TPS project 2016 - Assignment 3

Developed by GRY0057 & KOS0148

with no responsibility

Group 3 initialization: devices RE, RF, RS4, RS8

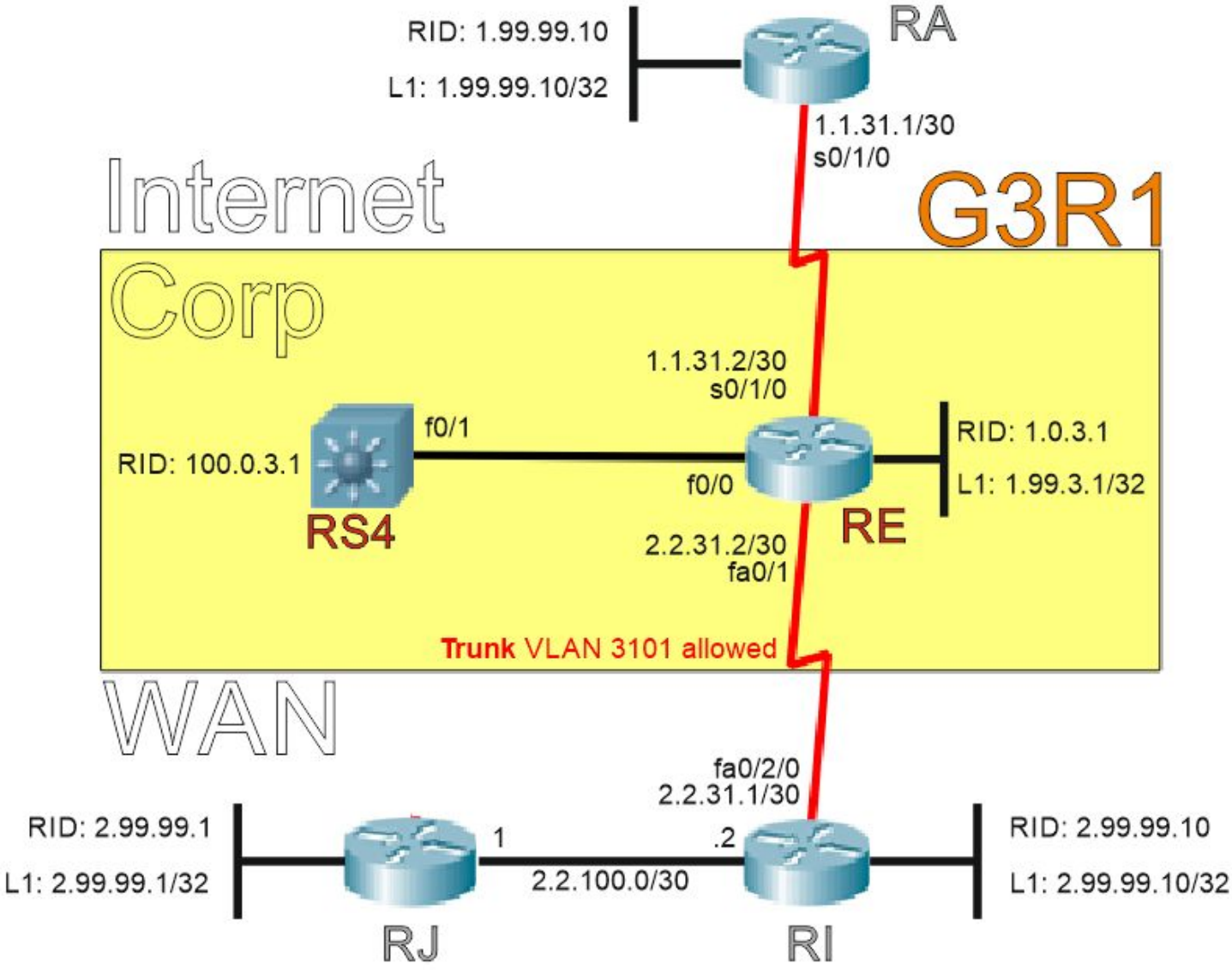
Steps:

- Část 1 - Základní L2 a L3 struktura pobočky, VRF Lite
- Část 2 - BGP-free Core, statické směrování provozu mezi VRF
- Část 3 – L3 MPLS/VPN s částečným překryvem a dynamickým směrováním PE-CE
- Část 4 – Záložní konektivita přes systém AToM pseudowires
- Část 5 – Záložní konektivita přes (DMVPN/IPSec/GRE)
- Část 6 – Implementace IPv6 (6to4/6rd/6PE/6VPE)

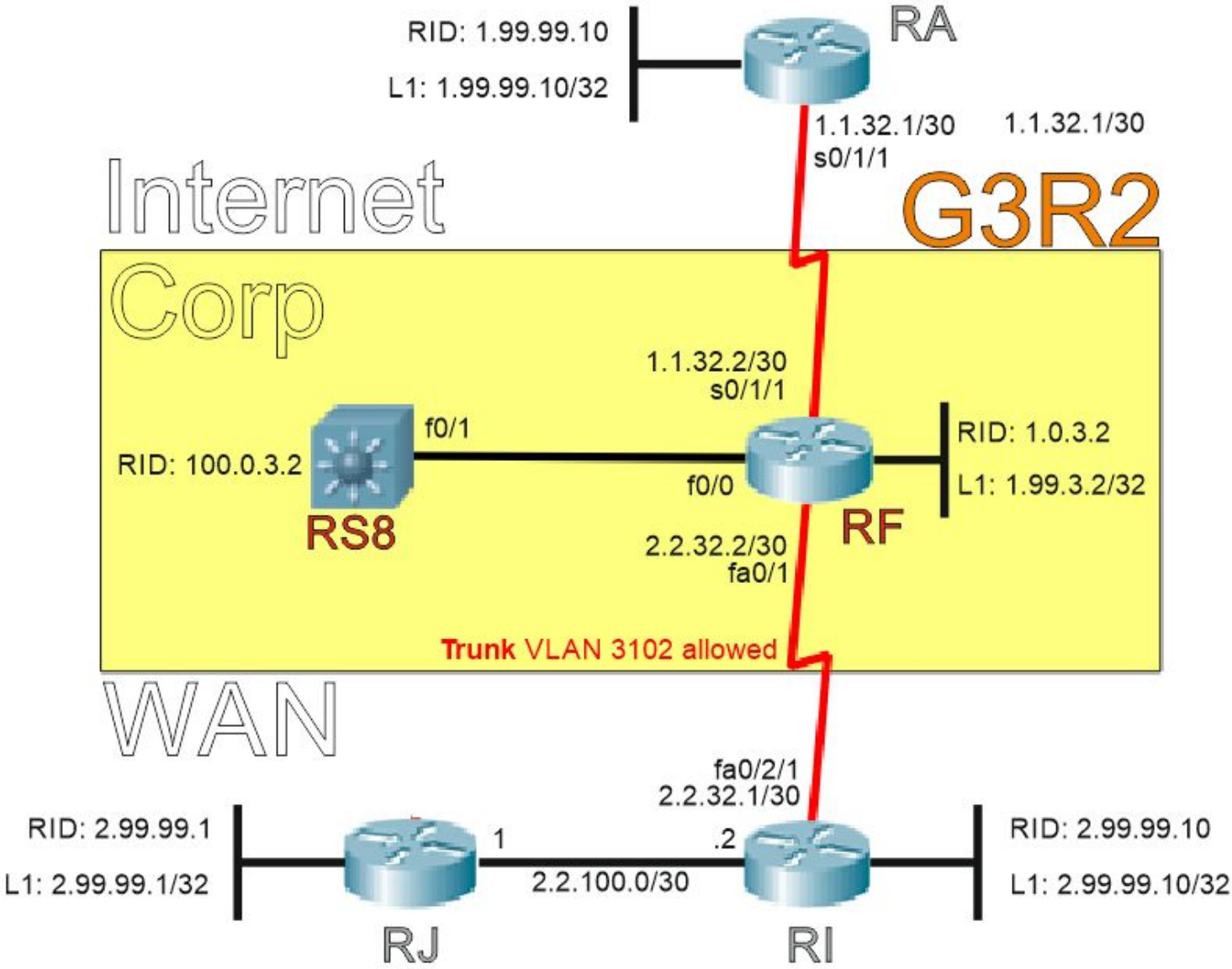
Každý za členů skupiny konfiguruje jednu pobočku síťové infrastruktury firmy připojené na sdílené mraky Service Provider Core a Corporate WAN Core.

Design

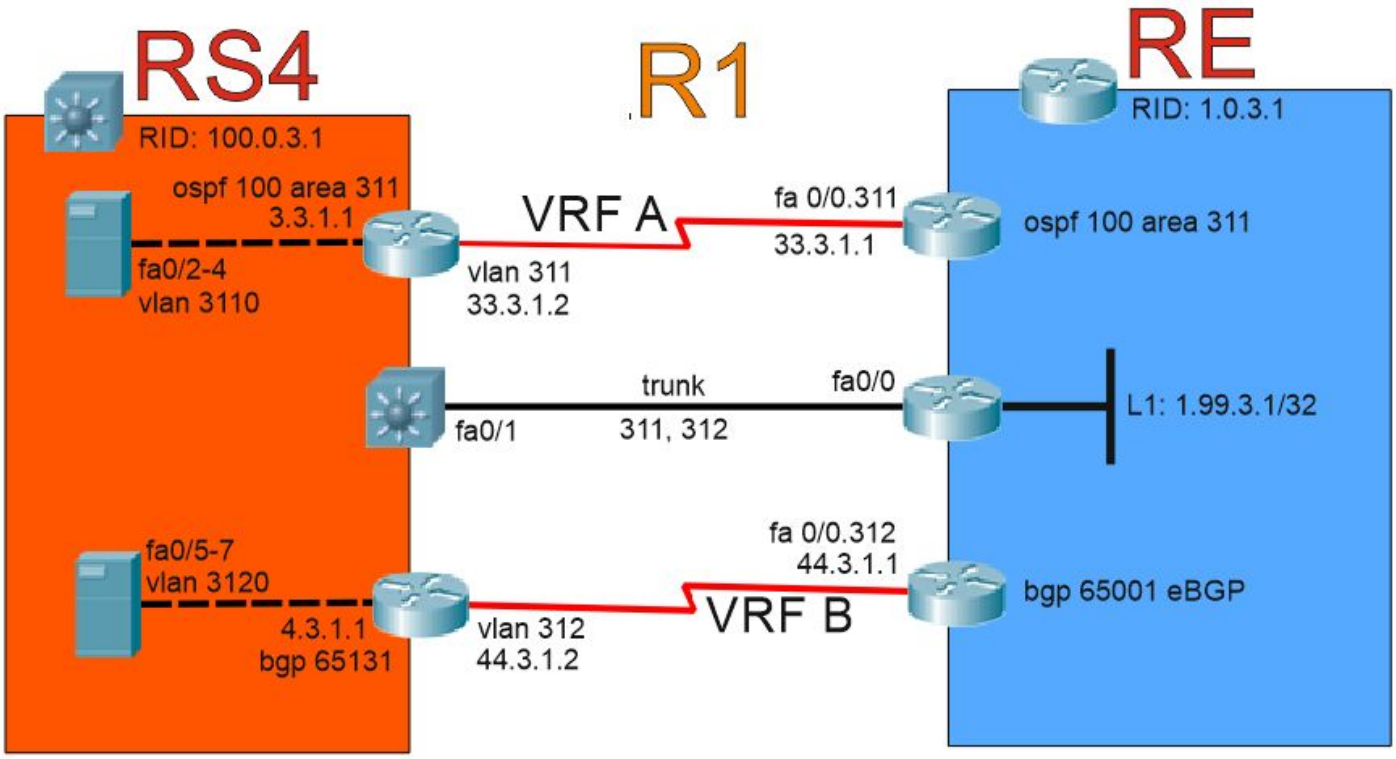
Global - customer1



Global - customer2

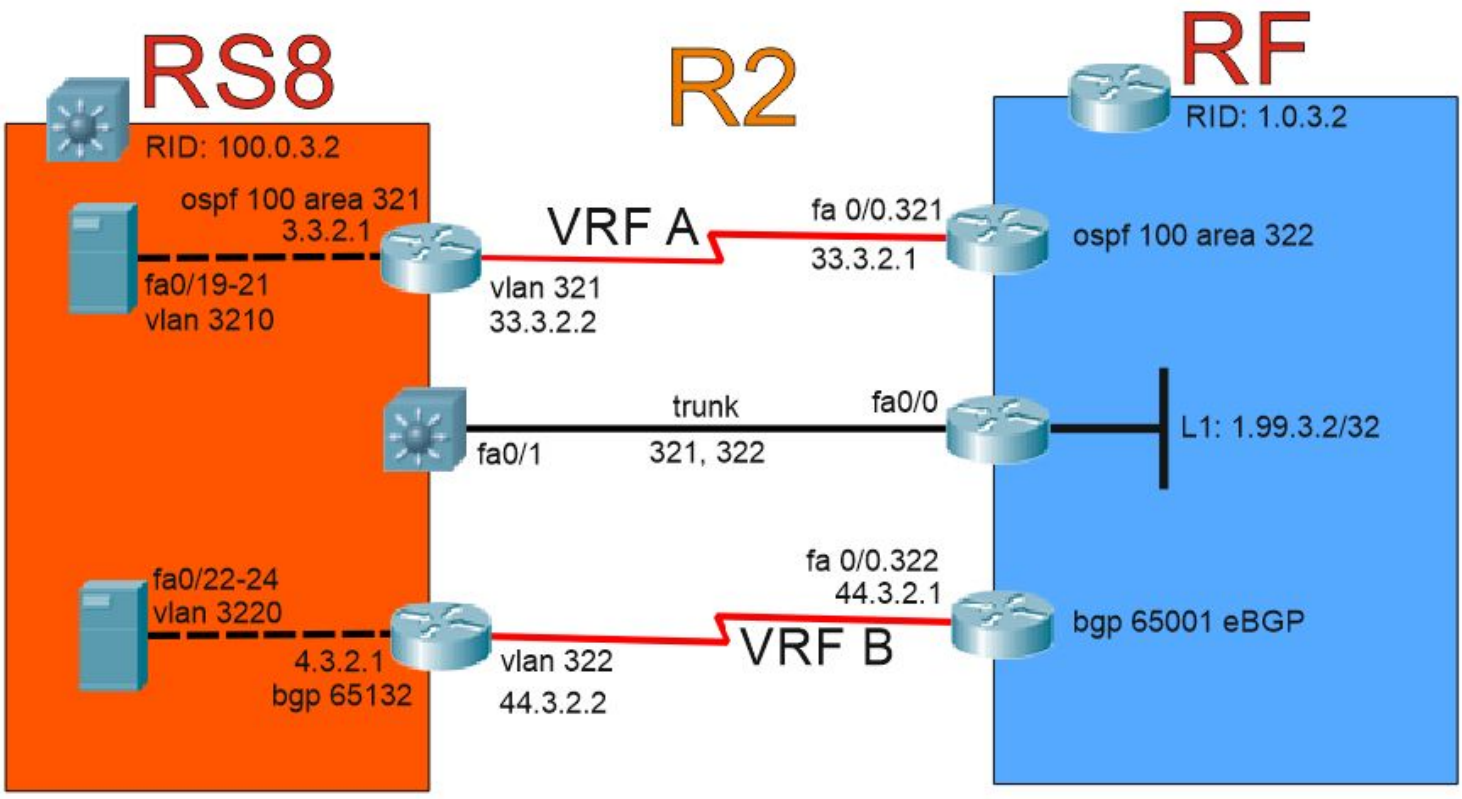


Detail - customer 1



images without VLANs for IPv6 3101 + 3130 and ATOM 316
přikreslit další VLAN 310 global (10.3.1.0)

Detail - customer 2



přikreslit další VLAN 320
10.3.2.0

Common Setup

```
!*Common
!initial settings to rule them all
en
terminal monitor
conf t
no ip domain-lookup
hostname something
username admin pass cisco
username root pass cisco
username en pass cisco
username cisco pass cisco
ena sec cisco
ip domain-name cisco.vsb.cz
cry key gen rsa
768
ip ssh v 2
line vty 0 4
 exec-timeout 0
 tra in tel ssh
 loggin sync
 login local
 exit
line con 0
 loggin sync
 exit
```

RE, RF

Initial configuration

```
hostname R31_RE
banner motd $
G: 3  ( )
R: 1   |
      ( )
       |
       |
[ ]---(*)
       |
       |
      ( )
$

!
! ^VRFs
!

ip vrf A
  rd 65001:99311
  route-t e 65001:311
  route-t i 65001:321
  exit

ip vrf B
```

```
hostname R32_RF
banner motd $
G: 3  ( )
R: 2   |
      ( )
       |
       |
[ ]---(*)
       |
       |
      ( )
$

!
! ^VRFs
!

ip vrf A
  rd 65001:99321
  route-t e 65001:321
  route-t i 65001:311
  exit

ip vrf B
```

```
  rd 65001:99312
  route-t e 65001:312
  route-t i 65001:322
  exit

!
! ^routing protocols
!

router ospf 100 vrf A
  router-id 1.0.3.1
  redistribute connected subnets
  redistribute static
  exit

router bgp 65001
  bgp router-id 1.0.3.1
  !redistribute connected !NO!
  add ipv4 vrf B
     bgp router-id 1.0.3.1
     redistribute connected
     nei 44.3.1.2 remote-as 65131
     nei 44.3.1.2 activate
     exi
  exit

!
! ^interfaces
!

int l1
  ip add 1.99.3.1 255.255.255.255
  ip ospf network point-to-point
  exit

interface fastEthernet 0/0
desc RE2RS4
no sh
exit

interface fastEthernet 0/0.310
  description GlobalTraffic
  encapsulation dot1Q 310
  ip address 100.3.1.1 255.255.255.252
  no shutdown
exit

interface fastEthernet 0/0.311
  ip vrf forwarding A
  description A-RE2RS4
  encapsulation dot1Q 311
  ip address 33.3.1.1 255.255.255.252
  ip ospf 100 a 311
  no shutdown
exit

interface fastEthernet 0/0.312
  ip vrf forwarding B
  description B-RE2RS4
  encapsulation dot1Q 312
  ip address 44.3.1.1 255.255.255.252
  no shutdown
```

```
  rd 65001:99322
  route-t e 65001:322
  route-t i 65001:312
  exit

!
! ^routing protocols
!

router ospf 100 vrf A
  router-id 1.0.3.2
  redistribute connected subnets
  exit

router bgp 65001
  bgp router-id 1.0.3.2
  !redi con !NO!
  add ipv4 vrf B
     bgp router-id 1.0.3.2
     redi con
     nei 44.3.2.2 remote-as 65132
     nei 44.3.2.2 activate
     exi
  exit

!
! ^interfaces
!

int l1
  ip add 1.99.3.2 255.255.255.255
  ip ospf network point-to-point
  exit

int f0/0
  desc R-RS-physical
  no sh
  exit

int f0/0.320
  description GlobalTraffic
  enc d 320
  ip add 100.3.2.1 255.255.255.252
  no sh
exit

int f0/0.321
  ip vrf forw A
  desc R-RS-A
  enc d 321
  ip add 33.3.2.1 255.255.255.252
  ip ospf 100 a 321
  no sh
  exit

int f0/0.322
  ip vrf forw B
  desc R-RS-B
  enc d 322
  ip add 44.3.2.1 255.255.255.252
  no sh
  exit
```

```
exit
```

ISIS, BGP-free core

```
clns routing

mpls ip
mpls label proto ldp
mpls ldp router-id l1 force

router isis 2
  !net <afi>.<area>.1.99.3.1.00
  net 49.0002.0010.9900.3001.00
exit

int l1
  ip router isis 2
  isis circuit-type level-1
  exit

interface s0/1/0
  ip add 1.1.31.2 255.255.255.252
  clo r 128000
  ip router isis 2
  isis circuit-type level-1
  mpls ip
no sh
exit


router bgp 65001
  neighbor 1.99.99.1 remote-as 789
  neighbor 1.99.99.1 update-source Loopback1
  neighbor 1.99.99.1 activate
  neighbor 1.99.99.1 ebgp-multihop 42
  neighbor 1.99.99.1 send-label
  redi stat
  exit

ip route 3.3.1.0 255.255.255.0 100.3.1.2
!lepsi redistribute static
```

```
clns routing

mpls ip
mpls label proto ldp
mpls ldp router-id l1 force

router isis 2
  net 49.0002.0010.9900.3002.00
  exit


int l1
  ip router isis 2
  isis circuit-type level-1
  exit

int s0/1/0
  ip add 1.1.32.2 255.255.255.252
  clo r 128000
  ip router isis 2
  isis circuit-type level-1 !interarea
  mpls ip
  no sh
  exit


router bgp 65001
  nei 1.99.99.1 remote-as 789
  nei 1.99.99.1 update-source l1
  nei 1.99.99.1 activate
  nei 1.99.99.1 ebgp-multihop 42
  nei 1.99.99.1 send-label
  redi stat
  exit

ip route 3.3.2.0 255.255.255.0 f0/0.320
100.3.2.2
```

MPLS/VPN

```
router ospf 1
  router-id 1.99.3.1
  exit

mpls ip
mpls label protocol ldp
mpls ldp router-id l1 force

int l1
  ip ospf 1 a 0
  exit

interface fa0/1
  desc RE-RI
```

```
router ospf 1
  router-id 1.99.3.2
  exit

mpls ip
mpls label proto ldp
mpls ldp router-id l1 force

int l1
  ip ospf 1 a 0
  exit

int f0/1
  desc RF-RI
```

```
  ip address 2.2.31.2 255.255.255.252
  ip ospf 1 a 0
  mpls ip
  no sh
  exit

router bgp 65001
 no bgp default ipv4-unicast
  nei 2.99.99.1 remote-as 65001
  nei 2.99.99.1 update-source l1
address-family ipv4
   nei 2.99.99.1 activate
   nei 2.99.99.1 send-label
   no auto-sum
   no sync
  exit
address-family vpnv4
    nei 2.99.99.1 activate
    nei 2.99.99.1 send-community extended
    exit
  address-family ipv4 vrf A
    bgp router-id 1.0.3.1
    redistribute ospf 100 vrf A
    nei 2.99.99.1 remote-as 65001
    nei 2.99.99.1 update-source loopback 1
    nei 2.99.99.1 activate
    exit
 address-family ipv4 vrf B
   bgp router-id 1.0.3.1
   nei 2.99.99.1 remote-as 65001
   nei 2.99.99.1 update-source loopback 1
   nei 2.99.99.1 activate
   exit
  exit

router ospf 100 vrf A
 redistribute vrf A bgp 65001 subnets
 exit

!missing access list
!mpls aply access list
```

```
  ip add 2.2.32.2 255.255.255.252
  ip ospf 1 a 0
  mpls ip
  no sh
  exit

router bgp 65001
  no bgp default ipv4-unicast
  nei 2.99.99.1 remote-as 65001
  nei 2.99.99.1 update-source l1
  address-family ipv4
    nei 2.99.99.1 activate
    nei 2.99.99.1 send-label
    no auto-sum
    no sync
    exit
  address-family vpnv4
    nei 2.99.99.1 activate
    nei 2.99.99.1 send-community extended
    exit
  address-family ipv4 vrf A
    bgp router-id 1.0.3.2
    redi ospf 100 vrf A
    nei 2.99.99.1 remote-as 65001
    nei 2.99.99.1 update-source loopback 1
    nei 2.99.99.1 activate
    exit
  address-family ipv4 vrf B
    bgp router-id 1.0.3.2
    nei 2.99.99.1 remote-as 65001
    nei 2.99.99.1 update-source loopback 1
    nei 2.99.99.1 activate
    exit
  exit

router ospf 100 vrf A
  redistribute vrf A bgp 65001 subnets
  exit

!access-list 1 permit 2.99.0.0 0.0.255.255
!mpls ldp advertise-labels for 1
```

PE routes:

PE routes:

```
R32_RF#sh ip ro
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      1.0.0.0/32 is subnetted, 2 subnets
O        1.99.3.1 [110/3] via 2.2.32.1, 00:14:11, FastEthernet0/1
C        1.99.3.2 is directly connected, Loopback1
      2.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O        2.2.31.0/30 [110/2] via 2.2.32.1, 00:14:11, FastEthernet0/1
C        2.2.32.0/30 is directly connected, FastEthernet0/1
L        2.2.32.2/32 is directly connected, FastEthernet0/1
O        2.2.100.0/30 [110/2] via 2.2.32.1, 00:14:11, FastEthernet0/1
O        2.99.99.1/32 [110/3] via 2.2.32.1, 00:14:11, FastEthernet0/1
O        2.99.99.10/32 [110/2] via 2.2.32.1, 00:14:11, FastEthernet0/1
      3.0.0.0/24 is subnetted, 1 subnets
S        3.3.2.0 [1/0] via 100.3.2.2, FastEthernet0/0.320
      100.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        100.3.2.0/30 is directly connected, FastEthernet0/0.320
L        100.3.2.1/32 is directly connected, FastEthernet0/0.320
```

PE routes (VRF A):

```
R31_RE#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      1.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
C        1.1.31.0/30 is directly connected, Serial0/1/0
L        1.1.31.2/32 is directly connected, Serial0/1/0
i L1     1.1.100.0/30 [115/20] via 1.1.31.1, 04:40:45, Serial0/1/0
C        1.99.3.1/32 is directly connected, Loopback1
O        1.99.3.2/32 [110/3] via 2.2.31.1, 00:10:16, FastEthernet0/1
i L1     1.99.99.1/32 [115/30] via 1.1.31.1, 04:40:45, Serial0/1/0
i L1     1.99.99.10/32 [115/20] via 1.1.31.1, 04:40:45, Serial0/1/0
      2.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C        2.2.31.0/30 is directly connected, FastEthernet0/1
L        2.2.31.2/32 is directly connected, FastEthernet0/1
O        2.2.32.0/30 [110/2] via 2.2.31.1, 00:10:16, FastEthernet0/1
O        2.2.100.0/30 [110/2] via 2.2.31.1, 00:10:16, FastEthernet0/1
O        2.99.99.1/32 [110/3] via 2.2.31.1, 00:10:16, FastEthernet0/1
O        2.99.99.10/32 [110/2] via 2.2.31.1, 00:10:16, FastEthernet0/1
      3.0.0.0/24 is subnetted, 1 subnets
S        3.3.1.0 is directly connected
      7.0.0.0/24 is subnetted, 1 subnets
B        7.8.9.0 [20/0] via 1.99.99.1, 00:08:12
      100.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        100.3.1.0/30 is directly connected, FastEthernet0/0.310
L        100.3.1.1/32 is directly connected, FastEthernet0/0.310
R31_RE#
```

PE routes (VRF A):

```
Gateway of last resort is not set

      3.0.0.0/24 is subnetted, 2 subnets
O        3.3.1.0 [110/2] via 33.3.1.2, 00:05:21, FastEthernet0/0.311
B        3.3.2.0 [200/2] via 1.99.3.2, 00:01:07
      30.0.0.0/30 is subnetted, 1 subnets
O E2     30.3.12.0 [110/20] via 33.3.1.2, 00:05:21, FastEthernet0/0.311
      33.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        33.3.1.0/30 is directly connected, FastEthernet0/0.311
L        33.3.1.1/32 is directly connected, FastEthernet0/0.311
B        33.3.2.0/30 [200/0] via 1.99.3.2, 00:01:07
R31_RE#
```

PE routes (VRF B):

```
R31_RE#show ip route vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      4.0.0.0/24 is subnetted, 2 subnets
B        4.3.1.0 [20/0] via 44.3.1.2, 02:01:23
B        4.3.2.0 [200/0] via 1.99.3.2, 00:03:39
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        44.3.1.0/30 is directly connected, FastEthernet0/0.312
L        44.3.1.1/32 is directly connected, FastEthernet0/0.312
B        44.3.2.0/30 [200/0] via 1.99.3.2, 00:03:39
R31_RE#
```

```
R32_RF#sh ip ro vrf A

Routing Table: A
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/24 is subnetted, 2 subnets
B        3.3.1.0 [200/2] via 1.99.3.1, 00:00:30
O        3.3.2.0 [110/2] via 33.3.2.2, 00:10:39, FastEthernet0/0.321
      30.0.0.0/30 is subnetted, 1 subnets
O E2     30.3.12.0 [110/20] via 33.3.2.2, 00:12:42, FastEthernet0/0.321
      33.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        33.3.1.0/30 [200/0] via 1.99.3.1, 00:00:30
C        33.3.2.0/30 is directly connected, FastEthernet0/0.321
L        33.3.2.1/32 is directly connected, FastEthernet0/0.321
```

PE routes (VRF B):

```
R32_RF#sh ip ro vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      4.0.0.0/24 is subnetted, 2 subnets
B        4.3.1.0 [200/0] via 1.99.3.1, 00:00:44
B        4.3.2.0 [20/0] via 44.3.2.2, 00:01:03
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        44.3.1.0/30 [200/0] via 1.99.3.1, 00:00:44
C        44.3.2.0/30 is directly connected, FastEthernet0/0.322
L        44.3.2.1/32 is directly connected, FastEthernet0/0.322
```

Route Reflector BGP Table:

```
PERR-RJ#sh ip bgp
BGP table version is 47, local router ID is 2.99.99.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>i 3.1.1.0/24       100.1.1.2                0    100      0 i
 *>i 3.1.2.0/24       100.1.2.2                0    100      0 ?
 *>i 3.3.1.0/24       1.99.3.1                 0    100      0 ?
 *>i 3.3.2.0/24       1.99.3.2                 0    100      0 ?
 * i 7.8.9.0/24       1.99.99.1                0    100      0 789 i
 * i                  1.99.99.1                0    100      0 789 i
 * i                  1.99.99.1                0    100      0 789 i
 *>i 100.1.1.0/30     1.99.1.1                 0    100      0 i
 *>i 100.1.2.0/30     1.99.1.2                 0    100      0 i
```

AToM (classical)

```
interface fastEthernet 0/0.316
  description PseudoDrat
```

```
int f0/0.325
  desc pseudo
```

```
   encapsulation dot1Q 316
   xconnect 1.99.3.2 312 encapsulation mpls
   no shutdown
  exit
```

```
   enc d 325
   xconnect 1.99.3.1 312 enc mpls
   no sh
   exit
```

XConnect:

```
R31_RE#sh xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down           AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby    RV=Recovering      NH=No Hardware

XC ST  Segment 1                      S1 Segment 2                      S2
------+--------------------------------+--+--------------------------------+--
UP pri   ac Fa0/0.316:316(Eth VLAN)     UP mpls 1.99.3.2:312              UP
R31_RE#
```

XConnect:

```
R32_RE#sh xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down           AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby    RV=Recovering      NH=No Hardware

XC ST  Segment 1                      S1 Segment 2                      S2
------+--------------------------------+--+--------------------------------+--
UP pri   ac Fa0/0.325:325(Eth VLAN)     UP mpls 1.99.3.1:312              UP
```

IPSec

```
!NTP server
do clock set 11:11:11 1 Jan 2016
ntp master

crypto isakmp policy 10
    auth pre-share
    exit

cry isakmp key cisco add 1.99.3.2 !peer
cry ipsec transform-set TRANSFORMER esp-3des
esp-sha-hmac
    mode tun
    exit

crypto ipsec profile IPSECPROFILE
    set transform-set TRANSFORMER
    exit

int T12
    ip vrf forw B
    ip add  111.3.12.1 255.255.255.252
    tun mode ipsec ipv4
    tun prot ipsec profile IPSECPROFILE
    tun sou l1
    tun dest 1.99.3.2
    no sh
    exit


!ip route vrf B 4.3.2.0 255.255.255.0 111.3.12.2
global

!BGP 2 RIP: pouze server subnet
ip prefix-list PLTORIP permit 4.3.1.0/24
route-map TORIP permit 1
match ip address prefix-list PLTORIP
exit

router rip
  version 2
  no auto-sum
  distance 210
  address-family ipv4 vrf B
    redi bgp 65001 route-map TORIP metric 4
    net 111.3.12.0
    exit
  exit
```

```
ntp server 1.99.3.1



crypto isakmp policy 10
  auth pre-share
  exit

cry isakmp key cisco add 1.99.3.1 !peer
cry ipsec transform-set TRANSFORMER esp-3des
esp-sha-hmac
  mode tun
  exit

crypto ipsec profile IPSECPROFILE
  set transform-set TRANSFORMER
  exit

int T12
  ip vrf forw B
  ip add 111.3.12.2 255.255.255.252
  tun mode ipsec ipv4
  tun prot ipsec profile IPSECPROFILE
  tun sou l1
  tun dest 1.99.3.1
  no sh
  exit


!ip route vrf B 4.3.1.0 255.255.255.0 111.3.12.1
global


ip prefix-list PLTORIP permit 4.3.2.0/24
route-map TORIP permit 1
  match ip address prefix-list PLTORIP
  exit

router rip
  version 2
  no auto-sum
  distance 210
  address-family ipv4 vrf B
    redi bgp 65001 route-map TORIP metric 4
    net 111.3.12.0
    exit
  exit
```

```
route-map RMTOBGP permit 10
  set community 65001:333
  exit
router bgp 65001
  address-family ipv4 vrf B
    redi rip route-map RMTOBGP
    exit
  exit

ip community-list 1 permit 65001:333
route-map TORR deny 10
  match community 1
  exit
route-map TORR permit 20
  exit
router bgp 65001
  address-family vpnv4
    nei 2.99.99.1 route-map TORR out
    exit
  exit

route-map FROMRR permit 10
  set weight 40000
  exit
router bgp 65001
  address-family vpnv4
    nei 2.99.99.1 route-map FROMRR in
    exit
  exit
```

```
route-map RMTOBGP permit 10
  set community 65001:333
  exit
router bgp 65001
  address-family ipv4 vrf B
    redi rip route-map RMTOBGP
    exit
  exit

ip community-list 1 permit 65001:333
route-map TORR deny 10
  match community 1
  exit
route-map TORR permit 20
  exit
router bgp 65001
  address-family vpnv4
    nei 2.99.99.1 route-map TORR out
    exit
  exit

route-map FROMRR permit 10
  set weight 40000
  exit
router bgp 65001
  address-family vpnv4
    nei 2.99.99.1 route-map FROMRR in
    exit
  exit
```

ping from LAN:

```
RS31_RS4#ping vrf B 4.3.2.1 source 4.3.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.3.2.1, timeout is 2 seconds:
Packet sent with a source address of 4.3.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 41/46/58 ms
RS31_RS4#
```

VRF B routing table on RS4:

```
RS31_RS4#show ip route vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      4.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        4.3.1.0/24 is directly connected, Vlan3120
L        4.3.1.1/32 is directly connected, Vlan3120
B        4.3.2.0/24 [20/4] via 44.3.1.1, 00:04:08
      44.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        44.3.1.0/30 is directly connected, Vlan312
L        44.3.1.2/32 is directly connected, Vlan312
      111.0.0.0/30 is subnetted, 1 subnets
B        111.3.12.0 [20/0] via 44.3.1.1, 00:05:56
RS31_RS4#
```

VRF B routing table on RE:

ping from LAN:

```
RS32_RS8#ping vrf B 4.3.1.1 source 4.3.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.3.1.1, timeout is 2 seconds:
Packet sent with a source address of 4.3.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/5/9 ms
```

PE VRF B routing table:

```
R32_RF#sh ip ro vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      4.0.0.0/24 is subnetted, 2 subnets
R        4.3.1.0 [120/4] via 111.3.12.1, 00:00:09, Tunnel12
B        4.3.2.0 [20/0] via 44.3.2.2, 01:13:16
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        44.3.1.0/30 [200/0] via 1.99.3.1, 00:09:38
C        44.3.2.0/30 is directly connected, FastEthernet0/0.322
L        44.3.2.1/32 is directly connected, FastEthernet0/0.322
      111.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        111.3.12.0/30 is directly connected, Tunnel12
L        111.3.12.2/32 is directly connected, Tunnel12
```

RS VRF B routing table:

```
R31_RE#show ip route vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      4.0.0.0/24 is subnetted, 2 subnets
B        4.3.1.0 [20/0] via 44.3.1.2, 00:18:50
R        4.3.2.0 [120/4] via 111.3.12.2, 00:00:08, Tunnel12
      44.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        44.3.1.0/30 is directly connected, FastEthernet0/0.312
L        44.3.1.1/32 is directly connected, FastEthernet0/0.312
      111.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        111.3.12.0/30 is directly connected, Tunnel12
L        111.3.12.1/32 is directly connected, Tunnel12
R31_RE#
```

```
RS32_RS8#sh ip ro vrf B

Routing Table: B
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     4.0.0.0/24 is subnetted, 2 subnets
C       4.3.2.0 is directly connected, Vlan3220
B       4.3.1.0 [20/4] via 44.3.2.1, 00:01:30
     111.0.0.0/30 is subnetted, 1 subnets
B       111.3.12.0 [20/0] via 44.3.2.1, 00:01:30
     44.0.0.0/30 is subnetted, 1 subnets
C       44.3.2.0 is directly connected, Vlan322
```

6VPE

```
ipv6 unicast-routing

vrf definition V6
  address-family ipv6
  rd 65001:99313
  route-t e 65001:313
  route-t i 65001:323
  exit

int f0/0.3101
  vrf forw V6
  encapsulation dot1Q 3101
  ipv6 add 2001:aaaa:3101::1/64
  no sh
  exit

ipv6 ro vrf V6 2001:aaaa:3100::/64
2001:aaaa:3101::2

router bgp 65001
  address-family vpnv6 unicast
    nei 2.99.99.1 activate
    nei 2.99.99.1 send-community extended
    exit
  address-family ipv6 unicast vrf V6
    redi stat
    redi con
  exit
```

```
ipv6 unicast-routing

vrf definition VRF6
  address-family ipv6
  rd 65001:99323
  route-t e 65001:323
  route-t i 65001:313
 exit

int f0/0.3201
  vrf forw VRF6
  enc d 3201
  ipv6 add 2001:aaaa:3201::1/64
  no sh
  exit

ipv6 ro vrf VRF6 2001:aaaa:3200::/64
2001:aaaa:3201::2

router bgp 65001
  address-family vpnv6 unicast
    nei 2.99.99.1 activate
    nei 2.99.99.1 send-community extended
    exit
 address-family ipv6 unicast vrf VRF6
    redi stat
    redi con
  exit
```

PE routers routing tables:

```
R31_RE#show ipv6 route vrf V6
IPv6 Routing Table - V6 - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, ND - ND Default
       NDp - ND Prefix, DCE - Destination, NDr - Redirect, O - OSPF Intra
       OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1
       ON2 - OSPF NSSA ext 2, la - LISP alt, lr - LISP site-registrations
       ld - LISP dyn-eid, a - Application
S   2001:AAAA:3100::/64 [1/0]
     via 2001:AAAA:3101::2
C   2001:AAAA:3101::/64 [0/0]
     via FastEthernet0/0.3101, directly connected
L   2001:AAAA:3101::1/128 [0/0]
     via FastEthernet0/0.3101, receive
B   2001:AAAA:3200::/64 [200/0]
     via 1.99.3.2%default, indirectly connected
B   2001:AAAA:3201::/64 [200/0]
     via 1.99.3.2%default, indirectly connected
L   FF00::/8 [0/0]
     via Null0, receive
R31_RE#
```

Connectivity between PE routers

PE routing table (vrf VRF6):

```
R32_RF#sh ipv6 ro vrf VRF6
IPv6 Routing Table - VRF6 - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, ND - ND Default
       NDp - ND Prefix, DCE - Destination, NDr - Redirect, O - OSPF Intra
       OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1
       ON2 - OSPF NSSA ext 2, la - LISP alt, lr - LISP site-registrations
       ld - LISP dyn-eid, a - Application
B   2001:AAAA:3100::/64 [200/0]
     via 1.99.3.1%default, indirectly connected
B   2001:AAAA:3101::/64 [200/0]
     via 1.99.3.1%default, indirectly connected
S   2001:AAAA:3200::/64 [1/0]
     via 2001:AAAA:3201::2
C   2001:AAAA:3201::/64 [0/0]
     via FastEthernet0/0.3201, directly connected
L   2001:AAAA:3201::1/128 [0/0]
     via FastEthernet0/0.3201, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Connectivity between routers:

```
R31_RE#
R31_RE#ping vrf V6 ipv6 2001:aaaa:3201::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:AAAA:3201::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R31_RE#
R31_RE#traceroute vrf V6 ipv6 2001:aaaa:3201::1
Type escape sequence to abort.
Tracing the route to 2001:AAAA:3201::1

  1 ::FFFF:2.2.31.1 [MPLS: Labels 17/42 Exp 0] 0 msec 4 msec 0 msec
  2 2001:AAAA:3201::1 0 msec 4 msec 0 msec
R31_RE#
```

```
R32_RF#ping vrf VRF6 ipv6 2001:aaaa:3101::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:AAAA:3101::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R32_RF#trace vrf VRF6 ipv6 2001:aaaa:3101::1
Type escape sequence to abort.
Tracing the route to 2001:AAAA:3101::1

  1 ::FFFF:2.2.32.1 [MPLS: Labels 19/68 Exp 0] 0 msec 0 msec 4 msec
  2 2001:AAAA:3101::1 0 msec 0 msec 4 msec
```

Route Reflector:

```
PERRB-RJ#sh bgp vpnv6 uni all lab
   Network          Next Hop      In label/Out label
Route Distinguisher: 65001:99313
   2001:AAAA:3100::/64
                    ::FFFF:1.99.3.1 nolabel/46
   2001:AAAA:3101::/64
                    ::FFFF:1.99.3.1 nolabel/68
Route Distinguisher: 65001:99323
   2001:AAAA:3200::/64
                    ::FFFF:1.99.3.2 nolabel/40
   2001:AAAA:3201::/64
                    ::FFFF:1.99.3.2 nolabel/42
```

Clear Commands

```
clear ip ospf process
clear ip bgp * soft
clear isis *
clear mpls ldp neighbor *

clear crypto sa
clear crypto isakmp
```

Show Commands

```
!shows
!L2 accessibility
show cdp nei

!VRFS
show ip vrf A
show ip vrf B
show ip vrf bri
show ip vrf detail
show ip vrf int

!IP
show ip int br
show ip route vrf A
show ip route vrf B
show ip route

!Routing protocols
sh ip proto
sh ip proto vrf A
sh ip cef exact-route <src> <dest>
!OSPF
sh ip ospf nei
sh ip ospf 100 nei
```

```
sh ip ospf int
!BGP
sh ip bgp
sh ip bgp sum
sh ip bgp all
sh ip bgp vpnv4 all labels
sh bgp sum
!ISIS
sh isis nei
!RIP
sh ip rip nei
sh ip rip dat

!MPLS
show mpls int
show mpls forw
show mpls ldp nei
show mpls ldp bind

!AToM
sh mpls l2transport vc
sh mpls l2transport vc detail
show xconnect all

!IPSec
show crypto isakmp sa
show crypto ipsec sa
debug crypto ipsec
debug crypto isakmp
show clock

!6VPE
show bgp vpnv6 uni all labels
```

Tests

```
ping vrf A 33.3.1.2 repeat 2
ping vrf B 44.3.1.2 repeat 2
```

```
telnet 33.3.2.2 /vrf A
telnet 44.3.2.2 /vrf B

ping vrf A 33.3.2.2 repeat 2
ping vrf B 44.3.2.2 repeat 2

traceroute 1.99.3.1 ! going through MPLS?

ping vrf VRF6 ipv6 2001:aaaa:3101::1
```

RS4, RS8

Initial configuration

```
hostname RS31_RS4
banner motd $
G: 3  ( )
```

```
hostname RS32_RS8
banner motd $
G: 3  ( )
```

```
R: 1   |
      ( )
       |
       |
[*]---( )
       |
       |
      ( )
$

vtp mode transparent
ip routing
ip cef dist
system mtu 1500

!
! ^VRFs
!

ip vrf A
       rd 65001:88311
       exit

ip vrf B
       rd 65001:88312
       exit

!
! ^vlans RS-R
!

vlan 310
  name GlobalService
  exit

vlan 311
       name vlan31A
       exit
vlan 312
       name vlan31B
       exit
!
! ^vlans for servers
!

vlan 3110
       name 31AServer
       exit
vlan 3120
       name 31BServer
       exit
!
! ^routing protocols
!

router ospf 100 vrf A
       router-id 100.0.3.1
       redistribute connected subnets
       exit

router bgp 65131
       bgp router-id 100.0.3.1
```

```
R: 2   |
      ( )
       |
       |
[*]---( )
       |
       |
      ( )
$

vtp mode off
ip routing
ip cef dist
system mtu 1500

!
! ^VRFs
!

ip vrf A
  rd 65001:88321
  exit

ip vrf B
  rd 65001:88322
  exit

!
! ^vlans RS-R
!

vlan 320
  name GlobalService
  exit

vlan 321
  name vlan32A

vlan 322
  name vlan32B

!
! ^vlans for servers
!

vlan 3210
  name vlan32AServer

vlan 3220
  name vlan32BServer

!
! ^routing protocols
!

router ospf 100 vrf A
  router-id 100.0.3.2
  redistribute connected subnets
  exit

router bgp 65132
  bgp router-id 100.0.3.2
```

```
      redistribute connected
 add ipv4 vrf B
      bgp router-id 100.0.3.1
      redistribute connected
      nei 44.3.1.1 remote-as 65001
      nei 44.3.1.1 activate
      exit
 exit

!
! ^interfaces
!

int r f0/1-24
  desc NULL
  sh
  exit
int r g0/1-2
  desc NULL
  sh
  exit

interface range FastEthernet0/2-4
       desc RS-Servers-A-physical
       switchport mode access
       switchport access vlan 3110
       spanning-tree portfast
       no sh
       exit

interface range FastEthernet0/5-7
       desc RS-Servers-B-physical
       switchport mode access
       switchport access vlan 3120
       spanning-tree portfast
       no sh
       exit

interface fa 0/1
       desc RS4toRE-trunk
       switchport trunk encapsulation dot1q
       switchport mode trunk
       switchport trunk allowed vlan 310,311,312
       no sh
       exit

int vlan 310
  desc GlobalVlanNonVRF
  ip address 100.3.1.2 255.255.255.252
  exit

int vlan 311
       desc RS4-vrfA
       ip vrf forw A
       ip address 33.3.1.2 255.255.255.252
       ip ospf 100 area 311
       exit

int vlan 312
       desc RS4-vrfB
       ip vrf forw B
       ip address 44.3.1.2 255.255.255.252
```

```
  redi con
  add ipv4 vrf B
       bgp router-id 100.0.3.2
       redi con
       nei 44.3.2.1 remote-as 65001
       nei 44.3.2.1 activate
       exit
  exit

!
! ^interfaces
!

int r f0/1-24
  desc NULL
  sh
  exit
int r g0/1-2
  desc NULL
  sh
  exit

int r f0/19-21
  desc RS-Servers-A-physical
  sw mo ac
  sw ac vlan 3210
  span portfast
  no sh
  exit

int r f0/22-24
  desc RS-Servers-B-physical
  sw mo ac
  sw ac vlan 3220
  span portfast
  no sh
  exit

int f0/1
  desc RS-R-physical
  sw tr enc dot1q
  sw mo tr
  sw tr all vlan 320,321,322
  no sh
  exit

 int vlan 320
   ip add 100.3.2.2 255.255.255.252
   no sh
   exit

int vlan 321
  desc RS-R-A
  ip vrf forw A
  ip add 33.3.2.2 255.255.255.252
  ip ospf 100 a 321
  exit

int vlan 322
  desc RS-R-B
  ip vrf forw B
  ip add 44.3.2.2 255.255.255.252
```

```
       exit

int vlan 3110
       desc Access-A
       ip vrf forw A
       ip address 3.3.1.1 255.255.255.0
       ip ospf 100 a 311
       exit

int vlan 3120
       desc Access-B
       ip vrf forw B
       ip address 4.3.1.1 255.255.255.0
       exit
```

```
  exit

int vlan 3210
  desc RS-Servers-A
  ip vrf forw A
  ip add 3.3.2.1 255.255.255.0
  ip ospf 100 a 321
  exit

int vlan 3220
  desc RS-Servers-B
  ip vrf forw B
  ip add 4.3.2.1 255.255.255.0
  exit
```

ISIS, BGP-free core

```
!
! ^routing
!
ip route 0.0.0.0 0.0.0.0 100.3.1.1
ip route vrf A 0.0.0.0 0.0.0.0 100.3.1.1 global
ip route 3.3.1.0 255.255.255.0 vlan 3110
```

```
!
! ^routing
!
ip route 0.0.0.0 0.0.0.0 100.3.2.1
ip route vrf A 0.0.0.0 0.0.0.0 100.3.2.1 global
ip route 3.3.2.0 255.255.255.0 vlan 3210
```

Routes (vrf A):

```
RS31_RS4#show ip route vrf A

Routing Table: A
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is 100.3.1.1 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 100.3.1.1
      3.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        3.3.1.0/24 is directly connected, Vlan3110
L        3.3.1.1/32 is directly connected, Vlan3110
R        3.3.2.0/24 [120/1] via 30.3.12.2, 00:00:25, Vlan316
      30.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        30.3.12.0/30 is directly connected, Vlan316
L        30.3.12.1/32 is directly connected, Vlan316
      33.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        33.3.1.0/30 is directly connected, Vlan311
L        33.3.1.2/32 is directly connected, Vlan311
RS31_RS4#
```

Routes (vrf A)(after completion):

```
RS32_RS8#sh ip ro vrf A

Routing Table: A
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 100.3.2.1 to network 0.0.0.0

     33.0.0.0/30 is subnetted, 1 subnets
C       33.3.2.0 is directly connected, Vlan321
     3.0.0.0/24 is subnetted, 2 subnets
R       3.3.1.0 [120/1] via 30.3.12.1, 00:00:19, Vlan325
C       3.3.2.0 is directly connected, Vlan3210
     30.0.0.0/30 is subnetted, 1 subnets
C       30.3.12.0 is directly connected, Vlan325
S*  0.0.0.0/0 [1/0] via 100.3.2.1
```

Routes (vrf B):

```
RS31_RS4#show ip route vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      4.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        4.3.1.0/24 is directly connected, Vlan3120
L        4.3.1.1/32 is directly connected, Vlan3120
B        4.3.2.0/24 [20/0] via 44.3.1.1, 00:33:38
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        44.3.1.0/30 is directly connected, Vlan312
L        44.3.1.2/32 is directly connected, Vlan312
B        44.3.2.0/30 [20/0] via 44.3.1.1, 00:33:38
     111.0.0.0/30 is subnetted, 1 subnets
B       111.3.12.0 [20/0] via 44.3.1.1, 00:33:36
RS31_RS4#
```

Routes (vrf B):

```
RS32_RS8#sh ip ro vrf B

Routing Table: B
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     4.0.0.0/24 is subnetted, 2 subnets
C       4.3.2.0 is directly connected, Vlan3220
B       4.3.1.0 [20/0] via 44.3.2.1, 00:06:03
     44.0.0.0/30 is subnetted, 2 subnets
C       44.3.2.0 is directly connected, Vlan322
B       44.3.1.0 [20/0] via 44.3.2.1, 00:06:03
```

Global routes:

Global routes:

```
RS31_RS4#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is 100.3.1.1 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 100.3.1.1
      3.0.0.0/24 is subnetted, 1 subnets
S        3.3.1.0 is directly connected, Vlan3110
      100.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        100.3.1.0/30 is directly connected, Vlan310
L        100.3.1.2/32 is directly connected, Vlan310
RS31_RS4#
```

```
RS32_RS8#sh ip ro
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 100.3.2.1 to network 0.0.0.0

     100.0.0.0/30 is subnetted, 1 subnets
C       100.3.2.0 is directly connected, Vlan320
     3.0.0.0/24 is subnetted, 1 subnets
S       3.3.2.0 is directly connected, Vlan3210
S*   0.0.0.0/0 [1/0] via 100.3.2.1
```

AToM (classical)

```
vlan 316
  name posrankovy
  exit

int vlan 316
  ip vrf forw A
  ip address 30.3.12.1 255.255.255.252
  exit

interface f0/1
  sw tr all vlan add 316
  exit
no span vlan 316

 router rip
   address-family ipv4 vrf A
     version 2
     no auto-summary
     network 3.0.0.0
     network 30.3.12.0
     exit
   exit
```

```
vlan 325
  name pseudo
exit

int vlan 325
  ip vrf forw A
  ip add 30.3.12.2 255.255.255.252
  exit

int f0/1
  sw tr all vlan add 325
  exit
no span vlan 325

 router rip
   address-family ipv4 vrf A
     version 2
     no auto-summary
     net 3.3.2.0    ! degrades to 3.0.0.0
     net 30.3.12.0  ! degrades to 30.0.0.0
     exit
   exit
```

XConnect working demo: ping + tracert

```
RS31_RS4#ping vrf A 3.3.2.1 source 3.3.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.2.1, timeout is 2 seconds:
Packet sent with a source address of 3.3.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 33/36/42 ms
RS31_RS4#traceroute vrf A 3.3.2.1
Type escape sequence to abort.
Tracing the route to 3.3.2.1
VRF info: (vrf in name/id, vrf out name/id)
  1 30.3.12.2 25 msec *  17 msec
RS31_RS4#
```

IP route (RIP is up)

Ping:

```
RS32_RS8#ping vrf A 3.3.1.1 source 3.3.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.1.1, timeout is 2 seconds:
Packet sent with a source address of 3.3.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 33/50/109 ms
```

Trace:

```
RS32_RS8#trace vrf A 3.3.1.1

Type escape sequence to abort.
Tracing the route to 3.3.1.1

  1 30.3.12.1 25 msec *  25 msec
```

IP route (RIP is up)

```
RS32_RS8#sh ip ro vrf A

Routing Table: A
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 100.3.2.1 to network 0.0.0.0

     33.0.0.0/30 is subnetted, 1 subnets
C       33.3.2.0 is directly connected, Vlan321
     3.0.0.0/24 is subnetted, 2 subnets
R       3.3.1.0 [120/1] via 30.3.12.1, 00:00:09, Vlan325
C       3.3.2.0 is directly connected, Vlan3210
     30.0.0.0/30 is subnetted, 1 subnets
C       30.3.12.0 is directly connected, Vlan325
S*   0.0.0.0/0 [1/0] via 100.3.2.1
```

```
RS31_RS4#show ip route vrf A

Routing Table: A
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is 100.3.1.1 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 100.3.1.1
      3.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        3.3.1.0/24 is directly connected, Vlan3110
L        3.3.1.1/32 is directly connected, Vlan3110
R        3.3.2.0/24 [120/1] via 30.3.12.2, 00:00:21, Vlan316
      30.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        30.3.12.0/30 is directly connected, Vlan316
L        30.3.12.1/32 is directly connected, Vlan316
      33.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        33.3.1.0/30 is directly connected, Vlan311
L        33.3.1.2/32 is directly connected, Vlan311
RS31_RS4#
```

6VPE

```
!sdm prefer dual-ipv4-and-ipv6 default

ipv6 unicast-routing

vlan 3130
  name IPv6LAN

vlan 3101
  name IPv6Link

int r f0/16-18
  sw mo ac
  sw ac vlan 3130
  no sh
  exit

int vlan 3130
  ipv6 ad 2001:aaaa:3100::1/64
  no sh
  exit

int vlan 3101
  ipv6 ad 2001:aaaa:3101::2/64
  no sh
  exit

int f0/1
  sw tr all vlan add 3101
  exit

ipv6 ro ::/0 2001:aaaa:3101::1
```

```
!sdm prefer dual-ipv4-and-ipv6 default

ipv6 unicast-routing

vlan 3230
  name IPv6LAN

vlan 3201
  name IPv6Link

int r f0/16-18
  sw mo ac
  sw ac vlan 3230
  no sh
  exit

int vlan 3230
  ipv6 ad 2001:aaaa:3200::1/64
  no sh
  exit

int vlan 3201
  ipv6 add 2001:aaaa:3201::2/64
  no sh
  exit

int f0/1
  sw tr all vlan add 3201
  exit

ipv6 ro ::/0 2001:aaaa:3201::1
```

Connectivity between LANs:

```
RS31_RS4#
RS31_RS4#ping ipv6 2001:aaaa:3200::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:AAAA:3200::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/3/9 ms
RS31_RS4#traceroute ipv6 2001:aaaa:3200::1
Type escape sequence to abort.
Tracing the route to 2001:AAAA:3200::1

  1 2001:AAAA:3101::1 0 msec 9 msec 0 msec
  2 ::FFFF:2.2.31.1 8 msec 0 msec 0 msec
  3 2001:AAAA:3201::1 8 msec 0 msec 0 msec
  4 2001:AAAA:3201::2 9 msec 8 msec 0 msec
RS31_RS4#
```

RS IPv6 routing table

```
RS31_RS4#
RS31_RS4#show ipv6 route
IPv6 Routing Table - default - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S   ::/0 [1/0]
     via 2001:AAAA:3101::1
C   2001:AAAA:3100::/64 [0/0]
     via Vlan3130, directly connected
L   2001:AAAA:3100::1/128 [0/0]
     via Vlan3130, receive
C   2001:AAAA:3101::/64 [0/0]
     via Vlan3101, directly connected
L   2001:AAAA:3101::2/128 [0/0]
     via Vlan3101, receive
L   FF00::/8 [0/0]
     via Null0, receive
RS31_RS4#
```

Connectivity between LANs:

```
RS32_RS8#ping ipv6 2001:aaaa:3100::1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:AAAA:3100::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/3/9 ms
RS32_RS8#traceroute ipv6 2001:aaaa:3100::1

Type escape sequence to abort.
Tracing the route to 2001:AAAA:3100::1

  1 2001:AAAA:3201::1 0 msec 9 msec 0 msec
  2 ::FFFF:2.2.32.1 8 msec 0 msec 8 msec
  3 2001:AAAA:3101::1 0 msec 9 msec 0 msec
  4 2001:AAAA:3101::2 8 msec 0 msec 9 msec
```

RS routing table:

```
RS32_RS8#sh ipv6 ro
IPv6 Routing Table - Default - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, D - EIGRP, EX - EIGRP external
       ND - Neighbor Discovery
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S   ::/0 [1/0]
     via 2001:AAAA:3201::1
C   2001:AAAA:3200::/64 [0/0]
     via Vlan3230, directly connected
L   2001:AAAA:3200::1/128 [0/0]
     via Vlan3230, receive
C   2001:AAAA:3201::/64 [0/0]
     via Vlan3201, directly connected
L   2001:AAAA:3201::2/128 [0/0]
     via Vlan3201, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Show Commands

```
show ip route vrf A
show ip route vrf B
show ip route
```

Tests

=>

```
telnet 33.3.2.1 /vrf A
telnet 44.3.2.1 /vrf B

ping vrf A


100.3.2.1
3


Y
3.3.2.1




!endofping
ping vrf A 7.8.9.1 source vlan 3210


ping ipv6 2001:aaaa:3100::1
```

PC Configuration

```
#!/bin/bash

dev="eth0"
inet="7.8.9.1"

if [ "$1" == "A" ]; then
    address="3.3.2.2/24";
    gw="3.3.2.1";
    rsr="33.3.2.0/30";
    nei="3.3.1.0/30";

elif [ "$1" == "B" ]; then
    address="4.3.2.2/24";
    gw="4.3.2.1";
    rsr="44.3.2.0/30";
    nei="4.3.1.0/30";

else
    echo "[-] Choose VRF (A/B)!"
    exit 1
fi

ip ad fl dev $dev
ip ad ad $address dev $dev

ip ro add $rsr via $gw dev $dev
ip ro add $inet via $gw dev $dev
ip ro add $nei via $gw dev $dev
```

```
#tests
#!/bin/bash

if [ "$1" == "A" ]; then
    ping -q -c 2 3.3.2.1; echo -e "\n\n";
    ping -q -c 2 33.3.2.1; echo -e "\n\n";
elif [ "$1" == "B" ]; then
    ping -q -c 2 4.3.2.1; echo -e "\n\n";
    ping -q -c 2 44.3.2.1; echo -e "\n\n";
else
    echo "[-] Choose VRF (A/B)!"
    exit 1
fi
```

!RA preconfigured

```
hostname PSP-RA

banner motd $
      ( )
       |
      (*)
       |
       |
[ ]---( )
       |
       |
```

!RB route-reflector

```
hostname PEINET-RB

clns routing
no mpls ldp advertise-labels
mpls ldp advertise-labels for 1

interface Loopback1
 ip address 1.99.99.1 255.255.255.255
 ip ospf network point-to-point
 ip router isis 2
 ip ospf 1 area 0
```

```
      ( )
$
clns routing

router isis 2
  net 49.0002.0010.9909.9010.00
  exit


interface Serial0/1/0
  description TO_RE
  ip address 1.1.31.1 255.255.255.252
  mpls ip
  ip router isis 2
  clo r 128000
  no sh
  exit

interface Serial0/1/1
  description TO_RF
  ip address 1.1.32.1 255.255.255.252
  mpls ip
  ip router isis 2
  clo r 128000
  no sh
  exit

interface l1
  ip router isis 2
  ip add 1.99.99.10 255.255.255.255
  no sh
  exit



!ISIS as carry for MPLS
```

```
!
interface Loopback789
 ip address 7.8.9.1 255.255.255.0
!
interface FastEthernet0/0
 description TO_PSP-RA
 ip address 1.1.100.1 255.255.255.252
 ip router isis 2
 ip ospf 1 area 0
 mpls ip

router ospf 1
 router-id 1.99.99.1

router isis 2
 net 49.0002.0010.9909.9001.00
 is-type level-1
 exit

router bgp 789
 bgp log-neighbor-changes
 neighbor 1.99.3.1 remote-as 65001
 neighbor 1.99.3.1 ebgp-multihop 2
 neighbor 1.99.3.1 update-source Loopback1
 neighbor 1.99.3.2 remote-as 65001
 neighbor 1.99.3.2 ebgp-multihop 2
 neighbor 1.99.3.2 update-source Loopback1
address-family ipv4
  network 7.8.9.0 mask 255.255.255.0
  neighbor 1.99.3.1 activate
  neighbor 1.99.3.2 activate
exit-address-family
address-family ipv6
  network 2001:7:8:9::/64
  neighbor 1.99.3.1 activate
  neighbor 1.99.3.1 send-label
  neighbor 1.99.3.2 activate
  neighbor 1.99.3.2 send-label
 exit-address-family
exit

mpls ldp router-id Loopback1
access-list 1 permit 1.99.99.1
```

!RI preconfigured

```
!hostname PWAN_RI
!desc backupWAN
banner motd $
      ( )
       |
```

!RJ route-reflector

```
!hostname PERR-RJ
!desc WANmplsRouteReflexctor
banner motd $
      ( )
       |
```

```
      ( )
       |
       |
[ ]---( )
       |
       |
      (*)---( )
$

!shared
interface loopback 1
ip address 2.99.99.10 255.255.255.255
ip ospf 2 area 0
exit

router ospf 2
router-id 2.99.99.10
exit
!do clear ip ospf process
!yes

interface fastEthernet 0/0
ip address 2.2.100.2 255.255.255.252
ip ospf 2 area 0
no sh
exit

interface fastEthernet 0/2/0
  description RI-RE
  !encapsulation dot1Q 3101
  !ip address 2.3.31.1 255.255.255.252
  sw mo ac
  sw ac vlan 3101
  mpls ip
  no shutdown
  exit

interface fastEthernet 0/2/1
  description RI-RF
  !encapsulation dot1Q 3102
  !ip address 2.3.32.1 255.255.255.252
  sw mo ac
  sw ac vlan 3102
  mpls ip
  no shutdown
  exit

!OSPF as carry for MPLS
mpls label protocol ldp
no mpls ldp advertise-labels
mpls ldp advertise-labels for 1

vlan 3101
  name GR31
  exit
vlan 3102
  name GR32
  exit

interface FastEthernet0/2/0
  sh
  switchport access vlan 3101
```

```
      ( )
       |
       |
[ ]---( )
       |
       |
      ( )---(*)
$

!...

access-list 1 permit 2.99.99.1

mpls ldp advertise-labels for 1

!shared
interface loopback 2
ip address 2.99.99.1 255.255.255.255
ip ospf 2 area 0
exit

router ospf 2
router-id 2.99.99.1
exit
do clear ip ospf process
yes

interface fastEthernet 0/0
ip address 2.2.100.1 255.255.255.252
ip ospf 2 area 0
no sh
exit

router bgp 65001
 bgp log-neighbor-changes
 no bgp default ipv4-unicast
 neighbor 1.99.3.1 remote-as 65001
 neighbor 1.99.3.1 update-source Loopback2
 neighbor 1.99.3.2 remote-as 65001
 neighbor 1.99.3.2 update-source Loopback2

 address-family ipv4
  !Jinak to nejede, ale
  !teoreticky to tu nema byt
  neighbor 1.99.2.1 activate
  neighbor 1.99.2.1 send-community extended
  neighbor 1.99.2.1 route-reflector-client
  neighbor 1.99.2.2 activate
  neighbor 1.99.2.2 send-community extended
  neighbor 1.99.2.2 route-reflector-client
  neighbor 1.99.3.1 activate
  neighbor 1.99.3.1 send-community extended
  neighbor 1.99.3.1 route-reflector-client
  neighbor 1.99.3.2 activate
  neighbor 1.99.3.2 send-community extended
  neighbor 1.99.3.2 route-reflector-client
 exit-address-family

 address-family vpnv4
  neighbor 1.99.3.1 activate
  neighbor 1.99.3.1 send-community extended
  neighbor 1.99.3.1 route-reflector-client
```

```
  no ip address
  no sh
  exit

interface FastEthernet0/2/1
  sh
  switchport access vlan 3102
  no ip address
  no sh
  exit

interface Vlan3101
  desc GR31
  ip address 2.2.31.1 255.255.255.252
  ip ospf 2 area 0
  exit

interface Vlan3102
  desc GR32
  ip address 2.2.32.1 255.255.255.252
  ip ospf 2 area 0
  exit

router ospf 2
  !SPOLECNE PRO VSECHNY SKUPINY
  router-id 2.99.99.10
  network 2.2.21.0 0.0.0.3 area 0 !CIZI
  network 2.2.22.0 0.0.0.3 area 0 !CIZI
  network 2.2.100.0 0.0.0.3 area 0  !RR
  network 2.99.99.10 0.0.0.0 area 0 !L1
  network 2.2.31.0 0.0.0.3 area 0 !NASE
  network 2.2.32.0 0.0.0.3 area 0 !NASE
  exit

access-list 1 permit 2.99.0.0 0.0.255.255
```

```
  neighbor 1.99.3.2 activate
  neighbor 1.99.3.2 send-community extended
  neighbor 1.99.3.2 route-reflector-client
 exit-address-family

 address-family ipv6
  !Jinak to nejede, ale
  !teoreticky to tu nema byt
  neighbor 1.99.3.1 activate
  neighbor 1.99.3.1 send-community extended
  neighbor 1.99.3.1 route-reflector-client
  neighbor 1.99.3.2 activate
  neighbor 1.99.3.2 send-community extended
  neighbor 1.99.3.2 route-reflector-client
 exit-address-family

 address-family vpnv6 unicast
  neighbor 1.99.3.1 activate
  neighbor 1.99.3.1 send-community extended
  neighbor 1.99.3.1 route-reflector-client
  neighbor 1.99.3.2 activate
  neighbor 1.99.3.2 send-community extended
  neighbor 1.99.3.2 route-reflector-client
 exit-address-family

exit
```

MPLS Filtering

(solution is merely theoretical)

RE, RF:
access-list 1 permit 1.99.0.0 0.0.255.255
access-list 2 permit 2.99.0.0 0.0.255.255
no mpls ldp ad
mpls ldp ad for 1
mpls ldp ad for 2

RA, RB:
access-list 1 permit 1.99.0.0 0.0.255.255
no mpls ldp ad
mpls ldp ad for 1

RI, RJ:
access-list 2 permit 2.99.0.0 0.0.255.255
no mpls ldp ad
mpls ldp ad for 2

VRF Interconnection

!RE:

```
ip vrf A
  rd 65001:99311
  route-t e 65001:311
  route-t i 65001:321
  route-t i 65001:312 !interVRF connection
  route-t i 65001:322 !interVRF connection
  exit

ip vrf B
  rd 65001:99312
  route-t e 65001:312
  route-t i 65001:322
  route-t i 65001:311 !interVRF connection
  route-t i 65001:321 !interVRF connection
  exit
```

!RF:

```
ip vrf A
  rd 65001:99321
  route-t e 65001:321
  route-t i 65001:311
  route-t i 65001:312 !interVRF connection
  route-t i 65001:322 !interVRF connection
  exit

ip vrf B
  rd 65001:99322
  route-t e 65001:322
  route-t i 65001:312
  route-t i 65001:311 !interVRF connection
  route-t i 65001:321 !interVRF connection
  exit
```

VRF A

```
R31_RE#show ip route vrf A

Routing Table: A
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/24 is subnetted, 2 subnets
O        3.3.1.0 [110/2] via 33.3.1.2, 04:08:30, FastEthernet0/0.311
B        3.3.2.0 [200/2] via 1.99.3.2, 00:03:33
      4.0.0.0/24 is subnetted, 2 subnets
B        4.3.1.0 [20/0] via 44.3.1.2 (B), 00:04:14
B        4.3.2.0 [200/0] via 1.99.3.2, 00:03:33
      30.0.0.0/30 is subnetted, 1 subnets
O E2     30.3.12.0 [110/20] via 33.3.1.2, 04:35:52, FastEthernet0/0.311
      33.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        33.3.1.0/30 is directly connected, FastEthernet0/0.311
L        33.3.1.1/32 is directly connected, FastEthernet0/0.311
B        33.3.2.0/30 [200/0] via 1.99.3.2, 00:03:33
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        44.3.1.0/30 is directly connected (B), 00:04:14, FastEthernet0/0.312
L        44.3.1.1/32 is directly connected, FastEthernet0/0.312
B        44.3.2.0/30 [200/0] via 1.99.3.2, 00:03:33
      111.0.0.0/30 is subnetted, 1 subnets
B        111.3.12.0 [200/0] via 1.99.3.2, 00:03:30
R31_RE#
```

VRF B

```
R31_RE#show ip route vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/24 is subnetted, 2 subnets
B        3.3.1.0 [20/2] via 33.3.1.2 (A), 00:04:35, FastEthernet0/0.311
B        3.3.2.0 [200/2] via 1.99.3.2, 00:03:54
      4.0.0.0/24 is subnetted, 2 subnets
B        4.3.1.0 [20/0] via 44.3.1.2, 02:29:48
R        4.3.2.0 [120/4] via 111.3.12.2, 00:00:07, Tunnel12
      33.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        33.3.1.0/30 is directly connected (A), 00:04:35, FastEthernet0/0.311
L        33.3.1.1/32 is directly connected, FastEthernet0/0.311
B        33.3.2.0/30 [200/0] via 1.99.3.2, 00:03:54
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        44.3.1.0/30 is directly connected, FastEthernet0/0.312
L        44.3.1.1/32 is directly connected, FastEthernet0/0.312
B        44.3.2.0/30 [200/0] via 1.99.3.2, 00:03:54
      111.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        111.3.12.0/30 is directly connected, Tunnel12
L        111.3.12.1/32 is directly connected, Tunnel12
R31_RE#
```

VRF A routing table:

```
R32_RF#sh ip ro vrf A

Routing Table: A
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/24 is subnetted, 2 subnets
B        3.3.1.0 [200/2] via 1.99.3.1, 00:01:41
O        3.3.2.0 [110/2] via 33.3.2.2, 05:34:29, FastEthernet0/0.321
      4.0.0.0/24 is subnetted, 2 subnets
B        4.3.1.0 [200/0] via 1.99.3.1, 00:01:41
B        4.3.2.0 [20/0] via 44.3.2.2 (B), 00:01:41
      30.0.0.0/30 is subnetted, 1 subnets
O E2     30.3.12.0 [110/20] via 33.3.2.2, 05:34:29, FastEthernet0/0.321
      33.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        33.3.1.0/30 [200/0] via 1.99.3.1, 00:01:41
C        33.3.2.0/30 is directly connected, FastEthernet0/0.321
L        33.3.2.1/32 is directly connected, FastEthernet0/0.321
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        44.3.1.0/30 [200/0] via 1.99.3.1, 00:01:41
B        44.3.2.0/30 is directly connected (B), 00:01:41, FastEthernet0/0.322
L        44.3.2.1/32 is directly connected, FastEthernet0/0.322
      111.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
B        111.3.12.0/30 is directly connected (B), 00:01:38, Tunnel12
L        111.3.12.2/32 is directly connected, Tunnel12
```

VRF B routing table:

```
R32_RF#sh ip ro vrf B

Routing Table: B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/24 is subnetted, 2 subnets
B        3.3.1.0 [200/2] via 1.99.3.1, 00:01:48
B        3.3.2.0 [20/2] via 33.3.2.2 (A), 00:01:48, FastEthernet0/0.321
      4.0.0.0/24 is subnetted, 2 subnets
R        4.3.1.0 [120/4] via 111.3.12.1, 00:00:16, Tunnel12
B        4.3.2.0 [20/0] via 44.3.2.2, 00:01:48
      33.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        33.3.1.0/30 [200/0] via 1.99.3.1, 00:01:48
B        33.3.2.0/30 is directly connected (A), 00:01:48, FastEthernet0/0.321
L        33.3.2.1/32 is directly connected, FastEthernet0/0.321
      44.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
B        44.3.1.0/30 [200/0] via 1.99.3.1, 00:01:48
C        44.3.2.0/30 is directly connected, FastEthernet0/0.322
L        44.3.2.1/32 is directly connected, FastEthernet0/0.322
      111.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        111.3.12.0/30 is directly connected, Tunnel12
L        111.3.12.2/32 is directly connected, Tunnel12
```

PoC inter-VRF ping:

PoC inter-VRF ping:

```
RS31_RS4#
RS31_RS4#ping vrf A 4.3.1.1 source 3.3.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.3.1.1, timeout is 2 seconds:
Packet sent with a source address of 3.3.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/5/9 ms
RS31_RS4#
RS31_RS4#tracer
RS31_RS4#tracer
RS31_RS4#traceroute vrf A 4.3.1.1
Type escape sequence to abort.
Tracing the route to 4.3.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 33.3.1.1 0 msec 8 msec 0 msec
  2 44.3.1.2 0 msec *  0 msec
RS31_RS4#
```

```
RS32_RS8#ping vrf A 4.3.2.1 source 3.3.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.3.2.1, timeout is 2 seconds:
Packet sent with a source address of 3.3.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/5/9 ms
RS32_RS8#ping vrf A 4.3.1.1 source 3.3.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.3.1.1, timeout is 2 seconds:
Packet sent with a source address of 3.3.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/4/9 ms
```

PoC Inter-VRF trace:

```
RS32_RS8#trace vrf A 4.3.2.1

Type escape sequence to abort.
Tracing the route to 4.3.2.1

  1 33.3.2.1 0 msec 0 msec 0 msec
  2 44.3.2.2 8 msec *  0 msec
RS32_RS8#trace vrf A 4.3.1.1

Type escape sequence to abort.
Tracing the route to 4.3.1.1

  1 33.3.2.1 0 msec 0 msec 8 msec
  2 2.2.32.1 0 msec 9 msec 0 msec
  3 44.3.1.1 8 msec 0 msec 8 msec
  4 44.3.1.2 0 msec *  0 msec
```

The End…