带MPLS设计的思科IOS-XR BGP

目录

简介

本文档介绍在Cisco IOS®-XR中对多协议标签交换(MPLS)和边界网关协议(BGP)的组合具有特殊行为和配置的几个方案。

1. AS间MPLS VPN选项B和C需要静态路由

此图显示AS间选项B设置。

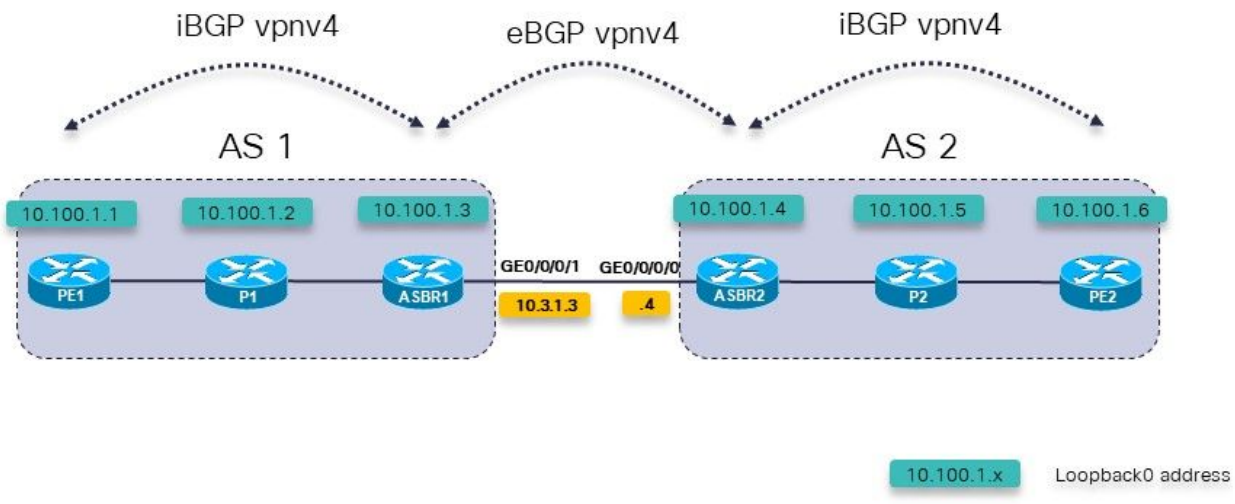

图1.

提供商边缘(PE)路由器PE1具有VRF前缀10.200.1.2/32的路由，但该路由未解析。

```
RP/0/0/CPU0:PE1#show cef vrf one 10.200.1.2
10.200.1.2/32, version 3, internal 0x5000001 0x0 (ptr 0xa140be74) [1], 0x0 (0x0), 0x208
(0xa14a7118)
 Updated Apr  7 14:36:45.628
 Prefix Len 32, traffic index 0, precedence n/a, priority 3
   via 10.3.1.4/32, 0 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0xa0d87468 0x0]
    recursion-via-/32
    next hop VRF - 'default', table - 0xe0000000
    unresolved
    labels imposed {24004}
```

PE1没有10.3.1.4/32的路由。它有10.3.1.0/24的路由。

```
RP/0/0/CPU0:PE1#show route 10.3.1.4

Routing entry for 10.3.1.0/24
  Known via "ospf 1", distance 110, metric 3, type intra area
  Installed Apr  7 14:07:01.140 for 00:32:48
  Routing Descriptor Blocks
    10.1.1.2, from 10.100.1.3, via GigabitEthernet0/0/0/0
      Route metric is 3
  No advertising protos.
```

下一跳的自治系统边界路由(ASBR)上必须有静态路由。您必须在每个ASBR上配置此静态路由并将其重分发到内部网关协议(IGP)。

```
router static
 address-family ipv4 unicast
  10.3.1.4/32 GigabitEthernet0/0/0/1
 !
!

router ospf 1
 redistribute static
```

路由现在已解析。

```
RP/0/0/CPU0:PE1#show cef vrf one 10.200.1.2
10.200.1.2/32, version 3, internal 0x5000001 0x0 (ptr 0xa140be74) [1], 0x0 (0x0), 0x208
(0xa14a7118)
 Updated Apr  7 14:36:45.628
 Prefix Len 32, traffic index 0, precedence n/a, priority 3
   via 10.3.1.4/32, 3 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0xa150f9f4 0x0]
    recursion-via-/32
    next hop VRF - 'default', table - 0xe0000000
    next hop 10.3.1.4/32 via 24005/0/21
     next hop 10.1.1.2/32 Gi0/0/0/0    labels imposed {24003 24004}
```

ASBR1为VPNv4/6前缀安装指向ASBR2的POP传出标签：

```
RP/0/0/CPU0:ASBR1#show mpls forwarding prefix 10.3.1.4/32
Local  Outgoing    Prefix            Outgoing     Next Hop        Bytes
```

```
Label  Label       or ID              Interface
Switched
------ ----------- ------------------ ------------ -------------- -----
-------
24005  Pop         10.3.1.4/32        Gi0/0/0/1    10.3.1.4       2506
```

即使ASBR上的next-hop-self指向iBGP邻居，如果ASBR上未配置静态路由，ASBR之间的标签转发也将中断。

在ASBR1上，使用next-hop-self到PE1，且没有静态路由：

```
RP/0/0/CPU0:ASBR1#show mpls forwarding labels 24006 detail
Local  Outgoing    Prefix           Outgoing     Next Hop        Bytes
Label  Label       or ID            Interface
Switched
------ ----------- ---------------- ------------ --------------- -----
-------
24006  24004       2:2:10.200.1.2/32               10.3.1.4
0
     Updated: Apr  7 14:49:58.190
     Path Flags: 0x6000 [  ]
     Label Stack (Top -> Bottom): { }
     MAC/Encaps: 0/0, MTU: 0
     Packets Switched: 0
```

请注意，“传出接口”列上缺少传出接口。ASBR上的静态路由是AS间选项B和C的必需。

2.保留AS间选项B的ASBR上的路由目标

需要命令来确保ASBR存储/保留vpnv4/6路由，然后通告它们。如果没有此命令，则如果ASBR上没有配置本地VRF来导入路由的任何路由目标，或者它不是地址系列vpnv4/6的路由反射器(RR)，则ASBR不存储路由。

```
router bgp 1
 address-family ipv4 unicast
 !
 address-family vpnv4 unicast
  retain route-target all
 !
```

3. ASBR不通告IPv4标记单播地址

AS间选项C或无缝MPLS（统一MPLS）网络需要IPv4标记单播。这是因为vpnv4/6前缀默认标记，但IPv4(IPv6)单播的情况并非如此。如果情况并非如此，则标签交换路径(LSP)端到端中断，流量端到端失败。

请看图2，它显示AS间选项C设置。

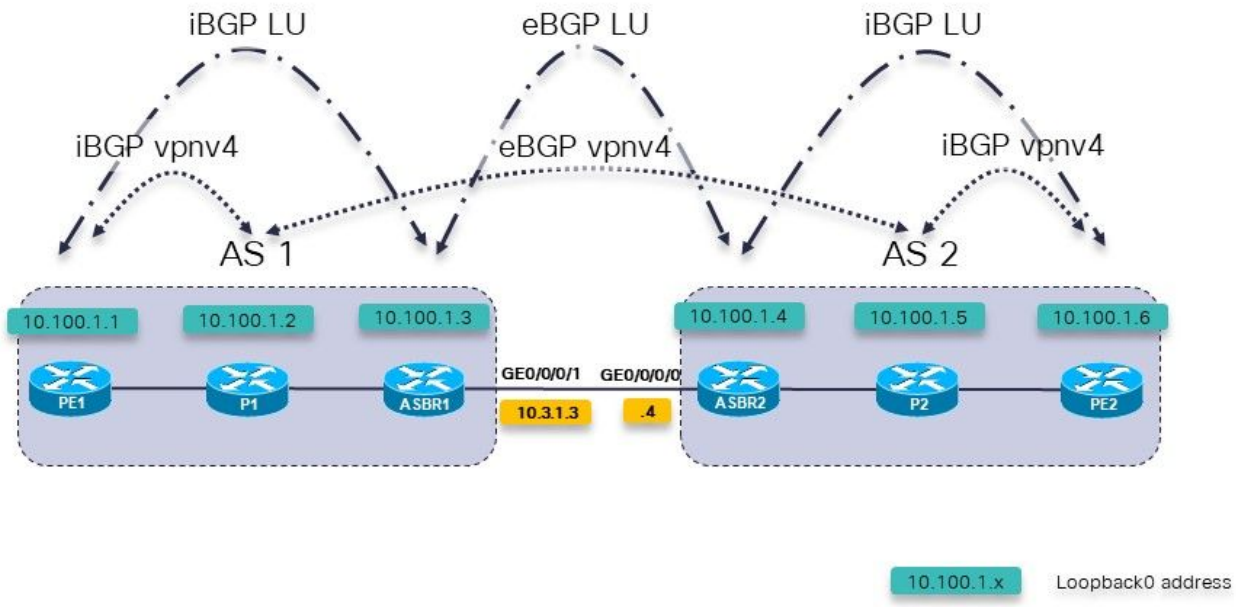

图2.

P1和P2路由器也是vpnv4的自治系统(AS)中的路由反射器。

标记单播(LU)用于将环回前缀从一个AS传输到另一个AS。

ASBR1已配置此地址系列，但其中没有路由：

```
RP/0/0/CPU0:ASBR1#show bgp ipv4 labeled-unicast
RP/0/0/CPU0:ASBR1#

RP/0/0/CPU0:ASBR1#show bgp ipv4 labeled-unicast summary
BGP router identifier 10.100.1.3, local AS number 1
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 41
BGP main routing table version 41
BGP NSR Initial initsync version 2 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

BGP is operating in STANDALONE mode.


Process       RcvTblVer   bRIB/RIB   LabelVer  ImportVer  SendTblVer
StandbyVer
Speaker              41         41         41         41
41           0

Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down
St/PfxRcd
10.3.1.4          0     2     150     151       41    0    0
00:06:29          0
10.100.1.2        0     1      52      52       41    0    0
```

```
00:06:42           0
```

原因是ASBR必须具有以下命令，以便为每条路由分配多协议标签交换(MPLS)标签，然后通告路由。

```
RP/0/0/CPU0:ASBR1#show run router bgp
router bgp 1
 address-family ipv4 unicast
  redistribute ospf 1
  allocate-label all
 !
```

注意：如果指定了路由策略，该命令可以将标签分配给特定前缀。

此命令的结果是：

```
RP/0/0/CPU0:ASBR1#show bgp ipv4 labeled-unicast
BGP router identifier 10.100.1.3, local AS number 1
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 52
BGP main routing table version 52
BGP NSR Initial initsync version 2 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
*> 10.1.1.0/24        10.1.2.2                 2         32768 ?
*> 10.1.2.0/24        0.0.0.0                  0         32768 ?
*> 10.2.1.0/24        10.3.1.4                 0             0 2 ?
*> 10.2.2.0/24        10.3.1.4                 2             0 2 ?
*> 10.3.1.0/24        0.0.0.0                  0         32768 ?
*                     10.3.1.4                 0             0 2 ?
*> 10.100.1.1/32      10.1.2.2                 3         32768 ?
*> 10.100.1.2/32      10.1.2.2                 2         32768 ?
*> 10.100.1.3/32      0.0.0.0                  0         32768 ?
*> 10.100.1.4/32      10.3.1.4                 0             0 2 ?
*> 10.100.1.5/32      10.3.1.4                 2             0 2 ?
*> 10.100.1.6/32      10.3.1.4                 3             0 2 ?

Processed 11 prefixes, 12 paths

RP/0/0/CPU0:ASBR1#show bgp ipv4 labeled-unicast 10.100.1.6/32
BGP routing table entry for 10.100.1.6/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                48          48
    Local Label: 24008
Last Modified: Apr  7 16:20:04.509 for 00:00:49
Paths: (1 available, best #1)
  Advertised to peers (in unique update groups):
    10.100.1.2
  Path #1: Received by speaker 0
  Advertised to peers (in unique update groups):
    10.100.1.2
  2
```

```
    10.3.1.4 from 10.3.1.4 (10.100.1.4)
      Received Label 24002
    Origin incomplete, metric 3, localpref 100, valid, external, best, group-best
      Received Path ID 0, Local Path ID 1, version 48
      Origin-AS validity: not-found
```

简而言之：

- 必须配置标签分配（在所有ASBR和PE路由器上）
- 必须为BGP邻居配置地址系列ipv4 labeled-unicast

4. eBGP-eBGP（背对背eBGP）Vpnv4需要虚拟iBGP邻居

看图3。

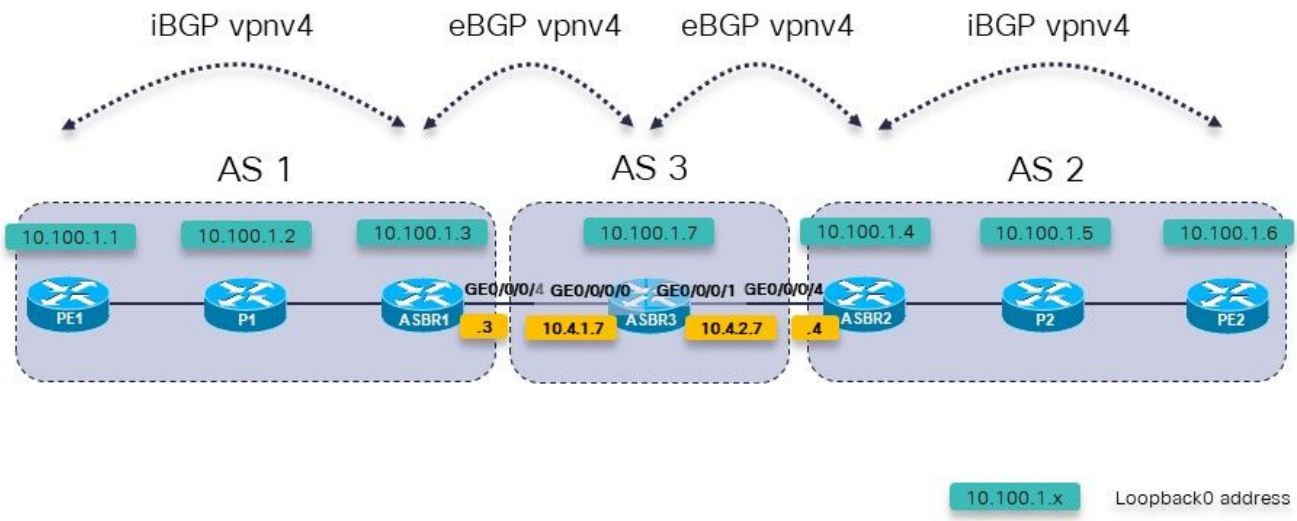

图3.

一连有三个ASBR。ASBR3将eBGP vpnv4单播运行到ASBR1和ASBR2。

注意：您还必须在ASBR3上配置静态路由。

```
RP/0/0/CPU0:ASBR3#show bgp vpnv4 unicast
BGP router identifier 10.100.1.7, local AS number 3
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0x0   RD version: 0
BGP main routing table version 3
BGP NSR Initial initsync version 2 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs
```

```
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 1:1
*> 10.200.1.1/32      10.4.1.3                               0 1 ?
Route Distinguisher: 2:2
*> 10.200.1.2/32      10.4.2.4                               0 2 ?

Processed 2 prefixes, 2 paths

RP/0/0/CPU0:ASBR3#show bgp vpnv4 unicast rd 1:1 10.200.1.1/32
BGP routing table entry for 10.200.1.1/32, Route Distinguisher: 1:1
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 2           2
Last Modified: Apr  7 18:45:21.510 for 00:03:30
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  1
    10.4.1.3 from 10.4.1.3 (10.100.1.3)
      Received Label 24009
      Origin incomplete, localpref 100, valid, external, best, group-
best, import-candidate, not-in-vrf
      Received Path ID 0, Local Path ID 1, version 2
      Extended community: RT:1:1
```

从ASBR3通告vpnv4路由时存在问题：ASBR3不向外部vpnv4路由通告。

解决方案是在ASBR3上配置虚拟iBGP邻居并启用next-hop-self:虚拟iBGP邻居不需要启动。

```
router bgp 3
 address-family vpnv4 unicast
  retain route-target all
 !
 neighbor 10.4.1.3
  remote-as 1  address-family vpnv4 unicast
   route-policy PASS in
   route-policy PASS out
  !
 !
 neighbor 10.4.2.4
  remote-as 2
  address-family vpnv4 unicast
   route-policy PASS in
   route-policy PASS out
  !
 !
neighbor 10.99.99.99
  remote-as 3
  description dummy-iBGP neighbor for back-to-back eBGP vpnv4
  update-source Loopback0
  address-family vpnv4 unicast
   next-hop-self
  !
 !
!
```

结果是，vpnv4路由现在被通告：

```
RP/0/0/CPU0:ASBR3#show bgp vpnv4 unicast rd 1:1 10.200.1.1/32
BGP routing table entry for 10.200.1.1/32, Route Distinguisher: 1:1
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 12          12
    Local Label: 24002
Last Modified: Apr  7 18:58:04.510 for 00:01:46
Paths: (1 available, best #1)
  Advertised to update-groups (with more than one peer):
    0.2
  Path #1: Received by speaker 0
  Advertised to update-groups (with more than one peer):
   0.2
  1
    10.4.1.3 from 10.4.1.3 (10.100.1.3)
      Received Label 24009
      Origin incomplete, localpref 100, valid, external, best, group-
best, import-candidate, not-in-vrf
      Received Path ID 0, Local Path ID 1, version 12
      Extended community: RT:1:1
```

5. AS间选项C - BGP标签优先于LDP标签

请参阅此映像，查看通过多条链路连接的两个ASBR的设置。为了实现此目的，ASBR之间的eBGP ipv4 LU会话必须是多跳，因为它们之间有并行链路。

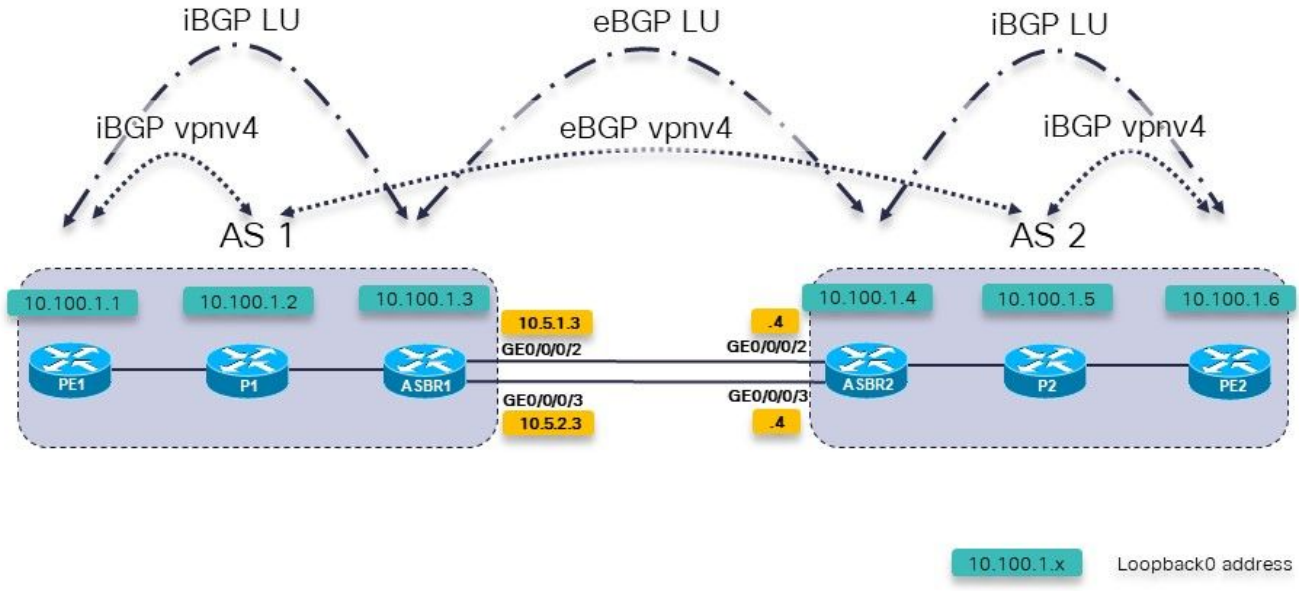

图4.

这是AS间选项C。路由器P1和P2也是vpnv4的路由反射器。

PE路由器和ASBR之间有标记为单播的IPv4。ASBR通过多条链路直接连接。

在ASBR上，您会看到：

```
router bgp 1
…
neighbor 10.100.1.4
  remote-as 2
  ebgp-multihop 2
  update-source Loopback0
  address-family ipv4 labeled-unicast
   route-policy PASS in
   route-policy PASS out
```

ASBR之间不需要标签分发协议(LDP)。BGP将负责ASBR之间链路上的MPLS转发。

```
RP/0/0/CPU0:ASBR1#show mpls interfaces

Interface                  LDP       Tunnel    Static    Enabled
-------------------------- --------  --------  --------  --------
GigabitEthernet0/0/0/0     Yes       No        No        Yes
GigabitEthernet0/0/0/1     No        No        No        Yes
GigabitEthernet0/0/0/2     No        No        No        Yes
GigabitEthernet0/0/0/3     No        No        No        Yes
GigabitEthernet0/0/0/4     No        No        No        Yes
```

到目前为止还不错。问题出在本图所示的场景。

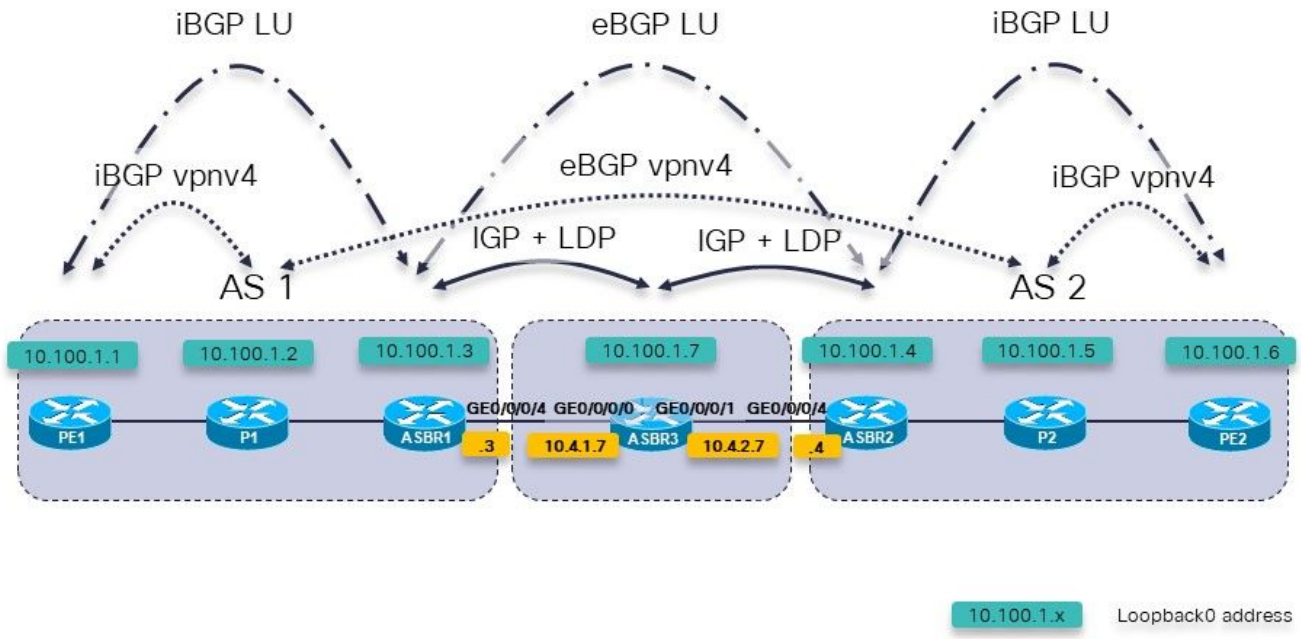

图5.

这是AS间选项C。路由器P1和P2也是vpnv4的路由反射器。

PE路由器和ASBR之间有标记为单播的IPv4。ASBR1和ASBR2未直接连接。它们通过运行IGP和LDP的网络连接多跳。在映像5中，此中间网络由路由器ASBR3表示，该路由器运行IGP和LDP，ASBR1和ASBR2。

在ASBR上使用eBGP多跳时，出现问题。每个AS中RR之间的BGP会话甚至不会启动。

```
RP/0/0/CPU0:P1#show cef 10.100.1.5
10.100.1.5/32, version 263, internal 0x1000001 0x0 (ptr 0xa13bde74) [1], 0x0 (0xa1389560), 0xa28
(0xa14a72a8)
 Updated Apr  8 09:38:02.551
 local adjacency 10.1.2.3
 Prefix Len 32, traffic index 0, precedence n/a, priority 3
   via 10.1.2.3/32, GigabitEthernet0/0/0/1, 5 dependencies, weight 0,
class 0 [flags 0x0]
    path-idx 0 NHID 0x0 [0xa0e8b2a4 0x0]
    next hop 10.1.2.3/32
    local adjacency
     local label 24004      labels imposed {24007}
```

为了从P1、AS 1中的RR到P2,AS 2中的RR，传出标签为24007。在ASBR1上，此标签与标签24000交换。

```
RP/0/0/CPU0:ASBR1#show mpls forwarding labels 24007
Local  Outgoing    Prefix           Outgoing     Next Hop       Bytes
Label  Label       or ID            Interface                   Switched
------ ----------- ---------------- ------------ --------------- -----------
24007  24000       10.100.1.5/32    10.100.1.4      1404

RP/0/0/CPU0:ASBR1#show cef 10.100.1.5
10.100.1.5/32, version 155, internal 0x5000001 0x0 (ptr 0xa13be174) [1],
0x0 (0xa138965c), 0xa08 (0xa14a72d0)
 Updated Apr  8 10:02:38.101
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
   via 10.100.1.4/32, 5 dependencies, recursive, bgp-ext [flags 0x6020]
    path-idx 0 NHID 0x0 [0xa150f874 0x0]
    recursion-via-/32
    next hop 10.100.1.4/32 via 24004/0/21
     local label 24007
     next hop 10.4.1.7/32 Gi0/0/0/4     labels imposed {ImplNull 24000}
```

标签24000是BGP LU从ASBR2在ASBR1上收到的标签。

```
RP/0/0/CPU0:ASBR1#show bgp ipv4 labeled-unicast 10.100.1.5
BGP routing table entry for 10.100.1.5/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 76          76
    Local Label: 24007
Last Modified: Apr  8 09:37:57.509 for 00:04:05
Paths: (1 available, best #1)
  Advertised to update-groups (with more than one peer):
    0.3
  Advertised to peers (in unique update groups):
    10.100.1.1      10.100.1.2
  Path #1: Received by speaker 0
  Advertised to update-groups (with more than one peer):
    0.3
  Advertised to peers (in unique update groups):
    10.100.1.1      10.100.1.2
  2
    10.100.1.4 from 10.100.1.4 (10.100.1.4)
      Received Label 24000
     Origin incomplete, metric 2, localpref 100, valid, external, best, group-best
      Received Path ID 0, Local Path ID 1, version 76
      Origin-AS validity: not-found
```

但是，中间的ASBR路由器不运行BGP，因此无法转发它接收的带有此标签的数据包，因为它未分配标签24000。应用于将数据包发送到10.100.1.5的标签是LDP的标签：

```
RP/0/0/CPU0:ASBR1#show route 10.100.1.5/32

Routing entry for 10.100.1.5/32
  Known via "bgp 1", distance 20, metric 2, [ei]-bgp, labeled unicast
(3107)
  Tag 2, type external
  Installed Apr  8 10:02:38.082 for 01:24:37
  Routing Descriptor Blocks
    10.100.1.4, from 10.100.1.4, BGP external
      Route metric is 2
  No advertising protos.
```

这会循环到下一跳10.100.1.4，即ASBR2的环回。

应使用LDP从ASBR3接收的标签，但不应使用。

添加的标签堆栈是{ImplNull 24000}，而不是{24002 24000}。

```
RP/0/0/CPU0:ASBR1#show mpls ldp bindings 10.100.1.4/32
10.100.1.4/32, rev 146
        Local binding: label: 24004
        Remote bindings: (2 peers)
            Peer                 Label
            -----------------    ---------
            10.100.1.2:0         24003
            10.100.1.7:0         24002
```

ASBR1应该将从ASBR3路由器收到的LDP标签24002加上。要禁用BGP MPLS转发，请将**mpls**关键字添加到eBGP multi-hop命令。

ASBR1:

```
router bgp 1
…
neighbor 10.100.1.4
 remote-as 2
 ebgp-multihop 2 mpls
  update-source Loopback0
 address-family ipv4 labeled-unicast
  route-policy PASS in
  route-policy PASS out
 !
```

ASBR1现在有正确的标签重写：

```
RP/0/0/CPU0:ASBR1#show cef 10.100.1.5
10.100.1.5/32, version 155, internal 0x5000001 0x0 (ptr 0xa13be174) [1], 0x0 (0xa138965c), 0xa08
(0xa14a72d0)
 Updated Apr  8 10:02:38.102
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
  via 10.100.1.4/32, 5 dependencies, recursive, bgp-ext [flags 0x6020]
   path-idx 0 NHID 0x0 [0xa150f874 0x0]
   recursion-via-/32
   next hop 10.100.1.4/32 via 24004/0/21
    local label 24007
```

```
    next hop 10.4.1.7/32 Gi0/0/0/4     labels imposed {24002 24000}
```

从命令参考：

在**ebgp-multihop**命令中使用**mpls**选项可防止BGP在对等接口上启用MPLS，还可防止为从对等体获取的下一跳地址分配隐式 — NULL重写标签。在MPLS将标签转发到下一代的某些场景中，这非常有用，因为MPLS已通过BGP标记单播或LDP获知了标签。

换句话说，在IOS-XR中，当BGP提供将标签分配给LFIB时，它将优先于LDP。ASBR路由器之间具有多跳的AS间选项C的场景就是这样的场景。

6. AS间选项B - BGP标签优先于LDP标签

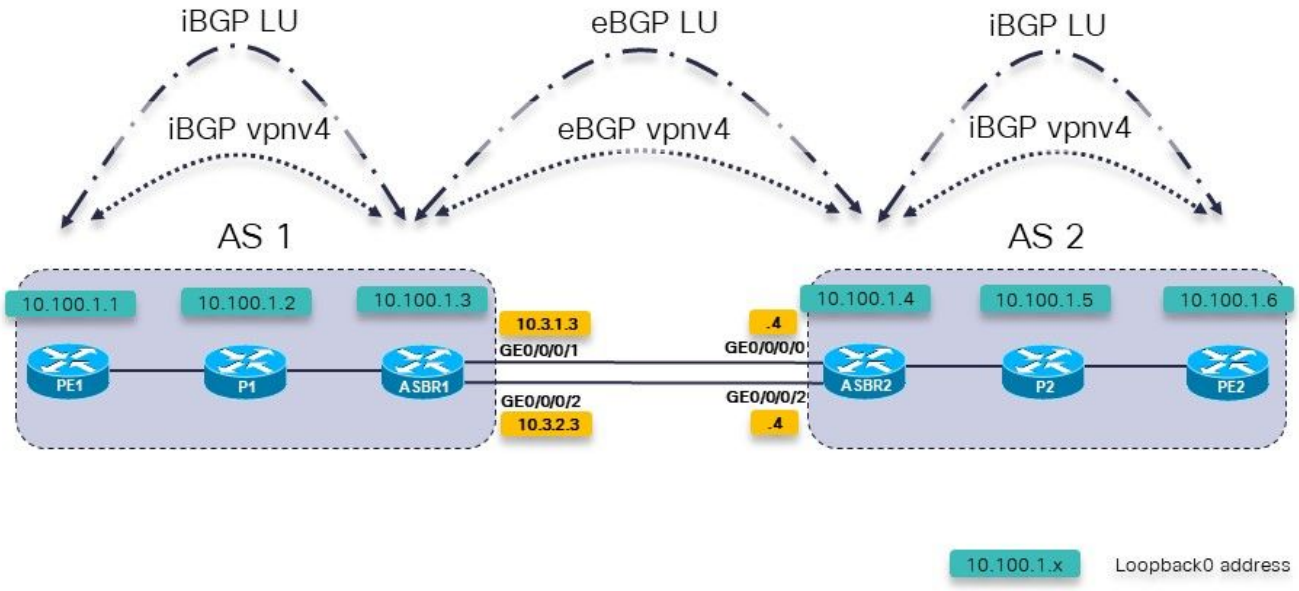

图6.

这是AS间选项B。但是，两个ASBR之间有多个并行链路。ASBR之间有RFC3107（交换IPv4路由和MPLS标签），而不是使用IGP和LDP。

要在ASBR1和ASBR2的环回接口之间启用eBGP多跳会话，两个ASBR之间需要eBGP LU。ASBR之间有两条链路，因此需要两个eBGP LU会话。地址系列IPv4需要allocate-label命令。

```
router bgp 65001
 address-family ipv4 unicast
  network 10.100.1.3/32
  allocate-label all
!
 neighbor 10.3.1.4
  remote-as 65002
  address-family ipv4 labeled-unicast
   route-policy pass in
   route-policy pass out
  !
 !
```

```
 neighbor 10.3.2.4
  remote-as 65002
  address-family ipv4 labeled-unicast
   route-policy pass in
   route-policy pass out
  !
 !
```

第1部分的静态路由仍然需要：

```
router static
 address-family ipv4 unicast
  10.3.1.4/32 GigabitEthernet0/0/0/1
  10.3.2.4/32 GigabitEthernet0/0/0/2
 !
!
```

ASBR之间的eBGP vpnv4会话：

```
router bgp 65001
 address-family ipv4 unicast
  network 10.100.1.3/32
  allocate-label all
 !
 address-family vpnv4 unicast
  retain route-target all
 !
 neighbor 10.100.1.4
  remote-as 65002
 ebgp-multihop 255
  update-source Loopback0
  address-family vpnv4 unicast
   route-policy pass in
   route-policy pass out
  !
 !
```

请注意，此处不需要mpls关键字，如第5部分所示。此外，如果为iBGP vpnv4会话配置了**next-hop-self，则不**需要PE和ASBR之间的iBGP LU会话。ASBR2通告的10.100.1.4/32标签为标签3:

```
RP/0/0/CPU0:ASBR1#show bgp ipv4 labeled-unicast 10.100.1.4/32
Fri Jun  2 11:50:16.178 UTC
BGP routing table entry for 10.100.1.4/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 8           8
    Local Label: 24005
Last Modified: Jun  2 11:48:39.920 for 00:01:36
Paths: (4 available, best #1)
  Advertised to update-groups (with more than one peer):
    0.3
  Advertised to peers (in unique update groups):
    10.100.1.7
  Path #1: Received by speaker 0
  Advertised to update-groups (with more than one peer):
    0.3
  Advertised to peers (in unique update groups):
    10.100.1.7
  65002
    10.3.1.4 from 10.3.1.4 (10.100.1.4)
      Received Label 3
```

```
      Origin IGP, metric 0, localpref 100, valid, external, best, group-best
      Received Path ID 0, Local Path ID 1, version 8
      Origin-AS validity: not-found
  Path #2: Received by speaker 0
  Not advertised to any peer
  65002
    10.3.2.4 from 10.3.2.4 (10.100.1.4)
      Received Label 3
      Origin IGP, metric 0, localpref 100, valid, external
      Received Path ID 0, Local Path ID 0, version 0
      Origin-AS validity: not-found
  Path #3: Received by speaker 0
  Not advertised to any peer
  65003 65002
    10.3.3.9 from 10.3.3.9 (10.100.1.9)
      Received Label 24001
      Origin IGP, localpref 100, valid, external, group-best
      Received Path ID 0, Local Path ID 0, version 0
      Origin-AS validity: not-found
  Path #4: Received by speaker 0
  Not advertised to any peer
  65003 65002
    10.3.4.9 from 10.3.4.9 (10.100.1.9)
      Received Label 24001
      Origin IGP, localpref 100, valid, external
      Received Path ID 0, Local Path ID 0, version 0
      Origin-AS validity: not-found

RP/0/0/CPU0:ASBR1#show cef 10.100.1.4
Fri Jun  2 11:51:06.994 UTC
10.100.1.4/32, version 254, internal 0x1000001 0x0 (ptr 0xa13be474) [1],
0x0 (0xa13896ec), 0xa20 (0xa14a70f0)
 Updated Jun  2 11:48:39.634
 local adjacency 10.3.1.4
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
   via 10.3.1.4/32, GigabitEthernet0/0/0/1, 5 dependencies, weight 0,
class 0 [flags 0x0]
    path-idx 0 NHID 0x0 [0xa0e8b1fc 0xa0e8b34c]
    next hop 10.3.1.4/32
    local adjacency
     local label 24005      labels imposed {ImplNull}

RP/0/0/CPU0:ASBR1#show mpls forwarding labels 24005
Fri Jun  2 11:51:20.204 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    
Switched
------ ----------- ------------------ ------------ --------------- -----
-------
24005  Pop         10.100.1.4/32      Gi0/0/0/1    10.3.1.4        610
```

当ASBR之间有另一条路径，且该路径使用IGP + LDP或MPLS TE时，eBGP multihop命令需要mpls关键字。

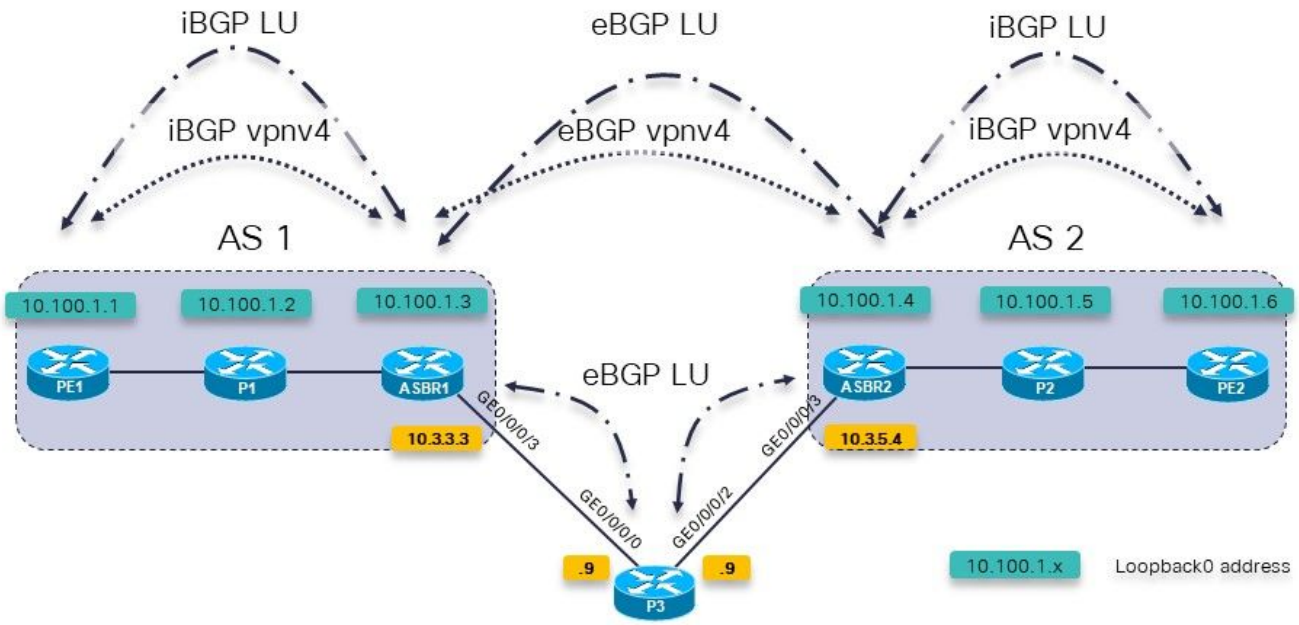

图7.

ASBR1上面向P3的BGP路由策略用于将权重设置得非常高，因此来自P3的前缀优先于来自ASBR2的前缀。

```
RP/0/0/CPU0:ASBR1#show bgp ipv4 labeled-unicast 10.100.1.4/32
Fri Jun  2 11:57:23.789 UTC
BGP routing table entry for 10.100.1.4/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 9           9
    Local Label: 24005
Last Modified: Jun  2 11:51:58.920 for 00:05:24
Paths: (4 available, best #3)
  Advertised to update-groups (with more than one peer):
    0.3
  Advertised to peers (in unique update groups):
    10.100.1.7
  Path #1: Received by speaker 0
  Not advertised to any peer
  65002
    10.3.1.4 from 10.3.1.4 (10.100.1.4)
      Received Label 3
      Origin IGP, metric 0, localpref 100, valid, external, group-best
      Received Path ID 0, Local Path ID 0, version 0
      Origin-AS validity: not-found
  Path #2: Received by speaker 0
  Not advertised to any peer
  65002
    10.3.2.4 from 10.3.2.4 (10.100.1.4)
      Received Label 3
      Origin IGP, metric 0, localpref 100, valid, external
      Received Path ID 0, Local Path ID 0, version 0
      Origin-AS validity: not-found
  Path #3: Received by speaker 0
  Advertised to update-groups (with more than one peer):
```

```
    0.3
  Advertised to peers (in unique update groups):
    10.100.1.7
  65003 65002
    10.3.3.9 from 10.3.3.9 (10.100.1.9)
      Received Label 24001
        Origin IGP, localpref 100, weight 65535, valid, external, best, group-best
        Received Path ID 0, Local Path ID 1, version 9
        Origin-AS validity: not-found
  Path #4: Received by speaker 0
  Not advertised to any peer
  65003 65002
    10.3.4.9 from 10.3.4.9 (10.100.1.9)
      Received Label 24001
      Origin IGP, localpref 100, valid, external
      Received Path ID 0, Local Path ID 0, version 0
      Origin-AS validity: not-found
```

ASBR1现在应将标签24001用作10.100.1.4/32的传出标签。它不：

```
RP/0/0/CPU0:ASBR1#show cef 10.100.1.4
Fri Jun  2 11:59:46.519 UTC
10.100.1.4/32, version 255, internal 0x1000001 0x0 (ptr 0xa13be474) [1],
0x0 (0xa13896ec), 0xa20 (0xa14a7140)
 Updated Jun  2 11:51:58.741
 local adjacency 10.3.3.9
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
   via 10.3.3.9/32, GigabitEthernet0/0/0/3, 7 dependencies, weight 0,
class 0 [flags 0x0]
    path-idx 0 NHID 0x0 [0xa0e8b544 0xa0e8b5ec]
    next hop 10.3.3.9/32
    local adjacency
     local label 24005      labels imposed {ImplNull}
```

解决方案与第5部分相同：对eBGP multihop命令使用mpls关键字。

```
RP/0/0/CPU0:ASBR1# conf t
Fri Jun  2 13:56:45.618 UTC
RP/0/0/CPU0:ASBR1(config)#router bgp 65001
RP/0/0/CPU0:ASBR1(config-bgp)# neighbor 10.100.1.4
RP/0/0/CPU0:ASBR1(config-bgp-nbr)#ebgp-multihop 255 mpls
RP/0/0/CPU0:ASBR1(config-bgp-nbr)#commit
```

ASBR1现在将标签24001用作10.100.1.4/32的传出标签。

```
RP/0/0/CPU0:ASBR1#show cef 10.100.1.4
Fri Jun  2 13:58:13.402 UTC
10.100.1.4/32, version 200, internal 0x5000001 0x0 (ptr 0xa13be474) [1],
0x0 (0xa13895cc), 0xa08 (0xa14a71b8)
 Updated Jun  2 13:56:59.378
 Prefix Len 32, traffic index 0, precedence n/a, priority 15
   via 10.3.3.9/32, 3 dependencies, recursive, bgp-ext [flags 0x6020]
    path-idx 0 NHID 0x0 [0xa15102f4 0x0]
    recursion-via-/32
    next hop 10.3.3.9/32 via 24014/0/21
     local label 24005
     next hop 10.3.3.9/32 Gi0/0/0/3    labels imposed {ImplNull 24001}
```

ASBR1推送此额外标签。从PE1到PE2的虚拟路由和转发(VRF)中的traceroute显示推送的额外标签。

```
RP/0/0/CPU0:PE1#trace vrf one 10.99.1.2
Fri Jun  2 13:49:38.959 UTC

Type escape sequence to abort.
Tracing the route to 10.99.1.2

 1  10.1.1.5 [MPLS: Labels 24002/24012 Exp 0] 29 msec  39 msec  39 msec
 2  10.1.2.3 [MPLS: Label 24012 Exp 0] 29 msec  29 msec  39 msec
 3  10.3.1.4 [MPLS: Label 24007 Exp 0] 39 msec  39 msec  39 msec
 4  10.2.1.6 [MPLS: Labels 24001/24005 Exp 0] 39 msec  39 msec  29 msec
 5  10.2.2.2 39 msec  *  239 msec
```

ASBR1和P3之间使用IGP和LDP，ASBR2和P3之间使用MPLS流量工程(TE)时，同样的问题和解决方案也存在。

从ASBR1到P3没有LDP，但有MPLS TE。

在eBGP multihop命令上不使用mpls关键字时，同样的问题再次出现：

转发到10.100.1.4的数据包不会推送BGP LU标签24000。

```
RP/0/0/CPU0:ASBR1#show cef 10.100.1.4
Tue Jun  6 10:36:56.528 UTC
10.100.1.4/32, version 50, internal 0x1000001 0x0 (ptr 0xa12cc1fc) [1],
0x0 (0xa12b18c0), 0xa20 (0xa14a7258)
 Updated Jun  6 10:36:32.930
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
   via 10.3.3.9/32, tunnel-te1, 7 dependencies, weight 0, class 0 [flags
0x0]
    path-idx 0 NHID 0x0 [0xa15d58f8 0xa15d5840]
    next hop 10.3.3.9/32
    local adjacency
     local label 24012      labels imposed {ImplNull}
```

而使用mpls关键字时，标签24000存在：

```
RP/0/0/CPU0:ASBR1#show cef 10.100.1.4
Tue Jun  6 10:36:03.241 UTC
10.100.1.4/32, version 34, internal 0x5000001 0x0 (ptr 0xa12cc1fc) [1],
0x0 (0xa12b15a8), 0xa08 (0xa14a70f0)
 Updated Jun  6 09:39:24.56
 Prefix Len 32, traffic index 0, precedence n/a, priority 15
 Extensions: context-label:24012
   via 10.3.3.9/32, 3 dependencies, recursive, bgp-ext [flags 0x6020]
    path-idx 0 NHID 0x0 [0xa150fecc 0x0]
    recursion-via-/32
    next hop 10.3.3.9/32 via 24011/0/21
     local label 24012
     next hop 10.3.3.9/32 tt1          labels imposed {ImplNull 24000}
```

使用mpls关键字，重写如下所示：

```
RP/0/0/CPU0:ASBR1#show mpls forwarding labels 24012
Tue Jun  6 10:43:50.559 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- -------
```

```
24012  24000       10.100.1.4/32      tt1          10.3.3.9        0
```

如果没有mpls关键字，重写将如下所示：

```
RP/0/0/CPU0:ASBR1#show mpls forwarding labels 24012
Tue Jun  6 10:45:08.734 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
24012  Pop         10.100.1.4/32      tt1          10.3.3.9        0
```

此标签14012不用于从VRF到VRF或从PE到PE的流量，但如果遇到，它可能表示标签转发实例库(LFIB)条目是或错误。

```
RP/0/0/CPU0:PE1# trace vrf one 10.99.1.2

Type escape sequence to abort.
Tracing the route to 10.99.1.2

 1  10.1.1.5 [MPLS: Labels 24001/24015 Exp 0] 129 msec  229 msec  129 msec
 2  10.1.2.3 [MPLS: Label 24015 Exp 0] 219 msec  439 msec  349 msec
 3  10.3.3.9 [MPLS: Labels 24000/24011 Exp 0] 169 msec  249 msec  139 msec
 4  10.3.5.4 [MPLS: Label 24011 Exp 0] 89 msec  129 msec  109 msec
 5  10.2.1.6 [MPLS: Labels 24004/24008 Exp 0] 139 msec  99 msec  139 msec
 6  10.2.2.2 129 msec  *  219 msec
```

在eBGP multihop命令上切换关键字mpls可能导致BGP标签冲突的系统日志消息：

```
bgp[1051]: %ROUTING-BGP-4-LABEL_COLLISION : Label 24012 collision: prev: [T: 3 RD:0:0:0 PFX/NHID:10.100.1.4/32] curr: [T: 13 RD:0:0:0 PFX/NHID:10.100.1.4/32]
```

此消息用于本地标签24012。

检查是为了确保BGP拥有的活动标签不会被BGP再次分配用于其他任何内容。此检查仅用于每前缀标签。

此消息是症状，不是本文任何问题的原因。

7.基于VPN（或6PE或EVPN）底层的多跳BGP会话

如果存在eBGP多跳会话，则无法通过vpnv4/6或6PE(IPv6 over MPLS)或以太网虚拟专用网络(EVPN)路由获取下一跳地址的路由，除非路由器具有Cisco IOS®-XR 6.3.2或更高版本。请参阅此映像。

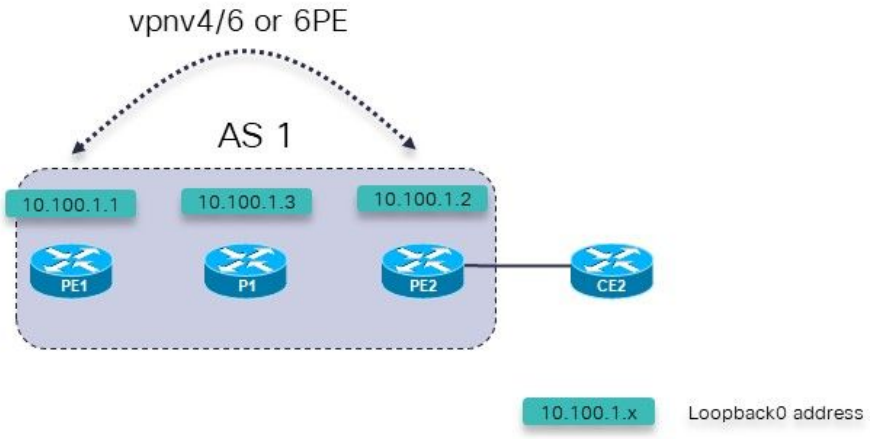

图8.

可能的故障场景：

1. 从PE1（在VRF内）到PE2（在VRF内）的eBGP多跳会话
2. 从PE1（在VRF内）到CE2的eBGP多跳会话

这适用：

eBGP多跳会话在PE路由器的路由器BGP下的VRF部分下配置。

eBGP多跳会话(从PE1（在VRF内）到PE2（在VRF内），或eBGP多跳会话从PE1（在VRF内）到CE2，仅从Cisco IOS®-XR 6.3.2开始受支持。

eBGP对等体地址可通过包含vnpv4的底层访问。vpnv6、6PE或EVPN。

在6.3.2之前的Cisco IOS®版本中，eBGP会话将处于空闲状态。

例如，配置了VRF1中eBGP多跳会话PE1到PE2。

PE1上从PE1到PE2的eBGP多跳会话的相关配置：

```
interface Loopback100
 vrf one
 ipv4 address 10.2.100.1 255.255.255.255

router bgp 1
 address-family vpnv4 unicast
 !
 neighbor 10.100.1.2
 remote-as 1
 update-source Loopback0
 address-family vpnv4 unicast
```

```
 !
 !
 vrf one
 rd 1:1
 address-family ipv4 unicast
 redistribute connected
 !
 neighbor 10.2.100.2
remote-as 65002
 ebgp-multihop 255
local-as 65001
 update-source Loopback100
 address-family ipv4 unicast
 route-policy pass in
 route-policy pass out
 !
 !
 !
!
```

eBGP会话保持空闲：

```
RP/0/0/CPU0:PE1#show bgp vrf one neighbors

BGP neighbor is 10.2.100.2, vrf one
 Remote AS 65002, local AS 65001, external link
 Remote router ID 0.0.0.0
 BGP state = Idle (No route to multi-hop neighbor)
```

eBGP对等体地址的路由存在于VRF 1路由表中：

```
RP/0/0/CPU0:PE1# show route vrf one

Codes: C - connected, S - static, R - RIP, B - BGP, (>) - Diversion path
 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, E - EGP
 i - ISIS, L1 - IS-IS level-1, L2 - IS-IS level-2
 ia - IS-IS inter area, su - IS-IS summary null, * - candidate default
 U - per-user static route, o - ODR, L - local, G - DAGR
 A - access/subscriber, a - Application route, (!) - FRR Backup path

Gateway of last resort is not set

L 10.2.100.1/32 is directly connected, 00:23:25, Loopback100
B 10.2.100.2/32 [200/0] via 10.100.1.2 (nexthop in vrf default), 00:19:28
```

```
RP/0/0/CPU0:PE1# show route vrf one 10.2.100.2/32

Routing entry for 10.2.100.2/32
 Known via "bgp 1", distance 200, metric 0, type internal
 Installed May 29 09:07:53.368 for 00:19:36
 Routing Descriptor Blocks
 10.100.1.2, from 10.100.1.2
 Nexthop in Vrf: "default", Table: "default", IPv4 Unicast, Table Id: 0xe0000000
Route metric is 0
 No advertising protos.
```

问题的根本原因是对等地址的路由是导入的路由：

```
RP/0/0/CPU0:PE1# show bgp vpnv4 unicast vrf one 10.2.100.2/32

BGP routing table entry for 10.2.100.2/32, Route Distinguisher: 1:1
Versions:
 Process bRIB/RIB SendTblVer
 Speaker 7 7
Last Modified: May 29 09:07:53.524 for 00:21:20
Paths: (1 available, best #1)
 Not advertised to any peer
 Path #1: Received by speaker 0
 Not advertised to any peer
 Local
 10.100.1.2 (metric 2) from 10.100.1.2 (10.100.1.2)
 Received Label 16001
 Origin incomplete, metric 0, localpref 100, valid, internal, best,
group-best, import-candidate, imported
Received Path ID 0, Local Path ID 1, version 7
 Extended community: RT:1:1
Source VRF: one, Source Route Distinguisher: 1:1
```

在Cisco IOS®-XR 6.3.2之后支持此功能。

8.将BGP重分发到LDP

这是统一或无缝MPLS的特点，以及它如何配置IOS-XR:Unified MPLS和IOS-XR

使用常规统一MPLS时，所有PE和ABR路由器之间都有BGP LU，如图所示。

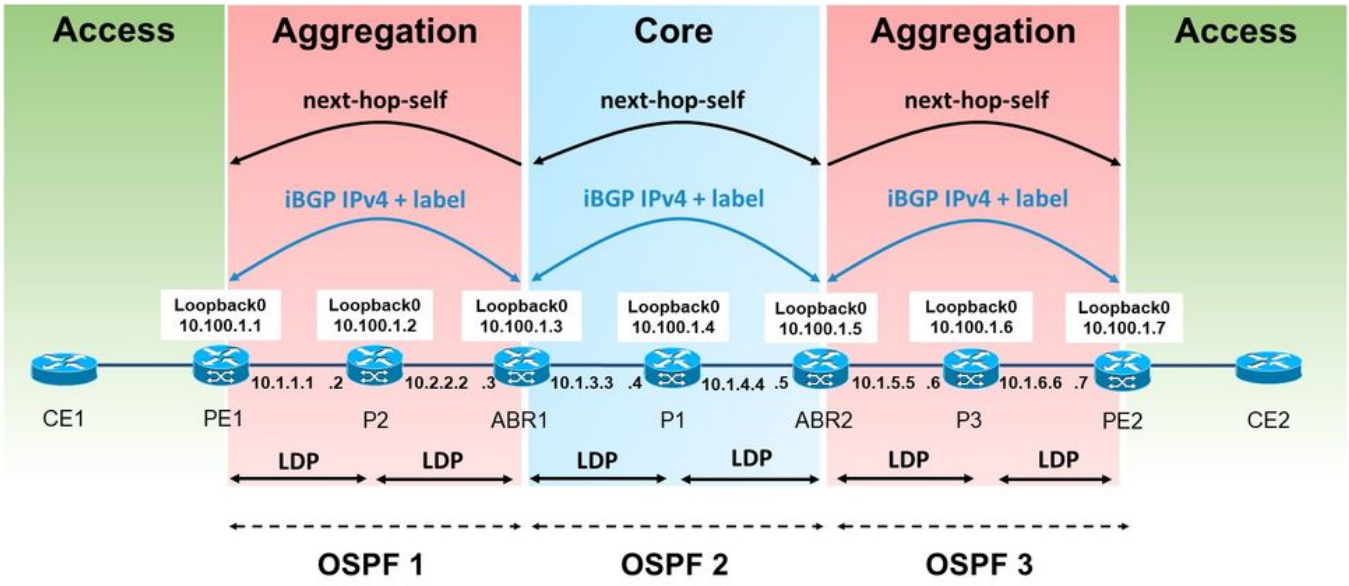

图9.

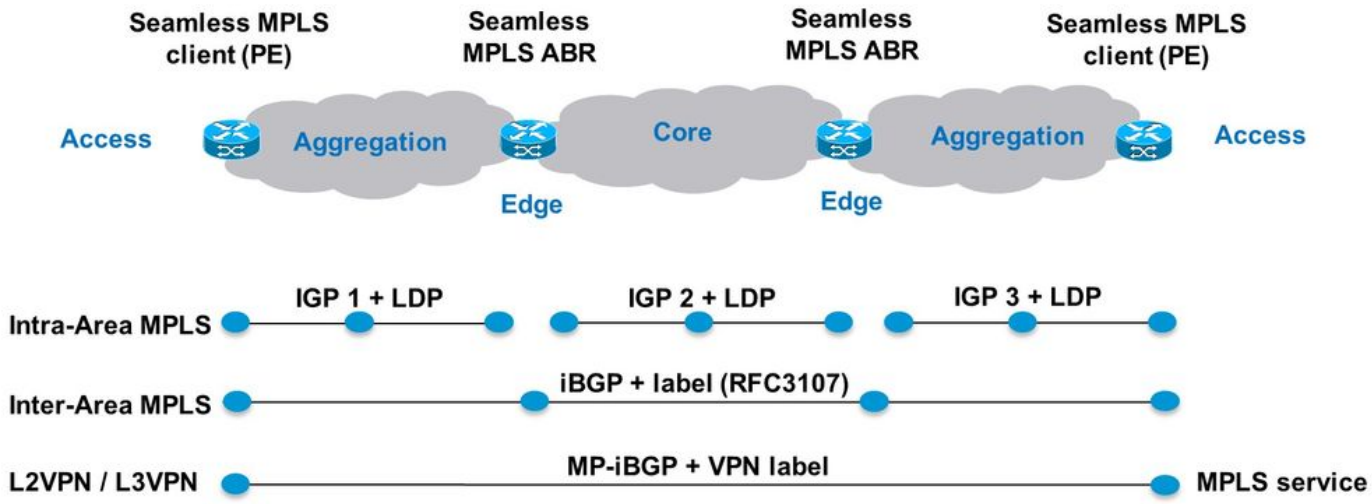

图10.

在本例中，有一个没有BGP LU的IGP区域/级别。在左侧，汇聚区域实际上是开放最短路径优先(OSPF)进程1，该进程在核心中没有与OSPF进程2的重分发。在使用OSPF 1的网络部分，PE和区域边界路由器(ABR)路由器之间没有BGP LU。

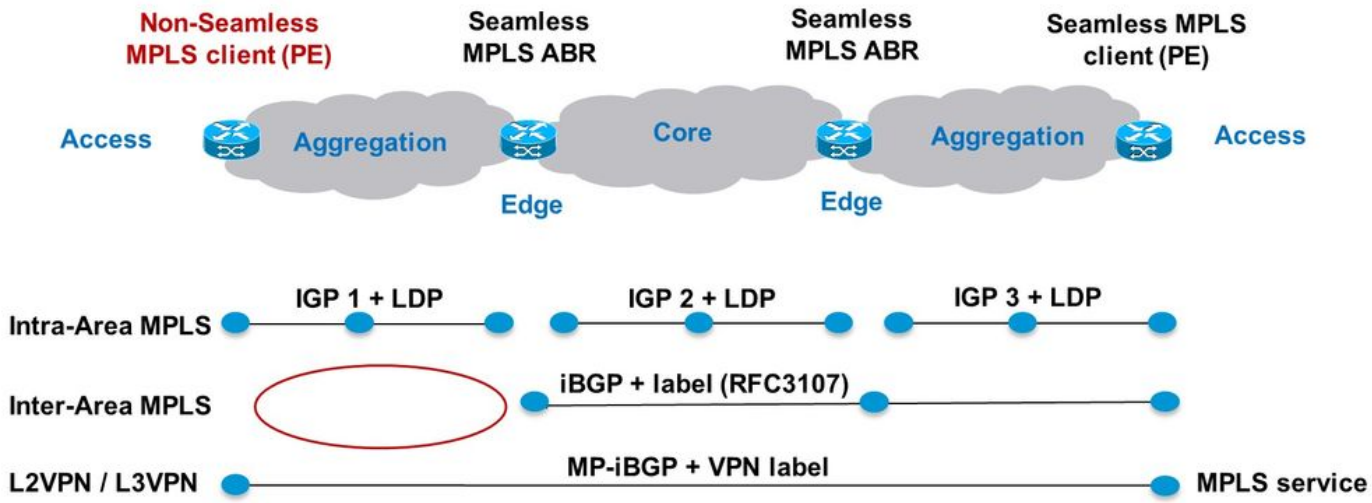

图11.

BGP LU前缀重分发到ABR1上的IGP OSPF 1，如图所示。

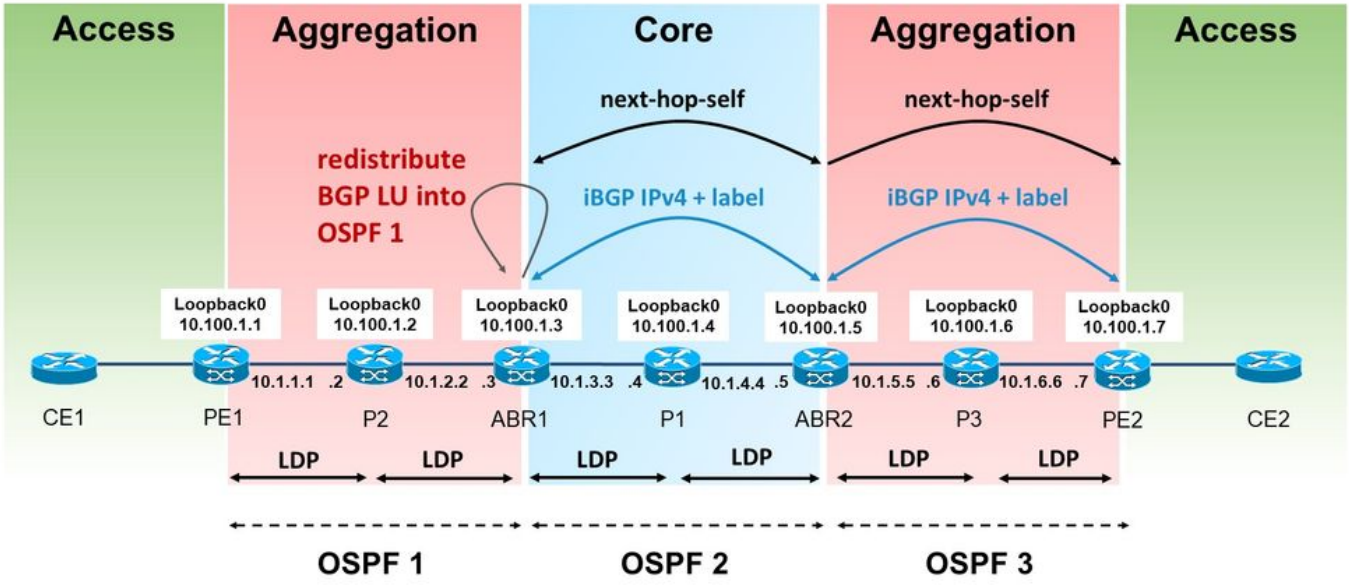

图12.

您需要BGP为收到的iBGP LU前缀分配标签。但是，LDP不会在标签绑定中为重分发的前缀自动通告此标签。默认情况下，IOS(-XE)会执行此操作。

请注意，ABR正在将内部BGP路由重分发到左侧区域的IGP中。这意味着路由器bgp下**需要bgp redistribute-internal**命令。

```
router bgp 1
bgp redistribute-internal

router ospf 1
 router-id 10.100.1.3
redistribute bgp 1 metric 10 route-policy select-to-allocate
 area 0
  interface Loopback0
  !
  interface GigabitEthernet0/0/0/0
   network point-to-point
  !
 !
!
route-policy select-to-allocate
  if destination in (10.100.1.7/32) then
    pass
  else
    drop
  endif
end-policy
```

当启用本地标签分配时，ABR将本地标签分配给收到的iBGP LU路由。

```
router bgp 1
 bgp redistribute-internal
 ibgp policy out enforce-modifications
```

```
 address-family ipv4 unicast
  redistribute ospf 1 metric 10 route-policy ospf-1-loopbacks-PE
  allocate-label route-policy select-to-allocate
```

路由策略选择分配可用于指定为哪些收到的BGP LU前缀分配了本地标签。

```
route-policy select-to-allocate
  if destination in (10.100.1.7/32) then
    pass
  else
    drop
  endif
end-policy
!
```

PE2的环回前缀在ABR1上显示，带有本地标签，但LDP没有看到此本地标签：

```
RP/0/0/CPU0:ABR1#show bgp ipv4 labeled-unicast 10.100.1.7/32

BGP routing table entry for 10.100.1.7/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 6           6
    Local Label: 24006
Last Modified: Sep  5 06:55:47.368 for 06:40:23
Paths: (1 available, best #1)
  Advertised IPv4 Labeled-unicast paths to update-groups (with more than
one peer):
    0.2
  Path #1: Received by speaker 0
  Advertised IPv4 Labeled-unicast paths to update-groups (with more than
one peer):
    0.2
  Local, (Received from a RR-client)
    10.100.1.5 (metric 20) from 10.100.1.5 (10.100.1.7)
      Received Label 24003
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-
best, labeled-unicast
      Received Path ID 0, Local Path ID 1, version 6
      Originator: 10.100.1.7, Cluster list: 10.100.1.5

RP/0/0/CPU0:ABR1#show mpls ldp bindings 10.100.1.7/32

10.100.1.7/32, rev 0 (no route)
        No local binding
        Remote bindings: (1 peers)
            Peer                Label
            -----------------   ---------
            10.100.1.2:0        18
```

这意味着从PE1到PE2的LSP被中断：

```
RP/0/0/CPU0:PE1#traceroute 10.100.1.7 source 10.100.1.1

Type escape sequence to abort.
Tracing the route to 10.100.1.7

 1  10.1.1.2 [MPLS: Label 18 Exp 0] 9 msec  0 msec  0 msec
 2  10.1.2.3 0 msec  0 msec  0 msec <<< no MPLS labels
 3  10.1.3.4 [MPLS: Labels 16/24003 Exp 0] 29 msec  19 msec  29 msec
 4  10.1.4.5 [MPLS: Label 24003 Exp 0] 9 msec  9 msec  9 msec
```

```
 5    *  *  *
 6  10.1.6.7 9 msec  *  19 msec
```

LSP在P2中断，因为它未从ABR1通过LDP获取远程标签。ABR1在LDP中没有本地分配的前缀10.100.1.7/32**标签**。

在ABR上需要配置，以将BGP重分发**到IGP**的路由器上的BGP重分发到LDP。

ABR1不向P2路由器通告前缀10.100.1.7/32的LDP标签绑定。

为使ABR1通告重分发的iBGP前缀的LDP标签绑定，ABR1必须具有以下配置（必须配置AS编号）。

```
mpls ldp
 mldp
  address-family ipv4
  !
 !
 router-id 10.100.1.3
 address-family ipv4
  redistribute
   bgp
    as 1
    !
   !
 !
```

您可以让LDP过滤通告。例如，可以配置如下过滤器：

```
mpls ldp
 mldp
  address-family ipv4
  !
 !
 router-id 10.100.1.3
 address-family ipv4
  redistribute
   bgp
    as 1
    advertise-to 1
   !

ipv4 access-list 1
 10 permit ipv4 host 10.100.1.2 any
```

在访问列表中指定LDP路由器ID。

在本例中，ABR仅将重分发的iBGP路由的LDP绑定通告给LDP邻居P2（而不是P1），因为10.100.1.2是P2的LDP路由器ID。

从PE1到PE2的LSP现在不中断：

```
RP/0/0/CPU0:PE1#traceroute 10.100.1.7 source 10.100.1.1

Type escape sequence to abort.
Tracing the route to 10.100.1.7

 1  10.1.1.2 [MPLS: Label 20 Exp 0] 39 msec  49 msec  29 msec
 2  10.1.2.3 [MPLS: Label 24006 Exp 0] 29 msec  49 msec  39 msec
```

```
 3   10.1.3.4 [MPLS: Labels 16/24003 Exp 0] 29 msec  19 msec  29 msec
 4   10.1.4.5 [MPLS: Label 24003 Exp 0] 29 msec  19 msec  29 msec
 5    *  *  *
 6   10.1.6.7 19 msec  *  19 msec
```

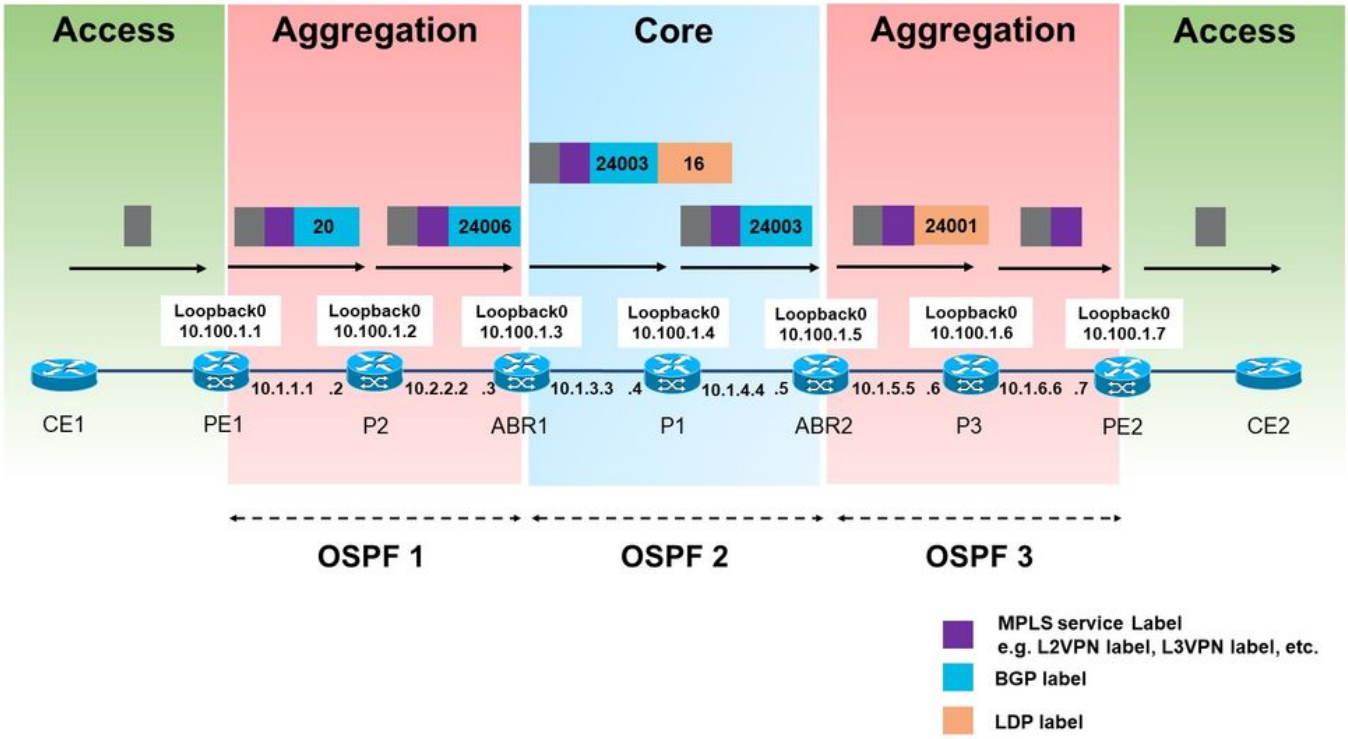

图13.

LDP通告到左汇聚区域的BGP分配标签(24006)现在用于从PE1到PE2的流量。

请注意，左侧聚合区域仅使用一个MPLS标签。如果这是常规统一MPLS，将使用两个标签。

此时，您无法过滤将哪些重分发的LU iBGP路由过滤到LDP中，接收本地标签，哪些则不过滤。一旦启用将iBGP LU路由重分发到LDP，它们都会获得本地标签。

PE2还在BGP LU中通告前缀10.100.1.99/32。此前缀不会由ABR1重分发到OSPF 1。但是，一旦打开iBGP LU路由到LDP的重分发，前缀10.100.1.99/32也会获得本地标签。

```
RP/0/0/CPU0:ABR1#show mpls ldp bindings 10.100.1.99/32

10.100.1.99/32, rev 24
        Local binding: label: 24007
        No remote bindings
```

9. MPLS激活接口命令

示例1. IGP但无LDP

如果有IGP负责内部路由，但没有LDP可通告标签绑定，则需要mpls activate命令。如果每一跳都运行BGP，则BGP LU可用于通告前缀和标签。当链路上的iBGP时，该链路需要在路由器BGP下使用命令mpls activate启用。请参阅此映像。

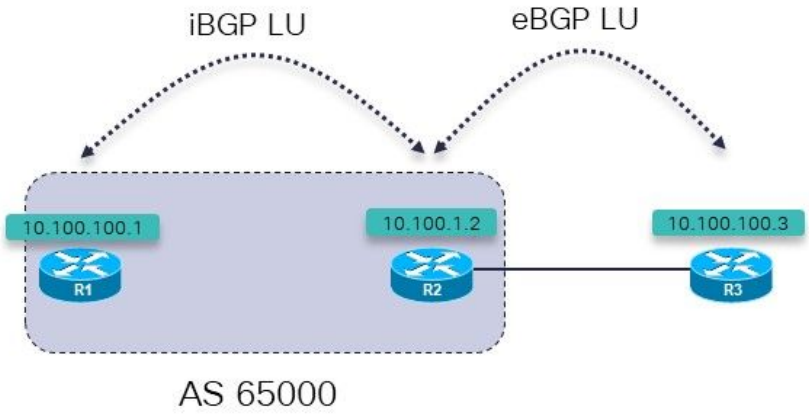

图14.

R1和R2在它们之间运行IGP和iBGP LU。R1和R2直接相连。R2有到R3的eBGP LU会话。

R3通过eBGP LU会话将前缀10.100.100.3/2通告给R2。R2通过iBGP LU会话将此前缀通告给R1。

目标是使从R1到R3的LSP不中断。它是否存在？

```
RP/0/0/CPU0:R1#trace 10.100.100.3 so 10.100.100.1

Type escape sequence to abort.
Tracing the route to 10.100.100.3

1 100.1.1 !N *  !N
```

第一跳没有此前缀的标签。

```
RP/0/0/CPU0:R1#traceroute mpls ipv4 10.100.100.3/32 ttl 5

Tracing MPLS Label Switched Path to 10.100.100.3/32, timeout is 2
seconds

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.

  0 0.0.0.0 MRU 0 [No Label]
Q 1 *
```

所以，没有标签。这并不奇怪，因为MPLS未在到R2的接口上启用：

```
RP/0/0/CPU0:R1#show mpls interfaces
RP/0/0/CPU0:R1#
```

但R3通告的LU前缀在R1上存在：

```
RP/0/0/CPU0:R1#show bgp ipv4 labeled-unicast 10.100.100.3/32
BGP routing table entry for 10.100.100.3/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 7           7
    Local Label: 24001
Last Modified: Sep 13 14:27:17.510 for 00:11:39
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  65001
    10.100.1.2 (metric 2) from 10.100.1.2 (10.100.1.2)
      Received Label 24002
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-
best, labeled-unicast
      Received Path ID 0, Local Path ID 1, version 7
```

您在R1上为到R2的接口配置mpls active命令：

```
router bgp 65000
mpls activate
  interface GigabitEthernet0/0/0/0
 !
 address-family ipv4 unicast
  network 10.100.100.1/32
  allocate-label all
 !
 neighbor 10.100.1.2
  remote-as 65000
  update-source Loopback0
  address-family ipv4 labeled-unicast
  !
 !
!
```

MPLS现在在传出接口上启用。

```
RP/0/0/CPU0:R1#show mpls interfaces
Interface                  LDP      Tunnel   Static   Enabled
-------------------------- -------- -------- -------- --------
GigabitEthernet0/0/0/0     No       No       No       Yes
```

traceroute现在显示LSP不中断。

```
RP/0/0/CPU0:R1#trace 10.100.100.3 so 10.100.100.1

Type escape sequence to abort.
Tracing the route to 10.100.100.3

 1  10.1.2.2 [MPLS: Label 24002 Exp 0] 39 msec  9 msec  9 msec
 2 10.2.3.3 19 msec *  9 msec
```

```
RP/0/0/CPU0:R1#traceroute mpls ipv4 10.100.100.3/32 ttl 5 source 10.100.100.1

Tracing MPLS Label Switched Path to 10.100.100.3/32, timeout is 2
seconds

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx labl,
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.

  0 10.1.2.1 MRU 1500 [Labels: implicit-null/24002 Exp: 0/0]
L 1 10.1.2.2 MRU 1500 [Labels: implicit-null/implicit-null Exp: 0/0] 0
ms
! 2 10.2.3.3 10 ms
```

示例2.联盟

本示例说明在使用BGP LU(RFC 3107)且未使用LDP时，eBGP（AS间）联盟链路上需要**mpls activate**命令。

此映像中的网络是具有65000自治系统65501、65502、65503和65504的联盟。

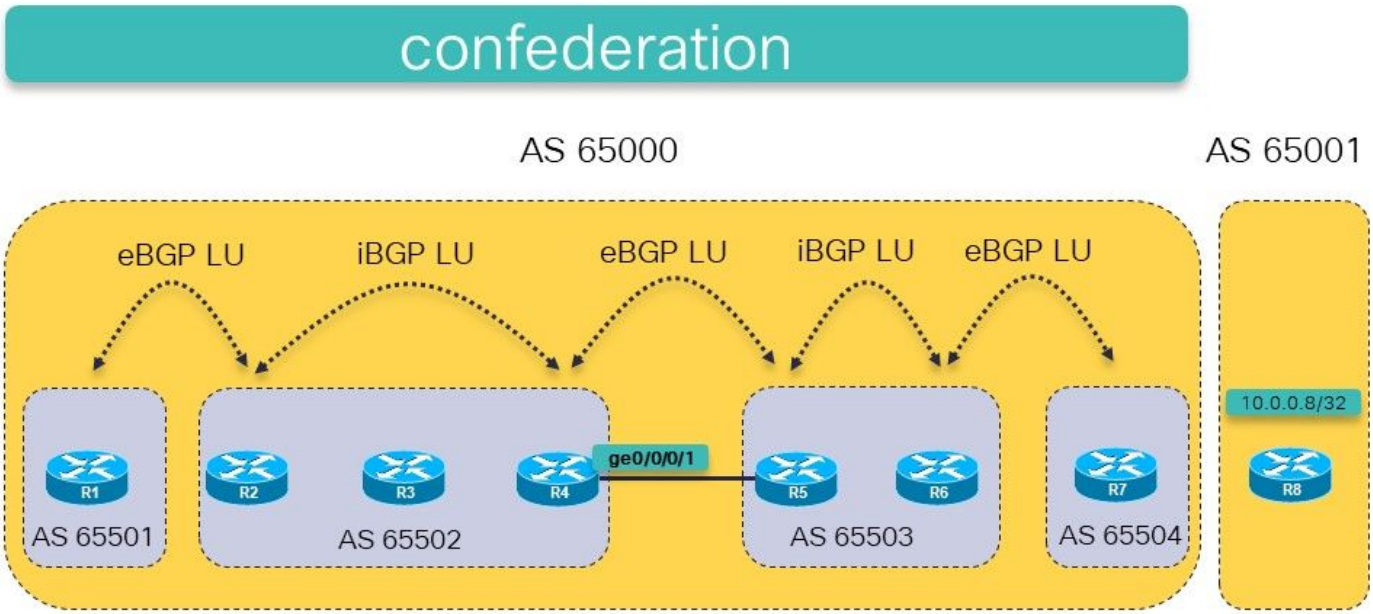

图15.

其思想是在两个自治系统中使用BGP LU，使MPLS LSP从R1到R8(BGP LU中的R8通告10.0.0.8/32)。

R7和R8之间有常规的eBGP LU。R2和R4之间以及R5和R6之间有连接的iBGP。R1和R2、R4和R5之间以及R6和R7之间有连接的eBGP。每个eBGP上都有下一跳 — self会话。

需要到eBGP对等体下一跳的静态路由（AS间BGP会话的典型路由），因为联盟内的子自治系统之间存在eBGP。

这是否足以在R1和R8之间建立连接？这意味着目标是从R1到R8的不间断LSP。

看这个。

```
RP/0/0/CPU0:R1#traceroute 10.0.0.8

Type escape sequence to abort.
Tracing the route to 10.0.0.8

 1    *  *  *
 2    *  *  *
 3    *  *  *
 4    *  *  *
 5    *  *  *
```

traceroute不返回任何跳/标签，如果命令上未提供TTL限制，将继续。路由器可能会应答traceroute，但数据包可能无法返回到R1。执行mpls traceroute是更安全的选择。

注意：只有在路径中的每台路由器上启用了MPLS OAM时，MPLS跟踪路由才有效。

```
RP/0/0/CPU0:R1#trace mpls ipv4 10.0.0.8/32

Tracing MPLS Label Switched Path to 10.0.0.8/32, timeout is 2 seconds

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.

  0 10.1.2.1 MRU 1500 [Labels: implicit-null/24015 Exp: 0/0]
L 1 10.1.2.2 MRU 1500 [Labels: 24003/24014 Exp: 0/0] 10 ms
L 2 10.2.3.3 MRU 1500 [Labels: implicit-null/24014 Exp: 0/0] 10 ms
N 3 10.3.4.4 MRU 0 [No Label] 10 ms
```

您看到问题出在R4上。LFIB中缺少传出接口：

```
RP/0/0/CPU0:R4#show mpls forwarding prefix 10.0.0.8/32
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
24014  24014       10.0.0.8/32                     10.4.5.5        5140
```

CEF中的条目未解析：

```
RP/0/0/CPU0:R4#show cef 10.0.0.8/32
10.0.0.8/32, version 109, drop adjacency, internal 0x5000001 0x0 (ptr
0xa14160e4) [1], 0x0 (0xa13f83c8), 0xa08 (0xa16cd370)
```

```
 Updated Sep 13 12:43:30.252
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
   via 10.4.5.5/32, 0 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0xa0f182d8 0x0]
    recursion-via-/32
    unresolved
     local label 24014
     labels imposed {24014}
```

GE0/0/0/1接口上未启用MPLS:

```
RP/0/0/CPU0:R4#show mpls interfaces
Interface                  LDP      Tunnel   Static   Enabled
-------------------------- -------- -------- -------- --------
GigabitEthernet0/0/0/0     Yes      No       No       Yes
```

使用命令激活R4和R5之间链路上的BGP的MPLS，即可解决该问题。R4和R5在此链路上有一个eBGP联盟会话。实际上，这是联盟65000中的iBGP会话。因此，需要使用激活MPLS命令来确保R4上的前缀解析到下一跳R5。在其他常规网络中，将由LDP负责，但R4和R5之间没有LDP，因为它是联盟内的eBGP会话。

为R4上的接口ge 0/0/0/1添加**mpls activate**命令：

```
router bgp 65502
 bgp confederation peers
  65501
  65503
  65504
 !
 bgp confederation identifier 65000
 mpls activate
  interface GigabitEthernet0/0/0/1
 !
…

RP/0/0/CPU0:R4#show mpls interfaces
Interface                  LDP      Tunnel   Static   Enabled
-------------------------- -------- -------- -------- --------
GigabitEthernet0/0/0/0     Yes      No       No       Yes
GigabitEthernet0/0/0/1     No       No       No       Yes
```

traceroute现在显示从R1到R8的不间断LSP。

```
RP/0/0/CPU0:R1#trace mpls ipv4 10.0.0.8/32

Tracing MPLS Label Switched Path to 10.0.0.8/32, timeout is 2 seconds

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.

  0 10.1.2.1 MRU 1500 [Labels: implicit-null/24015 Exp: 0/0]
L 1 10.1.2.2 MRU 1500 [Labels: 24003/24014 Exp: 0/0] 10 ms
L 2 10.2.3.3 MRU 1500 [Labels: implicit-null/24014 Exp: 0/0] 10 ms
```

```
L 3 10.3.4.4 MRU 1500 [Labels: implicit-null/24014 Exp: 0/0] 10 ms
L 4 10.4.5.5 MRU 1500 [Labels: implicit-null/24014 Exp: 0/0] 20 ms
L 5 10.5.6.6 MRU 1500 [Labels: implicit-null/24014 Exp: 0/0] 30 ms
L 6 10.6.7.7 MRU 1500 [Labels: implicit-null/implicit-null Exp: 0/0] 30
ms
! 7 10.7.8.8 30 ms

RP/0/0/CPU0:R1#traceroute 10.0.0.8

Type escape sequence to abort.

Tracing the route to 10.0.0.8

 1  10.1.2.2 [MPLS: Label 24015 Exp 0] 69 msec  29 msec  29 msec
 2  10.2.3.3 [MPLS: Labels 24003/24014 Exp 0] 49 msec  29 msec  29 msec
 3  10.3.4.4 [MPLS: Label 24014 Exp 0] 19 msec  19 msec  19 msec
 4  10.4.5.5 [MPLS: Label 24014 Exp 0] 49 msec  19 msec  29 msec
 5  10.5.6.6 [MPLS: Label 24014 Exp 0] 19 msec  19 msec  29 msec
 6  10.6.7.7 [MPLS: Label 24014 Exp 0] 29 msec  29 msec  29 msec
 7  10.7.8.8 29 msec  *  29 msec
```

LFIB中现在有一个传出接口用于此条目：

```
RP/0/0/CPU0:R4#show mpls forwarding prefix 10.0.0.8/32

Local  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface
Switched
------ ----------- ----------------- ------------ --------------- -----
-------
24014  24014       10.0.0.8/32       Gi0/0/0/1    10.4.5.5        2890
```

R4上存在用于前缀的传出标签，CEF显示已解析的前缀：

```
RP/0/0/CPU0:R4#show cef 10.0.0.8/32
Updated Sep 13 12:43:30.252
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
   via 10.4.5.5/32, 3 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0xa17420e4 0x0]
   recursion-via-/32
   next hop 10.4.5.5/32 via 24016/0/21
     local label 24014
     next hop 10.4.5.5/32 Gi0/0/0/1    labels imposed {ImplNull 24014}
```