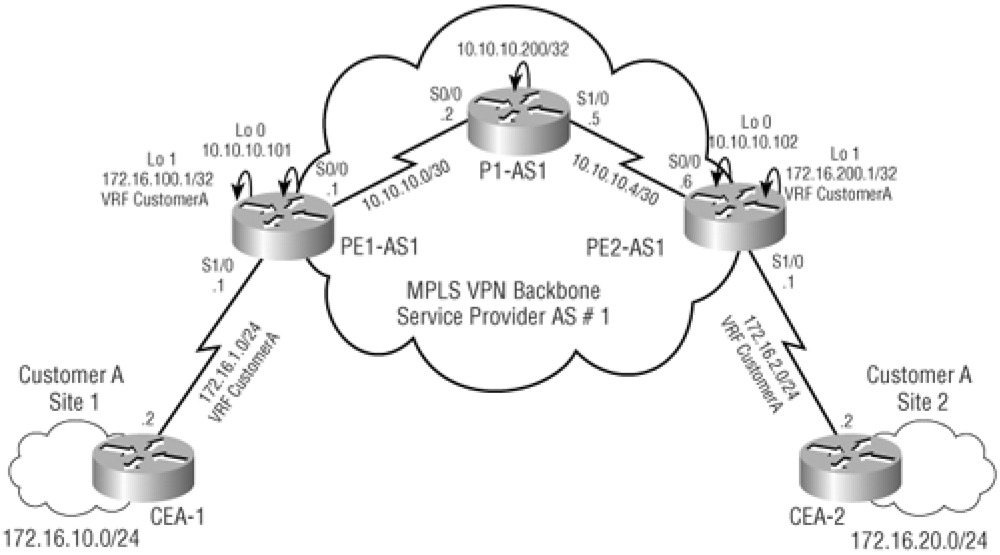
MPLS VPN Basic Configuration II.

This section outlines the generic configurations required on the routers in the service provider domain to implement MPLS VPN. The configurations of the PE and P routers will be covered in this section. The subsequent sections in this chapter delve into each of the configuration blocks on the PE and P routers alone. The configurations required to implement PE-CE routing sessions are discussed in Chapters 4 through 6, depending on the PE-CE protocol in use.

All configurations outlined in the following sections are performed in the network shown in Figure 3-11. For simplicity, only connected networks that are part of the VRF will be redistributed into the MP-BGP processes.

Figure 3-11. Network Topology: MPLS VPN PE and P Configuration



The topology in Figure 3-11 attempts to implement a simple intranet VPN between two sites belonging to Customer A, site 1 and site 2. The customer network consists of the CE routers CE1-A and CE2-A. In addition, two loopbacks (loopback 1) on PE1-AS1 and PE2-AS1 will be configured as part of the VRF CustomerA and be redistributed into the MP-BGP routing contexts.

Configuration of CE Routers

The configuration of route exchange between PE and CE routers involves the implementation of a routing protocol (or static/default routes) on the CE routers. No specific configuration other than the regular routing protocol configuration is required on the CE routers. On the PE router, VRF routing contexts (or address family contexts) are required for route exchange between the PE and CE. These routes are then mutually redistributed with the MP-BGP process per VRF. Configurations for the above based on protocol choice between PE and CE will be covered in Chapters 4 through 6.

Configuring MPLS Forwarding and VRF Definition on PE Routers

Configuring MPLS forwarding is the first step to provision the service provider's MPLS VPN backbone. This step ensures the service provider's readiness to provide MPLS- related services to prospective customers. At a minimum, the steps to configure MPLS forwarding on PE routers are

Step 1. Enable CEF.

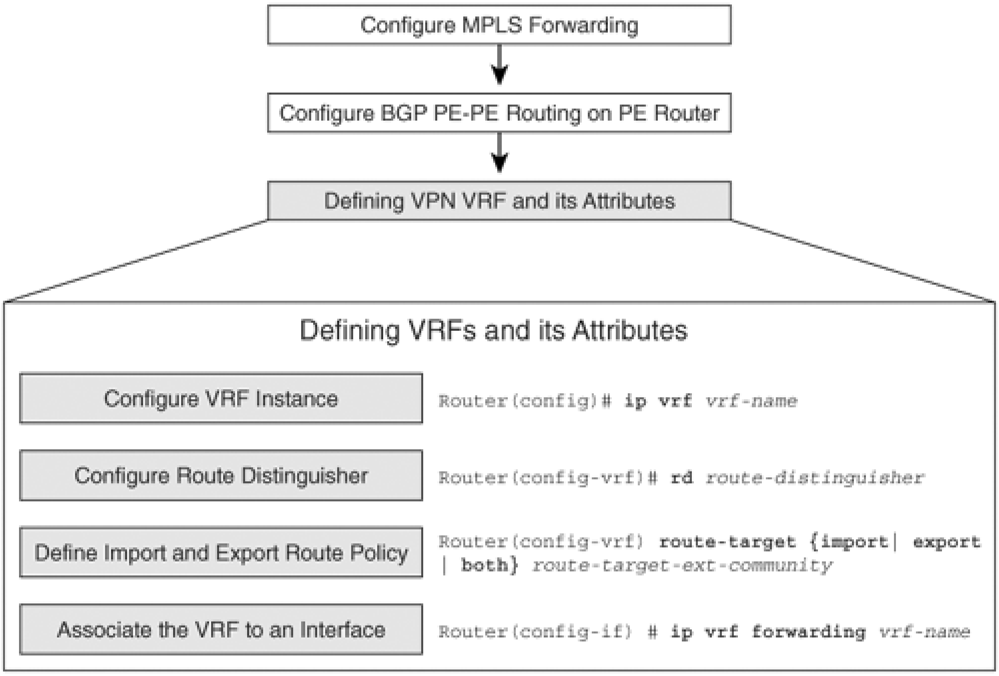
Step 2. Configure IGP routing protocol on the PE router.

Step 3. Configure MPLS or label forwarding on the PE interfaces connected to P.

These steps have already been discussed in Chapters 1 and 2 and thus have not been shown.

In this section, we configure VRFs on the PE routers. Figure 3-12 shows the configuration steps on the PE routers to configure VRF definition.

Figure 3-12. VRF Definition on PE Routers: Configuration Steps


Configure MPLS Forwarding
Configure BGP PE-PE Routing on PE Router
Defining VPN VRF and its Attributes
Defining VRFs and its Attributes
Configure VRF Instance
Configure Route Distinguisher
Define Import and Export Route Policy
Associate the VRF to an Interface

```
Router(config)# ip vrf vrf-name
Router(config-vrf)# rd route-distinguisher
Router(config-vrf) route-target {import| export
| both} route-target-ext-community
Router(config-if) # ip vrf forwarding vrf-name
```

Step 1. Configure VRF on PE router —Configure the VRF CustomerA on PE1 and PE2-AS1 router. This results in the creation of a VRF routing table and a Cisco Express Forwarding (CEF) table for CustomerA . Example 3-1 shows CustomerA VRF being configured on PE1-AS1 router. Note the VRF name is case sensitive.

Example 3-1. VRF Definition

```
PE1-AS1(config)#
```

```
ip vrf CustomerA
```

Note that creation or deletion of a VRF results in removal of the IP address from the interface. Example 3-2 illustrates the message that occurs on VRF deletion.

Example 3-2. VRF Deletion

```
PE1-AS1(config-vrf)#

no ip vrf CustomerA

% IP addresses from all interfaces in VRF CustomerA have been
removed
```

Step 2. Configure the RD —The RD creates routing and forwarding tables. The RD is added to the beginning of the customer's IPv4 prefixes to convert them into globally unique VPNv4 prefixes. Example 3-3 shows the configuration for defining the RD under the VRF.

Example 3-3. Configuring VRF Parameters: RD

```
PE1-AS1(config-vrf)#

rd 1:100
```

The RD can be used in either of these formats:

- 16-bit AS number: Your 32-bit number (for example, 1:100)
- 32-bit IP address: Your 16-bit number (for example, 10.10.10.101:1)

RD for an existing VRF can be changed only after deletion of that VRF. Example 3-4 illustrates the concept.

Example 3-4. Redefining VRF RD Value

```
PE1-AS1(config)#

ip vrf CustomerA

PE1-AS1(config-vrf)#

rd 1:100

% Do "no ip vrf " before redefining the VRF
```

RD has to be unique for that particular VRF. No two VRFs on the same router can have similar RD. Trying to set the same RD on the VRF on the same router results in the message shown in Example 3-5.

Example 3-5. RD Uniqueness

```
PE1-AS1(config)#

ip vrf CustomerA

PE1-AS1(config-vrf)#

rd 1:100

% Cannot set RD, check if it's unique
```

Step 3. Configure the import and export policy —Configure the import and export policy for the MP-BGP extended communities. The policy is used for filtering routes for that particular RT. Example 3-6 provides the relevant configuration for defining import and export policy.

Example 3-6. Configuring VRF Parameters: RT

```
PE1-AS1(config-vrf)#

route-target both 1:100
```

The both keyword in the previous command results in the configuration of import and export policy, and the configuration output is shown in Example 3-7.

Example 3-7. RT Configuration Options

```
PE1-AS1#

sh run

Building configuration...

ip vrf CustomerA

 rd 1:100

 route-target export 1:100

 route-target import 1:100
```

Step 4. Associate VRF with the interface —Associate virtual routing/forwarding instance (VRF) with an interface or subinterface in this CustomerA.

Associating the VRF to an interface results in removal of the IP address from that interface. This is only if VRF was associated to an interface that had the IP address already configured. This means that the IP address will have to be reconfigured after the VRF is associated with that interface. Example 3-8 shows the configuration for associating the VRF to an interface. Example 3-9 shows the removal of the IP address when no ip vrf forwarding vrfname is configured on the interface.

Example 3-8. Associating VRF with Interface

```
PE1-AS1(config)#
```

```
interface serial4/0

PE1-AS1(config-if)#

ip add 172.16.1.1 255.255.255.252

PE1-AS1(config-if)#

ip vrf forwarding CustomerA

% Interface Serial4/0 IP address 172.16.1.1 removed due to
enabling VRF CustomerA

PE1-AS1(config-if)#

ip add 172.16.1.1 255.255.255.252
```

Example 3-9. VRF Association to Interface IP Address

```
PE1-AS1(config-if)#

no ip vrf forwarding CustomerA

% Interface Serial4/0 IP address 172.16.1.1 removed due to
disabling VRF CustomerA
```

Final VRF Configuration on PE1-AS1 Router

Example 3-10 shows the VRF configuration on the PE1-AS1 router.

Example 3-10. VRF Configuration of PE1-AS1

```
ip vrf CustomerA

rd 1:100

route-target export 1:100

route-target import 1:100

!

interface Serial1/0

description PE-CE link to CE1-A

ip vrf forwarding CustomerA
ip address 172.16.1.1 255.255.255.0

!

Interface Loopback1

ip vrf forwarding CustomerA

ip address 172.16.100.1 255.255.255.255
```

Verification of VRF Configuration on PE Routers

The show ip vrf command is used to verify if the correct VRF exists on the interface. Example 3-11 indicates that the correct VRF CustomerA is configured on the Serial1/0 interface on the PE1 router.

Example 3-11. show ip vrf on PE1-AS1

```
PE1-AS1#

show ip vrf

Name                        Default RD          Interfaces

  CustomerA                     1:100               Se1/0

                                                    Lo1
```

The show ip vrf interfaces command provides the listing of interfaces that are activated for a particular VRF. Example 3-12 shows that Serial1/0 is active for VRF VRF-Static.

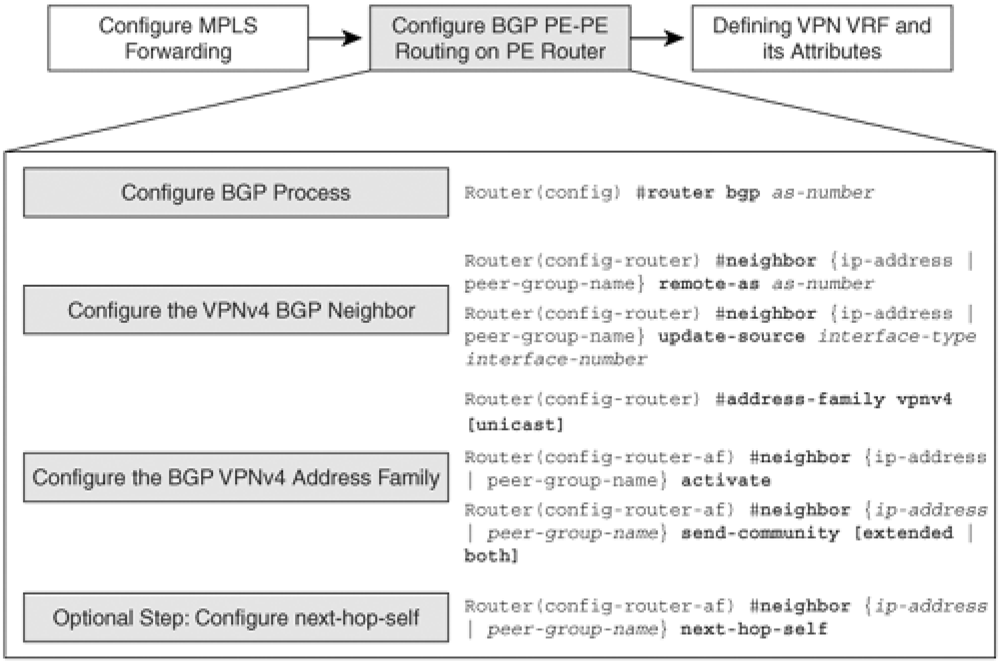
Example 3-12. show ip vrf interfaces on PE1-AS1

```
PE1-AS1#

show ip vrf interfaces

Interface              IP-Address       VRF
Protocol

Serial1/0              172.16.1.1       CustomerA                   up

Lo1                    172.16.100.1     CustomerA                   up
```

Configuration of BGP PE-PE Routing on PE Routers

Configuring BGP PE-PE routing between the PE routers is the next step in an MPLS VPN deployment. The purpose of this step is to ensure that VPNv4 routes can be transported across the service provider backbone using MP-iBGP. The P router is transparent to this entire process and, therefore, does not carry any customer routes. Figure 3-13 illustrates the steps for configuring BGP PE-PE routing sessions between the PE routers.

Figure 3-13. BGP PE-PE Routing Configuration Steps


Configure MPLS Forwarding
Configure BGP PE-PE Routing on PE Router
Defining VPN VRF and its Attributes
Configure BGP Process
Configure the VPNv4 BGP Neighbor
Configure the BGP VPNv4 Address Family
Optional Step: Configure next-hop-self

```
Router(config) #router bgp as-number

Router(config-router) #neighbor {ip-address |
peer-group-name} remote-as as-number
Router(config-router) #neighbor {ip-address |
peer-group-name} update-source interface-type
interface-number

Router(config-router) #address-family vpnv4
[unicast]
Router(config-router-af) #neighbor {ip-address
| peer-group-name} activate
Router(config-router-af) #neighbor {ip-address
| peer-group-name} send-community [extended |
both]

Router(config-router-af) #neighbor {ip-address
| peer-group-name} next-hop-self
```

Step 1. Configure BGP routing on PE routers —Enable BGP routing and identify the AS on the PE1-AS1 and PE2-AS1 routers. Example 3-13 highlights the configuration.

Example 3-13. Configuring BGP Routing on PE Routers

```
PE1-AS1(config)#

router bgp 1
```

```
PE2-AS1(config)#

router bgp 1
```

Step 2. Configure the MP-iBGP neighbors —Configure the remote MP-iBGP neighbor and use the loopback interface as the source of BGP messages and updates. Note that you have to use the update-source command only when the neighbor is peering to your loopback address. This is irrespective of whether it is an iBGP or eBGP neighbor. Example 3-14 shows the configuration for the PE1-AS1 and PE2-AS1 router.

Example 3-14. Configuring MP-iBGP Neighbors

```
PE1-AS1(config-router)#
```

```
neighbor 10.10.10.102 remote-as 1

PE1-AS1(config-router)#

neighbor 10.10.10.102 update-source loopback0
```

```
PE2-AS1(config-router)#

neighbor 10.10.10.101 remote-as 1

PE2-AS1(config-router)#

neighbor 10.10.10.101 update-source loopback0
```

Step 3. Configure the VPNv4 address family —Configure the address family for VPNv4 under the BGP configuration process. This step allows you to enter the VPNv4 address family to activate the VPNv4 neighbors. Activate the iBGP neighbor, which is essential for transporting VPNv4 prefixes across the service provider backbone. Using next-hop-self is optional and is primarily used when the service provider has an eBGP PE-CE routing with the customers, because internal BGP (iBGP) sessions preserve the next-hop attribute learned from eBGP peers, which is why it is important to have an internal route to the next hop. Otherwise, the BGP route is unreachable. To make sure you can reach the eBGP next hop, include the network that the next hop belongs to in the IGP or use the next-hop-self neighbor command to force the router to advertise itself, rather than the external peer, as the next hop.

In addition, configure the propagation of the extended communities with BGP routes so as to enable RT propagation, which identifies the VPNs that the routes have to be imported into. The configuration of the VPNv4 address family for PE1-AS1 and PE2-AS1 is shown in Example 3-15. Note that on some versions of IOS, adding the neighbor for VPNv4 route exchange using the neighbor ip-address activate command also automatically adds the neighbor ip-address send-community extended command. If the neighbor needs to be configured for both standard and extended community exchange, you will explicitly have to configure the neighbor ip-address send-community both command under the VPNv4 address family.

Example 3-15. Configuring BGP VPNv4 Address Family

```
PE1-AS1(config-router)#

address-family vpnv4

PE1-AS1(config-router-af)#

neighbor 10.10.10.102 activate

PE1-AS1(config-router-af)#

neighbor 10.10.10.102 send-community extended
```

```
_____

PE2-AS1(config-router)#

address-family vpnv4

PE2-AS1(config-router-af)#

neighbor 10.10.10.101 activate

PE2-AS1(config-router-af)#

neighbor 10.10.10.101 send-community extended
```

Step 4. Configure the IPv4 address family —Configure the peer VRF IPv4 address family under the BGP configuration process. This step allows you to enter the IPv4 networks that will be converted to VPNv4 routes in MP-BGP updates. In Chapters 4, 5, and 6, the individual PE-CE routing protocol interaction configuration involving redistribution of PE-CE routing protocol contexts or instances will be configured in the IPv4 address family per VRF under the BGP process. For simplicity, redistribution of all connected networks is configured into the MP-BGP process. Example 3-16 shows the configuration on PE1-AS1 and PE2-AS1 routers.

Example 3-16. Configuring BGP per VRF IPv4 Address Family (Routing Context)

```
PE1-AS1(config-router)#

address-family ipv4 vrf CustomerA

PE1-AS1(config-router-af)#

redistribute connected

PE1-AS1(config-router-af)#

exit-address-family

______________________________________________________________

PE2-AS1(config-router)#

address-family ipv4 vrf CustomerA

PE2-AS1(config-router-af)#

redistribute connected

PE2-AS1(config-router-af)#

exit-address-family
```

BGP PE-PE Routing Final Configuration on PE1-AS1 and PE2-AS1 Router

Example 3-17 shows the final BGP PE-PE routing configuration on the PE1-AS1 and PE2-

AS1 router.

Example 3-17. BGP PE-PE Configurations of PE1-AS1 and PE2-AS1 Routers

```
!PE1-AS1 Router:

router bgp 1

no synchronization

neighbor 10.10.10.102 remote-as 1

no auto-summary

!

address-family vpnv4

neighbor 10.10.10.102 activate

neighbor 10.10.10.102 send-community extended

exit-address-family

!

address-family ipv4 vrf CustomerA

redistribute connected

no auto-summary

no synchronization

exit-address-family
```

```
!PE2-AS1 Router:
```

```
router bgp 1

no synchronization

bgp log-neighbor-changes

neighbor 10.10.10.101 remote-as 1

neighbor 10.10.10.101 update-source Loopback0

no auto-summary

!

address-family vpnv4

neighbor 10.10.10.101 activate

neighbor 10.10.10.101 send-community extended

exit-address-family

!

address-family ipv4 vrf CustomerA

redistribute connected

no auto-summary

no synchronization

exit-address-family
```

Verification and Monitoring of BGP PE-PE Routing on PE Routers

After configuring BGP PE-PE routing between the PE routers, you can verify that the MP-iBGP neighbors are operational by issuing any of the following commands:

- show ip bgp vpnv4 * summary
- show IP bgp vpnv4 all

- show ip bgp summary
- show ip bgp neighbor ip-address

Example 3-18 shows that the VPNv4 neighbor relationship is formed .

Example 3-18. VPN Neighbor Relationship Verification

```
PE1#

show ip bgp vpnv4 all summary

BGP router identifier 10.10.10.101, local AS number 1

BGP table version is 7, main routing table version 7


Neighbor        V    AS MsgRcvd MsgSent   TblVer   InQ OutQ Up/Down  
State/PfxRcd

10.10.10.102    4     1     202     200        7     0    0 00:00:39      
0

___________________________________________________________________________
_______

PE2#

show ip bgp vpnv4 all summary

BGP router identifier 10.10.10.102, local AS number 1

BGP table version is 1, main routing table version 1


Neighbor        V    AS MsgRcvd MsgSent   TblVer   InQ OutQ Up/Down  
State/PfxRcd

10.10.10.101    4     1     11       11        1     0    0 00:07:16      
0
```

Configuration of P Router

No special configurations need to be performed on the P routers P1-AS1 and P1-AS2 for MPLS VPN support. Because the P routers only participate in MPLS labeled packet forwarding, the only requirements are those of an LSR in an MPLS network, namely, IGP for NLRI exchange and LDP for label assignment and distribution. As always, CEF needs to be enabled on all interfaces configured for MPLS forwarding. Configuration of the P1-AS1 router is shown in Example 3-19.

Example 3-19. P1-AS1 Configuration

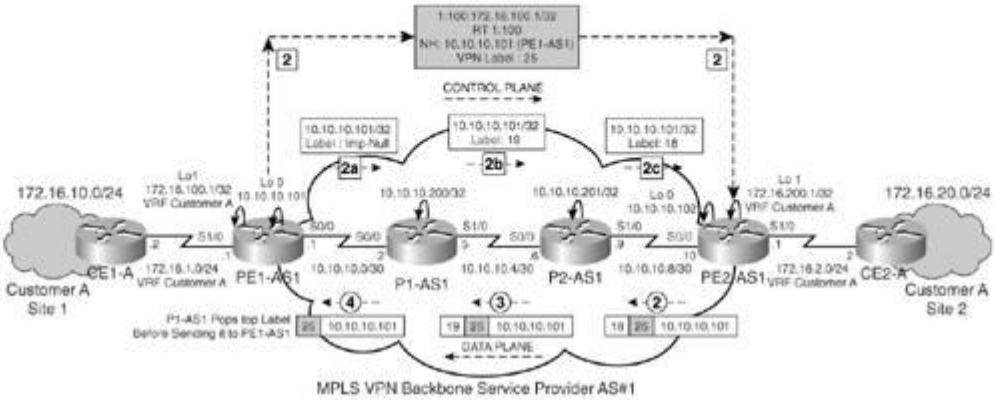
```
mpls ldp router-id loopback0
```

```
!

interface Serial0/0

ip address 10.10.10.2 255.255.255.252

mpls ip

!

interface Serial1/0

ip address 10.10.10.5 255.255.255.252

mpls ip

!

Interface loopback0

ip address 10.10.10.200 255.255.255.255

!

router ospf 1

network 10.0.0.0 0.255.255.255 area 0

!
```

Label Verification and Control and Data Plane Operation

After configuring devices in the network as per the previous steps, the verification of label allocation and propagation can be performed on the PE and P routers using the commands described in Figure 3-14.

Figure 3-14. Label Allocation Verification and Control/Data Plane Operation



```
PE1-AS1#show mpls forwarding-table vrf Customer_A
172.16.100.1

Local Outgoing Prefix Bytes tag Outgoing Next Hop

tag tag or VC or Tunnel Id switched interface
25 Aggregate 172.16.100.1/32[V] \
                         0
PE1-AS1#show ip cef vrf Customer_A 172.16.100.1 detail
172.16.100.1/32, version 15, epoch 0, connected, receive
 tag information set, all rewrites owned
  local tag: 25
PE1-AS1# show ip cef 10.10.10.101 detail
10.10.10.101/32, version 5, epoch 0, connected, receive
  tag information set, all rewrites inherited
  local tag: implicit-null
```

```
P1-AS1#show mpls forwarding-table 10.10.10.101
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
19 Pop tag 10.10.10.101/32 21114 Se0/0 point2point
```

```
P2-AS1#show mpls forwarding-table 10.10.10.101
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
18 19 10.10.10.101/32  22141 Se0/0 point2point
```

```
PE2-AS1#show mpls forwarding-table vrf A 172.16.100.1
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
None 18   172.16.100.1/32 0   Se0/0
point2point

PE2-AS1#show ip cef vrf Customer_A 172.16.100.1 detail
172.16.100.1/32, version 18, epoch 0, cached adjacency to Serial 0/0
0 packets, 0 bytes
 tag information set, all rewrites owned
  local tag: VPN route head
   fast tag rewrite with Se0/0, point2point, tags imposed {18 25}
 via 10.10.10.101, 0 dependencies, recursive
  next hop 10.10.10.9, Serial0/0 via 10.10.10.101/32 (Default)
  valid cached adjacency
  tag rewrite with Se0/0, point2point, tags imposed {18 25}

PE2-AS1#show ip cef 10.10.10.101 detail
10.10.10.101/32, version 11, epoch 0, cached adjacency to Serial 0/0
0 packets, 0 bytes
 tag information set, shared, all rewrites owned
  local tag: 19
  fast tag rewrite with Se0/0, point2point, tags imposed {18}
 via 10.10.10.9, Serial0/0, 0 dependencies
  next hop 10.10.10.9, Serial 0/0
  valid cached adjacency
  tag rewrite with Se0/0, point2point, tags imposed {18}
```

The control plane and data plane operation for network 172.16.100.1 as part of VRF CustomerA is depicted in Figure 3-14. Note that the outgoing label mapped to prefix 172.16.100.1 on PE1-AS1 is aggregate and not untagged. For all networks that are directly connected to the PE router (like loopbacks or interface IP networks) that are part of a VRF, the outgoing label mapped in the LFIB is the aggregate label. If, however, the incoming VPN packet is to be forwarded to a next-hop address (like that of a connected CE router), the outgoing label mapping is untagged. Thus, aggregate and untagged labels that were explained in Chapter 1 are encountered in MPLS VPN implementations .