Introduction

This document describes how to configure a Multiprotocol Label Switching (MPLS) VPN when additional protocols are on the Cisco client site.

Prerequisites

Requirements

There are no specific requirements for this document.

Components Used

The information in this document is based on these software and hardware versions:

- P and PE Routers Cisco IOS® Software Release which includes the MPLS VPN feature. Any Cisco router from the 7200 series or higher supports P functionality. The Cisco 2600, as well as any 3600 series or higher router supports PE functionality.
- C and CE Routers You can use any router that can exchange routing information with its PE router.

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, ensure that you understand the potential impact of any command.

Related Products
To implement the MPLS feature, you must have a router from the range of Cisco 2600 or higher. To select the required Cisco IOS with MPLS feature, use the Software Research tool. Also check for the additional RAM and Flash memory required to run the MPLS feature in the routers. WIC-1T, WIC-2T, and serial interfaces can be used.

Conventions

Refer to Cisco Technical Tips Conventions for more information on document conventions.

These letters represent the different types of routers and switches used:

- P — Provider core router.
- PE — Provider Edge router.
- CE — Customer Edge router.
- C — Customer router.

Note: PE routers are the last hop in the provider network and these are the devices that connect directly to the CE routers which are not aware of the MPLS feature, as shown in the next diagram.

This diagram shows a typical configuration that illustrates the conventions outlined previously.

![Network Diagram](MPLS VPN)

Background Information

This document provides a sample configuration of a Multiprotocol Label Switching (MPLS) VPN when Border Gateway Protocol (BGP) is present on the Cisco client site.

When used with MPLS, the VPN feature allows several sites to interconnect transparently through a service provider network. One Service Provider network can support several different IP VPNs. Each of these appears to its users as a private network, separate from all other networks. Within a VPN, each site can send IP packets to any other site in the same VPN.
Each VPN is associated with one or more Virtual Routing and Forwarding (VRF) instances. A VRF consists of an IP routing table, a derived Cisco Express Forwarding (CEF) table, and a set of interfaces that use this forwarding table. The router maintains a separate Routing Information Base (RIB) and CEF table for each VRF. Therefore, the information is not sent outside the VPN and allows the same subnet to be used in several VPNs and does not cause duplicate IP address problems. The router that uses Multiprotocol BGP (MP-BGP) distributes the VPN routing information with the MP-BGP extended communities.

**Configuration**

This section provides the configuration examples and how they are implemented.

**Network Diagram**

This document uses this network setup:

![Network Diagram](image)

**Configuration Procedures**

**MPLS Configuration**

1. Verify that `ip cef` is enabled on the routers where MPLS is required. For improved performance, use `ip cef distributed` (where available).

2. Configure an IGP on the service provider core, either Open Shortest Path First (OSPF) or Intermediate System-to-Intermediate System (IS-IS) protocols are the recommended options, and advertise the Loopback0 from each P and PE routers.

3. After the service provider core routers are fully L3 reachable between their loopbacks, configure
the command `mpls ip` on each L3 interface between P and PE routers.

**Note:** The PE router interface that connects directly to the CE router does not require the `mpls ip` command configuration.

Complete these steps on the PEs after MPLS has been set up (configuration of `mpls ip` on the interfaces).

1. Create one VRF for each VPN connected with the `vrf definition <VRF name>` command. Additional steps: Specify the correct route distinguisher used for that VPN. This command `rd <VPN route distinguisher>` is used to extend the IP address so that you can identify which VPN it belongs to.
   
   ```
   vrf definition Client_A
   rd 100:110
   ```

   Set up the import and export properties for the MP-BGP extended communities. These are used to filter the import and export process with the command `route-target [import|export|both] <target VPN extended community>` as shown in the next output:
   
   ```
   vrf definition Client_A
   rd 100:110
   route-target export 100:1000
   route-target import 100:1000
   
   address-family ipv4
   exit-address-family
   ```

   2. On the PE router, add the interfaces that connect the CE to the corresponding VRF. Configure the forwarding details for the respective interfaces with the `vrf forwarding` command and set up the IP address.

   ```
   Pescara#show run interface GigabitEthernet0/1
   Building configuration...
   
   Current configuration : 138 bytes
   
   !
   interface GigabitEthernet0/1
   vrf forwarding Client_A
   ip address 10.0.4.2 255.255.255.0
   duplex auto
   speed auto
   media-type rj45
   end
   
   Pescara#
   ```

**Configure MP-BGP**

There are several ways to configure BGP, for example, you can configure PE routers as BGP neighbors or use a Route Reflector (RR) or Confederation methods. A Route Reflector is used in the next example, which is more scalable than the use of direct neighbors between PE routers:

1. Enter the `address-family ipv4 vrf <VRF name>` command for each VPN present at this PE router. Carry out one or more of the next steps, as necessary: If you use BGP to exchange routing information with the CE, configure and activate the BGP neighbors with the CE routers. If you use a different dynamic routing protocol to exchange routing information with the CE, redistribute the routing protocols.
Note: Based on the PE-CE routing protocol you use, you can configure any dynamic routing protocols (EIGRP, OSPF or BGP) between PE and CE devices. If BGP is the protocol used to exchange routing information between PE and CE, there is no need to configure redistribution between protocols.

2. Enter the `address-family vpnv4` mode, and complete the next steps:

- Activate the neighbors, a VPNv4 neighbor session needs to be established between each PE router and the Route Reflector.
- Specify that extended community must be used. This is mandatory.

Configurations

This document uses these configurations to setup the MPLS VPN network example:

- **Pescara (PE)**
- **Pesaro (PE)**
- **Pomerol (P)**
- **Pulligny (RR)**
- **Pauillac (P)**

Pescara

hostname Pescara

vrf definition Client_A
rd 100:110
route-target export 100:1000
route-target import 100:1000

vrf definition Client_B
rd 100:120
route-target export 100:2000
route-target import 100:2000

interface Loopback0
ip address 10.10.10.4 255.255.255.255
ip router isis

interface GigabitEthernet0/1
vrf forwarding Client_A
ip address 10.0.4.2 255.255.255.0
duplex auto speed auto media-type rj45

interface GigabitEthernet0/2
vrf forwarding Client_B
ip address 10.0.4.2 255.255.255.0
duplex auto speed auto media-type rj45

interface GigabitEthernet0/0
description link to Pauillac
ip address 10.1.1.14 255.255.255.252
ip router isis
duplex auto speed auto media-type rj45

--- VPN Client_A commands.

vrf definition Client_A
rd 100:110
route-target export 100:1000
route-target import 100:1000

vrf definition Client_B
rd 100:120
route-target export 100:2000
route-target import 100:2000

--- Enables the VPN routing and forwarding (VRF) routing table.
--- Route distinguisher creates routing and forwarding tables for a VRF.
--- Route targets creates lists of import and export extended communities for the specified VRF.
--- Enables MPLS on the L3 interface connecting to the P router

router isis net 49.0001.0000.0000.0004.00 is-type level-2-only metric-style wide passive-interface Loopback0

--- Enables IS-IS as the IGP in the provider core network

router bgp 65000 bgp log-neighbor-changes
neighbor 10.10.10.2 remote-as 65000
neighbor 10.10.10.2 update-source Loopback0

--- Adds an entry to the BGP or MP-BGP neighbor table.
--- And enables BGP sessions to use a specific operational interface for TCP connections.

! address-family vpnv4 neighbor 10.10.10.2 activate neighbor 10.10.10.2 send-community both exit-address-family

--- To enter address family configuration mode that use standard VPN version 4 address prefixes.
--- Creates the VPNV4 neighbor session to the Route Reflector.
--- And to send the community attribute to the BGP neighbor.

! address-family ipv4 vrf Client_A neighbor 10.0.4.1 remote-as 65002 neighbor 10.0.4.1 activate exit-address-family

--- These are the eBGP sessions to each CE router belonging to different customers.
--- The eBGP sessions are configured within the VRF address family

end

Pesaro

hostname Pesaro

! ip cef

! vrf definition Client_A rd 100:110 route-target export 100:1000 route-target import 100:1000 ! address-family ipv4 exit-address-family

vrf definition Client_B rd 100:120 route-target export 100:2000 route-target import 100:2000 ! address-family ipv4 exit-address-family ! ip cef ! interface Loopback0 ip address 10.10.10.6 255.255.255.255

ip router isis

! interface GigabitEthernet0/0 description link to Pomerol ip address 10.1.1.22 255.255.255.252 ip router isis duplex auto speed auto media-type rj45 mpls ip ! interface GigabitEthernet0/1 vrf forwarding Client_A ip address 10.0.6.2 255.255.255.0 duplex auto speed auto media-type rj45 ! interface GigabitEthernet0/2 vrf forwarding Client_A ip address 10.1.6.2 255.255.255.0 duplex auto speed auto media-type rj45 ! interface GigabitEthernet0/3 vrf forwarding Client_A ip address 10.0.6.2 255.255.255.0 duplex auto speed auto media-type rj45 ! interface GigabitEthernet0/4 vrf forwarding Client_A ip address 10.1.6.2 255.255.255.0 duplex auto speed auto media-type rj45 ! router isis net 49.0001.0000.0000.0006.00 is-type level-2-only metric-style wide passive-interface Loopback0 ! router bgp 65000 bgp log-neighbor-changes neighbor 10.10.10.2 remote-as 65000 neighbor 10.10.10.2 update-source Loopback0 ! address-family vpnv4 neighbor 10.10.10.2 activate neighbor 10.10.10.2 send-community both exit-address-family ! address-family ipv4 vrf Client_A neighbor 10.0.6.1 remote-as 65002 neighbor 10.0.6.1 activate neighbor 10.0.6.1 activate neighbor 10.1.6.1 remote-as 65004 neighbor 10.1.6.1 activate exit-address-family ! address-family ipv4 vrf Client_B neighbor 10.0.6.1 remote-as 65003 neighbor 10.0.6.1 activate exit-address-family

end

Pomerol

hostname Pomerol

! ip cef

! interface Loopback0

ip address 10.10.10.3 255.255.255.255

ip router isis

! interface GigabitEthernet0/0 description link to Pesaro

ip address 10.1.1.21 255.255.255.252

ip router isis
duplex auto
speed auto
media-type rj45
mpls ip

! interface GigabitEthernet0/1
description link to Pauillac
ip address 10.1.1.6 255.255.255.252
ip router isis
duplex auto
speed auto
media-type rj45
mpls ip
!
interface GigabitEthernet0/2
description link to Pulligny
ip address 10.1.1.9 255.255.255.252
ip router isis
duplex auto
speed auto
media-type rj45
mpls ip

router isis
net 49.0001.0000.0000.0003.00
is-type level-2-only
metric-style wide
passive-interface Loopback0
!
end

Pulligny

hostname Pulligny
!
ip cef
!
interface Loopback0
ip address 10.10.10.2 255.255.255.255
ip router isis
!
interface GigabitEthernet0/0
description link to Pauillac
ip address 10.1.1.2 255.255.255.252
ip router isis
duplex auto
speed auto
media-type rj45
mpls ip
!
interface GigabitEthernet0/1
description link to Pomerol
ip address 10.1.1.10 255.255.255.252
ip router isis
duplex auto
speed auto
media-type rj45
mpls ip
!
interface GigabitEthernet0/3
no ip address
shutdown
duplex auto
speed auto
media-type rj45
!
router isis
net 49.0001.0000.0000.0000.0000.0000.0002.00
is-type level-2-only
metric-style wide
passive-interface Loopback0
!
router bgp 65000
bgp log-neighbor-changes
neighbor 10.10.10.4 remote-as 65000
neighbor 10.10.10.4 update-source Loopback0
neighbor 10.10.10.6 remote-as 65000
neighbor 10.10.10.6 update-source Loopback0
!
address-family vpnv4
neighbor 10.10.10.4 activate
neighbor 10.10.10.4 send-community both
neighbor 10.10.10.4 route-reflector-client
neighbor 10.10.10.6 activate
neighbor 10.10.10.6 send-community both
neighbor 10.10.10.6 route-reflector-client
exit-address-family
!
!
end

Pauillac

hostname pauillac
!
ip cef
!
interface Loopback0
  ip address 10.10.10.1 255.255.255.255
  ip router isis
!
interface GigabitEthernet0/0
  description link to Pescara
  ip address 10.1.1.13 255.255.255.252
  ip router isis
duplex auto
  speed auto
  media-type rj45
  mpls ip
!
interface GigabitEthernet0/1
  description link to Pulligny
  ip address 10.1.1.5 255.255.255.252
  ip router isis
duplex auto
  speed auto
  media-type rj45
  mpls ip
!
interface GigabitEthernet0/2
  description link to Pomerol
  ip address 10.1.1.1 255.255.255.252
  ip router isis
duplex auto
  speed auto
  media-type rj45
  mpls ip
!
router isis
net 49.0001.0000.0000.0000.0001.00
is-type level-2-only
metric-style wide
passive-interface Loopback0
!
end

CE-A1

core

hostname CE-A1
!
no ip cef
!
interface GigabitEthernet0/0
ip address 10.0.4.1 255.255.255.0
duplex auto
speed auto
media-type rj45
!
router bgp 65002
bgp log-neighbor-changes
redistribute connected
neighbor 10.0.4.2 remote-as 65000
!
end

CE-A3

core

hostname CE-A3
!
no ip cef
!
interface GigabitEthernet0/0
ip address 10.0.6.1 255.255.255.0
duplex auto
speed auto
media-type rj45
!
router bgp 65004
bgp log-neighbor-changes
redistribute connected
neighbor 10.0.6.2 remote-as 65000
!
end

Verification

This section provides information you can use to confirm that the configuration works properly:

PE to CE Verification Commands

- show ip vrf — Verifies that the correct VRF exists.
- show ip vrf interfaces — Verifies the activated interfaces.
- show ip route vrf <VRF name> — Verifies the routing information on the PE routers.
- traceroute vrf <VRF name> <IP address> — Verifies the routing information on the PE routers.
- show ip cef vrf <VRF name> <IP address> detail — Verifies the routing information on the PE routers.

MPLS LDP Verification Commands

- show mpls interfaces
- show mpls forwarding-table
- show mpls ldp bindings
- show mpls ldp neighbor

PE to PE/RR Verification Commands

- show bgp vpnv4 unicast all summary
- show bgp vpnv4 unicast all neighbor <neighbor IP address> advertised-routes — Verifies VPNv4 prefixes sent
- show bgp vpnv4 unicast all neighbor <neighbor IP address> routes — Verifies VPNv4 prefixes received

This is a sample command output of the show ip vrf command.

```
Pescara# show ip vrf
Name     Default RD Interfaces
Client_A  100:110          Gi0/1
Client_B  100:120          Gi0/2
```

This next is a sample command output of the show ip vrf interfaces command.
In this next sample, the show ip route vrf commands show the same prefix 10.0.6.0/24 in both the outputs. This is because the remote PE has the same network for two Cisco clients, CE_B2 and CE_A3, which is allowed in a typical MPLS VPN solution.

When you run a traceroute between two sites, in this example two sites of Client_A (CE-A1 to CE-A3), it is possible to see the label stack used by the MPLS network (if it is configured to do so by mpls ip propagate-ttl ).
Known via "bgp 65002", distance 20, metric 0
Tag 65000, type external
Last update from 10.0.4.2 11:16:14 ago
Routing Descriptor Blocks:
* 10.0.4.2, from 10.0.4.2, 11:16:14 ago
  Route metric is 0, traffic share count is 1
  AS Hops 2
  Route tag 65000
  MPLS label: none

CE-A1#
CE-A1#ping 10.0.6.1 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to
10.0.6.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip
min/avg/max = 7/8/9 ms CE-A1#
CE-A1#traceroute 10.0.6.1 probe 1 numeric Type escape sequence to abort. Tracing the
route to 10.0.6.1 VRF info: (vrf in name/id, vrf out name/id) 1 10.0.4.2 2 msec 2
10.1.1.13 [MPLS: Labels 20/26 Exp 0] 8 msec 3 10.1.1.6 [MPLS: Labels 21/26 Exp 0] 17
msec 4 10.0.6.2 [AS 65004] 11 msec 5 10.0.6.1 [AS 65004] 8 msec

Note: Exp 0 is an experimental field used for Quality of Service (QoS).

The next output shows the IS-IS and LDP adjacency established between the RR and some of the
P routers in the Service Provider core network:

Pulligny#show isis neighbors
Tag null:
System Id       Type Interface     IP Address      State Holdtime Circuit Id
Pauillac        L2   Gi0/0         10.1.1.1        UP    25       Pulligny.01
Pomerol         L2   Gi0/1         10.1.1.9        UP    23       Pulligny.02
Pulligny#

Pulligny#show mpls ldp neighbor
Peer LDP Ident: 10.10.10.1:0; Local LDP Ident 10.10.10.2:0
  TCP connection: 10.10.10.1.646 - 10.10.10.2.46298
  State: Oper; Msgs sent/rcvd: 924/921; Downstream
  Up time: 13:16:03
  LDP discovery sources:
    GigabitEthernet0/0, Src IP addr: 10.1.1.1
  Addresses bound to peer LDP Ident:
    10.1.1.13 10.1.1.5 10.1.1.1 10.10.10.1

Peer LDP Ident: 10.10.10.3:0; Local LDP Ident 10.10.10.2:0
  TCP connection: 10.10.10.3.14116 - 10.10.10.2.2.646
  State: Oper; Msgs sent/rcvd: 920/916; Downstream
  Up time: 13:13:09
  LDP discovery sources:
    GigabitEthernet0/1, Src IP addr: 10.1.1.9
  Addresses bound to peer LDP Ident:
    10.1.1.6 10.1.1.9 10.10.3 10.1.1.21

Related Information

- **MPLS Command Reference**
- **Technical Support & Documentation - Cisco Systems**