mVPN网络中IOS-XR PE路由器核心树协议的迁移

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简介

本文档介绍如何将组播VPN(mVPN)协议无关组播(PIM)基于核心树的组播分布树(MDT)迁移到多点标签分布协议(mLDP)基于核心树的MDT。此外，还详细说明了迁移时如何发送数据MDT信号。本文档仅介绍运行Cisco IOS®-XR的入口提供商边缘(PE)路由器的迁移。

核心树协议的迁移

Dual-encap是指能够同时将客户(C)组播流转发到不同类型核心树的入口路由器。例如，入口PE路由器将一个C组播流同时转发到基于PIM的核心树和基于mLDP的核心树上。这是将mVPN从一个核心树类型成功迁移到另一个核心树类型的要求。

PIM和mLDP支持双封装。

多协议标签交换(MPLS)P2MP流量工程(TE)不支持双封装。

默认MDT通用路由封装(GRE)和默认MDT mLDP迁移或共存依赖于入口PE路由器同时向基于PIM的核心树和基于mLDP的核心树转发一个C组播流这一事实。当入口PE转发到两个MDT时，出口PE路由器可以逐个从一个核心树类型迁移到另一个核心树类型。

通常，PE路由将从使用基于PIM的核心树的最旧mVPN部署模式迁移到使用基于mLDP的树的mVPN部署模式。最旧的mVPN实施是配置文件0，它是基于PIM的核心树、无边界网关协议(BGP)自动发现(AD)和重叠信令中的PIM。然而，迁移也可以以相反的方式发生。

让我们来看看此迁移方案，因为这是最常见的迁移：从核心中的GRE（配置文件0）到默认MDT mLDP配置文件。

可能有几种默认mLDP配置文件。

我们来看一下这些产品：

- 没有BGP AD的mLDP
- 具有BGP AD和PIM C信令的mLDP
- 带有BGP AD和BGP C信令的mLDP

在后一种情况下，C信令协议也发生了迁移。

需要记住的一件事是，使用BGP AD时，默认情况下数据MDT由BGP发出信号。如果没有BGP AD，则数据MDT无法通过BGP发出信号。

无论如何，入口PE必须同时配置配置文件0和mLDP配置文件。入口PE将C组播流量转发到两个核心树协议的两个MDT（默认或数据）上。因此，必须在入口PE上配置两个默认MDT。

如果出口PE能够运行核心树协议PIM和mLDP，它可以决定从哪个树提取C组播流量。这可以通过在出口PE上配置反向路径转发(RPF)策略来实现。

如果出口PE路由器仅支持配置文件0，则该PE将仅加入核心中的PIM树，并在基于PIM的树上接收C组播流。


注：如果使用PIM稀疏模式，则必须在基于GRE和基于mLDP的MDT上同时可访问RP-PE和S-PE。

C组播协议迁移

C组播协议可以从PIM迁移到BGP，反之亦然。这是通过将出口PE配置为选择PIM或BGP作为重叠协议来实现的。它是通过PIM或BGP发出加入的出口PE。入口PE可以在迁移场景中接收和处理两者。

下面是在出口PE上配置的C组播协议的迁移示例：

<#root>

```
router pim
  vrf one
   address-family ipv4
    rpf topology route-policy rpf-for-one


   mdt c-multicast-routing bgp


    !
    interface GigabitEthernet0/1/0/0
     enable
    !
   !
  !
 !
```

```
route-policy rpf-for-one
   set core-tree mldp-default
 end-policy
 !
```

BGP作为重叠信令协议启用。默认值为PIM。

场景

查看图1.以查看用于这些场景的设置。

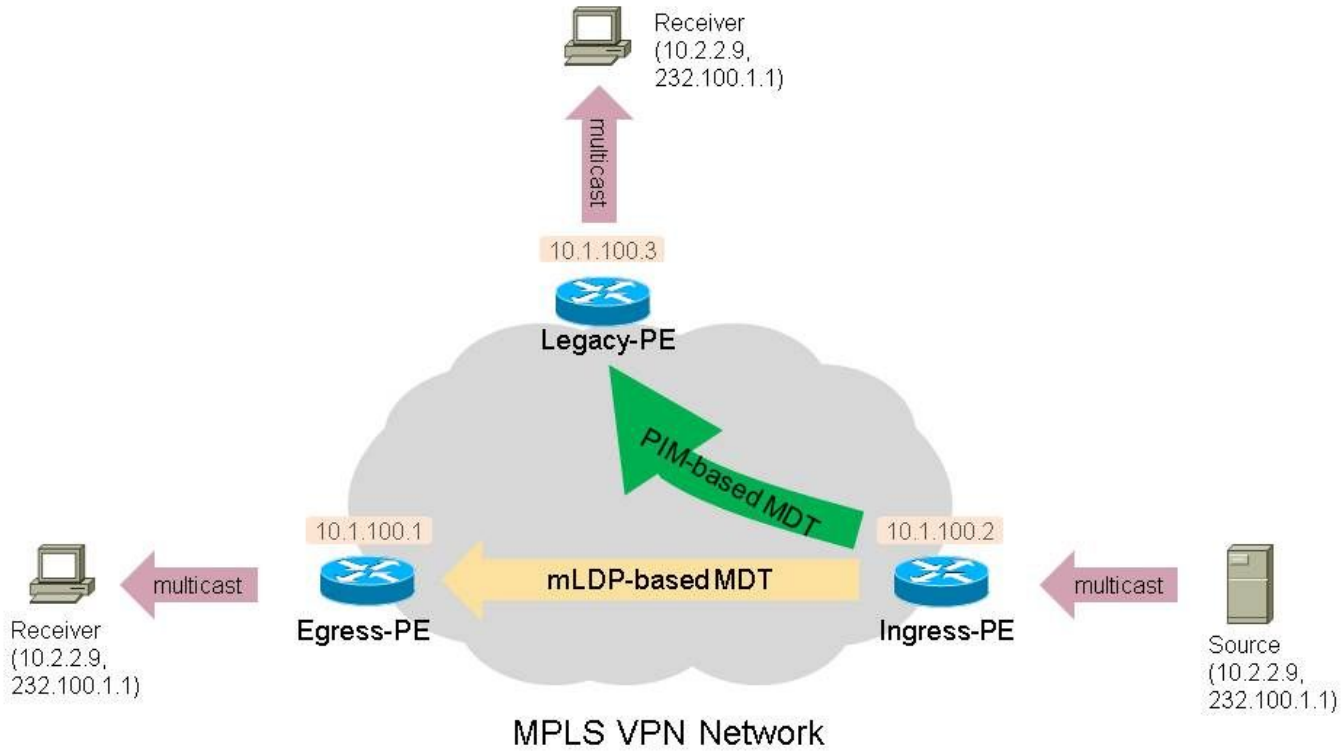

图 1.

在这些情况下，您至少有一个传统PE路由器作为接收器PE路由器。这是只运行配置文件0（默认MDT - GRE - PIM组播信令）的路由器。

此路由器必须配置BGP IPv4 MDT。

至少有一个接收器 — PE路由器运行基于mLDP的配置文件。这些都是默认MDT mLDP配置文件(1、9、13、12、17)、所有分区的MDT mLDP配置文件(2、4、5、14、15)和配置文件7。也支持P2MP TE的配置文件8。

入口PE路由器是双封装路由器：它运行配置文件0和基于mLDP的配置文件。

此入口PE路由器始终必须在基于PIM的MDT和基于mLDP的MDT上转发流量。这些MDT可以是默认MDT和数据MDT。

作为传统路由器，请采用运行IOS的路由器，该路由器只能运行配置文件0。传统路由器的配置如下。

```
vrf definition one
 rd 1:3
 vpn id 1:1
 route-target export 1:1
 route-target import 1:1
 !
 address-family ipv4
  mdt default 232.1.1.1
 exit-address-family
```

需要配置BGP IPv4 MDT:

```
router bgp 1
…
address-family ipv4 mdt
 neighbor 10.1.100.7 activate
 neighbor 10.1.100.7 send-community extended
 exit-address-family
 !
…
```

场景 1.

有一个或多个传统PE路由器作为Receiver-PE路由器。

有一个或多个PE路由器作为运行配置文件1（默认MDT - mLDP MP2MP PIM组播信令）的接收器 — PE路由器。

根本没有BGP AD或BGP C组播信令。

运行配置文件1的Receiver-PE路由器的配置：

<#root>

```
vrf one
  vpn id 1:1
  address-family ipv4 unicast
   import route-target
    1:1
   !
   export route-target
    1:1
   !
  !
```

```
 router pim
  vrf one
   address-family ipv4


rpf topology route-policy rpf-for-one


    !
    interface GigabitEthernet0/1/0/0
     enable
    !
   !
  !
 !

 route-policy rpf-for-one
   set core-tree mldp-default
 end-policy
 !

 multicast-routing
  vrf one
   address-family ipv4
    mdt source Loopback0


mdt default mldp ipv4 10.1.100.7


    mdt data 100
    rate-per-route
    interface all enable
    !
    accounting per-prefix
   !
  !
 !

 mpls ldp
  mldp
   logging notifications
   address-family ipv4
   !
  !
 !

route-policy rpf-for-one


set core-tree mldp-default
```

入口PE路由器的配置：

<#root>

```
vrf one
 vpn id 1:1
 address-family ipv4 unicast
  import route-target
```

```
   1:1
  !
  export route-target
   1:1
  !
 !

router pim
 vrf one
  address-family ipv4
  !
  interface GigabitEthernet0/1/0/0
   enable
  !
 !
!

multicast-routing
 vrf one
 address-family ipv4
  mdt source Loopback0
  interface all enable
  !
  mdt default ipv4 232.1.1.1


  mdt default mldp ipv4 10.1.100.7


  mdt data 255


  mdt data 232.1.2.0/24


  !
 !
!

mpls ldp
 mldp
 logging notifications
 address-family ipv4
 !
 !
!
```

入口PE路由器必须具有BGP地址系列IPv4 MDT，与传统PE路由器相同。

入口PE必须转发到两种类型的MDT:

<#root>

```
Ingress-PE#show mrib vrf one route 232.100.1.1

IP Multicast Routing Information Base
```

```
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(10.2.2.9,232.100.1.1) RPF nbr: 10.2.2.9 Flags: RPF

MT

MT Slot: 0/1/CPU0
Up: 00:56:09
Incoming Interface List
   GigabitEthernet0/1/0/0 Flags: A, Up: 00:56:09
Outgoing Interface List


mdtone

 Flags: F NS MI MT MA, Up: 00:22:59      <<< PIM-based tree


Lmdtone

Flags: F NS LMI MT MA, Up: 00:56:09    <<< mLDP-based tree
```

入口PE应该将接口mdtone上的传统PE和接口Lmdtone上的配置文件1 PE视为PIM邻居：

<#root>

```
Ingress-PE#

show pim vrf one neighbor



PIM neighbors in VRF one
Flag: B - Bidir capable, P - Proxy capable, DR - Designated Router,
     E - ECMP Redirect capable
     * indicates the neighbor created for this router

Neighbor Address             Interface             Uptime   Expires DR pri   Flags


10.1.100.1                   Lmdtone

 6w1d     00:01:29 1     P
10.1.100.2*                  Lmdtone               6w1d     00:01:15 1 (DR) P
10.1.100.2*                  mdtone                 5w0d     00:01:30 1     P

10.1.100.3                   mdtone
```

```
 00:50:20 00:01:30 1 (DR) P
```

入口PE上的“debug pim vrf one mdt data”：

您将看到发送了第1类（PIM核心树）和第2类（mLDP核心树）PIM加入TLV。第一个在mdtone上，第二个在Lmdtone上。

<#root>

```
pim[1140]: [13] MDT Grp lookup: Return match for grp 232.1.2.4 src 10.1.100.2 in local list (-)
pim[1140]: [13] In mdt timers process...
pim[1140]: [13] Processing MDT JOIN SEND timer for MDT null core mldp pointer in one
pim[1140]: [13] In join_send_update_timer: route->mt_head 50c53b44
pim[1140]: [13] Create new MDT tlv buffer for one for type 0x1
pim[1140]: [13] Buffer allocated for one mtu 1348 size 0
pim[1140]: [13] TLV type set to 0x1
pim[1140]: [13] TLV added for one mtu 1348 size 16
pim[1140]: [13] MDT cache upd: pe 0.0.0.0, (10.2.2.9,232.100.1.1),
```

mdt_type 0x1

,

core (10.1.100.2,232.1.2.4)

```
, for vrf one [local, -], mt_lc 0x11, mdt_if 'mdtone', cache NULL
pim[1140]: [13] Looked up cache pe 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x1 in one (found) - No error
pim[1140]: [13] Cache get: Found entry for 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x1 in one
pim[1140]: [13] pim_mvrf_mdt_cache_update:946, mt_lc 0x11, copied mt_mdt_ifname 'mdtone'
pim[1140]: [13] Create new MDT tlv buffer for one for type 0x2
pim[1140]: [13] Buffer allocated for one mtu 1348 size 0
pim[1140]: [13] TLV type set to 0x2, o_type 0x2
pim[1140]: [13] TLV added for one mtu 1348 size 36
pim[1140]: [13] MDT cache upd: pe 0.0.0.0, (10.2.2.9,232.100.1.1),
```

mdt_type 0x2

,

core src 10.1.100.2

,

id [mdt 1:1 1]

```
, for vrf one [local, -], mt_lc 0x11, mdt_if 'Lmdtone', cache NULL
pim[1140]: [13] Looked up cache pe 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x2 in one (found) - No error
pim[1140]: [13] Cache get: Found entry for 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
pim[1140]: [13] pim_mvrf_mdt_cache_update:946, mt_lc 0x11, copied mt_mdt_ifname 'Lmdtone'
pim[1140]: [13] Set next send time for core type (0x0/0x2) (v: 10.2.2.9,232.100.1.1) in one
pim[1140]: [13] 2.
```

Flush MDT Join for one on Lmdtone

```
(10.1.100.2) 6 (Cnt:1, Reached size 36 MTU 1348)
pim[1140]: [13] 2. Flush MDT Join for one (Lo0) 10.1.100.2
pim[1140]: [13] 2.
```

Flush MDT Join for one on mdtone

```
(10.1.100.2) 6 (Cnt:1, Reached size 16 MTU 1348)
```

```
pim[1140]: [13] 2. Flush MDT Join for one (Lo0) 10.1.100.2
```

<#root>

```
Ingress-PE#
```

show pim vrf one mdt cache

```
Core Source     Cust (Source, Group)              Core Data       Expires
10.1.100.2       (10.2.2.9, 232.100.1.1)            232.1.2.4       00:02:36
10.1.100.2       (10.2.2.9, 232.100.1.1)            [mdt 1:1 1]     00:02:36
```

注:PIM加入类型长度值(TLV)是通过默认MDT发送的PIM消息，用于发送数据MDT信号。它定期发送，每分钟一次。

传统出口PE:

"debug ip pim vrf one 232.100.1.1":

```
PIM(1): Receive MDT Packet (55759) from 10.1.100.2 (Tunnel3), length (ip: 44, udp: 24), ttl: 1PIM(1): T
```

传统PE缓存PIM加入TLV:

<#root>

```
Legacy-PE#
```

show ip pim vrf one mdt receive

```
Joined MDT-data [group/mdt number : source] uptime/expires for VRF: one
[232.1.2.4 : 10.1.100.2] 00:01:10/00:02:45
```

传统PE在核心中加入Data MDT:

<#root>

```
Legacy-PE#
```

show ip mroute vrf one 232.100.1.1

```
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
```

```
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report,
       Z - Multicast Tunnel, z - MDT-data group sender,
       Y - Joined MDT-data group, y - Sending to MDT-data group,
       G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
       N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
       Q - Received BGP S-A Route, q - Sent BGP S-A Route,
       V - RD & Vector, v - Vector, p - PIM Joins on route,
       x - VxLAN group
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(10.2.2.9, 232.100.1.1), 00:08:48/00:02:34, flags: sT

Y


 Incoming interface: Tunnel3, RPF nbr 10.1.100.2,

MDT:[10.1.100.2,232.1.2.4]

/00:02:46
 Outgoing interface list:
 GigabitEthernet1/1, Forward/Sparse, 00:08:48/00:02:34
```

配置文件1接收器 — PE也接收PIM加入TLV，但对于基于mLDP的数据MDT:

<#root>

```
Egress-PE#

debug pim vrf one mdt data



pim[1161]: [13] Received MDT Packet on Lmdtone (vrf:one) from 10.1.100.2, len 36
pim[1161]: [13] Processing type 2 tlv
pim[1161]: [13] Received MDT Join TLV from 10.1.100.2 for cust route 10.2.2.9,232.100.1.1
MDT number 1 len 36
pim[1161]: [13] Looked up cache pe 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
(found) - No error
pim[1161]: [13] MDT cache upd: pe 10.1.100.2, (10.2.2.9,232.100.1.1),

mdt_type 0x2

, core

src 10.1.100.2

,

id [mdt 1:1 1]

, for vrf one [remote, -], mt_lc 0xffffffff, mdt_if 'xxx',
cache NULL
pim[1161]: [13] Looked up cache pe 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
(found) - No error
pim[1161]: [13] Cache get: Found entry for 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2
```

```
in one
RP/0/RP1/CPU0:Nov 27 16:04:02.726 : Return match for [mdt 1:1 1] src 10.1.100.2 in remote
list (one)
pim[1161]: [13] Remote join: MDT [mdt 1:1 1] known in one. Refcount (1, 1)
```

<#root>

```
Egress-PE#
```

show pim vrf one mdt cache

```
Core Source     Cust (Source, Group)              Core Data       Expires
10.1.100.2       (10.2.2.9, 232.100.1.1)            [mdt 1:1 1]     00:02:12
```

<#root>

```
Egress-PE#
```

show mrib vrf one route 232.100.1.1

```
IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain,

   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(10.2.2.9,232.100.1.1) RPF nbr: 10.1.100.2 Flags: RPF
Up: 00:45:20
Incoming Interface List
```

Lmdtone

```
 Flags: A LMI, Up: 00:45:20
Outgoing Interface List
   GigabitEthernet0/0/0/9 Flags: F NS LI, Up: 00:45:20
```

场景 2：

有一个或多个传统PE路由器作为接收器 — PE路由器。

有一个或多个PE路由器作为运行配置文件9（默认MDT - mLDP MP2MP BGP-AD PIM组播信令）的接收器 — PE路由器。

涉及BGP AD，但不涉及BGP C组播信令。

运行Profile 9的Receiver-PE路由器的配置：

<#root>

```
vrf one
  vpn id 1:1
  address-family ipv4 unicast
   import route-target
    1:1
   !
   export route-target
    1:1
   !
  !

 router pim
  vrf one
   address-family ipv4
    rpf topology route-policy rpf-for-one
    !
    interface GigabitEthernet0/1/0/0
     enable
    !
   !
  !
 !

 route-policy rpf-for-one
   set core-tree mldp-default
 end-policy
 !

multicast-routing
 vrf one
  address-family ipv4
   mdt source Loopback0
   rate-per-route
   interface all enable
   accounting per-prefix


bgp auto-discovery mldp


   !
   mdt default mldp ipv4 10.1.100.7
!
!
!

router bgp 1
!
```

```
address-family vpnv4 unicast
!
!
 address-family ipv4 mvpn
!
!
neighbor 10.1.100.7     <<< iBGP neighbor
remote-as 1
update-source Loopback0

address-family vpnv4 unicast
!
 address-family ipv4 mvpn
!
!
vrf one
rd 1:1
address-family ipv4 unicast
   redistribute connected
!
 address-family ipv4 mvpn
!
!

 mpls ldp
  mldp
   logging notifications
   address-family ipv4
   !
  !
 !
```

入口PE路由器必须具有BGP地址系列IPv4 MDT，与传统PE路由器相同。入口PE路由器必须具有BGP地址系列IPv4 MVPN，与Profile 9出口PE路由器的功能匹配。

入口PE路由器的配置：

<#root>

```
vrf one
 vpn id 1:1
 address-family ipv4 unicast
  import route-target
   1:1
  !
  export route-target
   1:1
  !
 !
 address-family ipv6 unicast
 !
!
```

```
router pim
 vrf one
 address-family ipv4


mdt c-multicast-routing pim
   announce-pim-join-tlv

   !
   interface GigabitEthernet0/1/0/0
   enable
   !
  !
 !
!

multicast-routing
 vrf one
  address-family ipv4
   mdt source Loopback0
   interface all enable

   bgp auto-discovery mldp


   !

   mdt default ipv4 232.1.1.1



   mdt default mldp ipv4 10.1.100.7



   mdt data 255



   mdt data 232.1.2.0/24


 !
 !
!

router bgp 1
address-family vpnv4 unicast
!

 address-family ipv4 mdt

!

 address-family ipv4 mvpn

!
neighbor 10.1.100.7     <<< iBGP neighbor
remote-as 1
update-source Loopback0
address-family vpnv4 unicast
!

 address-family ipv4 mdt

!
```

```
 address-family ipv4 mvpn
!
!
vrf one
rd 1:2
address-family ipv4 unicast
   redistribute connected
!
 address-family ipv4 mvpn
!

mpls ldp
  mldp
   logging notifications
   address-family ipv4
   !
  !
 !
```

如果没有命令“announce-pim-join-tlv”，如果启用BGP自动发现(AD)，入口PE路由器不会通过默认MDT发送PIM加入TLV消息。如果没有此命令，入口PE路由器仅发送BGP IPv4 mvpn route-type 3更新。配置文件9出口PE路由器会接收BGP更新并将数据MDT消息安装到其缓存中。传统PE路由器不运行BGP AD，因此不会通过BGP获取数据MDT加入消息。

入口PE必须将C组播流量转发到两种类型的MDT:

<#root>

```
Ingress-PE#
show mrib vrf one route 232.100.1.1


IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(10.2.2.9,232.100.1.1) RPF nbr: 10.2.2.9 Flags: RPF MT
MT Slot: 0/1/CPU0
Up: 05:03:56
Incoming Interface List
```

```
   GigabitEthernet0/1/0/0 Flags: A, Up: 05:03:56
Outgoing Interface List
```

mdtone

```
 Flags: F NS MI MT MA, Up: 05:03:56
```

Lmdtone

```
 Flags: F NS LMI MT MA, Up: 05:03:12
```

入口PE应该将接口mdtone上的传统PE和接口Lmdtone上的配置文件9 PE视为PIM邻居：

<#root>

```
Ingress-PE#
```

show pim vrf one neighbor

```
PIM neighbors in VRF one
Flag: B - Bidir capable, P - Proxy capable, DR - Designated Router,
     E - ECMP Redirect capable
     * indicates the neighbor created for this router

Neighbor Address             Interface             Uptime   Expires DR pri   Flags

10.1.100.1
```

Lmdtone

```
               6w1d     00:01:18 1     P
10.1.100.2*                  Lmdtone               6w1d     00:01:34 1 (DR) P
10.1.100.2*                  mdtone                5w0d     00:01:18 1     P
10.1.100.3
```

mdtone

```
                06:00:03 00:01:21 1 (DR)
```

配置文件9出口PE接收数据MDT消息作为地址系列IPv4 MVPN中路由类型3的BGP更新：

<#root>

```
Egress-PE#
```

show bgp ipv4 mvpn vrf one

```
BGP router identifier 10.1.100.1, local AS number 1
BGP generic scan interval 60 secs
BGP table state: Active
Table ID: 0x0   RD version: 1367879340
BGP main routing table version 92
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 (default for vrf one)
*> [1][10.1.100.1]/40 0.0.0.0                                0 i
*>i[1][10.1.100.2]/40 10.1.100.2                   100     0 i
```

***>i[3][32][10.2.2.9][32][232.100.1.1][10.1.100.2]/120**

```
                      10.1.100.2                   100     0 i

Processed 3 prefixes, 3 paths
```

<#root>

```
Egress-PE#
```

show bgp ipv4 mvpn vrf one [3][32][10.2.2.9][32][232.100.1.1][10.1.100.2]/120

```
BGP routing table entry for [3][32][10.2.2.9][32][232.100.1.1][10.1.100.2]/120, Route
Distinguisher: 1:1
Versions:
Process           bRIB/RIB SendTblVer
Speaker                92         92
Last Modified: Nov 27 20:25:32.474 for 00:44:22
Paths: (1 available, best #1, not advertised to EBGP peer)
Not advertised to any peer
Path #1: Received by speaker 0
Not advertised to any peer
Local
   10.1.100.2 (metric 12) from 10.1.100.7 (10.1.100.2)
     Origin IGP, localpref 100, valid, internal, best, group-best, import-candidate,
imported
     Received Path ID 0, Local Path ID 1, version 92
     Community: no-export
     Extended community: RT:1:1
     Originator: 10.1.100.2, Cluster list: 10.1.100.7
     PMSI: flags 0x00,
```

type 2

```
, label 0, ID
0x060001040a016402000e02000b0000010000000100000001
     Source VRF: default, Source Route Distinguisher: 1:2
```

此BGP路由是协议隧道类型2的路由类型3，即mLDP P2MP LSP（在P2MP mLSP LSP上构建的数据MDT）。由于未为PIM启用BGP AD，因此任何PIM树都没有BGP路由类型3条目。

入口PE上的“debug pim vrf one mdt data”：

<#root>

```
pim[1140]: [13] In mdt timers process...
pim[1140]: [13] Processing MDT JOIN SEND timer for MDT null core mldp pointer in one
```

```
pim[1140]: [13] In join_send_update_timer: route->mt_head 50c53b44
pim[1140]: [13] Create new MDT tlv buffer for one for type 0x1
pim[1140]: [13] Buffer allocated for one mtu 1348 size 0
pim[1140]: [13] TLV type set to 0x1
pim[1140]: [13] TLV added for one mtu 1348 size 16
pim[1140]: [13] MDT cache upd: pe 0.0.0.0, (10.2.2.9,232.100.1.1),
```

mdt_type 0x1

```
, core
(10.1.100.2,232.1.2.5), for vrf one [local, -], mt_lc 0x11, mdt_if '
```

mdtone

```
', cache NULL
pim[1140]: [13] Looked up cache pe 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x1 in one
(found) - No error
pim[1140]: [13] Cache get: Found entry for 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x1 in
one
pim[1140]: [13] pim_mvrf_mdt_cache_update:946, mt_lc 0x11, copied mt_mdt_ifname 'mdtone'
pim[1140]: [13] Create new MDT tlv buffer for one for type 0x2
pim[1140]: [13] Buffer allocated for one mtu 1348 size 0
pim[1140]: [13] TLV type set to 0x2, o_type 0x2
pim[1140]: [13] TLV added for one mtu 1348 size 36
pim[1140]: [13] MDT cache upd: pe 0.0.0.0, (10.2.2.9,232.100.1.1),
```

mdt_type 0x2

```
, core src
10.1.100.2, id [mdt 1:1 1], for vrf one [local, -], mt_lc 0x11, mdt_if '
```

Lmdtone

```
', cache
NULL
: pim[1140]: [13] Looked up cache pe 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
(found) - No error
pim[1140]: [13] Cache get: Found entry for 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x2 in
one
pim[1140]: [13] pim_mvrf_mdt_cache_update:946, mt_lc 0x11, copied mt_mdt_ifname 'Lmdtone'
pim[1140]: [13] Set next send time for core type (0x0/0x2) (v: 10.2.2.9,232.100.1.1) in
one
pim[1140]: [13] 2. Flush MDT Join for one on Lmdtone(10.1.100.2) 6 (Cnt:1, Reached size



36 MTU 1348)



pim[1140]: [13] 2. Flush MDT Join for one (Lo0) 10.1.100.2
pim[1140]: [13] 2. Flush MDT Join for one on mdtone(10.1.100.2) 6 (Cnt:1, Reached size 16
MTU 1348)



pim[1140]: [13] 2. Flush MDT Join for one (Lo0) 10.1.100.2
```

入口PE为基于PIM和基于mLDP的数据MDT发送PIM加入TLV。

在传统PE上：

"debug ip pim vrf one 232.100.1.1":

```
PIM(1): Receive MDT Packet (56333) from 10.1.100.2 (Tunnel3), length (ip: 44, udp: 24), ttl: 1
PIM(1): TLV type: 1 length: 16 MDT Packet length: 16
```

传统PE接收并缓存PIM加入TLV:

<#root>

Legacy-PE#

show ip pim vrf one mdt receive

```
Joined MDT-data [group/mdt number : source] uptime/expires for VRF: one
[232.1.2.5 : 10.1.100.2] 00:23:30/00:02:33
```

传统PE在核心中加入Data MDT:

<#root>

Legacy-PE#

show ip mroute vrf one 232.100.1.1

```
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report,
       Z - Multicast Tunnel, z - MDT-data group sender,
       Y - Joined MDT-data group, y - Sending to MDT-data group,
       G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
       N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
       Q - Received BGP S-A Route, q - Sent BGP S-A Route,
       V - RD & Vector, v - Vector, p - PIM Joins on route,
       x - VxLAN group
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(10.2.2.9, 232.100.1.1), 05:13:35/00:03:02, flags: sT
```

Y

```
Incoming interface: Tunnel3, RPF nbr 10.1.100.2,
```

MDT:[10.1.100.2,232.1.2.5]

```
/00:02:37
Outgoing interface list:
```

```
   GigabitEthernet1/1, Forward/Sparse, 05:13:35/00:03:02
```

Profile 9 Receiver-PE。

配置文件9出口PE上的“debug pim vrf one mdt data”：

<#root>

```
pim[1161]: [13] Received MDT Packet on Lmdtone (vrf:one) from 10.1.100.2, len 36
pim[1161]: [13] Processing type 2 tlv
pim[1161]: [13] Received MDT Join TLV from 10.1.100.2 for cust route 10.2.2.9,232.100.1.1
MDT number 1 len 36
pim[1161]: [13] Looked up cache pe 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
(found) - No error
pim[1161]: [13] MDT cache upd: pe 10.1.100.2, (10.2.2.9,232.100.1.1),
```

mdt_type 0x2

```
, core
src 10.1.100.2, id [mdt 1:1 1], for vrf one [remote, -], mt_lc 0xffffffff, mdt_if 'xxx',
cache NULL
pim[1161]: [13] Looked up cache pe 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
(found) - No error
pim[1161]: [13] Cache get: Found entry for 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2
in one
pim[1161]: [13] MDT lookup: Return match for [mdt 1:1 1] src 10.1.100.2 in remote list
(one)
pim[1161]: [13] Remote join: MDT [mdt 1:1 1] known in one. Refcount (1, 1)
```

配置文件9接收器 — PE接收并缓存PIM加入TLV。由于从入口PE接收路由类型3的BGP更新消息，配置文件9接收器PE也获知了数据MDT。PIM加入TLV和BGP更新消息route-type是等效的，并且包含有关数据MDT的核心树隧道的相同信息。

<#root>

```
Egress-PE#
```

show pim vrf one mdt cache

```
Core Source     Cust (Source, Group)              Core Data       Expires
10.1.100.2       (10.2.2.9, 232.100.1.1)            [mdt 1:1 1]     00:02:35
```

<#root>

```
Egress-PE#
```

show mrib vrf one route 232.100.1.1

```
IP Multicast Routing Information Base
```

```
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(10.2.2.9,232.100.1.1) RPF nbr: 10.1.100.2 Flags: RPF
Up: 05:10:22
Incoming Interface List
   Lmdtone Flags: A LMI, Up: 05:10:22
Outgoing Interface List
   GigabitEthernet0/0/0/9 Flags: F NS LI, Up: 05:10:22
```

场景 3：

有一个或多个传统PE路由器作为Receiver-PE路由器。
有一个或多个PE路由器作为运行配置文件13的接收器 — PE路由器（默认MDT - mLDP MP2MP BGP-AD BGP C-mcast信令）。
存在涉及BGP AD和BGP C组播信令。

运行配置文件13的Receiver-PE路由器的配置：

<#root>

```
vrf one
 vpn id 1:1
 address-family ipv4 unicast
  import route-target
   1:1
  !
  export route-target
   1:1
  !
 !

router pim
 vrf one
  address-family ipv4
   rpf topology route-policy rpf-for-one
```

mdt c-multicast-routing bgp

```
   !
   interface GigabitEthernet0/1/0/0
    enable
   !
  !
 !
!

route-policy rpf-for-one
  set core-tree mldp-default
end-policy
!

multicast-routing
 vrf one
  address-family ipv4
   mdt source Loopback0
   rate-per-route
   interface all enable
   accounting per-prefix


bgp auto-discovery mldp


   !


mdt default mldp ipv4 10.1.100.7


  !
 !
!

router bgp 1
!
 address-family vpnv4 unicast
 !
!
address-family ipv4 mvpn


 !
!
 neighbor 10.1.100.7     <<< iBGP neighbor
  remote-as 1
  update-source Loopback0
  !
  address-family vpnv4 unicast
  !


address-family ipv4 mvpn


  !
 !
vrf one
  rd 1:1
  address-family ipv4 unicast
   redistribute connected
  !
```

```
address-family ipv4 mvpn


  !
 !

mpls ldp
 mldp
  logging notifications
  address-family ipv4
  !
 !
!
```

入口PE路由器的配置：

<#root>

```
vrf one
 vpn id 1:1
 address-family ipv4 unicast
  import route-target
   1:1
  !
  export route-target
   1:1
  !
 !
 address-family ipv6 unicast
 !
!

router pim
 vrf one
  address-family ipv4
   mdt c-multicast-routing bgp


    announce-pim-join-tlv


   !
   interface GigabitEthernet0/1/0/0
    enable
   !
  !
 !
!

multicast-routing
 vrf one
  address-family ipv4
   mdt source Loopback0
   interface all enable
   mdt default ipv4 232.1.1.1
```

```
   mdt default mldp ipv4 10.1.100.7


   mdt data 255


   mdt data 232.1.2.0/24


  !
 !
!

router bgp 1
 address-family vpnv4 unicast
 !
 address-family ipv4 mdt


 !
 address-family ipv4 mvpn


 !
 neighbor 10.1.100.7      <<< iBGP neighbor
  remote-as 1
  update-source Loopback0
  address-family vpnv4 unicast
  !
  address-family ipv4 mdt


  !
  address-family ipv4 mvpn


  !
 !
 vrf one
  rd 1:2
  address-family ipv4 unicast
   redistribute connected
  !
  address-family ipv4 mvpn


  !

mpls ldp
 mldp
  logging notifications
  address-family ipv4
  !
 !
!
```

如果没有命令announce-pim-join-tlv，如果启用BGP AD，入口PE路由器不会通过默认MDT发送PIM加入TLV消息。如果没有此命令，入口PE路由器仅发送BGP IPv4 mvpn route-type 3更新。配置文件13出口PE路由器会接收BGP更新并将数据MDT消息安装到其缓存中。传统PE路由器不运行BGP AD，因此不会通过BGP获取数据MDT加入消息。

入口PE必须转发到两种类型的MDT:

<#root>

```
Ingress-PE#
```

show mrib vrf one route 232.100.1.1

```
IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(10.2.2.9,232.100.1.1) RPF nbr: 10.2.2.9 Flags: RPF MT
MT Slot: 0/1/CPU0
Up: 19:49:27
Incoming Interface List
   GigabitEthernet0/1/0/0 Flags: A, Up: 19:49:27
Outgoing Interface List
```

mdtone

```
 Flags: F MI MT MA, Up: 19:49:27
```

Lmdtone

```
 Flags: F LMI MT MA, Up: 01:10:15
```

入口PE应将接口模块上的传统PE视为PIM邻居。但是，接口Lmdtone上的配置文件13 PE不是PIM邻居的必备条件，因为BGP现在用作C组播信令协议。

入口PE上的“debug pim vrf one mdt data”：

<#root>

```
pim[1140]: [13] In mdt timers process...
pim[1140]: [13] Processing MDT JOIN SEND timer for MDT null core mldp pointer in one
pim[1140]: [13] In join_send_update_timer: route->mt_head 50c53b44
pim[1140]: [13] Create new MDT tlv buffer for one for type 0x1
pim[1140]: [13] Buffer allocated for one mtu 1348 size 0
pim[1140]: [13] TLV type set to 0x1
pim[1140]: [13] TLV added for one mtu 1348 size 16
pim[1140]: [13] MDT cache upd: pe 0.0.0.0, (10.2.2.9,232.100.1.1),
```

mdt_type 0x1

,

core (10.1.100.2,232.1.2.5)

```
, for vrf one [local, -], mt_lc 0x11, mdt_if 'mdtone', cache NULL
pim[1140]: [13] Looked up cache pe 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x1 in one (found) - No error
pim[1140]: [13] Cache get: Found entry for 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x1 in one
pim[1140]: [13] pim_mvrf_mdt_cache_update:946, mt_lc 0x11, copied mt_mdt_ifname 'mdtone'
pim[1140]: [13] Create new MDT tlv buffer for one for type 0x2
pim[1140]: [13] Buffer allocated for one mtu 1348 size 0
pim[1140]: [13] TLV type set to 0x2, o_type 0x2
pim[1140]: [13] TLV added for one mtu 1348 size 36
pim[1140]: [13] MDT cache upd: pe 0.0.0.0, (10.2.2.9,232.100.1.1),
```

mdt_type 0x2

,

core src 10.1.100.2

,

id [mdt 1:1 1]

```
, for vrf one [local, -], mt_lc 0x11, mdt_if 'Lmdtone', cache NULL
pim[1140]: [13] Looked up cache pe 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x2 in one (found) - No error
pim[1140]: [13] Cache get: Found entry for 0.0.0.0(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
pim[1140]: [13] pim_mvrf_mdt_cache_update:946, mt_lc 0x11, copied mt_mdt_ifname 'Lmdtone'
pim[1140]: [13] Set next send time for core type (0x0/0x2) (v: 10.2.2.9,232.100.1.1) in one
pim[1140]: [13] 2.
```

Flush MDT Join for one on Lmdtone

```
(10.1.100.2) 6 (Cnt:1, Reached size 36 MTU 1348)
pim[1140]: [13] 2. Flush MDT Join for one (Lo0) 10.1.100.2
pim[1140]: [13] 2.
```

Flush MDT Join for one on mdtone

```
(10.1.100.2) 6 (Cnt:1, Reached size 16 MTU 1348)
pim[1140]: [13] 2. Flush MDT Join for one (Lo0) 10.1.100.2
pim[1140]: [13] MDT Grp lookup: Return match for grp 232.1.2.5 src 10.1.100.2 in local list (-)
```

入口PE为基于PIM和基于mLDP的数据MDT发送PIM加入TLV。

传统PE上的“debug ip pim vrf one 232.100.1.1”：

```
PIM(1): Receive MDT Packet (57957) from 10.1.100.2 (Tunnel3), length (ip: 44, udp: 24), ttl: 1
PIM(1): TLV type: 1 length: 16 MDT Packet length: 16
```

传统PE缓存PIM加入TLV:

<#root>

```
Legacy-PE#
```

show ip pim vrf one mdt receive

```
Joined MDT-data [group/mdt number : source]  uptime/expires for VRF: one
 [232.1.2.5 : 10.1.100.2]  00:03:36/00:02:24
```

传统PE在核心中加入Data MDT:

<#root>

```
Legacy-PE#
```

show ip mroute vrf one 232.100.1.1

```
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report,
       Z - Multicast Tunnel, z - MDT-data group sender,
       Y - Joined MDT-data group, y - Sending to MDT-data group,
       G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
       N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
       Q - Received BGP S-A Route, q - Sent BGP S-A Route,
       V - RD & Vector, v - Vector, p - PIM Joins on route,
       x - VxLAN group
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(10.2.2.9, 232.100.1.1), 18:53:53/00:02:50, flags: sT
```

Y

```
  Incoming interface: Tunnel3, RPF nbr 10.1.100.2,
```

MDT:[10.1.100.2,232.1.2.5]

```
/00:02:02
  Outgoing interface list:
    GigabitEthernet1/1, Forward/Sparse, 18:53:53/00:02:50
```

配置文件13 Receiver-PE:
配置文件13出口PE上的“debug pim vrf one mdt data”：

<#root>

```
pim[1161]: [13] Received MDT Packet on Lmdtone (vrf:one) from 10.1.100.2, len 36
pim[1161]: [13] Processing type 2 tlv
pim[1161]: [13] Received MDT Join TLV from 10.1.100.2 for cust route 10.2.2.9,232.100.1.1 MDT number 1
pim[1161]: [13] Looked up cache pe 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2 in one (found) - No er
pim[1161]: [13] MDT cache upd: pe 10.1.100.2, (10.2.2.9,232.100.1.1),
```

mdt_type 0x2

,

core src 10.1.100.2

,

id [mdt 1:1 1]

```
, for vrf one [remote, -], mt_lc 0xffffffff, mdt_if 'xxx', cache NULL
pim[1161]: [13] Looked up cache pe 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2 in one (found) - No er
pim[1161]: [13] Cache get: Found entry for 10.1.100.2(10.2.2.9,232.100.1.1) mdt_type 0x2 in one
pim[1161]: [13] MDT lookup: Return match for [mdt 1:1 1] src 10.1.100.2 in remote list (one)
pim[1161]: [13] Remote join: MDT [mdt 1:1 1] known in one. Refcount (1, 1)
```

<#root>

```
RP/0/RP1/CPU0:Legacy-PE#
```

show pim vrf one mdt cache

```
Core Source      Cust (Source, Group)              Core Data        Expires
10.1.100.2       (10.2.2.9, 232.100.1.1)           [mdt 1:1 1]      00:02:21
```

配置文件13接收器 — PE接收并缓存基于mLDP的MDT的PIM加入TLV。由于从入口PE接收路由类型3的BGP更新消息，配置文件13接收器PE也获知了数据MDT。PIM加入TLV和BGP更新消息route-type是等效的，并且包含有关数据MDT的核心树隧道的相同信息。

<#root>

```
Ingress-PE#
```

show bgp ipv4 mvpn vrf one

```
BGP router identifier 10.1.100.1, local AS number 1
BGP generic scan interval 60 secs
BGP table state: Active
Table ID: 0x0   RD version: 1367879340
BGP main routing table version 93
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 (default for vrf one)
*> [1][10.1.100.1]/40 0.0.0.0                                  0 i
*>i[1][10.1.100.2]/40 10.1.100.2                    100        0 i
```

***>i[3][32][10.2.2.9][32][232.100.1.1][10.1.100.2]/120**

```
                      10.1.100.2                    100        0 i
*> [7][1:2][1][32][10.2.2.9][32][232.100.1.1]/184
                      0.0.0.0                                  0 i

Processed 4 prefixes, 4 paths
```

<#root>

```
Egress-PE#
```

show bgp ipv4 mvpn vrf one [3][32][10.2.2.9][32][232.100.1.1][10.1.100.2]/120

```
BGP routing table entry for [3][32][10.2.2.9][32][232.100.1.1][10.1.100.2]/120, Route Distinguisher: 1:1
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                92          92
Paths: (1 available, best #1, not advertised to EBGP peer)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  Local
    10.1.100.2 (metric 12) from 10.1.100.7 (10.1.100.2)
      Origin IGP, localpref 100, valid, internal, best, group-best, import-candidate, imported
      Received Path ID 0, Local Path ID 1, version 92
      Community: no-export
      Extended community: RT:1:1
      Originator: 10.1.100.2, Cluster list: 10.1.100.7
      PMSI: flags 0x00,
```

type 2

```
, label 0, ID 0x060001040a016402000e02000b0000010000000100000001
      Source VRF: default, Source Route Distinguisher: 1:2
```

此BGP路由是协议隧道类型2的路由类型3，即mLDP P2MP LSP（在P2MP mLSP LSP上构建的数据MDT）。任何PIM树都没有BGP路由类型3，因为未为PIM启用BGP AD。

还有一个路由类型7，因为配置文件13出口PE和入口PE之间启用了C组播信令。路由类型7 BGP更新从配置文件13出口PE发送到入口PE。

场景 4.

在此场景中，VPN情景中存在PIM稀疏模式。

有一个或多个传统PE路由器作为源PE路由器。

有一个或多个PE路由器作为运行配置文件13的接收器 — PE路由器（默认MDT - mLDP MP2MP BGP-AD BGP C-mcast信令）。存在涉及BGP AD和BGP C组播信令。由于这些PE路由器需要能够直接从源PE（传统PE路由器）接收流量，因此它们还需要运行配置文件0。

RP-PE是运行配置文件13（默认MDT - mLDP MP2MP BGP-AD BGP C-mcast信令）的PE路由器。存在涉及BGP AD和BGP C组播信令。由于RP-PE路由器需要能够直接从源PE（传统PE路由器）接收流量，因此它们还需要运行配置文件0。

组播路由在场景3中有效，但可能仅适用于源特定组播(SSM)。如果C信令为稀疏模式，则组播可能会失败。这取决于伦德斯视频点(RP)的位置。如果重叠中的信令只有(S， G)，则组播路由将如场景3中一样工作。如果RP位于接收方站点，则会发生这种情况。如果RP位于接收方的站点，则接收方PE不会通过PIM或BGP在重叠中发送(*, G)加入。但是，如果RP位于源PE或其他PE，则重叠中会有(*, G)和(S， G)信令。如果按照场景3中的配置完成此操作，则组播路由可能会失败。

请看图2。它显示了一个具有源PE（传统PE）、RP-PE(PE2)和接收器PE(PE1)的网络。

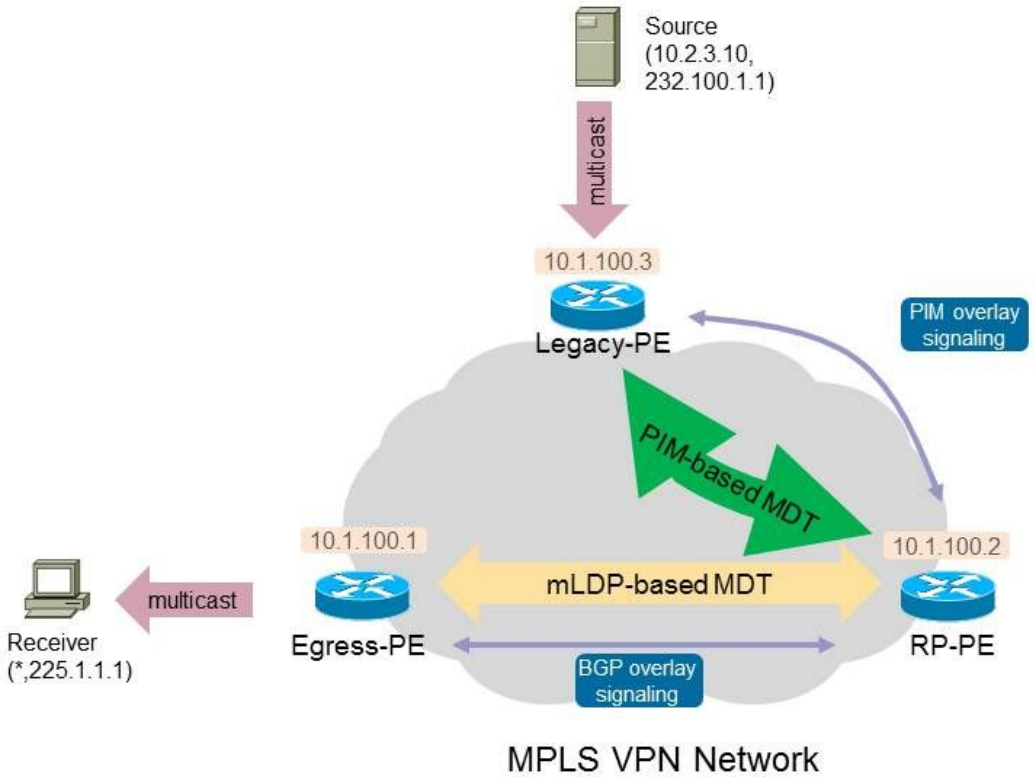

图 2.

出口PE路由器需要发出(*,G)的联合。它们将使用的协议取决于配置。出口PE将使用BGP，传统源PE路由器也将使用PIM（如果它也有接收器）。因此共享树将发出良好的信号。当源开始发送时将出现问题：不会发出源树信号。

问题

一旦源开始发送，RP将接收来自PIM第一跳路由器(FHR)的注册数据包。此处可能是Legacy-Source-PE路由器。然后，RP-PE需要向Legacy-Source-PE发送PIM(S，G)加入，因为Legacy-Source-PE不会将BGP作为重叠信令协议运行。但是，RP-PE将BGP配置为重叠信令协议。因此，旧版源PE永远不会收到来自RP-PE的PIM(S， G)加入消息，因此从源到RP的源树无法发信号。

安装程序处于注册阶段。Legacy-Source-PE上的传出接口列表(OIL)为空：

<#root>

```
Legacy-PE#
```

show ip mroute vrf one 225.1.1.1

```
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set,
```

F - Register flag

```
,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report,
       Z - Multicast Tunnel, z - MDT-data group sender,
       Y - Joined MDT-data group, y - Sending to MDT-data group,
       G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
       N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
       Q - Received BGP S-A Route, q - Sent BGP S-A Route,
       V - RD & Vector, v - Vector, p - PIM Joins on route,
       x - VxLAN group
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 225.1.1.1), 00:05:47/stopped, RP 10.2.100.9, flags: SPF
Incoming interface: Tunnel3, RPF nbr 10.1.100.2
Outgoing interface list: Null

(10.2.3.10, 225.1.1.1), 00:05:47/00:02:42, flags: P
```

F

```
T
Incoming interface: GigabitEthernet1/1, RPF nbr 10.2.3.10
```

Outgoing interface list: Null

要解决此问题，您需要让RP-PE将(S， G)的PIM加入发送到旧版源PE，而RP-PE仍启用了BGP作为非旧版路由器的重叠信令协议。如果源在非传统路由器的后面联机，则RP-PE需要向该非传统路由器发送路由类型7 BGP更新消息。

RP-PE可以同时使用PIM和BGP作为重叠信令。路由策略将决定选择哪一个。您需要在VRF的路由器PIM下使用migration命令。对于图2所示的网络，这是RP-PE上所需的配置：

<#root>

```
router pim
 vrf one
 address-family ipv4
```

rpf topology route-policy rpf-for-one

```
   mdt c-multicast-routing bgp


migration route-policy PIM-to-BGP

    announce-pim-join-tlv
   !
   interface GigabitEthernet0/1/0/0
    enable
   !
  !
 !
!
route-policy rpf-for-one

 if next-hop in (10.1.100.3/32) then
   set core-tree pim-default

else
   set core-tree mldp-default
endif
end-policy
!

route-policy PIM-to-BGP

 if next-hop in (10.1.100.3/32) then
   set c-multicast-routing pim

 else
   set c-multicast-routing bgp
 endif
end-policy
!

multicast-routing
 vrf one
  address-family ipv4
   mdt source Loopback0
   rate-per-route
   interface all enable
   accounting per-prefix
   bgp auto-discovery mldp
   !

   mdt default ipv4 232.1.1.1
   mdt default mldp ipv4 10.1.100.7

  !
 !
!
```

路由策略PIM到BGP指定如果远程PE路由器是10.1.100.3(Legacy-Source-PE)，则使用PIM作为重叠信令协议。否则（对于非传统PE路由器），BGP用作重叠信令协议。因此，RP-PE现在在基于PIM的默认MDT上向旧源PE发送PIM(S， G)加入。Legacy-Source-PE现在具有(S， G)条目：

<#root>

```
Legacy-PE#
```

show ip mroute vrf one 225.1.1.1

```
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report,
       Z - Multicast Tunnel, z - MDT-data group sender,
       Y - Joined MDT-data group, y - Sending to MDT-data group,
       G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
     N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
       Q - Received BGP S-A Route, q - Sent BGP S-A Route,
       V - RD & Vector, v - Vector, p - PIM Joins on route,
       x - VxLAN group
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 225.1.1.1), 00:11:56/stopped, RP 10.2.100.9, flags: SPF
 Incoming interface: Tunnel3, RPF nbr 10.1.100.2
 Outgoing interface list: Null

(10.2.3.10, 225.1.1.1), 00:11:56/00:03:22, flags: FT
 Incoming interface: GigabitEthernet1/1, RPF nbr 10.2.3.10
 Outgoing interface list:
```

Tunnel3

```
, Forward/Sparse, 00:00:11/00:03:18
```

如果RP-PE U-turn数据包，接收方可以接收组播数据包：它将从MDT接收的组播数据包转发到Lmdt树上。

注：检查RP-PE路由器是否支持该平台和软件上的PE周转功能。

<#root>

RP/0/3/CPU1:PE2#

show mrib vrf one route 225.1.1.1

```
IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
```

```
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(*,225.1.1.1) RPF nbr: 10.2.2.9 Flags: C RPF
 Up: 00:53:59
 Incoming Interface List
   GigabitEthernet0/1/0/0 Flags: A, Up: 00:53:59
 Outgoing Interface List
   Lmdtone Flags: F LMI, Up: 00:53:59

(10.2.3.10,225.1.1.1) RPF nbr: 10.1.100.3 Flags: RPF
 Up: 00:03:00
 Incoming Interface List
```

mdtone

```
 Flags: A MI, Up: 00:03:00
 Outgoing Interface List
```

Lmdtone

```
 Flags: F NS LMI, Up: 00:03:00
```

无论最后一跳路由器(LHR)是否配置了SPT切换，组播流量都会继续通过共享树转发到RP-PE。查看图3.以查看组播流量的转发方式。

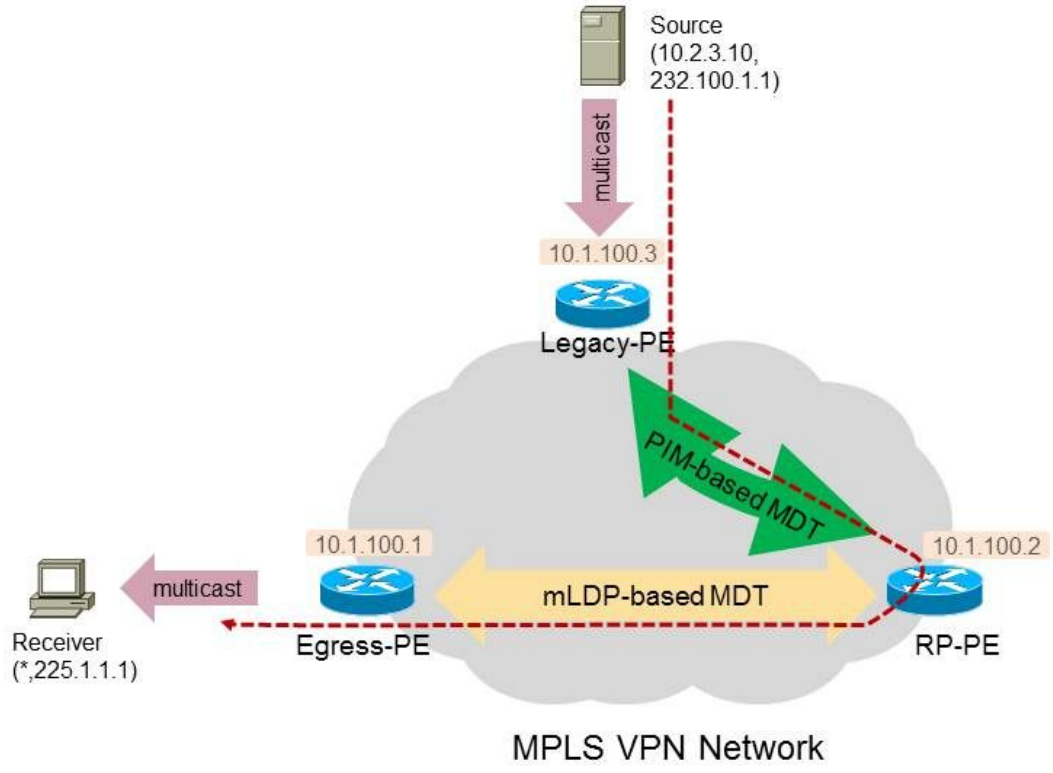

图 3.

出口PE没有(S， G)条目：

<#root>

RP/0/RP1/CPU0:PE1#

show mrib vrf one route 225.1.1.1

```
IP Multicast Routing Information Bas
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,   IF - Inherit From, D - Drop, ME - M
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(*,225.1.1.1) RPF nbr: 10.1.100.2 Flags: C RPF
 Up: 04:35:36
 Incoming Interface List
   Lmdtone Flags: A LMI, Up: 03:00:24
 Outgoing Interface List
   GigabitEthernet0/0/0/9 Flags: F NS, Up: 04:35:36
```

如果Egress-PE是LHR，则它没有(S， G)条目。出口PE无法切换到(S， G)条目的原因是它没有收到来自PE路由器的BGP源活动路由。组播流量会如图3所示进行转发。

但是，Egress-PE可能不是LHR，但Egress-PE站点的CE路由器是LHR。如果CE路由器切换到源树，则出口PE将收到PIM(S， G)加入并安装(S， G)条目。

<#root>

RP/0/RP1/CPU0:PE1#

show mrib vrf one route 225.1.1.1

```
IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
```

```
   IRMI - IR MDT Interface


(*,225.1.1.1) RPF nbr: 10.1.100.2 Flags: C RPF
 Up: 00:04:51
 Incoming Interface List
   Lmdtone Flags: A LMI, Up: 00:04:51
 Outgoing Interface List
   GigabitEthernet0/0/0/9 Flags: F NS, Up: 00:04:51

(10.2.3.10,225.1.1.1)
```

RPF nbr: 10.1.100.3

```
 Flags: RPF
 Up: 00:00:27
 Incoming Interface List
   Lmdtone Flags: A LMI, Up: 00:00:27
 Outgoing Interface List
   GigabitEthernet0/0/0/9 Flags: F NS, Up: 00:00:27
```

但是，Egress-PE现在将RPF连接到源，并查找路由器旧版源PE作为RPF邻居：

<#root>

RP/0/RP1/CPU0:PE1#

show pim vrf one rpf 10.2.3.10

```
Table: IPv4-Unicast-default
* 10.2.3.10/32 [200/0]
   via Lmdtone with
```

rpf neighbor 10.1.100.3

```
   Connector: 1:3:10.1.100.3, Nexthop: 10.1.100.3
```

由于出口PE和传统Source PE之间没有MDT，因此，出口PE无法向传统Source PE发送加入。请记住，出口PE仅构建mLDP树并执行BGP客户信令。请记住，Legacy-Source-PE仅构建基于PIM的树，并且仅构建PIM客户信令。

但是，由于出口PE具有指向传入接口Lmdt的RPF信息，并且组播流量仍然从RP-PE到达该MDT，因此组播流量将转发到接收方，不会导致RPF失败。原因是RPF不执行严格RPF检查以检查组播流量是否实际从RPF邻居10.1.100.3（传统PE路由器）到达。请注意，Lmdt上的PE1上没有10.1.100.3的PIM邻接关系，因为传统PE不能有Lmdt，因为它仅将PIM作为核心树协议（配置文件0）运行：

<#root>

RP/0/RP1/CPU0:PE1#

show pim vrf one neighbor

```
PIM neighbors in VRF one
Flag: B - Bidir capable, P - Proxy capable, DR - Designated Router,
     E - ECMP Redirect capable
     * indicates the neighbor created for this router

Neighbor Address             Interface             Uptime   Expires DR pri   Flags

10.1.100.1*                  Lmdtone               01:32:46 00:01:32 100 (DR) P
10.1.100.2                   Lmdtone               01:30:46 00:01:16 1     P
10.1.100.4                   Lmdtone               01:30:38 00:01:24 1     P
10.1.100.1*                  mdtone                 01:32:46 00:01:34 100 (DR) P
10.1.100.2                   mdtone                 01:32:45 00:01:29 1     P
10.1.100.3                   mdtone                 01:32:17 00:01:29 1     P
10.1.100.4                   mdtone                 01:32:43 00:01:20 1     P
10.2.1.1*                    GigabitEthernet0/0/0/9 01:32:46 00:01:18 100     B P E
10.2.1.8                     GigabitEthernet0/0/0/9 01:32:39 00:01:16 100 (DR)
```

PE1选择Lmdt作为传入接口的原因是，这是从PE1上的RPF topology命令接收的信息：

```
route-policy rpf-for-one
 set core-tree mldp-default
end-policy
!
```

如果PE1上的RPF仍然正常，则组播流量可以到达PE1后面的接收器。但是，流量不采用到核心中PE1的最短路径Legacy-PE。

解决方案

要解决此问题，必须将出口PE(PE1)配置为将基于PIM的MDT和BGP也配置为重叠信令。这种情况下，出口PE上需要此配置：

<#root>

```
router pim
 vrf one
  address-family ipv4
   rpf topology route-policy rpf-for-one
   mdt c-multicast-routing bgp
    migration route-policy PIM-to-BGP
    announce-pim-join-tlv
   !
   rp-address 10.2.100.9 override
   !
   interface GigabitEthernet0/0/0/9
    enable
   !
  !
 !
!
```

```
route-policy rpf-for-one
 if next-hop in (10.1.100.3/32) then
    set core-tree pim-default


 else
   set core-tree mldp-default
 endif
end-policy
!

route-policy PIM-to-BGP
 if next-hop in (10.1.100.3/32) then
   set c-multicast-routing pim
 else
   set c-multicast-routing bgp
 endif
end-policy
!

multicast-routing
 vrf one
 address-family ipv4
   mdt source Loopback0
   rate-per-route
   interface all enable
   accounting per-prefix
   bgp auto-discovery mldp
   !


mdt default ipv4 232.1.1.1
   mdt default mldp ipv4 10.1.100.7
  !
 !
!
```

请看图4。现在，传统PE和出口PE之间有一个基于PIM的MDT。

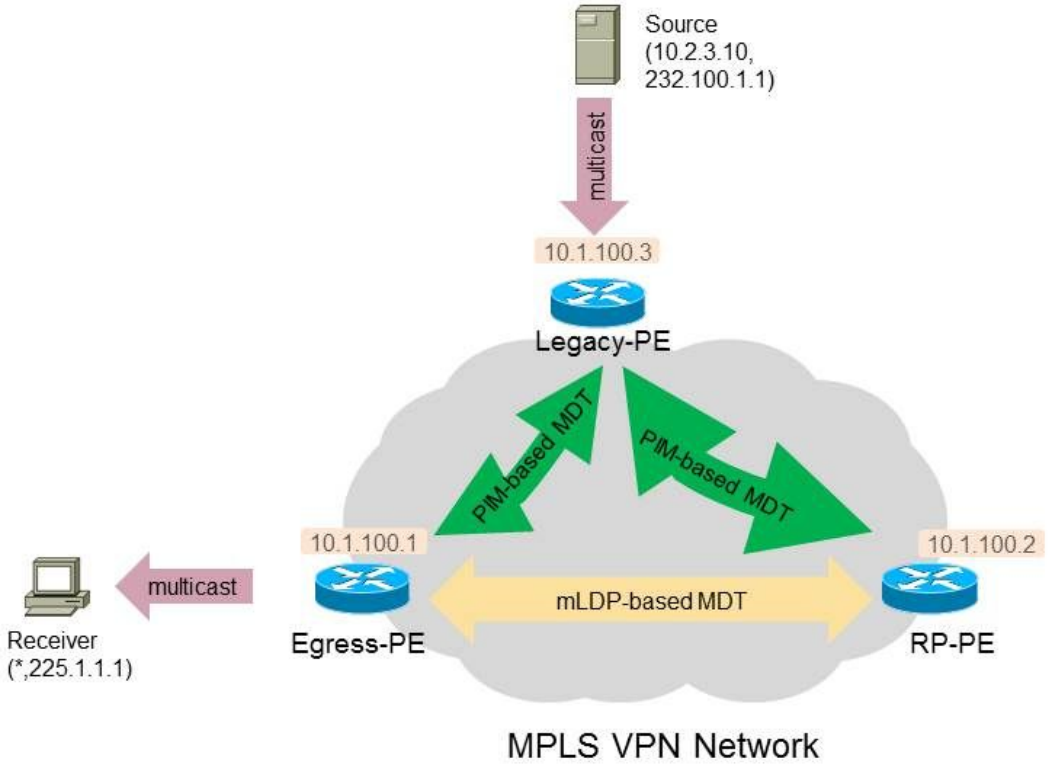

图 4.

在SPT切换后，出口PE通过基于PIM的MDT将PIM加入消息发送到(S， G)的传统源PE。Egress-PE上的传入接口现在是mdtone。RP-PE不再是组播流量的周转路由器。

<#root>

RP/0/RP1/CPU0:PE1#

show mrib vrf one route 225.1.1.1

```
IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
   C - Directly-Connected Check, S - Signal, IA - Inherit Accept,
   IF - Inherit From, D - Drop, ME - MDT Encap, EID - Encap ID,
   MD - MDT Decap, MT - MDT Threshold Crossed, MH - MDT interface handle
   CD - Conditional Decap, MPLS - MPLS Decap, MF - MPLS Encap, EX - Extranet
   MoFE - MoFRR Enabled, MoFS - MoFRR State, MoFP - MoFRR Primary
   MoFB - MoFRR Backup, RPFID - RPF ID Set, X - VXLAN
Interface flags: F - Forward, A - Accept, IC - Internal Copy,
   NS - Negate Signal, DP - Don't Preserve, SP - Signal Present,
   II - Internal Interest, ID - Internal Disinterest, LI - Local Interest,
   LD - Local Disinterest, DI - Decapsulation Interface
   EI - Encapsulation Interface, MI - MDT Interface, LVIF - MPLS Encap,
   EX - Extranet, A2 - Secondary Accept, MT - MDT Threshold Crossed,
   MA - Data MDT Assigned, LMI - mLDP MDT Interface, TMI - P2MP-TE MDT Interface
   IRMI - IR MDT Interface

(*,225.1.1.1) RPF nbr: 10.1.100.2 Flags: C RPF
Up: 00:09:59
Incoming Interface List
   Lmdtone Flags: A LMI, Up: 00:09:59
```

```
Outgoing Interface List
   GigabitEthernet0/0/0/9 Flags: F NS, Up: 00:09:59

(10.2.3.10,225.1.1.1) RPF nbr: 10.1.100.3 Flags: RPF
Up: 00:14:29
Incoming Interface List


 mdtone

 Flags: A MI, Up: 00:14:29
Outgoing Interface List
   GigabitEthernet0/0/0/9 Flags: F NS, Up: 00:14:29
```

并且PE1具有源设备的以下PIM RPF信息：

<#root>

```
RP/0/RP1/CPU0:PE1#

show pim vrf one rpf 10.2.3.10



Table: IPv4-Unicast-default
* 10.2.3.10/32 [200/0]


via mdtone

 with rpf neighbor 10.1.100.3
   RT:1:1 ,Connector: 1:3:10.1.100.3, Nexthop: 10.1.100.3
```

这意味着流量现在通过基于PIM的MDT从核心网络中的传统源PE直接流向出口PE。请参阅图 5。

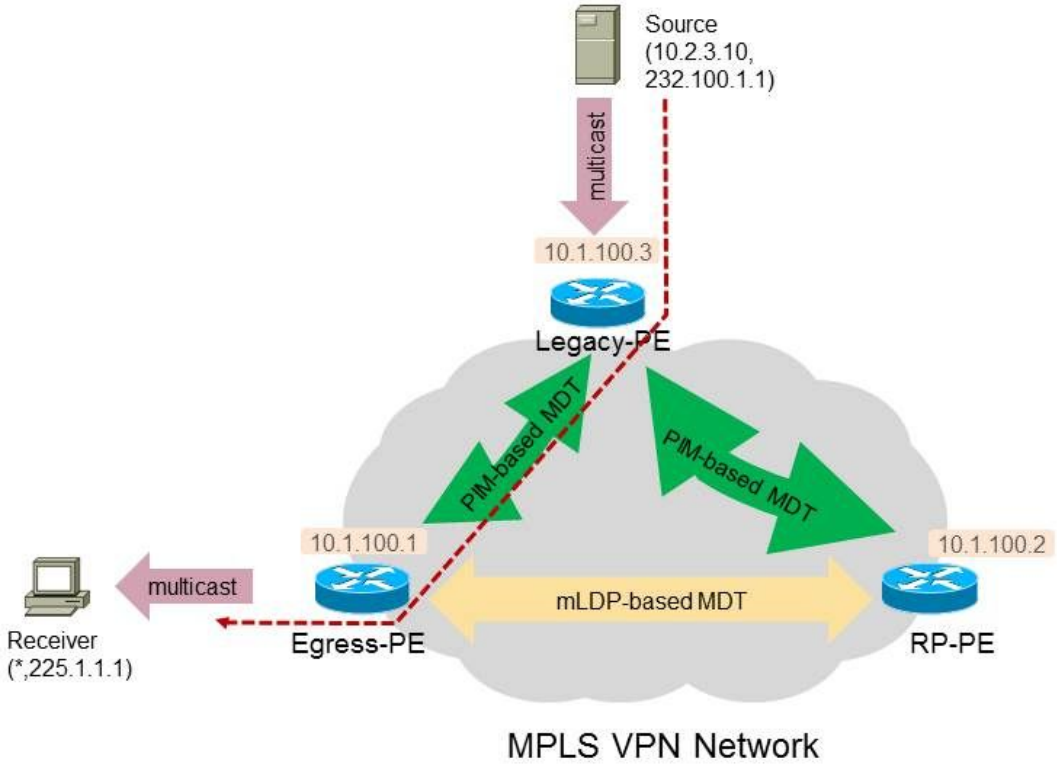

图 5.

结论

所有非传统PE路由器（接收方PE或RP-PE路由器）必须具备迁移核心树协议和迁移C信令协议的配置。

或者，解决方法是确保SPT切换不会发生，但组播流量的路由可能不在网络核心中的最短路径上。

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