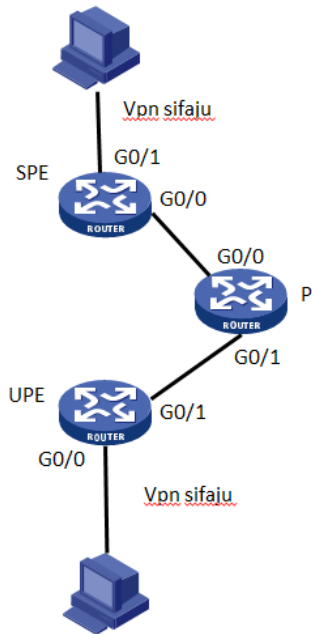


在MPLS L3VPN解决方案中，PE设备最为关键，它完成两方面的功能：首先是为用户提供接入功能，这需要PE具有大量接口；然后是管理和发布VPN路由，处理用户报文，这需要PE设备具有大容量存储和高转发能力。

而MPLS L3VPN是一种平面模型，对网络中所有PE设备的性能要求相同，当网络中某些PE在性能和可扩展性方面存在问题时，整个网络的性能和可扩展性将受到影响。

在MPLS L3VPN领域，HoVPN (Hierarchy of VPN, 分层VPN) 解决方案的提出，实现了将PE的功能分布到多个PE设备上，多个PE承担不同的角色，并形成层次结构，共同完成一个PE的功能。

HoVPN对处于较高层次的设备的路由能力和转发性能要求较高，而对处于较低层次的设备的要求也较低，符合典型的分层网络模型。



SPE配置:

```
[SPE]display current-configuration
#
version 5.20, Release 2507, Standard
#
sysname SPE
#
mpls lsr-id 7.175.20.4
#
ip vpn-instance sifaju
route-distinguisher 65000:657
vpn-target 65000:657 export-extcommunity
vpn-target 65000:657 import-extcommunity
#
mpls
#
mpls ldp
#
interface LoopBack0
ip address 7.175.20.4 255.255.255.255
#
interface GigabitEthernet0/0
port link-mode route
ip address 7.175.20.2 255.255.255.0
mpls
mpls ldp
#
interface GigabitEthernet0/1
port link-mode route
```

```
nat outbound static
ip binding vpn-instance sifaju
ip address 10.0.0.254 255.255.255.0
#
bgp 65000
synchronization
peer 7.218.20.4 as-number 65000
peer 7.218.20.4 connect-interface LoopBack0
#
ipv4-family vpn-instance sifaju
network 0.0.0.0
import-route direct
#
ipv4-family vpnv4
peer 7.218.20.4 enable
peer 7.218.20.4 upe
peer 7.218.20.4 default-route-advertise vpn-instance sifaju
#
ospf 1 router-id 7.175.20.4
area 0.0.0.0
network 7.175.20.4 0.0.0.3
```

UPE配置:

```
[R3]display current-configuration
#
version 5.20, Release 2509, Standard
#
sysname R3

#
mpls lsr-id 7.218.20.4
#

ip vpn-instance sifaju
route-distinguisher 65000:657
vpn-target 65000:657 export-extcommunity
vpn-target 65000:657 import-extcommunity
#
vlan 1
#
mpls
#
mpls ldp
#
interface LoopBack0
ip address 7.218.20.4 255.255.255.255
#
interface GigabitEthernet0/0
port link-mode route
ip binding vpn-instance sifaju
ip address 20.0.0.254 255.255.255.0
#
interface GigabitEthernet0/1
port link-mode route
ip address 7.218.20.2 255.255.255.0
mpls
mpls ldp
#

bgp 65000
network 0.0.0.0
undo synchronization
peer 7.175.20.4 as-number 65000
```

```
peer 7.175.20.4 connect-interface LoopBack0
#
ipv4-family vpn-instance sifaju
import-route direct
#
ipv4-family vpnv4
peer 7.175.20.4 enable
#
ospf 1 router-id 7.218.20.4
area 0.0.0.0
network 7.218.20.0 0.0.0.3
network 7.218.20.4 0.0.0.0
#
```

P设备配置:

```
[P]display current-configuration
#
version 5.20, Release 2509P01, Standard
#
sysname P
#
mpls lsr-id 3.3.3.3
#
mpls
#
mpls ldp

interface LoopBack0
ip address 3.3.3.3 255.255.255.255
#
interface GigabitEthernet0/0
port link-mode route
ip address 7.175.20.3 255.255.255.0
mpls
mpls ldp
#
interface GigabitEthernet0/1
port link-mode route
ip address 7.218.20.3 255.255.255.0
mpls
mpls ldp
#
ospf 1
area 0.0.0.0
network 7.218.20.0 0.0.0.255
network 7.175.20.0 0.0.0.255
network 3.3.3.3 0.0.0.0
#
```

结果显示

```
[SPE]display ip routing-table vpn-instance sifaju
Routing Tables: sifaju
Destinations : 5 Routes : 5
```

Destination/Mask	Proto	Pre	Cost	NextHop	Interface
10.0.0.0/24	Direct	0	0	10.0.0.254	GE0/1
10.0.0.254/32	Direct	0	0	127.0.0.1	InLoop0
20.0.0.0/24	BGP	255	0	7.218.20.4	NULL0
127.0.0.0/8	Direct	0	0	127.0.0.1	InLoop0
127.0.0.1/32	Direct	0	0	127.0.0.1	InLoop0

```
[R3]display ip routing-table vpn-instance sifaju
Routing Tables: sifaju
Destinations : 5 Routes : 5
```

Destination/Mask Proto Pre Cost NextHop Interface

```
0.0.0.0/0 BGP 255 0 7.175.20.4 NULL0
20.0.0.0/24 Direct 0 0 20.0.0.254 GE0/0
20.0.0.254/32 Direct 0 0 127.0.0.1 InLoop0
127.0.0.0/8 Direct 0 0 127.0.0.1 InLoop0
127.0.0.1/32 Direct 0 0 127.0.0.1 InLoop0
```

说明：HOPE方式，是为了减轻PE设备的工作负担，同时不改变原有的公私网边界，故此处UPE只有一条默认路由

1. SPE/UPE/P设备的mpls lsr-id直接必须是可达的，即需要将三个设备的loopback通告进OSPF，否则直连设备之间是无法正确建立LDP session的
2. 如果P设备的3.3.3.3是未进行通告的，则在SPE和UPE中，对应的路由在BGP路由表中不是最优的（同步/下一跳），此处同步已经关闭，因此影响路由不是最优的因素就是下一跳不可达（指的是MPLS下一跳不可达），
即：ping lsp ipv4 7.218.20.4是不可达的
3. [SPE]display mpls ldp peer

LDP Peer Information in Public network

Total number of peers: 1

```
-----
Peer-ID      Transport-Address Discovery-Source
-----
3.3.3.3:0    3.3.3.3           GigabitEthernet0/0
-----
```

说明：在P设备即使不通告3.3.3.3，此时在SPE上执行display mpls ldp peer也是存在此表象的，原因在于P设备已经从G0/0和G0/1发出了LDP的hello报文而正确查看LDP邻居是否正常的命令为：

[SPE]display mpls ldp session

LDP Session(s) in Public Network

Total number of sessions: 1

```
-----
Peer-ID      Status   SsnRole FT MD5 KA-Sent/Rcv
-----
3.3.3.3:0    Operational Active Off Off 11/11
-----
```

FT : Fault Tolerance

如果此处显示:operational，则表示正常，否则显示为：Non Existent（尚未建立TCP连接）