Carrier Supporting Carrier

This document details the concept know as Carrier Supporting Carrier. The design will be explained first followed by an example showing both the control path advertisements and the data plane traffic flow.

CsC Design

CsC works by having one Service Provider (the Backbone Provider), treat another Provider (the Customer Provider) as a customer. However this isn't a simple Option A setup. In order to maintain a continuous LSP from one part the Customer Providers network to another, prefixes and corresponding labels must be exchanged between the Customer and Backbone Providers. These prefixes correspond to the Customer Providers LSP endpoints which are typically router loopbacks.

There are two ways to do this:

1. Run BGP Labelled Unicast between the Customer and Backbone Providers edge routers.
2. Run IGP and LDP between the Customer and Backbone Providers edge routers.

Both options will be explored in this document. Once these prefixes + labels have been exchanged, they need to be distributed throughout the Customer Providers networks. This can be done either using BGP LU or redistribution into the local IGP, from which LDP will then dynamically allocated labels. Only the later option is show in the CLI output here, but the downloadable GNS3 lab that accompanies this document uses both.

The Backbone Provider must put the attachment circuits connecting to the Customer Provider into a VRF. This results in VRF aware LDP being run if the IGP + LDP option is used between the Customer and Backbone Providers.

The Customer Provider does not need to put its attachment circuits to the Backbone Provider into a VRF.

The Backbone Provider can then run any internal MPLS setup it wishes. Here we will use standard MPLS VPNv4 between the Backbone Provider PEs. The Customer Provider runs the same type of setup with respect to *its* customers.

CsC Example

To illustrate these concepts, the sample network shown on the right is used.

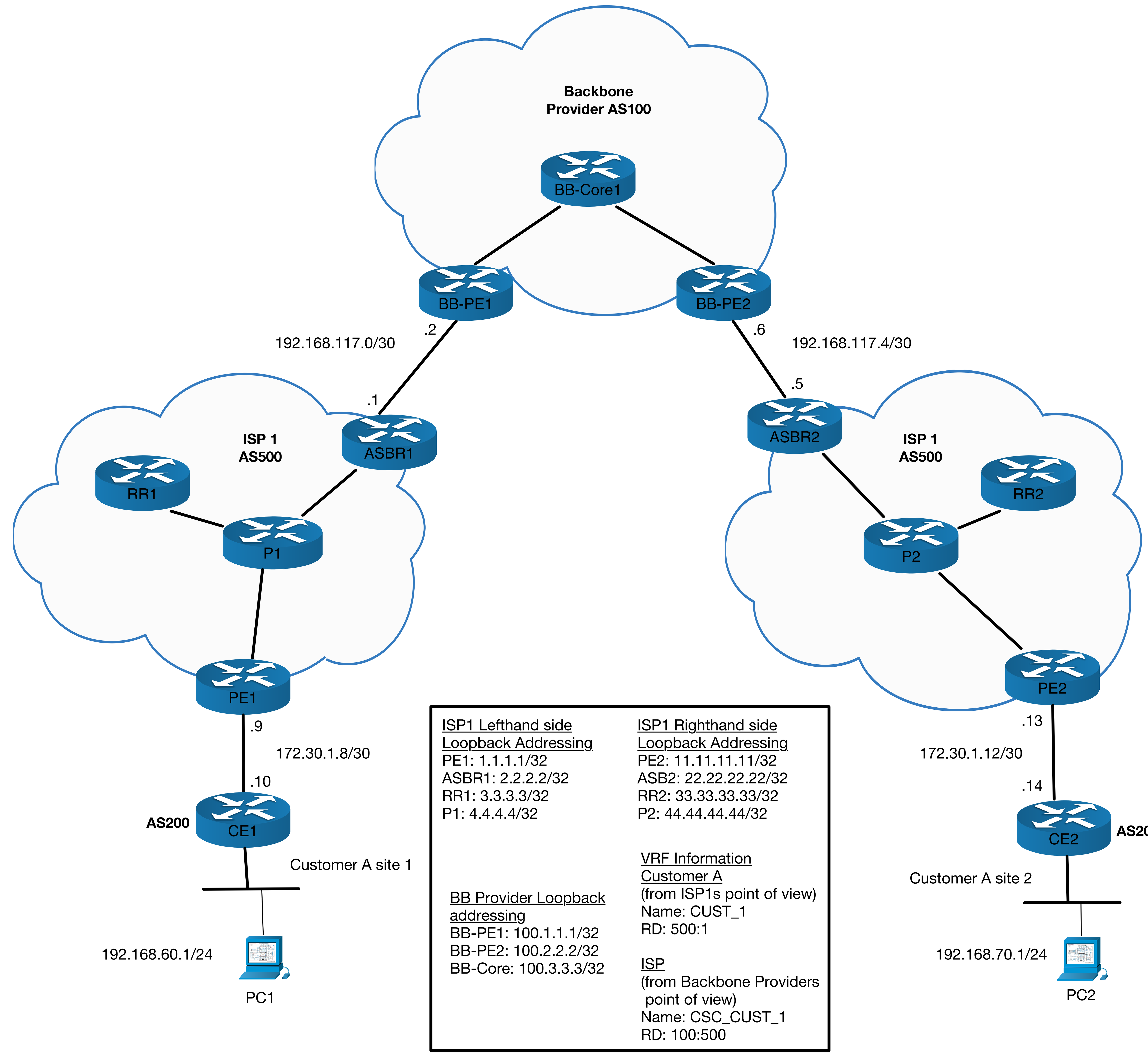
Customer A has two sites connected to ISP1 in a VRF called CUST_1.

ISP1 has two separate disparate areas. The Backbone Provider implements CsC to connect to the two sides together. ISP1 has one route reflector in each area running VPNv4 to the PE routers, and between each other. IS-IS and LDP is used throughout ISP1.

The connection between ASBR1 and BB-PE1 is running OSPF and LDP. The loopbacks of RR1 and PE1 are redistributed from IS-IS into OSPF and sent to BB-PE1. The loopback for RR1 is needed to provide reachability for the iBGP VPNv4 session between the reflectors. The loopback for PE1 is needed for next-hop reachability when using this PE as an LSP endpoint. ASBR1 also redistributes from OSPF into IS-IS. This is expected to be loopbacks for RR2 and PE2. LDP will then allocate labels for these.

The connection between ASBR2 and BB-PE2 is running BGP-LU. The loopbacks for RR2 and PE2 are advertised to BB-PE2 for the same reason ASBR1 redistributes from IS-IS to OSPF. ABSR2 should be receiving the loopback for RR1 and PE1. Instead of redistributing into the local IGP, ASRB1 runs BGP-LU to RR2 who in turn runs BGP-LU to PE2 into order to communicate the label for PE1.

The examples given in this document will follow the control plane advertisements and traffic flow involved when PC1 sends a packet to PC2. All output shown and referenced is based on Cisco IOS. The local PC is represented by loopbacks on the CE routers.



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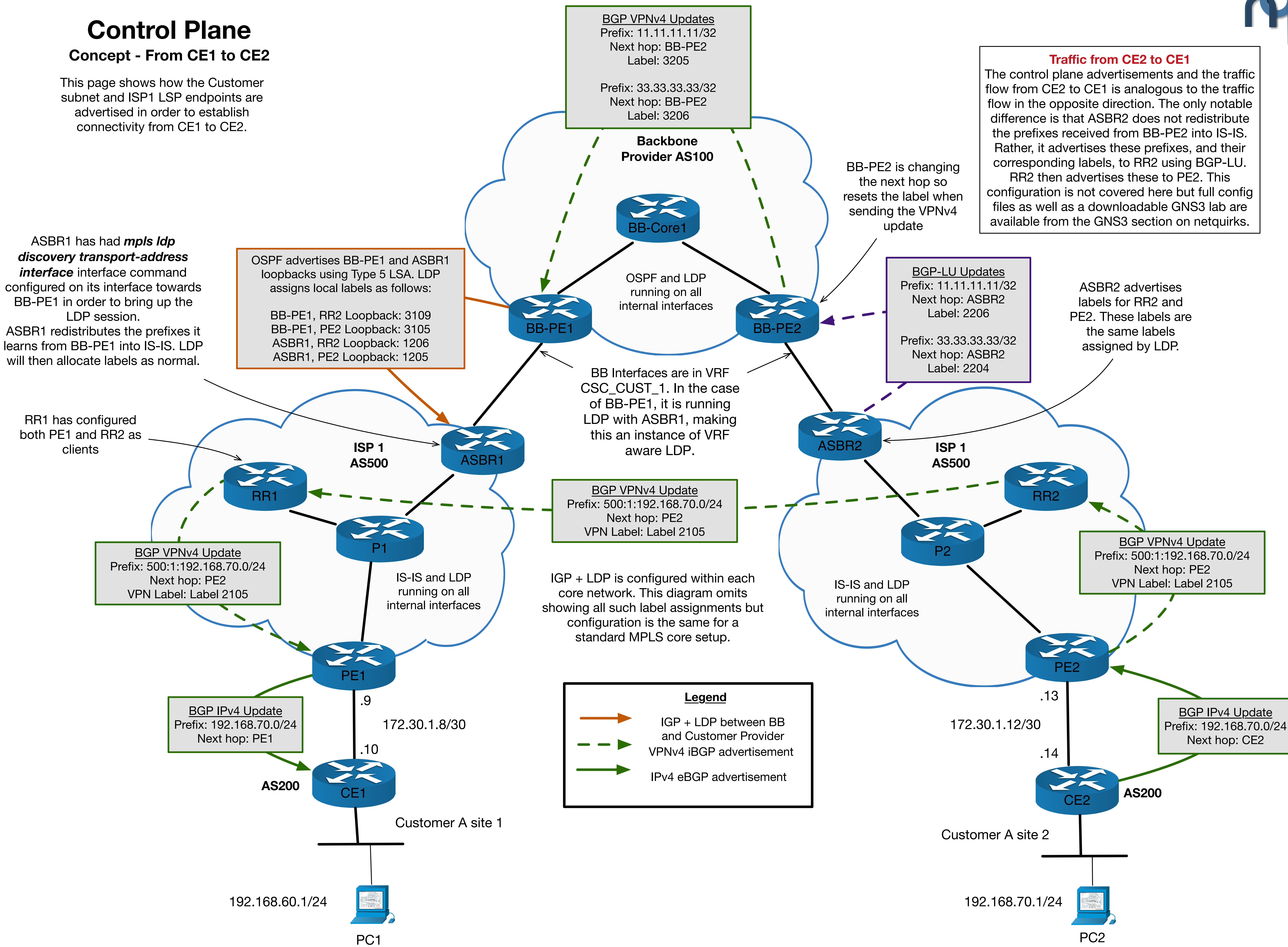
Control Plane

Concept - From CE1 to CE2

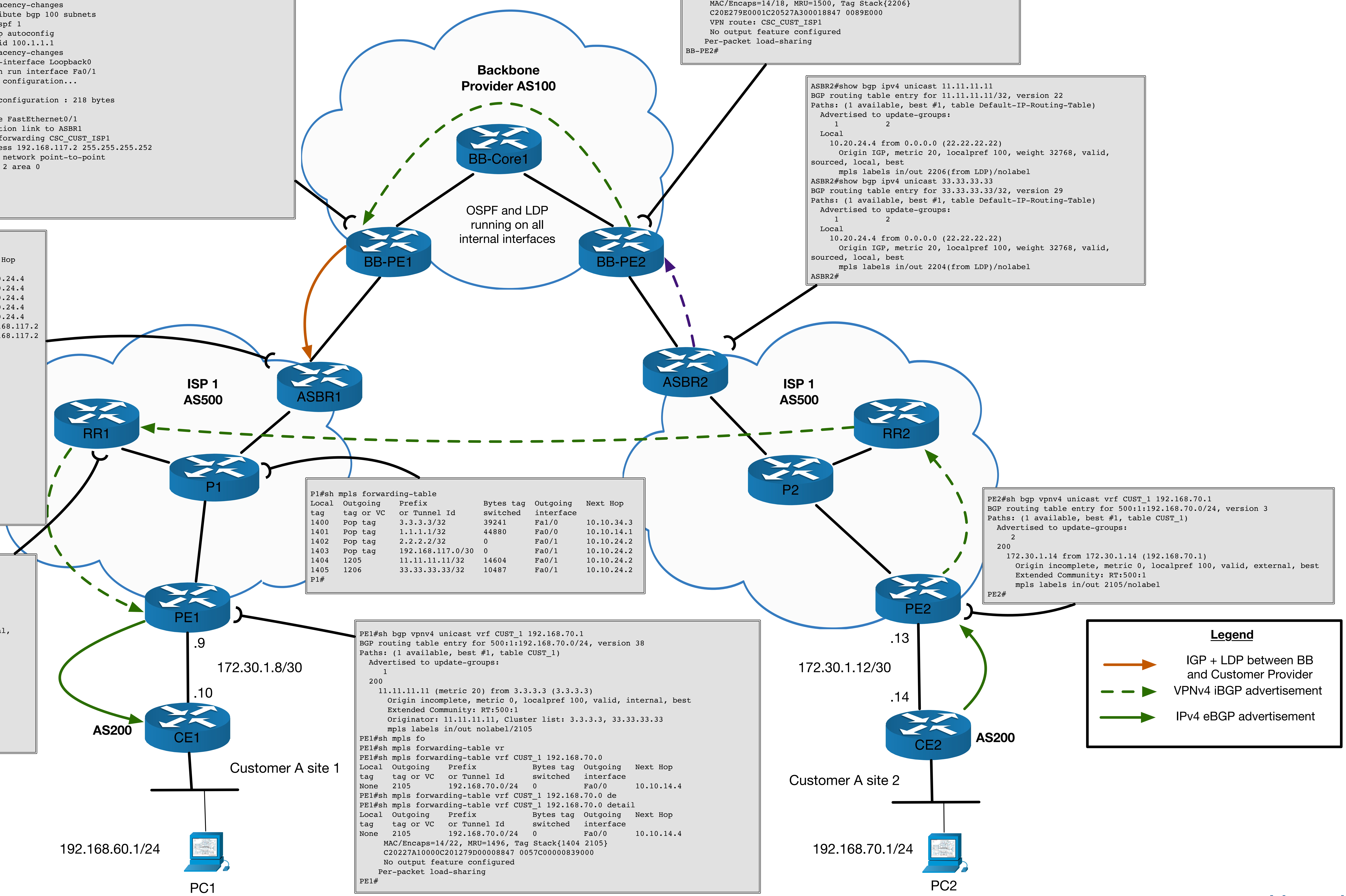
This page shows how the Customer subnet and ISP1 LSP endpoints are advertised in order to establish connectivity from CE1 to CE2.



Control Plane

CLI output - From CE1 to CE2

This page shows relevant CLI output for the CsC setup - demonstrating how label switching is done and what you'd expect to see.




```
BB-PE1#show mpls forwarding-table vrf CSC_CUST_ISP1 11.11.11.11 detail
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
3105   3205        11.11.11.11/32[V] 18660      Fa0/0      10.30.13.3
     MAC/Encaps=14/22, MRU=1496, Tag Stack{3301 3205}
     C20627A40000C20427A200008847 00CE500000C85000
     VPN route: CSC_CUST_ISP1
     No output feature configured
    Per-packet load-sharing
BB-PE1#sh run | sec router ospf
router ospf 2 vrf CSC_CUST_ISP1
 log-adjacency-changes
 redistribute bgp 100 subnets
router ospf 1
 mpls ldp autoconfig
 router-id 100.1.1.1
 log-adjacency-changes
 passive-interface Loopback0
BB-PE1#sh run interface Fa0/1
Building configuration...

Current configuration : 218 bytes
!
interface FastEthernet0/1
 description link to ASBR1
 ip vrf forwarding CSC_CUST_ISP1
 ip address 192.168.117.2 255.255.255.252
 ip ospf network point-to-point
 ip ospf 2 area 0
 mpls ip
end

BB-PE1#
```

```
BB-PE2#sh bgp vpnv4 unicast vrf CSC_CUST_ISP1 11.11.11.11/32
BGP routing table entry for 100:500:11.11.11.11/32, version 24
Paths: (1 available, best #1, table CSC_CUST_ISP1)
  Advertised to update-groups:
     2
  500
    192.168.117.5 from 192.168.117.5 (22.22.22.22)
      Origin IGP, metric 20, localpref 100, valid, external, best
      Extended Community: RT:100:500
      mpls labels in/out 3205/2206
BB-PE2#sh mpls forwarding-table vrf CSC_CUST_ISP1 11.11.11.11 detail
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
3205   2206        11.11.11.11/32[V] 21564      Fa0/1
192.168.117.5
     MAC/Encaps=14/18, MRU=1500, Tag Stack{2206}
     C20E279E0001C20527A300018847 0089E000
     VPN route: CSC_CUST_ISP1
     No output feature configured
    Per-packet load-sharing
BB-PE2#
```

```
ASBR2#show bgp ipv4 unicast 11.11.11.11
BGP routing table entry for 11.11.11.11/32, version 22
Paths: (1 available, best #1, table Default-IP-Routing-Table)
  Advertised to update-groups:
     1          2
  Local
    10.20.24.4 from 0.0.0.0 (22.22.22.22)
      Origin IGP, metric 20, localpref 100, weight 32768, valid,
sourced, local, best
      mpls labels in/out 2206(from LDP)/nolabel
ASBR2#show bgp ipv4 unicast 33.33.33.33
BGP routing table entry for 33.33.33.33/32, version 29
Paths: (1 available, best #1, table Default-IP-Routing-Table)
  Advertised to update-groups:
     1          2
  Local
    10.20.24.4 from 0.0.0.0 (22.22.22.22)
      Origin IGP, metric 20, localpref 100, weight 32768, valid,
sourced, local, best
      mpls labels in/out 2204(from LDP)/nolabel
ASBR2#
```

```
ASBR1#sh mpls forwarding-table
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
1200   Pop tag     4.4.4.4/32        0          Fa0/0      10.10.24.4
1201   Pop tag     10.10.14.0/24     0          Fa0/0      10.10.24.4
1202   Pop tag     10.10.34.0/24     0          Fa0/0      10.10.24.4
1203   1401        1.1.1.1/32        26328      Fa0/0      10.10.24.4
1204   1400        3.3.3.3/32        17701      Fa0/0      10.10.24.4
1205   3105        11.11.11.11/32    16332      Fa0/1      192.168.117.2
1206   3109        33.33.33.33/32    7877       Fa0/1      192.168.117.2
ASBR1#sh run | sec router ospf
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes detail
 redistribute isis LAB level-2 subnets route-map LOOPBACKS
 match ip address prefix-list LOOPBACKS
ASBR1#sh route-map LOOPBACKS
route-map LOOPBACKS, permit, sequence 10
  Match clauses:
    ip address prefix-lists: LOOPBACKS
  Set clauses:
  Policy routing matches: 0 packets, 0 bytes
ASBR1#sh ip pref
ASBR1#sh ip prefix-list LOOPBACKS
ip prefix-list LOOPBACKS: 2 entries
   seq 5 permit 3.3.3.3/32
   seq 10 permit 1.1.1.1/32
ASBR1#
```

```
P1#sh mpls forwarding-table
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
1400   Pop tag     3.3.3.3/32        39241      Fa1/0      10.10.34.3
1401   Pop tag     1.1.1.1/32        44880      Fa0/0      10.10.14.1
1402   Pop tag     2.2.2.2/32        0          Fa0/1      10.10.24.2
1403   Pop tag     192.168.117.0/30  0          Fa0/1      10.10.24.2
1404   1205        11.11.11.11/32    14604      Fa0/1      10.10.24.2
1405   1206        33.33.33.33/32    10487      Fa0/1      10.10.24.2
P1#
```

```
RR1#sh bgp vpnv4 unicast rd 500:1 192.168.70.0
BGP routing table entry for 500:1:192.168.70.0/24, version 33
Paths: (1 available, best #1, no table)
  Advertised to update-groups:
     1
  200, (Received from a RR-client)
    11.11.11.11 (metric 20) from 33.33.33.33 (33.33.33.33)
      Origin incomplete, metric 0, localpref 100, valid, internal,
best
      Extended Community: RT:500:1
      Originator: 11.11.11.11, Cluster list: 33.33.33.33
      mpls labels in/out nolabel/2105
RR1#sh ip route 33.33.33.33
Routing entry for 33.33.33.33/32
  Known via "isis", distance 115, metric 20, type level-2
  Redistributing via isis
  Last update from 10.10.34.4 on FastEthernet0/0, 01:56:36 ago
  Routing Descriptor Blocks:
  * 10.10.34.4, from 2.2.2.2, via FastEthernet0/0
      Route metric is 20, traffic share count is 1
```

```
PE1#sh bgp vpnv4 unicast vrf CUST_1 192.168.70.1
BGP routing table entry for 500:1:192.168.70.0/24, version 38
Paths: (1 available, best #1, table CUST_1)
  Advertised to update-groups:
     1
  200
    11.11.11.11 (metric 20) from 3.3.3.3 (3.3.3.3)
      Origin incomplete, metric 0, localpref 100, valid, internal, best
      Extended Community: RT:500:1
      Originator: 11.11.11.11, Cluster list: 3.3.3.3, 33.33.33.33
      mpls labels in/out nolabel/2105
PE1#sh mpls fo
PE1#sh mpls forwarding-table vr
PE1#sh mpls forwarding-table vrf CUST_1 192.168.70.0
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
None   2105        192.168.70.0/24   0          Fa0/0      10.10.14.4
PE1#sh mpls forwarding-table vrf CUST_1 192.168.70.0 de
PE1#sh mpls forwarding-table vrf CUST_1 192.168.70.0 detail
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
None   2105        192.168.70.0/24   0          Fa0/0      10.10.14.4
     MAC/Encaps=14/22, MRU=1496, Tag Stack{1404 2105}
     C20227A10000C201279D00008847 0057C00000839000
     No output feature configured
    Per-packet load-sharing
PE1#
```

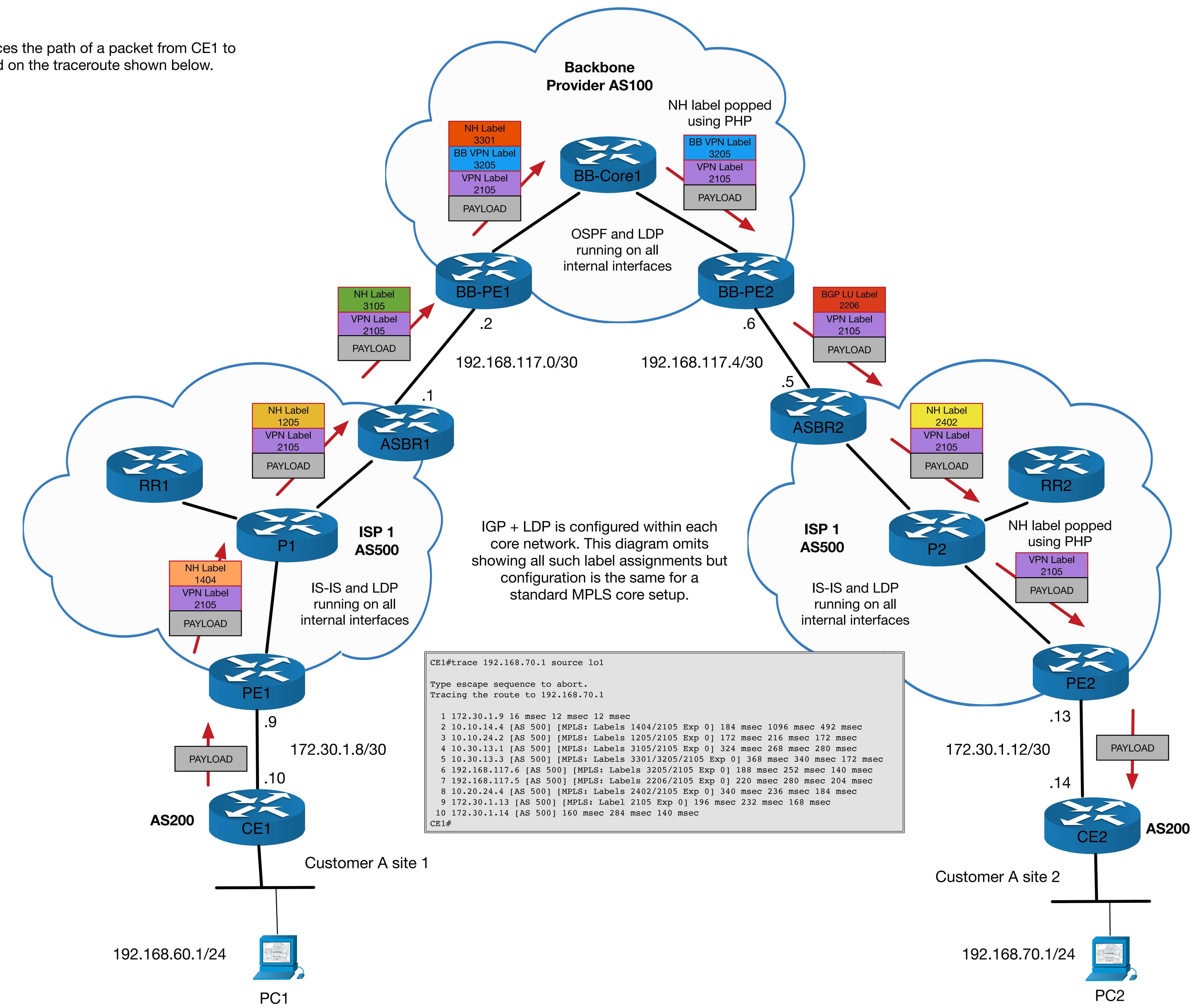
```
PE2#sh bgp vpnv4 unicast vrf CUST_1 192.168.70.1
BGP routing table entry for 500:1:192.168.70.0/24, version 3
Paths: (1 available, best #1, table CUST_1)
  Advertised to update-groups:
     2
  200
    172.30.1.14 from 172.30.1.14 (192.168.70.1)
      Origin incomplete, metric 0, localpref 100, valid, external, best
      Extended Community: RT:500:1
      mpls labels in/out 2105/nolabel
PE2#
```

by Steven Crutchley

Data Plane

Life of a packet from CE1 to CE2

This page traces the path of a packet from CE1 to CE2 based on the traceroute shown below.




```
CE1#trace 192.168.70.1 source lo1

Type escape sequence to abort.
Tracing the route to 192.168.70.1

  1 172.30.1.9 16 msec 12 msec 12 msec
  2 10.10.14.4 [AS 500] [MPLS: Labels 1404/2105 Exp 0] 184 msec 1096 msec 492 msec
  3 10.10.24.2 [AS 500] [MPLS: Labels 1205/2105 Exp 0] 172 msec 216 msec 172 msec
  4 10.30.13.1 [AS 500] [MPLS: Labels 3105/2105 Exp 0] 324 msec 268 msec 280 msec
  5 10.30.13.3 [AS 500] [MPLS: Labels 3301/3205/2105 Exp 0] 368 msec 340 msec 172 msec
  6 192.168.117.6 [AS 500] [MPLS: Labels 3205/2105 Exp 0] 188 msec 252 msec 140 msec
  7 192.168.117.5 [AS 500] [MPLS: Labels 2206/2105 Exp 0] 220 msec 280 msec 204 msec
  8 10.20.24.4 [AS 500] [MPLS: Labels 2402/2105 Exp 0] 340 msec 236 msec 184 msec
  9 172.30.1.13 [AS 500] [MPLS: Label 2105 Exp 0] 196 msec 232 msec 168 msec
 10 172.30.1.14 [AS 500] 160 msec 284 msec 140 msec
CE1#
```

Traceroute Step	Forwarding Process
1	CE1 has a route for 192.168.70.0/42 via BGP with a next-hop of 192.30.1.9. It forwards the packet to PE1.
2	PE1 has a BGP VPNv4 route for 192.168.70/24 with a VPN label of 2105 and next-hop of 11.11.11.11/32 (PE2). PE1 recursively looks for a route to PE2. It finds an IS-IS route with a next-hop of P1, out of a directly connected interface running LDP. P1's local label for PE2 is 1404. So, PE1 imposes a VPN label of 2105 and then a transport (or next-hop) label of 1404.
3	P1 receives the labelled packet, sees the top label (1404) and matches its local label for PE2. P1's next hop for PE2 is ABSR1. P1 swaps 1404 label for 1205 - ABSR1's local label for PE2
4	ASBR1 receives the labelled packet and sees the top label matches its local label for PE2. This label was assigned by the LDP session running between ABSR1 and BB-PE1. ASBR2 swaps 1205 with 3105 - BB-PE1's local label for PE2.
5	BB-PE1 receives the labelled packet and sees the top label matches its local label for the 11.11.11.11/32 route in its VRF CSC_CUST_ISP1. BB-PE1 has a BGP VPNv4 route for 11.11.11.11/32 with a VPN label of 3205 and next-hop of 100.1.1.1 (BB-PE2). BB-PE1 recursively looks for a route to BB-PE2. It finds an OSPF route with a next-hop of BB-PE3, out of a directly connected interface running LDP. BB-PE3's local label for BB-PE2 is 3301. BB-PE1 swaps the top label 3105 with the VPN label 3205. It then imposes the transport label of 3301. At this point there are 3 labels on the stack (from top to bottom): 3301/3205/2105
6	BB-PE3 receives the labelled packet and sees the top label matches it's local label for BB-PE2. BB-PE3's next hop for BB-PE2 is via a directly connected interface running LDP. BB-PE3 is the penultimate hop to BB-PE2 so it simply pops the top transport label and forwards the packet to BB-PE2 (normal PHP behaviour).
7	BB-PE2 receives the labelled packet and sees the top label matches its VPN label for 11.11.11.11/32 (PE2) in VRF CSC_CUST_ISP1. BB-PE2's VRF route to PE2 is known via BGP-LU with a next-hop of 192.168.117.5. BB-PE2 has also received a label value of 2206 for this prefix over this BGP-LU session so it's LFIB has a swap entry. BB-PE2 swaps the top label 3205 with the BGP-LU learned label 2206 and forwards it to ASBR2.
8	ASBR2 receives the labelled packet and sees the top label matches its local LDP assigned label for 11.11.11.11/32 (PE2). ASBR2's next hop for PE2 is P2. ASBR2 swaps 2206 label for 2402 - P2's local label for PE2.
9	P2 receives the labelled packet and sees the top label matches its local label for PE2. P2's next hop for PE2 is via a directly connected interface running LDP. P2 is the penultimate hop to PE2 so it simply pops the top transport label and forwards the packet to PE2 (normal PHP behaviour).
10	PE2 receives the labelled packet and sees the top (and only) label matches its VPN label for 192.168.70.0/24 (CE2's loopback 1) in VRF CUST_1. PE2 VRF next-hop for 192.168.70.0/24 is known via IPv4 BGP out of a local attachment circuit in VRF CUST_1. PE2 removes the 2105 label and forwards the ICMP packet unlabelled.