JUNIPER NETWORKS

Technology Overview

Understanding VPLS Label Blocks Operation

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Release 13.1
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The information in this document is current as of the date on the title page.

YEAR 2000 NOTICE

Juniper Networks hardware and software products are Year 2000 compliant. Junos OS has no known time-related limitations through the year 2038. However, the NTP application is known to have some difficulty in the year 2036.

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VPLS Label Blocks Operation

A virtual private LAN service (VPLS) is a Layer 2 (L2) service that emulates a local area network (LAN) across a wide area network (WAN). VPLS labels are defined and exchanged in the Border Gateway Protocol (BGP) control plane. In the Junos OS implementation, label blocks are allocated and used in the VPLS control plane for two primary functions: autodiscovery and signaling.

- Autodiscovery—A method for automatically recognizing each provider edge (PE) router in a particular VPLS domain, using BGP update messages.
- Signaling—Each pair of PE routers in a VPLS domain sends and withdraws VPN labels to each other. The labels are used to establish and dismantle pseudowires between the routers. Signaling is also used to transmit certain characteristics of a pseudowire.

The PE router uses BGP extended communities to identify the members of its VPLS. Once the PE router discovers its members, it is able to establish and tear down pseudowires between members by exchanging and withdrawing labels and transmitting certain characteristics of the pseudowires.

The PE router sends common update messages to all remote PE routers, using a distinct BGP update message, thereby reducing the control plane load. This is achieved by using VPLS label blocks.

Elements of Network Layer Reachability Information

VPLS BGP network layer reachability information (NLRI) is used to exchange VPLS membership and parameters. The elements of a VPLS BGP NLRI are defined in Table 1 on page 1.

Table 1: NLRI Elements

Element	Acronym	Description	Default Size (Octets)
Length		Total length of the NLRI size represented in bytes.	2
Route Distinguisher	RD	Unique identifier for each routing instance configured on a PE.	8
VPLS Edge ID	VE ID	Unique number to identify the edge site.	2
VE Block Offset	VBO	Value used to identify a label block from which a label value is selected to set up pseudowires for a remote site.	2
VE Block Size	VBS	Indicates the number of pseudowires that peers can have in a single block.	2
Label Base	LB	Starting value of the label in the advertised label block.	3

Requirements for NLRI Elements

Junos OS requires a unique route distinguisher (RD) for each routing instance configured on a PE router. A PE router might use the same RD across a VPLS (or VPN) domain or it might use different RDs. Using different RDs helps identify the originator of the VPLS NLRI.

The VPLS edge (VE) ID can be a unique VE ID, site ID, or customer edge (CE) ID. The VE ID is used by a VPLS PE router to index into label blocks used to derive the transmit and receive VPN labels needed for transport of VPLS traffic. The VE ID identifies a particular site, so it needs to be unique within the VPLS domain, except for some scenarios such as multihoming.

All PE routers have full mesh connectivity with each other to exchange labels and set up pseudowires. The VE block size (VBS) is a configurable value that represents the number of label blocks required to cover all the pseudowires for the remote peer.

A single label block contains 8 labels (1 octet) by default. The default VBS in Junos OS is 2 blocks (2 octets) for a total of 16 labels.

How Labels are Used in Label Blocks

Each PE router creates a mapping of the labels in the label block to the sites in a VPLS domain. A PE router advertising a label block with a block offset indicates which sites can use the labels to reach it. When a PE router is ready to advertise its membership to a VPLS domain, it allocates a label block and advertises the VPLS NLRI. In this way, other PE routers in the same VPLS domain can learn of the existence of the VPLS and set up pseudowires to it if needed. The VPLS NLRI advertised for this purpose is referred to as the *default VPLS NLRI*. The label block in the default VPLS NLRI is referred to as the *default label block*.

Label Block Composition

A label block (set of labels) is used to reach a given site ID. A single label block contains 8 labels (1 octet) by default. The VBS is 2 octets by default in Junos OS.

The label block advertised is defined as a label base (LB) and a VE block size (VBS). It is a contiguous set of labels (LB, LB+1,...LB+VBS-1). For example, when Router PE-A sends a VPLS update, it sends the same label block information to all other PE routers. Each PE router that receives the LB advertisement infers the label intended for Router PE-A by adding its own site ID to the label base.

In this manner, each receiving PE gets a unique label for PE-A for that VPLS. This simple method is enhanced by using a VE block offset (VBO).

A label block is defined as: <Label Base (LB), VE block offset (VBO), VE block size (VBS)> is the set {LB+VBO, LB+VBO+1,...,LB+VBO+VBS-1}.

Label Blocks in Junos OS

Instead of a single large label block to cover all VE IDs in a VPLS, the Junos OS implementation contains several label blocks, each with a different label base. This makes label block management easier, and also allows Router PE-A to seemlessly integrate a PE router joining a VPLS with a site ID not covered by the set of label blocks that Router PE-A has already advertised.

VPLS Label Block Structure

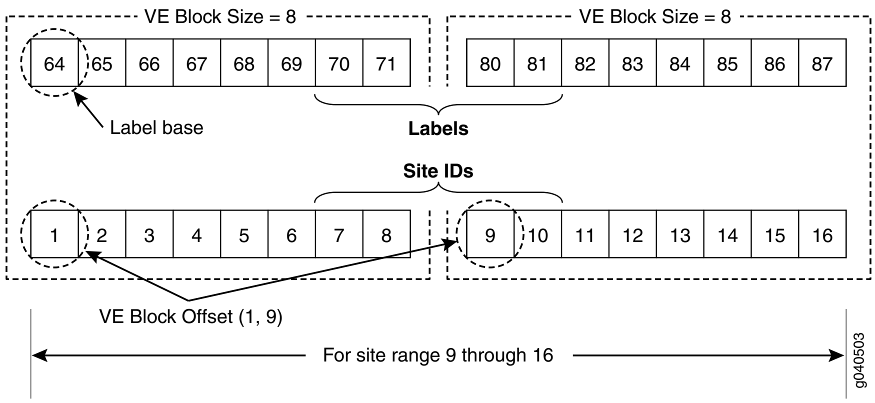
This section illustrates how a label block is uniquely identified.

A VPLS BGP NLRI with site ID V, VE block offset VBO, VE block size VBS, and label base LB communicates the following to its peers:

- Label block for V: Labels from LB to (LB + VBS -1).
- Remote VE set for V: from VBO to (VBO + VBS -1).

The label block advertised is a set of labels used to reach a given site ID. If there are several label blocks, the remote VE set helps to identify which label block to use. The example in Figure 1 on page 3 illustrates label blocks. There are two blocks and each block has eight labels. In this example, the label values are 64 to 71 and 80 to 87.

Figure 1: VPLS Label Block Structure



To create a one-to-one mapping of these 16 labels to 16 sites, assume the site IDs are the numbers 1 to 16, as shown in the illustration. The site block indicates which site ID can use which label in the label block. So, in the first block, site ID 1 uses 64, site ID 2 uses 65, and so forth. Finally, site ID 8 uses 71. The 9th site ID will use the second block instead of the first block.

The labels are calculated by comparing the values of VBO <= Local site ID < (VBO +VBS). Consequently, site ID 9 uses 80, site ID 10 uses 81, and so on.

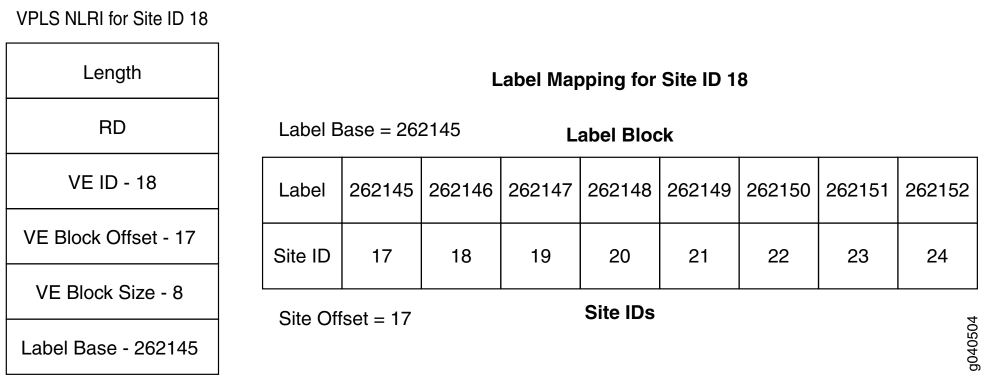
To further illustrate the one-to-one mapping of labels to sites, assume a label block with site offset of 1 and a label base of 10. The combination of label base and block offset contained in the VPLS NLRI provides the mapping of labels to site IDs. The block offset is the starting site ID that can use the label block as advertised in the VPLS NLRI.

To advertise the default VPLS NLRI, a PE router picks a starting block offset that fits its own site ID and is such that the end block offset is a multiple of a single label block. In Junos OS a single label block is eight labels by default.

The end block offset is the last site ID that maps to the last label in the label block. The end offset for the first block is 8 which maps to label 17 and the second block is 16. For example, a site with ID 3 picks a block offset of 1 and advertises a label block of size 8 to cover sites with IDs 1 to 8. A site with ID 10 picks a block offset of 9 to cover sites with IDs 9 to 16.

The VPLS NLRI shown in Figure 2 on page 4 is for site ID 18. The label base contains value 262145. The block offset contains value 17. The illustration shows which site IDs correspond to which labels.

Figure 2: Label Mapping Example



If a PE router configured with site ID 17 is in the same VPLS domain as a PE router configured with site ID 18, it receives the VPLS NLRI as shown in Figure 3. So it uses label 262145 to send traffic to site 18. Similarly, a PE router configured with site ID 19 uses label 262147 to send traffic to a PE router configured with site ID 18. However, only PE routers configured with site IDs 17 to 24 can use the label block shown to set up pseudowires.

Related Documentation

- Example: Building a VPLS From Router 1 to Router 3 to Validate Label Blocks on page 4

Example: Building a VPLS From Router 1 to Router 3 to Validate Label Blocks

This example illustrates how VPLS label blocks are allocated for a specific configuration. It is organized in the following sections:

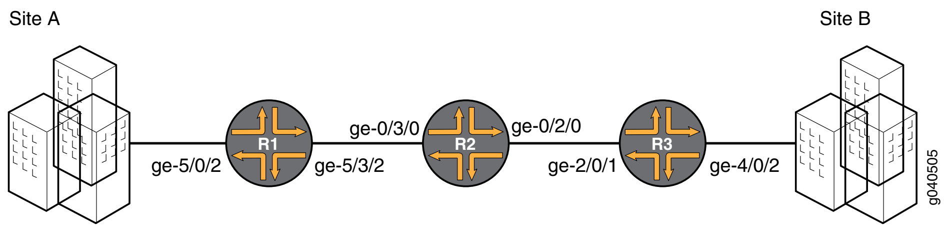
Requirements

This configuration example requires three Juniper Networks routers.

Overview and Topology

In the network shown in Figure 3 on page 5 Router 1 is establishing a pseudowire to Router 3

Figure 3: Router 1 to Router 3 Topology



Each PE filters the VPLS NLRI contained in the BGP update messages based on route target communities. Those VPLS NLRI instances that match the route target (in this case 8717:2000:2:1) are imported for further processing. The NLRI for Router 1 and Router 3 is shown in Table 2 on page 5.

Table 2: NLRI Exchange Between for Router 1 and Router 3

Router 1 NLRI Advertisement to Router 3	Router 3 NLRI Advertisement to Router 1
RD - 8717:1000	RD - 8717:1000
VE ID - 1	VE ID - 2
VE Block Offset - 1	VE Block Offset - 1
VE Block Size - 8	VE Block Size - 8
Label Base - 262161	Label Base - 262153

To set up a pseudowire to Router 3, Router 1 must select a label to use to send traffic to Router 3 and also select a label that it expects Router 3 to use to send traffic to itself. The site ID contained in the VPLS NLRI from Router 3 is 2.

Router 1 learns of the existence of site ID 2 in the same VPLS domain. Using the equation VBO <= Local Site ID < (VBO +VBS), Router 1 checks if the route advertised by site ID 2 fits in the label block and block offset that it previously advertised to Router 3. In this example it does fit, so the site ID 2 is mapped by the VPLS NLRI advertised by Router 1, and Router 1 is ready to set up a pseudowire to Router 3.

To select the label to reach Router 3, Router 1 looks at the label block advertised by Router 3 and performs a calculation. The calculation a PE router uses to check if its site ID is mapped in the label block from the remote peer is VBO <= Local Site ID < (VBO +VBS). So, Router 1 selects label (262153 + (1 -1)) = 262153 to send traffic to Router 3. Using the same equation, Router 1 looks at its own label block that it advertised and selects label (262161 + (2 - 1)) = 262162 to receive traffic from Router 3. Router 1 programs its forwarding state such that any traffic destined to Router 3 carries the pseudowire label 262153 and any traffic coming from Router 3 is expected to have the pseudowire label 262162. This completes the operations on the VPLS NLRI received from Router 3. Router 1 now has a pseudowire set up to Router 3.

Router 3 operation is very similar to the Router 1 operation. Since the Router 3 site ID of 2 fits in the label block and block offset advertised by Router 1, Router 3 selects label

(262161 + (2 - 1)) = 262162 to send traffic to Router 1. Router 3 looks at its own label block that it advertised and selects label (262153 + (1 - 1)) = 262153 to receive traffic from Router 1. This completes the creation of a pseudowire to Router 1.

By default, for VPLS operation Junos OS uses a virtual tunnel (VT) loopback interface to represent a pseudowire. This example uses a label-switched interface (LSI) instead of a VT interface because there is no change in the VPLS control plane operation. Thus, for an MX platform, if there is a tunnel physical interface card (PIC) configured, it is mandatory to include the **no-tunnel-services** statement at the **[edit routing-instances *routing-instance-name* protocols vpls]** hierarchy level.

Configuration

The following sections present the steps to configure and verify the example in Figure 3 on page 5.

Configuring Router 1

Step-by-Step Procedure

1. Configure Router 1. Create the **edut** routing instance. Specify the **vpls** instance type. Configure the route distinguisher and specify the value **8717:1000**. Configure the route target and specify the value **8717:100** Configure the VPLS protocol. Specify **10** as the site range. Specify **1** as the site ID. Include the **no-tunnel-services** statement.

```
[edit routing-instances]
edut {
  instance-type vpls;
  interface ge-5/0/2.0;
  route-distinguisher 8717:1000;
  vrf-target target:8717:100;
  protocols {
    vpls {
      site-range 10;
      no-tunnel-services;
      site router-1 {
        site-identifier 1;
      }
    }
  }
}
```

Configuring Router 3

Step-by-Step Procedure

1. Configure Router 3. Create the **edut** routing instance. Specify the **vpls** instance type. Configure the route distinguisher and specify the value **8717:2000**. Configure the route target and specify the value **8717:200** Configure the VPLS protocol. Specify **10** as the site range. Specify **2** as the site ID. Include the **no-tunnel-services** statement.

```
[edit routing-instances]
edut {
```

```
    instance-type vpls;
    interface ge-4/0/2.0;
    route-distinguisher 8717:2000;
    vrf-target target:8717:100;
    protocols {
      vpls {
        site-range 10;
        no-tunnel-services;
        site router-3 {
          site-identifier 2;
        }
      }
    }
  }
```

Verifying the VPLS Label Allocations

Step-by-Step Procedure

1. As shown in the figure and the configuration, Site A is attached to Router 1. Site A is assigned a site ID of 1. Before Router 1 can announce its membership to VPLS **edut** using a BGP update message, Router 1 needs to allocate a default label block. In this example, the label base of the label block allocated by Router 1 is 262161. Since Router 1's site ID is 1, Router 1 associates the assigned label block with block offset of 1. The following messages aresent from Router 1 to Router 3 and displayed using the **monitor traffic interface *interface-name*** command:

```
user@Router1> monitor traffic interface ge-5/3/2
Jun 14 12:26:31.280818 BGP SEND 10.10.10.1+179 -> 10.10.10.3+53950
Jun 14 12:26:31.280824 BGP SEND message type 2 (Update) length 88
Jun 14 12:26:31.280828 BGP SEND flags 0x40 code Origin(1): IGP
Jun 14 12:26:31.280833 BGP SEND flags 0x40 code ASPath(2) length 0: <null>
Jun 14 12:26:31.280837 BGP SEND flags 0x40 code LocalPref(5): 100
Jun 14 12:26:31.280844 BGP SEND flags 0xc0 code Extended Communities(16):
2:8717:100 800a:19:0:0
Jun 14 12:26:31.280848 BGP SEND flags 0x90 code MP_reach(14): AFI/SAFI 25/65
Jun 14 12:26:31.280853 BGP SEND         nhop 10.10.10.1 len 4
Jun 14 12:26:31.280862 BGP SEND        8717:1000:1:1 (label base : 262161 range
: 8, ce id: 1, offset: 1)
Jun 14 12:26:31.405067 BGP RECV 10.10.10.3+53950 -> 10.10.10.1+179
Jun 14 12:26:31.405074 BGP RECV message type 2 (Update) length 88
Jun 14 12:26:31.405080 BGP RECV flags 0x40 code Origin(1): IGP
Jun 14 12:26:31.405085 BGP RECV flags 0x40 code ASPath(2) length 0: <null>
Jun 14 12:26:31.405089 BGP RECV flags 0x40 code LocalPref(5): 100
Jun 14 12:26:31.405096 BGP RECV flags 0xc0 code Extended Communities(16):
2:8717:100 800a:19:0:0
Jun 14 12:26:31.405101 BGP RECV flags 0x90 code MP_reach(14): AFI/SAFI 25/65
Jun 14 12:26:31.405106 BGP RECV         nhop 10.10.10.3 len 4
Jun 14 12:26:31.405116 BGP RECV         8717:2000:2:1 (label base : 262153
range : 8, ce id: 2, offset: 1)
```

2. As shown in the figure and the configuration, Site B is attached to Router 3. Site B is assigned a site ID of 2. Before Router 3 can announce its membership to VPLS **edut** using a BGP update message, Router 3 assigns a default label block with the label base of **262153**. The block offset for this label block is 1 because its own site ID of 2 fits in the block being advertised. The following messages are sent from Router 3 to Router 1 and displayed using the **monitor traffic interface *interface-name*** command:

```
user@Router3> monitor traffic interface ge-2/0/1
Jun 14 12:26:31.282008 BGP SEND 10.10.10.3+53950 -> 10.10.10.1+179
Jun 14 12:26:31.282018 BGP SEND message type 2 (Update) length 88
Jun 14 12:26:31.282026 BGP SEND flags 0x40 code Origin(1): IGP
Jun 14 12:26:31.282034 BGP SEND flags 0x40 code ASPath(2) length 0: <null>
Jun 14 12:26:31.282041 BGP SEND flags 0x40 code LocalPref(5): 100
Jun 14 12:26:31.282052 BGP SEND flags 0xc0 code Extended Communities(16):
2:8717:100 800a:19:0:0
Jun 14 12:26:31.282078 BGP SEND flags 0x90 code MP_reach(14): AFI/SAFI 25/65
Jun 14 12:26:31.282088 BGP SEND        nhop 10.10.10.3 len 4
Jun 14 12:26:31.282102 BGP SEND        8717:2000:2:1 (label base : 262153 range
: 8, ce id: 2, offset: 1)

Jun 14 12:26:31.283395 BGP RECV 10.10.10.1+179 -> 10.10.10.3+53950
Jun 14 12:26:31.283405 BGP RECV message type 2 (Update) length 88
Jun 14 12:26:31.283412 BGP RECV flags 0x40 code Origin(1): IGP
Jun 14 12:26:31.283419 BGP RECV flags 0x40 code ASPath(2) length 0: <null>
Jun 14 12:26:31.283426 BGP RECV flags 0x40 code LocalPref(5): 100
Jun 14 12:26:31.283435 BGP RECV flags 0xc0 code Extended Communities(16):
2:8717:100 800a:19:0:0
Jun 14 12:26:31.283443 BGP RECV flags 0x90 code MP_reach(14): AFI/SAFI 25/65
Jun 14 12:26:31.283471 BGP RECV        nhop 10.10.10.1 len 4
Jun 14 12:26:31.283486 BGP RECV        8717:1000:1:1 (label base : 262161
range : 8, ce id: 1, offset: 1)
```

3. Verify the connection status messages for Router 1 using the **show vpls connections** command. Notice the base label is **262161**, the incoming label from Router 3 is **262162**, and the outgoing label to Router 3 is **262153**.

```
user@Router1> show vpls connections instance edut extensive
Instance: edut
  Local site: router-1 (1)
    Number of local interfaces: 1
    Number of local interfaces up: 1
    IRB interface present: no
    ge-5/0/2.0
    lsi.1049600         2         Intf - vpls edut local site 1 remote site
 2
    Label-base        Offset     Range     Preference
    262161            1          8         100
    connection-site           Type  St     Time last up          # Up trans

    2                         rmt   Up     Jun 14 12:26:31 2009           1

      Remote PE: 10.10.10.3, Negotiated control-word: No
      Incoming label: 262162, Outgoing label: 262153
      Local interface: lsi.1049600, Status: Up, Encapsulation: VPLS
        Description: Intf - vpls edut local site 1 remote site 2
    Connection History:
        Jun 14 12:26:31 2009  status update timer
        Jun 14 12:26:31 2009  loc intf up                  lsi.1049600
        Jun 14 12:26:31 2009  PE route changed
        Jun 14 12:26:31 2009  Out lbl Update                    262153
        Jun 14 12:26:31 2009  In lbl Update                     262162
        Jun 14 12:26:31 2009  loc intf down

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 availble
BK -- Backup connection          ST -- Standby connection
PF -- Profile parse failure      PB -- Profile busy

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

4. Verify the connection status messages for Router 3 using the **show vpls connections** command. Notice the base label is **262153**, the incoming label from Router 1 is **262153**, and the outgoing label to Router 1 is **262162**.

```
user@Router3> show vpls connections instance edut extensive
Instance: edut
  Local site: router-3 (2)
    Number of local interfaces: 1
    Number of local interfaces up: 1
    IRB interface present: no
    ge-4/0/2.0
    lsi.1050368         1         Intf - vpls edut local site 2 remote site
 1
    Label-base        Offset     Range     Preference
    262153            1          8         100
    connection-site           Type  St     Time last up          # Up trans

    1                         rmt   Up     Jun 14 12:26:31 2009           1

      Remote PE: 10.10.10.1, Negotiated control-word: No
      Incoming label: 262153, Outgoing label: 262162
      Local interface: lsi.1050368, Status: Up, Encapsulation: VPLS
        Description: Intf - vpls edut local site 2 remote site 1
    Connection History:
        Jun 14 12:26:31 2009  status update timer
        Jun 14 12:26:31 2009  loc intf up                  lsi.1050368
        Jun 14 12:26:31 2009  PE route changed
        Jun 14 12:26:31 2009  Out lbl Update                    262162
        Jun 14 12:26:31 2009  In lbl Update                     262153
        Jun 14 12:26:31 2009  loc intf down

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 availble
BK -- Backup connection         ST -- Standby connection
PF -- Profile parse failure     PB -- Profile busy

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

Related Documentation

- VPLS Label Blocks Operation on page 1