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Junos® OS

Translational Cross-Connect and Layer 2.5 VPNs Feature Guide

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Junos® OS Translational Cross-Connect and Layer 2.5 VPNs Feature Guide
Release 11.4

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Translational Cross-Connect and Layer 2.5 VPNs

CHAPTER 1

Translational Cross-Connect and Layer 2.5 VPNs Concepts and Reference Materials

This chapter covers these topics:

Translational Cross-Connect and Layer 2.5 VPNs Overview

Translational cross-connect (TCC) is a switching concept that allows you to establish interconnections between a variety of Layer 2 protocols or circuits. It is similar to its predecessor, circuit cross-connect (CCC). However, while CCC requires the same Layer 2 encapsulations on both sides of a Juniper Networks router (such as PPP-to-PPP or Frame Relay-to-Frame Relay), TCC lets a network administrator connect different types of Layer 2 protocols interchangeably. With TCC, combinations such as PPP-to-ATM and Ethernet-to-Frame Relay cross-connections are possible. Also, TCC can be used to create Layer 2.5 VPNs and Layer 2.5 circuits.

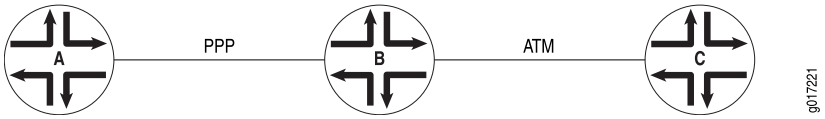
The Junos OS makes interworking between unlike protocols possible. The software strips off the Layer 2 header when frames enter the router and adds a different Layer 2 header before the frames exit the router. TCC supports these Layer 2 protocols:

- ATM
- Cisco HDLC
- Ethernet
- Extended VLAN

- Frame Relay
- PPP

In Figure 1 on page 4, the PPP header is stripped from frames arriving at Router B and an ATM header is added before the frames are sent to Router C. All Layer 2 negotiations are terminated at the interconnecting router (Router B). Examples include Link Control Protocol (LCP) and Network Control Protocol (NCP) for PPP, keepalives for Cisco HDLC, and Local Management Interface (LMI) for Frame Relay.

Figure 1: TCC Concept Example



TCC functionality is different from standard Layer 2 switching. TCC only swaps Layer 2 headers. No other processing, such as header checksums, time-to-live (TTL) decrementing, or protocol handling, is performed. Currently, TCC is supported in IPv4, ISO, and MPLS.

This guide shows you how to use the Layer 2 interworking nature of TCC for interface switching and for constructing Layer 2.5 virtual private networks (VPNs).

Translational Cross-Connect and Layer 2.5 VPNs System Requirements

To implement TCC, your system must meet these minimum requirements:

- Junos OS Release 10.1 or later for support of IS-IS and MPLS traffic over Layer 2.5 VPNs on MX Series routers.
- Junos OS Release 8.3 or later for support of IS-IS and MPLS traffic over Layer 2.5 VPNs on T Series and M320 routers.
- Junos OS Release 8.2 or later for support on M120 routers and MX Series routers
- Junos OS Release 6.2 or later for CCC, TCC, and Layer 2.5 VPN support on M320 routers
- Junos OS Release 6.0 or later for CCC, TCC, and Layer 2.5 VPN support on T Series routers
- Junos OS Release 5.6 or later for proxy Address Resolution Protocol (ARP) functionality in Ethernet TCC and extended VLAN TCC networks on M Series routers
- Junos OS Release 5.4 or later for Ethernet TCC and extended VLAN TCC interface encapsulation types on M Series routers
- Junos OS Release 5.2 or later for PPP TCC, Cisco HDLC TCC, ATM TCC, and Frame Relay TCC interface encapsulation types on M Series routers
- Ethernet-based PICs to support Ethernet TCC and extended VLAN TCC interface encapsulation types, with the following exceptions:
  - All 8-port, 12-port, and 48-port Fast Ethernet PICs do not support TCC.

  - 4-port Gigabit Ethernet PICs do not support extended VLAN TCC.

- Any combination of three Juniper Networks M Series or T Series routers for TCC or five routers for Layer 2.5 VPNs or Layer 2.5 circuits

Translational Cross-Connect and Layer 2.5 VPNs Terms and Acronyms

C

circuit cross-connect (CCC) — A method of exchanging frames between two router interfaces running the same Layer 2 protocol, such as ATM, Cisco HDLC, Ethernet, extended VLAN, Frame Relay, and PPP. For more information about CCC, see the *Junos Network Interfaces Configuration Guide*.

customer edge router (CE) — Any router that connects a customer site to a PE router.

L

Layer 2.5 circuits — A method of privately connecting sites across the Internet. Layer 2.5 circuits function like Layer 2 circuits, but connect two sites that use different Layer 2 protocols. For more information about Layer 2 circuits, see the *Junos VPNs Configuration Guide*.

Layer 2.5 VPNs — A method of privately connecting sites across the Internet. Layer 2.5 VPNs function like Layer 2 VPNs, but connect two sites that use different Layer 2 protocols. For more information about Layer 2 VPNs, see the *Junos VPNs Configuration Guide*.

P

provider core router (P) — Any router that lies between PE routers in the provider core network.

provider edge router (PE) — Any router that connects customer edge (CE) routers to the provider core network.

T

translational cross-connect (TCC) — A Juniper Networks method of exchanging frames between two router interfaces running different Layer 2 protocols, such as ATM, Cisco HDLC, Ethernet, extended VLAN, Frame Relay, and PPP. For more information about TCC, see the *Junos Network Interfaces Configuration Guide*.

Configuring Layer 2.5 VPNs

Layer 2.5 VPNs are an extension to Layer 2 VPNs. The main difference is that Layer 2.5 VPNs are not required to have the same media on both ends of the connection. In general, Layer 2.5 VPNs combine the capabilities of TCC with Layer 2 VPNs.

Layer 2.5 VPNs support the same media types as TCC: ATM, Cisco HDLC, Ethernet, extended VLAN, Frame Relay, and PPP. They support IPv4, IS-IS, and MPLS traffic types, but do not support IPv6 traffic.

Although not covered in this manual, you can also use TCC in conjunction with Layer 2 circuits to connect two CE sites that use different Layer 2 protocols. You can use these

so-called Layer 2.5 circuits as an alternative to Layer 2.5 VPNs. For more information about Layer 2 circuits, see the *Junos VPNs Configuration Guide*.

To configure Layer 2.5 VPNs, complete the following tasks:

- Configuring the Encapsulation on Interfaces Participating in the Layer 2.5 VPN on page 6
- Configuring the Layer 2.5 VPN on page 7
- Option: Configuring ISO or MPLS Traffic on T Series, M320, and MX Series Routers on page 14

Configuring the Encapsulation on Interfaces Participating in the Layer 2.5 VPN

The encapsulation types used for Layer 2.5 VPNs are parallel to CCC encapsulations and identical to the TCC encapsulations explained in "Configuring TCC Interface Switching" on page 9. The encapsulation types are:

- **atm-tcc-vc-mux**
- **atm-tcc-snap**
- **cisco-hdlc-tcc**
- **ethernet-tcc**
- **extended-vlan-tcc**
- **frame-relay-tcc**
- **ppp-tcc**

When you configure a TCC encapsulation type, some modifications are needed to handle VPN connections over unlike Layer 2 links and to terminate the Layer 2 protocol locally. The router performs the following media-specific changes:

- PPP TCC—Both Link Control Protocol (LCP) and Network Control Protocol (NCP) are terminated on the router. Internet Protocol Control Protocol (IPCP) IP address negotiation is not supported. The Junos OS strips all PPP encapsulation data from incoming frames before forwarding them. For frames destined to a PPP-connected neighbor, PPP encapsulation is added.
- Cisco HDLC TCC—Keepalive processing is terminated on the router. The Junos OS strips all Cisco HDLC encapsulation data from incoming frames before forwarding them. Cisco-HDLC encapsulation is added onto frames that are destined to a Cisco HDLC-connected neighbor.
- Frame Relay TCC—All Local Management Interface (LMI) processing is terminated on the router. The Junos OS strips all Frame Relay encapsulation data from incoming frames before forwarding them. For frames destined to a Frame Relay-connected neighbor, Frame Relay encapsulation is added.
- ATM—Operation, Administration, and Maintenance (OAM) and Interim Local Management Interface (ILMI) processing is terminated at the router. Cell relay is not

supported. The Junos OS strips all ATM encapsulation data from incoming frames before forwarding them. ATM encapsulation is added onto frames that are destined to an ATM-connected neighbor.

Configuring the Layer 2.5 VPN

Layer 2.5 VPNs use essentially the same configuration format as Layer 2 VPNs. You should already have experience configuring Layer 2 VPNs before you attempt to configure a Layer 2.5 VPN. The major steps required to create a Layer 2 VPN are:

- Enable MPLS on interfaces pointing toward the core and the edge on your provider edge (PE) and provider core (P) routers.
- Configure Label Distribution Protocol (LDP) on all P and PE routers for traffic traveling from the PEs, through the core, and to the remote PEs.
- Establish an internal BGP (IBGP) Layer 2 VPN peering relationship between PE routers.
- Set up policies on your PE routers that will set a private community tag on outbound BGP traffic heading to the remote PEs and accept incoming traffic that matches similar community traffic from the remote PEs.
- Build VPN routing and forwarding (VRF) instances on your PE routers and apply the previously configured policies to deliver private traffic to the customer edge (CE) routers.
- In addition to the above configurations procedures, you can specify a Layer 3 protocol family for a Layer 2.5 VPN on T Series and M320 routers. See the "Option: Configuring ISO or MPLS Traffic on T Series, M320, and MX Series Routers" on page 14 section for configuration information.

CHAPTER 2

Translational Cross-Connect and Layer 2.5 VPNs Configuration

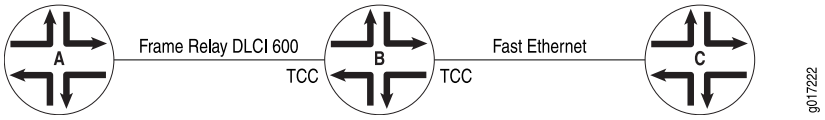
This chapter contains the following:

Configuring TCC Interface Switching

TCC joins disparate Layer 2 logical interfaces by means of a virtual Layer 2 switching technique.

Figure 2 on page 9 illustrates Layer 2 TCC switching. In this example, Router A is connected by Frame Relay to Router B and Router B is connected by Fast Ethernet to Router C. Router B is a Juniper Networks router. TCC allows you to configure Router B to act as a multiservice Layer 2 switch. To do this, you configure a connection from Router A to Router C that passes through Router B. This effectively establishes Router B as a Frame Relay-to-Fast Ethernet switch and allows the router to switch frames transparently between Router A and Router C without regard to the frames' contents or the Layer 3 protocols. Router B removes the Frame Relay header from frames arriving on data-link connection identifier (DLCI) 600 and adds an Ethernet header onto the frames before sending them to the Fast Ethernet link.

Figure 2: Layer 2 TCC Switching



You can configure Layer 2 TCC switching on ATM, Cisco HDLC, Ethernet, extended VLAN, Frame Relay, and PPP circuits. TCC enables unlike interfaces to be connected with a single cross-connect.

To configure Layer 2 TCC switching, perform the following tasks on the router that is acting as the switch (Router B in Figure 2 on page 9):

Defining the Encapsulation for Layer 2 TCC Switching

To begin implementation of Layer 2 TCC switching, configure TCC encapsulation on the desired interfaces of the router that is acting as the switch (Router B in Figure 2 on page 9).

NOTE: You cannot configure standard protocol families on TCC or CCC interfaces. Only the CCC family is allowed on CCC-encapsulated interfaces. Likewise, only the TCC family is allowed on TCC-encapsulated interfaces.

For ATM connections, specify the encapsulation type when configuring ATM virtual circuits (VCs) at the **[edit interfaces *interface-name* unit *unit-number*]** hierarchy level. For each VC, you configure whether it is a circuit or a regular logical interface. The default interface type is **point-to-point**.

```
[edit]
interfaces {
  at-fpc/pic/port {
    atm-options {
      vpi vpi-identifier  maximum-vcs maximum-vcs;
    }
    unit logical-unit-number {
      point-to-point; # This is the default interface type.
      encapsulation (atm-tcc-vc-mux | atm-tcc-snap);
      vci vpi-identifier.vci-identifier;
    }
  }
}
```

For Cisco HDLC and PPP circuits, specify the encapsulation in the **encapsulation** statement at the **[edit interfaces *interface-name*]** hierarchy level. This statement configures the entire physical device. Also, you must configure the logical interface **unit 0**.

```
[edit]
```

```
interfaces {
  type-fpc/pic/port {
    encapsulation (cisco-hdlc-tcc | ppp-tcc);
    unit 0;
  }
}
```

You can specify the encapsulation for Frame Relay circuits at the **[edit interfaces *interface-name*]** hierarchy level and the **[edit interfaces *interface-name* unit *unit-number*]** hierarchy level. For TCC and CCC interfaces, the DLCI value must be configured in the range of 512 through 1022. The default interface type is **point-to-point**.

```
[edit]
interfaces {
  type-fpc/pic/port  {
    encapsulation frame-relay-tcc;
    unit logical-unit-number {
      point-to-point; # This is the default interface type.
      encapsulation frame-relay-tcc;
      dlci dlci-identifier;
    }
  }
}
```

Configuring ARP Functionality for Ethernet TCC Circuits

For Ethernet TCC circuits, include the **encapsulation ethernet-tcc** statement. This statement configures the encapsulation for the entire physical interface.

To provide Address Resolution Protocol (ARP) functionality for an Ethernet-based neighbor, configure the **remote** statement at the **[edit interfaces *interface-name* unit *unit-number* family tcc]** hierarchy level and specify either the MAC address or IP address of the TCC router's Ethernet neighbor. To complete the setup of ARP, configure the **proxy** statement at the **[edit interfaces *interface-name* unit *unit-number* family tcc]** hierarchy level and specify the IP address of the TCC router's non-Ethernet neighbor.

APR packet policing on TCC Ethernet interfaces is effective for Junos OS Release 10.4 and later on all platforms except the M7i, M10i, and M40e routers.

```
[edit]
interfaces
EthernetType-fpc/pic/port {
  encapsulation ethernet-tcc;
  unit 0 {
    family tcc {
      remote { # Addresses associated with the Ethernet TCC neighbor.
        mac-address mac-address; # Select a MAC or IP address.
        inet-address inet-address;
      }
      proxy { # Addresses belonging to the non-Ethernet TCC neighbor.
        inet-address inet-address;
      }
    }
  }
```

```
}
```

Configuring ARP Functionality for Extended VLAN Circuits

For extended VLAN circuits, include the **encapsulation extended-vlan-tcc** statement. This statement configures the encapsulation for the entire physical interface.

You must also enable VLAN tagging. Ethernet interfaces in VLAN mode can have multiple logical interfaces. For encapsulation type **extended-vlan-tcc**, all VLAN IDs from 0 through 4094 are valid, up to a maximum of 1024 VLANs.

To enable ARP functionality, configure the **remote** statement at the **[edit interfaces** *interface-name* **unit** *unit-number* **family tcc]** hierarchy level with either the MAC address or IP address of your Ethernet TCC neighbor. To complete the ARP setup, configure the **proxy** statement at the **[edit interfaces** *interface-name* **unit** *unit-number* **family tcc]** hierarchy level and specify the IP address of the non-Ethernet TCC neighbor.

```
[edit]
interfaces {
  EthernetType-fpc/pic/port {
    vlan-tagging;
    encapsulation extended-vlan-tcc;
    unit 0 {
      vlan-id 600;
      family tcc {
        remote { # Addresses associated with the Ethernet TCC neighbor.
          mac-address mac-address; # Select a MAC or IP address.
          inet-address inet-address;
        }
        proxy { # Addresses belonging to the non-Ethernet TCC neighbor.
          inet-address inet-address;
        }
      }
    }
  }
}
```

Configuring Static ARP For Ethernet and Extended VLAN TCCs

If you do not use the **proxy** statement to configure ARP functionality in an Ethernet TCC or extended VLAN TCC, you must use another method to allow ARP to function. To retain the functionality of ARP for Ethernet networks, you must configure static ARP on the Ethernet neighbor. Use of static ARP assumes that you have already configured the **remote** statement on the TCC router (see "Configuring ARP Functionality for Ethernet TCC Circuits" on page 11 and "Configuring ARP Functionality for Extended VLAN Circuits" on page 12).

You configure the **arp** statement on the Ethernet neighbor at the **[edit interfaces** *interface-number* **unit** *unit-number* **family inet address** *ip-address***]** hierarchy level. Your static ARP statement must contain the IP address of the non-Ethernet neighbor on the opposite side of the TCC router and the Ethernet interface MAC address of the TCC router.

This static ARP configuration enables return path ARP functionality and complements the **remote** statement previously set on the TCC router.

In Figure 4 on page 17, you would configure an ARP statement on the **fe-0/0/0** interface of Router C. The ARP statement would contain the IP address for interface **so-0/1/0.600** on Router A and the MAC address of the **fe-1/0/0** interface of Router B.

Configure static ARP on an Ethernet neighbor at the **[edit interfaces *interface-name* unit *unit-number* family inet address *ip-address*]** hierarchy level.

```
[edit]
interfaces
EthernetType-fpc/pic/port {
   unit 0 {
      family inet {
         address ip-address { # The local IP address.
            arp ip-address mac mac-address; # IP address of the non-Ethernet
         }       # TCC neighbor and MAC address of the TCC
      }       # router's Ethernet interface.
   }
}
```

Defining the Connection for Layer 2 TCC Switching

The next step in configuring Layer 2 TCC switching is to define the connection between the two circuits. You configure this on the router acting as the TCC switch. When you specify the interface names, include the logical portion of the name, which corresponds to the logical unit number. The cross-connect is bidirectional, so packets received on the first interface are transmitted by the second interface, and those received on the second interface are transmitted by the first.

```
[edit]
protocols {
   connections {
      interface-switch connection-name {
         interface first-interface-name.unit-number;
         interface second-interface-name.unit-number;
      }
   }
}
```

Configuring MPLS

You must also configure MPLS for a Layer 2 cross-connect to work. The following is a minimal MPLS configuration:

```
[edit]
interfaces {
   interface-name  {
      unit  logical-unit-number;
   }
}
protocols {
   mpls {
```

```
    interface all;
  }
}
```

Option: Configuring ISO or MPLS Traffic on T Series, M320, and MX Series Routers

Layer 2.5 VPNs on T Series, M320, and MX Series routers support IPv4, IS-IS, and MPLS traffic types. Layer 2.5 VPNs running on M Series routers support only IPv4 traffic. Layer 2.5 VPNs do not support IPv6.

By default, IPv4 traffic runs on T Series, M320, and MX Series routers. To configure IS-IS (ISO traffic) or MPLS traffic on Layer 2.5 VPNs, you must configure both ends of the VPN with the protocol configuration.

The same type of Layer 3 traffic must be configured on both ends of a TCC connection. By default, TCC connections carry IPv4 traffic. To specify which traffic can run over a TCC interface, include the [**inet** | **mpls** | **iso**] statement at the [**edit interfaces** *interface-name* **encapsulation** *encapsulation-type* **logical-unit-number family tcc protocol**] hierarchy level:

```
[edit]
interfaces {
  interface so-2/0/0  {
    encapsulation ppp-tcc;
      unit 0  {
      family tcc {
        protocols [iso | inet | mpls];
      }
    }
  }
}
```

When enabling ISO over a Layer 2.5 VPN that is configured on a CE Ethernet interface, include the [**point-to-point**] statement at the [**edit protocols isis interface** *interface-name*] hierarchy level:

```
[edit]
protocols {
  isis {
    interface fe-1/0/0.0 {
      point-to-point;
    }
  }
}
```

For a full explanation of Layer 2 VPNs and configuration samples, see the *Junos VPNs Configuration Guide*.

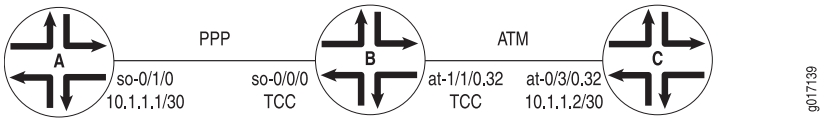
CHAPTER 3

Translational Cross-Connect and Layer 2.5 VPNs Configuration Example

This section contains configuration examples and commands you can issue to verify your Layer 2 TCC switching configuration:

Example: PPP to ATM TCC Configuration

Figure 3: TCC Interface Switching—PPP to ATM



In Figure 3 on page 15, Router A uses PPP to connect with Router B, while Router C connects with Router B through ATM. Router B acts as the Layer 2 virtual switch and transparently connects Router A to Router C.

On Router A, configure basic PPP encapsulation and any desired Layer 3 protocol families on the SONET/SDH interface.

Router A

```
[edit]
interfaces {
   so-0/1/0 {
      description "to Router B so-0/0/0";
      unit 0 {
         encapsulation ppp;
         family inet {
            address 10.1.1.1/30;
         }
      }
   }
}
```

Router B acts as the virtual Layer 2 switch. Here you configure the appropriate TCC encapsulations on the corresponding interfaces. In this case, **encapsulation ppp-tcc** is bound to physical interface **so-0/0/0**, and **encapsulation atm-tcc-vc-mux** is placed on VC 32 of interface **at-1/1/0**. Because the switching occurs at Layer 2, you cannot configure IP addresses or other Layer 3 family information on these interfaces.

You also need to configure MPLS and establish the cross-connect by adding the necessary interfaces to the **interface-switch** statement at the **[edit protocols connections]** hierarchy level.

Router B

```
[edit]
interfaces {
    so-0/0/0 {
        description "to Router A so-0/1/0";
        encapsulation ppp-tcc;
        unit 0 {
        }
        at-1/1/0 {
            description "to Router C at-0/3/0";
            atm-options {
                vpi 0 maximum-vcs 2000;
            }
            unit 32 {
                vci 32;
                encapsulation atm-tcc-vc-mux;
            }
        }
    }
    protocols {
        mpls {
            interface so-0/0/0.0;
            interface at-1/1/0.32;
        }
        connections {
            interface-switch PPP-to-ATM {
                interface so-0/0/0.0;
                interface at-1/1/0.32;
            }
        }
    }
}
```

On Router C, the encapsulation option used to connect to the TCC-encapsulated ATM interface on Router B is **atm-vc-mux**. Since this ATM connection is switched at Layer 2 to reach the PPP link, it is transparent to Layer 3 addressing. As a result, the IP address must be configured in the same address space as Router A's **so-0/1/0** interface.

Router C

```
[edit]
interfaces {
    at-0/3/0 {
        description "to Router B at-1/1/0";
        atm-options {
            vpi 0 maximum-vcs 2000;
        }
        unit 32 {
```

```
        vci 32;
        encapsulation atm-vc-mux;
        family inet {
          address 10.1.1.2/30;
        }
      }
    }
  }
```

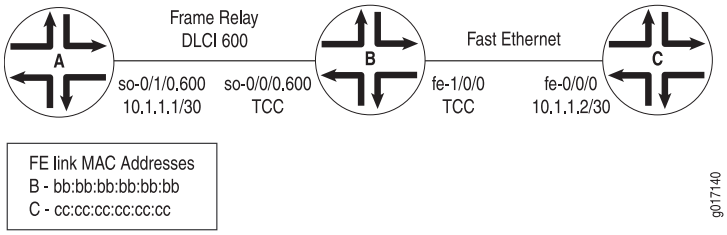
Verifying Your Work

To verify your TCC connection, use the **show connections** command on Router B:

```
user@router_b> show connections
CCC and TCC connections [Link Monitoring On]
  Legend for status (St)              Legend for connection types
  UN -- uninitialized                 if-sw:  interface switching
  NP -- not present                   rmt-if: remote interface switching
  WE -- wrong encapsulation           lsp-sw: LSP switching
  DS -- disabled
  Dn -- down                          Legend for circuit types
  -> -- only outbound conn is up      intf -- interface
  <- -- only inbound  conn is up      tlsp -- transmit LSP
  Up -- operational                   rlsp -- receive LSP
Connection/Circuit                  Type    St  Time last up     # Up trans
PPP-to-ATM                          if-sw   Up  Nov 30 08:57:53           1
  at-1/1/0.32                         intf  Up
  so-0/0/0.0                          intf  Up
```

Example: Frame Relay to Fast Ethernet TCC Configuration

Figure 4: TCC Interface Switching—Frame Relay to Fast Ethernet



In the configuration example in Figure 4 on page 17, Router A uses Frame Relay to connect with Router B, while Router C connects to Router B by using Fast Ethernet. Router B acts as the Layer 2 virtual switch and transparently connects Router A to Router C.

You must enable Frame Relay encapsulation on Router A at the physical interface level.

Router A

```
[edit]
interfaces {
  so-0/1/0 {
    description "to Router B so-0/0/0";
    encapsulation frame-relay;
    unit 600 {
      point-to-point;
      dlci 600;
      family inet {
```

```
            address 10.1.1.1/30;
          }
        }
      }
    }
```

Router B acts as the virtual switch. Enable the appropriate TCC encapsulations on the corresponding interfaces. In this case, configure the **encapsulation frame-relay-tcc** option on the logical and physical interfaces of **so-0/0/0.600**. Next, add the **ethernet-tcc** encapsulation type to the physical interface of **fe-1/0/0**. To enable ARP, configure the remote MAC address or IP address of Router C's Fast Ethernet interface with the **remote** statement at the **[edit interfaces *interface-name* unit 0 family tcc]** hierarchy level. To enable proxy ARP, include the **proxy** statement at the **[edit interfaces *interface-name* unit 0 family tcc]** hierarchy level and specify the IP address of Router A.

After configuring the correct interface encapsulations, complete your cross-connect by adding both interfaces into your MPLS configuration. Include the same interfaces in the **interface-switch** statement at the **[edit protocols connections]** hierarchy level.

Router B

```
[edit]
interfaces {
  so-0/0/0 {
    description "to Router A so-0/1/0";
    dce;
    encapsulation frame-relay-tcc;
    unit 600 {
      point-to-point;
      encapsulation frame-relay-tcc;
      dlci 600;
    }
  }
  fe-1/0/0 {
    description "to Router C fe-0/0/0";
    encapsulation ethernet-tcc;
    unit 0 {
      family tcc {
        protocol inet
        remote { # Addresses associated with the Ethernet TCC neighbor Router C.
          mac-address cc:cc:cc:cc:cc:cc; # Or, specify Router C's IP address here.
        }
        proxy { # Addresses associated with the other TCC neighbor—Router A.
          inet-address 10.1.1.1;
        }
      }
    }
  }
}
protocols {
  mpls {
    interface so-0/0/0.600;
    interface fe-1/0/0.0;
  }
  connections {
    interface-switch FR-to-Ether {
      interface so-0/0/0.600;
```

```
        interface fe-1/0/0.0;
      }
    }
  }
```

Ethernet encapsulation is the default for Router C. Because the Fast Ethernet connection is switched at Layer 2 to reach the Frame Relay link, it is transparent to Layer 3 addressing. As a result, you must configure the IP address for the **fe-0/0/0** interface in the same address space as Router A's **so-0/1/0.600** interface.

Optionally, configure static ARP on the **fe-0/0/0** interface if you omit the **proxy** statement on Router B. The **arp** statement must contain the IP address from interface **so-0/1/0.600** on Router A and the MAC address of the Fast Ethernet interface on Router B.

Router C

```
[edit]
interfaces
fe-0/0/0 {
  description "to Router B fe-1/0/0";
  unit 0 {
    family inet {
      address 10.1.1.2/30 {
        arp 10.1.1.1 mac bb:bb:bb:bb:bb:bb; # Configure this only if you did not
      }     # enter a proxy statement on Router B.
    }
  }
}
```

Verifying Your Work

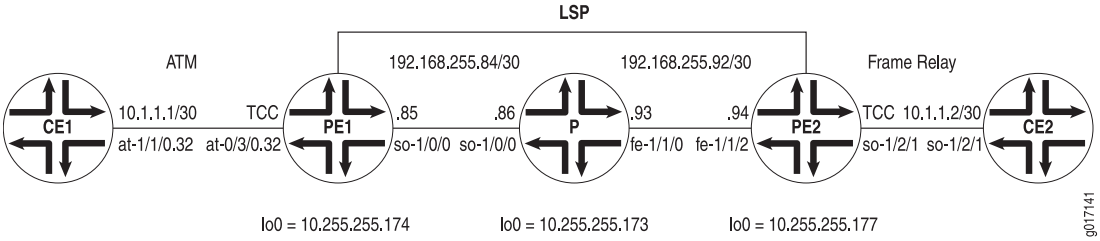
To verify the operational status of your TCC connection, use the **show connections** command on Router B:

```
user@router_b> show connections
CCC and TCC connections [Link Monitoring On]
  Legend for status (St)              Legend for connection types
  UN -- uninitialized                 if-sw:  interface switching
  NP -- not present                   rmt-if: remote interface switching
  WE -- wrong encapsulation           lsp-sw: LSP switching
  DS -- disabled
  Dn -- down                          Legend for circuit types
  -> -- only outbound conn is up      intf -- interface
  <- -- only inbound  conn is up      tlsp -- transmit LSP
  Up -- operational                   rlsp -- receive LSP
Connection/Circuit                  Type    St  Time last up     # Up trans
FR-to-Ether                         if-sw   Up  Dec 30 09:57:23           1
  so-0/0/0.600                      intf    Up
  fe-1/0/0.0                        intf    Up
```

Example: Layer 2.5 VPN Configuration

This section contains a configuration example and commands you can issue to verify your Layer 2.5 VPN configuration:

Figure 5: Layer 2.5 VPN Topology Diagram



In Figure 5 on page 20, ATM is configured between CE1 and PE1 and Frame Relay is configured between PE2 and CE2. To begin the Layer 2 VPN configuration, enable ATM and the corresponding encapsulation on CE1.

Router CE1

```
[edit]
interfaces
at-1/1/0 {
   description "to PE1 at-0/3/0";
   atm-options {
      vpi 0 maximum-vcs 2000;
   }
   unit 32 {
      vci 32;
      encapsulation atm-vc-mux;
      family inet {
         address 10.1.1.1/30;
      }
   }
}
```

The first provider edge (PE1) router uses ATM TCC encapsulation on the ATM VC connecting to CE1. After this, standard Layer 2 VPN design rules apply. You use MPLS on interfaces pointing toward the core and the edge, establish a Layer 2 VPN BGP peer relationship with PE2, use LDP or Resource Reservation Protocol (RSVP) for traffic traveling through the core, and configure the proper VRF instance. Finally, you create policies for PE1 that will set a private community tag on outbound BGP traffic heading to PE2 and accept incoming traffic that matches similar community traffic from PE2.

Router PE1

```
[edit]
interfaces {
   at-0/3/0 {
      description "to CE1 at-1/1/0";
      atm-options {
         vpi 0 maximum-vcs 2000;
      }
      unit 32 {
         encapsulation atm-tcc-vc-mux;
         vci 32;
      }
   }
   so-1/0/0 {
      description "to P so-1/0/0";
      unit 0 {
         family inet {
            address 192.168.255.86/30;
```

```
        }
        family mpls;
      }
    }
    lo0 {
      unit 0 {
        family inet {
          address 10.255.255.174/32;
        }
      }
    }
}
protocols {
    mpls {
      interface at-0/3/0.32;
      interface so-1/0/0.0;
    }
    bgp {
      group my-internal-peers {
        type internal;
        local-address 10.255.255.174;
        family l2vpn {
          signaling;
        }
        neighbor 10.255.255.177;
      }
    }
    ldp {
      interface so-1/0/0.0;
    }
}
policy-options {
    policy-statement companyA-import {
      term T1 {
        from {
          protocol bgp;
          community companyA;
        }
        then accept;
      }
      term Final {
        then reject;
      }
    }
    policy-statement companyA-export {
      term T1 {
        then {
          community add companyA;
          accept;
        }
      }
      term Final {
        then reject;
      }
    }
    community companyA members target:100:1;
```

```
}
routing-instances {
   companyA {
      instance-type l2vpn;
      interface at-0/3/0.32;
      route-distinguisher 10.255.255.174:1;
      vrf-import companyA-import;
      vrf-export companyA-export;
      protocols {
         l2vpn {
            encapsulation-type interworking;
            site Denver {
               site-identifier 1;
               interface at-0/3/0.32 {
                  remote-site-id 2;
               }
            }
         }
      }
   }
}
```

On the provider core router (P), you need only enable MPLS and LDP on the interfaces that bridge the gap between the PE routers.

Router P

```
[edit]
interfaces {
   so-1/0/0 {
      description "to PE1 so-1/0/0";
      unit 0 {
         family inet {
            address 192.168.255.85/30;
         }
         family mpls;
      }
   }
   fe-1/1/0 {
      description "to PE2 fe-1/1/2";
      unit 0 {
         family inet {
            address 192.168.255.93/30;
         }
         family mpls;
      }
   }
   lo0 {
      unit 0 {
         family inet {
            address 10.255.255.173/32;
         }
      }
   }
}
protocols {
   mpls {
      interface so-1/0/0.0;
```

```
        interface fe-1/1/0.0;
    }
    ldp {
        interface so-1/0/0.0;
        interface fe-1/1/0.0;
    }
}
```

The PE2 router uses Frame Relay TCC encapsulation on the Frame Relay DLCI connecting to CE2. To establish the Layer 2.5 VPN, follow the same steps you used to configure PE1. You use MPLS on interfaces pointing toward the core and the edge, establish a Layer 2 VPN BGP peer relationship with PE1, use LDP or RSVP for traffic traveling through the core, and configure the proper VRF instance. Finally, you create policies on PE2 that will set a private community tag on outbound BGP traffic heading to PE1 and accept incoming traffic that matches similar community traffic from PE1.

Router PE2

```
[edit]
interfaces {
    fe-1/1/2 {
        description "to P fe-1/1/0";
        unit 0 {
            family inet {
                address 192.168.255.94/30;
            }
            family mpls;
        }
    }
    so-1/2/1 {
        description "to CE2 so-1/2/1";
        dce;
        encapsulation frame-relay-tcc;
        unit 600 {
            encapsulation frame-relay-tcc;
            dlci 600;
        }
    }
    lo0 {
        unit 0 {
            family inet {
                address 10.255.255.177/32;
            }
        }
    }
}
protocols {
    mpls {
        interface fe-1/1/2.0;
        interface so-1/2/1.600;
    }
    bgp {
        group my-internal-peers {
            type internal;
            local-address 10.255.255.177;
            family l2vpn {
                signaling;
```

```
        }
        neighbor 10.255.255.174;
      }
    }
  }
  ldp {
    interface fe-1/1/2.0;
  }
  policy-options {
    policy-statement companyA-import {
      term T1 {
        from {
          protocol bgp;
          community companyA;
        }
        then accept;
      }
      term Final {
        then reject;
      }
    }
    policy-statement companyA-export {
      term T1 {
        then {
          community add companyA;
          accept;
        }
      }
      term Final {
        then reject;
      }
    }
    community companyA members target:100:1;
  }
  routing-instances {
    companyA {
      instance-type l2vpn;
      interface so-1/2/1.600;
      route-distinguisher 10.255.255.177:1;
      vrf-import companyA-import;
      vrf-export companyA-export;
      protocols {
        l2vpn {
          encapsulation-type interworking;
          site NewYork {
            site-identifier 2;
            interface so-1/2/1.600 {
              remote-site-id 1;
            }
          }
        }
      }
    }
  }
```

To complete the Layer 2.5 VPN configuration, enable Frame Relay encapsulation on CE2.

Router CE2

```
[edit]
interfaces
so-1/2/1 {
   description "to PE2 so-1/2/1";
   encapsulation frame-relay;
   unit 600 {
      dlci 600;
      family inet {
         address 10.1.1.2/30;
      }
   }
}
```

Verifying Your Work

To verify the operational status of your Layer 2.5 VPN, use the following commands:

- **show route forwarding-table**
- **show ldp database**
- **show l2vpn connections**
- **show bgp summary**
- **show route**

To view sample output of these commands as used with the configuration example, see the following:

- Router PE1 Status on page 25
- Router PE2 Status on page 27
- Router P Status on page 29

Router PE1 Status

```
user@PE1> show route forwarding-table
<snip>
Routing table:: ccc
MPLS:
Interface.Label    Type RtRef Nexthop           Type Index NhRef Netif
default            perm     0                  dscd    10     1
0                  user     0                  recv    12     2
1                  user     0                  recv    12     2
100128             user     0                  Pop           so-1/0/0.0
100128(S=0)        user     0                  Pop           so-1/0/0.0
100129             user     0                  Swap  100000  so-1/0/0.0
800001             user     0                  ucst   137     1 at-0/3/0.32
at-0/3/0. (CCC)    user     0                  indr   133     2
                                               Push 800000, Push 100000(top)

so-1/0/0.0
<snip>


user@PE1> show ldp database
Input label database, 10.255.255.174:0-10.255.255.173:0
  Label     Prefix
 100002     10.255.255.174/32
```

```
 100000     10.255.255.177/32
      3     10.255.255.173/32
Output label database, 10.255.255.174:0-10.255.255.173:0
  Label     Prefix
 100128     10.255.255.173/32
 100129     10.255.255.177/32
      3     10.255.255.174/32
```

```
user@PE1> show l2vpn connections
L2VPN Connections:
Legend for connection status (St)   Legend for interface status
OR -- out of range                  up -- operational
EI -- encapsulation invalid         Dn -- down
EM -- encapsulation mismatch        NP -- no present
CN -- circuit not present           DS -- disabled
OL -- no outgoing label             WE -- wrong encapsulation
Dn -- down                          UN -- uninitialized
VC-Dn -- Virtual circuit down
WE -- intf encaps != instance encaps
-> -- only outbound conn is up
<- -- only inbound  conn is up
UP -- operational
XX -- unknown
Instance: companyA
Local site: Denver (1)
    connection-site           Type  St     Time last up          # Up trans
    2                         rmt   Up     Nov 30 08:21:07 2001           1
      Local interface: at-0/3/0.32, Status: Up, Encapsulation: INTERWORKING
      Remote PE: 10.255.255.177
      Incoming label: 800001, Outgoing label: 800000
```

```
user@PE1> show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
inet.0                 0          0          0          0          0          0
bgp.l2vpn.0            1          1          0          0          0          0
Peer               AS      InPkt     OutPkt    OutQ   Flaps Last
Up/DwnState|#Active/Received/Damped...
10.255.255.177      69         49         45       0       1       19:16 Establ
  bgp.l2vpn.0: 1/1/0
  companyA.l2vpn.0: 1/1/0
```

```
user@PE1> show route
<snip>
mpls.0: 7 destinations, 7 routes (7 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
0                  *[MPLS/0] 1d 18:54:24, metric 1
                      Receive
1                  *[MPLS/0] 1d 18:54:24, metric 1
                      Receive
100128             *[LDP/9] 00:24:03, metric 1
                    > via so-1/0/0.0, Pop
100128(S=0)        *[LDP/9] 00:24:03, metric 1
                    > via so-1/0/0.0, Pop
100129             *[LDP/9] 00:24:03, metric 1
                    > via so-1/0/0.0, Swap 100000
800001             *[L2VPN/7] 00:10:35
                    > via at-0/3/0.32, Pop      [0]
at-0/3/0.32        *[L2VPN/7] 00:10:35
```

```
                    > via so-1/0/0.0, Push 800000, Push 100000(top)
companyA.l2vpn.0: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
1:1:1:1         /96
                    *[L2VPN/7] 00:19:55
                       Discard
1:1:2:1         /96
                    *[BGP/170] 00:06:46, localpref 100, from 10.255.255.177
                       AS path: I
                     > via so-1/0/0.0, Push 100000
bgp.l2vpn.0: 1 destinations, 1 routes (1 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
1:1:2:1         /96
                    *[BGP/170] 00:10:35, localpref 100, from 10.255.255.177
                       AS path: I
                     > via so-1/0/0.0, Push 100000
<snip>
```

Router PE2 Status

```
user@vpn07> show route forwarding-table
<snip>
Routing table:: ccc
MPLS:
Interface.Label    Type RtRef Nexthop           Type Index NhRef Netif
default            perm     0                  dscd     8     1
0                  user     0                  recv    10     2
1                  user     0                  recv    10     2
100002             user     0                  Pop           fe-1/1/2.0
100002(S=0)        user     0                  Pop           fe-1/1/2.0
100003             user     0                  Swap  100002  fe-1/1/2.0
800000             user     0                  ucst    60     1 so-1/2/1.0
so-1/2/1. (CCC)    user     0                  indr    59     2
<snip>


user@vpn07>  show ldp database
Input label database, 10.255.255.177:0-10.255.255.173:0
  Label     Prefix
 100000     10.255.255.177/32
      3     10.255.255.173/32
 100002     10.255.255.174/32
Output label database, 10.255.255.177:0-10.255.255.173:0
  Label     Prefix
 100002     10.255.255.173/32
      3     10.255.255.177/32
 100003     10.255.255.174/32


user@vpn07>  show l2vpn connections
L2VPN Connections:
Legend for connection status (St)   Legend for interface status
OR -- out of range                  up -- operational
EI -- encapsulation invalid         Dn -- down
EM -- encapsulation mismatch        NP -- no present
CN -- circuit not present           DS -- disabled
OL -- no outgoing label             WE -- wrong encapsulation
Dn -- down                          UN -- uninitialized
VC-Dn -- Virtual circuit down
WE -- intf encaps != instance encaps
-> -- only outbound conn is up
```

```
<- -- only inbound  conn is up
UP -- operational
XX -- unknown
Instance: companyA
Local site: NewYork (2)
    connection-site           Type  St     Time last up          # Up trans
    1                         rmt   Up     Nov 30 08:21:01 2001           1
      Local interface: so-1/2/1.0, Status: Up, Encapsulation: INTERWORKING
      Remote PE: 10.255.255.174
      Incoming label: 800000, Outgoing label: 800001


user@vpn07>  show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l2vpn.0            1          1          0          0          0          0
inet.0                 0          0          0          0          0          0
Peer               AS      InPkt     OutPkt    OutQ   Flaps Last
Up/DwnState|#Active/Received/Damped...
10.255.255.174      69         45         52       0       0       20:20 Establ
  bgp.l2vpn.0: 1/1/0
  companyA.l2vpn.0: 1/1/0


user@vpn07>  show route
<snip>
mpls.0: 7 destinations, 7 routes (7 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
0                  *[MPLS/0] 02:34:04, metric 1
                      Receive
1                  *[MPLS/0] 02:34:04, metric 1
                      Receive
100002             *[LDP/9] 00:25:39, metric 1
                    > via fe-1/1/2.0, Pop
100002(S=0)        *[LDP/9] 00:25:39, metric 1
                    > via fe-1/1/2.0, Pop
100003             *[LDP/9] 00:25:01, metric 1
                    > via fe-1/1/2.0, Swap 100002
800000             *[L2VPN/7] 00:07:50
                    > via so-1/2/1.0, Pop      [0]
so-1/2/1.0         *[L2VPN/7] 00:07:50
                    > via fe-1/1/2.0, Push 800001, Push 100002(top)
companyA.l2vpn.0: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
1:1:1:1        /96
                   *[BGP/170] 00:04:59, localpref 100, from 10.255.255.174
                      AS path: I
                    > via fe-1/1/2.0, Push 100002
1:1:2:1        /96
                   *[L2VPN/7] 00:11:34
                      Discard
bgp.l2vpn.0: 1 destinations, 1 routes (1 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
1:1:1:1        /96
                   *[BGP/170] 00:11:38, localpref 100, from 10.255.255.174
                      AS path: I
                    > via fe-1/1/2.0, Push 100002
<snip>
```

Router P Status

```
user@P> show ldp database
Input label database, 10.255.255.173:0-10.255.255.174:0
  Label     Prefix
 100128     10.255.255.173/32
 100129     10.255.255.177/32
      3     10.255.255.174/32
Output label database, 10.255.255.173:0-10.255.255.174:0
  Label     Prefix
      3     10.255.255.173/32
 100000     10.255.255.177/32
 100002     10.255.255.174/32
Input label database, 10.255.255.173:0-10.255.255.177:0
  Label     Prefix
      3     10.255.255.177/32
 100002     10.255.255.173/32
 100003     10.255.255.174/32
Output label database, 10.255.255.173:0-10.255.255.177:0
  Label     Prefix
      3     10.255.255.173/32
 100000     10.255.255.177/32
 100002     10.255.255.174/32
```

For More Information

For additional information about TCC or Layer 2.5 VPNs, see the following documents:

- *Junos VPNs Configuration Guide*
- *Junos MPLS Applications Configuration Guide*
- *Junos Network Interfaces Configuration Guide*

PART 2

Index

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