Network Configuration Example

Interconnecting a Layer 2 VPN with a Layer 3 VPN

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Juniper Networks, Inc.
1194 North Mathilda Avenue
Sunnyvale, California 94089
USA
408-745-2000
www.juniper.net

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Introduction

This document describes a general mechanism to have a Layer 2 VPN network terminate into a Layer 3 VPN network using a logical tunnel interface.

Layer 2 VPN Overview

As the need to link different Layer 2 services to one another for expanded service offerings grows, Layer 2 MPLS VPN services are increasingly in demand.

Implementing a Layer 2 VPN on a router is similar to implementing a VPN using a Layer 2 technology, such as Asynchronous Transfer Mode (ATM). However, for a Layer 2 VPN on a router, traffic is forwarded to the router in a Layer 2 format. It is carried by Multiprotocol Label Switching (MPLS) over the service provider's network, and then converted back to Layer 2 format at the receiving site. You can configure different Layer 2 formats at the sending and receiving sites. The security and privacy of an MPLS Layer 2 VPN are equal to those of an ATM or Frame Relay VPN. The service provisioned with Layer 2 VPNs is also known as Virtual Private Wire Service (VPWS).

On a Layer 2 VPN, routing typically occurs on the customer edge (CE) router. The CE router connected to a service provider on a Layer 2 VPN must select the appropriate circuit on which to send traffic. The provider edge (PE) router receiving the traffic sends the traffic across the service provider's network to the PE router connected to the receiving site. The PE routers do not need to store or process the customer's routes; they only need to be configured to send data to the appropriate tunnel. For a Layer 2 VPN, customers need to configure their own routers to carry all Layer 3 traffic. The service provider needs to know only how much traffic the Layer 2 VPN will need to carry. The service provider's routers carry traffic between the customer's sites using Layer 2 VPN interfaces. The VPN topology is determined by policies configured on the PE routers.

Because Layer 2 VPNs use BGP as the signaling protocol, they have a simpler design and require less overhead than traditional VPNs over Layer 2 circuits. BGP signaling also enables autodiscovery of Layer 2 VPN peers. Layer 2 VPNs are similar to BGP or MPLS VPNs and VPLS in many respects; all three types of services employ BGP for signaling.

Related Documentation

- Layer 2 VPN Applications
- Using the Layer 2 Interworking Interface to Interconnect a Layer 2 Circuit to a Layer 2 VPN
- Using the Layer 2 Interworking Interface to Interconnect a Layer 2 VPN to a Layer 2 VPN
- Interconnecting Layer 2 VPNs with Layer 3 VPNs Overview on page 7
- Example: Interconnecting a Layer 2 VPN with a Layer 2 VPN
- Example: Interconnecting a Layer 2 Circuit with a Layer 2 VPN
- Example: Interconnecting a Layer 2 VPN with a Layer 3 VPN on page 9

Layer 3 VPN Overview

Layer 3 VPNs are based on RFC 2547bis, *BGP/MPLS IP VPNs*. RFC 2547bis defines a mechanism by which service providers can use their IP backbones to provide VPN services to their customers. A Layer 3 VPN is a set of sites that share common routing information and whose connectivity is controlled by a collection of policies. The sites that make up a Layer 3 VPN are connected over a provider's existing Internet backbone. RFC 2547bis VPNs are also known as BGP/MPLS VPNs because BGP is used to distribute VPN routing information across the provider's backbone, and MPLS is used to forward VPN traffic across the backbone to remote VPN sites.

Customer networks, because they are private, can use either public addresses or private addresses, as defined in RFC 1918, *Address Allocation for Private Internets*. When customer networks that use private addresses connect to the Internet infrastructure, the private addresses might overlap with the same private addresses used by other network users. MPLS/BGP VPNs solve this problem by adding a *route distinguisher*, a VPN identifier prefix to each address from a particular VPN site, thereby creating an address that is unique both within the VPN and within the Internet.

In addition, each VPN has its own VPN-specific routing table that contains the routing information for that VPN only. To separate VPN routes from routes in the Internet or those in other VPNs, the PE router creates a separate routing table for each VPN called a VPN routing and forwarding (VRF) table. The PE router creates one VRF table for each VPN that has a connection to a customer edge (CE) router. Any customer or site that belongs to the VPN can access only the routes in the VRF tables for that VPN. Every VRF table has one or more extended community attributes associated with it that identify the route as belonging to a specific collection of routers. One of these, the *route target* attribute, identifies a collection of sites (VRF tables) to which a PE router distributes routes. The PE router uses the route target to constrain the import of remote routes into its VRF tables.

When an ingress PE router receives routes advertised from a directly connected CE router, it checks the received route against the VRF export policy for that VPN.

- If the route matches, the route is converted to VPN-IPv4 format—that is, the route distinguisher is added to the route. The PE router then announces the route in VPN-IPv4 format to the remote PE routers. It also attaches a route target to each route learned from the directly connected sites. The route target attached to each route is based on the configured export target policy of the VRF table. The routes are then distributed using IBGP sessions, which are configured in the provider's core network.
- If the route from the CE router does not match, it is not exported to other PE routers, but it can still be used locally for routing, for example, if two CE routers in the same VPN are directly connected to the same PE router.

When an egress PE router receives a route, it checks it against the import policy on the IBGP session between the PE routers. If it passes, the router places the route into its bgp.l3vpn.0 table. At the same time, the router checks the route against the VRF import policy for the VPN. If it matches, the route distinguisher is removed from the route and the route is placed into the VRF table (the *routing-instance-name*.inet.0 table) in IPv4 format.

Related Documentation

- Layer 2 Circuit Overview
- Layer 2 VPN Overview on page 3
- Interconnecting Layer 2 VPNs with Layer 3 VPNs Overview on page 7
- Applications for Interconnecting a Layer 2 Circuit with a Layer 3 VPN
- Example: Interconnecting a Layer 2 Circuit with a Layer 3 VPN
- Example: Interconnecting a Layer 2 VPN with a Layer 3 VPN on page 9

Interconnecting Layer 2 VPNs with Layer 3 VPNs Overview

As MPLS-based Layer 2 services grow in demand, new challenges arise for service providers to be able to interoperate with Layer 2 and Layer 3 services and give their customers value-added services. Junos OS has various features to address the needs of service providers. One of these features is the use of a logical tunnel interface. This Junos OS functionality makes use of a tunnel PIC to loop packets out and back from the Packet Forwarding Engine to link the Layer 2 network with the Layer 3 network. The solution is limited by the logical tunnel bandwidth constraints imposed by the tunnel PIC.

Interconnecting Layer 2 VPNs with Layer 3 VPNs Applications

Interconnecting a Layer 2 VPN with a Layer 3 VPN provides the following benefits:

- A single access line to provide multiple services—Traditional VPNs over Layer 2 circuits require the provisioning and maintenance of separate networks for IP and for VPN services. In contrast, Layer 2 VPNs enable the sharing of a provider's core network infrastructure between IP and Layer 2 VPN services, thereby reducing the cost of providing those services.
- Flexibility—Many different types of networks can be accommodated by the service provider. If all sites in a VPN are owned by the same enterprise, this is an intranet. If various sites are owned by different enterprises, the VPN is an extranet. A site can be located in more than one VPN.
- Wide range of possible policies—You can give every site in a VPN a different route to every other site, or you can force traffic between certain pairs of sites routed via a third site and so pass certain traffic through a firewall.
- Scalable network—This design enhances the scalability because it eliminates the need for provider edge (PE) routers to maintain all of the service provider's VPN routes. Each PE router maintains a VRF table for each of its directly connected sites. Each customer connection (such as a Frame Relay PVC, an ATM PVC, or a VLAN) is mapped to a specific VRF table. Thus, it is a port on the PE router and not a site that is associated with a VRF table. Multiple ports on a PE router can be associated with a single VRF table. It is the ability of PE routers to maintain multiple forwarding tables that supports the per-VPN segregation of routing information.
- Use of route reflectors—Provider edge routers can maintain IBGP sessions to route reflectors as an alternative to a full mesh of IBGP sessions. Deploying multiple route reflectors enhances the scalability of the RFC 2547bis model because it eliminates the need for any single network component to maintain all VPN routes.
- Multiple VPNs are kept separate and distinct from each other—The customer edge routers do not peer with each other. Two sites have IP connectivity over the common backbone only, and only if there is a VPN which contains both sites. This feature keeps the VPNs separate and distinct from each other, even if two VPNs have an overlapping address space.
- Simple for customers to use—Customers can obtain IP backbone services from a service provider, and they do not need to maintain their own backbones.

Related Documentation

- Layer 2 VPN Overview on page 3
- Layer 3 VPN Overview on page 5
- Example: Interconnecting a Layer 2 VPN with a Layer 3 VPN on page 9

Example: Interconnecting a Layer 2 VPN with a Layer 3 VPN

This example provides a step-by-step procedure and commands for interconnecting and verifying a Layer 2 VPN with a Layer 3 VPN. It contains the following sections:

Requirements

This example uses the following hardware and software components:

- Junos OS Release 9.3 or later
- Five MX Series routers
- Three M Series routers
- Two T Series routers

Overview and Topology

A Layer 2 VPN is a type of virtual private network (VPN) that uses MPLS labels to transport data. The communication occurs between the provider edge (PE) routers.

Layer 2 VPNs use BGP as the signaling protocol and, consequently, have a simpler design and require less provisioning overhead than traditional VPNs over Layer 2 circuits. BGP signaling also enables autodiscovery of Layer 2 VPN peers. Layer 2 VPNs can have either a full-mesh or a hub-and-spoke topology. The tunneling mechanism in the core network is, typically, MPLS. However, Layer 2 VPNs can also use other tunneling protocols, such as GRE.

Layer 3 VPNs are based on RFC 2547bis, *BGP/MPLS IP VPNs*. RFC 2547bis defines a mechanism by which service providers can use their IP backbones to provide VPN services to their customers. A Layer 3 VPN is a set of sites that share common routing information and whose connectivity is controlled by a collection of policies. The sites that make up a Layer 3 VPN are connected over a provider's existing public Internet backbone. RFC 2547bis VPNs are also known as BGP/MPLS VPNs because BGP is used to distribute VPN routing information across the provider's backbone, and MPLS is used to forward VPN traffic across the backbone to remote VPN sites.

Customer networks, because they are private, can use either public addresses or private addresses, as defined in RFC 1918, *Address Allocation for Private Internets*. When customer networks that use private addresses connect to the public Internet infrastructure, the private addresses might overlap with the same private addresses used by other network users. MPLS/BGP VPNs solve this problem by adding a *distinguisher*, a VPN identifier prefix to each address from a particular VPN site, thereby creating an address that is unique both within the VPN and within the public Internet.

In addition, each VPN has its own VPN-specific routing table that contains the routing information for that VPN only. To separate a VPN's routes from routes in the public Internet or those in other VPNs, the PE router creates a separate routing table for each VPN called a VPN routing and forwarding (VRF) table. The PE router creates one VRF table for each VPN that has a connection to a customer edge (CE) router. Any customer or site that belongs to the VPN can access only the routes in the VRF tables for that VPN. Every VRF table has one or more extended community attributes associated with it that identify the route as belonging to a specific collection of routers. One of these, the *route target* attribute, identifies a collection of sites (VRF tables) to which a PE router distributes routes. The PE router uses the route target to constrain the import of remote routes into its VRF tables.

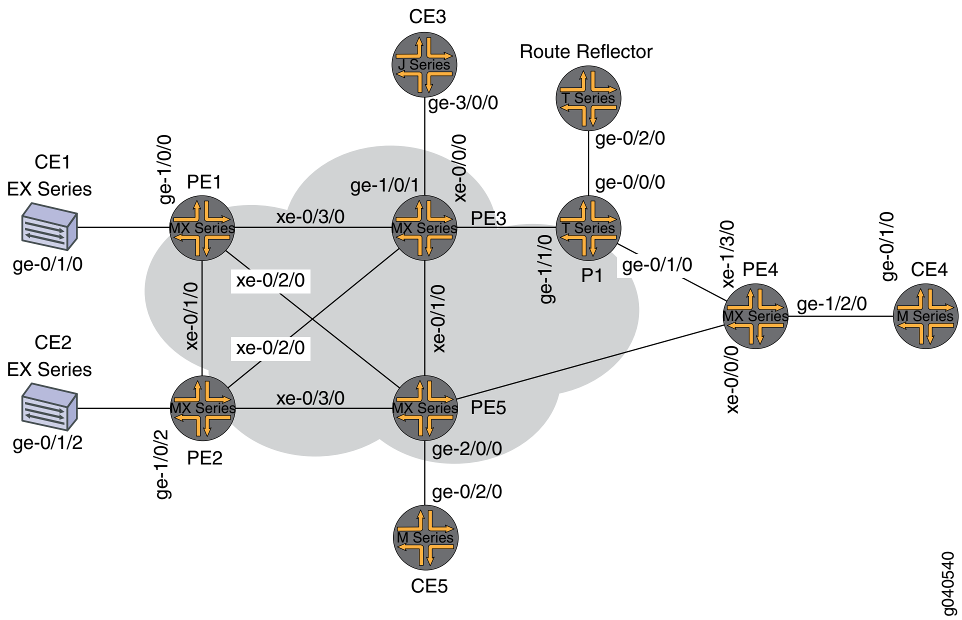
When an ingress PE router receives routes advertised from a directly connected CE router, it checks the received route against the VRF export policy for that VPN.

- If it matches, the route is converted to VPN-IPv4 format—that is, the route distinguisher is added to the route. The PE router then announces the route in VPN-IPv4 format to the remote PE routers. It also attaches a route target to each route learned from the directly connected sites. The route target attached to the route is based on the value of the VRF table's configured export target policy. The routes are then distributed using IBGP sessions, which are configured in the provider's core network.
- If the route from the CE router does not match, it is not exported to other PE routers, but it can still be used locally for routing, for example, if two CE routers in the same VPN are directly connected to the same PE router.

When an egress PE router receives a route, it checks it against the import policy on the IBGP session between the PE routers. If it passes, the router places the route into its bgp.l3vpn.0 table. At the same time, the router checks the route against the VRF import policy for the VPN. If it matches, the route distinguisher is removed from the route and the route is placed into the VRF table (the *routing-instance-name*.inet.0 table) in IPv4 format.

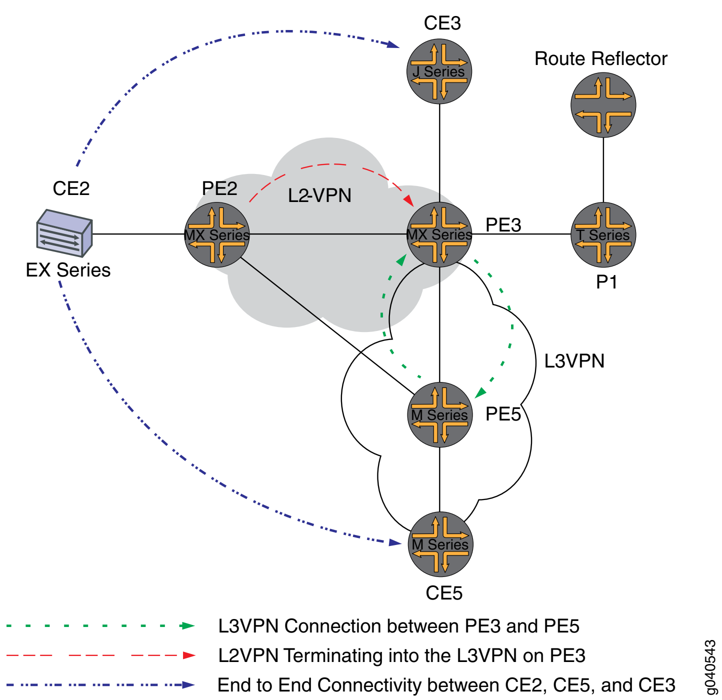
Figure 1 on page 11 shows the physical topology of a Layer 2 VPN-to-Layer 3 VPN interconnection.

Figure 1: Physical Topology of a Layer 2 VPN Terminating into a Layer 3 VPN



The logical topology of a Layer 2 VPN-to-Layer 3 VPN interconnection is shown in Figure 2 on page 11.

Figure 2: Logical Topology of a Layer 2 VPN Terminating into a Layer 3 VPN



The following definitions describe the meaning of the device abbreviations used in Figure 1 on page 11 and Figure 2 on page 11.

- Customer edge (CE) device—A device at the customer premises that provides access to the service provider's VPN over a data link to one or more provider edge (PE) routers.

  Typically the CE device is an IP router that establishes an adjacency with its directly connected PE routers. After the adjacency is established, the CE router advertises the site's local VPN routes to the PE router and learns remote VPN routes from the PE router.

- Provider edge (PE) device—A device, or set of devices, at the edge of the provider network that presents the provider's view of the customer site.

  PE routers exchange routing information with CE routers. PE routers are aware of the VPNs that connect through them, and PE routers maintain VPN state. A PE router is only required to maintain VPN routes for those VPNs to which it is directly attached. After learning local VPN routes from CE routers, a PE router exchanges VPN routing information with other PE routers using IBGP. Finally, when using MPLS to forward VPN data traffic across the provider's backbone, the ingress PE router functions as the ingress label-switching router (LSR) and the egress PE router functions as the egress LSR.

- Provider (P) device—A device that operates inside the provider's core network and does not directly interface to any CE.

  Although the P device is a key part of implementing VPNs for the service provider's customers and may provide routing for many provider-operated tunnels that belong to different VPNs, it is not itself VPN-aware and does not maintain VPN state. Its principal role is allowing the service provider to scale its VPN offerings, for example, by acting as an aggregation point for multiple PE routers.

  P routers function as MPLS transit LSRs when forwarding VPN data traffic between PE routers. P routers are required only to maintain routes to the provider's PE routers; they are not required to maintain specific VPN routing information for each customer site.

Configuration

To interconnect a Layer 2 VPN with a Layer 3 VPN, perform these tasks:

- Configuring the Base Protocols and Interfaces on page 12
- Configuring the VPN Interfaces on page 16

Configuring the Base Protocols and Interfaces

Step-by-Step Procedure

1. On each PE and P router, configure OSPF with traffic engineering extensions on all interfaces. Disable OSPF on the **fxp0.0** interface.

```
[edit protocols]
ospf {
  traffic-engineering;
  area 0.0.0.0 {
    interface all;
```

```
      interface fxp0.0 {
         disable;
      }
   }
}
```

2. On all the core routers, enable MPLS on all interfaces. Disable MPLS on the **fxp0.0** interface.

```
[edit protocols]
mpls {
   interface all;
   interface fxp0.0 {
      disable;
   }
}
```

3. On all the core routers, create an internal BGP peer group and specify the route reflector address (7.7.7.7) as the neighbor. Also enable BGP to carry Layer 2 VPLS network layer reachability information (NLRI) messages for this peer group by including the **signaling** statement at the **[edit protocols bgp group *group-name* family l2vpn]** hierarchy level.

```
[edit protocols]
bgp {
   group RR {
      type internal;
      local-address 2.2.2.2;
      family l2vpn {
         signaling;
      }
      neighbor 7.7.7.7;
   }
}
```

4. On Router PE3, create an internal BGP peer group and specify the route reflector IP address (7.7.7.7) as the neighbor. Enable BGP to carry Layer 2 VPLS NLRI messages for this peer group and enable the processing of VPN-IPv4 addresses by including the **unicast** statement at the **[edit protocols bgp group *group-name* family inet-vpn]** hierarchy level.

```
[edit protocols]
bgp {
   group RR {
      type internal;
      local-address 3.3.3.3;
      family inet-vpn {
         unicast;
      }
      family l2vpn {
         signaling;
      }
      neighbor 7.7.7.7;
   }
}
```


5. For the Layer 3 VPN domain on Router PE3 and Router PE5, enable RSVP on all interfaces. Disable RSVP on the **fxp0.0** interface.

```
[edit protocols]
rsvp {
   interface all;
   interface fxp0.0 {
      disable;
   }
}
```

6. On Router PE3 and Router PE5, create label-switched paths (LSPs) to the route reflector and the other PE routers. The following example shows the configuration on Router PE5.

```
[edit protocols]
mpls {
   label-switched-path to-RR {
      to 7.7.7.7;
   }
   label-switched-path to-PE2 {
      to 2.2.2.2;
   }
   label-switched-path to-PE3 {
      to 3.3.3.3;
   }
   label-switched-path to-PE4 {
      to 4.4.4.4;
   }
   label-switched-path to-PE1 {
      to 1.1.1.1;
   }
}
```

7. On Routers PE1, PE2, PE3, and PE5, configure the core interfaces with an IPv4 address and enable the MPLS address family. The following example shows the configuration of the **xe-0/1/0** interface on Router PE2.

```
[edit]
interfaces {
   xe-0/1/0 {
      unit 0 {
         family inet {
            address 10.10.2.2/30;
         }
         family mpls;
      }
   }
}
```


8. On Router PE2 and Router PE3, configure LDP for the Layer 2 VPN MPLS signaling protocol for all interfaces. Disable LDP on the **fxp0.0** interface. (RSVP can also be used.)

```
[edit protocols]
ldp {
   interface all;
   interface fxp0.0 {
      disable;
   }
}
```

9. On the route reflector, create an internal BGP peer group and specify the PE routers IP addresses as the neighbors.

```
[edit]
protocols {
   bgp {
      group RR {
         type internal;
         local-address 7.7.7.7;
         family inet {
            unicast;
         }
         family inet-vpn {
            unicast;
         }
         family l2vpn {
            signaling;
         }
         cluster 7.7.7.7;
         neighbor 1.1.1.1;
         neighbor 2.2.2.2;
         neighbor 4.4.4.4;
         neighbor 5.5.5.5;
         neighbor 3.3.3.3;
      }
   }
}
```

10. On the route reflector, configure MPLS LSPs towards Routers PE3 and PE5 to resolve the BGP next hops from inet.3 routing table.

```
[edit]
protocols {
   mpls {
      label-switched-path to-pe3 {
         to 3.3.3.3;
      }
      label-switched-path to-pe5 {
         to 5.5.5.5;
      }
      interface all;
   }
}
```

Configuring the VPN Interfaces

Step-by-Step Procedure

Router PE2 is one end of the Layer 2 VPN. Router PE3 is performing the Layer 2 VPN stitching between the Layer 2 VPN and the Layer 3 VPN. Router PE3 uses the logical tunnel interface (**lt** interface) configured with different logical interface units applied under two different Layer 2 VPN instances. The packet is looped though the **lt** interface configured on Router PE3. The configuration of Router PE5 contains the PE-CE interface.

1. On Router PE2, configure the **ge-1/0/2** interface encapsulation. Include the encapsulation statement and specify the **ethernet-ccc** option (**vlan-ccc** encapsulation is also supported) at the **[edit interfaces ge-1/0/2]** hierarchy level. The encapsulation should be the same in a whole Layer 2 VPN domain (Routers PE2 and PE3). Also, configure interface **lo0**.

```
[edit]
interfaces {
  ge-1/0/2 {
    encapsulation ethernet-ccc;
    unit 0;
  }
  lo0 {
    unit 0 {
      family inet {
        address 2.2.2.2/32;
      }
    }
  }
}
```

2. On Router PE2, configure the routing instance at the [**edit routing-instances]** hierarchy level. Also, configure the Layer 2 VPN protocol at the [**edit routing-instances *routing-instances-name* protocols]** hierarchy level. Configure the remote site ID as 3. Site ID 3 represents Router PE3 (Hub-PE). The Layer 2 VPN is using LDP as the signaling protocol. Be aware that in the following example, both the routing instance and the protocol are named **l2vpn**.

```
[edit]
routing-instances {
  l2vpn { # routing instance
    instance-type l2vpn;
    interface ge-1/0/2.0;
    route-distinguisher 65000:2;
    vrf-target target:65000:2;
    protocols {
      l2vpn { # protocol
        encapsulation-type ethernet;
        site CE2 {
          site-identifier 2;
          interface ge-1/0/2.0 {
            remote-site-id 3;
          }
        }
      }
    }
```



```
    }
  }
```

3. On Router PE5, configure the Gigabit Ethernet interface for the PE-CE link **ge-2/0/0** and configure the **lo0** interface.

```
[edit interfaces]
ge-2/0/0 {
  unit 0 {
    family inet {
      address 80.80.80.1/24;
    }
  }
}
lo0 {
  unit 0 {
  }
}
```

4. On Router PE5, configure the Layer 3 VPN routing instance (**L3VPN**) at the **[edit routing-instances]** hierarchy level. Also configure BGP at the **[edit routing-instances L3VPN protocols]** hierarchy level.

```
[edit]
routing-instances {
  L3VPN {
    instance-type vrf;
    interface ge-2/0/0.0;
    route-distinguisher 65000:5;
    vrf-target target:65000:2;
    vrf-table-label;
    protocols {
      bgp {
        group ce5 {
          neighbor 80.80.80.2 {
            peer-as 200;
          }
        }
      }
    }
  }
}
```

5. In an MX Series router, such as Router PE3, you must create the tunnel services interface to be used for tunnel services. To create the tunnel service interface, include the **bandwidth** statement and specify the amount of bandwidth to reserve for tunnel services in gigabits per second at the **[edit chassis fpc *slot-number* pic *slot-number* tunnel-services]** hierarchy level.

```
[edit]
chassis {
  dump-on-panic;
  fpc 1 {
    pic 1 {
      tunnel-services {
        bandwidth 1g;
      }
```

```
            }
        }
    }
```

6. On Router PE3, configure the Gigabit Ethernet interface.

   Include the **address** statement at the **[edit interfaces ge-1/0/1.0 family inet]** hierarchy level and specify **90.90.90.1/24** as the IP address.

   ```
   [edit]
   interfaces {
       ge-1/0/1 {
           unit 0 {
               family inet {
                   address 90.90.90.1/24;
               }
           }
       }
   }
   ```

7. On Router PE3, configure the **lt-1/1/10.0** logical tunnel interface at the **[edit interfaces lt-1/1/10 unit 0]** hierarchy level. Router PE3 is the router that is *stitching* the Layer 2 VPN to the Layer 3 VPN using the logical tunnel interface. The configuration of the peer unit interfaces is what makes the interconnection.

   To configure the interface, include the **encapsulation** statement and specify the **ethernet-ccc** option. Include the **peer-unit** statement and specify the logical interface unit **1** as the peer tunnel interface. Include the **family** statement and specify the **ccc** option.

   ```
   [edit]
   interfaces {
       lt-1/1/10 {
           unit 0 {
               encapsulation ethernet-ccc;
               peer-unit 1;
               family ccc;
           }
       }
   }
   ```

8. On Router PE3, configure the **lt-1/1/10.1** logical tunnel interface at the **[edit interfaces lt-1/1/10 unit 1]** hierarchy level.

   To configure the interface, include the **encapsulation** statement and specify the **ethernet** option. Include the **peer-unit** statement and specify the logical interface unit **0** as the peer tunnel interface. Include the **family** statement and specify the **inet** option. Include the **address** statement at the **[edit interfaces lt-1/1/10 unit 0]** hierarchy level and specify **70.70.70.1/24** as the IPv4 address.

   ```
   [edit]
   interfaces {
       lt-1/1/10 {
           unit 1 {
               encapsulation ethernet;
               peer-unit 0;
               family inet {
   ```



```
            address 70.70.70.1/24;
          }
        }
      }
    }
```

9. On Router PE3, add the **lt** interface unit 1 to the routing instance at the **[edit routing-instances L3VPN]** hierarchy level. Configure the instance type as **vrf** with **lt** peer-unit 1 as a PE-CE interface to terminate the Layer 2 VPN on Router PE2 into the Layer 3 VPN on Router PE3.

```
[edit]
routing-instances {
  L3VPN {
    instance-type vrf;
    interface ge-1/0/1.0;
    interface lt-1/1/10.1;
    route-distinguisher 65000:33;
    vrf-target target:65000:2;
    vrf-table-label;
    protocols {
      bgp {
        export direct;
        group ce3 {
          neighbor 90.90.90.2 {
            peer-as 100;
          }
        }
      }
    }
  }
}
```

10. On Router PE3, add the **lt** interface unit 0 to the routing instance at the **[edit routing-instances protocols l2vpn]** hierarchy level. Also configure the same vrf target for the Layer 2 VPN and Layer 3 VPN routing instances, so that the routes can be leaked between the instances. The example configuration in the previous step shows the vrf target for the **L3VPN** routing instance. The following example shows the vrf target for the **l2vpn** routing instance.

```
[edit]
routing-instances {
  l2vpn {
    instance-type l2vpn;
    interface lt-1/1/10.0;
    route-distinguisher 65000:3;
    vrf-target target:65000:2;
    protocols {
      l2vpn {
        encapsulation-type ethernet;
        site CE3 {
          site-identifier 3;
          interface lt-1/1/10.0 {
            remote-site-id 2;
          }
        }
```



```
            }
          }
        }
      }
```

11. On Router PE3, configure the **policy-statement** statement to export the routes learned from the directly connected **lt** interface unit 1 to all the CE routers for connectivity, if needed.

```
[edit]
policy-options {
  policy-statement direct {
    term 1 {
      from protocol direct;
      then accept;
    }
  }
}
```

Results The following output shows the full configuration of Router PE2:

Router PE2

```
interfaces {
  xe-0/1/0 {
    unit 0 {
      family inet {
        address 10.10.2.2/30;
      }
      family mpls;
    }
  }
  xe-0/2/0 {
    unit 0 {
      family inet {
        address 10.10.5.1/30;
      }
      family mpls;
    }
  }
  xe-0/3/0 {
    unit 0 {
      family inet {
        address 10.10.4.1/30;
      }
      family mpls;
    }
  }
  ge-1/0/2 {
    encapsulation ethernet-ccc;
    unit 0;
  }
  fxp0 {
    apply-groups [ re0 re1 ];
  }
  lo0 {
    unit 0 {
      family inet {
```



```
                address 2.2.2.2/32;
            }
        }
    }
}
routing-options {
    static {
        route 172.0.0.0/8 next-hop 172.19.59.1;
    }
    autonomous-system 65000;
}
protocols {
    mpls {
        interface all;
        interface fxp0.0 {
            disable;
        }
    }
    bgp {
        group RR {
            type internal;
            local-address 2.2.2.2;
            family l2vpn {
                signaling;
            }
            neighbor 7.7.7.7;
        }
    }
    ospf {
        traffic-engineering;
        area 0.0.0.0 {
            interface all;
            interface fxp0.0 {
                disable;
            }
        }
    }
    ldp {
        interface all;
        interface fxp0.0 {
            disable;
        }
    }
}
routing-instances {
    l2vpn {
        instance-type l2vpn;
        interface ge-1/0/2.0;
        route-distinguisher 65000:2;
        vrf-target target:65000:2;
        protocols {
            l2vpn {
                encapsulation-type ethernet;
                site CE2 {
                    site-identifier 2;
                    interface ge-1/0/2.0 {
```



```
                    remote-site-id 3;
                }
            }
        }
    }
}
```

The following output shows the final configuration of Router PE5:

Router PE5

```
interfaces {
    ge-0/0/0 {
        unit 0 {
            family inet {
                address 10.10.4.2/30;
            }
            family mpls;
        }
    }
    xe-0/1/0 {
        unit 0 {
            family inet {
                address 10.10.6.2/30;
            }
            family mpls;
        }
    }
    ge-1/0/0 {
        unit 0 {
            family inet {
                address 10.10.9.1/30;
            }
            family mpls;
        }
    }
    xe-1/1/0 {
        unit 0 {
            family inet {
                address 10.10.3.2/30;
            }
            family mpls;
        }
    }
    ge-2/0/0 {
        unit 0 {
            family inet {
                address 80.80.80.1/24;
            }
        }
    }
    lo0 {
        unit 0 {
            family inet {
                address 5.5.5.5/32;
            }
        }
```



```
    }
}
routing-options {
    static {
        route 172.0.0.0/8 next-hop 172.19.59.1;
    }
    autonomous-system 65000;
}
protocols {
    rsvp {
        interface all {
            link-protection;
        }
        interface fxp0.0 {
            disable;
        }
    }
    mpls {
        label-switched-path to-RR {
            to 7.7.7.7;
        }
        label-switched-path to-PE2 {
            to 2.2.2.2;
        }
        label-switched-path to-PE3 {
            to 3.3.3.3;
        }
        label-switched-path to-PE4 {
            to 4.4.4.4;
        }
        label-switched-path to-PE1 {
            to 1.1.1.1;
        }
        interface all;
        interface fxp0.0 {
            disable;
        }
    }
    bgp {
        group to-rr {
            type internal;
            local-address 5.5.5.5;
            family inet-vpn {
                unicast;
            }
            family l2vpn {
                signaling;
            }
            neighbor 7.7.7.7;
        }
    }
    ospf {
        traffic-engineering;
        area 0.0.0.0 {
            interface all;
            interface fxp0.0 {
```

```
            disable;
          }
        }
      }
      ldp {
        interface all;
        interface fxp0.0 {
          disable;
        }
      }
    }
    routing-instances {
      L3VPN {
        instance-type vrf;
        interface ge-2/0/0.0;
        route-distinguisher 65000:5;
        vrf-target target:65000:2;
        vrf-table-label;
        protocols {
          bgp {
            group ce5 {
              neighbor 80.80.80.2 {
                peer-as 200;
              }
            }
          }
        }
      }
    }
```

The following output shows the final configuration of Router PE3:

Router PE3

```
chassis {
  dump-on-panic;
  fpc 1 {
    pic 1 {
      tunnel-services {
        bandwidth 1g;
      }
    }
  }
  network-services ip;
}
interfaces {
  ge-1/0/1 {
    unit 0 {
      family inet {
        address 90.90.90.1/24;
      }
    }
  }
  lt-1/1/10 {
    unit 0 {
      encapsulation ethernet-ccc;
      peer-unit 1;
      family ccc;
```



```
            }
            unit 1 {
                encapsulation ethernet;
                peer-unit 0;
                family inet {
                    address 70.70.70.1/24;
                }
            }
        }
        xe-2/0/0 {
            unit 0 {
                family inet {
                    address 10.10.20.2/30;
                }
                family mpls;
            }
        }
        xe-2/1/0 {
            unit 0 {
                family inet {
                    address 10.10.6.1/30;
                }
                family mpls;
            }
        }
        xe-2/2/0 {
            unit 0 {
                family inet {
                    address 10.10.5.2/30;
                }
                family mpls;
            }
        }
        xe-2/3/0 {
            unit 0 {
                family inet {
                    address 10.10.1.2/30;
                }
                family mpls;
            }
        }
        lo0 {
            unit 0 {
                family inet {
                    address 3.3.3.3/32;
                }
            }
        }
    }
    routing-options {
        static {
            route 172.0.0.0/8 next-hop 172.19.59.1;
        }
        autonomous-system 65000;
    }
    protocols {
```

```
rsvp {
   interface all;
   interface fxp0.0 {
      disable;
   }
}
mpls {
   label-switched-path to-RR {
      to 7.7.7.7;
   }
   }
   label-switched-path to-PE2 {
      to 2.2.2.2;
   }
   label-switched-path to-PE5 {
      to 5.5.5.5;
   }
   label-switched-path to-PE4 {
      to 4.4.4.4;
   }
   label-switched-path to-PE1 {
      to 1.1.1.1;
   }
   interface all;
   interface fxp0.0 {
      disable;
   }
}
bgp {
   group RR {
      type internal;
      local-address 3.3.3.3;
      family inet-vpn {
         unicast;
      }
      family l2vpn {
         signaling;
      }
      neighbor 7.7.7.7;
   }
}
ospf {
   traffic-engineering;
   area 0.0.0.0 {
      interface all;
      interface fxp0.0 {
         disable;
      }
   }
}
ldp {
   interface all;
   interface fxp0.0 {
      disable;
   }
}
```



```
}
policy-options {
  policy-statement direct {
    term 1 {
      from protocol direct;
      then accept;
    }
  }
}
routing-instances {
  L3VPN {
    instance-type vrf;
    interface ge-1/0/1.0;
    interface lt-1/1/10.1;
    route-distinguisher 65000:33;
    vrf-target target:65000:2;
    vrf-table-label;
    protocols {
      bgp {
        export direct;
        group ce3 {
          neighbor 90.90.90.2 {
            peer-as 100;
          }
        }
      }
    }
  }
  l2vpn {
    instance-type l2vpn;
    interface lt-1/1/10.0;
    route-distinguisher 65000:3;
    vrf-target target:65000:2;
    protocols {
      l2vpn {
        encapsulation-type ethernet;
        site CE3 {
          site-identifier 3;
          interface lt-1/1/10.0 {
            remote-site-id 2;
          }
        }
      }
    }
  }
}
```

Verification

Verify the Layer 2 VPN-to-Layer 3 VPN interconnection:

- Verifying Router PE2 VPN Interface on page 28
- Verifying Router PE3 VPN Interface on page 29
- Verifying End-to-End connectivity from Router CE2 to Router CE5 and Router CE3 on page 32

Verifying Router PE2 VPN Interface

Purpose Check that the Layer 2 VPN is up and working at the Router PE2 interface and that all the routes are there.

Action

1. Use the **show l2vpn connections** command to verify that the connection site ID is 3 for Router PE3 and that the status is **Up**.

```
user@PE2> show l2vpn connections

Layer-2 VPN connections:
Legend for connection status (St)
EI -- encapsulation invalid      NC -- interface encapsulation not
CCC/TCC/VPLS
EM -- encapsulation mismatch     WE -- interface and instance encaps not
 same
VC-Dn -- Virtual circuit down    NP -- interface hardware not present
CM -- control-word mismatch      -> -- only outbound connection is up
CN -- circuit not provisioned    <- -- only inbound connection is up
OR -- out of range               Up -- operational
OL -- no outgoing label          Dn -- down
LD -- local site signaled down   CF -- call admission control failure
RD -- remote site signaled down SC -- local and remote site ID collision
LN -- local site not designated LM -- local site ID not minimum designated
RN -- remote site not designated RM -- remote site ID not minimum
designated
XX -- unknown connection status  IL -- no incoming label
MM -- MTU mismatch               MI -- Mesh-Group ID not available
BK -- Backup connection          ST -- Standby connection
PF -- Profile parse failure      PB -- Profile busy
RS -- remote site standby

Legend for interface status
Up -- operational
Dn -- down

Instance: l2vpn
  Local site: CE2 (2)
    connection-site     Type  St     Time last up         # Up trans
    3                   rmt   Up     Jan  7 14:14:37 2010        1
      Remote PE: 3.3.3.3, Negotiated control-word: Yes (Null)
      Incoming label: 800000, Outgoing label: 800001
      Local interface: ge-1/0/2.0, Status: Up, Encapsulation: ETHERNET
```

2. Use the **show route table** command to verify that the Layer 2 VPN route is present and that there is a next hop of **10.10.5.2** through the **xe-0/2/0.0** interface. The following

output verifies that the Layer 2 VPN routes are present in the l2vpn.l2vpn.0 table. Similar output should be displayed for Router PE3.

```
user@PE2> show route table l2vpn.l2vpn.0

l2vpn.l2vpn.0: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

65000:2:2:3/96
                   *[L2VPN/170/-101] 02:40:35, metric2 1
                      Indirect
65000:3:3:1/96
                   *[BGP/170] 02:40:35, localpref 100, from 7.7.7.7
                      AS path: I
                    > to 10.10.5.2 via xe-0/2/0.0
```

3. Verify that Router PE2 has a Layer 2 VPN MPLS label pointing to the LDP label to Router PE3 in both directions (PUSH and POP).

```
user@PE2> show route table mpls.0

 mpls.0: 13 destinations, 13 routes (13 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 1w3d 08:57:41, metric 1
                      Receive
1                  *[MPLS/0] 1w3d 08:57:41, metric 1
                      Receive
2                  *[MPLS/0] 1w3d 08:57:41, metric 1
                      Receive
300560             *[LDP/9] 19:45:53, metric 1
                    > to 10.10.2.1 via xe-0/1/0.0, Pop
300560(S=0)        *[LDP/9] 19:45:53, metric 1
                    > to 10.10.2.1 via xe-0/1/0.0, Pop
301008             *[LDP/9] 19:45:53, metric 1
                    > to 10.10.4.2 via xe-0/3/0.0, Swap 299856
301536             *[LDP/9] 19:45:53, metric 1
                    > to 10.10.4.2 via xe-0/3/0.0, Pop
301536(S=0)        *[LDP/9] 19:45:53, metric 1
                    > to 10.10.4.2 via xe-0/3/0.0, Pop
301712             *[LDP/9] 16:14:52, metric 1
                    > to 10.10.5.2 via xe-0/2/0.0, Swap 315184
301728             *[LDP/9] 16:14:52, metric 1
                    > to 10.10.5.2 via xe-0/2/0.0, Pop
301728(S=0)        *[LDP/9] 16:14:52, metric 1
                    > to 10.10.5.2 via xe-0/2/0.0, Pop
800000       *[L2VPN/7] 02:40:35
        > via ge-1/0/2.0, Pop      Offset: 4
ge-1/0/2.0       *[L2VPN/7] 02:40:35, metric2 1
        > to 10.10.5.2 via xe-0/2/0.0, Push 800001 Offset: -4
```

Meaning The **l2vpn** routing instance is up at interface **ge-1/0/2** and the Layer 2 VPN route is shown in table l2vpn.l2vpn.0. Table **mpls.0** shows the Layer 2 VPN routes used to forward the traffic using an LDP label.

Verifying Router PE3 VPN Interface

Purpose Check that the Layer 2 VPN connection from Router PE2 and Router PE3 is **Up** and working.

Action 1. Verify that the BGP session with the route reflector for the family **l2vpn-signaling** and the family **inet-vpn** is established.

```
user@PE3> show bgp summary

Groups: 2 Peers: 2 Down peers: 0
Table        Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l2vpn.0          1          1          0          0          0          0
bgp.L3VPN.0          1          1          0          0          0          0
Peer        AS   InPkt    OutPkt   OutQ   Flaps Last Up/Dwn   State|#Active /Received/Accepted/Damped...
7.7.7.7  65000    2063      2084      0       1    15:35:16   Establ
  bgp.l2vpn.0: 1/1/1/0
  bgp.L3VPN.0: 1/1/1/0
  L3VPN.inet.0: 1/1/1/0
  l2vpn.l2vpn.0: 1/1/1/0
```

2. The following output shows the L3VPN.inet.0 routing table, which has Routers CE1, CE3, and CE5 listed.

```
user@PE3> show route table L3VPN.inet.0

L3VPN.inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

70.70.70.0/24      *[Direct/0] 02:45:16
                    > via lt-1/1/10.1
70.70.70.1/32      *[Local/0] 14:45:42
                      Local via lt-1/1/10.1
80.80.80.0/24      *[BGP/170] 02:47:51, localpref 100, from 7.7.7.7
                      AS path: I
                    > to 10.10.6.2 via xe-2/1/0.0, Push 16
90.90.90.0/24      *[Direct/0] 15:26:24
                    > via ge-1/0/1.0
90.90.90.1/32      *[Local/0] 15:26:24
                      Local via ge-1/0/1.0
```

3. The following output verifies the Layer 2 VPN route and the label associated with it.

```
user@PE3> show route table l2vpn.l2vpn.0 detail

l2vpn.l2vpn.0: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
65000:2:2:3/96 (1 entry, 1 announced)
        *BGP    Preference: 170/-101
                Route Distinguisher: 65000:2
                Next hop type: Indirect
                Next-hop reference count: 4
                Source: 7.7.7.7
                Protocol next hop: 2.2.2.2
                Indirect next hop: 2 no-forward
                State: <Secondary Active Int Ext>
                Local AS: 65000 Peer AS: 65000
                Age: 2:45:52    Metric2: 1
                Task: BGP_65000.7.7.7.7+60585
                Announcement bits (1): 0-l2vpn-l2vpn
                AS path: I (Originator) Cluster list:  7.7.7.7
                AS path:  Originator ID: 2.2.2.2
               Communities: target:65000:2 Layer2-info: encaps:ETHERNET,
 control flags:Control-Word, mtu: 0, site preference: 100  Accepted
                Label-base: 800000, range: 2, status-vector: 0x0
                Localpref: 100
```



```
Router ID: 7.7.7.7
Primary Routing Table bgp.l2vpn.0
```

4. The following output show the L2VPN MPLS.0 route in the mpls.0 route table.

```
user@PE3> show route table mpls.0

mpls.0: 21 destinations, 21 routes (21 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 1w3d 09:05:41, metric 1
                      Receive
1                  *[MPLS/0] 1w3d 09:05:41, metric 1
                      Receive
2                  *[MPLS/0] 1w3d 09:05:41, metric 1
                      Receive
16                 *[VPN/0] 15:59:24
                      to table L3VPN.inet.0, Pop
315184             *[LDP/9] 16:21:53, metric 1
                    > to 10.10.20.1 via xe-2/0/0.0, Pop
315184(S=0)        *[LDP/9] 16:21:53, metric 1
                    > to 10.10.20.1 via xe-2/0/0.0, Pop
315200             *[LDP/9] 01:13:44, metric 1
                      to 10.10.20.1 via xe-2/0/0.0, Swap 625297
                    > to 10.10.6.2 via xe-2/1/0.0, Swap 299856
315216             *[LDP/9] 16:21:53, metric 1
                    > to 10.10.6.2 via xe-2/1/0.0, Pop
315216(S=0)        *[LDP/9] 16:21:53, metric 1
                    > to 10.10.6.2 via xe-2/1/0.0, Pop
315232             *[LDP/9] 16:21:45, metric 1
                    > to 10.10.1.1 via xe-2/3/0.0, Pop
315232(S=0)        *[LDP/9] 16:21:45, metric 1
                    > to 10.10.1.1 via xe-2/3/0.0, Pop
315248             *[LDP/9] 16:21:53, metric 1
                    > to 10.10.5.1 via xe-2/2/0.0, Pop
315248(S=0)        *[LDP/9] 16:21:53, metric 1
                    > to 10.10.5.1 via xe-2/2/0.0, Pop
315312             *[RSVP/7] 15:02:40, metric 1
                    > to 10.10.6.2 via xe-2/1/0.0, label-switched-path
to-pe5
315312(S=0)        *[RSVP/7] 15:02:40, metric 1
                    > to 10.10.6.2 via xe-2/1/0.0, label-switched-path
to-pe5
315328             *[RSVP/7] 15:02:40, metric 1
                    > to 10.10.20.1 via xe-2/0/0.0, label-switched-path
to-RR
315360             *[RSVP/7] 15:02:40, metric 1
                    > to 10.10.20.1 via xe-2/0/0.0, label-switched-path
to-RR
316272             *[RSVP/7] 01:13:27, metric 1
                    > to 10.10.6.2 via xe-2/1/0.0, label-switched-path
Bypass->10.10.9.1
316272(S=0)        *[RSVP/7] 01:13:27, metric 1
                    > to 10.10.6.2 via xe-2/1/0.0, label-switched-path
Bypass->10.10.9.1
800001             *[L2VPN/7] 02:47:33
                    > via lt-1/1/10.0, Pop       Offset: 4
lt-1/1/10.0        *[L2VPN/7] 02:47:33, metric2 1
                   > to 10.10.5.1 via xe-2/2/0.0, Push 800000 Offset: -4
```

5. Use the **show route table mpls.0** command with the **detail** option to see the BGP attributes of the route such as next-hop type and label operations.

```
user@PE5> show route table mpls.0 detail

lt-1/1/10.0 (1 entry, 1 announced)
        *L2VPN  Preference: 7
                Next hop type: Indirect
                Next-hop reference count: 2
                Next hop type: Router, Next hop index: 607
                Next hop: 10.10.5.1 via xe-2/2/0.0, selected
                Label operation: Push 800000 Offset: -4
                Protocol next hop: 2.2.2.2
                Push 800000 Offset: -4
                Indirect next hop: 8cae0a0 1048574
                State:  <Active Int>
                Age: 2:46:34    Metric2: 1
                Task: Common L2 VC
                Announcement bits (2): 0-KRT 2-Common L2 VC
                AS path: I
               Communities: target:65000:2 Layer2-info: encaps:ETHERNET,
 control flags:Control-Word, mtu: 0, site preference: 100
```

Verifying End-to-End connectivity from Router CE2 to Router CE5 and Router CE3

Purpose Check the connectivity between Routers CE2, CE3, and CE5.

Action

1. Ping the Router CE3 IP address from Router CE2.

```
user@CE2> ping 90.90.90.2 # CE3 IP address

PING 90.90.90.2 (90.90.90.2): 56 data bytes
64 bytes from 90.90.90.2: icmp_seq=0 ttl=63 time=0.708 ms
64 bytes from 90.90.90.2: icmp_seq=1 ttl=63 time=0.610 ms
```

2. Ping the Router CE5 IP address from Router CE2.

```
user@CE2> ping 80.80.80.2 # CE5 IP address

PING 80.80.80.2 (80.80.80.2): 56 data bytes
64 bytes from 80.80.80.2: icmp_seq=0 ttl=62 time=0.995 ms
64 bytes from 80.80.80.2: icmp_seq=1 ttl=62 time=1.005 ms
```

Related Documentation

- Layer 2 VPN Overview on page 3
- Layer 3 VPN Overview on page 5
- Interconnecting Layer 2 VPNs with Layer 3 VPNs Overview on page 7

