# Cisco és Juniper eszközök együttműködése SRv6 alapú hálózati környezetben

Füstös Balázs
ACE Network

2025.11.13

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# Agenda

- ACENet
- Labor bemutatása
- SRv6 röviden
- Tesztek, tapasztalatok
  - Célkitűzések
  - Side note
  - Underlay rész
  - Overlay rész
    - L3VPN
    - L2VPN
  - Későbbi tervek

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# ACENet

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# ACE Network Zrt. (nem ACE telecom)

- A 4iG csoport multivendor hálózatos kompetencia központja
- 50 fő, masszív mérnöki hangsúllyal, 5+ CCIE
- Multivendor: Cisco, Aruba, Juniper, Arista, F5, Check-point, Palo-Alto
- Cisco Gold Integrator és Provider partner

**Specializations (12)**

- Advanced Collaboration Architecture Specialization
- Advanced SP Architecture Specialization
- Advanced Enterprise Networks Architecture Specialization
- Collaboration SaaS Specialization
- Customer Experience Specialization
- Environmental Sustainability Specialization
- Secure Access Service Edge Solution Specialization
- Hybrid Cloud Computing Solution Specialization
- Hybrid Cloud Networking Solution Specialization
- Hybrid Cloud Software Solution Specialization
- Extended Detection and Response Solution Specialization
- Secure Networking Solution Specialization

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4iG

# Lab bemutatása

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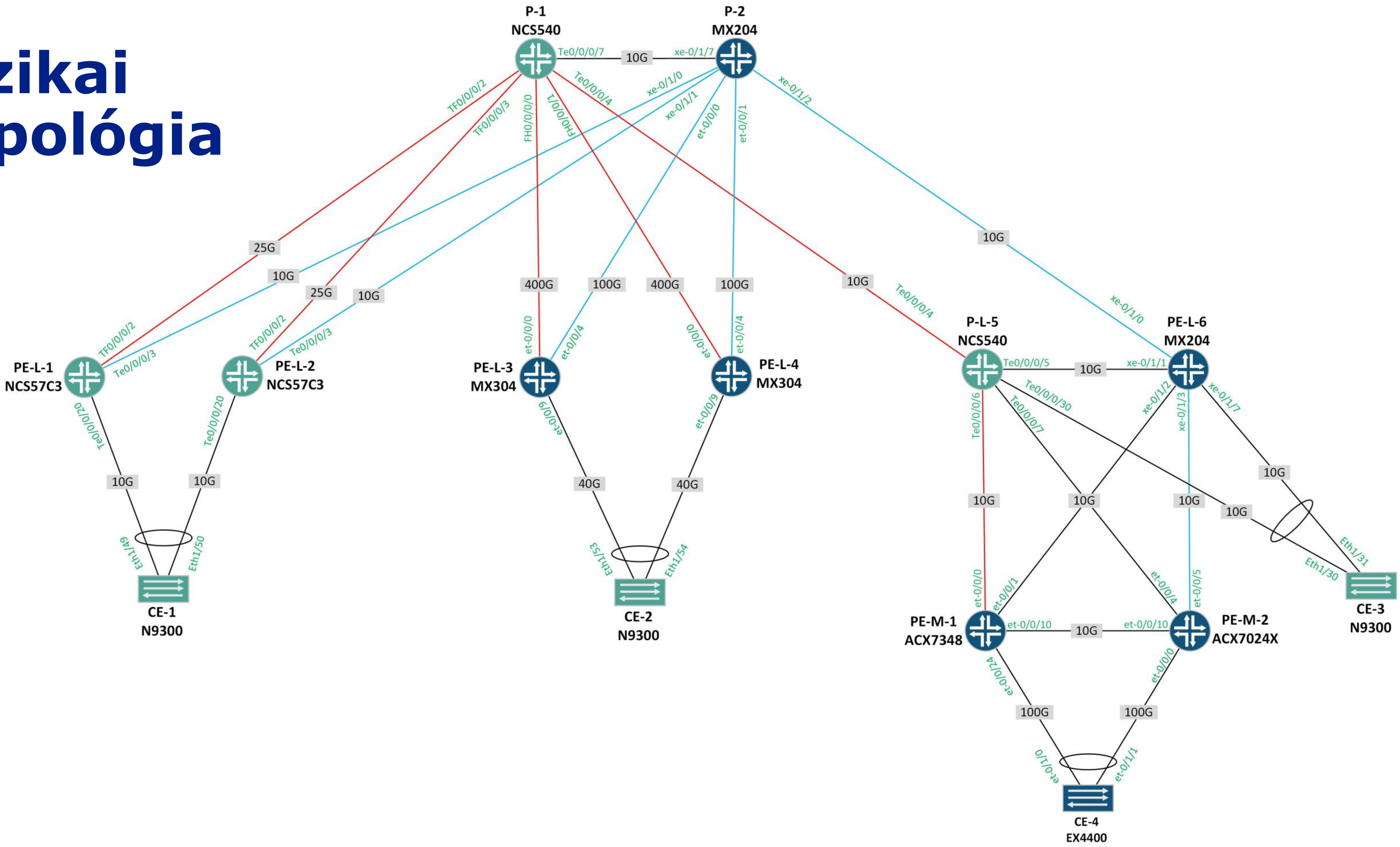
# Lab kialakulása

- Meglévő Cisco RON labor: NCS57C3, 400G Bright ZRP DCO, PLE

- Multi-vendor törekvések
  - SP területen a Juniper a másik erős versenyző. Partnerség, presales, mérnöki tudás megszerzése

- Konkrét projektek
  - PRO-M gerinchálózat konszolidáció tervezés
    - HBONE, MVMNet integráció
  - 2Connect
    - Vodafone, Digi, Invitech, AH integrációból létrejövő infra szolgáltató (InfraCo) vezetékes gerinchálózat tervezés, Low-Level Design
    - MPLS alapú együttműködés az elődhálózatok között
    - SRv6 az induláskor, minden új szolgáltatásra

# Fizikai topológia



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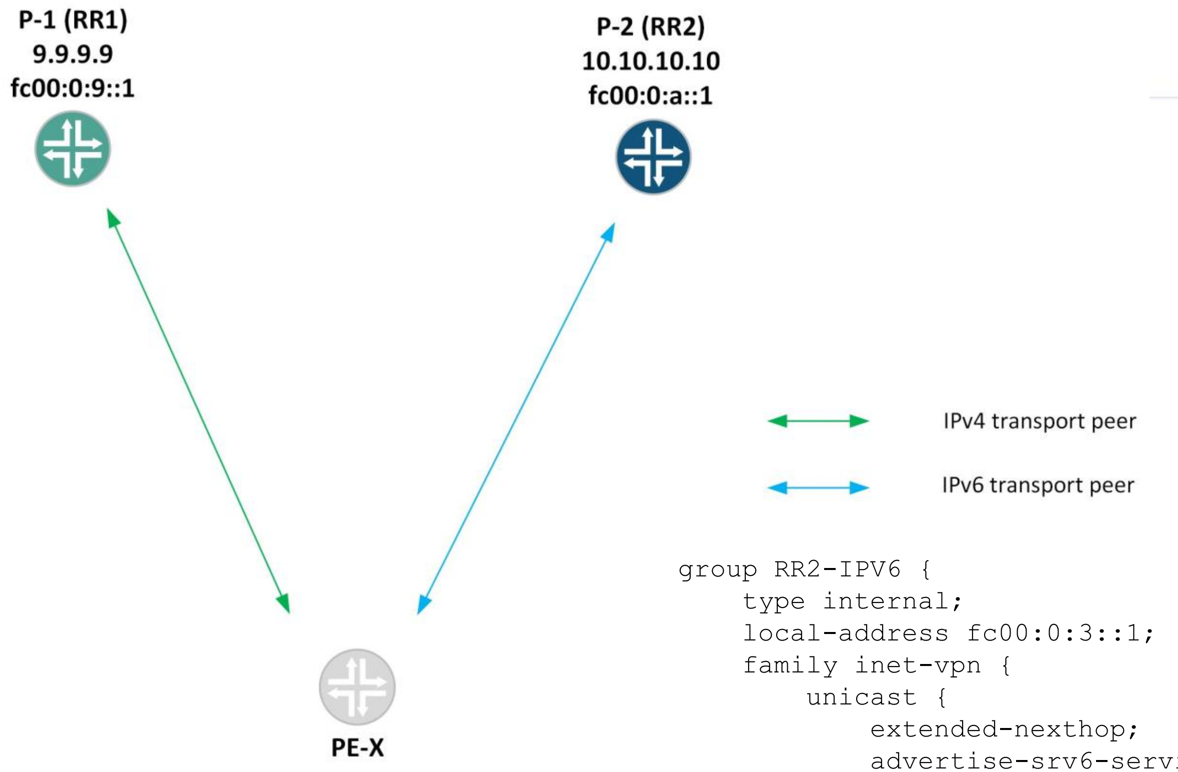
# Route Reflector

- Cisco MPLS labels
- Juniper SRv6 SIDs




```
neighbor-group RR2-IPV6
 remote-as 65000
 update-source Loopback0
 address-family vpnv4 unicast
  encapsulation-type srv6
 !
 address-family vpnv6 unicast
  encapsulation-type srv6
 !
 address-family l2vpn evpn
  encapsulation-type srv6
 !
!
neighbor fc00:0:a::1
 use neighbor-group RR2-IPV6
!
```

```
group RR2-IPV6 {
    type internal;
    local-address fc00:0:3::1;
    family inet-vpn {
        unicast {
            extended-nexthop;
            advertise-srv6-service;
            accept-srv6-service;
        }
    }
    family inet6-vpn {
        unicast {
            advertise-srv6-service;
            accept-srv6-service;
        }
    }
    family evpn {
        signaling {
            advertise-srv6-service;
            accept-srv6-service;
        }
    }
    peer-as 65000;
    neighbor fc00:0:a::1
}
```

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# Inventory

MX:

Trio ASIC
JunOS 25.2R1.9

ACX:

Broadcom ASIC
JunOS 24.2R2.16-EVO

NCS:

Broadcom ASIC
IOS-XR 25.3.1

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PE-L-3: MX304
MRATE LMIC 16x100G/4x400G

PE-L-4: MX304
MRATE LMIC 16x100G/4x400G

PE-L-6: MX204

P-2: MX204

PE-M-1: ACX7348

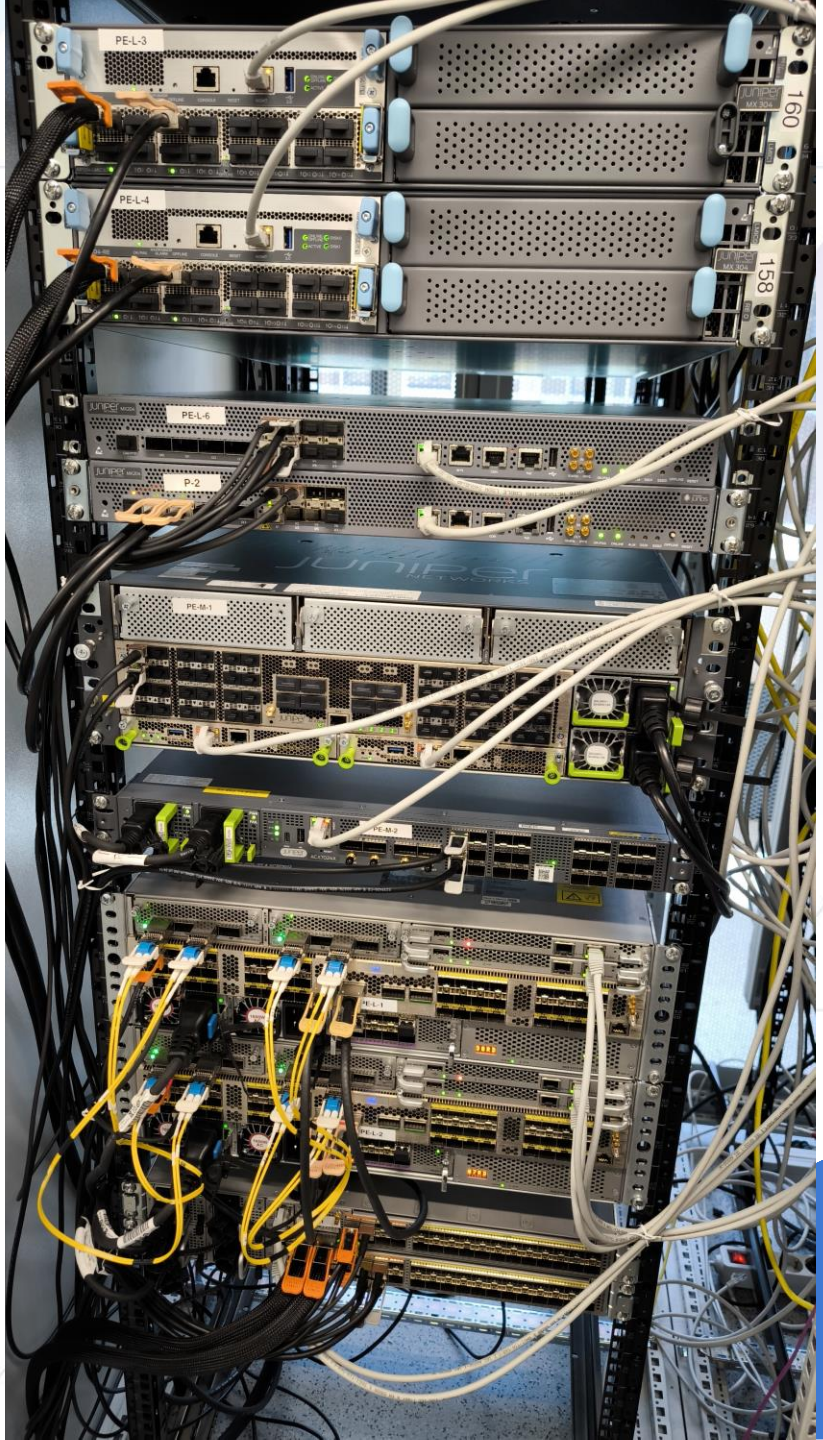
PE-M-2: ACX7024X

PE-L-1: NCS-57C3-MODS-SYS
NC57-MPA-2D4H-S

PE-L-2: NCS-57C3-MODS-SYS
NC57-MPA-2D4H-S

P-1: N540-24Q8L2DD-SYS

PE-L-5: N540-24Q8L2DD-SYS



# SRv6 röviden

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# SRv6

- 2023: Segment Routing IPv6 — avagy élet az MPLS után
  [Szabó Gábor – Cisco Systems]

- Segment (Source) Routing funkció MPLS dataplane helyett, IPv6 dataplane-nel. Lehetnek olyan hálózatrészek amelyek csak natív IPv6 routingot támogatnak.

- Any Service: Underlay, overlay VPNs, TE, FRR, NFV service-chaining

- Any Domain: Access, metro, core, DC, campus közös underlay technológia (lehet majd valamikor…)

# SRv6 – „problémák”

## HW támogatás

- Segment routing header
- uSID támogatás, address shifting

## Service szempontból

- SR-MPLS csak transport: ugyanazok a service-ek változtatás nélkül használhatók
- SRv6: Endpoint, Headend behavior határozza meg a service működését, vagyis minden service-nek egyesével támogatnia kell az SRv6 feletti működést

# Tesztek, tapasztalatok

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# Side note

- Aktuális állapotot, tapasztalatokat mutatjuk be
- Nem minősítünk gyártót, technológiát
- Az út elején járunk, minden ami elhangzik fenntartásokkal kezelendő…


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# Célkitűzések

- IPv4 + LDP legacy setup mellett próbálunk ki minden SRv6 funkciót. (LDP, SRv6 dual-stack)

- Párhuzamosan próbálunk haladni és mélyebbre menni több területen
  - Underlay működés
  - Overlay service-ek
  - SR-TE

- Junos magabiztosság megszerzése

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# Underlay

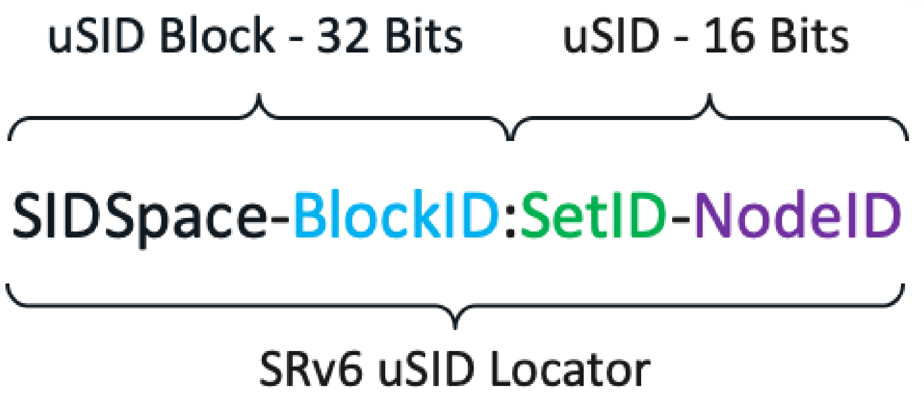
- LOCATOR: /48
  - 1 locator
  - Flex-Algo virtuális

  laborban már teszteltük: OK

- uSID
  - F3216 mindkét vendornál: OK

- Loopback a LOCATOR része

- Single area IS-IS

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# L3VPN

- VPNv4 (inet-vpn), VPNv6 (inet6-vpn) AFI
  - IPv4/IPv6 dual-stack a VPN-en belül

- Dual-connected PE: MPLS LDP és SRv6 data-plane vegyesen
  - 1 Cisco: MPLS LDP
  - 1 Juniper: MPLS LDP
  - 1 Cisco: MPLS LDP + SRv6 (uDT4 és uDT6 endpoint behavior)
  - 1 Juniper: MPLS LDP + SRv6 (uDT4 és uDT6 endpoint behavior)

- A cél a full connectivity az SRv6 preferelásával, migrációs scenario

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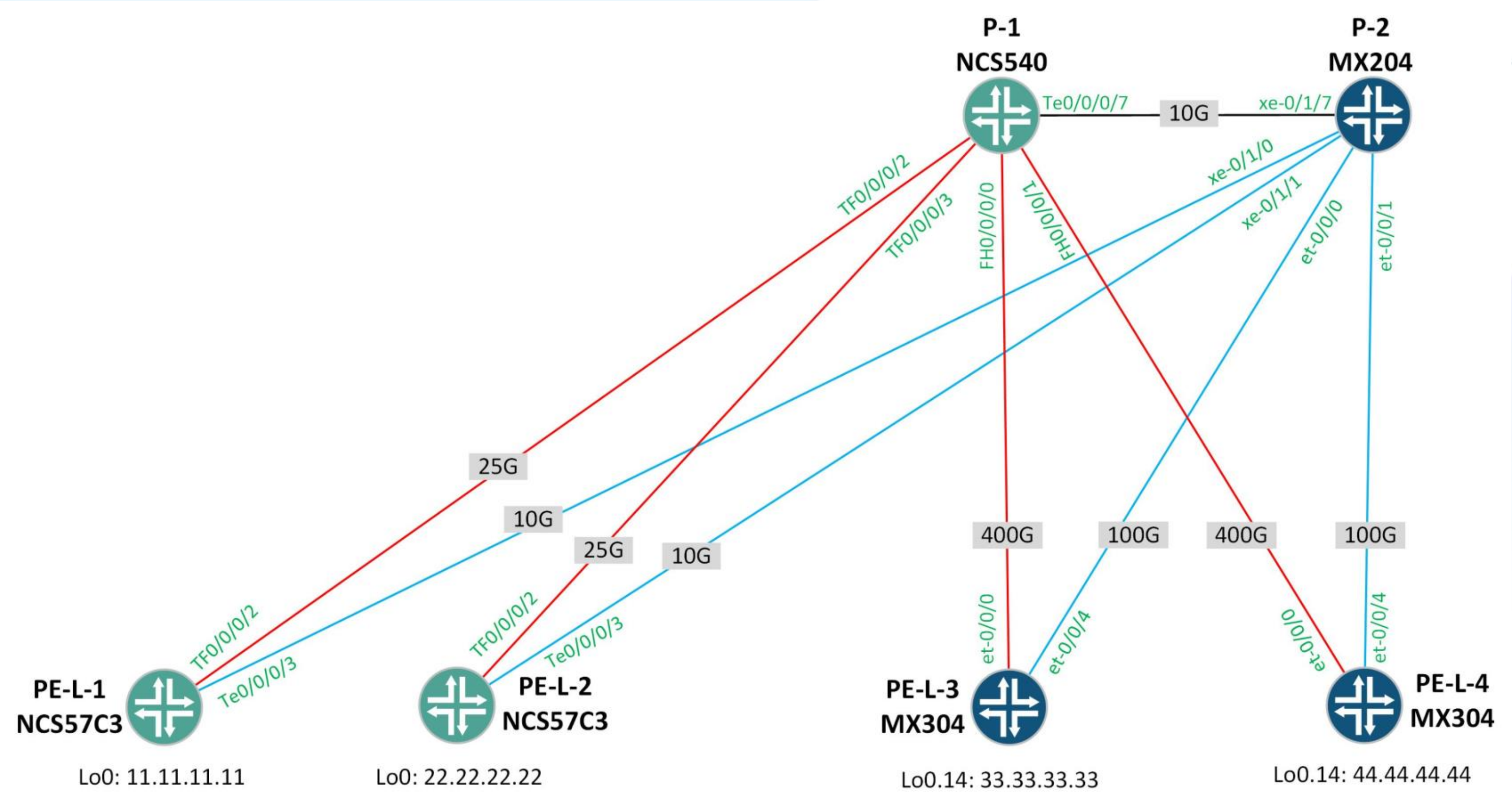
# L3VPN

## SRv6 preferencia:

- RR2 minden bejövő route set loc-pref 200




| PE-L-1 | PE-L-2 | PE-L-3 | PE-L-4 |
|---|---|---|---|
| LDP<br>RR1-IPv4 | LDP + SRv6<br>RR1-IPv4<br>RR2-IPv6 | LDP<br>RR1-IPv4 | LDP + SRv6<br>RR1-IPv4<br>RR2-IPv6 |

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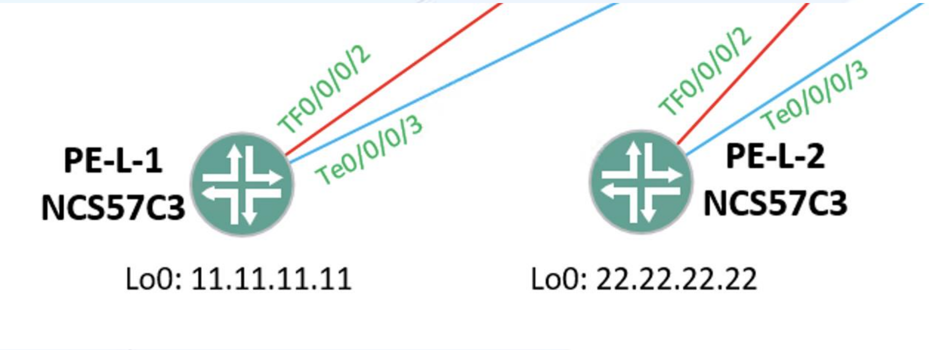
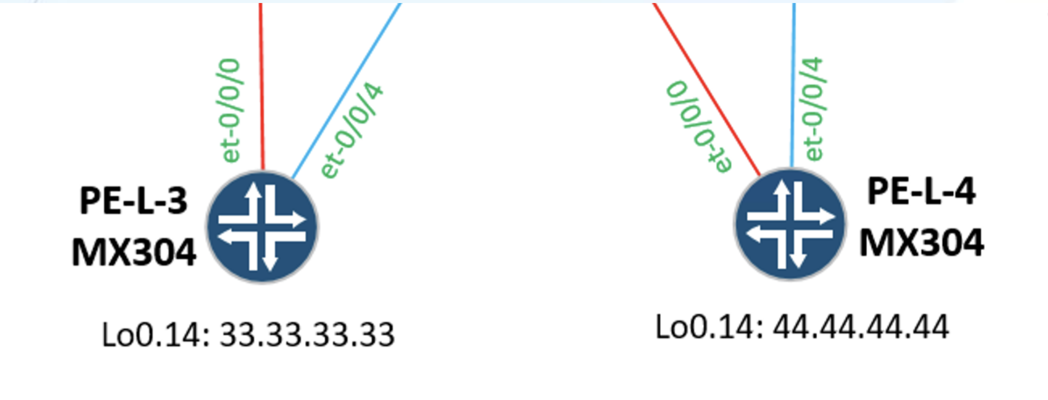



```
router bgp 65000
 vrf M
  rd 65000:4
  address-family ipv4 unicast
   mpls alloc enable
   label mode per-vrf
   redistribute connected route-policy RP-PERMIT
   redistribute static route-policy RP-PERMIT
  !
  address-family ipv6 unicast
   mpls alloc enable
   label mode per-vrf
   redistribute connected route-policy RP-PERMIT
   redistribute static route-policy RP-PERMIT
  !
 !
!
```

```
router bgp 65000
 vrf M
  rd 65000:4
  address-family ipv4 unicast
   mpls alloc enable
   label mode per-vrf
   segment-routing srv6
    locator ALGO0
    alloc mode per-vrf
   !
   redistribute connected route-policy RP-PERMIT
   redistribute static route-policy RP-PERMIT
  !
  address-family ipv6 unicast
   mpls alloc enable
   label mode per-vrf
   segment-routing srv6
    locator ALGO0
    alloc mode per-vrf
   !
   redistribute connected route-policy RP-PERMIT
   redistribute static route-policy RP-PERMIT
  !
 !
!
```




```
routing-instances {
    M {
        instance-type vrf;
        interface lo0.14;
        route-distinguisher 65000:4;
        vrf-target {
            import target:65000:4;
            export target:65000:4;
        }
    }
}
```

```
routing-instances {
    M {
        instance-type vrf;
        protocols {
            bgp {
                source-packet-routing {
                    srv6 {
                        locator ALGO0 {
                            micro-dt4-sid;
                            micro-dt6-sid;
                        }
                    }
                }
            }
        }
        interface lo0.14;
        route-distinguisher 65000:4;
        vrf-target {
            import target:65000:4;
            export target:65000:4;
        }
    }
}
```

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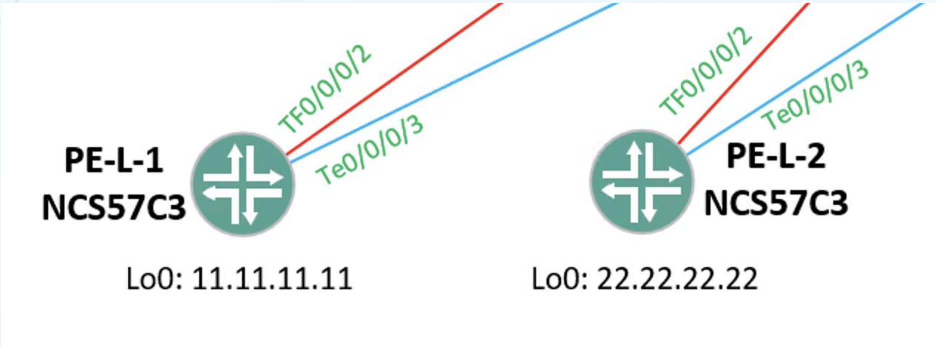


```
RP/0/RP0/CPU0:PE-L-1#show ip cef vrf A 22.22.22.22/32
…
   via 2.2.2.2/32, 7 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x9516b548 0x0]
    recursion-via-/32
    next hop VRF - 'default', table - 0xe0000000
    next hop 2.2.2.2/32 via 24009/0/21
     next hop 10.0.0.0/32 TwentyFiveGigE0/0/0/2 labels imposed {24013 24027}
     next hop 10.0.0.10/32 TenGigE0/0/0/3 labels imposed {20 24027}

    Load distribution: 0 (refcount 1)

    Hash  OK  Interface                 Address
    0     Y   recursive                 24009/0
```

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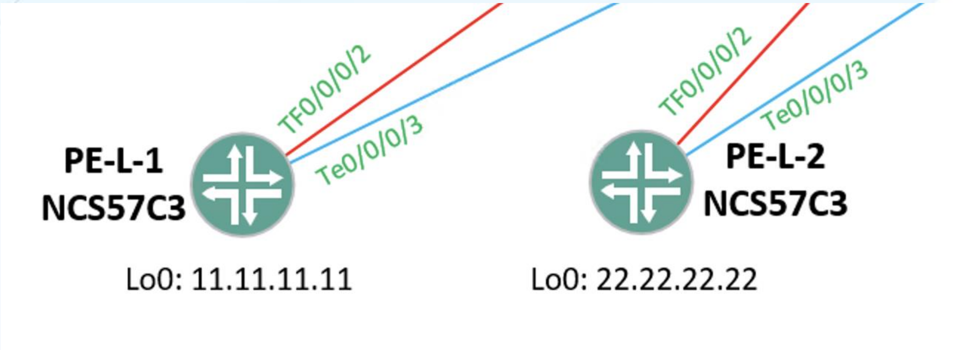


```
RP/0/RP0/CPU0:PE-L-2#show ip cef vrf M 11.11.11.11/32
…
   via 1.1.1.1/32, 9 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x9526b3e8 0x0]
    recursion-via-/32
    next hop VRF - 'default', table - 0xe0000000
    next hop 1.1.1.1/32 via 24009/0/21
     next hop 10.0.0.2/32 TwentyFiveGigE0/0/0/2 labels imposed {24006 24028}
     next hop 10.0.0.12/32 TenGigE0/0/0/3 labels imposed {19 24028}

    Load distribution: 0 (refcount 1)

    Hash  OK  Interface                    Address
    0     Y   recursive                    24009/0
```

```
RP/0/RP0/CPU0:PE-L-2#show ip cef vrf M 44.44.44.44/32
…
   via fc00:0:4::/128, 7 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x93d99a90 0x0]
    next hop VRF - 'default', table - 0xe0800000
    next hop fc00:0:4::/128 via fc00:0:4::/48
    SRv6 H.Encaps.Red SID-list {fc00:0:4:e006::}

    Load distribution: 0 1 (refcount 1)

    Hash  OK  Interface                    Address
    0     Y   TwentyFiveGigE0/0/0/2        fe80::361b:2dff:fec3:2815
    1     Y   TenGigE0/0/0/3               fe80::1e9c:8cff:fe1f:f838
```

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```
admin@PE-L-3> show route table M.inet.0

M.inet.0: 4 destinations, 4 routes (4 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

11.11.11.11/32     *[BGP/170] 20:30:04, MED 0, localpref 100, from 9.9.9.9
                      AS path: ?, validation-state: unverified
                    >  to 10.0.0.4 via et-0/0/0.0, Push 24028, Push 24006(top)
                       to 10.0.0.14 via et-0/0/4.0, Push 24028, Push 19(top)
22.22.22.22/32     *[BGP/170] 20:30:04, MED 0, localpref 100, from 9.9.9.9
                      AS path: ?, validation-state: unverified
                    >  to 10.0.0.4 via et-0/0/0.0, Push 24028, Push 24013(top)
                       to 10.0.0.14 via et-0/0/4.0, Push 24028, Push 20(top)
33.33.33.33/32     *[Direct/0] 3w4d 02:11:52
                    >  via lo0.14
44.44.44.44/32     *[BGP/170] 20:20:19, localpref 100, from 9.9.9.9
                      AS path: I, validation-state: unverified
                    >  to 10.0.0.4 via et-0/0/0.0, Push 414, Push 24005(top)
                       to 10.0.0.14 via et-0/0/4.0, Push 414, Push 22(top)
```

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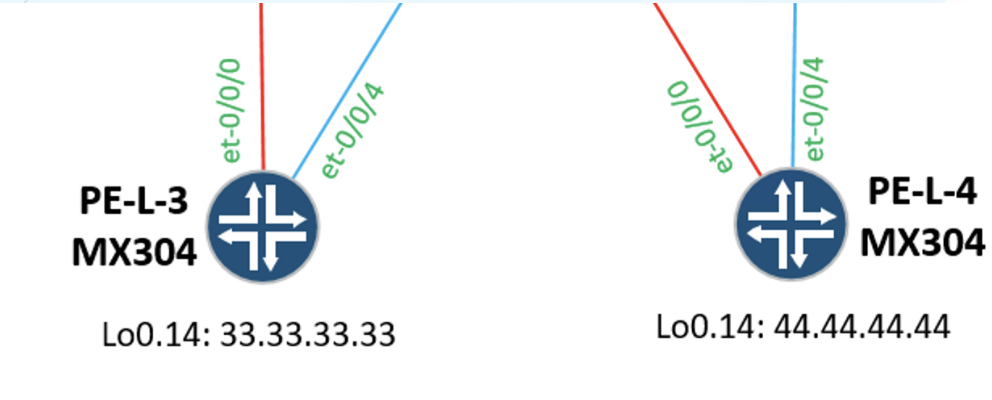


```
admin@PE-L-4> show route table M.inet.0

M.inet.0: 4 destinations, 5 routes (4 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

11.11.11.11/32     *[BGP/170] 20:27:50, MED 0, localpref 100, from 9.9.9.9
                      AS path: ?, validation-state: unverified
                    >  to 10.0.0.6 via et-0/0/0.0, Push 24028, Push 24006(top)
                       to 10.0.0.16 via et-0/0/4.0, Push 24028, Push 19(top)
22.22.22.22/32     *[BGP/170] 00:40:13, MED 0, localpref 200, from fc00:0:a::1
                      AS path: ?, validation-state: unverified
                    >  to fe80::361b:2dff:fec3:280c via et-0/0/0.0, SRv6 SID: fc00:0:2:e004::, SRV6-Tunnel, Dest: fc00:0:2::
                       to fe80::1e9c:8cff:fe1f:f443 via et-0/0/4.0, SRv6 SID: fc00:0:2:e004::, SRV6-Tunnel, Dest: fc00:0:2::
                    [BGP/170] 20:27:50, MED 0, localpref 100, from 9.9.9.9
                      AS path: ?, validation-state: unverified
                    >  to 10.0.0.6 via et-0/0/0.0, Push 24028, Push 24013(top)
                       to 10.0.0.16 via et-0/0/4.0, Push 24028, Push 20(top)
33.33.33.33/32     *[BGP/170] 20:27:50, localpref 100, from 9.9.9.9
                      AS path: I, validation-state: unverified
                    >  to 10.0.0.6 via et-0/0/0.0, Push 406, Push 24016(top)
                       to 10.0.0.16 via et-0/0/4.0, Push 406, Push 21(top)
44.44.44.44/32     *[Direct/0] 3w4d 02:06:41
                    >  via lo0.14
```

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# L3VPN

MPLS, SRv6 Dual-connected PE tökéletesen működik, két apró trükk után!

# 2. Juniper inet-vpn AFI esetén IPv6 next-hop esetén pre-RFC formátumot használ

```
RP/0/RP0/CPU0:May  8 13:55:10.028 UTC: bgp[1090]: [default-rtr]: UPDATE from fc00:0:9::1 contains wrong nexthop length of 16:
gwafi=5, nlriafi=4, tableafi=4, table=TBL:default (1/128), gwlen=32, gwdaddrlen=128

RP/0/RP0/CPU0:May  8 14:17:42.396 UTC: bgp[1090]: %ROUTING-BGP-5-ADJCHANGE_DETAIL : neighbor fc00:0:9::1 Down - BGP Notification
sent, invalid length for attribute (VRF: default; AFI/SAFI: 1/128, 2/128) (AS: 65000)
```

```
Path Attribute - MP_REACH_NLRI
  Flags: 0x90, Optional, Extended-Length, Non-transitive, Complete
  Type Code: MP_REACH_NLRI (14)
  Length: 37
  Address family identifier (AFI): IPv4 (1)
  Subsequent address family identifier (SAFI): Labeled VPN Unicast (128)
  Next hop: fc000000000900000000000000000001
    [Expert Info (Error/Malformed): Unknown Next Hop length (16 bytes)]
      [Unknown Next Hop length (16 bytes)]
      [Severity level: Error]
      [Group: Malformed]
  Number of Subnetwork points of attachment (SNPA): 0
```

```
Path Attribute - MP_REACH_NLRI
  Flags: 0x90, Optional, Extended-Length, Non-transitive, Complete
  Type Code: MP_REACH_NLRI (14)
  Length: 45
  Address family identifier (AFI): IPv4 (1)
  Subsequent address family identifier (SAFI): Labeled VPN Unicast (128)
  Next hop:  RD=0:0 IPv6=fc00:0:3::1
    Route Distinguisher: 0:0
    IPv6 Address: fc00:0:3::1
  Number of Subnetwork points of attachment (SNPA): 0
```

```
protocols {
    bgp {
        rfc8950-compliant;
    }
}
```

# 2. Juniper next-hop structure flattening (compressing)

Hardveres optimalizácó történelmi okok miatt, aktuális hardvereken egyéb előnyöket is hoz a kikapcsolása

```
routing-options {
    resolution {
        preserve-nexthop-hierarchy;
    }
}
protocols {
    bgp {
        multipath {
            list-nexthop;
        }
    }
}
```

# L2VPN

## EVPN (evpn) AFI

- SRv6 dataplane stack-kel
- Multipoint (ELAN), vlan-based (1 VLAN, dot1Q tag nélkül)
- Dual-hosted, all-active

## EVPN-t miért szeretjük

- Data-plane learning pseudowire helyett, control-plane vezérelt forwarding
- L2/L3 IRB VPN, adatközponti világban VxLAN felett már jól bevált
- Gyártó (vPC, ICL, mLACP, StackWise) független L2 redundancia megoldás

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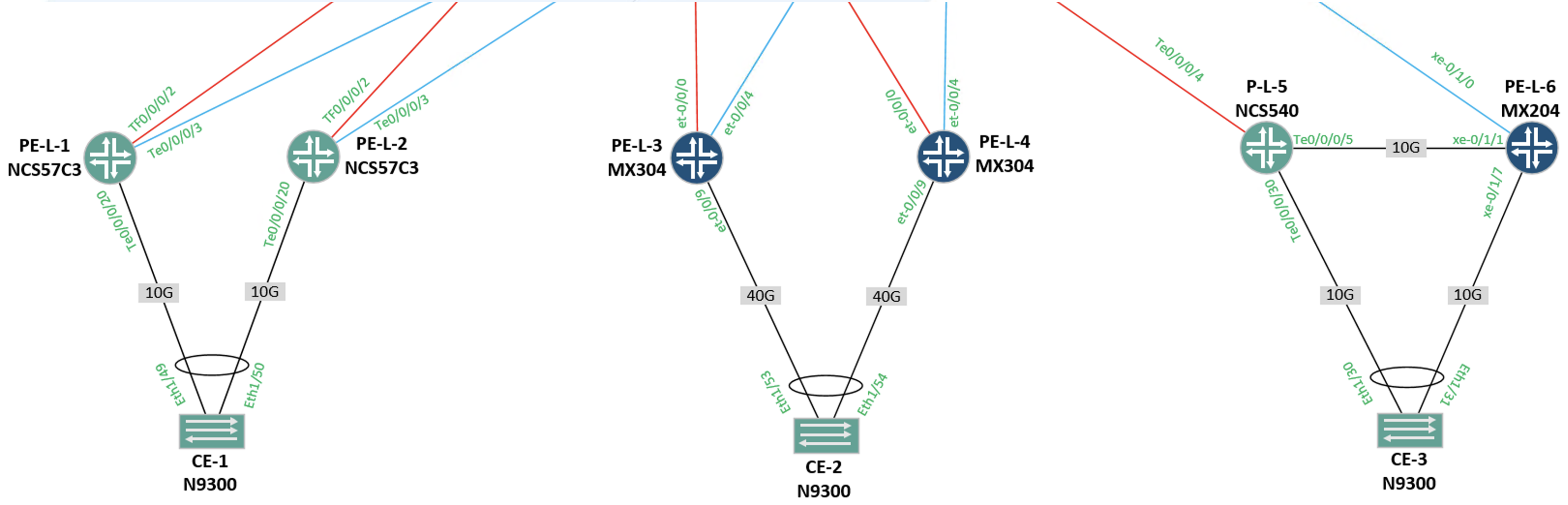
# L2VPN

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- CE-k felé LACP, aktív-aktív módban

# L2VPN

## CE felé LACP

- A CE felé el kell hitetni, hogy a két PE eszköz egy

- multi-chassis setup-ban egyeznie kell:
  - System MAC, LACP Admin Key, LACP Oper Key

  Cisco admin key: Bundle-Ether száma
  Juniper admin key: ae száma + 1

## ESI (Ethernet Segment ID)

- Manuális konfig vagy auto-sense

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# L2VPN - Cisco

```
interface TenGigE0/0/0/30
 description --> CE-3 Eth1/30
 bundle id 56 mode active
 lldp
 !
!
interface Bundle-Ether56
 description --> CE-3 Po56
 lacp period short
 lacp system mac cafe.0000.0056
!
interface Bundle-Ether56.20 l2transport
 encapsulation dot1q 20
 rewrite ingress tag pop 1 symmetric
!
```

```
evpn
 evi 20 segment-routing srv6
  bgp
   rd 65000:20
   route-target import 65000:20
   route-target export 65000:20
  !
  advertise-mac
  !
  locator ALGO0
  !
 !
 interface Bundle-Ether56
  ethernet-segment
   identifier type 0 ca.fe.ca.fe.ca.fe.ca.fe.56
  !
 !
 segment-routing srv6
  locator ALGO0
  !
 !
!
l2vpn
 bridge group BG
  bridge-domain EVPN-ELAN-SRV6
   interface Bundle-Ether56.20
   !
   evi 20 segment-routing srv6
   !
  !
 !
!
```

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# L2VPN - Juniper

```
interfaces {
    ae56 {
        flexible-vlan-tagging;
        encapsulation flexible-ethernet-services;
        esi {
            00:ca:fe:ca:fe:ca:fe:ca:fe:56;
            all-active;
        }
        aggregated-ether-options {
            lacp {
                active;
                system-id ca:fe:00:00:00:56;
                admin-key 56;
            }
        }
        unit 20 {
            encapsulation vlan-bridge;
            vlan-id 20;
            input-vlan-map pop;
            output-vlan-map push;
            family bridge;
        }
    }
}
```

```
routing-instances {
    EVPN-ELAN-SRV6 {
        instance-type mac-vrf;
        protocols {
            evpn {
                encapsulation srv6;
                source-packet-routing {
                    srv6 locator ALGO0 micro-dt2-sid;
                }
            }
        }
        bridge-domains {
            BD20 {
                interface ae56.20;
            }
        }
        service-type vlan-based;
        route-distinguisher 65000:20;
        vrf-target target:65000:20;
    }
}
```

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# L2VPN - Juniper

- MPLS encapsulation támogatott evpn és mac-vrf routing-instance típussal is
- SRv6 csak mac-vrf routing-instance típussal támogatott

```
EVPN-ELAN-MPLS {
    instance-type evpn;
    protocols {
        evpn {
            encapsulation mpls;
            advertise-zero-ethernet-tag;
            control-word;
        }
    }
    vlan-id 10;
    no-normalization;
    interface ae34.10;
    route-distinguisher 65000:10;
    vrf-target target:65000:10;
}
```

```
EVPN-ELAN-SRV6 {
    instance-type mac-vrf;
    protocols {
        evpn {
            encapsulation srv6;
            source-packet-routing {
                srv6 locator ALGO0 micro-dt2-sid;
            }
        }
    }
    bridge-domains {
        BD20 {
            interface ae34.20;
        }
    }
    service-type vlan-based;
    route-distinguisher 65000:20;
    vrf-target target:65000:20;
}
```

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# L2VPN

## EVPN ELAN

- Működik (*) a két vendor között ha az ESI páron belül azonos vendor eszközei vannak
  - DF election: OK
  - Data-plane: OK
  - Redundancia teszt: OK (ESI páron belüli access link vagy eszköz hiba esetén)

- Nem működik (**) ha az ESI vegyes páros
  - DF election: nem OK
  - Data-plane: duplikált csomagok

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* Ha mindkét RR aktív

** DF election: mindkét router aktívvá válik

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# További tervek

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# További tervek

- Underlay
  - FlexAlgo: virtualizált laborban már megvolt
  - TI-LFA
  - SR-TE: PCE
- Overlay
  - EVPN: IRB, distributed anycast GW
  - mVPN
- Koherens optika
  - Interop

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# Köszönöm a figyelmet!

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