Junos® OS

Ethernet Networking Feature Guide for MX Series Routers

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Junos® OS Ethernet Networking Feature Guide for MX Series Routers

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Table of Contents

About the Documentation ix
Documentation and Release Notes ix
Supported Platforms ix
Using the Examples in This Manual ix
Merging a Full Example x
Merging a Snippet x
Documentation Conventions xi
Documentation Feedback xiii
Requesting Technical Support xiii
Self-Help Online Tools and Resources xiii
Opening a Case with JTAC xiv

Part 1 Overview

Chapter 1 **Overview of Ethernet Solutions 3**
Ethernet Terms and Acronyms 3
Networking and Internetworking with Bridges and Routers 6
Network Addressing at Layer 2 and Layer 3 7
Networking at Layer 2: Benefits of Ethernet Frames 9
Networking at Layer 2: Challenges of Ethernet MAC Addresses 10
Networking at Layer 2: Forwarding VLAN Tagged Frames 11
Networking at Layer 2: Forwarding Dual-Tagged Frames 13
Networking at Layer 2: Logical Interface Types 14
A Metro Ethernet Network with MX Series Routers 15
Layer 2 Networking Standards 17

Chapter 2 **Basic Layer 2 Features on MX Series Routers 19**
Layer 2 Features for a Bridging Environment 19

Chapter 3 **Virtual Switches 21**
Layer 2 Features for a Switching Environment 21

Chapter 4 **VLANs Within Bridge Domain and VPLS Environments 23**
VLANs Within a Bridge Domain or VPLS Instance 23
Packet Flow Through a Bridged Network with Normalized VLANs 24

Chapter 5 **Bulk Administration of Layer 2 Features on MX Series Routers 27**
Bulk Configuration of VLANs and Bridge Domains 27

Part 2 Configuration

Chapter 6 **Configuration Task for Virtual Switches 31**
Configuring Virtual Switches as Separate Routing Instances 31

Chapter 7 Basic Layer 2 Feature Examples 33

Example Roadmap: Configuring a Basic Bridge Domain Environment 33
Example Topology 33
Example Scenario 34
Example Configuration Summary 35
Example Step: Configuring Interfaces and VLAN Tags 35
Example Step: Configuring Bridge Domains 41
Example Step: Configuring Spanning Tree Protocols 43
Example Step: Configuring Integrated Bridging and Routing 45
Example: Configuring Basic Layer 2 Switching on MX Series 49

Chapter 8 VLANs Within Bridge Domain and VPLS Environments Examples 59

Configuring a Normalized VLAN for Translation or Tagging 59
Implicit VLAN Translation to a Normalized VLAN 60
Sending Tagged or Untagged Packets over VPLS Virtual Interfaces 60
Configuring a Normalized VLAN 61
Configuring Learning Domains for VLAN IDs Bound to Logical Interfaces 61
Example: Configuring a Provider Bridge Network with Normalized VLAN Tags . . 62
Example: Configuring a Provider VPLS Network with Normalized VLAN Tags . . . 66
Example: Configuring One VPLS Instance for Several VLANs 70

Chapter 9 Bulk Administration of Layer 2 Features on MX Series Routers Examples 79

Example: Configuring VLAN Translation with a VLAN ID List 79
Example: Configuring Multiple Bridge Domains with a VLAN ID List 80

List of Figures

Part 1 Overview

Chapter 1 **Overview of Ethernet Solutions 3**

Figure 1: Native (Normal) and VLAN-Tagged Ethernet Frames 12
Figure 2: A Metro Ethernet Network 15
Figure 3: A Metro Ethernet Network with MX Series Routers 16
Figure 4: VLAN Tags on a Metro Ethernet Network 16

Part 2 Configuration

Chapter 7 **Basic Layer 2 Feature Examples 33**

Figure 5: Bridging Network with MX Series Routers 34
Figure 6: Designated, Root, and Alternate Ports 45
Figure 7: Basic Layer 2 Switching 50

Chapter 8 **VLANs Within Bridge Domain and VPLS Environments Examples 59**

Figure 8: Provider Bridge Network Using Normalized VLAN Tags 63
Figure 9: VLAN Tags and VPLS Labels 67
Figure 10: Many VLANs on One VPLS Instance 71

List of Tables

About the Documentation ix

Table 1: Notice Icons xi
Table 2: Text and Syntax Conventions xii

About the Documentation

- Documentation and Release Notes on page ix
- Supported Platforms on page ix
- Using the Examples in This Manual on page ix
- Documentation Conventions on page xi
- Documentation Feedback on page xiii
- Requesting Technical Support on page xiii

Documentation and Release Notes

To obtain the most current version of all Juniper Networks® technical documentation, see the product documentation page on the Juniper Networks website at http://www.juniper.net/techpubs/.

If the information in the latest release notes differs from the information in the documentation, follow the product Release Notes.

Juniper Networks Books publishes books by Juniper Networks engineers and subject matter experts. These books go beyond the technical documentation to explore the nuances of network architecture, deployment, and administration. The current list can be viewed at http://www.juniper.net/books.

Supported Platforms

For the features described in this document, the following platforms are supported:

- MX Series

Using the Examples in This Manual

If you want to use the examples in this manual, you can use the **load merge** or the **load merge relative** command. These commands cause the software to merge the incoming configuration into the current candidate configuration. The example does not become active until you commit the candidate configuration.

If the example configuration contains the top level of the hierarchy (or multiple hierarchies), the example is a *full example*. In this case, use the **load merge** command.

If the example configuration does not start at the top level of the hierarchy, the example is a *snippet*. In this case, use the **load merge relative** command. These procedures are described in the following sections.

Merging a Full Example

To merge a full example, follow these steps:

1. From the HTML or PDF version of the manual, copy a configuration example into a text file, save the file with a name, and copy the file to a directory on your routing platform.

   For example, copy the following configuration to a file and name the file **ex-script.conf**. Copy the **ex-script.conf** file to the **/var/tmp** directory on your routing platform.

   ```
   system {
     scripts {
       commit {
         file ex-script.xsl;
       }
     }
   }
   interfaces {
     fxp0 {
       disable;
       unit 0 {
         family inet {
           address 10.0.0.1/24;
         }
       }
     }
   }
   ```

2. Merge the contents of the file into your routing platform configuration by issuing the **load merge** configuration mode command:

   ```
   [edit]
   user@host# load merge /var/tmp/ex-script.conf
   load complete
   ```

Merging a Snippet

To merge a snippet, follow these steps:

1. From the HTML or PDF version of the manual, copy a configuration snippet into a text file, save the file with a name, and copy the file to a directory on your routing platform.

   For example, copy the following snippet to a file and name the file **ex-script-snippet.conf**. Copy the **ex-script-snippet.conf** file to the **/var/tmp** directory on your routing platform.

   ```
   commit {
     file ex-script-snippet.xsl; }
   ```

2. Move to the hierarchy level that is relevant for this snippet by issuing the following configuration mode command:

```
[edit]
user@host# edit system scripts
[edit system scripts]
```

3. Merge the contents of the file into your routing platform configuration by issuing the **load merge relative** configuration mode command:

```
[edit system scripts]
user@host# load merge relative /var/tmp/ex-script-snippet.conf
load complete
```

For more information about the **load** command, see CLI Explorer.

Documentation Conventions

Table 1 on page xi defines notice icons used in this guide.

Table 1: Notice Icons

Icon	Meaning	Description
	Informational note	Indicates important features or instructions.
	Caution	Indicates a situation that might result in loss of data or hardware damage.
	Warning	Alerts you to the risk of personal injury or death.
	Laser warning	Alerts you to the risk of personal injury from a laser.
	Tip	Indicates helpful information.
	Best practice	Alerts you to a recommended use or implementation.

Table 2 on page xii defines the text and syntax conventions used in this guide.

Table 2: Text and Syntax Conventions

Convention	Description	Examples
Bold text like this	Represents text that you type.	To enter configuration mode, type the **configure** command: user@host> **configure**
`Fixed-width text like this`	Represents output that appears on the terminal screen.	`user@host>` **show chassis alarms** `No alarms currently active`
Italic text like this	• Introduces or emphasizes important new terms. • Identifies guide names. • Identifies RFC and Internet draft titles.	• A policy *term* is a named structure that defines match conditions and actions. • *Junos OS CLI User Guide* • RFC 1997, *BGP Communities Attribute*
Italic text like this	Represents variables (options for which you substitute a value) in commands or configuration statements.	Configure the machine's domain name: [edit] root@# **set system domain-name** *domain-name*
Text like this	Represents names of configuration statements, commands, files, and directories; configuration hierarchy levels; or labels on routing platform components.	• To configure a stub area, include the **stub** statement at the **[edit protocols ospf area area-id]** hierarchy level. • The console port is labeled **CONSOLE**.
< > (angle brackets)	Encloses optional keywords or variables.	**stub <default-metric** *metric***>;**
| (pipe symbol)	Indicates a choice between the mutually exclusive keywords or variables on either side of the symbol. The set of choices is often enclosed in parentheses for clarity.	**broadcast | multicast** **(***string1* **|** *string2* **|** *string3***)**
# (pound sign)	Indicates a comment specified on the same line as the configuration statement to which it applies.	**rsvp { # Required for dynamic MPLS only**
[ ] (square brackets)	Encloses a variable for which you can substitute one or more values.	**community name members [** *community-ids* **]**

Indention and braces ({ })	Identifies a level in the configuration hierarchy.	[edit]
		routing-options {
		  static {
		  route default {
		  nexthop *address*;
		  retain;
		  }
		  }
		}

; (semicolon)	Identifies a leaf statement at a configuration hierarchy level.	

GUI Conventions

Table 2: Text and Syntax Conventions *(continued)*

Convention	Description	Examples
Bold text like this	Represents graphical user interface (GUI) items you click or select.	• In the Logical Interfaces box, select **All Interfaces**. • To cancel the configuration, click **Cancel**.
> (bold right angle bracket)	Separates levels in a hierarchy of menu selections.	In the configuration editor hierarchy, select **Protocols>Ospf**.

Documentation Feedback

We encourage you to provide feedback, comments, and suggestions so that we can improve the documentation. You can provide feedback by using either of the following methods:

- Online feedback rating system—On any page of the Juniper Networks TechLibrary site at http://www.juniper.net/techpubs/index.html, simply click the stars to rate the content, and use the pop-up form to provide us with information about your experience. Alternately, you can use the online feedback form at http://www.juniper.net/techpubs/feedback/.
- E-mail—Send your comments to techpubs-comments@juniper.net. Include the document or topic name, URL or page number, and software version (if applicable).

Requesting Technical Support

Technical product support is available through the Juniper Networks Technical Assistance Center (JTAC). If you are a customer with an active J-Care or Partner Support Service support contract, or are covered under warranty, and need post-sales technical support, you can access our tools and resources online or open a case with JTAC.

- JTAC policies—For a complete understanding of our JTAC procedures and policies, review the *JTAC User Guide* located at http://www.juniper.net/us/en/local/pdf/resource-guides/7100059-en.pdf.
- Product warranties—For product warranty information, visit http://www.juniper.net/support/warranty/.
- JTAC hours of operation—The JTAC centers have resources available 24 hours a day, 7 days a week, 365 days a year.

Self-Help Online Tools and Resources

For quick and easy problem resolution, Juniper Networks has designed an online self-service portal called the Customer Support Center (CSC) that provides you with the following features:

- Find CSC offerings: http://www.juniper.net/customers/support/
- Search for known bugs: http://www2.juniper.net/kb/
- Find product documentation: http://www.juniper.net/techpubs/
- Find solutions and answer questions using our Knowledge Base: http://kb.juniper.net/
- Download the latest versions of software and review release notes: http://www.juniper.net/customers/csc/software/
- Search technical bulletins for relevant hardware and software notifications: http://kb.juniper.net/InfoCenter/
- Join and participate in the Juniper Networks Community Forum: http://www.juniper.net/company/communities/
- Open a case online in the CSC Case Management tool: http://www.juniper.net/cm/

To verify service entitlement by product serial number, use our Serial Number Entitlement (SNE) Tool: https://tools.juniper.net/SerialNumberEntitlementSearch/

Opening a Case with JTAC

You can open a case with JTAC on the Web or by telephone.

- Use the Case Management tool in the CSC at http://www.juniper.net/cm/.
- Call 1-888-314-JTAC (1-888-314-5822 toll-free in the USA, Canada, and Mexico).

For international or direct-dial options in countries without toll-free numbers, see http://www.juniper.net/support/requesting-support.html.

PART 1

Overview

- Overview of Ethernet Solutions on page 3
- Basic Layer 2 Features on MX Series Routers on page 19
- Virtual Switches on page 21
- VLANs Within Bridge Domain and VPLS Environments on page 23
- Bulk Administration of Layer 2 Features on MX Series Routers on page 27

CHAPTER 1

Overview of Ethernet Solutions

- Ethernet Terms and Acronyms on page 3
- Networking and Internetworking with Bridges and Routers on page 6
- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9
- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Ethernet Terms and Acronyms

Networking with a switch over Ethernet on a LAN is different than networking with a router with IP over a wider area. Even the words used to talk about Ethernet networking are different from those used in IP routing. This topic provides a list of all the terms and acronyms used in the *Junos OS Layer 2 Switching and Bridging Library* , as well terms that apply to a complete network using Ethernet as a carrier technology.

- 802.1ad—The IEEE specification for “Q-in-Q” encapsulation and bridging of Ethernet frames.
- 802.1ah—The IEEE specification for media access control (MAC) tunneling encapsulation and bridging of Ethernet frames across a provided backbone-managed bridge.
- 802.3ag—The IEEE specification for a wide range of Ethernet Operations, Administration, and Maintenance (OAM) features. See also *OAM*, *CFM*, and *ETH-DM*.
- 802.3ah—The IEEE specification for link fault management (LFM), a method for OAM of Ethernet links.
- 802.1Q—The IEEE specification for adding virtual local area network (VLAN) tags to an Ethernet frame.
- B–MAC—The backbone source and destination MAC address fields found in the IEEE 802.1ah provider MAC encapsulation header.

- bridge—A network component defined by the IEEE that forwards frames from one LAN segment or VLAN to another. The bridging function can be contained in a router, LAN switch, or other specialized device. See also *switch*.
- bridge domain—A set of logical ports that share the same flooding or broadcast characteristics. As in a virtual LAN, a bridge domain spans one or more ports of multiple devices. By default, each bridge domain maintains its own forwarding database of MAC addresses learned from packets received on ports belonging to that bridge domain. See also *broadcast domain* and *VLAN*.
- B-TAG—A field defined in the IEEE 802.1ah provider MAC encapsulation header that carries the backbone VLAN identifier information. The format of the B-TAG field is the same as that of the IEEE 802.1ad S-TAG field. See also *S-TAG*.
- B-VID—The specific VLAN identifier carried in a B-TAG.
- CFM—Connectivity-fault management. The part of Ethernet OAM that monitors events at levels above the physical level, as does LFM. See also *OAM*, *LFM*, and *ETH-DM*.
- CIST—Common and Internal Spanning Tree. The single spanning tree calculated by the spanning tree protocol (STP) and the rapid spanning tree protocol (RSTP) and the logical continuation of that connectivity through multiple spanning tree (MST) bridges and regions, calculated to ensure that all LANs in the bridged LAN are simply and fully connected. See also *MSTI*.
- ETH-DM—Ethernet Frame Delay Measurements. See also *OAM*, *CFM*, and *Y.1731*.
- Ethernet—A term loosely applied to a family of LAN standards based on the original proprietary Ethernet from DEC, Intel, and Xerox (DIX Ethernet), and the open specifications developed by the IEEE 802.3 committee (IEEE 802.3 LANs). In practice, few LANs comply completely with DIX Ethernet or IEEE 802.3.
- IRB—Integrated bridging and routing. IRB provides simultaneous support for Layer 2 bridging and Layer 3 routing within the same bridge domain. Packets arriving on an interface of the bridge domain are Layer 2 switched or Layer 3 routed based on the destination MAC address. Packets addressed to the router's MAC address are routed to other Layer 3 interfaces.
- I-SID—The 24–bit service instance identifier field carried inside an I-TAG. The I-SID defines the service instance to which the frame is mapped.
- I-TAG—A field defined in the IEEE 802.1ah provider MAC encapsulation header that carries the service instance information (I-SID) associated with the frame.
- learning domain—A MAC address database where the MAC addresses are added based on the normalized VLAN tags.
- LFM—Link fault management. A method used to detect problems on links and spans on an Ethernet network defined in IEEE 802.3ah. See also *OAM*.
- MSTI—Multiple Spanning Tree Instance. One of a number of spanning trees calculated by MSTP within an MST region. The MSTI provides a simple and fully connected active topology for frames classified as belonging to a VLAN that is mapped to the MSTI by the MST configuration table used by the MST bridges of that MST region. See also *CIST*.

- MSTP—Multiple Spanning Tree Protocol. A spanning-tree protocol used to prevent loops in bridge configurations. Unlike other types of STPs, MSTP can block ports selectively by VLAN. See also *RSTP*.
- OAM—Operation, Administration, and Maintenance. A set of tools used to provide management for links, device, and networks. See also *LFM*.
- PBB—Provider backbone bridge.
- Q-in-Q—See *802.1ad*.
- PBBN—Provider backbone bridged network.
- RSTP—Rapid Spanning Tree Protocol. A spanning-tree protocol used to prevent loops in bridge configurations. RSTP is not aware of VLANs and blocks ports at the physical level. See also *MSTP*.
- S-TAG—A field defined in the IEEE 802.1ad Q-in-Q encapsulation header that carries the S-VLAN identifier information. See also *B-TAG*.
- S-tagged service interface—The interface between a customer edge (CE) device and the I-BEB or IB-BEB network components. Frames passed through this interface contain an S-TAG field. See also *B-tagged service interface*.
- S-VLAN—The specific service instance VLAN identifier carried inside the S-TAG field. See also *B-VID*.
- switch—A network device that attempts to perform as much of the forwarding task in hardware as possible. The switch can function as a bridge (LAN switch), router, or some other specialized device, and forwards frames, packets, or other data units. See also *bridge*.
- virtual switch—A routing instance that can contain one or more bridge domains.
- VLAN—Virtual LAN. Defines a broadcast domain, a set of logical ports that share the same flooding or broadcast characteristics. VLANs span one or more ports on multiple devices. By default, each VLAN maintains its own Layer 2 forwarding database containing MAC addresses learned from packets received on ports belonging to the VLAN. See also *bridge domain*.
- Y.1731—The international standard for Ethernet Frame Delay Measurements (ETH-DM).

At this point, these acronyms and terms are just a bewildering array of letters and words. It is the goal of this manual to make the contents of this list familiar and allow you to place each of them in context and understand how they relate to each other. To do that, a basic understanding of modern Ethernet standards and technology is necessary.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Networking and Internetworking with Bridges and Routers on page 6
- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9
- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
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- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Networking and Internetworking with Bridges and Routers

Traditionally, different hardware, software, and protocols have been used on LANs and on networks that cover wider areas (national or global). A LAN switch is different than a router, an Ethernet frame is different than an IP packet, and the methods used to find destination MAC addresses are different than those used to find destination IP addresses. This is because LANs based on Ethernet were intended for different network environments than networks based on IP. The Internet protocol suite (TCP/IP) was intended as an internetworking method to connect local customer networks. The local customer network that a service provider's IP routers connected was usually based on some form of Ethernet. This is why Ethernet and IP fit so well together: Ethernet defines the LAN, and the Internet protocols define how these LANs are connected.

More specifically, Ethernet LANs and IP networks occupy different layers of the Internet's TCP/IP protocol suite. Between sender and receiver, networks deal with the bottom three layers of the model: the physical layer (Layer 1), the data link or MAC layer (Layer 2), and the network layer (Layer 3).

NOTE: **These layers are also found in the Open Systems Interconnect Reference Model (OSI-RM); however, in this chapter they are applied to the TCP/IP protocol suite.**

All digital networks ultimately deal with zeroes and ones, and the physical layer defines bit representation on the media. Physical layer standards also define mechanical aspects of the network, such as electrical characteristics or connector shapes, functional aspects such as bit sequence and organization, and so on. The physical layer only "spits bits" and has very little of the intelligence required to implement a complete network. Devices that connect LAN segments at the physical layer are called *hubs*, and all bits that appear on one port of the hub are also sent out on the other ports. This also means that bad bits that appear on one LAN segment are propagated to all other LAN segments.

Above the physical layer, the data link layer defines the first-order bit structure, or *frame*, for the network type. Also loosely called the MAC layer (technically, the MAC layer is a sublayer required only on LANs), Layer 2 sends and receives frames. Frames are the last things that bits were before they left the sender and the first things that bits become when they arrive on an interface. Because frames have a defined structure, unlike bits, frames can be used for error detection, control plane activities (not all frames must carry user data: some frames are used by the network to control the link), and so forth. LAN segments can be linked at the frame level, and these devices are called *bridges*. Bridges examine arriving frames and decide whether to forward them on an interface. All bridges today are called *learning bridges* because they can find out more about the network than

could older bridges that were less intelligent devices. Bridges learn much about the LAN segments they connect to from protocols like those in the Spanning Tree Protocol (STP) family.

The network layer (Layer 3) is the highest layer used by network nodes to forward traffic as part of the data plane. On the Internet, the network layer is the IP layer and can run either IPv4 or IPv6, which are independent implementations of the same functions. The IP layer defines the structure and purpose of the packet, which is in turn the content of the frame at Layer 2. As expected, LAN segments (which now form perfectly functional networks on their own at the frame level) can be linked at the network layer, and in fact that is one of the major functions of IP. Devices that link LANs at the network layer are called *routers*, and IP routers are the network nodes of the Internet.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
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- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Network Addressing at Layer 2 and Layer 3

The Internet is a global, public network with IP subnets connected by routers and exchanging packets. Can a global, public network consist of Ethernet LANs connected by bridges and exchanging frames? Yes, it can, but there are several differences that must be addressed before Ethernet can function as effectively as IP in the metropolitan area (Metro Ethernet), let alone globally. One of the key differences is the addresses used by Layer 2 frames and Layer 3 packets.

Both Ethernet and IP use globally unique network addresses that can be used as the basis for a truly global network. Ethernet MAC addresses come from the IEEE and IP subnet addresses come from various Internet authorities. (IP also employs a naming convention absent in Ethernet, but we'll ignore that in this discussion.) The key differences in how these addresses are assigned make all the difference when it comes to the basic functions of a bridge as opposed to a router.

NOTE: The opposite of a “globally unique network address” is the “locally significant connection identifier” which connects two endpoints on a network. For example, MPLS labels such as 1000001 can repeat in a network, but a public IP address can appear on the Internet in only one place at a time (otherwise it is an error).

All devices on LANs that are attached to the Internet have both MAC layer and IP addresses. Frames and packets contain both source and destination addresses in their headers. In general:

- MAC addresses are 48 bits long. The first 24 bits are assigned by the IEEE and form the organizationally unique identifier (OUI) of the manufacturer or vendor requesting the address. The last 24 bits form the serial number of the LAN interface cards and their uniqueness must be enforced by the company (some companies reuse numbers of bad or returned cards while others do not).
- IPv4 addresses are 32 bits long. A variable number of the beginning bits are assigned by an Internet authority and represent a subnet located somewhere in the world. The remaining bits are assigned locally and, when joined to the network portion of the address, uniquely identify some host on a particular network.
- IPv6 addresses are 128 bits long. Although there are significant differences, for the purposes of this discussion, it is enough to point out that there is also a network and host portion to an IPv6 address.

Note that MAC addresses are mainly organized by manufacturer and IP addresses are organized by network, which is located in a particular place. Therefore, the IP address can easily be used by routers for a packet's overall direction (for example, “192.168.27.48 is west of here”). However, the MAC addresses on a vendor's interface cards can end up anywhere in the world, and often do. Consider a Juniper Networks router as a simple example. Every Ethernet LAN interface on the router that sends or receives packets places them inside Ethernet frames with MAC addresses. All of these interfaces share the initial 24 bits assigned to Juniper Networks. Two might differ only in one digit from one interface to another. Yet the routers containing these MAC interfaces could be located on opposite sides of the world.

An Internet backbone router only needs a table entry for every network (not host) in the world. Most other routers only have a portion of this full table, and a default route for forwarding packets with no entries in their table. In contrast, to perform the same role, a bridge would need one table entry for every LAN interface, on host or bridge, in the world. This is hard enough to do for Ethernets that span a metropolitan area, let alone the entire world.

NOTE: There are other reasons that Ethernet would be hard-pressed to become a truly global network, including the fact that MAC addresses do not often have names associated with them while IP addresses do (for example, 192.168.27.48 might be host48.accounting.juniper.net). This section addresses only the address issues.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
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- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Networking at Layer 2: Benefits of Ethernet Frames

In spite of the difficulties of using a bridge to perform the network role of a router, many vendors, customers, and service providers are attracted to the idea of using Ethernet in as many places of their networks as possible.

The perceived benefits of Ethernet are:

- Most information starts and ends inside Ethernet frames. Today, this applies to data, as well as voice (for example, VoIP) and video (for example, Web cams).
- Ethernet frames have all the essentials for networking, such as globally unique source and destination addresses, error control, and so on.
- Ethernet frames can carry any kind of packet. Networking at Layer 2 is protocol independent (independent of the Layer 3 protocol). Layer 2 networks work for IP packets and all other Layer 3 protocols.
- More layers added to the Ethernet frame only slow the networking process down ("nodal processing delay").
- Adjunct networking features such as class of service (CoS) or multicasting can be added to Ethernet as readily as IP networks.

If more of the end-to-end transfer of information from a source to a destination can be done in the form of Ethernet frames, more of the benefits of Ethernet can be realized on the network. Networking at Layer 2 can be a powerful adjunct to IP networking, but it is not usually a substitute for IP networking.

NOTE: Networking at the frame level says nothing about the presence or absence of IP addresses at the packet level. Almost all ports, links, and devices on a network of LAN switches still have IP addresses, just as do all the source and destination hosts. There are many reasons for the continued need for IP, not the least of which is the need to manage the network. A device or link without an IP address is usually invisible to most management applications. Also, utilities such as remote access for diagnostics, file transfer of configurations and software, and so on cannot run without IP addresses as well as MAC addresses.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Ethernet Terms and Acronyms on page 3
- Networking and Internetworking with Bridges and Routers on page 6
- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Networking at Layer 2: Challenges of Ethernet MAC Addresses

If a networked Layer 2 device such as a bridge or LAN switch could contain a list of all known MAC addresses, then the network node could function in much the same way as a router, forwarding frames instead of packets hop-by-hop through the network from source LAN to destination LAN. However, the MAC address is much larger than the IPv4 address currently used on the Internet backbone (48 bits compared to the 32 bits of IPv4).

This poses problems. Also, because the MAC address has no “network organization” like the IPv4 or IPv6 address, an Layer 2 network node must potentially store every conceivable MAC address in memory for next-hop table lookups. Instead of tables of about 125,000 entries, every Layer 2 network node would have to store millions of entries (for example, 24 bits, the potential NIC production from *one* Ethernet vendor, would require a table of more than 16 million entries).

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Ethernet Terms and Acronyms on page 3
- Networking and Internetworking with Bridges and Routers on page 6

- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Networking at Layer 2: Forwarding VLAN Tagged Frames

VLAN tags were not developed as a way to limit network node table entries. They were originally invented to allow LAN switches to distinguish between physical groups of LAN ports and logical groups of LAN ports. In other words, there was a need to configure a LAN switch (or group of local LAN switches) to know that "these ports belong to VLAN A" and "these ports belong to VLAN B."

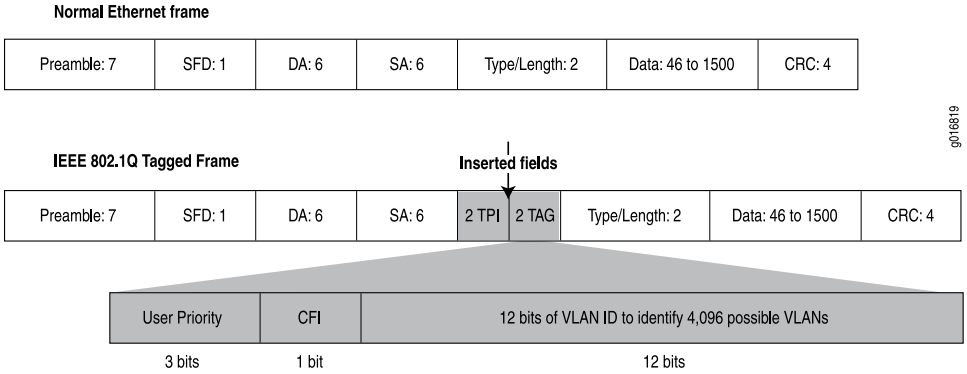
This was important because of how all LANs, not just Ethernet, work at the frame level. Lots of frames on a LAN are broadcast to all stations (hosts and network nodes) on the LAN segment. Also, multicasting works by flooding traffic within the VLAN. The stations that received broadcast frames form the *broadcast domain* of the LAN. Only Ethernet frames belonging to same broadcast domain are forwarded out certain ports on the LAN switch. This prevents broadcast storms and isolates routine control frames onto the LAN segment where they make the most sense.

The VLAN tag was invented to distinguish among different VLAN broadcast domains on a group of LAN switches. The VLAN tag is a two-byte field inserted between the source MAC address and the Ethertype (or length) field in an Ethernet frame. Another two-byte field, the Tag Protocol Identifier (TPI or TPID), precedes the VLAN tag field.

Two fields were necessary to hold one piece of information, the VLAN tag, to enable receivers to distinguish between untagged or plain Ethernet frames and those containing VLAN tags. A mechanism was required to differentiate between the Ethertype and length field for the untagged case and to distinguish among VLAN tag, Ethertype, and length field for the tagged case. The answer was to constrain the TPID field to values that were not valid Ethernet frame lengths or defined as valid Ethertypes. The first VLAN tag added to an Ethernet frame is always indicated by a TPID value of **0x8100**. This is not the VLAN identifier, which appears in the next two bytes.

In Figure 1 on page 12, a native or normal Ethernet frame is compared to a VLAN-tagged Ethernet frame. The lengths of each field, in bytes, is shown next to the field name.

Figure 1: Native (Normal) and VLAN-Tagged Ethernet Frames



The VLAN tag subtracts four bytes from the total MTU length of the Ethernet frame, but this is seldom a problem if kept in mind. When this tag is used in an Ethernet frame, the frame complies with the IEEE 802.1Q (formerly IEEE 802.1q) specification.

Together, the four added bytes form the VLAN tag, but the individual fields that comprise it are more important. The 2–byte TPID field is just a number and has no structure, only having allowed and disallowed values. However, the 2-byte Tag Control Information (TCI) field has a defined structure:

- The three bits of the User Priority field are defined by the IEEE 802.1p specification. These can mimic class-of-service (CoS) parameters established at other layers of the network (IP precedence bits, or MPLS EXP bits, and so on).
- The Canonical Format Indicator (CFI) bit indicates whether the following 12 bits of VLAN identifier conform to Ethernet or not. For Ethernet frames, this bit is always set to 0. (The other possible value, CFI=1, is used for Token Ring LANs, and tagged frames should never be bridged between an Ethernet and Token Ring LAN regardless of the VLAN tag or MAC address.)
- The 12-bit VLAN ID allows for 4096 possible VLANs, but not all values are used in all cases.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Ethernet Terms and Acronyms on page 3
- Networking and Internetworking with Bridges and Routers on page 6
- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9
- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Networking at Layer 2: Forwarding Dual-Tagged Frames

The use of VLAN tagging to group (or bundle) sets of MAC addresses is a start toward a method of forwarding LAN traffic based on information found in the frame, not on IP address in the packet. However, there is a major limitation in trying to build forwarding tables based on VLAN tags. Simply put, there are not enough VLAN tags.

Twelve bits only supply enough space for 4096 unique VLAN tags. This is hardly enough for all the LANs on a large corporate campus, let alone the whole world. A 12-bit tag might suffice for the local campus arena, but for the metropolitan area, comprising a whole city, more bits are needed.

The number of bits in the VLAN tag, two bytes for the TPID and two bytes for the TCI field, are fixed and cannot be extended. However, another VLAN tag can be added to the frame, forming an inner and outer VLAN tag arrangement. This arrangement is defined in the IEEE 802.1ad specification and applies to devices that function on the provider bridge level. This means that Ethernet frames tagged at the local (or customer) VLAN level can receive another outer VLAN tag when they are sent to the provider's LAN switches. As a result, Ethernet frames can be switched across a metropolitan area, not just among the local organizations devices at the campus level.

The outer tag defined in IEEE 802.1ad is often called the Virtual Metropolitan Area Network (VMAN) tag, a good way to recall the intended scope of the specification. The outer tag is placed after the MAC source address, moving the inner tag backwards in the frame. Both tags can be added at the same time by the same device (called a push/push operation), changed by a device (a swap operation), or removed by a device one at a time (pop) or together (pop/pop). Devices can perform elaborate variations on these operations (such as pop/swap/push) to accomplish the necessary networking tasks with the frames they process.

The IEEE specification indicates that the outer tag of a doubly-tagged Ethernet frame should have a TPID value of **0x88a8**. Any network device can easily tell if it has received a frame with one tag (**0x8100**) or two tags (**0x88a8**). However, because the value **0x8100** always means that a VLAN tag is present, most vendors and networks use the same TPID value (**0x8100**) for the inner and outer tags. As long as the configuration and processing are consistent, there is no confusion, and the TPID value can usually be changed if necessary.

How do nested VLAN tags solve the VLAN numbering limitation? Taken together, the two VLAN tags can be thought of as providing 24 bits for tagging space: 12 bits at the outer level and 12 bits at the inner level. However, it is important to realize that the bits are not acted on as if they were all one tag. Even when the tags are nested, bridges on a provider backbone will normally only switch on the outer VLAN tag. All in all, the inner 12-bit tagging space is more than adequate for a Metro Ethernet network. Any limitations in the VLAN tag space can be addressed by adding more VLAN tags to the basic Ethernet frame.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Ethernet Terms and Acronyms on page 3

- Networking and Internetworking with Bridges and Routers on page 6
- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9
- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

Networking at Layer 2: Logical Interface Types

Two main types of interfaces are used in Layer 2 configurations:

- Layer 2 logical interface—This type of interface uses the VLAN-ID as a virtual circuit identifier and the scope of the VLAN-ID is local to the interface port. This type of interface is often used in service-provider-centric applications.
- Access or trunk interface—This type of interface uses a VLAN-ID with global significance. The access or trunk interface is implicitly associated with bridge domains based on VLAN membership. Access or trunk interfaces are typically used in enterprise-centric applications.

NOTE: The difference between access interfaces and trunk interfaces is that access interfaces can be part of one VLAN only and the interface is normally attached to an end-user device (packets are implicitly associated with the configured VLAN). In contrast, trunk interfaces multiplex traffic from multiple VLANs and usually interconnect switches.

Related Documentation

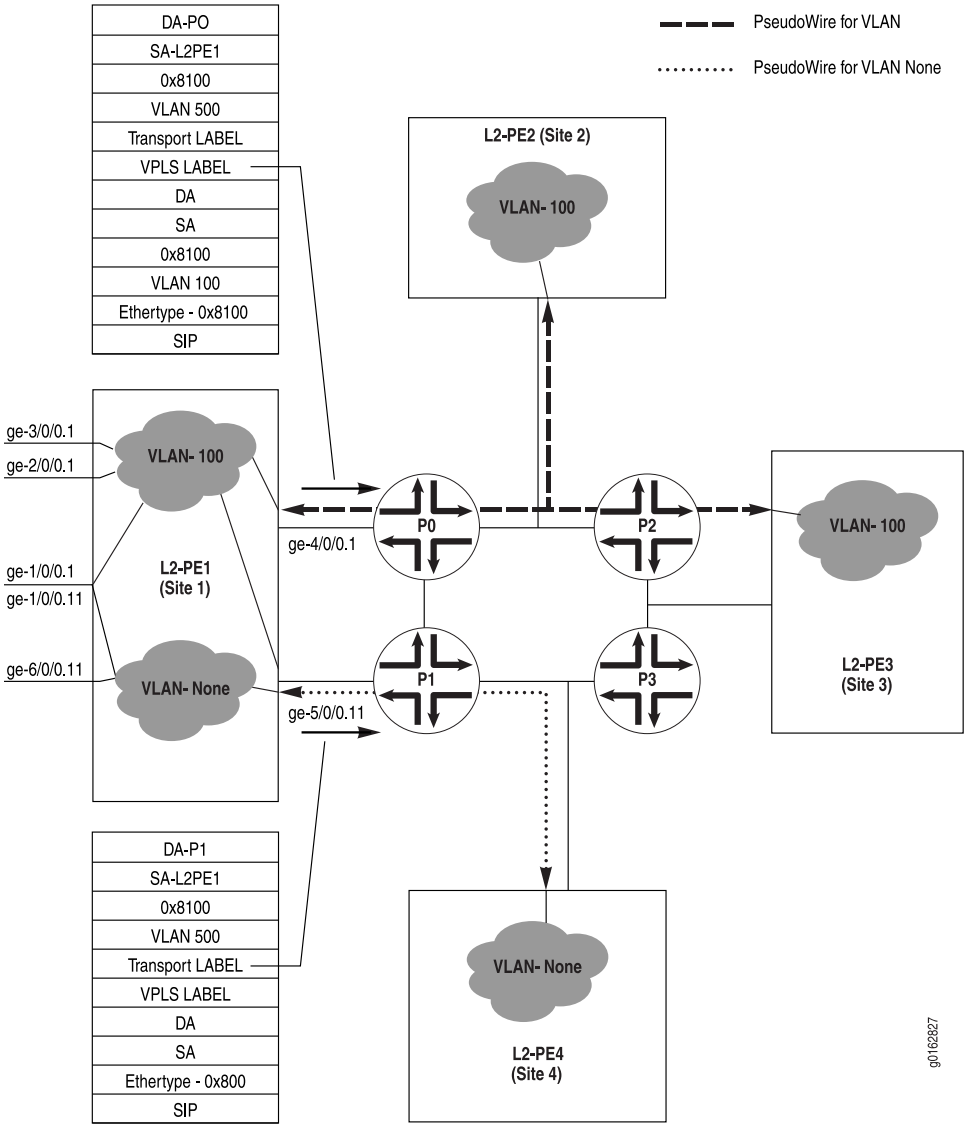
- *Ethernet Networking Feature Guide for MX Series Routers*
- Ethernet Terms and Acronyms on page 3
- Networking and Internetworking with Bridges and Routers on page 6
- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9
- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- A Metro Ethernet Network with MX Series Routers on page 15
- Layer 2 Networking Standards on page 17

A Metro Ethernet Network with MX Series Routers

What would a Metro Ethernet network with Juniper Networks MX Series 3D Universal Edge Router look like? It is very likely that the Metro Ethernet network will place MX Series routers at the edge of a VPLS and MPLS core network.

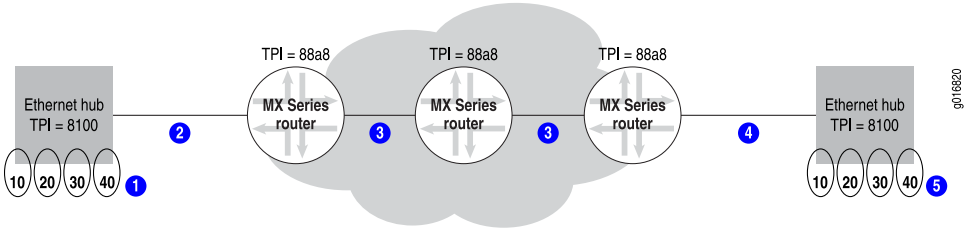
The VLAN labels in the packet are stacked with MPLS labels, as shown in Figure 2 on page 15. For a more detailed examination of this type of Metro Ethernet network, see "Example: Configuring a Provider VPLS Network with Normalized VLAN Tags" on page 66.

Figure 2: A Metro Ethernet Network



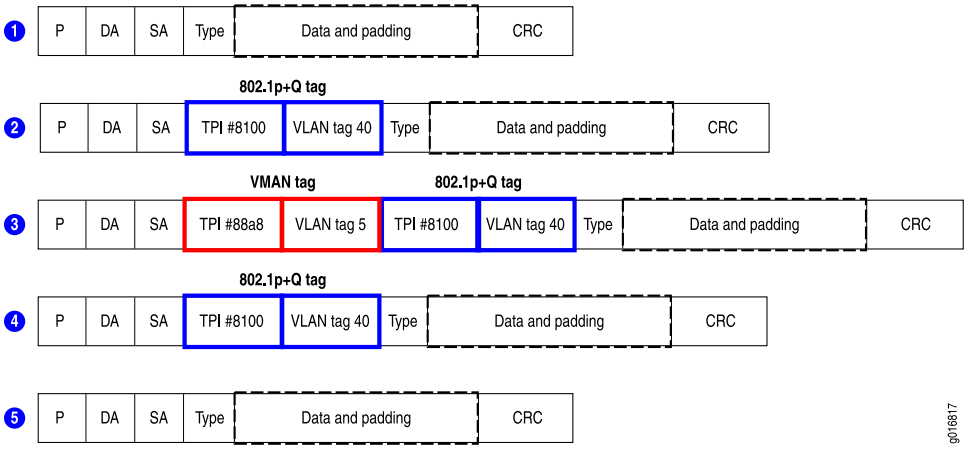
Another possible configuration, this one without the VPLS and MPLS core, is shown in Figure 3 on page 16.

Figure 3: A Metro Ethernet Network with MX Series Routers



In Figure 3 on page 16, the circled numbers reflect the different formats that the Ethernet frames can take as the frames make their way from a host on one Ethernet switching hub to a host on the other hub. The frame can have two VLAN tags (inner and outer), one tag (only the inner), or no tags at all. The structure of these various Ethernet frames is shown in Figure 4 on page 16.

Figure 4: VLAN Tags on a Metro Ethernet Network



As the frame flows from a LAN-based host on one end of Figure 4 on page 16 to the other, the Ethernet frame can have:

- No VLAN tags—At locations 1 and 5, the Ethernet frames can be native and have no VLAN tags at all (many NIC cards can include configuration of a VLAN identifier, but not all).
- One VLAN tag—At locations 2 and 4, from the VLAN-aware switching hub to the MX Series router, the Ethernet frame has one VLAN tag (if a VLAN tag is not present on arriving frames, a tag is added by the MX Series router).
- Two VLAN tags—At location 3, between two provider bridges, the MX Series routers exchange frames with two VLAN tags. The outer tags are added and removed by the MX Series routers.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Ethernet Terms and Acronyms on page 3
- Networking and Internetworking with Bridges and Routers on page 6

- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9
- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- Layer 2 Networking Standards on page 17

Layer 2 Networking Standards

For additional information about the Layer 2 networking features available on Juniper Networks MX Series 3D Universal Edge Router, see the following references:

- 802.1ad—IEEE standard *Provider Bridges* .
- 802.1ag—IEEE standard *Connectivity Fault Management*.
- 802.1ah—IEEE standard *Provider Backbone Bridges*.
- 802.1p—IEEE draft standard *Wireless Access in Vehicular Environments*.
- 802.1Q—IEEE standard *Provider Backbone Bridge Traffic Engineering*.
- 802.3ah-2004—IEEE standard *Operations Administration, and Management (OAM)* for link fault management (LFM), or simple connectivity fault management (CFM) at the data link layer. Also known as “Ethernet in the First Mile (EFM)” and EFM-OAM.
- 802.3-2008, Clause 57—IEEE standard *Operations Administration, and Maintenance (OAM)*. Incorporates 802.3ah-2004 within the IEEE standard *Carrier sense multiple access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*.
- RFC 4761—IETF draft *Virtual Private LAN Service (VPLS) Using BGP for Auto-discovery and Signaling*.
- RFC 4762—IETF draft *Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling*.
- Y.1731—ITU-T recommendation *OAM Functions and Mechanisms for Ethernet-based Networks*.
- OSI-RM—*Open Systems Interconnection Reference Model*.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Ethernet Terms and Acronyms on page 3
- Networking and Internetworking with Bridges and Routers on page 6
- Network Addressing at Layer 2 and Layer 3 on page 7
- Networking at Layer 2: Benefits of Ethernet Frames on page 9

- Networking at Layer 2: Challenges of Ethernet MAC Addresses on page 10
- Networking at Layer 2: Forwarding VLAN Tagged Frames on page 11
- Networking at Layer 2: Forwarding Dual-Tagged Frames on page 13
- Networking at Layer 2: Logical Interface Types on page 14
- A Metro Ethernet Network with MX Series Routers on page 15

CHAPTER 2

Basic Layer 2 Features on MX Series Routers

- Layer 2 Features for a Bridging Environment on page 19

Layer 2 Features for a Bridging Environment

You configure MX Series routers exactly as you would any other router running the Junos OS. That is, all the familiar Layer 3 features and protocols are available on the MX Series routers. However, you can configure Layer 2 features that are unique to the MX Series routers. This chapter addresses Layer 2 configuration for the MX Series routers. For information about configuring Layer 3 features and protocols, as well as comprehensive information about interfaces and system basics, please see the other Junos configuration guides.

Configuring Layer 2 features on an MX Series router can vary from the very simple (aggregated Ethernet trunk interfaces, spanning trees), to the more complex (inner and outer VLAN tags, broadcast domains), to the very complicated (integrated bridging and routing, Layer 2 filtering). This chapter offers a fairly complex configuration for Layer 2 processing in a bridged environment.

Generally, there are four things that you must configure in an Layer 2 environment:

- Interfaces and virtual LAN (VLAN) tags—Layer 2 interfaces are usually various type of Ethernet links with VLAN tags used to connect to customer devices or other bridges or routers.
- Bridge domains—Bridge domains limit the scope of media access control (MAC) learning (and thereby the size of the MAC table) and also determine where the device should propagate frames sent to broadcast, unknown unicast, and multicast (BUM) MAC addresses.
- Spanning Tree Protocols (xSTP, where the “x” represents the STP type)—Bridges function by associating a MAC address with an interface, similar to the way a router associates an IP network address with a next-hop interface. Just as routing protocols use packets to detect and prevent routing loops, bridges use xSTP frames to detect

and prevent bridging loops. (Layer 2 loops are more devastating to a network because of the broadcast nature of Ethernet LANs.)

- Integrated bridging and routing (IRB)—Support for both Layer 2 bridging and Layer 3 routing on the same interface. Frames are bridged if they are not sent to the router's MAC address. Frames sent to the router's MAC address are routed to other interfaces configured for Layer 3 routing.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Example Roadmap: Configuring a Basic Bridge Domain Environment on page 33
- Example Step: Configuring Interfaces and VLAN Tags on page 35
- Example Step: Configuring Bridge Domains on page 41
- Example Step: Configuring Spanning Tree Protocols on page 43
- Example Step: Configuring Integrated Bridging and Routing on page 45

CHAPTER 3

Virtual Switches

- Layer 2 Features for a Switching Environment on page 21

Layer 2 Features for a Switching Environment

Juniper Networks MX Series 3D Universal Edge Routers include all standard Ethernet capabilities as well as enhanced mechanisms for service providers to provision and support large numbers of Ethernet services in addition to all Layer 3 services. The MX Series routers include several features to contain and control the Ethernet environment.

One of these features is the virtual switch. MX Series routers allow the collapsing of multiple diverse switch networks to a single platform by running virtual instances of as many Spanning Tree Protocols (STPs) as needed to support all broadcast domains. This is important because there are many incompatible versions of STP, and without a way to run multiple virtual instances, a separate switch would be needed to support each one. With MX Series virtual switch configuration, you can continue to running existing STP protocols with the option to migrate to a common STP protocol if desired.

Virtual switches also make it easy to separate independent switched Ethernet networks, each possibly carrying several VLANs. Because the same VLAN ID can be used in multiple switched networks, virtual switches can keep each VLAN and broadcast domain logically separated.

NOTE: In a router environment, there is always a default routing instance. When you need only one routing instance on the router, you use the default routing instance without qualification. However, if you need more than one routing instance, you must configure statements to create additional routing instances. In a switching environment, the same is true of virtual switches: if you need more than one virtual switch in addition to the "default," you must create them.

For more information about STPs and virtual switches, see the *Junos OS Layer 2 Switching and Bridging Library* .

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Configuring Virtual Switches as Separate Routing Instances on page 31

CHAPTER 4

VLANs Within Bridge Domain and VPLS Environments

- VLANs Within a Bridge Domain or VPLS Instance on page 23
- Packet Flow Through a Bridged Network with Normalized VLANs on page 24

VLANs Within a Bridge Domain or VPLS Instance

A packet received on a physical port is only accepted for processing if the VLAN tags of the received packet match the VLAN tags associated with one of the logical interfaces configured on the physical port. The VLAN tags of the received packet are translated only if they are different than the normalized VLAN tags. For the translation case, the VLAN identifier tags specify the normalized VLAN. For this case, the terms “learn VLAN” and “normalized VLAN” can be used interchangeably.

You can specify the normalized VLAN using one of the following conditions:

- The VLAN identifier is determined explicitly by configuration
- The VLAN identifier is specified as “none,” meaning the VLAN tags are not translated or generated
- The inner and outer VLAN identifier tags are both determined explicitly by configuration

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Packet Flow Through a Bridged Network with Normalized VLANs on page 24
- Configuring a Normalized VLAN for Translation or Tagging on page 59
- Configuring Learning Domains for VLAN IDs Bound to Logical Interfaces on page 61
- Example: Configuring a Provider Bridge Network with Normalized VLAN Tags on page 62
- Example: Configuring a Provider VPLS Network with Normalized VLAN Tags on page 66
- Example: Configuring One VPLS Instance for Several VLANs on page 70

Packet Flow Through a Bridged Network with Normalized VLANs

Packets received over a Layer 2 logical interface for bridging are processed in a strict sequence of steps.

Packets received over a Layer 2 logical interface for bridging when a normalized VLAN is configured with a single or inner and outer VLAN identifier tags under the bridge domain or the VPLS routing instance are processed with the following steps:

1. A packet received on a physical port is only accepted for further processing if the VLAN tags of the received packet match the VLAN tags associated with one of the logical interfaces configured on that physical port.

2. The VLAN tags of the received packet are compared with the normalized VLAN tags. If the VLAN tags of the received packet are different from the normalized VLAN, then the appropriate VLAN operations (such as push-push, pop-pop, pop-swap, swap-swap, swap, and others) are done implicitly to convert the received VLAN tags to the normalized VLAN tag value. For more information these operations, see the *Junos Routing Protocols Configuration Guide*.

3. If the source MAC address of the received packet is not present in the source MAC table, then it is learned based on the normalized VLAN tag value.

4. The packet is forwarded toward one or more egress Layer 2 logical interfaces based on the destination MAC address. A packet with a known unicast destination MAC address is only forwarded to one egress logical interface. For each egress Layer 2 logical interface, the normalized VLAN tag within the packet is compared with the VLAN tags configured on that logical interface. If the VLAN tags associated with an egress logical interface do not match the normalized VLAN tag in the frame, then appropriate VLAN operations (such as push-push, pop-pop, pop-swap, swap-swap, swap, and others) are implicitly done to convert the normalized VLAN tags to the VLAN tags of the egress logical interface. For more information these operations, see the *Junos Routing Protocols Configuration Guide*.

NOTE: **This packet flow applies to both VPLS and bridge domains.**

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- VLANs Within a Bridge Domain or VPLS Instance on page 23
- Configuring a Normalized VLAN for Translation or Tagging on page 59
- Configuring Learning Domains for VLAN IDs Bound to Logical Interfaces on page 61
- Example: Configuring a Provider Bridge Network with Normalized VLAN Tags on page 62
- Example: Configuring a Provider VPLS Network with Normalized VLAN Tags on page 66

- Example: Configuring One VPLS Instance for Several VLANs on page 70

CHAPTER 5

Bulk Administration of Layer 2 Features on MX Series Routers

- Bulk Configuration of VLANs and Bridge Domains on page 27

Bulk Configuration of VLANs and Bridge Domains

In some cases, service providers must deal with thousands of bridge domains on a single switch. By default the router does not create more than one bridge domain. The configuration of even several hundred bridge domains one at a time can be a burden.

However, you can configure multiple bridge domains with only one statement. Each bridge domain will have the form ***prefix*-vlan-*number***. The prefix and number are supplied by the configuration statement.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Example: Configuring VLAN Translation with a VLAN ID List on page 79
- Example: Configuring Multiple Bridge Domains with a VLAN ID List on page 80

PART 2

Configuration

- Configuration Task for Virtual Switches on page 31
- Basic Layer 2 Feature Examples on page 33
- VLANs Within Bridge Domain and VPLS Environments Examples on page 59
- Bulk Administration of Layer 2 Features on MX Series Routers Examples on page 79

CHAPTER 6

Configuration Task for Virtual Switches

- Configuring Virtual Switches as Separate Routing Instances on page 31

Configuring Virtual Switches as Separate Routing Instances

You can configure two virtual switches as separate routing instances on an MX Series router with bridge domains and VLANs.

Before you begin, you should have already configured a basic bridge domain environment. For a general description of a basic bridge domain environment, see "Layer 2 Features for a Bridging Environment" on page 19. For an example of a basic bridge domain configuration, see "Example Roadmap: Configuring a Basic Bridge Domain Environment" on page 33. More detailed examples are also provided for the four features generally required in a Layer 2 environment:

- Interfaces and VLAN tags required.
- Bridge domains required by the topology.
- Spanning tree protocols required by the topology.
- Integrated bridging and routing required by the topology.

At the end of this configuration, you create two virtual switches as separate routing instances to separate the VLANs and broadcast domains. Because the same VLAN ID can be used in multiple switched networks, virtual switches can keep each VLAN and broadcast domain logically separated.

To configure two virtual switches as separate routing instances:

1. The following statements configure the first virtual switch in a routing instance.

```
[edit]
routing-instances {
  virtual-switch-1 {
    instance-type virtual-switch;
    ...virtual-switch-1 configuration with one STP/VLAN ID set...
  }
}
```

2. The following statement configure the second virtual switch in a different routing instance.

```
[edit]
routing-instances {
  virtual-switch-2 {
    instance-type virtual-switch;
    ...virtual-switch-2 configuration with another STP/VLAN ID set...
  }
}
```

This is not a complete configuration.

For more information about configuring virtual switches, see the *Junos OS Layer 2 Switching and Bridging Library* .

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Layer 2 Features for a Switching Environment on page 21

CHAPTER 7

Basic Layer 2 Feature Examples

- Example Roadmap: Configuring a Basic Bridge Domain Environment on page 33
- Example Step: Configuring Interfaces and VLAN Tags on page 35
- Example Step: Configuring Bridge Domains on page 41
- Example Step: Configuring Spanning Tree Protocols on page 43
- Example Step: Configuring Integrated Bridging and Routing on page 45
- Example: Configuring Basic Layer 2 Switching on MX Series on page 49

Example Roadmap: Configuring a Basic Bridge Domain Environment

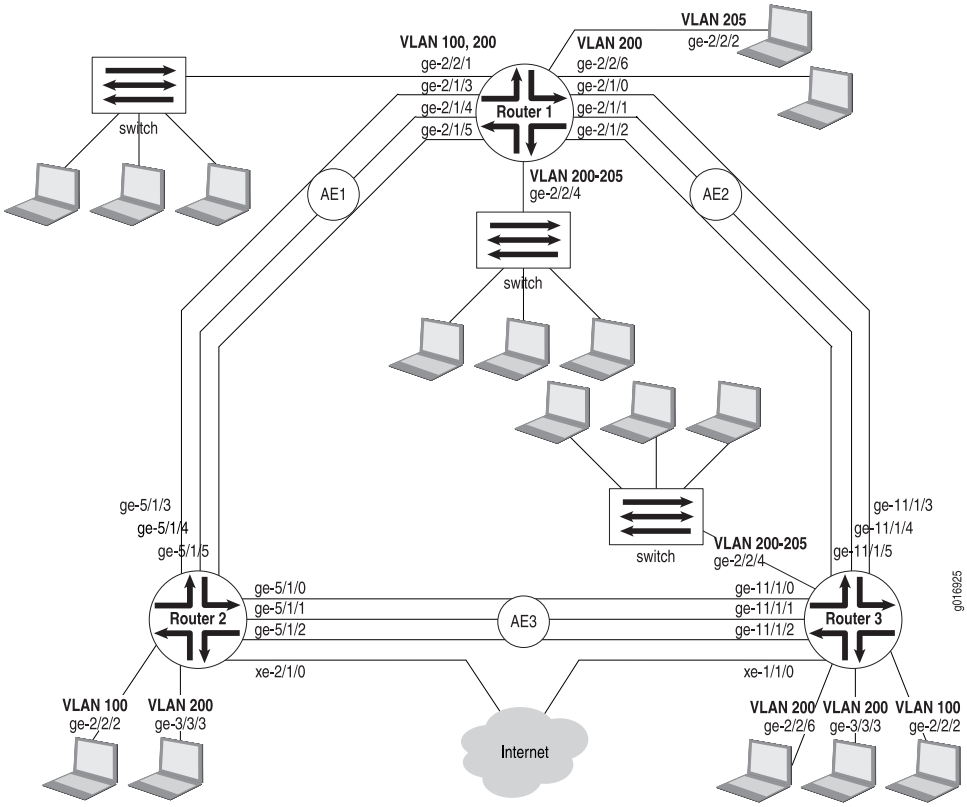
Configuring Layer 2 features on MX Series routers can vary from the very simple (aggregated Ethernet trunk interfaces, spanning trees), to the more complex (inner and outer VLAN tags, broadcast domains), to the very complicated (integrated bridging and routing, Layer 2 filtering). This example offers a fairly complex configuration for Layer 2 processing in a bridged environment.

- Example Topology on page 33
- Example Scenario on page 34
- Example Configuration Summary on page 35

Example Topology

Consider the network in Figure 5 on page 34. The figure shows three MX Series routers acting as Layer 2 devices.

Figure 5: Bridging Network with MX Series Routers



The three routers each have a series of hosts on their Ethernet interfaces, as well as aggregated Ethernet links between them. Router 2 and Router 3 are linked to the Internet, and Router 1 and Router 3 are also linked to switches configured with a range of VLANs, as shown in the figure. Because the VLAN tags are important, the routers run Multiple STP (MSTP) on the links connecting them to prevent bridging loops (Rapid STP, or RSTP, does not recognize VLAN tags and blocks ports without regard for VLAN tagging).

Example Scenario

The network administrator wants to configure these links and devices so that:

- The six Gigabit Ethernet links between Router 1 and the other routers (**ge-2/1/0** through **ge-2/1/5**) are gathered into two aggregated Ethernet (AE) links mixing bridged traffic from the VLANs. **AE1** will consist of the first three links and **AE2** will use the last three links. The same approach is taken for the links on Router 2 and Router 3.
- The Gigabit Ethernet links from Router 1 to the customer devices (**ge-2/2/1** and **ge-2/2/6**) will be bridged and include VLAN tag 100 on **ge-2/2/1** and VLAN tag 200 on **ge-2/2/6**. The other two routers, Router 2 and Router 3, also have two ports configured to handle VLAN 100 on one port (**ge-2/2/2**) and VLAN 200 on the other (**ge-3/3/3**).
- Router 2 and Router 3 have IRB configured so that they can pass traffic to other routers in the rest of the network.

- Router 1 has an access interface which provides bridging on VLAN 205 and is connected to a customer device configured on **ge-2/2/2**. Router 3 has an access interface which provides bridging on VLAN 200 and is connected to a customer device configured on **ge-2/2/6**.
- Router 1 and Router 3 are configured with a trunk interface to a switch for VLANs 200–205. On both routers, this interface is **ge-2/2/4**.

Example Configuration Summary

This procedure summarizes the minimum configuration steps required for Layer 2 processing in a bridged environment, as described in "Layer 2 Features for a Bridging Environment" on page 19. The individual configuration steps are described in greater detail in separate topics.

To configure Layer 2 processing in a bridged domain network:

1. Configure the Ethernet interfaces and VLAN tags on all three routers, as described in "Example Step: Configuring Interfaces and VLAN Tags" on page 35
2. Configure the bridge domains on all three routers, as described in "Example Step: Configuring Bridge Domains" on page 41.
3. Configure the Spanning Tree Protocol on all three routers, as described in "Example Step: Configuring Spanning Tree Protocols" on page 43
4. Configure IRB, as described in "Example Step: Configuring Integrated Bridging and Routing" on page 45

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Layer 2 Features for a Bridging Environment on page 19
- Example Step: Configuring Interfaces and VLAN Tags on page 35
- Example Step: Configuring Bridge Domains on page 41
- Example Step: Configuring Spanning Tree Protocols on page 43
- Example Step: Configuring Integrated Bridging and Routing on page 45

Example Step: Configuring Interfaces and VLAN Tags

Configure the Ethernet interfaces and VLAN tags on all three routers.

NOTE: **The configurations in this chapter are only partial examples of complete and functional router configurations. Do not copy these configurations and use them directly on an actual system.**

To configure the Ethernet interfaces and VLAN tags on all three routers:

1. Configure the Ethernet interfaces and VLAN tags on Router 1:

```
[edit]
chassis {
  aggregated-devices {
    ethernet {
      device-count 2; # Number of AE interfaces on router
    }
  }
}
interfaces ge-2/1/0 {
  gigether-options {
    802.3ad ae2;
  }
}
interfaces ge-2/1/1 {
  gigether-options {
    802.3ad ae2;
  }
}
interfaces ge-2/1/2 {
  gigether-options {
    802.3ad ae2;
  }
}
interfaces ge-2/1/3 {
  gigether-options {
    802.3ad ae1;
  }
}
interfaces ge-2/1/4 {
  gigether-options {
    802.3ad ae1;
  }
}
interfaces ge-2/1/5 {
  gigether-options {
    802.3ad ae1;
  }
}
interfaces ge-2/2/1 {
  encapsulation flexible-ethernet-services;
  vlan-tagging; # Customer interface uses singly-tagged frames
  unit 100 {
    encapsulation vlan-bridge;
    vlan-id 100;
  }
  unit 200 {
    encapsulation vlan-bridge;
    vlan-id 200;
  }
}
interfaces ge-2/2/2 {
  unit 0 {
```

```
      family bridge {
        interface-mode access;
        vlan-id 205;
      }
    }
  }
  interfaces ge-2/2/4 {
    native-vlan-id 200; # Untagged packets get vlan 200 tag
    unit 0 {
      family bridge {
        interface-mode trunk;
        vlan-id-list 200-205; # This trunk port is part of VLAN range 200–205
      }
    }
  }
  interfaces ge-2/2/6 {
    encapsulation flexible-ethernet-services;
    vlan-tagging; # Customer interface uses singly-tagged frames
    unit 200 {
      encapsulation vlan-bridge;
      vlan-id 200;
    }
  }
  interfaces ae1 {
    encapsulation extended-vlan-bridge;
    vlan-tagging;
    unit 100 {
      vlan-id 100;
    }
    unit 200 {
      vlan-id 200;
    }
  }
  interfaces ae2 {
    unit 0 {
      family bridge {
        interface-mode trunk;
        vlan-id-list 100, 200–205;
      }
    }
  }
```

2. Configure the Ethernet interfaces and VLAN tags on Router 2:

```
[edit]
chassis {
  aggregated-devices {
    ethernet {
      device-count 2; # Number of AE interfaces on the router
    }
  }
}
interfaces ge-2/2/2 {
  encapsulation flexible-ethernet-services;
  vlan-tagging; # Customer interface uses singly-tagged frames
```

```
    unit 100 {
      encapsulation vlan-bridge;
      vlan-id 100;
    }
  }
  interfaces ge-3/3/3 {
    encapsulation flexible-ethernet-services;
    vlan-tagging; # Customer interface uses singly-tagged frames
    unit 200 {
      encapsulation vlan-bridge;
      vlan-id 200;
    }
  }
  interfaces ge-5/1/0 {
    gigether-options {
      802.3ad ae3;
    }
  }
  interfaces ge-5/1/1 {
    gigether-options {
      802.3ad ae3;
    }
  }
  interfaces ge-5/1/2 {
    gigether-options {
      802.3ad ae3;
    }
  }
  interfaces ge-5/1/3 {
    gigether-options {
      802.3ad ae1;
    }
  }
  interfaces ge-5/1/4 {
    gigether-options {
      802.3ad ae1;
    }
  }
  interfaces ge-5/1/5 {
    gigether-options {
      802.3ad ae1;
    }
  }
  interfaces ae1 {
    encapsulation extended-vlan-bridge;
    vlan-tagging;
    unit 100 {
      vlan-id 100;
    }
    unit 200 {
      vlan-id 200;
    }
  }
  interfaces ae3 {
    encapsulation extended-vlan-bridge;
    vlan-tagging;
```

```
    unit 100 {
      vlan-id 100;
    }
    unit 200 {
      vlan-id 200;
    }
  }
```

3. Configure the Ethernet interfaces and VLAN tags on Router 3:

```
[edit]
chassis {
  aggregated-devices {
    ethernet {
      device-count 2; # Number of AE interfaces on router
    }
  }
}
interfaces ge-2/2/2 {
  encapsulation flexible-ethernet-services;
  vlan-tagging; # Customer interface uses singly-tagged frames
  unit 100 {
    encapsulation vlan-bridge;
    vlan-id 100;
  }
}
interfaces ge-2/2/4 {
  unit 0 {
    family bridge {
      interface-mode trunk;
      vlan-id-list 200-205; # This trunk port is part of VLAN range 200–205
    }
  }
}
interfaces ge-2/2/6 {
  unit 0 {
    family bridge {
      interface-mode access;
      vlan-id 200;
    }
  }
}
interfaces ge-3/3/3 {
  encapsulation flexible-ethernet-services;
  vlan-tagging; # Customer interface uses singly-tagged frames
  unit 200 {
    encapsulation vlan-bridge;
    vlan-id 200;
  }
}
interfaces ge-11/1/0 {
  gigether-options {
    802.3ad ae3;
  }
}
```

```
interfaces ge-11/1/1 {
    gigether-options {
        802.3ad ae3;
    }
}
interfaces ge-11/1/2 {
    gigether-options {
        802.3ad ae3;
    }
}
interfaces ge-11/1/3 {
    gigether-options {
        802.3ad ae2;
    }
}
interfaces ge-11/1/4 {
    gigether-options {
        802.3ad ae2;
    }
}
interfaces ge-11/1/5 {
    gigether-options {
        802.3ad ae2;
    }
}
interfaces ae2 {
    unit 0 {
        family bridge {
            interface-mode trunk;
            vlan-id-list 100, 200–205;
        }
    }
}
interfaces ae3 {
    encapsulation extended-vlan-bridge;
    vlan-tagging;
    unit 100 {
        vlan-id 100;
    }
    unit 200 {
        vlan-id 200;
    }
}
```

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Layer 2 Features for a Bridging Environment on page 19
- Example Roadmap: Configuring a Basic Bridge Domain Environment on page 33
- Example Step: Configuring Bridge Domains on page 41
- Example Step: Configuring Spanning Tree Protocols on page 43
- Example Step: Configuring Integrated Bridging and Routing on page 45

Example Step: Configuring Bridge Domains

There are two supported ways to configure an IRB with bridge domains. One way is to use the **interface-mode trunk** statement. The other way is shown here and is known as the encapsulation method. The encapsulation method is the preferred way to configure an IRB with bridge domains.

To configure the bridge domains on all three routers:

1. Configure a bridge domain on Router 1:

```
[edit]
bridge-domains {
  vlan100 {
    domain-type bridge;
    vlan-id 100;
    interface ge-2/2/1.100;
    interface ae1.100;
  }
  vlan200 {
    domain-type bridge;
    vlan-id 200;
    interface ge-2/2/1.200;
    interface ge-2/2/6.200;
    interface ae1.200;
  }
  vlan201 {
    domain-type bridge;
    vlan-id 201;
  }
  vlan202 {
    domain-type bridge;
    vlan-id 202;
  }
  vlan203 {
    domain-type bridge;
    vlan-id 203;
  }
  vlan204 {
    domain-type bridge;
    vlan-id 204;
  }
  vlan205 {
    domain-type bridge;
    vlan-id 205;
  }
}
```

2. Configure a bridge domain on Router 2:

```
[edit]
bridge-domains {
  vlan100 {
    domain-type bridge;
```

```
    vlan-id 100;
    interface ge-2/2/2.100;
    interface ae1.100;
    interface ae3.100;
  }
  vlan200 {
    domain-type bridge;
    vlan-id 200;
    interface ge-3/3/3.200;
    interface ae1.200;
    interface ae3.200;
  }
}
```

3. Configure a bridge domain on Router 3:

```
[edit]
bridge-domains {
  vlan100 {
    domain-type bridge;
    vlan-id 100;
    interface ge-2/2/2.100;
    interface ae3.100;
  }
  vlan200 {
    domain-type bridge;
    vlan-id 200;
    interface ge-3/3/3.200;
    interface ae3.200;
  }
  vlan201 {
    domain-type bridge;
    vlan-id 201;
  }
  vlan202 {
    domain-type bridge;
    vlan-id 202;
  }
  vlan203 {
    domain-type bridge;
    vlan-id 203;
  }
  vlan204 {
    domain-type bridge;
    vlan-id 204;
  }
  vlan205 {
    domain-type bridge;
    vlan-id 205;
  }
}
```

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Layer 2 Features for a Bridging Environment on page 19

- Example Roadmap: Configuring a Basic Bridge Domain Environment on page 33
- Example Step: Configuring Interfaces and VLAN Tags on page 35
- Example Step: Configuring Spanning Tree Protocols on page 43
- Example Step: Configuring Integrated Bridging and Routing on page 45

Example Step: Configuring Spanning Tree Protocols

Configure the Spanning Tree Protocol on all three routers. This is necessary to avoid the potential bridging loop formed by the triangular architecture of the routers. MSTP is configured on the three routers so the set of VLANs has an independent, loop-free topology. The Layer 2 traffic can be load-shared over 65 independent paths (64 Multiple Spanning Tree Instances [MSTIs] and one Common and Internal Spanning Tree [CIST]), each spanning a set of VLANs. The configuration names, revision level, and VLAN-to-MSTI mapping must match in order to utilize the load-sharing capabilities of MSTP (otherwise, each router will be in a different region).

To configure the Spanning Tree Protocol on all three routers:

1. Configure MSTP on Router 1:

```
[edit]
protocols {
  mstp {
    configuration-name mstp-for-R1-2-3; # The names must match to be in the same
      region
    revision-level 3; # The revision levels must match
    bridge-priority 0; # This bridge acts as root bridge for VLAN 100 and 200
    interface ae1;
    interface ae2;
    msti 1 {
      vlan100; # This VLAN corresponds to MSTP instance 1
    }
    msti 2 {
      vlan200; # This VLAN corresponds to MSTP instance 2
    }
  }
}
```

2. Configure MSTP on Router 2:

```
[edit]
protocols {
  mstp {
    configuration-name mstp-for-R1-2-3; # The names must match to be in the same
      region
    revision-level 3; # The revision levels must match
    interface ae1;
    interface ae3;
    msti 1 {
      vlan100; # This VLAN corresponds to MSTP instance 1
      bridge-priority 4096; # This bridge acts as VLAN 100 designated bridge on
```

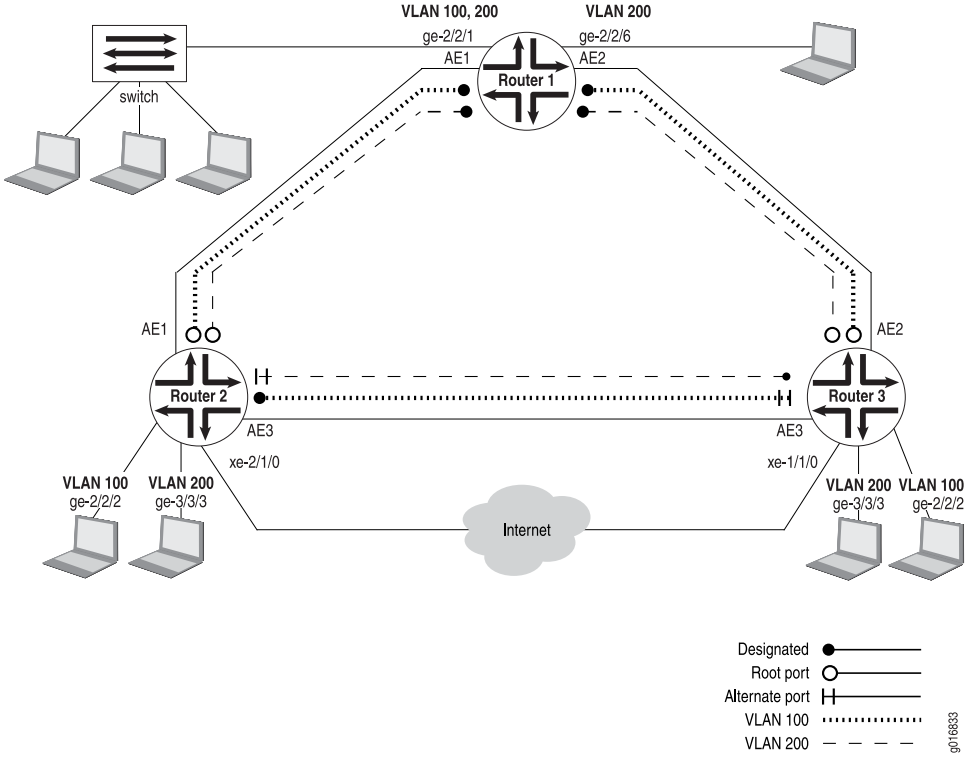
```
                    # the R2-R3 segment
        }
        msti 2 {
          vlan200; # This VLAN corresponds to MSTP instance 2
        }
      }
    }
```

3. Configure MSTP on Router 3:

```
[edit]
protocols {
  mstp {
    configuration-name mstp-for-R1-2-3; # The names must match to be in the same
      region
    revision-level 3; # The revision levels must match
    interface ae2;
    interface ae3;
    msti 1 {
      vlan100; # This VLAN corresponds to MSTP instance 1
    }
    msti 2 {
      vlan200; # This VLAN corresponds to MSTP instance 2
      bridge-priority 4096; # This bridge acts as VLAN 200 designated bridge on
                    # the R2-R3 segment
    }
  }
}
```

As a result of this configuration, VLAN 100 and VLAN 200 share physical links, but have different designated ports, root ports, and alternate ports on the three different routers. The designated, root, and alternate ports for the two VLANs on the three routers are shown in Figure 6 on page 45.

Figure 6: Designated, Root, and Alternate Ports



Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Layer 2 Features for a Bridging Environment on page 19
- Example Roadmap: Configuring a Basic Bridge Domain Environment on page 33
- Example Step: Configuring Interfaces and VLAN Tags on page 35
- Example Step: Configuring Bridge Domains on page 41
- Example Step: Configuring Integrated Bridging and Routing on page 45

Example Step: Configuring Integrated Bridging and Routing

Router 2 and Router 3 on the bridging network act as a kind of gateway to the Layer 3 routers in the rest of the network. Router 2 and Router 3 must be able to route packets as well as bridge frames. This requires the configuration of integrated routing and bridging (IRB) on Routers 2 and 3. The link to the router network is **xe-2/1/0** on Router 2 and **xe-1/1/0** on Router 3.

You configure IRB in two steps:

1. Configure the IRB interface using the **irb** statement.
2. Reference the IRB interface at the bridge domain level of the configuration.

IRB supports Layer 2 bridging and Layer 3 routing on the same interface. If the MAC address on the arriving frame is the same as that of the IRB interface, then the packet inside the frame is routed. Otherwise, the MAC address is learned or looked up in the MAC address database.

NOTE: You configure IRB on Router 2 and Router 3. The Virtual Router Redundancy Protocol (VRRP) is configured on the IRB interface so that both links can be used to carry traffic between the bridge domain and the router network.

To configure IRB on Router 2 and Router 3:

NOTE: The configurations in this chapter are only partial examples of complete and functional router configurations. Do not copy these configurations and use them directly on an actual system. The ae1 and ae3 interfaces have been previously configured in "Example Step: Configuring Interfaces and VLAN Tags" on page 35.

1. Configure the router link and IRB on Router 2:

```
[edit]
interfaces {
  xe-2/1/0 {
    unit 0 {
      family inet {
        address 10.0.10.2/24; # Routing interface
      }
    }
  }
  irb {
    unit 0 {
      family inet {
        address 10.0.1.2/24 {
        vrrp-group 1 {
          virtual-address 10.0.1.51;
            priority 254;
          }
        }
      }
    }
    unit 1 {
      family inet {
        address 10.0.2.2/24 {
        vrrp-group 2 {
          virtual-address 10.0.2.51;
            priority 100;
          }
        }
      }
    }
```

```
    }
  }
  bridge-domains {
    vlan-100 {
      domain-type bridge;
      vlan-id 100;
      interface ge-2/2/2.100;
      interface ae1.100;
      interface ae3.100
      routing-interface irb.0;
    }
    vlan-200 {
      domain-type bridge;
      vlan-id 200;
      interface ge-3/3/3.200;
      interface ae1.200;
      interface ae3.200
      routing-interface irb.1;
    }
  }
```

2. Configure the router link and IRB on Router 3:

```
[edit]
interfaces {
  xe-1/1/0 {
    unit 0 {
      family inet {
        address 10.0.20.3/24; # Routing interface
      }
    }
  }
  irb {
    unit 0 {
      family inet {
        address 10.0.1.3/24 {
        vrrp-group 1 {
          virtual-address 10.0.1.51;
            priority 100;
          }
        }
      }
    }
    unit 1 {
      family inet {
        address 10.0.2.3/24 {
        vrrp-group 2 {
          virtual-address 10.0.2.51;
            priority 254;
          }
        }
      }
    }
    unit 2 {
      family inet {
```

```
            address 10.0.3.2/24 {
          }
        }
        unit 3 {
          family inet {
            address 10.0.3.3/24 {
          }
        }
        unit 4 {
          family inet {
            address 10.0.3.4/24 {
          }
        }
        unit 5 {
          family inet {
            address 10.0.3.5/24 {
          }
        }
        unit 6 {
          family inet {
            address 10.0.3.6/24 {
          }
        }
        unit 7 {
          family inet {
            address 10.0.3.7/24 {
          }
        }
        unit 8 {
          family inet {
            address 10.0.3.8/24 {
          }
        }
      }
    }
    bridge-domains {
      vlan-100 {
        domain-type bridge;
        vlan-id 100;
        interface ge-2/2/2.100;
        interface ae2.100;
        interface ae3.100;
        routing-interface irb.0;
      }
      vlan-200 {
        domain-type bridge;
        vlan-id 200;
        interface ge-3/3/3.200;
        interface ae2.200;
        interface ae3.200;
        routing-interface irb.1;
      }
      vlan201 {
        vlan-id 201;
        routing-interface irb.2
      }
```

```
    vlan202 {
      vlan-id 202;
      routing-interface irb.3
    }
    vlan203 {
      vlan-id 203;
      routing-interface irb.4
    }
    vlan204 {
      vlan-id 204;
      routing-interface irb.5
    }
    vlan205 {
      vlan-id 205;
      routing-interface irb.6
    }
  }
```

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Layer 2 Features for a Bridging Environment on page 19
- Example Roadmap: Configuring a Basic Bridge Domain Environment on page 33
- Example Step: Configuring Interfaces and VLAN Tags on page 35
- Example Step: Configuring Bridge Domains on page 41
- Example Step: Configuring Spanning Tree Protocols on page 43

Example: Configuring Basic Layer 2 Switching on MX Series

This example shows how to configure Layer 2 switching with all interfaces participating in a single VLAN.

- Requirements on page 49
- Overview on page 49
- Configuration on page 50
- Verification on page 52

Requirements

No special configuration beyond device initialization is required before configuring this example.

This example uses an MX Series device to perform Layer 2 switching.

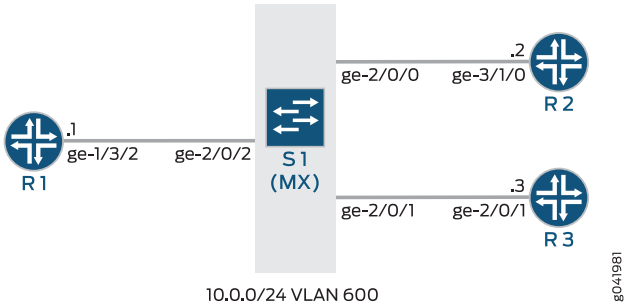
Overview

In this example, a single MX Series device is configured to act as a basic single-VLAN switch. Three connections are in place. The connections from the MX Series device attach to Junos OS routers, but the routers are used here for testing purposes only. In place of routers, you can use any IP networking devices.

Topology

Figure 7 on page 50 shows the sample network.

Figure 7: Basic Layer 2 Switching



"CLI Quick Configuration" on page 50 shows the configuration for all of the devices in Figure 7 on page 50.

The section "Step-by-Step Procedure" on page 51 describes the steps on Device S1.

Configuration

CLI Quick Configuration

To quickly configure this example, copy the following commands, paste them into a text file, remove any line breaks, change any details necessary to match your network configuration, and then copy and paste the commands into the CLI at the **[edit]** hierarchy level.

Device S1

```
set interfaces ge-2/0/0 vlan-tagging
set interfaces ge-2/0/0 encapsulation extended-vlan-bridge
set interfaces ge-2/0/0 unit 0 vlan-id 600
set interfaces ge-2/0/1 vlan-tagging
set interfaces ge-2/0/1 encapsulation extended-vlan-bridge
set interfaces ge-2/0/1 unit 0 vlan-id 600
set interfaces ge-2/0/2 vlan-tagging
set interfaces ge-2/0/2 encapsulation extended-vlan-bridge
set interfaces ge-2/0/2 unit 0 vlan-id 600
set bridge-domains customer1 domain-type bridge
set bridge-domains customer1 interface ge-2/0/0.0
set bridge-domains customer1 interface ge-2/0/2.0
set bridge-domains customer1 interface ge-2/0/1.0
```

Device R1

```
set interfaces ge-1/3/2 vlan-tagging
set interfaces ge-1/3/2 unit 0 vlan-id 600
set interfaces ge-1/3/2 unit 0 family inet address 10.0.0.1/24
```

Device R2

```
set interfaces ge-3/1/0 vlan-tagging
set interfaces ge-3/1/0 unit 0 vlan-id 600
set interfaces ge-3/1/0 unit 0 family inet address 10.0.0.2/24
```

Device R3

```
set interfaces ge-2/0/1 vlan-tagging
set interfaces ge-2/0/1 unit 0 vlan-id 600
```

```
set interfaces ge-2/0/1 unit 0 family inet address 10.0.0.3/24
```

Step-by-Step Procedure

The following example requires that you navigate various levels in the configuration hierarchy. For information about navigating the CLI, see *Using the CLI Editor in Configuration Mode* in the *CLI User Guide*.

To configure Device S1:

1. Configure the device interfaces.

```
[edit interfaces]
user@S1# set interfaces ge-2/0/0 vlan-tagging
user@S1# set interfaces ge-2/0/0 encapsulation extended-vlan-bridge
user@S1# set interfaces ge-2/0/0 unit 0 vlan-id 600

user@S1# set interfaces ge-2/0/1 vlan-tagging
user@S1# set interfaces ge-2/0/1 encapsulation extended-vlan-bridge
user@S1# set interfaces ge-2/0/1 unit 0 vlan-id 600

user@S1# set interfaces ge-2/0/2 vlan-tagging
user@S1# set interfaces ge-2/0/2 encapsulation extended-vlan-bridge
user@S1# set interfaces ge-2/0/2 unit 0 vlan-id 600
```

2. Configure the bridge domain.

```
[edit interfaces]
user@S1# set bridge-domains customer1 domain-type bridge
user@S1# set bridge-domains customer1 interface ge-2/0/0.0
user@S1# set bridge-domains customer1 interface ge-2/0/2.0
user@S1# set bridge-domains customer1 interface ge-2/0/1.0
```

Results

From configuration mode, confirm your configuration by entering the **show interfaces** and **show bridge-domains** commands. If the output does not display the intended configuration, repeat the instructions in this example to correct the configuration.

```
user@S1# show interfaces
ge-2/0/0 {
    vlan-tagging;
    encapsulation extended-vlan-bridge;
    unit 0 {
        vlan-id 600;
    }
}
ge-2/0/1 {
    vlan-tagging;
    encapsulation extended-vlan-bridge;
    unit 0 {
        vlan-id 600;
    }
}
ge-2/0/2 {
    vlan-tagging;
```

```
    encapsulation extended-vlan-bridge;
    unit 0 {
      vlan-id 600;
    }
  }
```

```
user@S1# show bridge-domains
customer1 {
  domain-type bridge;
  interface ge-2/0/0.0;
  interface ge-2/0/2.0;
  interface ge-2/0/1.0;
}
```

If you are done configuring the device, enter **commit** from configuration mode.

Verification

Confirm that the configuration is working properly.

- Confirming the MAC Address Learning on page 52
- Making Sure That the Attached Devices Can Reach Each Other on page 53
- Checking the Bridge Domain on page 54
- Checking the Bridge Statistics on page 55
- Checking the Bridge Flooding on page 55
- Checking Layer 2 Learning on page 56

Confirming the MAC Address Learning

Purpose Display Layer 2 MAC address information.

Action

- From Device S1, run the **show bridge mac-table** command.

```
user@S1> show bridge mac-table

MAC flags (S -static MAC, D -dynamic MAC, L -locally learned, C -Control MAC
           SE -Statistics enabled, NM -Non configured MAC, R -Remote PE MAC)

Routing instance : default-switch
 Bridging domain : customer1, VLAN : NA
   MAC                 MAC      Logical          NH     RTR
   address             flags    interface        Index  ID
   00:12:1e:ee:34:dd   D        ge-2/0/2.0
   00:1d:b5:5e:86:79   D        ge-2/0/0.0
   00:21:59:0f:35:2b   D        ge-2/0/1.0
```

- From Device S1, run the **show bridge mac-table extensive** command.

```
user@S1> show bridge mac-table extensive

MAC address: 00:12:1e:ee:34:dd
  Routing instance: default-switch
   Bridging domain: customer1, VLAN : NA
   Learning interface: ge-2/0/2.0
```

```
    Layer 2 flags: in_hash,in_ifd,in_ifl,in_vlan,in_rtt,kernel,in_ifbd
    Epoch: 1                          Sequence number: 0
    Learning mask: 0x00000004

MAC address: 00:1d:b5:5e:86:79
  Routing instance: default-switch
    Bridging domain: customer1, VLAN : NA
    Learning interface: ge-2/0/0.0
    Layer 2 flags: in_hash,in_ifd,in_ifl,in_vlan,in_rtt,kernel,in_ifbd
    Epoch: 1                          Sequence number: 0
    Learning mask: 0x00000004

MAC address: 00:21:59:0f:35:2b
  Routing instance: default-switch
    Bridging domain: customer1, VLAN : NA
    Learning interface: ge-2/0/1.0
    Layer 2 flags: in_hash,in_ifd,in_ifl,in_vlan,in_rtt,kernel,in_ifbd
    Epoch: 3                          Sequence number: 0
    Learning mask: 0x00000004
```

Meaning The output shows that the MAC addresses have been learned.

Making Sure That the Attached Devices Can Reach Each Other

Purpose Verify connectivity.

Action

```
user@R1> ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2): 56 data bytes
64 bytes from 10.0.0.2: icmp_seq=0 ttl=64 time=1.178 ms
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1.192 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=1.149 ms
^C
--- 10.0.0.2 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max/stddev = 1.149/1.173/1.192/0.018 ms


user@R1> ping 10.0.0.3
PING 10.0.0.3 (10.0.0.3): 56 data bytes
64 bytes from 10.0.0.3: icmp_seq=0 ttl=64 time=1.189 ms
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=1.175 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=1.178 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=1.133 ms
^C
--- 10.0.0.3 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
round-trip min/avg/max/stddev = 1.133/1.169/1.189/0.021 ms


user@R2> ping 10.0.0.3
PING 10.0.0.3 (10.0.0.3): 56 data bytes
64 bytes from 10.0.0.3: icmp_seq=0 ttl=64 time=0.762 ms
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.651 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.722 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.705 ms
^C
--- 10.0.0.3 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.651/0.710/0.762/0.040 ms
```

Meaning The output shows that the attached devices have established Layer 3 connectivity, with Device S1 doing transparent Layer 2 bridging.

Checking the Bridge Domain

Purpose Display bridge domain information.

Action

```
user@S1> show bridge domain extensive

Routing instance: default-switch
Bridge domain: customer1                        State: Active
Bridge VLAN ID: NA
Interfaces:
    ge-2/0/0.0
    ge-2/0/1.0
    ge-2/0/2.0
Total MAC count: 3
```

Meaning The output shows that bridge domain is active.

Checking the Bridge Statistics

Purpose Display bridge statistics.

Action `user@S1>` **show bridge statistics**

```
Local interface: ge-2/0/0.0, Index: 65543
  Broadcast packets:                    0
  Broadcast bytes  :                    0
  Multicast packets:                   80
  Multicast bytes  :                 8160
  Flooded packets  :                    0
  Flooded bytes    :                    0
  Unicast packets  :                    1
  Unicast bytes    :                   64
  Current MAC count:                    1 (Limit 1024)
Local interface: ge-2/0/2.0, Index: 324
  Broadcast packets:                    0
  Broadcast bytes  :                    0
  Multicast packets:                   80
  Multicast bytes  :                 8160
  Flooded packets  :                    1
  Flooded bytes    :                   74
  Unicast packets  :                   52
  Unicast bytes    :                 4332
  Current MAC count:                    1 (Limit 1024)
Local interface: ge-2/0/1.0, Index: 196613
  Broadcast packets:                    2
  Broadcast bytes  :                  128
  Multicast packets:                    0
  Multicast bytes  :                    0
  Flooded packets  :                    1
  Flooded bytes    :                   93
  Unicast packets  :                   51
  Unicast bytes    :                 4249
  Current MAC count:                    1 (Limit 1024)
```

Meaning The output shows that bridge domain interfaces are sending and receiving packets.

Checking the Bridge Flooding

Purpose Display bridge flooding information.

Action

```
user@S1> show bridge flood extensive

Name: __juniper_private1__
CEs: 0
VEs: 0
Name: default-switch
CEs: 3
VEs: 0
Bridging domain: customer1
  Flood route prefix: 0x30003/51
  Flood route type: FLOOD_GRP_COMP_NH
  Flood route owner: __all_ces__
  Flood group name: __all_ces__
  Flood group index: 1
  Nexthop type: comp
  Nexthop index: 568
    Flooding to:
    Name             Type          NhType          Index
    __all_ces__      Group          comp            562
        Composition: split-horizon
        Flooding to:
        Name             Type          NhType          Index
        ge-2/0/0.0       CE             ucst            524
        ge-2/0/1.0       CE             ucst            513
        ge-2/0/2.0       CE             ucst            523

  Flood route prefix: 0x30005/51
  Flood route type: FLOOD_GRP_COMP_NH
  Flood route owner: __re_flood__
  Flood group name: __re_flood__
  Flood group index: 65534
  Nexthop type: comp
  Nexthop index: 565
    Flooding to:
    Name             Type          NhType          Index
    __all_ces__      Group          comp            562
        Composition: split-horizon
        Flooding to:
        Name             Type          NhType          Index
        ge-2/0/0.0       CE             ucst            524
        ge-2/0/1.0       CE             ucst            513
        ge-2/0/2.0       CE             ucst            523
```

Meaning If the destination MAC address of a packet is unknown to the device (that is, the destination MAC address in the packet does not have an entry in the forwarding table), the device duplicates the packet and floods it on all interfaces in the bridge domain other than the interface on which the packet arrived. This is known as packet flooding and is the default behavior for the device to determine the outgoing interface for an unknown destination MAC address.

Checking Layer 2 Learning

Purpose Display Layer 2 learning information for all the interfaces.

Action

```
user@S1> show l2-learning interface

Routing Instance Name : default-switch
Logical Interface flags (DL -disable learning, AD -packet action drop,
                         LH - MAC limit hit, DN - Interface Down )
Logical             BD         MAC        STP          Logical
Interface           Name       Limit      State        Interface flags
ge-2/0/2.0                     0
                    custom..   1024       Forwarding
Routing Instance Name : default-switch
Logical Interface flags (DL -disable learning, AD -packet action drop,
                         LH - MAC limit hit, DN - Interface Down )
Logical             BD         MAC        STP          Logical
Interface           Name       Limit      State        Interface flags
ge-2/0/0.0                     0
                    custom..   1024       Forwarding
Routing Instance Name : default-switch
Logical Interface flags (DL -disable learning, AD -packet action drop,
                         LH - MAC limit hit, DN - Interface Down )
Logical             BD         MAC        STP          Logical
Interface           Name       Limit      State        Interface flags
ge-2/0/1.0                     0
                    custom..   1024       Forwarding
```

Related Documentation

- *Understanding OSPF Areas*
- *Examples: Configuring OSPF Stub and Not-So-Stubby Areas*

CHAPTER 8

VLANs Within Bridge Domain and VPLS Environments Examples

- Configuring a Normalized VLAN for Translation or Tagging on page 59
- Configuring Learning Domains for VLAN IDs Bound to Logical Interfaces on page 61
- Example: Configuring a Provider Bridge Network with Normalized VLAN Tags on page 62
- Example: Configuring a Provider VPLS Network with Normalized VLAN Tags on page 66
- Example: Configuring One VPLS Instance for Several VLANs on page 70

Configuring a Normalized VLAN for Translation or Tagging

This topic provides configuration and operational information to help you manipulate virtual local area networks (VLANs) within a bridge domain or a virtual private LAN service (VPLS) instance. The VPLS configuration is not covered in this topic. For more information about configuring Ethernet pseudowires as part of VPLS, see the *Junos OS, Release 15.1*.

NOTE: **This topic is not intended as a troubleshooting guide. However, you can use it with a broader troubleshooting strategy to identify Juniper Networks MX Series 3D Universal Edge Router network problems.**

The manipulation of VLANs within a bridge domain or a VPLS instance can be done in several ways:

- By using the **vlan-map** statements at the **[edit interfaces]** hierarchy level. This chapter does not use **vlan-map**. For more information about VLAN maps, see the *Junos OS Network Interfaces Library for Routing Devices*.
- By using **vlan-id** statements within a bridge domain or VPLS instance hierarchy. This method is used in the configuration in this chapter.

The **vlan-id** and **vlan-tags** statements under the bridge domain or VPLS routing instance are used to:

- Translate (normalize) received VLAN tags, or
- Implicitly create multiple learning domains, each with a “learn” VLAN.

The use of a VLAN map or a normalized VLAN is optional.

NOTE: You cannot use **vlan-map** when configuring a normalized VLAN.

This section discusses the following topics:

- Implicit VLAN Translation to a Normalized VLAN on page 60
- Sending Tagged or Untagged Packets over VPLS Virtual Interfaces on page 60
- Configuring a Normalized VLAN on page 61

Implicit VLAN Translation to a Normalized VLAN

The VLAN tags of a received packet are compared with the normalized VLAN tags specified with either the **vlan-id** or **vlan-tags** statements. If the VLAN tags of the received packet are different from the normalized VLAN tags, then appropriate VLAN tag operations (such as push-push, pop-pop, pop-swap, swap-swap, swap, and others) are implicitly made to convert the received VLAN tags to the normalized VLAN tags. For more information about these operations, see the *Junos OS Routing Protocols Library*.

Then, the source MAC address of a received packet is learned based on the normalized VLAN configuration.

For output packets, if the VLAN tags associated with an egress logical interface do not match the normalized VLAN tags within the packet, then appropriate VLAN tag operations (such as push-push, pop-pop, pop-swap, swap-swap, swap, and others) are implicitly made to convert the normalized VLAN tags to the VLAN tags for the egress logical interface. For more information about these operations, see the *Junos OS Routing Protocols Library*.

Sending Tagged or Untagged Packets over VPLS Virtual Interfaces

If the packets sent over the VPLS virtual interfaces (**vt-** or **lsi-** interfaces) need to be tagged by the normalized VLAN, use one of the following configuration statements:

- **vlan-id *vlan-number***—Tags all packets sent over the VPLS virtual interface with the configured ***vlan-number***. For an example of this configuration, see "Example: Configuring One VPLS Instance for Several VLANs" on page 70.
- **vlan-tags outer *outer-vlan-number* inner *inner-vlan-number***—Tags all packets sent over the VPLS virtual interfaces with the specified inner and outer VLAN tags.

If the incoming VLAN tags identifying a Layer 2 logical interface are removed when packets are sent over VPLS virtual interfaces, use the **vlan-id none** statement.

NOTE: Even when the **vlan-id none** statement is configured, the packets can still contain other customer VLAN tags.

Configuring a Normalized VLAN

The following factors are important when configuring a normalized VLAN:

- Use either the **vlan-id** ***vlan-number*** statement (to tag all packets with one normalized VLAN tag) or the **vlan-tags outer** ***outer-vlan-number*** **inner** ***inner-vlan-number*** statement (to tag all packets with the normalized outer and inner VLAN tags) if you want to tag packets sent onto the VPLS pseudowires.
- Use the **vlan-id none** statement to remove the incoming VLAN tags identifying a Layer 2 logical interface when packets are sent over VPLS pseudowires. This statement is also used to configure shared VLAN learning.

  NOTE: **The outgoing packets can still contain customer VLAN tags.**

- If integrated routing and bridging (IRB) is configured for a bridge domain or a VPLS routing instance, then you must configure a normalized VLAN using one of the following statements:
  - **vlan-id** ***vlan-number***
  - **vlan-id none**
  - **vlan-tags outer** ***outer-vlan-number*** **inner** ***inner-vlan-number***
- Use the **vlan-id all** statement to configure bridging for several VLANS with minimal amount of configuration and switch resources. For an example of this configuration, see "Example: Configuring One VPLS Instance for Several VLANs" on page 70.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- VLANs Within a Bridge Domain or VPLS Instance on page 23
- Packet Flow Through a Bridged Network with Normalized VLANs on page 24
- Example: Configuring a Provider Bridge Network with Normalized VLAN Tags on page 62
- Example: Configuring a Provider VPLS Network with Normalized VLAN Tags on page 66

Configuring Learning Domains for VLAN IDs Bound to Logical Interfaces

A learning domain is a MAC address database to which the MAC addresses are added based on the normalized VLAN tags. The normalized VLAN tags associated with a learning domain are always carried within packets sent over VPLS virtual interfaces.

To configure bridging for several VLANs using a minimal amount of configuration and switch resources, use the **vlan-id all** configuration statement to implicitly configure multiple learning domains for a bridge domain or VPLS instance:

- For a logical interface with a single VLAN tag, the statement implicitly creates a learning domain for each normalized VLAN of the interface.

- For a logical interface with dual VLAN tags, the statement implicitly creates a learning domain for each inner VLAN (normalized VLAN).

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- VLANs Within a Bridge Domain or VPLS Instance on page 23
- Packet Flow Through a Bridged Network with Normalized VLANs on page 24
- Example: Configuring One VPLS Instance for Several VLANs on page 70

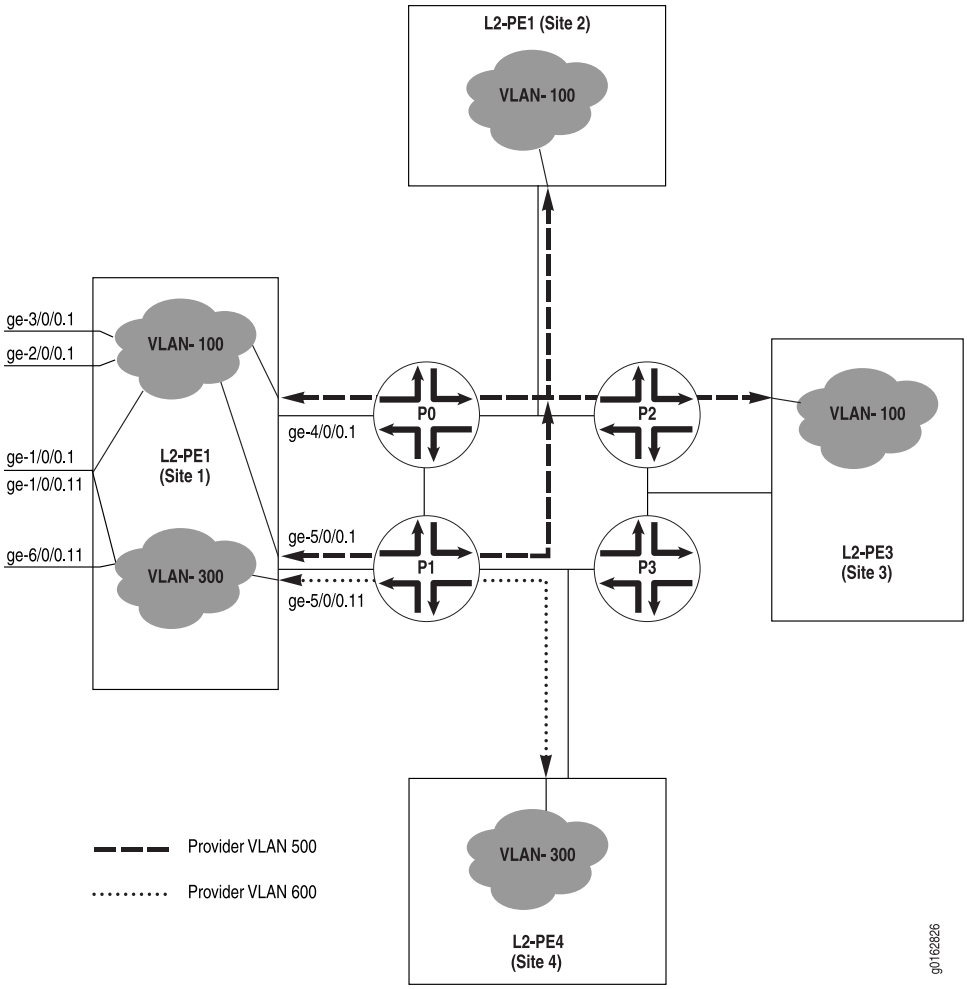
Example: Configuring a Provider Bridge Network with Normalized VLAN Tags

This topic provides a configuration example to help you effectively configure a network of Juniper Networks MX Series 3D Universal Edge Routers for a bridge domain or virtual private LAN service (VPLS) environment. The emphasis here is on choosing the normalized virtual LAN (VLAN) configuration. The VPLS configuration is not covered in this chapter. For more information about configuring Ethernet pseudowires as part of VPLS, see the *Junos OS, Release 15.1*.

NOTE: **This topic does not present exhaustive configuration listings for all routers in the figures. However, you can use it with a broader configuration strategy to complete the MX Series router network configurations.**

Consider the provider bridge network shown in Figure 8 on page 63.

Figure 8: Provider Bridge Network Using Normalized VLAN Tags



The Layer 2 provider edge (PE) routers are MX Series routers. Each site is connected to two provider (P) routers for redundancy, although both links are only shown for L2-PE1 at Site 1. Site 1 is connected to P0 and P1 (as shown), Site 2 is connected to P0 and P2 (not shown), Site 3 is connected to P2 and P3 (as shown), and Site 4 is connected to P1 and P3 (as shown). VPLS pseudowires configured on the PE and P routers carry traffic between the sites.

The VLANs' bridging paths are shown with distinct dashed and dotted lines. The VLANs at each site are:

- L2-PE1 at Site 1: VLAN 100 and VLAN 300
- L2-PE2 at Site 2: VLAN 100
- L2-PE3 at Site 3: VLAN 100
- L2-PE4 at Site 4: VLAN 300

NOTE: The configurations in this chapter are only partial examples of complete and functional router configurations. Do not copy these configurations and use them directly on an actual system.

The following is the configuration of interfaces, virtual switches, and bridge domains for MX Series router L2-PE1:

```
[edit]
interfaces ge-1/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    unit 1 {
        encapsulation vlan-bridge;
        vlan-id 100;
    }
    unit 11 {
        encapsulation vlan-bridge;
        vlan-id 301;
    }
}
interface ge-2/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    unit 1 {
        encapsulation vlan-bridge;
        vlan-id 100;
    }
}
interface ge-3/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    unit 1 {
        encapsulation vlan-bridge;
        vlan-id 200; # NOTE: 200 is translated to normalized VLAN value
    }
}
interfaces ge-4/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    unit 1 {
        encapsulation vlan-bridge;
        vlan-tags outer 500 inner 100; # This places two VLAN tags on the provider
                                       # pseudowire
    }
}
interfaces ge-5/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    unit 1 {
        encapsulation vlan-bridge;
        vlan-tags outer 500 inner 100; # This places two VLAN tags on the provider
                                       # pseudowire
    }
```

```
    unit 11 {
      encapsulation vlan-bridge;
      vlan-tags outer 600 inner 300; # This places two VLAN tags on the provider
                                     # pseudowire
    }
  }
  interfaces ge-6/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    unit 11 {
      encapsulation vlan-bridge;
      vlan-id 300;
    }
  }
  routing-instances {
    customer-c1-virtual-switch {
      instance-type virtual-switch ;
      bridge-domains {
        c1-vlan-100 {
          domain-type bridge;
          vlan-id 100; # Customer VLAN 100 uses these five logical interfaces
          interface ge-1/0/0.1;
          interface ge-2/0/0.1;
          interface ge-3/0/0.1;
          interface ge-4/0/0.1;
          interface ge-5/0/0.1;
        } # End of c1-vlan-100
      } # End of bridge-domains
    } # End of customer-c1-virtual-switch
    customer-c2-virtual-switch {
      instance-type virtual-switch ;
      bridge-domains {
        c2-vlan-300 {
          domain-type bridge;
          vlan-id 300; # Customer VLAN 300 uses these three logical interfaces
          interface ge-1/0/0.11;
          interface ge-5/0/0.11;
          interface ge-6/0/0.11;
        } # End of c1-vlan-300
      } # End of bridge-domains
    } # End of customer-c2-virtual-switch
  } # end of routing-instances
```

Bridge domain **c1–vlan-100** for **customer-c1–virtual-switch** has five logical interfaces:

- Logical interface **ge-1/0/0.1** configured on physical port **ge-1/0/0**.
- Logical interface **ge-2/0/0.1** configured on physical port **ge-2/0/0**.
- Logical interface **ge-3/0/0.1** configured on physical port **ge-3/0/0**.
- Logical interface **ge-4/0/0.1** can exist on an extended port/subinterface defined by the pair **ge-4/0/0** and **outer-vlan-tag 500**.
- Logical interface **ge-5/0/0.1** can exist on an extended port/subinterface defined by the pair **ge-5/0/0** and **outer-vlan-tag 500**.

The association of the received packet to a logical interface is done by matching the VLAN tags of the received packet with the VLAN tags configured on one of the logical interfaces on that physical port. The **vlan-id 100** configuration within the bridge domain **c1–vlan-100** sets the normalized VLAN value to 100.

The following happens as a result of this configuration:

- Packets received on logical interfaces **ge-1/0/0.1** or **ge-2/0/0.1** with a single VLAN tag of 100 in the frame are accepted.
- Packets received on logical interface **ge-3/0/0.1** with a single VLAN tag of 200 in the frame are accepted and have their tag values translated to the normalized VLAN tag value of 100.
- Packets received on logical interfaces **ge-4/0/0.1** and **ge-5/0/0.1** with outer tag values of 500 and inner tag values of 100 are accepted.
- Unknown source MAC addresses and unknown destination MAC addresses are learned based on their normalized VLAN values of 100 or 300.
- All packets sent on a logical interface always have their associated **vlan-id** value(s) in their VLAN tag fields.

Configuration and function of bridge domain **c2-vlan-300** for **customer-c2-virtual-switch** is similar to, but not identical to, that of bridge **domain c1-vlan-100** for **customer-c1-virtual-switch**.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- VLANs Within a Bridge Domain or VPLS Instance on page 23
- Packet Flow Through a Bridged Network with Normalized VLANs on page 24
- Configuring a Normalized VLAN for Translation or Tagging on page 59

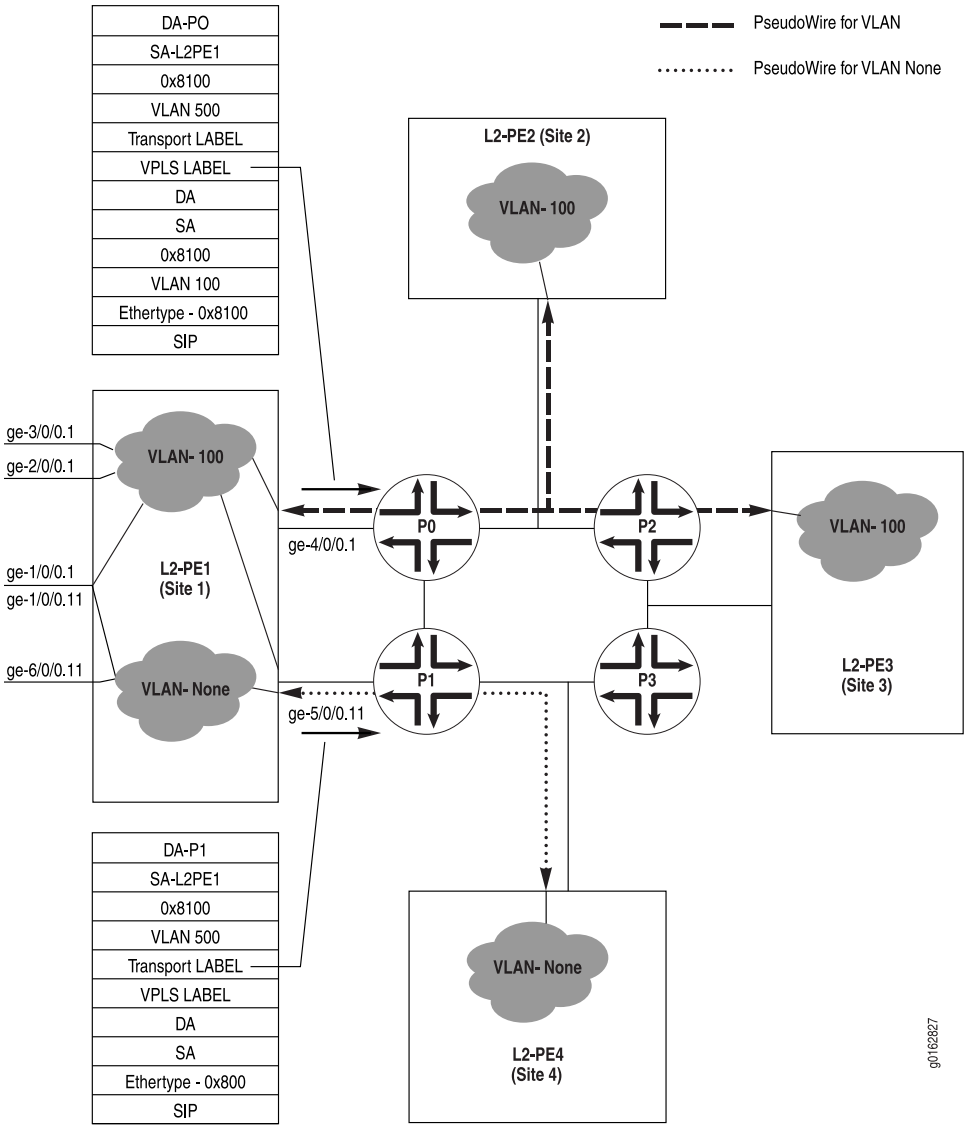
Example: Configuring a Provider VPLS Network with Normalized VLAN Tags

This topic provides a configuration example to help you effectively configure a network of Juniper Networks MX Series 3D Universal Edge Routers for a bridge domain or virtual private LAN service (VPLS) environment. The emphasis here is on choosing the normalized virtual LAN (VLAN) configuration. The VPLS configuration is not covered in this chapter. For more information about configuring Ethernet pseudowires as part of VPLS, see the *Junos OS, Release 15.1*.

NOTE: This topic does not present exhaustive configuration listings for all routers in the figures. However, you can use it with a broader configuration strategy to complete the MX Series router network configurations.

Consider the VPLS network shown in Figure 9 on page 67.

Figure 9: VLAN Tags and VPLS Labels



The Layer 2 PE routers are MX Series routers. Each site is connected to two P routers for redundancy, although both links are only shown for L2-PE1 at Site 1. Site 1 is connected to P0 and P1, Site 2 is connected to P0 and P2 (not shown), Site 3 is connected to P2 and P3, and Site 4 is connected to P1 and P3. VPLS pseudowires configured on the PE and P routers carry traffic between the sites.

The pseudowires for the VPLS instances are shown with distinct dashed and dotted lines. The VLANs at each site are:

- L2-PE1 at Site 1: VLAN 100 and VLAN 300
- L2-PE2 at Site 2: VLAN 100

- L2-PE3 at Site 3: VLAN 100
- L2-PE4 at Site 4: VLAN 300

Service provider SP-1 is providing VPLS services for customer C1 and C2. L2-PE1 is configured with a VPLS instance called **customer-c1-vsi**. The VPLS instance sets up pseudowires to remote Site 2 and Site 3. L2-PE1 is also configured with a VPLS instance called **customer-c2-vsi**. The VPLS instance sets up a pseudowire to remote Site 4.

The following is the configuration of interfaces, virtual switches, and bridge domains for MX Series router L2-PE1:

```
[edit]
interfaces ge-1/0/0 {
   encapsulation flexible-ethernet-services;
   flexible-vlan-tagging;
   unit 1 {
      encapsulation vlan-vpls;
      vlan-id 100;
   }
   unit 11 {
      encapsulation vlan-vpls;
      vlan-id 301;
   }
}
interfaces ge-2/0/0 {
   encapsulation flexible-ethernet-services;
   flexible-vlan-tagging;
   unit 1 {
      encapsulation vlan-vpls;
      vlan-id 100;
   }
}
interfaces ge-3/0/0 {
   encapsulation flexible-ethernet-services;
   flexible-vlan-tagging;
   unit 1 {
      encapsulation vlan-vpls;
      vlan-id 200; # Should be translated to normalized VLAN value
   }
}
interfaces ge-6/0/0 {
   encapsulation flexible-ethernet-services;
   flexible-vlan-tagging;
   unit 11 {
      encapsulation vlan-vpls;
      vlan-id 302;
   }
}
routing-instances {
   customer-c1-vsi {
      instance-type vpls;
      vlan-id 100;
      interface ge-1/0/0.1;
      interface ge-2/0/0.1;
      interface ge-3/0/0.1;
```

```
    } # End of customer-c1-vsi
    customer-c2-vsi {
      instance-type vpls;
      vlan-id none; # This will remove the VLAN tags from packets sent on VPLS for customer
        2
      interface ge-1/0/0.11;
      interface ge-6/0/0.11;
    } # End of customer-c2-vsi
  } # End of routing-instances
```

NOTE: This is not a complete router configuration.

Consider the first VLAN for customer C1. The **vlan-id 100** statement in the VPLS instance called **customer-c1-vsi** sets the normalized VLAN to 100. All packets sent over the pseudowires have a VLAN tag of 100.

The following happens on VLAN 100 as a result of this configuration:

- Packets received on logical interfaces **ge-1/0/0.1** or **ge-2/0/0.1** with a single VLAN tag of 100 in the frame are accepted.
- Packets received on logical interface **ge-3/0/0.1** with a single VLAN tag of 200 in the frame are accepted and have their tag values translated to the normalized VLAN tag value of 100.
- Unknown source MAC addresses and unknown destination MAC addresses are learned based on their normalized VLAN values of 100.
- All packets sent on the VPLS pseudowire have **vlan-id 100** in their VLAN tag fields.

Now consider the second VLAN for Customer C2. The **vlan-id none** statement in the VPLS instance called **customer-c2-vsi** removes the incoming VLAN tags before the packets are sent over the VPLS pseudowires.

The following happens on the C2 VLAN as a result of the **vlan-id none** configuration:

- A MAC table is created for each instance of **vlan-id none**. All MAC addresses learned over the interfaces belonging to this VPLS instance are added to this table. The received or configured VLAN tags are not considered when the MAC addresses are added to this table. This is a case of shared VLAN learning.
- Packets with a single VLAN tag value of 301 are accepted on interface **ge-1/0/0.11**. The VLAN tag value 301 is then popped and removed from the frame of this packet.
- Packets with a single VLAN tag value of 302 are accepted on interface **ge-6/0/0.11**. The VLAN tag value 302 is then popped and removed from the frame of this packet.
- All packets sent on pseudowires will not have any VLAN tags used to identify the incoming Layer 2 logical interface.

NOTE: The packet can still contain other customer VLAN tags.

- Packets received from pseudowires are looked up in the MAC table associated with the VPLS instance. Any customer VLAN tags in the frame are ignored.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- VLANs Within a Bridge Domain or VPLS Instance on page 23
- Packet Flow Through a Bridged Network with Normalized VLANs on page 24
- Configuring a Normalized VLAN for Translation or Tagging on page 59

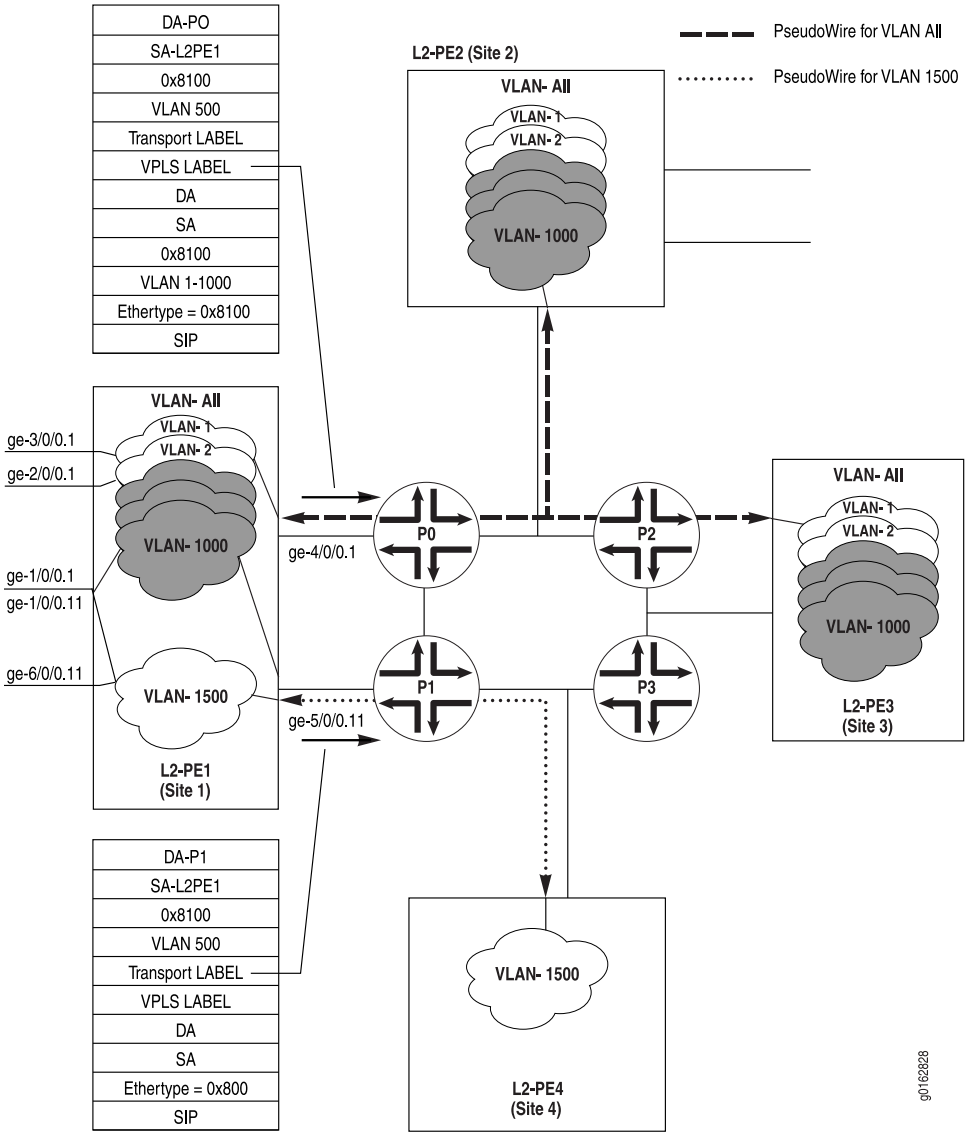
Example: Configuring One VPLS Instance for Several VLANs

This topic provides a configuration example to help you effectively configure a network of Juniper Networks MX Series 3D Universal Edge Routers for a bridge domain or virtual private LAN service (VPLS) environment. The emphasis here is on choosing the normalized virtual LAN (VLAN) configuration. The VPLS configuration is not covered in this chapter. For more information about configuring Ethernet pseudowires as part of VPLS, see the *Junos OS, Release 15.1*.

NOTE: This topic does not present exhaustive configuration listings for all routers in the figures. However, you can use it with a broader configuration strategy to complete the MX Series router network configurations.

Consider the VPLS network shown in Figure 10 on page 71.

Figure 10: Many VLANs on One VPLS Instance



The Layer 2 PE routers are MX Series routers. Each site is connected to two P routers for redundancy, although both links are only shown for L2-PE1 at Site 1. Site 1 is connected to P0 and P1, Site 2 is connected to P0 and P2 (not shown), Site 3 is connected to P2 and P3, and Site 4 is connected to P1 and P3. VPLS pseudowires configured on the PE and P routers carry traffic between the sites.

The pseudowires for the VPLS instances are shown with distinct dashed and dotted lines. Most sites have multiple VLANs configured.

Service provider SP-1 is providing VPLS services for customer C1, services that could span several sites. Now customer C1 can have many VLANs in the range from 1 through 1000 (for example).

If VLANs 1 through 1000 for customer C1 span the same sites, then the **vlan-id all** and **vlan-id-list** statements provide a way to switch all of these VLANs with a minimum configuration effort and fewer switch resources.

NOTE: **You cannot use the vlan-id all statement if you configure an IRB interface on one or more of the VLANs.**

Alternatively, instead of configuring a VPLS instance, you can define a virtual switch with a bridge domain and associate the logical interfaces as trunk ports with the bridge domain. This configuration is necessary if you want to configure a list or range of VLAN IDs on the logical interfaces and use the **vlan-id all** statement to normalize VLANs.

A Layer 2 virtual switch, which isolates a LAN segment with its spanning-tree protocol instance and separates its VLAN ID space, filters and forwards traffic only at the data link layer. Each bridge domain consists of a set of logical ports that participate in Layer 2 learning and forwarding.

You can configure VPLS ports in a virtual switch so that the logical interfaces of the Layer 2 bridge domains in the virtual switch can handle VPLS routing instance traffic. VPLS configuration no longer requires a dedicated routing instance of type vpls. Packets received on a Layer 2 trunk interface are forwarded within a bridge domain that has the same VLAN identifier. A trunk interface is implicitly associated with bridge domains based on VLAN membership.

You can use either of the following two mechanisms to normalize VLAN identifiers and process them in a bridge domain or a VPLS routing instance:

- By using the **input-vlan-map** and the **output-vlan-map** statements at the **[edit interfaces interface-name]** hierarchy level to configure VLAN mapping.
- By using either the **vlan-id** statement or the **vlan-tags** statement to configure a normalizing VLAN identifier.

The **vlan-id** and **vlan-tags** statements are used to specify the normalizing VLAN identifier under the bridge domain or VPLS routing instance. The normalizing VLAN identifier is used to perform the following functions:

- Translate, or normalize, the VLAN tags of received packets received into a learn VLAN identifier.
- · Create multiple learning domains that each contain a learn VLAN identifier. A learning domain is a MAC address database to which MAC addresses are added based on the learn VLAN identifier.

If you configure the **vlan-id all** statement in a VPLS routing instance, we recommend using the **input-vlan-map pop** and **output-vlan-map push** statements on the logical interface to pop the service VLAN ID on input and push the service VLAN ID on output and in this way limit the impact of doubly-tagged frames on scaling. You cannot use the native **vlan- id** statement when the **vlan-id all** statement is included in the configuration.

For the same network topology illustrated in Figure 10 on page 71, if VLANs 1 through 1000 for customer C1 span the same sites, you can normalize the VLANs by doing one of the following. Using either of these optimal methods, you can switch and normalize all of these VLANs in an effective, streamlined manner without configuring separately for each VLAN ID.

- By configuring a VPLS routing instance if the logical interfaces are specified with a range of consecutive VLANs or a list of non-contiguous VLAN IDs and using VLAN maps to rewrite the VLAN tags on all of the incoming and outgoing packets on the logical interfaces with a normalized VLAN ID
- By configuring a virtual-switch instance consisting of a set of bridge domains that are associated with one or more logical interfaces configured as a trunk port

You cannot use the **vlan-id** statement to enable VLAN normalization in VPLS instances, if the logical interfaces in the VPLS instance are configured with the **vlan-id-list** or **vlan-id-range** statement. In such a scenario, you can use the **input-vlan-map** or the **output-vlan-map** option to achieve VLAN normalization.

The following example illustrates the use of the VLAN mapping functionality in VPLS routing instances to normalize VLANs. This method is beneficial in scenarios with flexible VLAN tagging (asymmetric tag depth). In such an environment, the VLAN configuration data that you specified applies the appropriate VLAN tags to the input and output VLAN maps for the ingress and egress logical interfaces respectively. For example, if certain packets are received as single- tagged packets and if the remaining packets are received as double-tagged packets, using VLAN mapping enables normalization.

Using the VLAN mapping capability is effective only if packets of unequal VLAN tags are received or transmitted from logical interfaces to achieve normalization. We recommend that you do not use VLAN mapping in environments in which the VLAN tags are of equal tag depths for optimal configuration. In such cases, you can use the **vlan-id all** statement to enable normalization of VLANs.

```
[edit]
interfaces ge-1/0/0 {
   encapsulation flexible-ethernet-services;
   flexible-vlan-tagging;
   unit 1 {
      encapsulation vlan-vpls;
      vlan-id-range 1-1000;
      input-vlan-map {
         push; /* Push the service vlan on input */
         vlan-id 1200; # This VLAN ID is the normalized VLAN for incoming packets
         }
      output-vlan-map pop; /* Pop the service vlan on output */
   }
   unit 11 {
      encapsulation vlan-vpls;
      vlan-id 1500;
   }
}
interfaces ge-2/0/0 {
   encapsulation flexible-ethernet-services;
   flexible-vlan-tagging;
   unit 1 {
```

```
        encapsulation vlan-vpls;
        vlan-id-range 1-1000; # Note the use of the VLAN id range statement.
        input-vlan-map {
          push; /* Push the service vlan on input */
          vlan-id 1300; # This VLAN ID is the normalized VLAN for incoming packets
          }
        output-vlan-map pop; /* Pop the service vlan on output */
        }
      }
    }
    interfaces ge-3/0/0 {
      encapsulation flexible-ethernet-services;
      flexible-vlan-tagging;
      unit 1 {
        encapsulation vlan-vpls;
        vlan-id 1-1000;
        input-vlan-map {
          push; /* Push the service vlan on input */
          vlan-id 1400; # This VLAN ID is the normalized VLAN for incoming packets
          }
        output-vlan-map pop; /* Pop the service vlan on output */
        }
      }
    }
    interfaces ge-6/0/0 {
      encapsulation flexible-ethernet-services;
      flexible-vlan-tagging;
      unit 11 {
        encapsulation vlan-vpls;
        vlan-id 1500;
      }
    }
    routing-instances {
      customer-c1-v1-to-v1000 {
        instance-type vpls;
        interface ge-1/0/0.1;
        interface ge-2/0/0.1;
        interface ge-3/0/0.1;
      } # End of customer-c1-v1-to-v1000
      customer-c1-v1500 {
        instance-type vpls;
        interface ge-1/0/0.11;
        interface ge-6/0/0.11;
      } # End of customer-c1-v1500
    } # End of routing-instances
```

The following operations are performed when you use the VLAN mapping configuration:

- Packets received on logical interfaces **ge-1/0/0.1** , or **ge-2/0/0.1**, or **ge-3/0/0.1**, with a single VLAN tag in the range from 1 through 1000 in the frame are accepted.
- The VLAN tags of a received packet are compared with the normalized VLAN tags specified with the vlan-id statement in the input VLAN map. If the VLAN tags of the received packet are different from the normalized VLAN tags, then the received VLAN tag is converted to the normalized VLAN tag of 1200 for packets received on the logical interface **ge-1/0/0.1**. Similarly, for logical interface **ge-2/0/0.1**, the normalized VLAN

tag is 1300 for received packets and for logical interface **ge-3/0/0.1**, the normalized VLAN tag is 1400. Then, the source MAC address of a received packet is learned based on the normalized VLAN configuration.

For output packets, based on the **output vlan-map pop** statement configured on the logical interfaces **ge-1/0/0.1** , or **ge-2/0/0.1**, or **ge-3/0/0.1**, if the VLAN tags associated with an egress logical interface do not match the normalized VLAN tags within the packet, then the VLAN tags in the packets that are being transmitted from the egress logical interface are removed.

- Unknown source MAC addresses and unknown destination MAC addresses are learned based on their normalized VLAN values of 1 through 1000.
- All packets sent on the VPLS pseudowire have a normalized VLAN tag after the source MAC address field in the encapsulated Ethernet packet.
- The **input-vlan-map pop** and **output-vlan-map push** statements on the logical interface cause the service VLAN ID to be popped on input and the service VLAN ID to be pushed on output and in this way, the impact of doubly-tagged frames on scaling is limited.

The following example illustrates the use of the **vlan-id all** statement in logical interfaces when a virtual switch instance with a bridge domain is associated with the logical interfaces. You can normalize VLANs and create learning domains for each VLAN. A routing instance uses a trunk bridge to connect different departments in an organization, each with their own VLANs, at two different sites. You must configure a bridge domain and VLAN identifier for each VLAN associated with the trunk interface.

```
[edit]
interfaces ge-1/0/0 {
  encapsulation flexible-ethernet-services;
  flexible-vlan-tagging;
  unit 1 {
    encapsulation vlan-vpls;
    family bridge {
      interface-mode trunk;
        vlan-id-list 1-1000; # Note the use of the VLAN id list statement.
    }
  }
  unit 11 {
    encapsulation vlan-vpls;
    family bridge {
      interface-mode trunk;
        vlan-id-list 1500;
    }
  }
}
interfaces ge-2/0/0 {
  encapsulation flexible-ethernet-services;
  flexible-vlan-tagging;
  unit 1 {
    encapsulation vlan-vpls;
    family bridge {
      interface-mode trunk;
        vlan-id-list 1-1000; # Note the use of the VLAN id list statement.
    }
```

```
    }
  }
  interfaces ge-3/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    family bridge {
    unit 1 {
      encapsulation vlan-vpls;
        interface-mode trunk;
          vlan-id-list 1-1000; # Note the use of the VLAN id list statement.
      }
    }
  }
  interfaces ge-6/0/0 {
    encapsulation flexible-ethernet-services;
    flexible-vlan-tagging;
    family bridge {
    unit 11 {
      encapsulation vlan-vpls;
        interface-mode trunk;
          vlan-id-list 1500;
      }
    }
  }
  routing-instances {
    customer-c1-virtual-switch {
      instance-type virtual-switch;
      interface ge-1/0/0.1;
      interface ge-2/0/0.1;
      interface ge-3/0/0.1;
      bridge-domains {
        c1-vlan-v1-to-v1000 {
          vlan-id all; # Note the use of the VLAN id all statement
        }
      }
    } # End of customer-c1-v1-to-v1000
    customer-c2-virtual-switch {
      instance-type virtual-switch;
      interface ge-1/0/0.11;
      interface ge-6/0/0.11;
      bridge-domains {
        c1-vlan-v1500 {
          vlan-id all; # Note the use of the VLAN id all statement
        }
      }
    } # End of customer-c1-v1500
  } # End of routing-instances
```

Note the use of the **vlan-id all** statement in the virtual-switch instance called **customer-c1-v1-to-v1000**. The **vlan-id all** statement implicitly creates multiple learning domains, each with its own normalized VLAN.

The following operations are performed when you use the **vlan-id all** configuration:

- The logical interfaces are configured as a trunk port that multiplexes traffic from multiple VLANs and usually interconnects switches.
- All the VLAN identifiers are associated with a Layer 2 trunk port. Each of the logical interfaces, **ge-1/0/0.1** , or **ge-2/0/0.1**, or **ge-3/0/0.1**, accepts packets tagged with any VLAN ID specified in the respective **vlan-id-list** statements.
- The association of the received packet to a logical interface is done by matching the VLAN tags of the received packet with the VLAN tags configured on one of the logical interfaces on that physical port. The **vlan-id all** configuration within the bridge domain **c1-vlan-v1-to-v1000** for **customer-c1-virtual-switch** sets the normalized VLAN value. For a logical interface with a single VLAN tag, a learning domain implicitly created for each normalized VLAN of the interface.
- Bridge domain **c1-vlan-v1-to-v1000** for **customer-c1-virtual-switch** has three logical interfaces:
  - Logical interface **ge-1/0/0.1** configured on physical port **ge-1/0/0**.
  - Logical interface **ge-2/0/0.1**configured on physical port **ge-2/0/0**.
  - Logical interface **ge-3/0/0.1**configured on physical port **ge-3/0/0**.
- Packets received on logical interfaces **ge-1/0/0.11** or **ge-6/0/0.11** with a single VLAN tag of 1500 in the frame are accepted.
- Unknown source MAC addresses and unknown destination MAC addresses are learned based on their normalized VLAN values of 1 through 1000.
- All packets sent on the VPLS pseudowire have a normalized VLAN tag after the source MAC address field in the encapsulated Ethernet packet.
- Although there are only three logical interfaces in the VPLS instance called **customer-c1-virtual-switch**, the same MAC address (for example, M1) can be learned on different logical interfaces for different VLANs. For example, MAC address M1 could be learned on logical interface **ge-1/0/0.1** for VLAN 500 and also on logical interface **ge-2/0/0.1** for VLAN 600.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- VLANs Within a Bridge Domain or VPLS Instance on page 23
- Packet Flow Through a Bridged Network with Normalized VLANs on page 24
- Configuring Learning Domains for VLAN IDs Bound to Logical Interfaces on page 61

CHAPTER 9

Bulk Administration of Layer 2 Features on MX Series Routers Examples

- Example: Configuring VLAN Translation with a VLAN ID List on page 79
- Example: Configuring Multiple Bridge Domains with a VLAN ID List on page 80

Example: Configuring VLAN Translation with a VLAN ID List

In many cases, the VLAN identifiers on the frames of an interface's packets are not exactly correct. VLAN translation, or VLAN rewrite, allows you to configure bidirectional VLAN identifier translation with a list on frames arriving on and leaving from a logical interface. This lets you use unique VLAN identifiers internally and maintain legacy VLAN identifiers on logical interfaces.

To perform VLAN translation on the packets on a trunk interface, insert the **vlan-rewrite** statement at the **[edit interfaces *interface-name* unit *unit-number*]** hierarchy level. You must also include the **family bridge** statement at the same level because VLAN translation is only supported on trunk interfaces. The reverse translation takes place on egress. In other words, if VLAN 200 is translated to 500 on ingress, VLAN 500 is translated to VLAN 200 on egress.

The following example translates incoming trunk packets from VLAN identifier 200 to 500 and 201 to 501 (other valid VLAN identifiers are not affected):

```
[edit interfaces ge-1/0/1]
unit 0 {
   ... # Other logical interface statements
   family bridge {
      interface-mode trunk # Translation is only for trunks
      vlan-id-list [ 100 500–600 ];
      vlan-rewrite {
         translate 200 500;
         translate 201 501;
      }
   ... # Other bridge statements
   }
}
```

NOTE: This example also translates frame VLANs from 500 to 200 and 501 to 201 on egress.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Bulk Configuration of VLANs and Bridge Domains on page 27
- Example: Configuring Multiple Bridge Domains with a VLAN ID List on page 80

Example: Configuring Multiple Bridge Domains with a VLAN ID List

To configure multiple bridge domains with one statement, include the **vlan-id-list** statement at the **[edit bridge-domains]** hierarchy level.

The following example automatically configures 4093 bridge domains named **sales-vlan-2** through **sales-vlan-4094**:

```
[edit]
bridge-domains {
   sales { # This is the prefix
      vlan-id-list [ 2–4096 ]; # These are the numbers
   }
}
```

You can configure these bridge domains in a virtual switch routing instance. However, if a VLAN identifier is already part of a VLAN identifier list in a bridge domain under a routing instance, then you cannot configure an explicit bridge domain with that VLAN identifier. In other words. there can be no overlap between a VLAN identifier list and another VLAN identifier configuration.

The following example removes the VLAN identifier 5 from the original VLAN list (**vlan-id-list [1–10]**) and configures the bridge domain explicitly:

```
[edit routing-instance rtg-inst-10]
instance-type virtual-switch;
interface ge-7/3/0.0;
bridge-domains {
   bd-vlan–5 {
      vlan-id 5;
   }
   bd {
      vlan-id [ 1–4 6–10 ];
   }
}
```

If a VLAN identifier is already part of a VLAN identifier list in a bridge domain under a routing instance, then you must delete the VLAN identifier from the list before you can configure an explicit or “regular” bridge domain. Also, the explicit bridge domain will not perform properly unless it has the same name as the bridge domain in the VLAN identifier list.

In other words, if **sales-vlan-100** was part of a bridge domain VLAN list and you wish to configure it explicitly, you must use the same naming convention:

```
[edit]
bridge-domains {
   sales-vlan-100 { # You must use this name explicitly
      vlan-id 100;
   }
}
```

The following limitations apply to automatic bridge domain configuration:

- Only one **vlan-id-list** statement is allowed in a routing instance.
- Bridge options are not supported with the **vlan-id-list** statement.
- Only trunk interfaces are supported.
- There is no support for integrated routing and bridging (IRB).

You display the status and other parameters for automatic bridge domains configured with the **vlan-id-list** statement using the same **show l2-learning instance** command as used for individually configured bridge domains.

Related Documentation

- *Ethernet Networking Feature Guide for MX Series Routers*
- Bulk Configuration of VLANs and Bridge Domains on page 27
- Example: Configuring VLAN Translation with a VLAN ID List on page 79

