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EVPN

One Control Plane to rule them all

GRNOG 20

Athens

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Traditional VPN Service Landscape

Draft-Rosen
PWE
Targeted-LDP
LDP-VPLS
IP-VPN
LDP-PW
E-LAN
GRE
MVPN
E-LINE
BGP-VPLS
BGP-PW
eBGP
Flood-&-Learn
Option-C
H-VPLS
PIM-SSM
MC-LAG
BGP-AD
PIM-ASM

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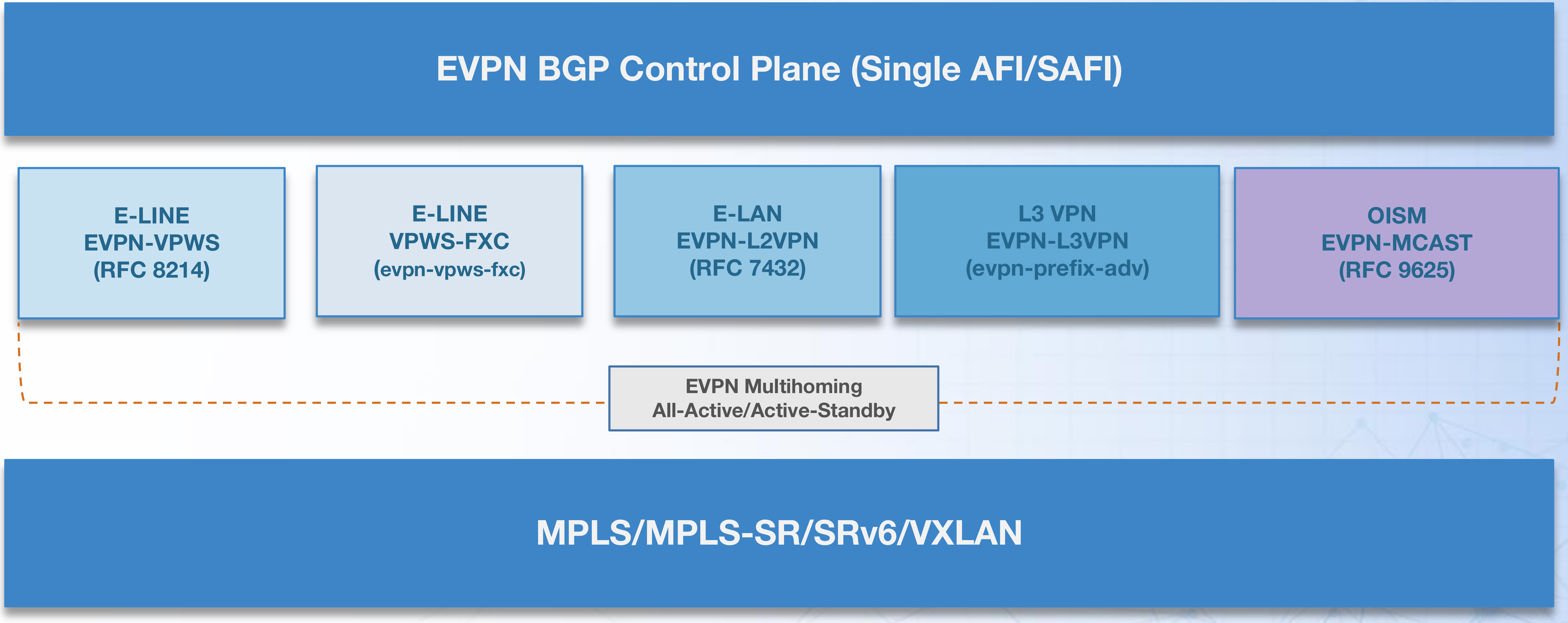
Routing Services - EVPN as a Platform

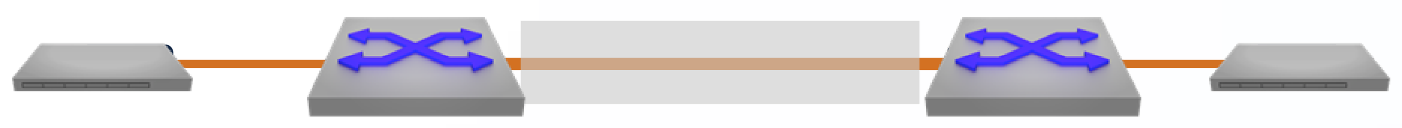
EVPN provides a flexible foundation for the broad range of services



Simplification with EVPN

Traditional for Brownfield | EVPN for Greenfield

E-LINE (Point-to-Point) services



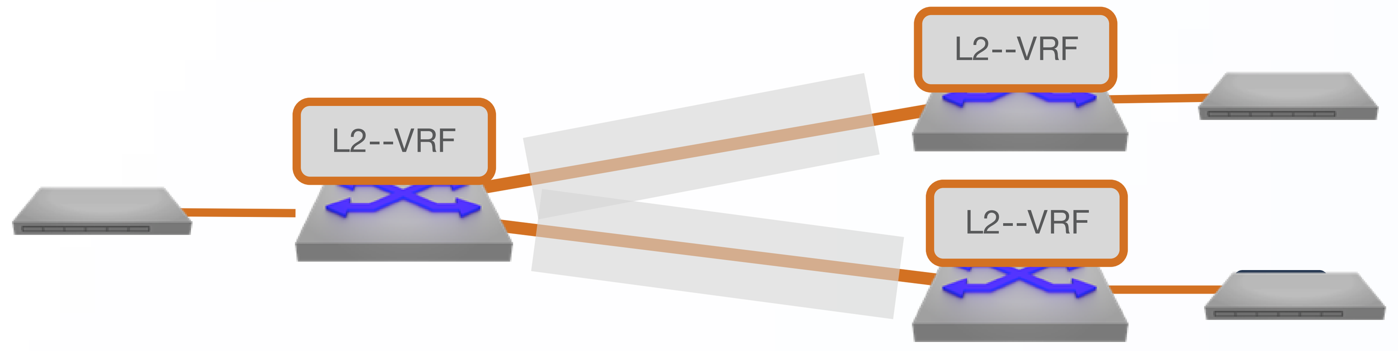
LDP/BGP signaled PW (Traditional for Brownfield)

- LDP control-plane for signaling
- Type-4, Type-5 modes, Standby PW support
- PW coloring for traffic engineering

EVPN VPWS (RFC 8214) (EVPN for Greenfield)

- Consistent BGP EVPN Control-plane
- Auto-discovery via BGP EVPN (Type-1)
- Support for standards-based A-A/A-S models

E-LAN (Point-to-multipoint) services



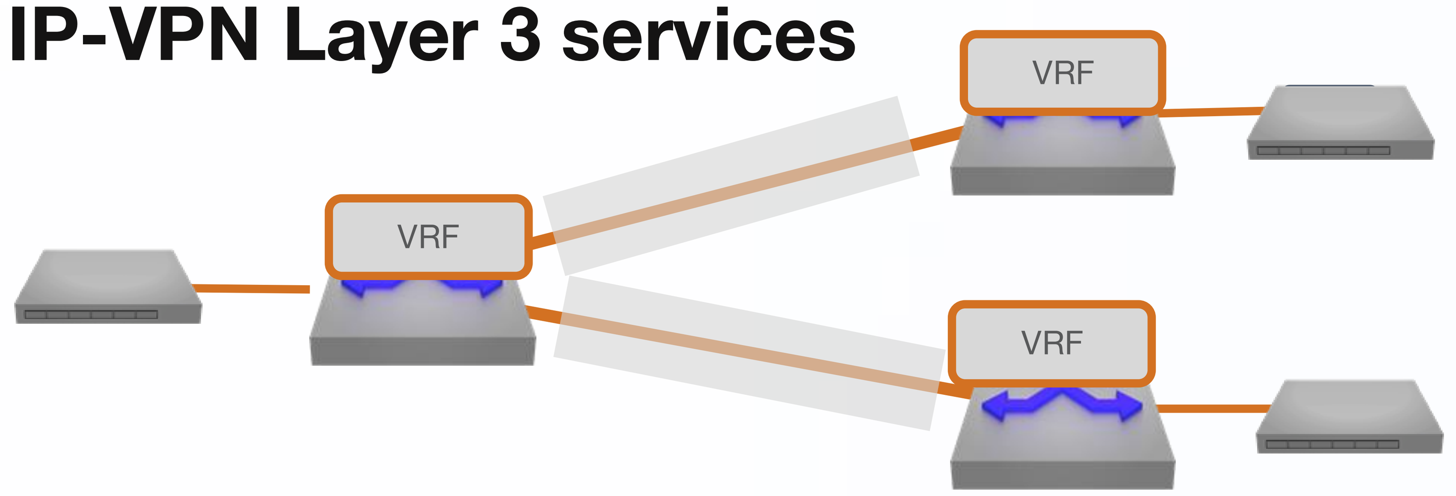
VPLS (RFC 7432) (Traditional for Brownfield)

- LDP signaled VPLS support
- LDP signaled with BGP A-D
- Hierarchical VPLS, with standby PWs

EVPN L2 VPNs (RFC 7432) (EVPN for Greenfield)

- Consistent BGP EVPN Control-plane
- Control-plane learning with Type-2 routes
- Support for standards based A-A/A-S models

IP-VPN Layer 3 services



IP-VPN (RFC 4364) (Traditional for Brownfield)

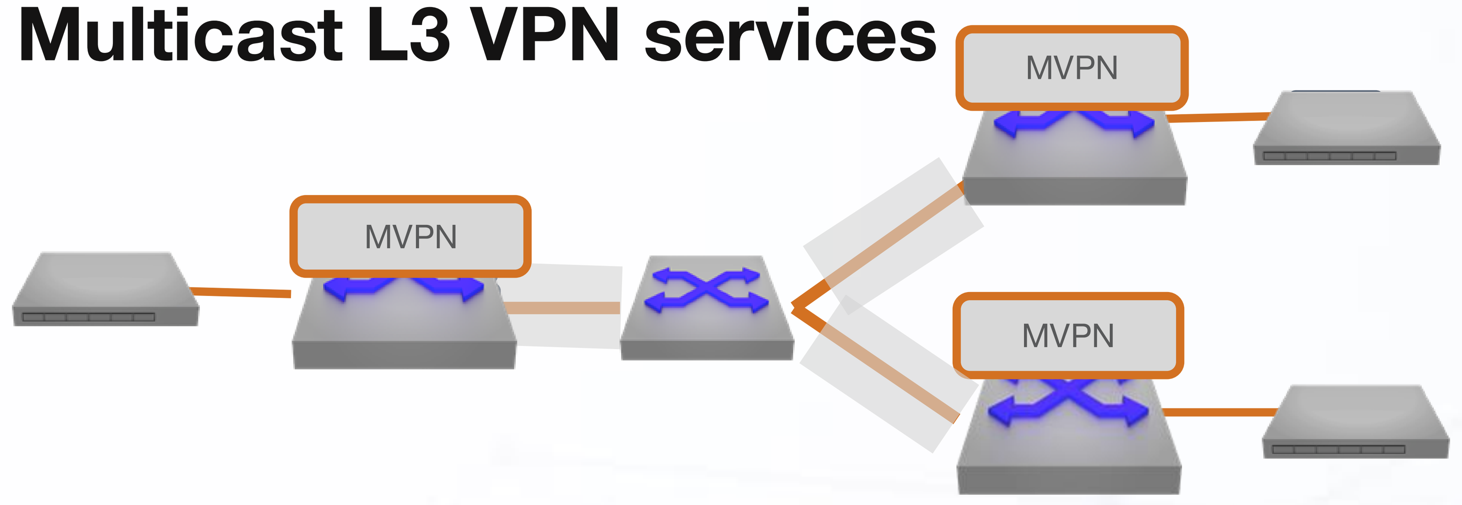
- BGP signaling and auto-discovery
- Control-plane learning via BGP
- Layer 3 only solution no L2 VPN support

EVPN L3 VPNs (RFC 9136) (EVPN for Greenfield)

- Consistent BGP EVPN Control-plane
- Control-plane learning with Type-5 routes
- Seamless integration with L2VPN models

IP Unicast and Ethernet VPNs

Multicast L3 VPN services



NG MVPN (RFC 6513) (Traditional for Brownfield)

- BGP signaling and auto-discovery RFC 6514
- P2MP transport with mLDP
- Profile 12, 14 and 22 Supported!

New

EVPN-Multicast (RFC 9625) (EVPN for Greenfield)

- EVPN control-plane with MPLS, replace for NG-MVPN
- Support for Layer 2 and 3 multicast with A-A
- Only mLDP Signaling (today - more to come)

Multicast VPNs

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Why EVPN…

… for service delivery …

Simplification	**Protocol Reduction** – Single BGP AF for all Ethernet and IP VPN services removing the need for dedicated protocols per services, PW, VPLS, MVPN, IP-VPN
Consistency	**Repeatable model** – Consistent implementation and operational model for deploying any service type E-LINE, E-LAN, IP unicast/multicast enabling road to automation
Resiliency	**Flexible multi-homing** – Standard based consistent multi-homing procedures across all Ethernet and IP VPN services
Flexible	**Any encapsulation** – Support for multiple encapsulation models VXLAN/MPLS/SR and SRv6, allowing a consistent operation model from the WAN to the DC and Campus
Skillset	**Converged Teams** - One operational and implementation team for managing VPN services across both the WAN and DC infrastructure

CapEx

The simplicity of EVPN removes the need for dedicated HW platforms to for VPN services, service can now be achieved on a standard DC ToR

OpEx

A consistent operational models for MPLS/SR and VXLAN means OpEX saving trough automation and the merging of teams


EVPN
One Control Plane to rule them all
MPLS
SR
SRv6
VXLAN

Recap: transport models …

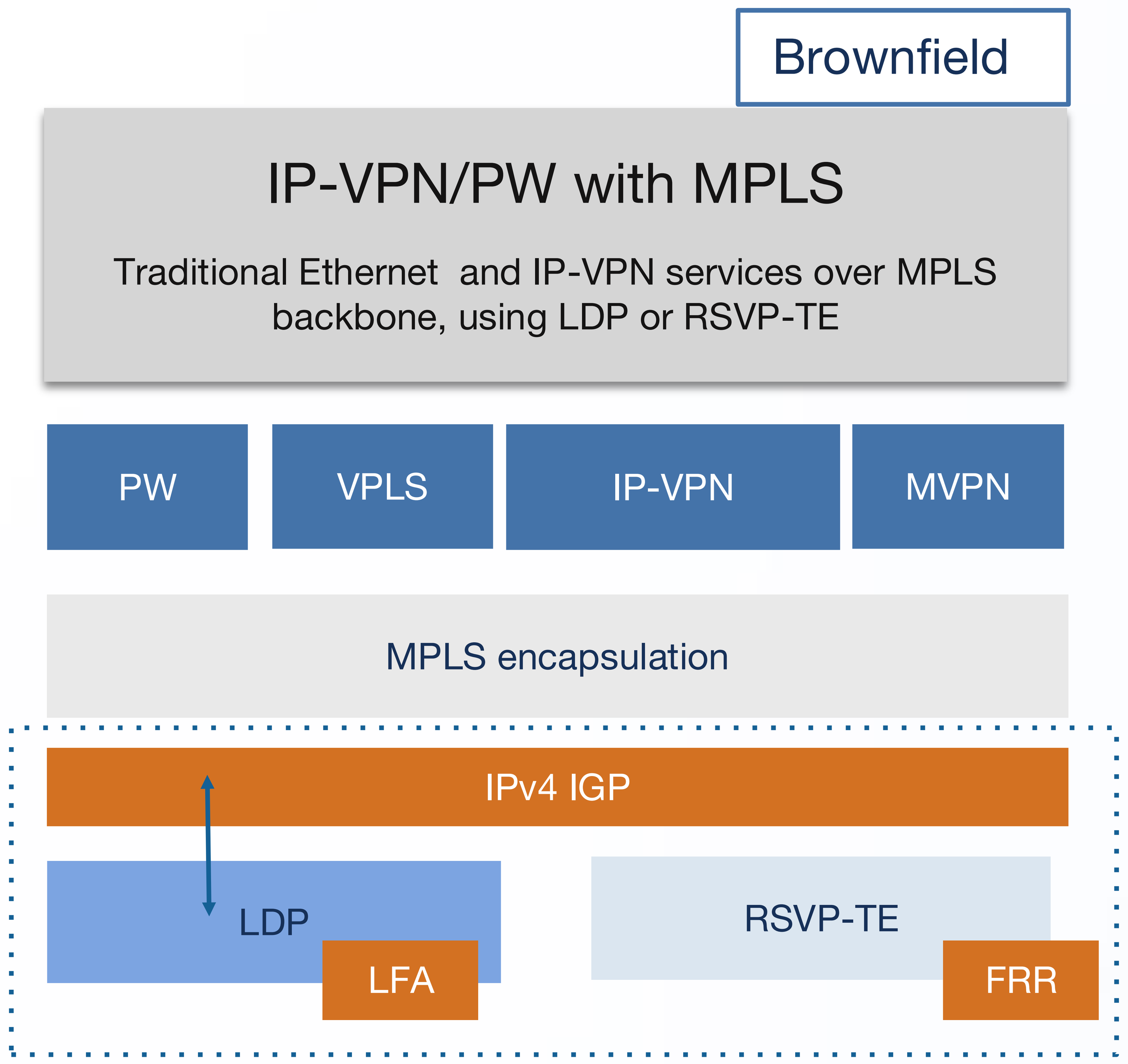
Picking the correct transport for the use cases is critical…

- Market adoption : Segment Routing in combination with EVPN/IP-VPN/L2VPN
- Overlay requirement : L2/L3
- Traffic Engineering: Yes as BW is not freely available
- Service stitching: Yes to the DC
- Cost: feature rich and high BW platforms

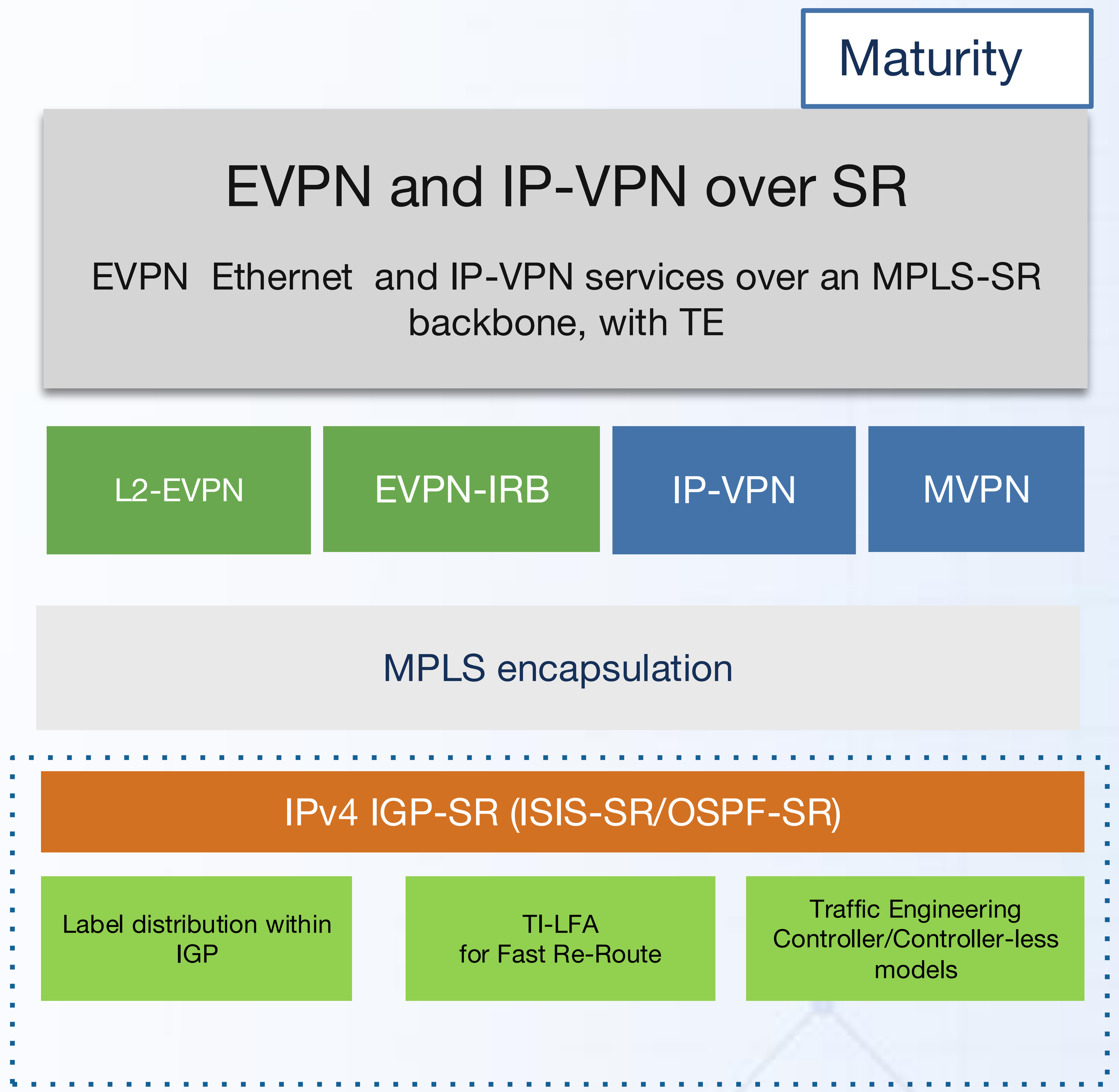
SR strategic direction for transport simplification

General trend across the industry (Operators and Enterprise) is to simplify

Protocol and state reduction to simplify operations and scale



Traditional VPN and MPLS deployment model



Mature/Moden software and deployment models

New problems to solve ?

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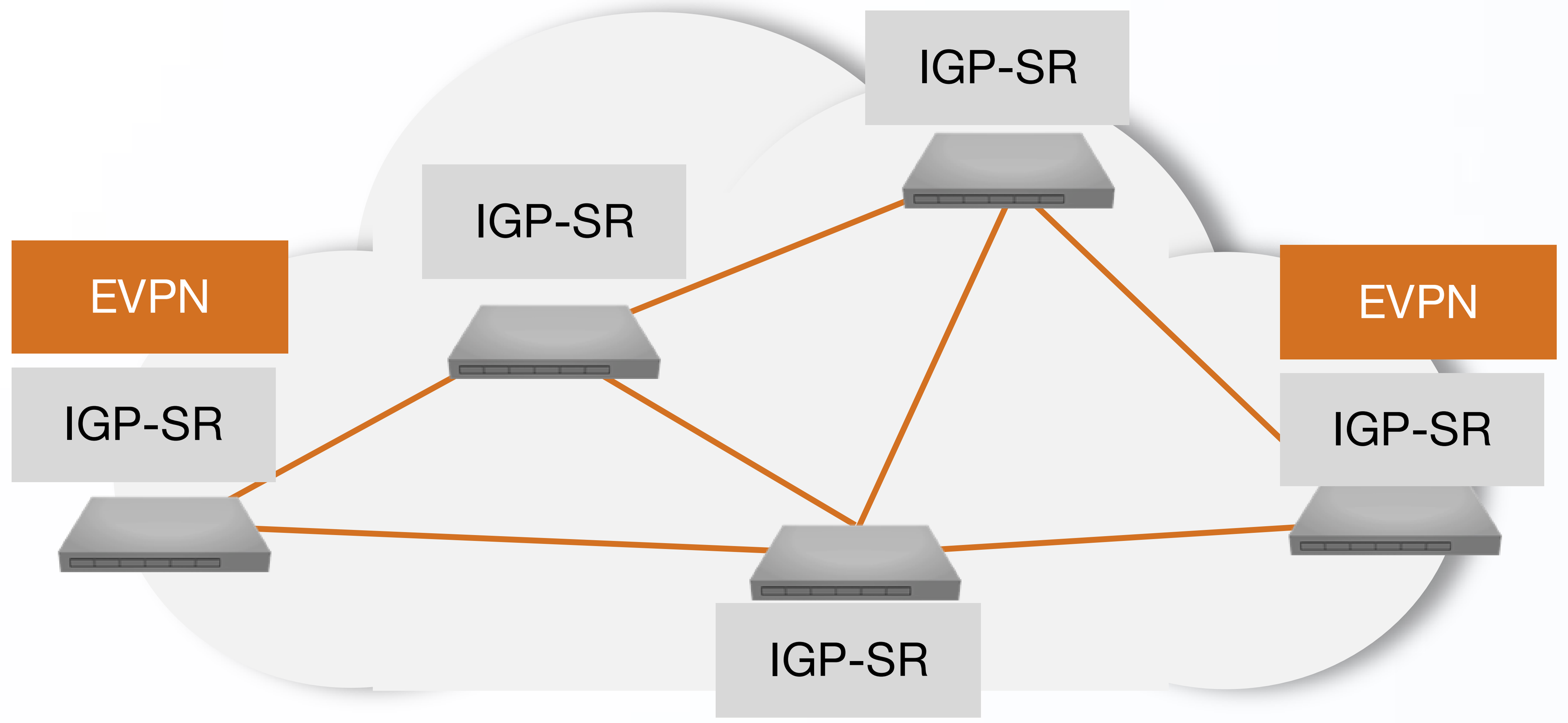
MPLS-SR

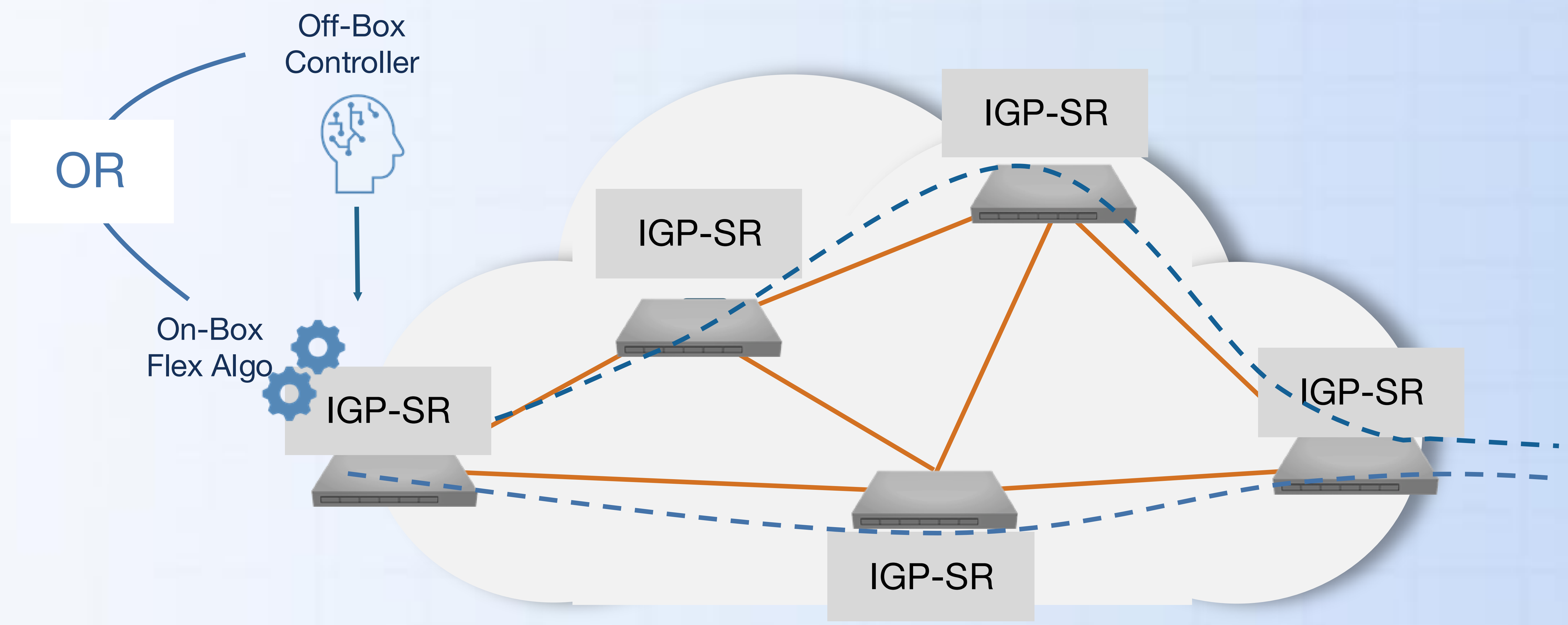
Segment Routing
Non–Traffic Engineering Applications



- Re-use the IGP for SID distribution
- Protocol reduction no need for LDP and IGP-sync
- Fast reroute capability (50ms) with TI-LFA
- Native ECMP and Anycast capabilities

✓ **ISIS-SR TI-LFA** ✓ **OSPF-SR TI-LFA**

Segment Routing
Traffic Engineering Applications



- Replacement of stateful RSVP-TE solutions
- Macro Traffic Engineering with FlexAlgo (Controller-less)
- Micro Traffic Engineering with Controller-based solutions
- Simplification with improved scale due to reduction of state
- Full coverage of SP and Enterprise use cases

✓ **Static SR-TE** ✓ **FlexAlgo** ✓ **Dynamic SR-TE** ✓ **BGP SR-TE policies** **. . .**

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Simplification with SR

Segment Routing

Alternative

SR-MPLSv4

Maturity

- SR SID programmed as an MPLS label
- Re-use existing MPLS IPv4 forwarding plane
- Re-use existing MPLS capable hardware
- Re-use existing BGP (label) control-plane
- Simplified Migration path no forklift upgrade

Pros: Incremental learning curve with no platform change

BGP EVPN
IGPv4-SR
MPLS

SR-MPLSv6

incremental migration

- SR SID programmed as an MPLS label
- Re-use existing MPLS capable hardware
- Upgrade to a new IPv6 forwarding plane
- Re-use existing BGP (Label) control-plane
- Minimal HW platform change

Pros: Incremental change to support IPv6 underlay buy may require HW upgrade

BGP EVPN
IGPv6-SR
MPLS

SRv6

Evolving

- SR uSID programmed in the IPv6 Dest Address
- Likely to require a hardware platform upgrade
- New BGP control-plane to support uSID
- Native support for a IPv6 forwarding plane

Pros: Support IPv6 underlay, potential for large scale and service chaining

BGP EVPN
IGP-SRv6

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Routing - SRv6 General use case

The general use case will be a next-gen SRv6 replacement of MPLS VPNs

Replacement of an existing MPLS or MPLS-SR backbone

SRv6 Deployment model

Greenfield

- New end-to-end build out or dedicated parallel deployment - Greenfield
- No migration or interop concerns for services or transport.
- HW purchased specifically for it's SRv6 capability

Brownfield

Common model

- Migration of an existing MPLS or MPLS-SR – Brownfield
- Requirement for MPLS/MPLS-SR to co-exist and interop with SRv6 for a period of time
- HW will be a mix of existing and new HW platforms, both being required to support SRv6

Inter-Domain working

- New SRv6 domain level build out
- Requirement for the SRv6 domain to interop with legacy MPLS/MPLS-SR domain
- New HW purchased specifically for the SRv6 domain but a need for a Service GWs interop between domains

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Why Do We Need EVPN Gateways?

- Scaling limits in large EVPN fabrics lead to excessive control-plane state
- Fault containment is harder in flat, single-domain EVPN topologies
- Service continuity demands seamless L2/L3 VPN across multiple domains or sites
- Hybrid interconnects (VXLAN ↔ MPLS) require translation and encapsulation at domain boundaries

Standards That Define EVPN Gateways

- The IETF BESS Working Group has defined a number of RFCs and drafts that govern EVPN gateway behaviour. These standards enable:
  - Support for both Layer 2 (Type-2 and Type-3) and Layer 3 (Type-5) DCI solutions
  - Interoperability across different BGP address families and control planes
  - Data-plane encapsulation interworking between VXLAN and MPLS

Draft	Overview
A Network Virtualization Overlay Solution using EVPN **RFC 8365**	EVPN control plane for L2 VPNs with an NVO environment with VXLAN, NVGRE and GENEVE encap– DCI using GWs and DCI using ASBRs
EVPN and IP-VPN Integrated Solution **draft-ietf-bess-evpn-ipvpn-interworking**	Layer 3 DCI interop between EVPN-VXLAN/MPLS and IP-VPN WAN for layer 3 DCI
Multi-site EVPN based VXLAN using Border Gateways **draft-sharma-bess-multi-site-evpn**	GW DCI solution focused only on EVPN-VXLAN, support for a single control planes (EVPN) and single data-plane (VXLAN)
Interconnect Solution for EVPN Overlay networks **RFC 9014**	EVPN GW solution for L2 interconnecting of multiple control planes (VPLS/EVPN) and data-planes (MPLS, VXLAN, PBB)
EVPN multicast forwarding for EVPN to EVPN GWs **draft-rabnic-bess-evpn-mcast-eeg**	EVPN GW solution for providing seamless multicast interconnect between EVPN domains, across VXLAN and MPLS data-planes
Domain Path (D-PATH) for Ethernet VPN (EVPN) Interconnect Networks **draft-sr-bess-evpn-dpath**	D-path community for EVPN routes to provide loop-free route advertisement between EVPN domains for layer 2.

L3 GW solution

Industry adopted L2 solution

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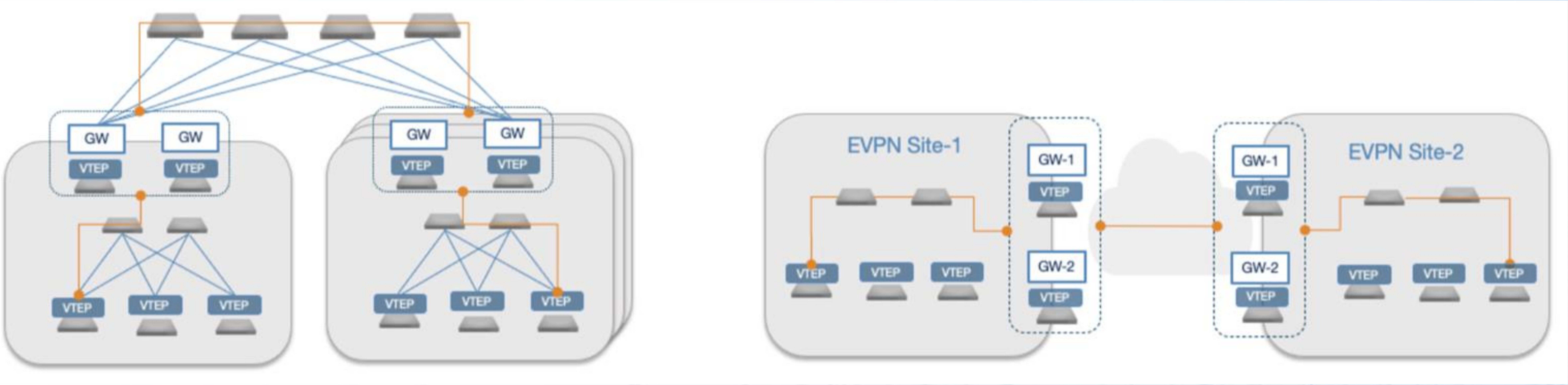
Real-World EVPN Gateway Use Cases

Intra-DC POD Interconnect

- Interconnects multiple EVPN PODs within a single data centre
- Improves scalability by limiting EVPN state to local PODs
- Enhances fault isolation and simplifies control plane convergence

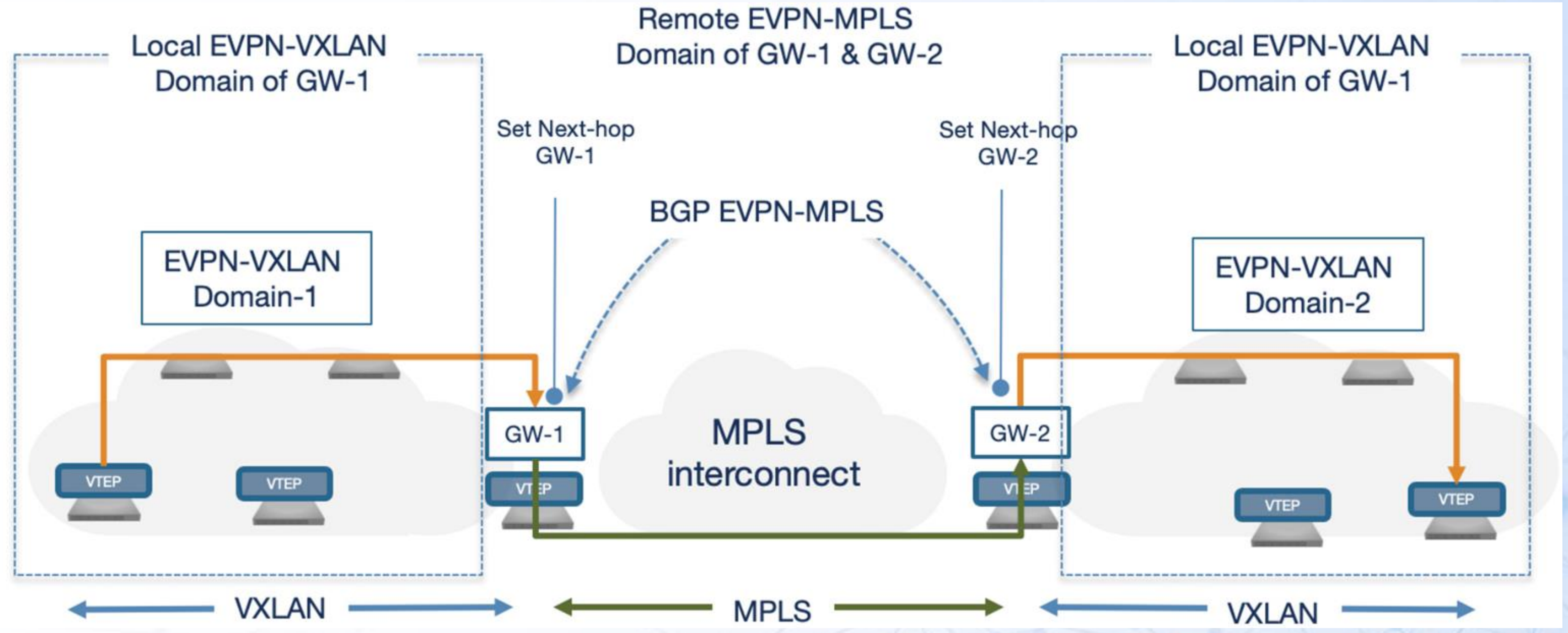
Data Center Interconnect (DCI)

- Seamless L2/L3 VPN connectivity between geographically dispersed sites
- Works over both IP and MPLS backbones
- Enables active-active multi-site designs with local gateway functionality



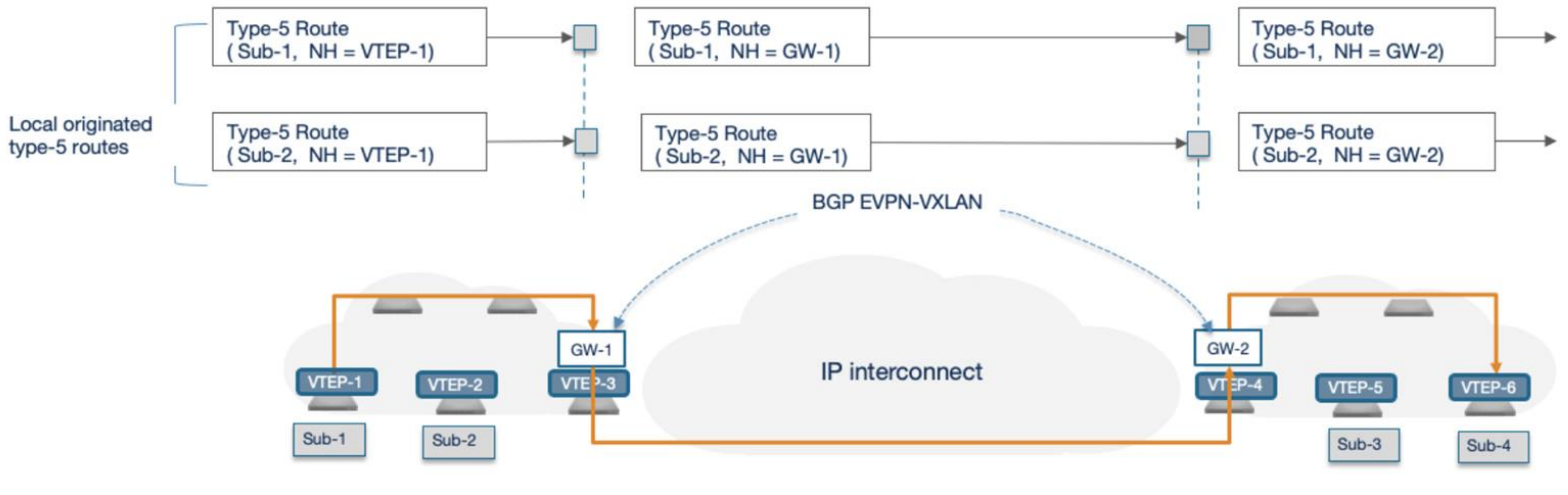
EVPN Gateway: VXLAN ↔ MPLS Interworking

- Used when interconnecting EVPN-VXLAN domains across an MPLS backbone
- Gateway performs control and data-plane translation between VXLAN and MPLS
- EVPN-MPLS routes use VPN and LSP labels; VXLAN routes use VNIs
- Type-2 and Type-5 routes are re-advertised across domains with appropriate encapsulation and next-hop
- Type-1, 3, and 4 routes remain local to each domain
- Supports both Layer 2 bridging and Layer 3 routing between VXLAN and MPLS environments



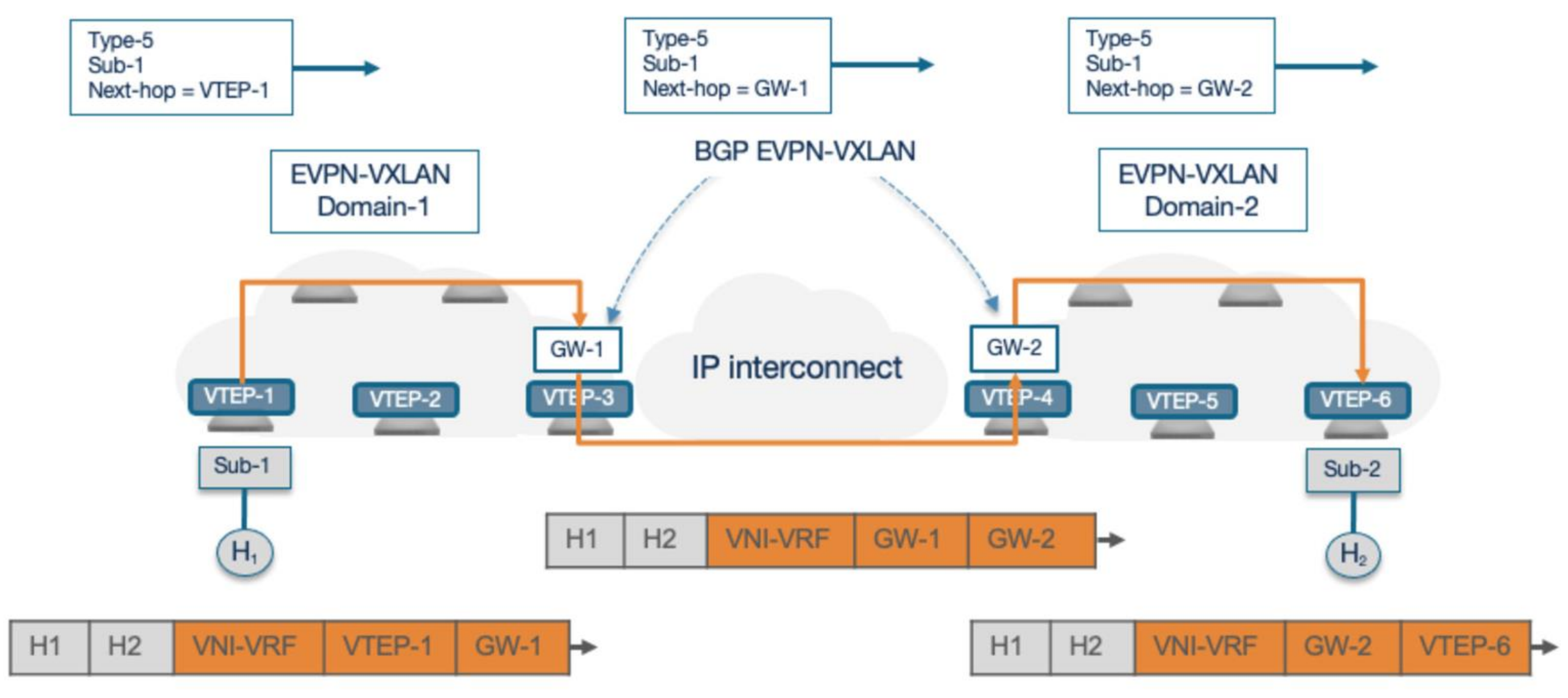
GW Control Plane Operations (Layer 3 Example)

- VTEP advertises a Type-5 (IP prefix) route with its own IP as next-hop
- Local gateway imports the route and re-advertises it to the remote gateway with its own IP as next-hop
- Remote gateway re-advertises the route into its local domain using its own IP as next-hop
- Only gateways require end-to-end IP reachability between domains
- Leaf nodes learn next-hops for local nodes and their local gateway only



GW Data Plane Operations (VXLAN-VXLAN Example)

- Traffic from Host-1 is routed by its local VTEP to the local gateway
- Gateway performs a VXLAN decapsulation and L3 route lookup
- Packet is re-encapsulated in VXLAN and forwarded to the remote gateway
- Remote gateway decapsulates, routes the packet, and re-encapsulates for delivery to destination VTEP
- Destination VTEP removes VXLAN and forwards to Host-2



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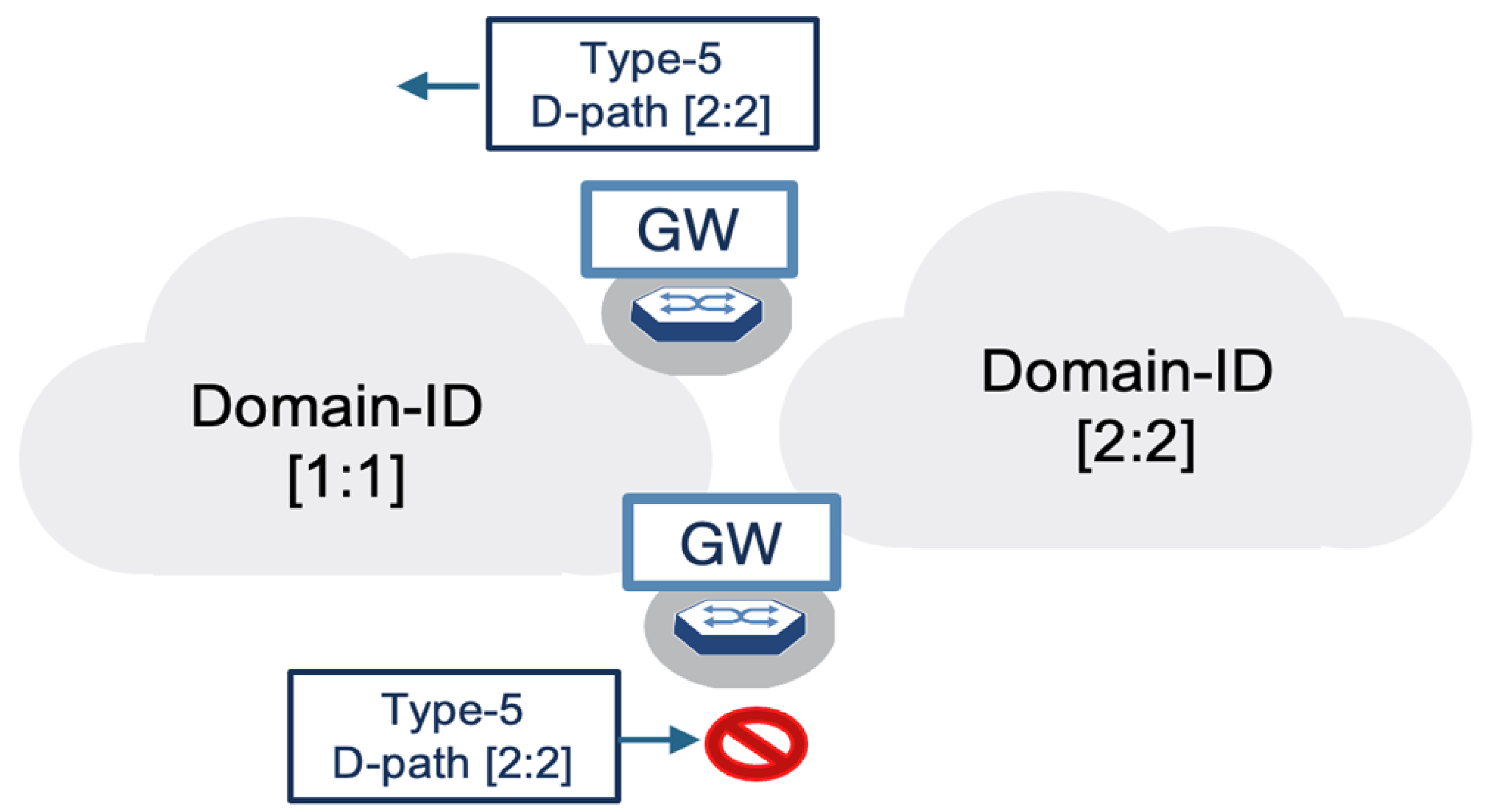
Confidential.

Gateway Enhancements

Domain Path (D-PATH)

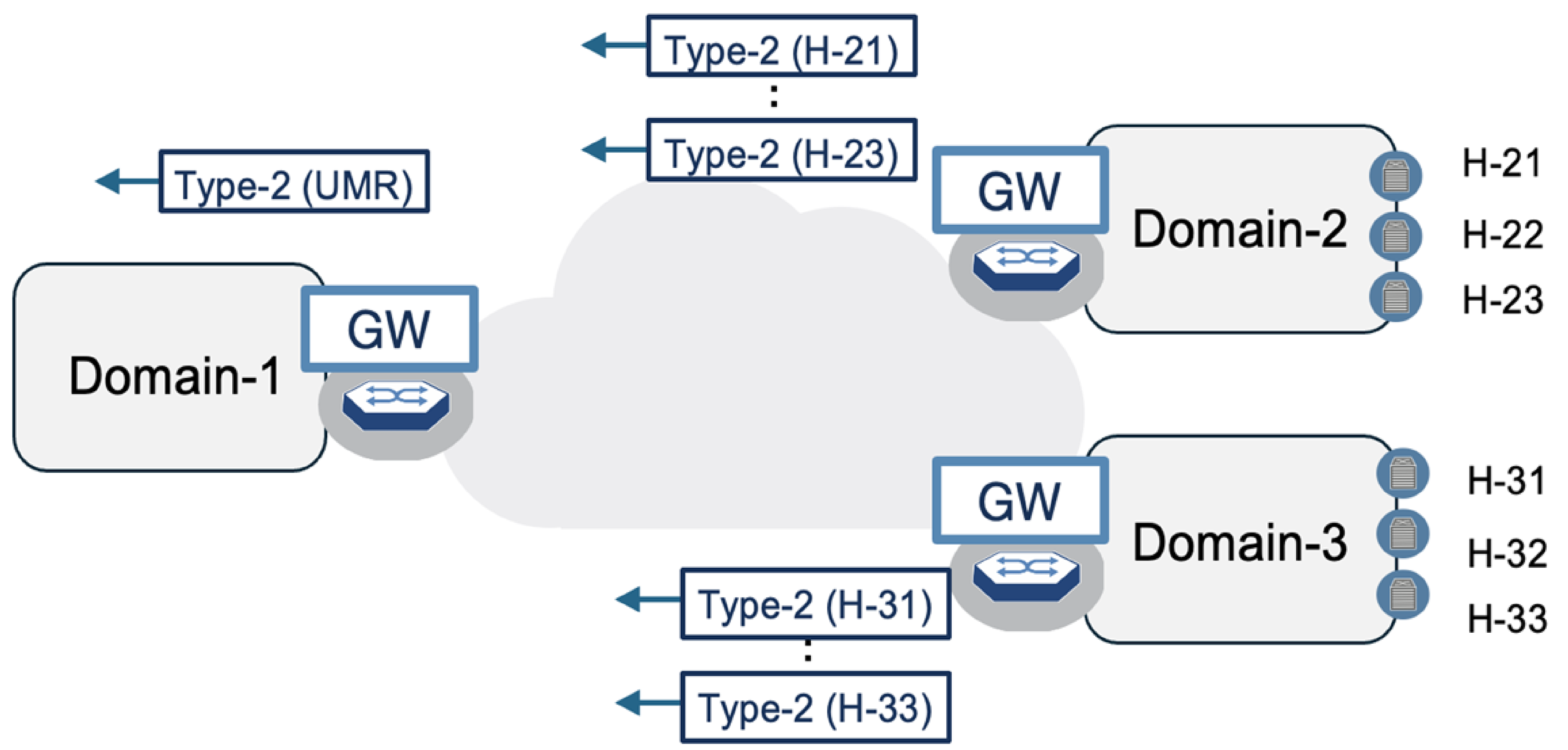
Loop avoidance in EVPN gateway deployments



- Domain Path (D-PATH) BGP attribute is optional and transitive
- Prevents EVPN/IPVPN route loops by tagging routes with source domain ID
- Gateways do not re-advertise routes containing their own domain ID in D-PATH
- Enables control-plane loop prevention across inter-domain mesh

Unknown MAC Route (UMR)

Enables MAC-scale efficiency while preserving correct forwarding

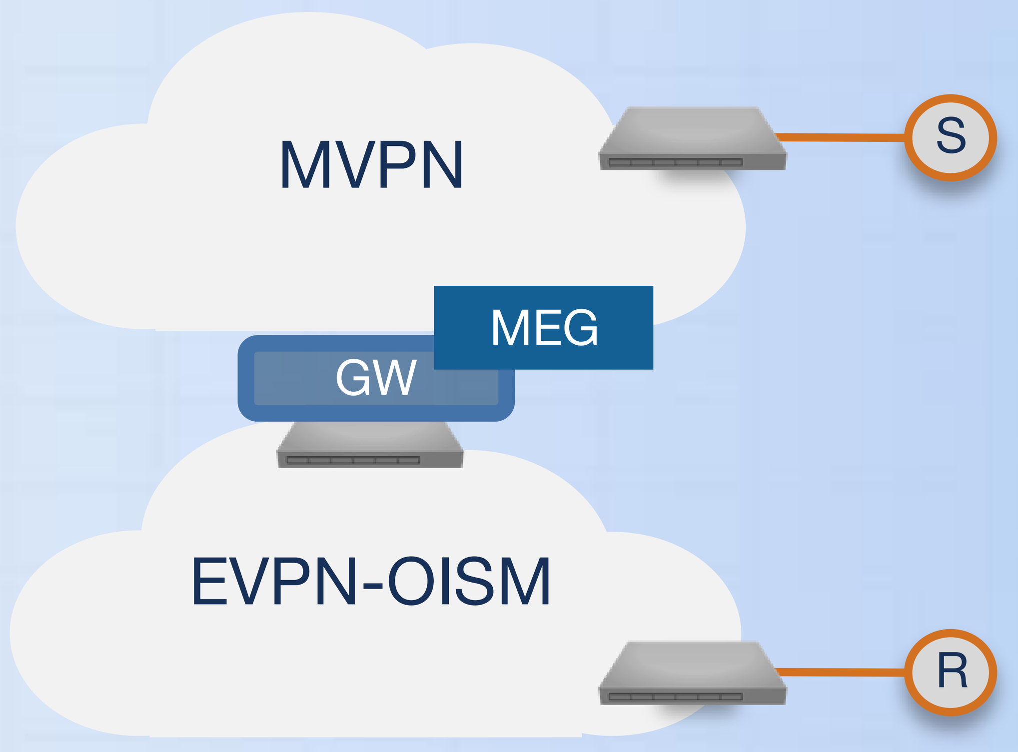


- Unknown MAC Route (UMR) is a special EVPN MAC route with MAC=0 and ESI set to gateway
- Used to reduce MAC scale in multi-domain/DC EVPN, avoiding flooding full MAC tables
- Leaf VTEPs forward unknown traffic to gateway instead of flooding
- Gateway may selectively inject real MAC routes to handle MAC mobility

Future

MVPN–EVPN Gateway (MEG)

Facilitates interworking between MVPN and EVPN OISM domains

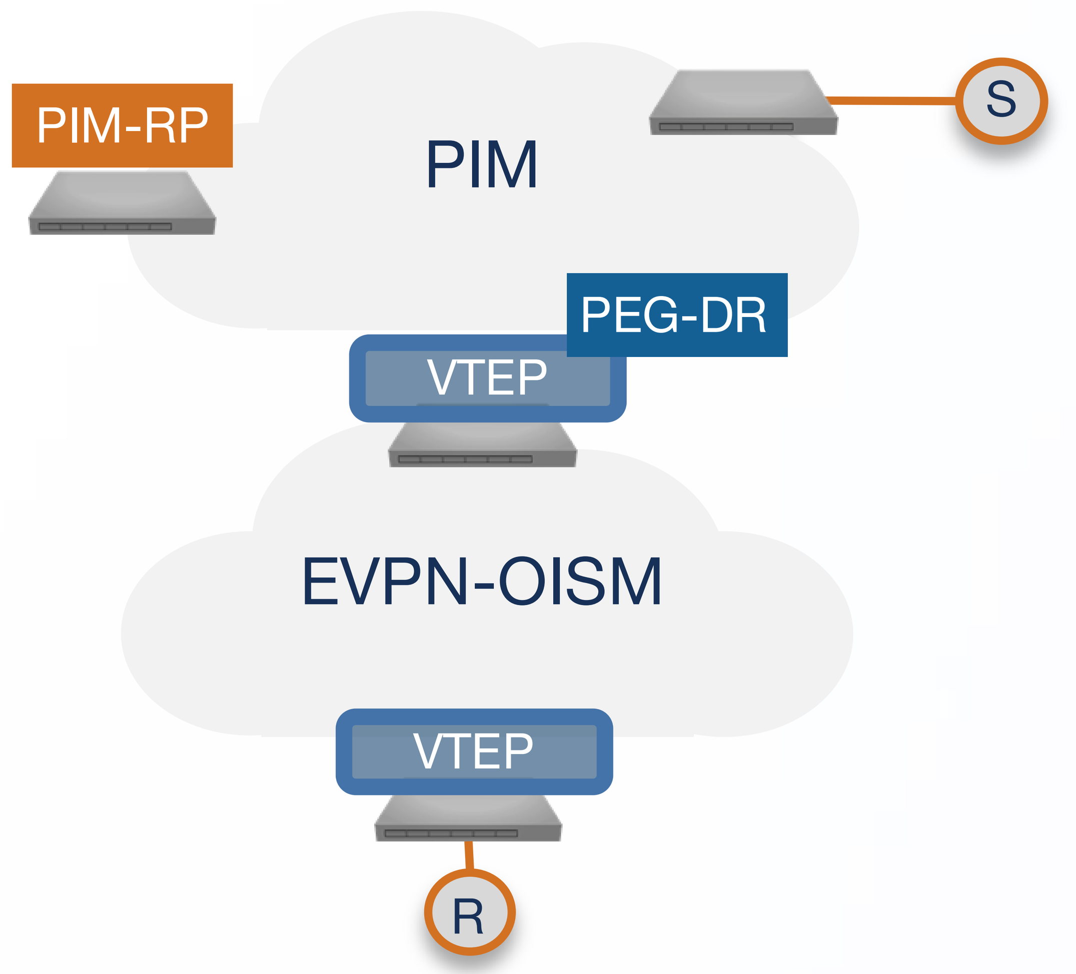


- Translates EVPN route types (e.g. Type 7 for Join, Type 8 for Leave) into equivalent MVPN route types, and vice versa

Completing the Picture: Multicast Joins the Party

PIM EVPN Gateway (PEG)

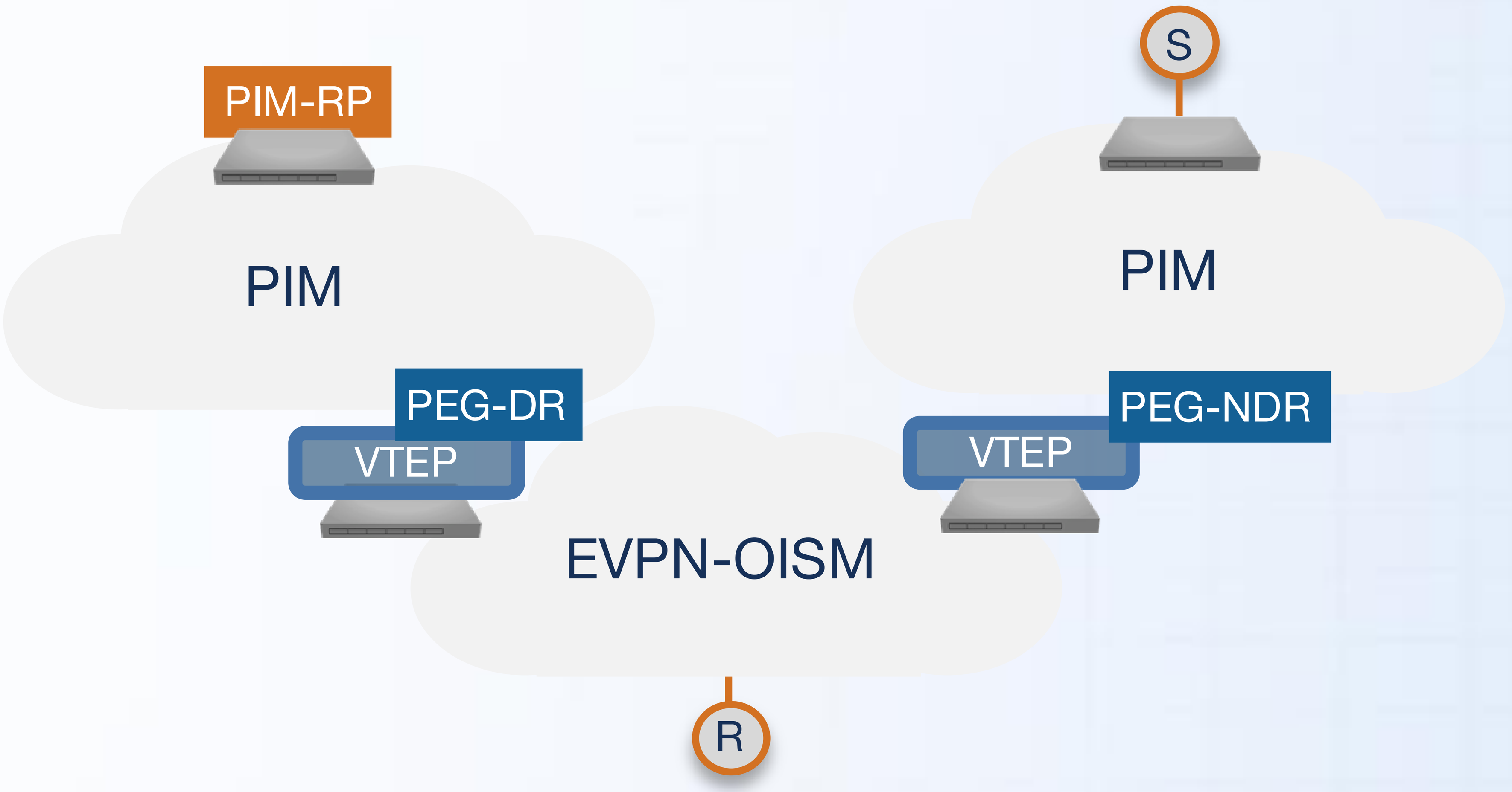
Provide connectivity to external sources and receivers outside of the EVPN OISM domain



- Provide multicast connectivity to external PIM sources and receivers
- PEG node acts as a GW between the EVPN and PIM domains
- Sending PIM joins/registers upstream to the RP or the source

PEG GW for Transit

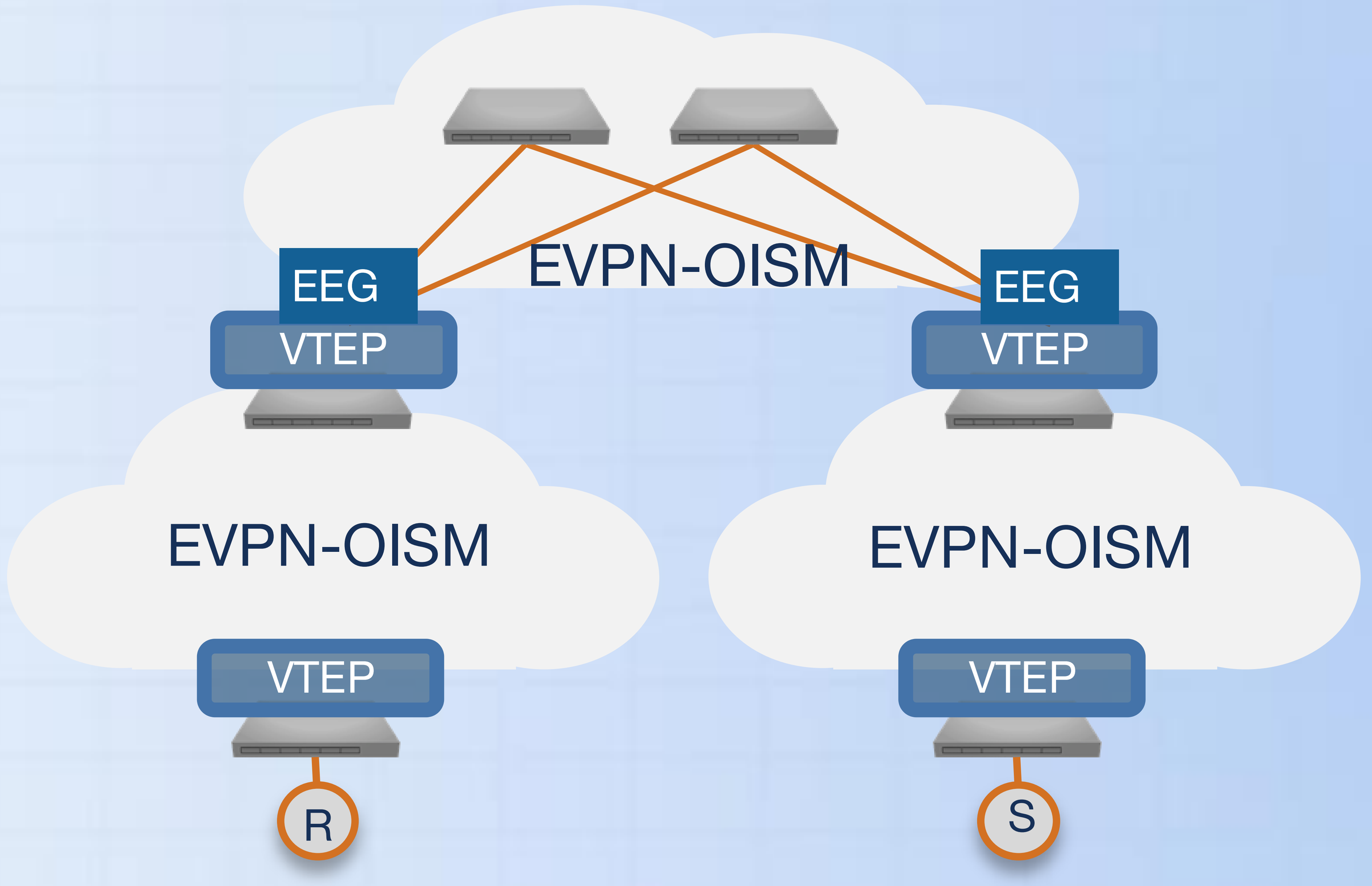
Provide connectivity to external sources and receivers when the connectivity to the PIM source or RP needs to transit the EVPN domain



- PIM domain is split between the EVPN domain
- Provide transit connectivity to both the Source and RP via the EVPN domain
- All PEG nodes are able to process and send PIM joins and registers

EVPN to EVPN GW (EEG)

Provide connectivity to sources and receivers in a different EVPN OISM domain



- Need OISM connectivity between EVPN domain via the EVPN GW
- EEG GW responsible for proxying SMET routes and OISM forwarding across EVPN domains
- GW provides seamless EVPN-VXLAN between domains

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Routing Strategy

Single Service Plane

EVPN end-to-end from the Campus to the Data Center, across the WAN or securely internet via SD-WAN

Single consistent end-to-end operational model for Service delivery – EVPN

- Open, standards, No vendor lock-in to prevent end-to-end connectivity
- Convergence of skill-set across` domains (WAN, Campus, DC) – Reduction, in OpEx cost
- Single operational model to troubleshoot, model and automate

Any Transport

Support for the appropriate, cost-effective transport. Campus, DC, WAN and SD-WAN

Connectivity agnostic, allowing appropriate transport layer for the use case

- Cost sensitive high bandwidth - Campus and DC – VXLAN
- Security sensitive WAN – VXLAN over IPSec
- Bandwidth, connectivity restrictive WAN – SR, SR-TE or SRv6 (future)

Future proof

Zero technology lock-in provides incremental upgrades to next-Gen solutions i,e, SRv6

Enables, incremental network upgrade without a lock-in

- Ability to change transport and service layer at the customer's pace
- No need for a big bang approach
- No vendor lock-in to prevent end-to-end connectivity

Thank You

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