Project Report
Communication Architectures

University of Aveiro

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Introduction

The goal of this project is to design the technical aspects in GNS3, configure and test a Content Delivery Network (CDN) with multiple corporate clients.

CDNRUS LLC is a CDN company that provides Infrastructure as a Service (IaaS), hosting, and connecting cluster servers virtually and bare-metal. They have different Points of Presence (PoP) in geographically distinct locations (Aveiro, Lisbon, Madrid, and New York) with various large and small clients requiring specific connectivity.

The project involves interconnecting the PoPs, configuring virtual private networks (VPN), and reserving bandwidth to meet the specific connectivity requirements of each client.
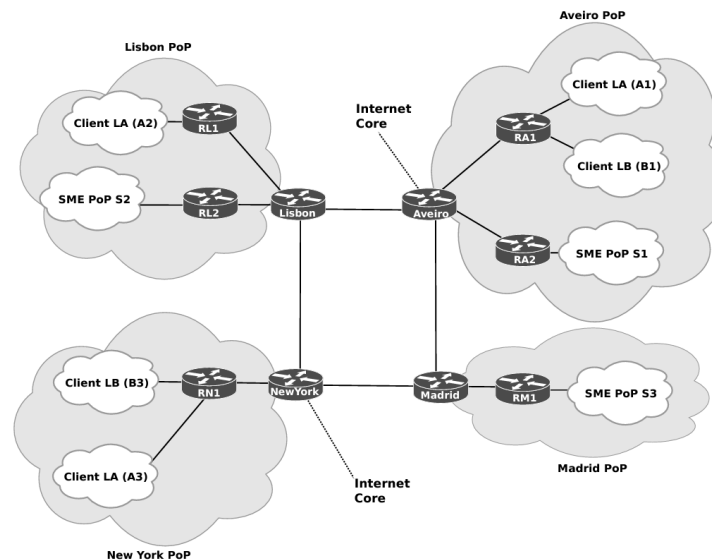

Figure 1.1: Conceptual Project Topology.

Overall topology

As we could see in the previous image the network has the 4 Pop's connected to each other. Besides that we have different clients with these following characteristics:

- Clients SME1, SME2, and SME3 belong to the same industrial association that will share the same CDN server clusters.They requested a MPLS Layer 3 VPN to interconnect its server cluster

- Client LB, has two server clusters B1 and B3, subdivided in three Ethernet VLANs (VLAN 10: 10.10.0.0/24, VLAN 20: 10.20.0.0/24, VLAN 30: 10.30.0.0/24). They requested a Layer 2 point-to-point overlay network between its server locations, with 10 Mbps.

- Client LA, has three server clusters A1, A2, and A3 (that share the same IPv4 network 10.2.0.0/16) connected to the respective PoPs. They requested a Layer 2 VPN between its server cluster locations.

Basic assembly and core connectivity

For the overall basic assembly we started by configuring each interface with the appropriate ip address for each necessary interface. Here is an example how we did a simple configuration:

```
1 Lisbon# configure terminal
2 Lisbon(config)# interface FastEthernet 0/0
3 Lisbon(config-if)# ip add 10.0.0.1 255.255.255.252
4 Lisbon(config-if)# no shutdown
5 Lisbon(config-if)# end
```

Then we configured OSPF(Open Shortest Path First) in all interfaces to distribute IP routing information throughout our AS. Here is a following example in how to do it:

```
1 Lisbon(config)# configure terminal
2 Lisbon(config)# interface f0/1
3 Lisbon(config-if)# ip ospf 1 area 0
4 Lisbon(config-if)# end
```

To actually get our OSPF working we created our company Internet Autonomous System with number 33900 and configured our iBGP Neighboring. Here is a following example:

```
1 Lisbon#configure terminal
2 Lisbon(config)#router bgp 33900
3 isbon(config-router)# neighbor 10.0.0.2 remote-as 33900
4 Lisbon(config-router)# neighbor 10.0.0.18 remote-as 33900
5 Lisbon(config-router)# neighbor 10.0.0.22 remote-as 33900
6 Lisbon(config-router)#end
```

Finally, we configured all loopback0 interfaces and activated ospf by doing the following configuration:

```
1 Lisbon#configure terminal
2 Lisbon(config)#int loopback 0
3 Lisbon(config-if)# ip ospf 1 area 0
4 Lisbon(config-if)#ip add 10.0.0.202 255.255.255.255
5 Lisbon(config-if)#no shutdown
6 Lisbon(config-if)#end
```

In the end we could ping successfully all interfaces.

3.1   Lisbon show run

This was Lisbon Full configuration as an example:

```
 1  Lisbon#show run
 2  Building configuration...
 3
 4  Current configuration : 1723 bytes
 5  !
 6  ! Last configuration change at 01:41:25 UTC Sat Jan 6 2024
 7  !
 8  version 15.2
 9  service timestamps debug datetime msec
10  service timestamps log datetime msec
11  !
12  hostname Lisbon
13  !
14  boot-start-marker
15  boot-end-marker
16  !
17  !
18  !
19  no aaa new-model
20  no ip icmp rate-limit unreachable
21  ip cef
22  !
23  !
24  !
25  !
26  !
27  !
28  no ip domain lookup
29  no ipv6 cef
30  !
31  !
32  multilink bundle-name authenticated
33  !
34  !
35  !
36  !
37  !
38  !
39  !
40  !
41  !
42  ip tcp synwait-time 5
43  !
44  !
45  !
46  !
47  !
48  !
49  !
50  !
```

```
51  !
52  !
53  !
54  !
55  interface Loopback0
56   ip address 10.0.0.202 255.255.255.255
57   ip ospf 1 area 0
58  !
59  interface FastEthernet0/0
60   ip address 10.0.0.1 255.255.255.252
61   ip ospf 1 area 0
62   speed auto
63   duplex auto
64  !
65  interface FastEthernet0/1
66   ip address 10.0.0.13 255.255.255.252
67   ip ospf 1 area 0
68   speed auto
69   duplex auto
70  !
71  interface FastEthernet1/0
72   ip address 10.0.0.17 255.255.255.252
73   ip ospf 1 area 0
74   speed auto
75   duplex auto
76  !
77  interface FastEthernet1/1
78   ip address 10.0.0.21 255.255.255.252
79   ip ospf 1 area 0
80   speed auto
81   duplex auto
82  !
83  interface FastEthernet2/0
84   no ip address
85   shutdown
86   speed auto
87   duplex auto
88  !
89  interface FastEthernet2/1
90   no ip address
91   shutdown
92   speed auto
93   duplex auto
94  !
95  interface FastEthernet3/0
96   no ip address
97   shutdown
98   speed auto
99   duplex auto
100 !
101 interface FastEthernet3/1
102  no ip address
103  shutdown
104  speed auto
105  duplex auto
106 !
107 router ospf 1
```

```
108  !
109  router bgp 33900
110   bgp log-neighbor-changes
111   redistribute ospf 1
112   neighbor 10.0.0.2 remote-as 33900
113   neighbor 10.0.0.18 remote-as 33900
114   neighbor 10.0.0.22 remote-as 33900
115  !
116  ip forward-protocol nd
117  !
118  !
119  no ip http server
120  no ip http secure-server
121  !
122  !
123  !
124  !
125  control-plane
126  !
127  !
128  line con 0
129   exec-timeout 0 0
130   privilege level 15
131   logging synchronous
132   stopbits 1
133  line aux 0
134   exec-timeout 0 0
135   privilege level 15
136   logging synchronous
137   stopbits 1
138  line vty 0 4
139   login
140  !
141  !
142  end
```

Here is an example of a successful ping:

```
1  Lisbon#ping 10.0.0.32
2  Type escape sequence to abort.
3  Sending 5, 100-byte ICMP Echos to 10.0.0.32, timeout is 2 seconds:
4  !!!!!
5  Success rate is 100 percent (5/5), round-trip min/avg/max =
       52/64/96 ms
```

SME1, SME2, and SME3 Association MPLS Layer 3 VPN

For this part of the project we started by, firstly, create the vrf in routers RL2, RA2 and RM1. We named our vrf "VPN-1" and in each physical interface (mpls ip) except the ones connected to the VPN-1.

4.1 Configuration process

```
1 RL2#configure terminal
2 RL2(config)#ip vrf VPN-1
3 RL2(config-vrf)#rd 33900:1
4 RL2(config-vrf)#route-target export 33900:1
5 RL2(config-vrf)#route-target import 33900:1
6 RL2(config-vrf)#exit
7 RL2(config)#interface f1/0
8 RL2(config-if)#ip vrf forwarding VPN-1
9 RL2(config-if)#ip add 10.0.2.1 255.255.255.0
10 RL2(config-if)#end
```

We, successfully, could ping the local vrf:

```
1 RL2#ping vrf VPN-1 10.0.2.1
2 Type escape sequence to abort.
3 Sending 5, 100-byte ICMP Echos to 10.0.0.22, timeout is 2 seconds:
4 !!!!!
5 Success rate is 100 percent (5/5), round-trip min/avg/max = 4/5/8
    ms
```

After doing it in the two remaining routers it was time to do the global and VRF inter-routing. Here is an example of how we did it in RL2:

```
1 RL2#configure terminal
2 RL2(config)#router bgp 33900
3 RL2(config-router)# bgp router-id 10.0.0.102
4 RL2(config-router)# bgp log-neighbor-changes
5 RL2(config-router)# neighbor 10.0.0.21 remote-as 33900
6 RL2(config-router)# neighbor 10.0.0.112 remote-as 33900
7 RL2(config-router)# neighbor 10.0.0.112 update-source Loopback0
```

7

```
 8  RL2(config-router)# neighbor 10.0.0.121 remote-as 33900
 9  RL2(config-router)# neighbor 10.0.0.121 update-source Loopback0
10  RL2(config-router)# address-family vpnv4
11  RL2(config-router-af)#  neighbor 10.0.0.112 activate
12  RL2(config-router-af)#  neighbor 10.0.0.112 send-community both
13  RL2(config-router-af)#  neighbor 10.0.0.121 activate
14  RL2(config-router-af)#  neighbor 10.0.0.121 send-community both
15  RL2(config-router-af)#exit
16  RL2(config-router)#address-family ipv4 vrf VPN-1
17  RL2(config-router-af)#redistribute connected
```

After doing the same configuration for the remaining routers we managed to ping between the vrf successfully:

```
 1  RL2#ping vrf VPN-1 10.0.0.102
 2  Type escape sequence to abort.
 3  Sending 5, 100-byte ICMP Echos to 10.0.0.102, timeout is 2 seconds:
 4  .....
 5  Success rate is 0 percent (0/5)
 6  RL2#ping vrf VPN-1 10.0.2.1
 7  Type escape sequence to abort.
 8  Sending 5, 100-byte ICMP Echos to 10.0.2.1, timeout is 2 seconds:
 9  !!!!!
10  Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4
        ms
11  RL2#ping vrf VPN-1 10.0.3.1
12  Type escape sequence to abort.
13  Sending 5, 100-byte ICMP Echos to 10.0.3.1, timeout is 2 seconds:
14  !!!!!
15  Success rate is 100 percent (5/5), round-trip min/avg/max =
        100/113/132 ms
16  RL2#ping vrf VPN-1 10.0.1.1
17  Type escape sequence to abort.
18  Sending 5, 100-byte ICMP Echos to 10.0.1.1, timeout is 2 seconds:
19  !!!!!
20  Success rate is 100 percent (5/5), round-trip min/avg/max =
        64/79/100 ms
```

4.2   RL2 show ip route vrf VPN-1

This is the command `show ip route vrf VPN-1` in RL2 as an example:

```
 1  RL2#show ip route vrf VPN-1
 2  Routing Table: VPN-1
 3  Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B
        - BGP
 4         D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter
       area
 5         N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type
        2
 6         E1 - OSPF external type 1, E2 - OSPF external type 2
 7         i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-
       IS level-2
 8         ia - IS-IS inter area, * - candidate default, U - per-user
       static route
```

```
 9          o - ODR, P - periodic downloaded static route, H - NHRP, l -
        LISP
10          + - replicated route, % - next hop override
11
12 Gateway of last resort is not set
13
14        10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
15 B         10.0.1.0/24 [200/0] via 10.0.0.112, 00:17:06
16 C         10.0.2.0/24 is directly connected, FastEthernet1/0
17 L         10.0.2.1/32 is directly connected, FastEthernet1/0
18 B         10.0.3.0/24 [200/0] via 10.0.0.121, 00:17:05
```

4.3   RL2 show ip cef vrf VPN-1 detail

This is the command `show ip cef vrf VPN-1 detail` in RL2 as an example:

```
1 RL2#show ip cef vrf VPN-1 detail
2 IPv4 CEF is enabled and running
3 VRF VPN-1
4  14 prefixes (14/0 fwd/non-fwd)
5  Table id 0x1
6  Database epoch:        0 (14 entries at this epoch)
7
8 0.0.0.0/0, epoch 0, flags default route handler, default route
9   no route
10 0.0.0.0/8, epoch 0
11   Special source: drop
12   drop
13 0.0.0.0/32, epoch 0, flags receive
14   Special source: receive
15   receive
16 10.0.1.0/24, epoch 0, flags rib defined all labels
17   recursive via 10.0.0.112 label 34
18     nexthop 10.0.0.21 FastEthernet0/0 label 24
19 10.0.2.0/24, epoch 0, flags attached, connected, cover dependents,
      need deagg
20   local label info: other/34
21   Covered dependent prefixes: 2
22     need deagg: 2
23   attached to FastEthernet1/0
24 10.0.2.0/32, epoch 0, flags receive
25   Interface source: FastEthernet1/0 flags: none
26   Dependent covered prefix type cover need deagg, cover 10.0.2.0/24
27   receive for FastEthernet1/0
28 10.0.2.1/32, epoch 0, flags receive, local, source eligible
29   Interface source: FastEthernet1/0 flags: local, source eligible
30   receive for FastEthernet1/0
31 10.0.2.255/32, epoch 0, flags receive
32   Interface source: FastEthernet1/0 flags: none
33   Dependent covered prefix type cover need deagg, cover 10.0.2.0/24
34   receive for FastEthernet1/0
35 10.0.3.0/24, epoch 0, flags rib defined all labels
36   recursive via 10.0.0.121 label 34
37     nexthop 10.0.0.21 FastEthernet0/0 label 22
```

```
38  127.0.0.0/8, epoch 0
39    Special source: drop
40    drop
41  224.0.0.0/4, epoch 0
42    Special source: drop
43    drop
44  224.0.0.0/24, epoch 0, flags receive
45    Special source: receive
46    receive
47  240.0.0.0/4, epoch 0
48    Special source: drop
49    drop
50  255.255.255.255/32, epoch 0, flags receive
51    Special source: receive
52    receive
```

Client LB Layer 2 point-to-point Overlay network
Client LB bandwidth reservation and usage/routing

To do the Client LB Layer 2 point-to-point Overlay network we needed to activate RSVP-TE and create a Tunnel between Aveiro and New York and Enabling traffic engineering features on OSPF in order to announce Multiprotocol Label Switching (MPLS) traffic engineering (TE).

5.1   Configuration process

We did the following steps:

1. In general configuration mode and in each physical interface: `no mpls ip`

2. We Enable MPLS (RSVP-TE) in each physical interface, like this:

```
1  Aveiro#configure terminal
2  Aveiro(config)#int f0/0
3  Aveiro(config-if)#mpls traffic-eng tunnels
4  Aveiro(config-if)#end
```

3. Enable traffic engineering features on OSPF configuration mode of all routers like this:

```
1  Aveiro#configure terminal
2  Aveiro(config)#router ospf 1
3  Aveiro(config-router)#mpls traffic-eng area 0
4  Aveiro(config-router)#mpls traffic-eng router-id Loopback 0
5  Aveiro(config-router)#end
```

4. Use the command **clear ip ospf process** to reinitialize the OSPF process in each router.

11

```
1 Aveiro#clear ip ospf process
2 Reset ALL OSPF processes? [no]: yes
```

5. We created 2 dynamic tunnels. First from Aveiro to New York:

```
 1 Aveiro#configure terminal
 2 Enter configuration commands, one per line.  End with CNTL/Z.
 3 Aveiro(config)#interface Tunnel1
 4 Aveiro(config-if)# ip unnumbered Loopback0
 5 Aveiro(config-if)# tunnel mode mpls traffic-eng
 6 Aveiro(config-if)# tunnel destination 10.0.0.130  ! 10.0.0.130
       = int lo0 New york
 7 Aveiro(config-if)# tunnel mpls traffic-eng autoroute announce
 8 Aveiro(config-if)# tunnel mpls traffic-eng priority 7 7
 9 Aveiro(config-if)# tunnel mpls traffic-eng bandwidth 10000
10 Aveiro(config-if)# tunnel mpls traffic-eng path-option 1
       dynamic
11 Aveiro(config-if)# end
```

We did these symmetric configurations from New york to Aveiro. Note that we also setup bandwidth values to 10Mbps. Since the specification of the tunnel bandwidth is in Kbit/s, 10Mbps = 10000 Kbit/s.

6. Finally for each necessary interface in router Lisbon, Aveiro, New York and Madrid we setup 10 Mbps of guaranteed bandwidth between Client LB sites:

```
1 Aveiro#configure terminal
2 Aveiro(config)#interface f0/0
3 Aveiro(config-if)#ip rsvp bandwidth 10000
4 Aveiro(config-if)#end
```

5.2   Show run Aveiro

This was Aveiro's full configuration:

```
 1 Aveiro#show run
 2 Building configuration...
 3
 4 Current configuration : 2249 bytes
 5 !
 6 version 15.2
 7 service timestamps debug datetime msec
 8 service timestamps log datetime msec
 9 !
10 hostname Aveiro
11 !
12 boot-start-marker
13 boot-end-marker
14 !
15 !
16 !
17 no aaa new-model
18 no ip icmp rate-limit unreachable
```

```
19  ip cef
20  !
21  !
22  !
23  !
24  !
25  !
26  no ip domain lookup
27  no ipv6 cef
28  !
29  !
30  mpls traffic-eng tunnels
31  multilink bundle-name authenticated
32  !
33  !
34  !
35  !
36  !
37  !
38  !
39  !
40  !
41  ip tcp synwait-time 5
42  !
43  !
44  !
45  !
46  !
47  !
48  !
49  !
50  !
51  !
52  !
53  !
54  interface Loopback0
55   ip address 10.0.0.110 255.255.255.255
56   ip ospf 1 area 0
57  !
58  interface Tunnel1
59   ip unnumbered Loopback0
60   tunnel mode mpls traffic-eng
61   tunnel destination 10.0.0.130
62   tunnel mpls traffic-eng autoroute announce
63   tunnel mpls traffic-eng priority 7 7
64   tunnel mpls traffic-eng bandwidth 10000
65   tunnel mpls traffic-eng path-option 1 dynamic
66  !
67  interface FastEthernet0/0
68   ip address 10.0.0.2 255.255.255.252
69   ip ospf 1 area 0
70   speed auto
71   duplex auto
72   mpls ip
73   mpls traffic-eng tunnels
74   ip rsvp bandwidth 10000
75  !
```

13

```
76  interface FastEthernet0/1
77   ip address 10.0.0.5 255.255.255.252
78   ip ospf 1 area 0
79   speed auto
80   duplex auto
81   mpls ip
82   mpls traffic-eng tunnels
83   ip rsvp bandwidth 10000
84  !
85  interface FastEthernet1/0
86   ip address 10.0.0.25 255.255.255.252
87   ip ospf 1 area 0
88   speed auto
89   duplex auto
90   mpls ip
91   mpls traffic-eng tunnels
92   ip rsvp bandwidth 10000
93  !
94  interface FastEthernet1/1
95   ip address 10.0.0.29 255.255.255.252
96   ip ospf 1 area 0
97   speed auto
98   duplex auto
99   mpls ip
100 !
101 interface FastEthernet2/0
102  no ip address
103  shutdown
104  speed auto
105  duplex auto
106 !
107 interface FastEthernet2/1
108  no ip address
109  shutdown
110  speed auto
111  duplex auto
112 !
113 interface FastEthernet3/0
114  no ip address
115  shutdown
116  speed auto
117  duplex auto
118 !
119 interface FastEthernet3/1
120  no ip address
121  shutdown
122  speed auto
123  duplex auto
124 !
125 router ospf 1
126  mpls traffic-eng router-id Loopback0
127  mpls traffic-eng area 0
128 !
129 router bgp 33900
130  bgp log-neighbor-changes
131  redistribute ospf 1
132  neighbor 10.0.0.1 remote-as 33900
```

```
133  neighbor 10.0.0.6 remote-as 33900
134  neighbor 10.0.0.26 remote-as 33900
135  neighbor 10.0.0.30 remote-as 33900
136 !
137 ip forward-protocol nd
138 !
139 !
140 no ip http server
141 no ip http secure-server
142 !
143 !
144 !
145 !
146 control-plane
147 !
148 !
149 line con 0
150  exec-timeout 0 0
151  privilege level 15
152  logging synchronous
153  stopbits 1
154 line aux 0
155  exec-timeout 0 0
156  privilege level 15
157  logging synchronous
158  stopbits 1
159 line vty 0 4
160  login
161 !
162 !
163 end
```

5.3   Aveiro show mpls traffic-eng tunnels

```
1 Aveiro#show mpls traffic-eng tunnels
2
3 P2P TUNNELS/LSPs:
4
5 Name: Aveiro_t1                         (Tunnel1) Destination:
      10.0.0.130
6   Status:
7     Admin: up          Oper: up      Path: valid         Signalling:
      connected
8     path option 1, type dynamic (Basis for Setup, path weight 2)
9
10  Config Parameters:
11    Bandwidth: 10000    kbps (Global)  Priority: 7  7    Affinity: 0
      x0/0xFFFF
12    Metric Type: TE (default)
13    AutoRoute: enabled   LockDown: disabled Loadshare: 10000
      [200000] bw-based
14    auto-bw: disabled
15  Active Path Option Parameters:
16    State: dynamic path option 1 is active
```

```
17      BandwidthOverride: disabled   LockDown: disabled    Verbatim:
        disabled
18
19
20    InLabel   :   -
21    OutLabel : FastEthernet0/0, 17
22    Next Hop : 10.0.0.1
23    RSVP Signalling Info:
24        Src 10.0.0.110, Dst 10.0.0.130, Tun_Id 1, Tun_Instance 10
25      RSVP Path Info:
26        My Address: 10.0.0.2
27        Explicit Route: 10.0.0.1 10.0.0.13 10.0.0.14 10.0.0.130
28        Record    Route:    NONE
29        Tspec: ave rate=10000 kbits, burst=1000 bytes, peak rate
        =10000 kbits
30      RSVP Resv Info:
31        Record    Route:    NONE
32        Fspec: ave rate=10000 kbits, burst=1000 bytes, peak rate
        =10000 kbits
33    History:
34      Tunnel:
35        Time since created: 5 minutes, 5 seconds
36        Time since path change: 4 minutes, 22 seconds
37        Number of LSP IDs (Tun_Instances) used: 10
38      Current LSP: [ID: 10]
39        Uptime: 4 minutes, 22 seconds
40
41 LSP Tunnel NewYork_t1 is signalled, connection is up
42    InLabel   : FastEthernet0/0, implicit-null
43    Prev Hop : 10.0.0.1
44    OutLabel :   -
45    RSVP Signalling Info:
46        Src 10.0.0.130, Dst 10.0.0.110, Tun_Id 1, Tun_Instance 11
47      RSVP Path Info:
48        My Address: 10.0.0.110
49        Explicit Route:   NONE
50        Record    Route:    NONE
51        Tspec: ave rate=10000 kbits, burst=1000 bytes, peak rate
        =10000 kbits
52      RSVP Resv Info:
53        Record    Route:    NONE
54        Fspec: ave rate=10000 kbits, burst=1000 bytes, peak rate
        =10000 kbits
55
56 P2MP TUNNELS:
57
58 P2MP SUB-LSPS:
```

5.4   Lisbon show run

```
1 Lisbon#show run
2 Building configuration...
3
4 Current configuration : 1888 bytes
5 !
```

```
 6  version 15.2
 7  service timestamps debug datetime msec
 8  service timestamps log datetime msec
 9  !
10  hostname Lisbon
11  !
12  boot-start-marker
13  boot-end-marker
14  !
15  !
16  !
17  no aaa new-model
18  no ip icmp rate-limit unreachable
19  ip cef
20  !
21  !
22  !
23  !
24  !
25  !
26  no ip domain lookup
27  no ipv6 cef
28  !
29  !
30  mpls traffic-eng tunnels
31  multilink bundle-name authenticated
32  !
33  !
34  !
35  !
36  !
37  !
38  !
39  !
40  !
41  ip tcp synwait-time 5
42  !
43  !
44  !
45  !
46  !
47  !
48  !
49  !
50  !
51  !
52  !
53  !
54  interface Loopback0
55   ip address 10.0.0.100 255.255.255.255
56   ip ospf 1 area 0
57  !
58  interface FastEthernet0/0
59   ip address 10.0.0.1 255.255.255.252
60   ip ospf 1 area 0
61   speed auto
62   duplex auto
```

```
63  mpls ip
64  mpls traffic-eng tunnels
65  ip rsvp bandwidth 10000
66 !
67 interface FastEthernet0/1
68  ip address 10.0.0.13 255.255.255.252
69  ip ospf 1 area 0
70  speed auto
71  duplex auto
72  mpls ip
73  mpls traffic-eng tunnels
74  ip rsvp bandwidth 10000
75 !
76 interface FastEthernet1/0
77  ip address 10.0.0.17 255.255.255.252
78  ip ospf 1 area 0
79  speed auto
80  duplex auto
81  mpls ip
82 !
83 interface FastEthernet1/1
84  ip address 10.0.0.21 255.255.255.252
85  ip ospf 1 area 0
86  speed auto
87  duplex auto
88  mpls ip
89 !
90 interface FastEthernet2/0
91  no ip address
92  shutdown
93  speed auto
94  duplex auto
95 !
96 interface FastEthernet2/1
97  no ip address
98  shutdown
99  speed auto
100  duplex auto
101 !
102 interface FastEthernet3/0
103  no ip address
104  shutdown
105  speed auto
106  duplex auto
107 !
108 interface FastEthernet3/1
109  no ip address
110  shutdown
111  speed auto
112  duplex auto
113 !
114 router ospf 1
115  mpls traffic-eng router-id Loopback0
116  mpls traffic-eng area 0
117 !
118 router bgp 33900
119  bgp log-neighbor-changes
```

```
120   redistribute ospf 1
121   neighbor 10.0.0.2 remote -as 33900
122   neighbor 10.0.0.18 remote -as 33900
123   neighbor 10.0.0.22 remote -as 33900
124 !
125 ip forward -protocol nd
126 !
127 !
128 no ip http server
129 no ip http secure -server
130 !
131 !
132 !
133 !
134 control -plane
135 !
136 !
137 line con 0
138   exec -timeout 0 0
139   privilege level 15
140   logging synchronous
141   stopbits 1
142 line aux 0
143   exec -timeout 0 0
144   privilege level 15
145   logging synchronous
146   stopbits 1
147 line vty 0 4
148   login
149 !
150 !
151 end
```

5.4.1   Client LB VLANs

Client LA Layer 2 VPN

6.1 RA1

6.1.1 RA1 show conf

```
1  vyos@RA1:~$ show conf
2  interfaces {
3      bridge br101 {
4          address 10.2.1.1/16
5          description "client LA1"
6          member {
7              interface eth1 {
8              }
9              interface vxlan101 {
10             }
11         }
12     }
13     bridge br110 {
14         member {
15             interface eth2.10 {
16             }
17             interface vxlan110 {
18             }
19         }
20     }
21     bridge br120 {
22         member {
23             interface eth2.20 {
24             }
25             interface vxlan120 {
26             }
27         }
28     }
29     bridge br130 {
30         member {
31             interface eth2.30 {
32             }
33             interface vxlan130 {
```

```
34              }
35          }
36      }
37      dummy dum0 {
38          address 10.0.0.111/32
39      }
40      ethernet eth0 {
41          address 10.0.0.26/30
42          hw-id 08:00:27:58:13:bb
43      }
44      ethernet eth1 {
45          hw-id 08:00:27:1d:74:c5
46      }
47      ethernet eth2 {
48          hw-id 08:00:27:75:74:d2
49          vif 10 {
50          }
51          vif 20 {
52          }
53          vif 30 {
54          }
55      }
56      ethernet eth3 {
57          hw-id 08:00:27:95:c4:17
58      }
59      ethernet eth4 {
60          hw-id 08:00:27:72:88:53
61      }
62      ethernet eth5 {
63          hw-id 08:00:27:75:b1:69
64      }
65      loopback lo {
66      }
67      vxlan vxlan101 {
68          mtu 1500
69          source-address 10.0.0.111
70          vni 101
71      }
72      vxlan vxlan110 {
73          mtu 1500
74          remote 10.0.0.38
75          vni 110
76      }
77      vxlan vxlan120 {
78          mtu 1500
79          remote 10.0.0.38
80          vni 120
81      }
82      vxlan vxlan130 {
83          mtu 1500
84          remote 10.0.0.38
85          vni 130
86      }
87 }
88 protocols {
89      bgp {
90          address-family {
```

```
 91                l2vpn-evpn {
 92                    advertise-all-vni
 93                }
 94            }
 95            neighbor 10.0.0.101 {
 96                peer-group evpn
 97            }
 98            neighbor 10.0.0.131 {
 99                peer-group evpn
100            }
101            parameters {
102                router-id 10.0.0.111
103            }
104            peer-group evpn {
105                address-family {
106                    l2vpn-evpn {
107                        nexthop-self {
108                        }
109                        route-reflector-client
110                    }
111                }
112                remote-as 33900
113                update-source dum0
114            }
115            system-as 33900
116        }
117        ospf {
118            area 0 {
119                network 10.0.0.24/30
120                network 10.0.0.111/32
121            }
122        }
123 }
124 system {
125     config-management {
126         commit-revisions 100
127     }
128     conntrack {
129         modules {
130             ftp
131             h323
132             nfs
133             pptp
134             sip
135             sqlnet
136             tftp
137         }
138     }
139     console {
140         device ttyS0 {
141             speed 115200
142         }
143     }
144     host-name RA1
145     login {
146         user vyos {
147             authentication {
```

```
148                   encrypted-password ****************
149                   plaintext-password ****************
150              }
151          }
152      }
153      ntp {
154          server time1.vyos.net {
155          }
156          server time2.vyos.net {
157          }
158          server time3.vyos.net {
159          }
160      }
161      syslog {
162          global {
163              facility all {
164                  level info
165              }
166              facility protocols {
167                  level debug
168              }
169          }
170      }
171 }
```

6.1.2   RA1 show bgp l2vpn evpn

```
 1 vyos@RA1:~$ show bgp l2vpn evpn
 2 BGP table version is 1, local router ID is 10.0.0.111
 3 Status codes: s suppressed, d damped, h history, * valid, > best, i
        - internal
 4 Origin codes: i - IGP, e - EGP, ? - incomplete
 5 EVPN type-1 prefix: [1]:[EthTag]:[ESI]:[IPlen]:[VTEP-IP]:[Frag-id]
 6 EVPN type-2 prefix: [2]:[EthTag]:[MAClen]:[MAC]:[IPlen]:[IP]
 7 EVPN type-3 prefix: [3]:[EthTag]:[IPlen]:[OrigIP]
 8 EVPN type-4 prefix: [4]:[ESI]:[IPlen]:[OrigIP]
 9 EVPN type-5 prefix: [5]:[EthTag]:[IPlen]:[IP]
10
11    Network          Next Hop            Metric LocPrf Weight Path
12 Route Distinguisher: 10.0.0.101:2
13 *>i[3]:[0]:[32]:[10.0.0.101]
14                     10.0.0.101                    100      0 i
15                     RT:33900:101 ET:8
16 Route Distinguisher: 10.0.0.111:5
17 *> [3]:[0]:[32]:[10.0.0.111]
18                     10.0.0.111                         32768 i
19                     ET:8 RT:33900:101
20 Route Distinguisher: 10.0.0.131:5
21 *>i[3]:[0]:[32]:[10.0.0.131]
22                     10.0.0.131                    100      0 i
23                     RT:33900:101 ET:8
24
25 Displayed 3 out of 3 total prefixes
```

6.2 RL1

6.2.1 RL1 show conf

```
 1 vyos@RL1:~$ show conf
 2 interfaces {
 3     bridge br101 {
 4         address 10.2.2.2/16
 5         description "client LA2"
 6         member {
 7             interface eth1 {
 8             }
 9             interface vxlan101 {
10             }
11         }
12     }
13     dummy dum0 {
14         address 10.0.0.101/32
15     }
16     ethernet eth0 {
17         address 10.0.0.18/30
18         hw-id 08:00:27:c0:e3:50
19     }
20     ethernet eth1 {
21         hw-id 08:00:27:8e:e7:79
22     }
23     ethernet eth2 {
24         hw-id 08:00:27:88:19:50
25     }
26     ethernet eth3 {
27         hw-id 08:00:27:aa:3f:c5
28     }
29     ethernet eth4 {
30         hw-id 08:00:27:2f:34:05
31     }
32     ethernet eth5 {
33         hw-id 08:00:27:36:3c:98
34     }
35     loopback lo {
36     }
37     vxlan vxlan101 {
38         mtu 1500
39         source-address 10.0.0.101
40         vni 101
41     }
42 }
43 protocols {
44     bgp {
45         address-family {
46             l2vpn-evpn {
47                 advertise-all-vni
48             }
49         }
50         neighbor 10.0.0.111 {
51             peer-group evpn
52         }
```

```
53          parameters {
54              router - id 10.0.0.101
55          }
56          peer - group evpn {
57              address - family {
58                  l2vpn - evpn {
59                      nexthop - self {
60                      }
61                  }
62              }
63              remote - as 33900
64              update - source dum0
65          }
66          system - as 33900
67      }
68      ospf {
69          area 0 {
70              network 10.0.0.16/30
71              network 10.0.0.101/32
72          }
73      }
74  }
75  system {
76      config - management {
77          commit - revisions 100
78      }
79      conntrack {
80          modules {
81              ftp
82              h323
83              nfs
84              pptp
85              sip
86              sqlnet
87              tftp
88          }
89      }
90      console {
91          device ttyS0 {
92              speed 115200
93          }
94      }
95      host - name RL1
96      login {
97          user vyos {
98              authentication {
99                  encrypted - password ****************
100                 plaintext - password ****************
101             }
102         }
103     }
104     ntp {
105         server time1.vyos.net {
106         }
107         server time2.vyos.net {
108         }
109         server time3.vyos.net {
```

```
110            }
111        }
112        syslog {
113            global {
114                facility all {
115                    level info
116                }
117                facility protocols {
118                    level debug
119                }
120            }
121        }
122 }
```

6.2.2   RL1 show bgp l2vpn evpn

```
1 vyos@RL1:~$ show bgp l2vpn evpn
2 BGP table version is 1, local router ID is 10.0.0.101
3 Status codes: s suppressed, d damped, h history, * valid, > best, i
         - internal
4 Origin codes: i - IGP, e - EGP, ? - incomplete
5 EVPN type-1 prefix: [1]:[EthTag]:[ESI]:[IPlen]:[VTEP-IP]:[Frag-id]
6 EVPN type-2 prefix: [2]:[EthTag]:[MAClen]:[MAC]:[IPlen]:[IP]
7 EVPN type-3 prefix: [3]:[EthTag]:[IPlen]:[OrigIP]
8 EVPN type-4 prefix: [4]:[ESI]:[IPlen]:[OrigIP]
9 EVPN type-5 prefix: [5]:[EthTag]:[IPlen]:[IP]
10
11    Network          Next Hop            Metric LocPrf Weight Path
12 Route Distinguisher: 10.0.0.101:2
13 *> [3]:[0]:[32]:[10.0.0.101]
14                     10.0.0.101                          32768 i
15                     ET:8 RT:33900:101
16 Route Distinguisher: 10.0.0.111:5
17 *>i[3]:[0]:[32]:[10.0.0.111]
18                     10.0.0.111                  100      0 i
19                     RT:33900:101 ET:8
20 Route Distinguisher: 10.0.0.131:5
21 *>i[3]:[0]:[32]:[10
```

6.3   RN1

6.3.1   RN1 show conf

```
1 vyos@RN1:~$ show conf
2 interfaces {
3     bridge br101 {
4         address 10.2.3.3/16
5         description "client LA3"
6         member {
7             interface eth2 {
8             }
9             interface vxlan101 {
```

```
10                    }
11              }
12          }
13      bridge br110 {
14          member {
15              interface eth1.10 {
16              }
17              interface vxlan110 {
18              }
19          }
20      }
21      bridge br120 {
22          member {
23              interface eth1.20 {
24              }
25              interface vxlan120 {
26              }
27          }
28      }
29      bridge br130 {
30          member {
31              interface eth1.30 {
32              }
33              interface vxlan130 {
34              }
35          }
36      }
37      dummy dum0 {
38          address 10.0.0.131/32
39      }
40      ethernet eth0 {
41          address 10.0.0.38/30
42          hw-id 08:00:27:38:c7:4d
43      }
44      ethernet eth1 {
45          hw-id 08:00:27:9d:9e:aa
46          vif 10 {
47          }
48          vif 20 {
49          }
50          vif 30 {
51          }
52      }
53      ethernet eth2 {
54          hw-id 08:00:27:3e:fc:6d
55      }
56      ethernet eth3 {
57          hw-id 08:00:27:51:b5:f5
58      }
59      ethernet eth4 {
60          hw-id 08:00:27:69:3e:53
61      }
62      ethernet eth5 {
63          hw-id 08:00:27:9e:f9:53
64      }
65      loopback lo {
66      }
```

```
67      vxlan vxlan101 {
68          mtu 1500
69          source-address 10.0.0.131
70          vni 101
71      }
72      vxlan vxlan110 {
73          mtu 1500
74          remote 10.0.0.26
75          vni 110
76      }
77      vxlan vxlan120 {
78          mtu 1500
79          remote 10.0.0.26
80          vni 120
81      }
82      vxlan vxlan130 {
83          mtu 1500
84          remote 10.0.0.26
85          vni 130
86      }
87  }
88  protocols {
89      bgp {
90          address-family {
91              l2vpn-evpn {
92                  advertise-all-vni
93              }
94          }
95          neighbor 10.0.0.111 {
96              peer-group evpn
97          }
98          parameters {
99              router-id 10.0.0.131
100         }
101         peer-group evpn {
102             address-family {
103                 l2vpn-evpn {
104                     nexthop-self {
105                     }
106                 }
107             }
108             remote-as 33900
109             update-source dum0
110         }
111         system-as 33900
112     }
113     ospf {
114         area 0 {
115             network 10.0.0.131/32
116             network 10.0.0.36/30
117         }
118     }
119 }
120 system {
121     config-management {
122         commit-revisions 100
123     }
```

```
124      conntrack {
125          modules {
126              ftp
127              h323
128              nfs
129              pptp
130              sip
131              sqlnet
132              tftp
133          }
134      }
135      console {
136          device ttyS0 {
137              speed 115200
138          }
139      }
140      host-name RN1
141      login {
142          user vyos {
143              authentication {
144                  encrypted-password ****************
145                  plaintext-password ****************
146              }
147          }
148      }
149      ntp {
150          server time1.vyos.net {
151          }
152          server time2.vyos.net {
153          }
154          server time3.vyos.net {
155          }
156      }
157      syslog {
158          global {
159              facility all {
160                  level info
161              }
162              facility protocols {
163                  level debug
164              }
165          }
166      }
167 }
```

6.3.2 RN1 show bgp l2vpn evpn

```
vyos@RN1:~$ show bgp l2vpn evpn
BGP table version is 1, local router ID is 10.0.0.131
Status codes: s suppressed, d damped, h history, * valid, > best, i
       - internal
Origin codes: i - IGP, e - EGP, ? - incomplete
EVPN type-1 prefix: [1]:[EthTag]:[ESI]:[IPlen]:[VTEP-IP]:[Frag-id]
EVPN type-2 prefix: [2]:[EthTag]:[MAClen]:[MAC]:[IPlen]:[IP]
EVPN type-3 prefix: [3]:[EthTag]:[IPlen]:[OrigIP]
EVPN type-4 prefix: [4]:[ESI]:[IPlen]:[OrigIP]
EVPN type-5 prefix: [5]:[EthTag]:[IPlen]:[IP]

   Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 10.0.0.101:2
*>i[3]:[0]:[32]:[10.0.0.101]
                    10.0.0.101               0    100      0 i
                    RT:33900:101 ET:8
Route Distinguisher: 10.0.0.111:5
*>i[3]:[0]:[32]:[10.0.0.111]
                    10.0.0.111                    100      0 i
                    RT:33900:101 ET:8
Route Distinguisher: 10.0.0.131:5
*> [3]:[0]:[32]:[10.0.0.131]
                    10.0.0.131                        32768 i
                    ET:8 RT:33900:101

Displayed 3 out of 3 total prefixes
```
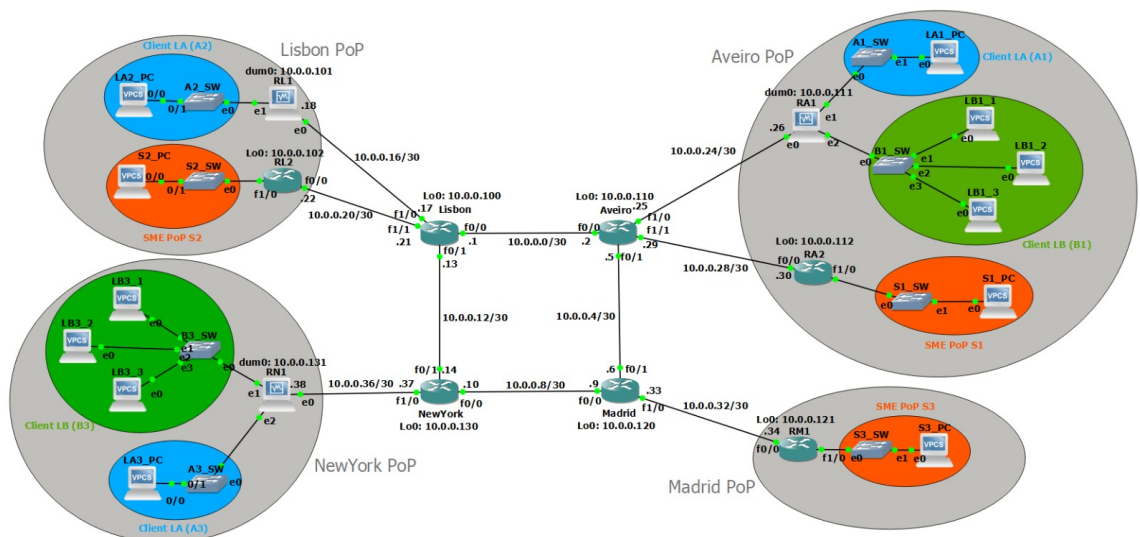
Final Network Topology

Figure 7.1: Enter Caption