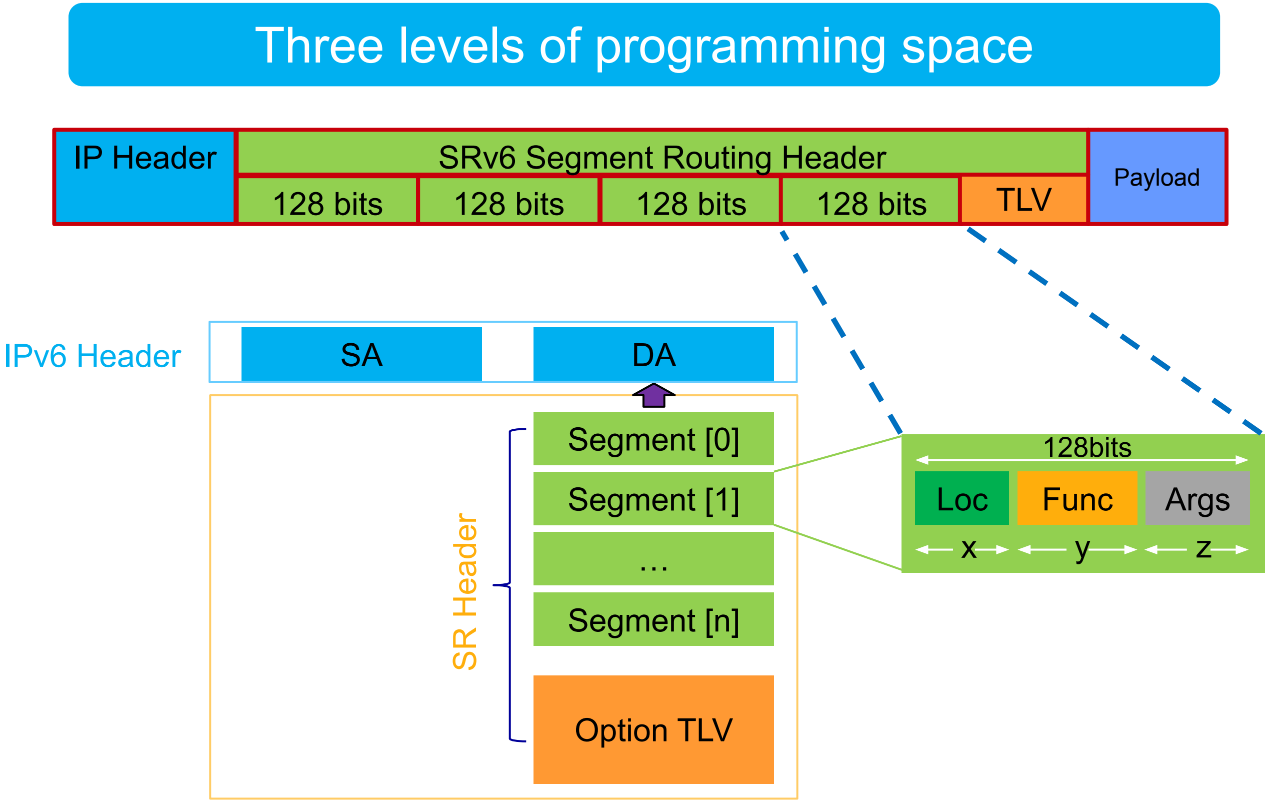
SRv6 SRH: Three Levels of Programming Space



IPv6 Service-aware ID Option
IPv6 Service-aware Para Option

1. Network Routing Programmability
2. Network Behaviors Programmability
3. Network Service Programmability

SRv6 compared with SR-MPLS



SRv6 SID: **2001:db8:1::End.DT4:100**
2001:db8:1::/64 is the locator
End.DT4 is the function
100 is the argument

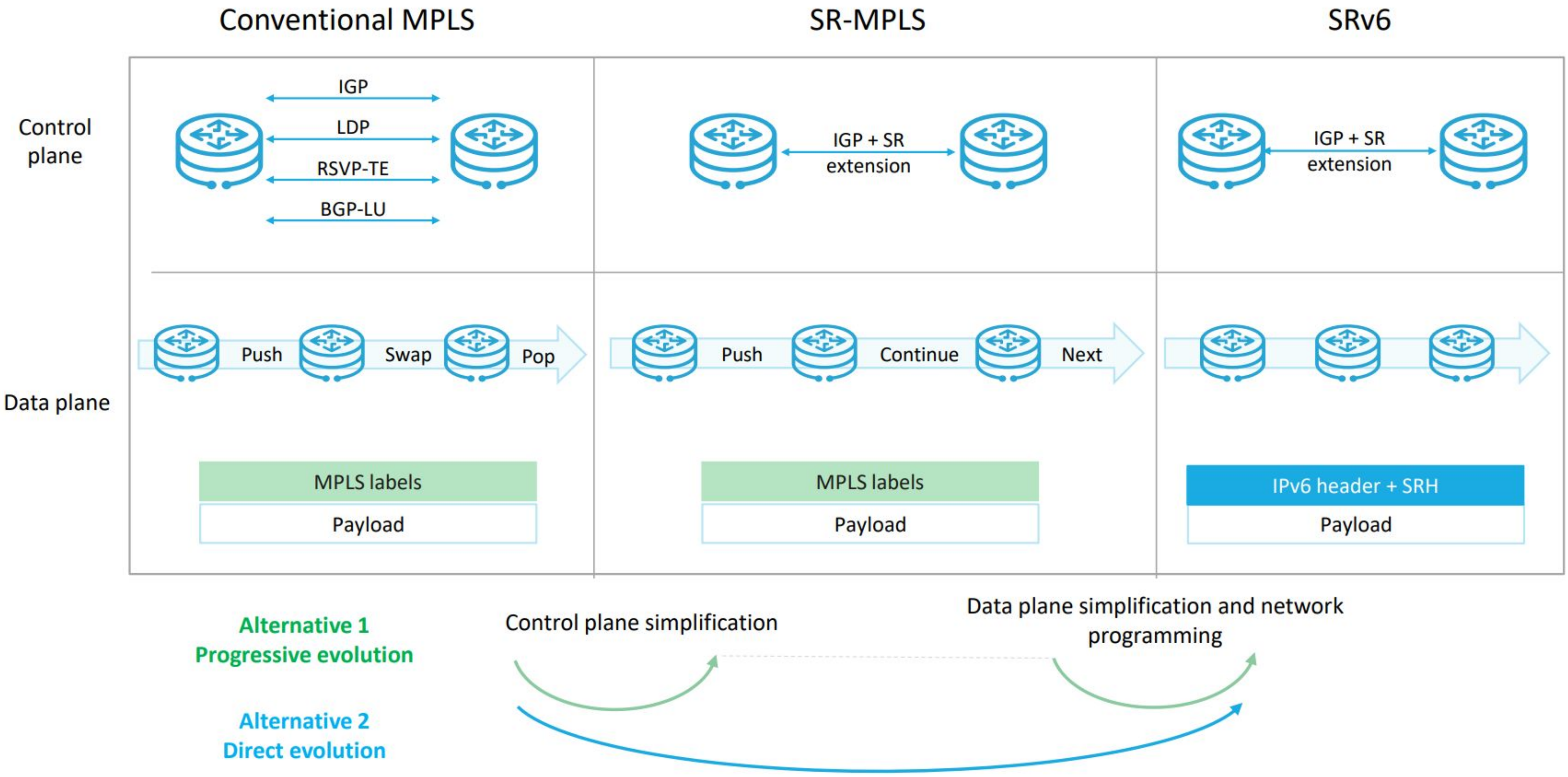
- Easy cross-domain communication
  - Unified data plane – IPv6
  - Few protocols – replace RSVP/LDP
- Large-scale networking
  - Routing Aggregation
- Incremental deployment **vs. SR-/MPLS**
  - Upgrading on demand

- Multi-levels of programming capabilities
  - Flexible segments combination
    - Unified network & service programming
  - Flexible fields of Segment
  - Flexible TLVs combination
- Easy to introduce new features
  - SFC, iOAM, network slicing, low latency, …
- A good foundation for innovations

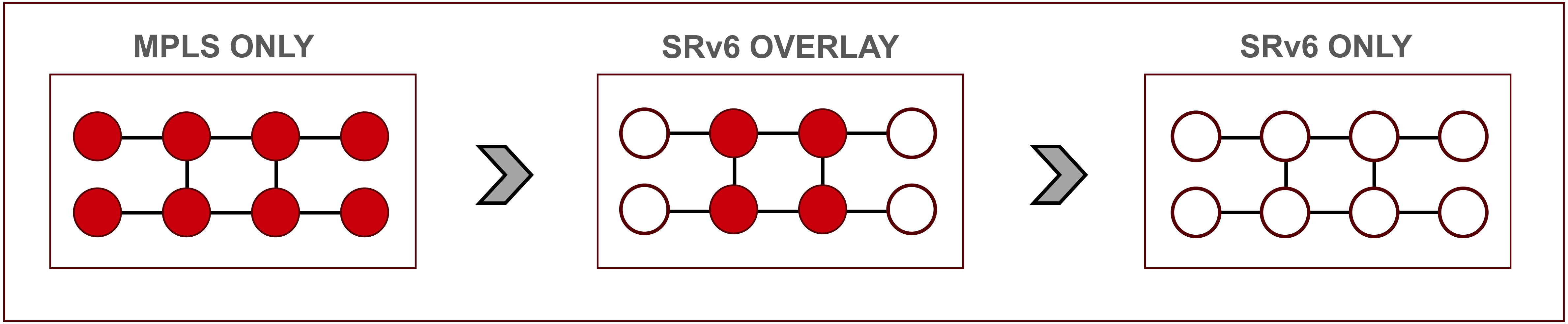
Interdomain SRv6

- SRv6 was designed for controlled networks.
    - SRv6 works best in operator-managed domains (e.g., data centers, enterprise networks, ISP backbones).
    - Traffic engineering policies are centrally managed (e.g., via SDN).
    - Networks support IPv6 extension headers (like the SRH).
    - Including cooperatively managed inter-domain environments.
- Inter-domain SRv6 requires coordination.
    - Domains need to agree on SRv6 policies (e.g., path segments, SIDs).
    - Intermediate routers support SRv6 (no stripping of IPv6 extension headers).
    - Traffic engineering is collaboratively managed (e.g., via BGP-LS + PCE).
- IETF has several Inter-domain related SRv6 standards.
- Vendors have their own solutions.

Progressive vs Direct Evolution



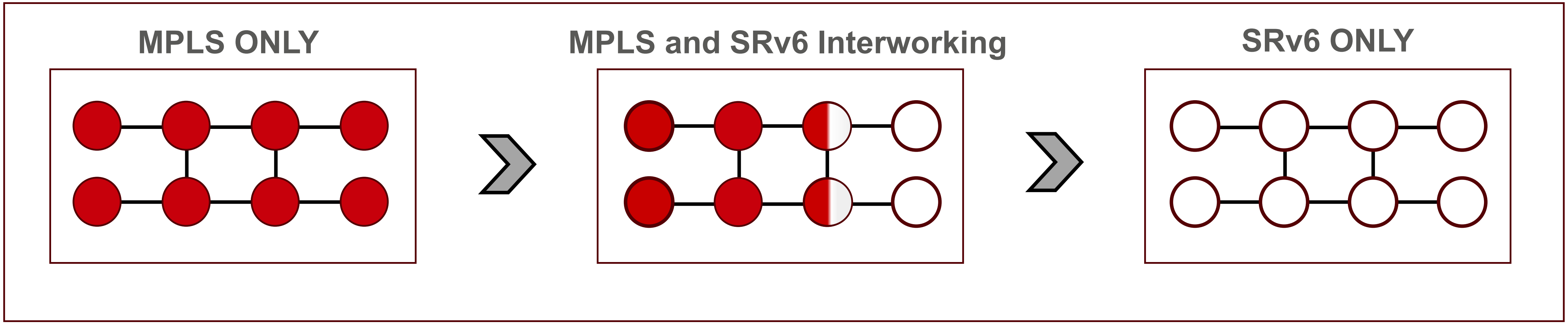
Overlay vs Interworking



MPLS ONLY

SRv6 OVERLAY

SRv6 ONLY

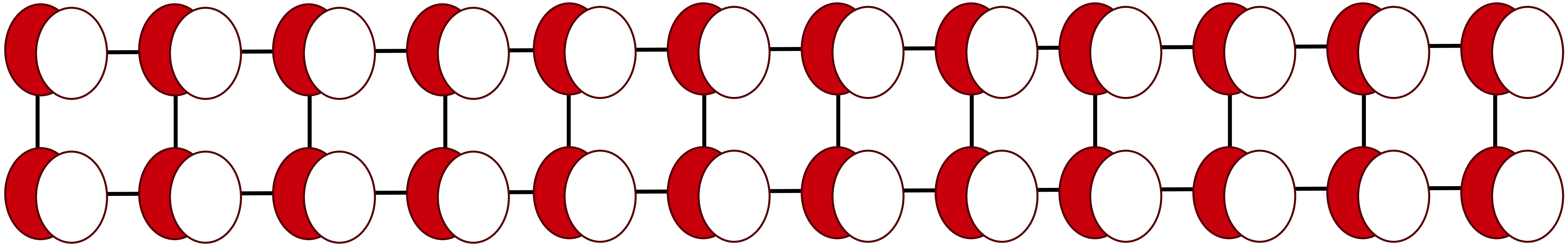


MPLS ONLY

MPLS and SRv6 Interworking

SRv6 ONLY

Ships-in-the-Night



● MPLS ONLY

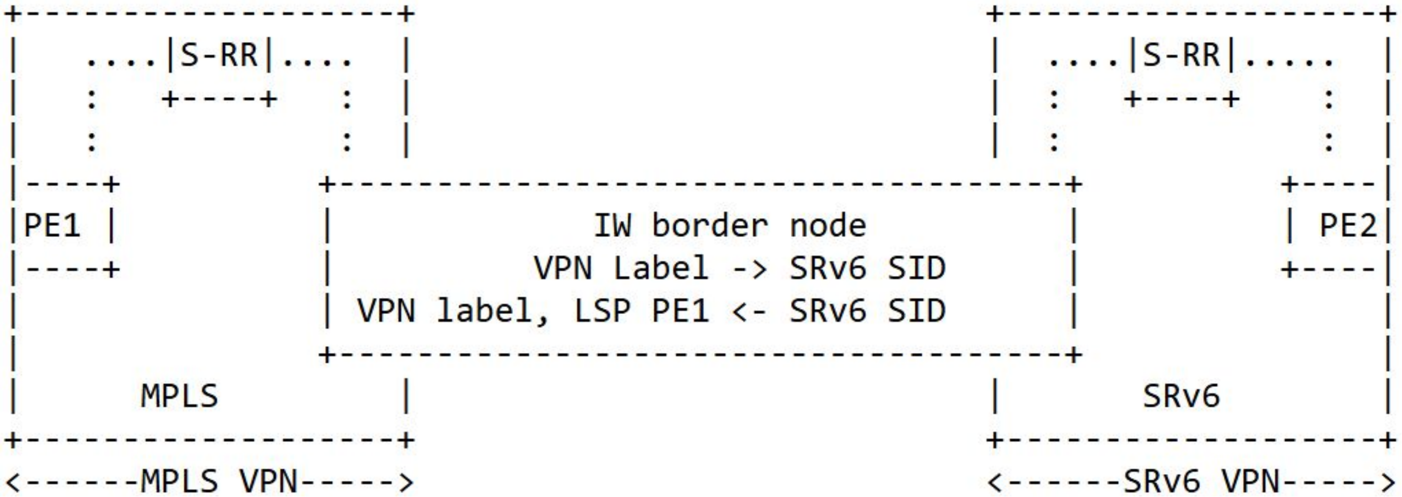
○ SRv6 ONLY

MPLS and SRv6 Interworking

Existing MPLS network interworks with SRv6.
ietf-spring-srv6-mpls-interworking describes SRv6 and MPLS/SR-MPLS interworking procedures.

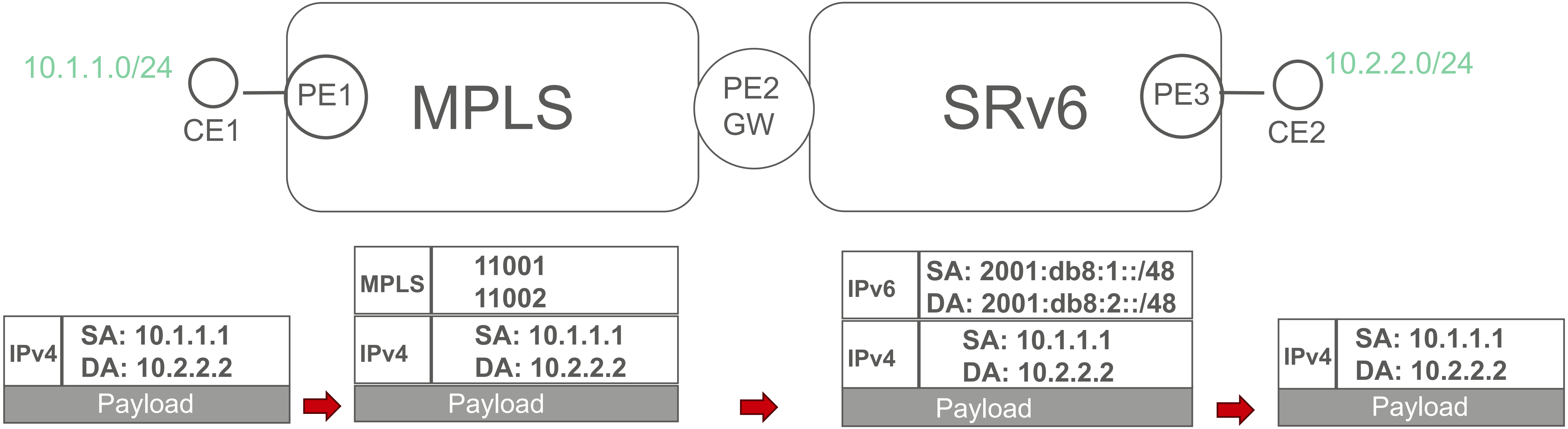
New SRv6 behaviors, and MPLS labels, stitch the end to end path across different data planes.

SRv6 to MPLS (6toM) and MPLS to SRv6 (Mto6): Converting between SRv6 and MPLS packet formats.



```
+-------------------+                                    +-------------------+
|   ....|S-RR|....  |                                    |  ....|S-RR|.....   |
|   :   +----+   :  |                                    |  :   +----+    :   |
|   :            :  |                                    |  :             :   |
|----+          +--------------------------------------+         +----|
|PE1 |          |             IW border node           |         | PE2|
|----+          |          VPN Label -> SRv6 SID       |         +----|
|               | VPN label, LSP PE1 <- SRv6 SID       |              |
|               +--------------------------------------+              |
|      MPLS          |                                    |      SRv6          |
+-------------------+                                    +-------------------+
<------MPLS VPN----->                                    <------SRv6 VPN----->
```

Interworking Packet Flow



PE2 functions as the border node GW between MPLS domain and SRv6 domain.
PE2 receives SRv6 L3VPN route and installs route to VPN routing table and re-originates an MPLS L3VPN route.
PE2 advertises the route to PE1, changing the next hop to itself and assigns a VPN label.
After receiving packet from MPLS domain, PE2 pops outer label and searches for corresponding VPN instance.
Once corresponding route and VPN SID, in the SRv6 domain, PE2 encaps packet w/SRv6 packet header.

Ships-in-the-night

Run separate MPLS and SRv6 networks.

- SRv6 and MPLS operate independently in the same network w/o interaction
- They coexist as separate "ships in the night"

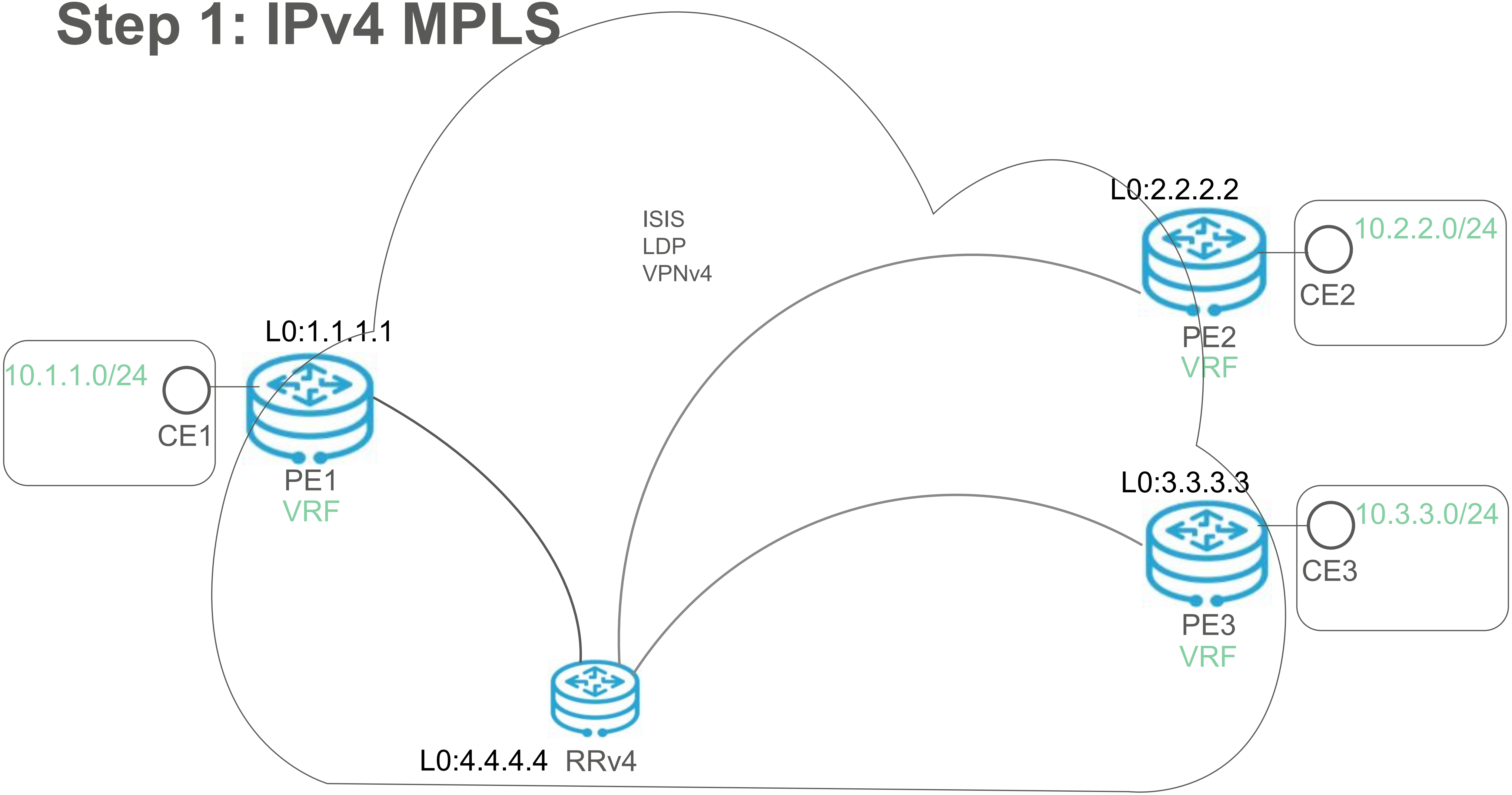
Drawbacks to running ships-in-the-night:

- Cost, Complexity, Processing power, Security…

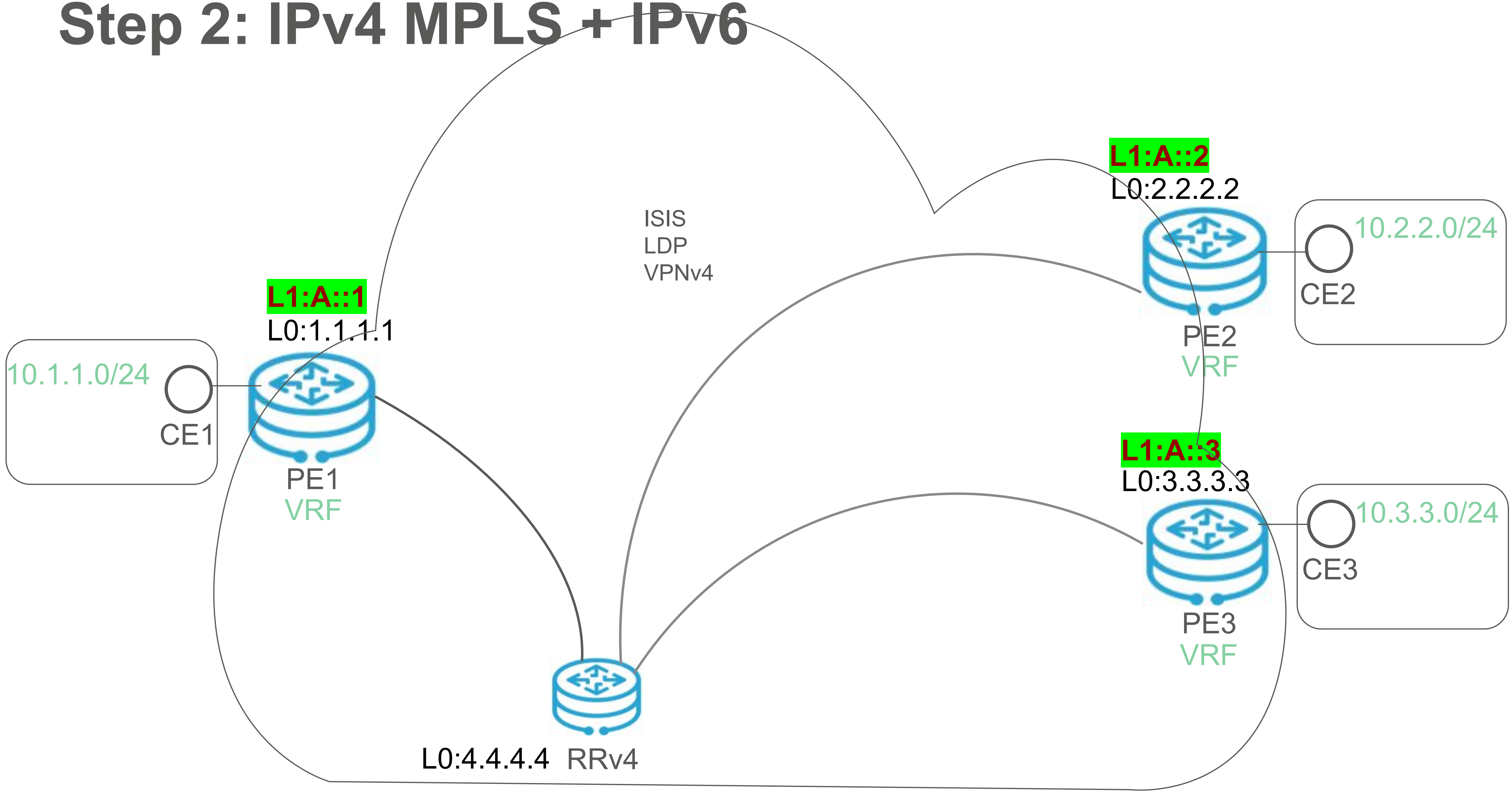
Migration can be performed gradually w/o a flag day:

1. MPLS transport and overlay services
2. Enable IPv6 and SRv6 parallel to MPLS
3. Migrate services from MPLS to SRv6
4. Disable MPLS transport

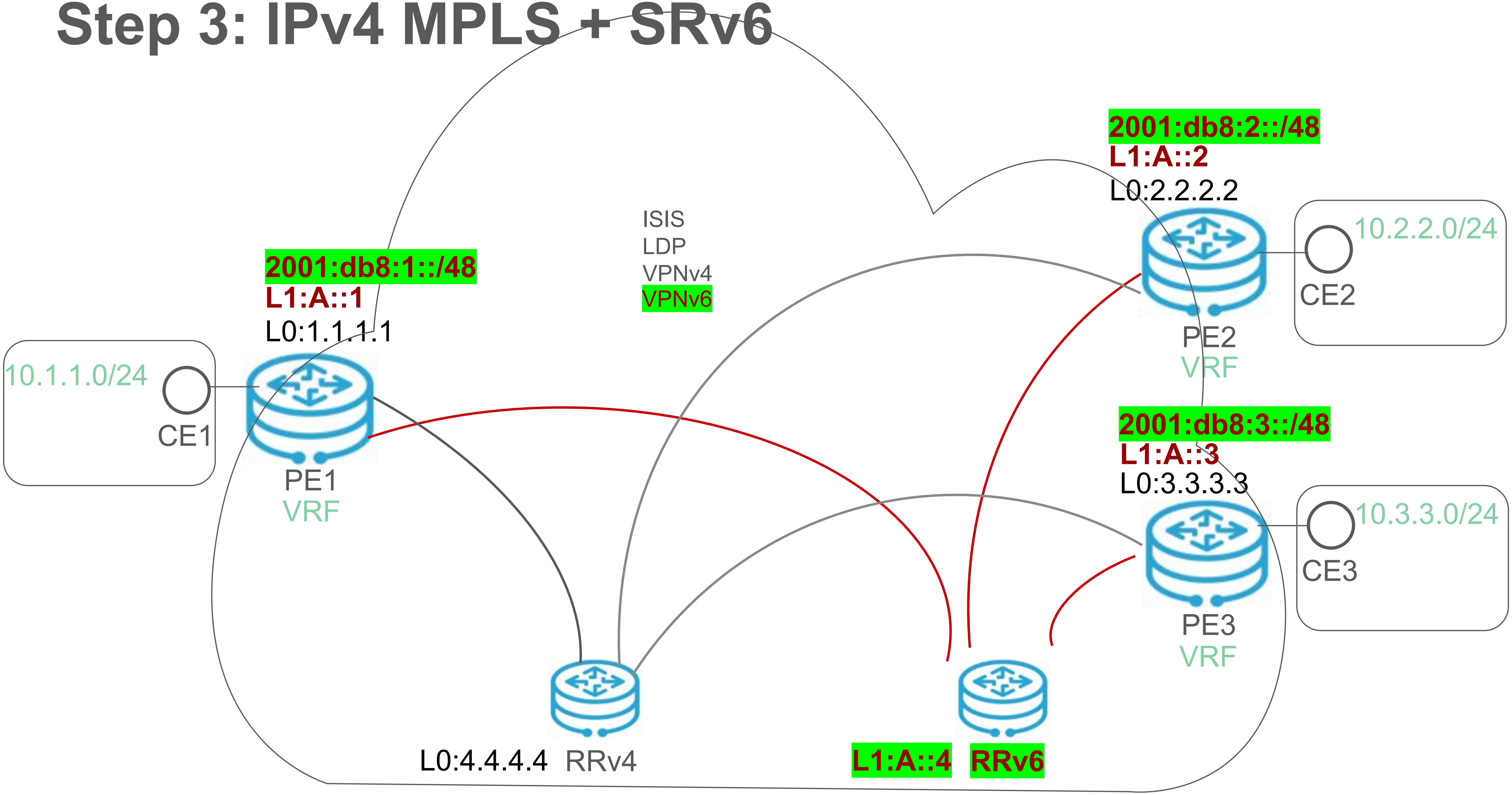
Step 1: IPv4 MPLS



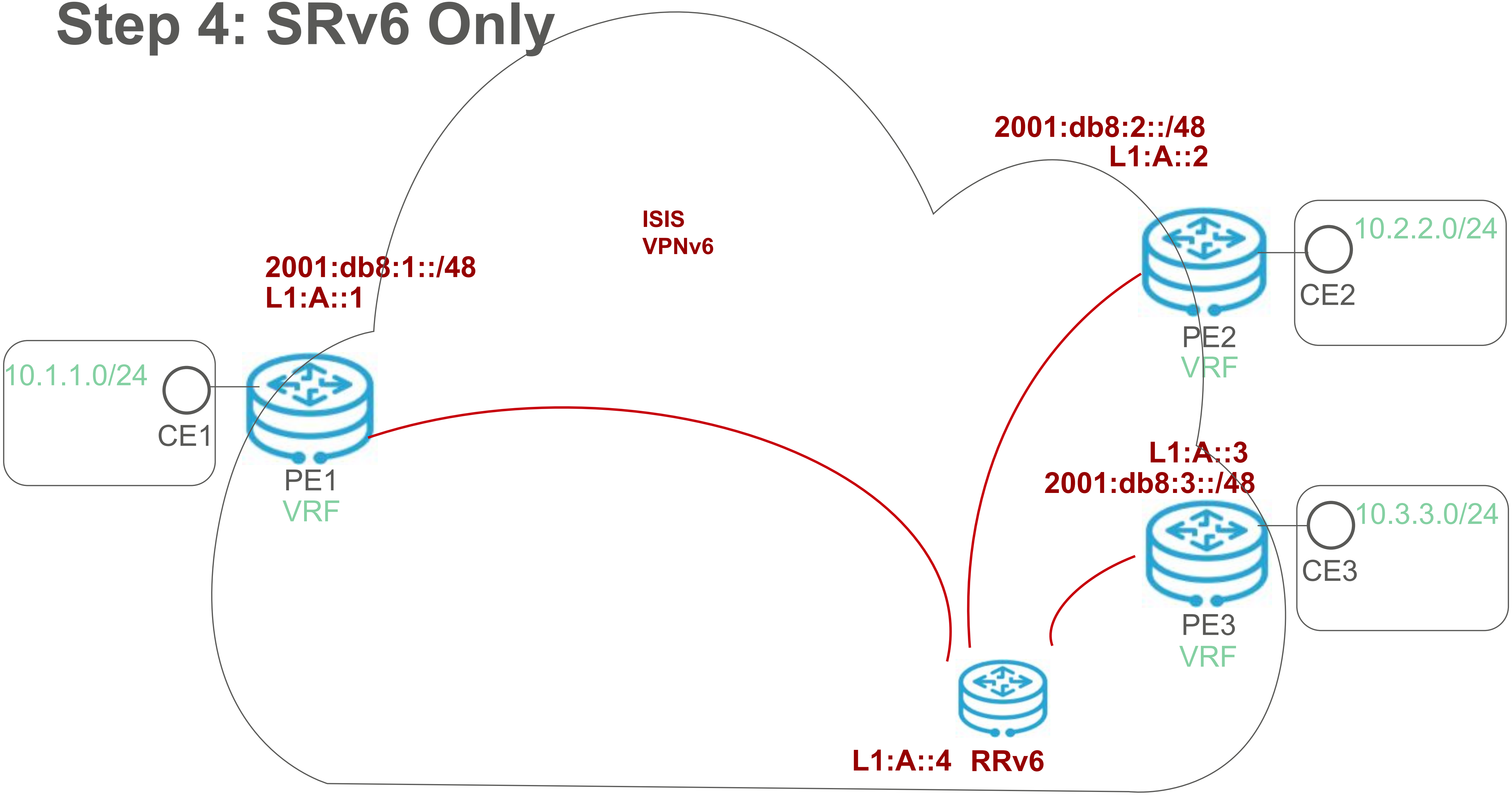
Step 2: IPv4 MPLS + IPv6



Step 3: IPv4 MPLS + SRv6



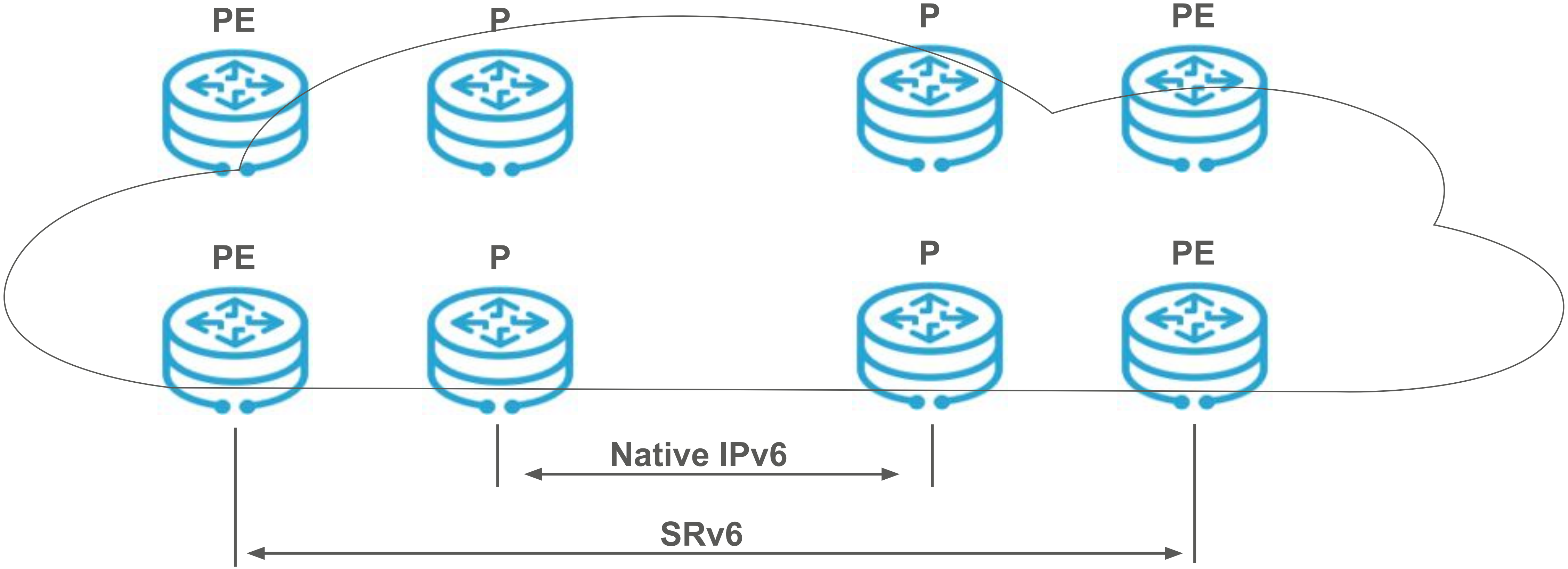
Step 4: SRv6 Only



MPLS to SRv6 Evolution Steps

1. Configure interface IPv6 addresses and locators.
2. Configure IS-IS IPv6 and enable SRv6, and then configure the forwarders to advertise locator routes.
3. Establish BGP peer relationships between the controller and forwarders using the IPv6 unicast address family, and enable BGP-LS and BGP IPv6 SR-Policy. The controller delivers SRv6 Policies, and SRv6 TE tunnels are established on forwarders.
4. On Forwarders, establish BGP VPNv4 peer relationships using IPv6 addresses so that BGP VPNv4 peers advertise VPN routes to each other. The color attribute of the VPN routes is consistent with that of SRv6 Policies to ensure that VPN routes can recurse to the SRv6 Policy.
5. Each forwarder has two routes with the same prefix, one carrying the MPLS VPN label received from the BGP peer established using IPv4 addresses and the other carrying the VPN SID received from the BGP peer established using IPv6 addresses. If the two routes have the same attributes, a forwarder by default preferentially selects the route received from the BGP peer established using IPv4 addresses, and services can still be carried over MPLS tunnels.
6. Configure a route policy so that the forwarder preferentially selects the route received from the BGP peer established using IPv6 addresses. Then, traffic will be automatically switched to SRv6 tunnels, and L3VPN services will be migrated to the SRv6 tunnels.
7. Delete MPLS, BGP peer relationships established using the IPv4, and MPLS configurations.

Overlay – Native IPv6



PE

P

P

PE

PE

P

P

PE

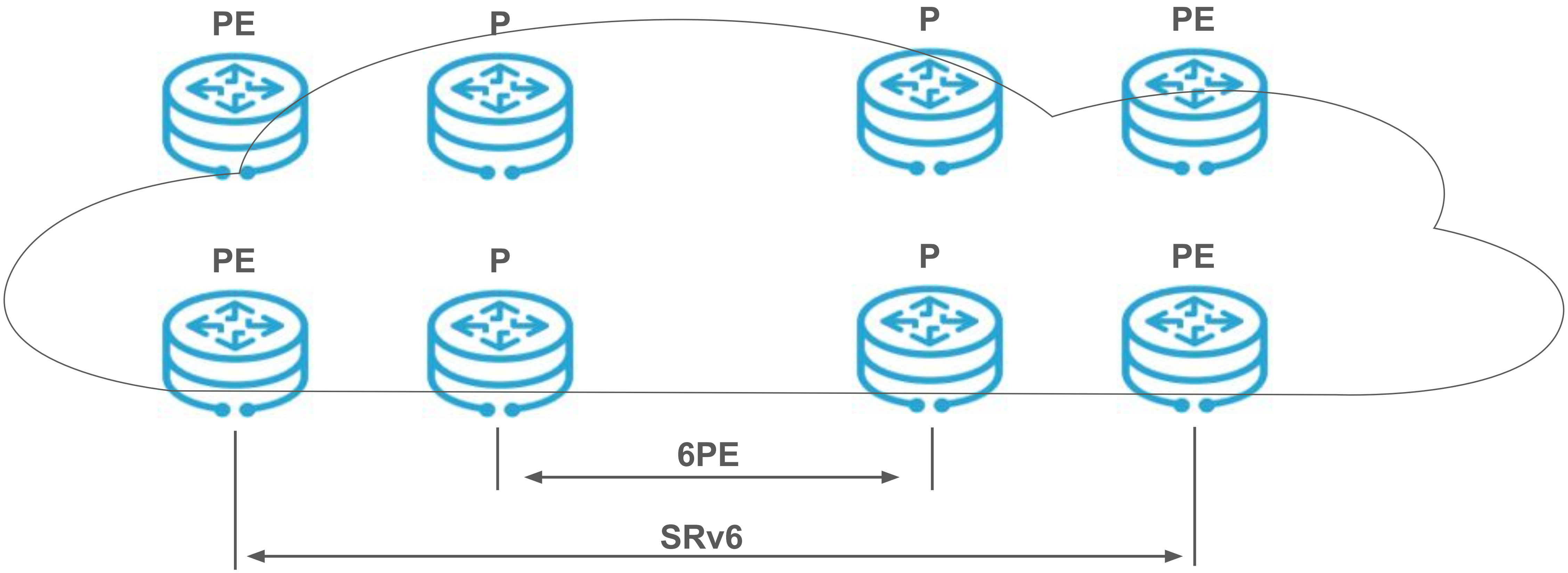
Native IPv6

SRv6

IPv6 + SRH

Payload

Overlay – 6PE

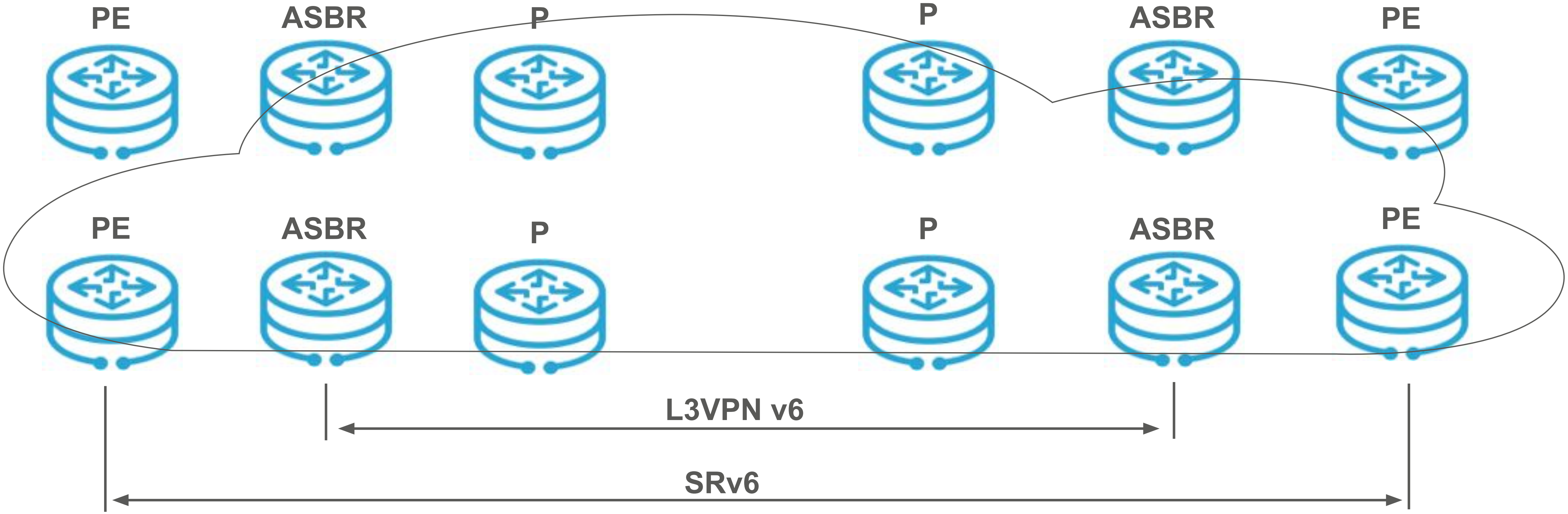


Outer Label

IPv6 + SRH | IPv6 + SRH | IPv6 + SRH

Payload | Payload | Payload

Overlay – L3VPN



PE ASBR P P ASBR PE

PE ASBR P P ASBR PE

L3VPN v6

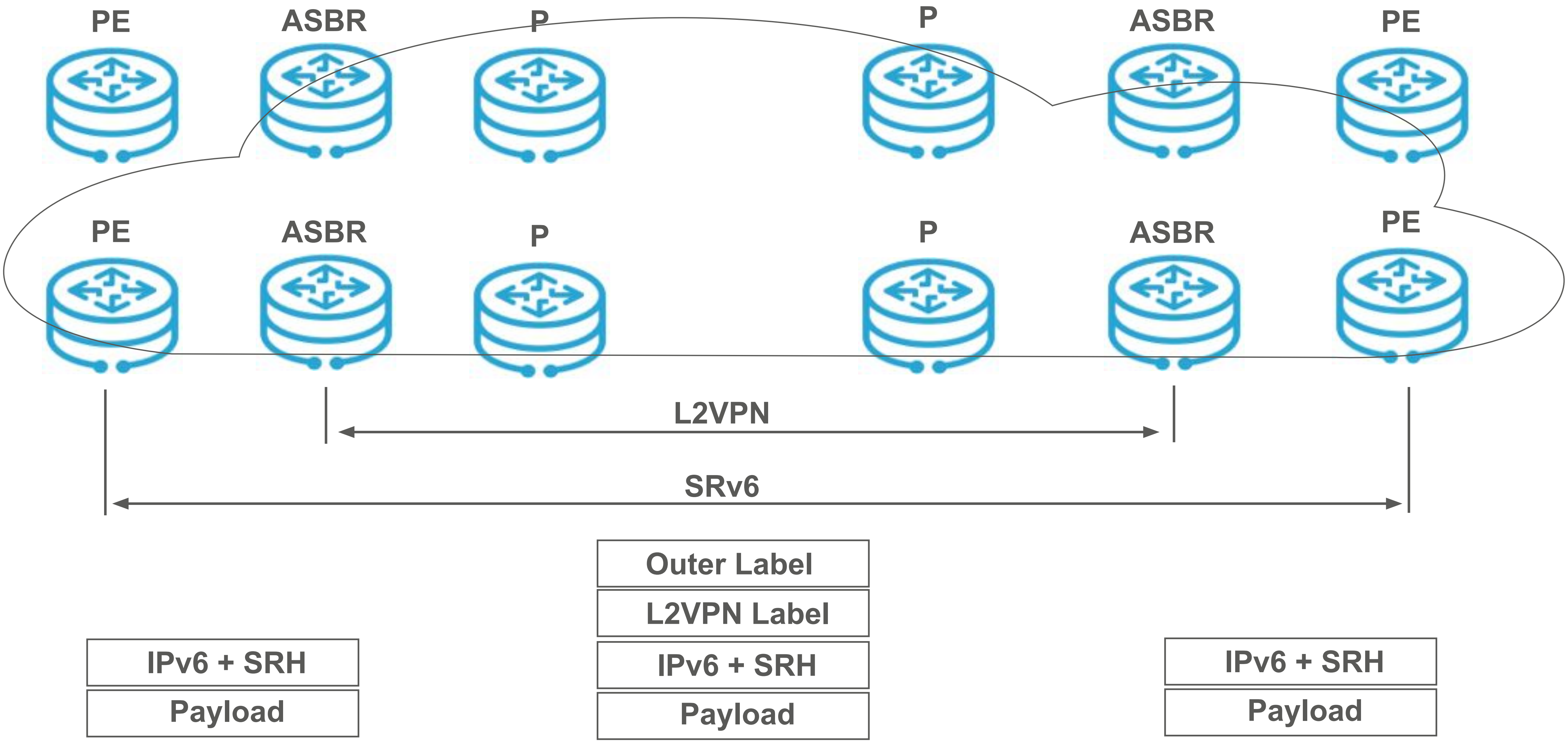
SRv6

IPv6 + SRH
Payload

Outer Label
L3VPN Label
IPv6 + SRH
Payload

IPv6 + SRH
Payload

Overlay – L2VPN



PE ASBR P P ASBR PE

PE ASBR P P ASBR PE

L2VPN

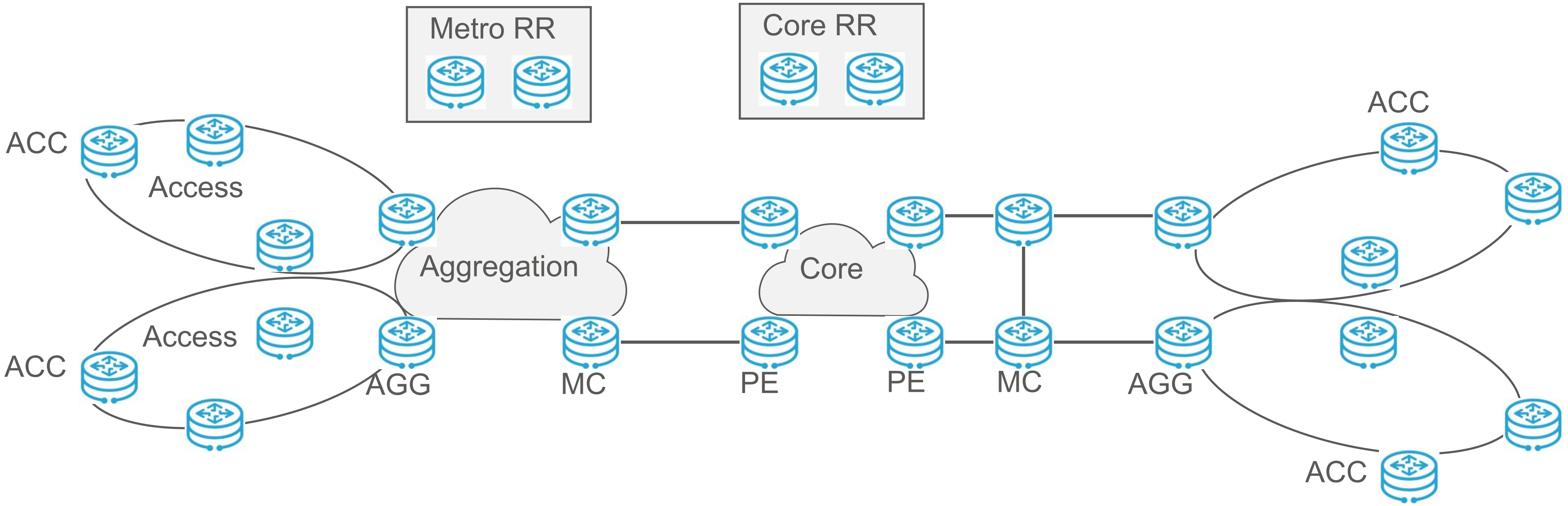
SRv6

IPv6 + SRH
Payload

Outer Label
L2VPN Label
IPv6 + SRH
Payload

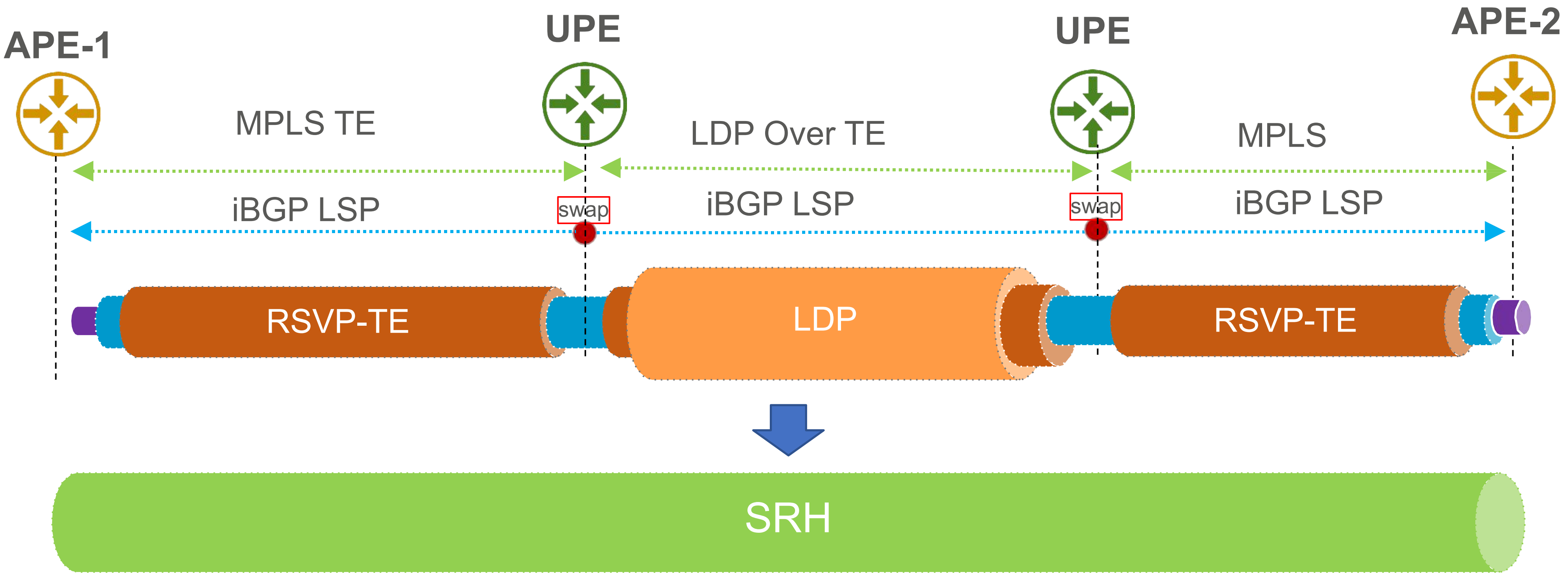
IPv6 + SRH
Payload

SRv6 and MPLS Interworking



Scenario 1	MPLS VPN	Option A	SRv6 EVPN	Option A	MPLS VPN
Scenario 2	SRv6 EVPN Overlay		6PE/MPLS		
Scenario 3	SRv6 EVPN			Option A	MPLS VPN
Scenario 4	SRv6 EVPN	Option A	MPLS VPN	Option A	MPLS VPN
	AS X		AS Y		AS Z

Turkcell Case Study – MPLS Complexity



Servis Label (BGP VPNv4 or Remote LDP)

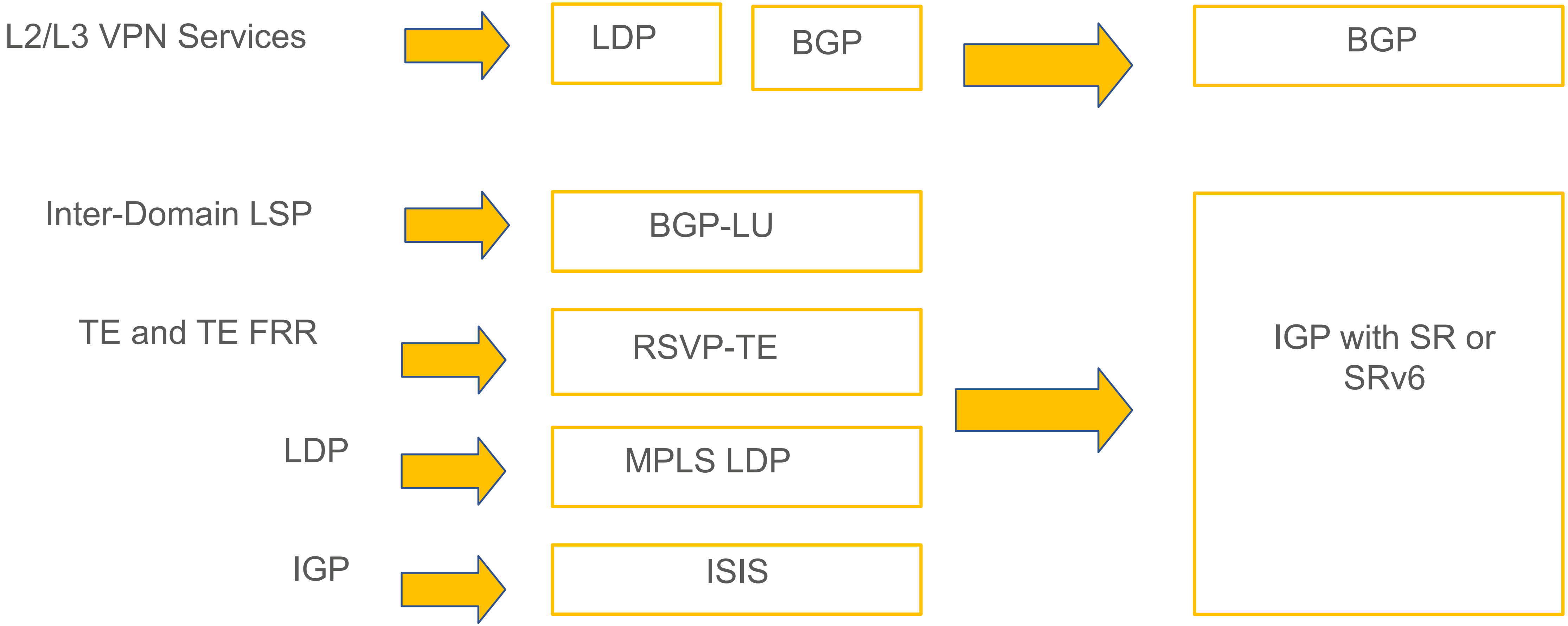
BGP IPv4 Prefix Label

RSVP-TE with FRR

MPLS LDP

SRH (Service and Path SIDs)

Segment Routing = Simplicity



L2/L3 VPN Services → LDP BGP → BGP

Inter-Domain LSP → BGP-LU

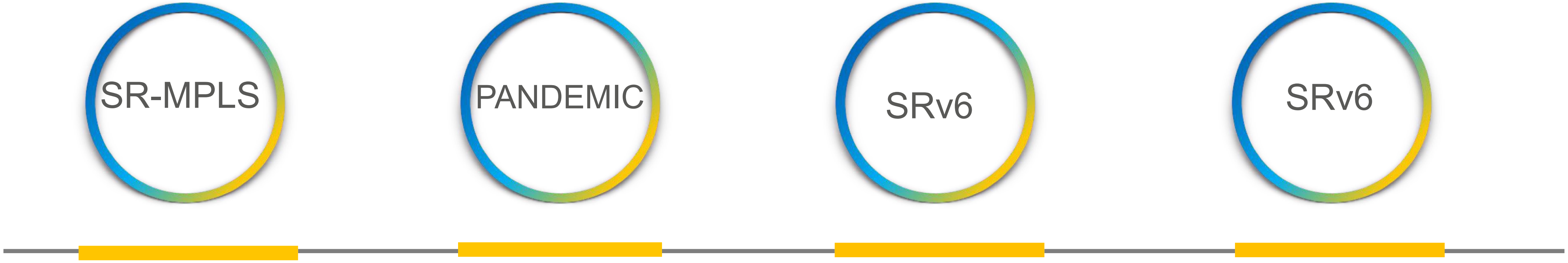
TE and TE FRR → RSVP-TE

LDP → MPLS LDP

IGP → ISIS

→ IGP with SR or SRv6

Segment Routing Journey



SR-MPLS

2019

Service

Chaining FRR

Readines for 5G

SRv6 is not

Mature SR-MPLS

Activated

PANDEMIC

2020

Pandemi
c
Started

SRv6

2023

Stopped
SR-MPLS

Focus on SRv6

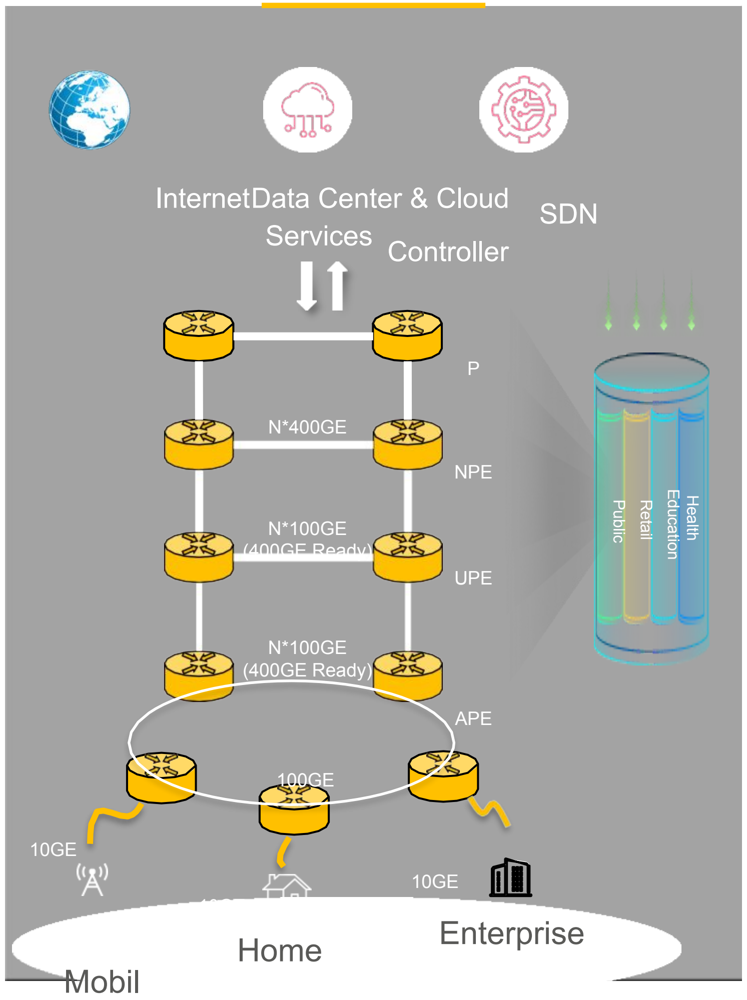
SRv6

2024

Start SRv6
Tests

Start Readiness

SRv6 Readiness



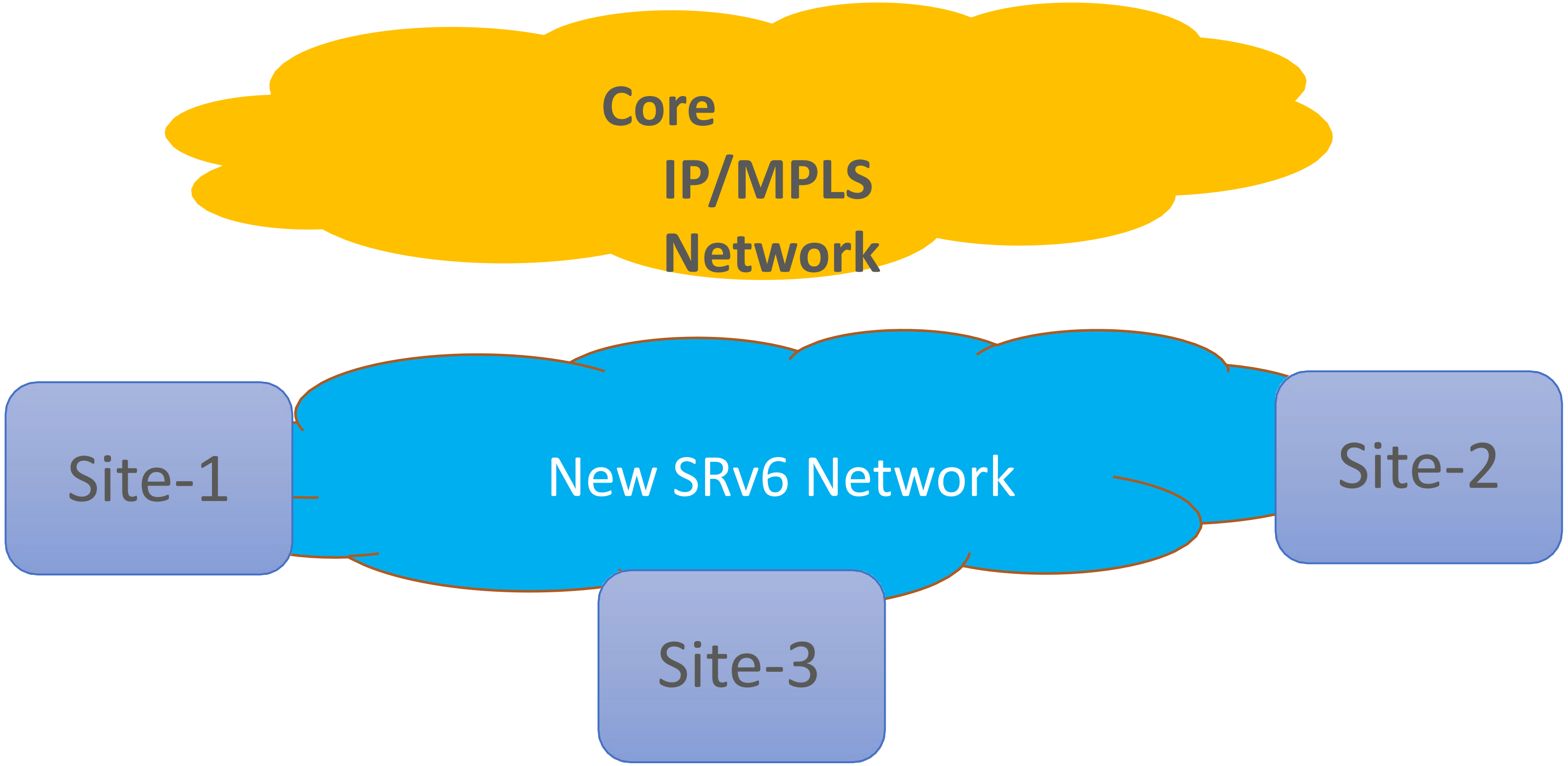
Evaluating HW & SW Compatibility Across Vendors

Defining SRv6 Roadmap

Training & Awareness

New Procurement for SW and HW that not support SRv6

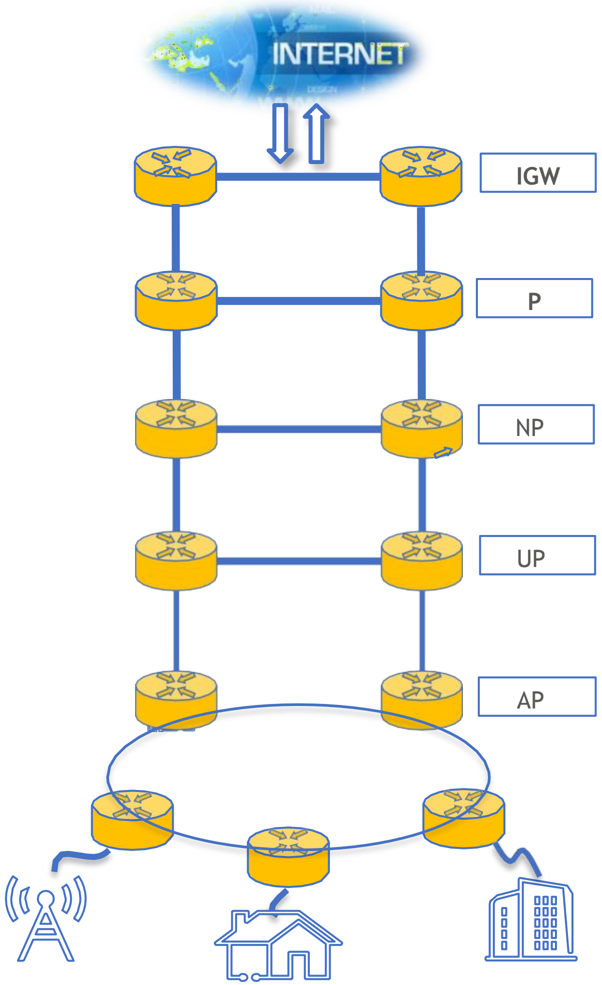
On Going SRv6 Site Studies



- L3VPN, L2VPN , EVPN Services
- 3 Vendor Topology

- 2 Vendors Controller PoC
- Full SID using instead of uSID
- IPv6 Transition

SRv6 Deployment Roadmap



EVPN RR

IPv6 Activation

ISISv6 Transition

First Live Migration

2025

EVPN RR

Procuremen
t
Installatio

n

Integratio

n

2025

IPv6 Activation on all IP Network Interfaces

2026

ISISv6

Activatio
n

2027

EVPN for Service Chaining

TI-LFA for Fast

Convergance

Controller for Centralized Control

SRv6 addressing

Interface IPv6 addresses need to be configured prior to SRv6 configuration.

If IPv6 has been deployed, and IPv6 addresses have been planned, the original IPv6 address planning does not need to be modified, and we only need to select a reserved network prefix and use it to allocate SRv6 locators.

If neither IPv6 has been deployed on a network, nor IPv6 addresses have planned, IPv6 address planning can be performed by determining the principles for IPv6 address planning on the network, determining the method of IPv6 address allocation, and hierarchically allocating IPv6 addresses.

draft-liu-srv6ops-sid-address-assignment

Mature standardization and vendor support

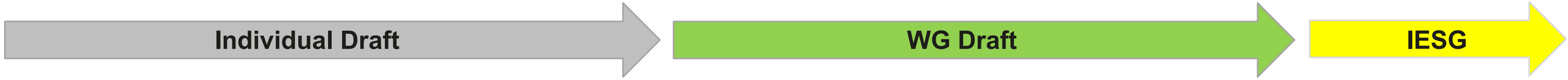
RFC 8402	SR Architecture
RFC 8986	SRv6 Network Programming
RFC 8754	IPv6 Segment Routing Header
RFC 9252	SRv6 VPN
RFC 9256	SR Policy Architecture
RFC 9259	OAM in SRv6
RFC 9352	IS-IS Extensions
RFC 9513	OSPFv3 Extensions
RFC 9514	BGP-LS Extensions
RFC 9603	PCEP Extension
IESG review	BGP SR policy
In WGLC	SRv6 Compression

network provider Juniper Networks, Cisco, Arista, Nokia, Huawei

chipset provider Broadcom, Marvell

instrument provider Spirent Communications, ixia

……



Period：Average 2-3 years

Summary

SRv6 Overlay

SRv6 tunnels are built over an underlay network (e.g., MPLS, LDP, RSVP-TE).
The underlay does not need to be SRv6-aware.
SRv6 SIDs are used only for overlay services (e.g., VPNs, traffic engineering).
Gradual migration to SRv6 without disrupting the existing underlay.
Useful in multi-vendor networks where some devices don’t support SRv6.

SRv6 Ships-in-the-night

Both SRv6 and legacy protocols coexist on the same routers but do not interact.
SRv6 packets are forwarded based on their own SIDs, while traditional packets use MPLS labels or IPv6 routing.
No translation or interworking between SRv6 and legacy protocols.

Interworking is also an option if you need MPLS and SRv6 islands

Ex: Keep an MPLS core but deploy SRv6 in edge/access.

Thank You.

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