Network Design Reference for Avaya Virtual Services Platform 4000 Series

Release 4.2.1
NN46251-200
Issue 07.01
June 2015

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Contents

Chapter 1: Introduction

Purpose

This document provides information on features in VSP Operating System Software (VOSS). VOSS runs on the following product families:

- Avaya Virtual Services Platform 4000 Series
- Avaya Virtual Services Platform 7200 Series
- Avaya Virtual Services Platform 8000 Series

This document provides information to help you build robust and efficient networks using the Avaya Virtual Services Platform 4000 Series . You can use the examples and important design guidelines listed in this document for many features and protocols.

Related resources

Documentation

See the *Documentation Roadmap for Avaya Virtual Services Platform 4000 Series*, NN46251-100, for a list of the documentation for this product.

Training

Ongoing product training is available. For more information or to register, access the website at http://avaya-learning.com/.

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Procedure

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  - In **Search**, type the product name. On the Search Results page, select **Video** in the **Content Type** column on the left.
- To find the Avaya Mentor videos on YouTube, go to www.youtube.com/AvayaMentor and perform one of the following actions:
  - Enter a key word or key words in the **Search Channel** to search for a specific product or topic.
  - Scroll down Playlists, and click the name of a topic to see the available list of videos posted on the website.

Note:

Videos are not available for all products.

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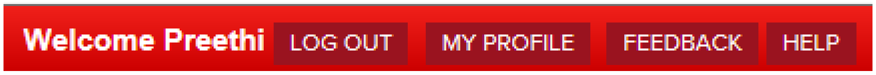
About this task

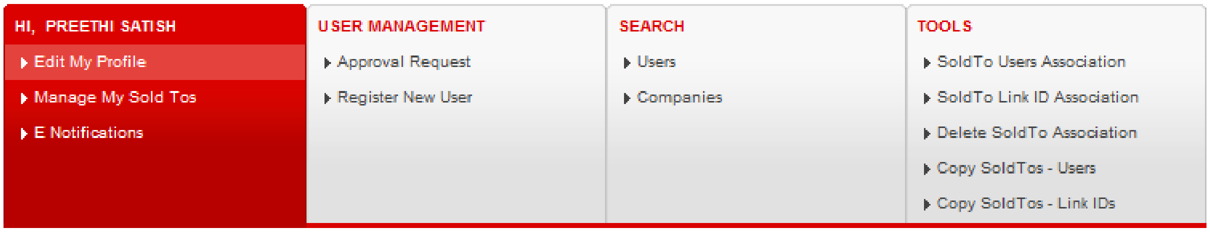
You can subscribe to different types of general notifications, for example, Product Correction Notices (PCN), which apply to any product or a specific product. You can also subscribe to specific types of documentation for a specific product, for example, Application & Technical Notes for Ethernet Routing Switch 8800.

Procedure

1. In an Internet browser, go to https://support.avaya.com.
2. Type your username and password, and then click **Login**.
3. Click **MY PROFILE**.



4. On the site toolbar, click your name, and then click **E Notifications**.



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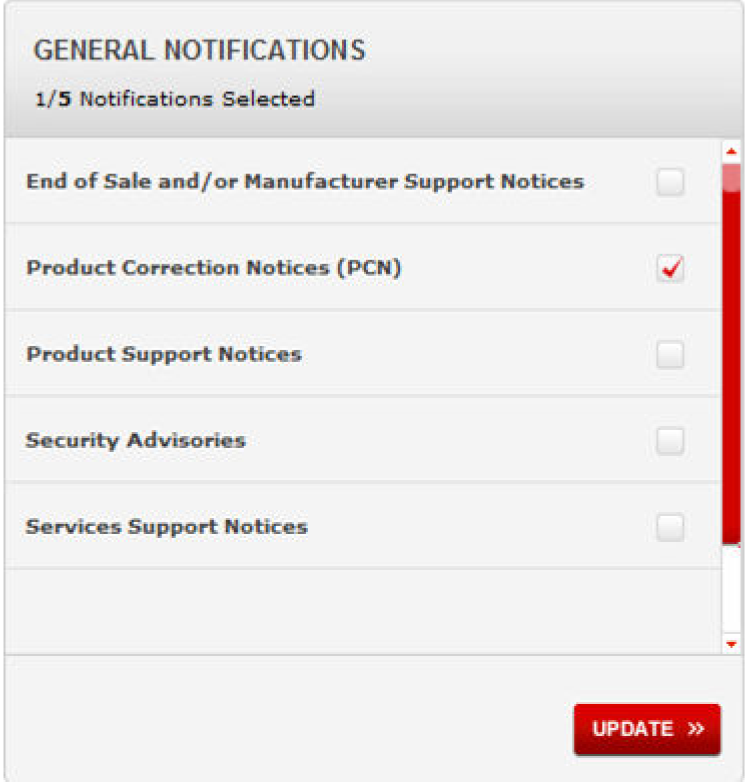

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- Product Support Notices ☐
- Security Advisories ☐
- Services Support Notices ☐

6. Click **OK**.
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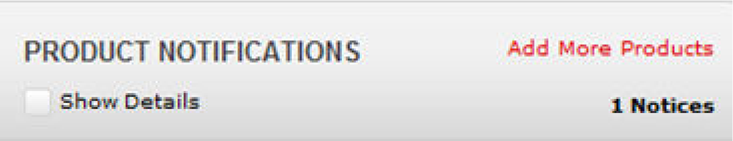

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1 Notices

8. Scroll through the list, and then select the product name.
9. Select a release version.
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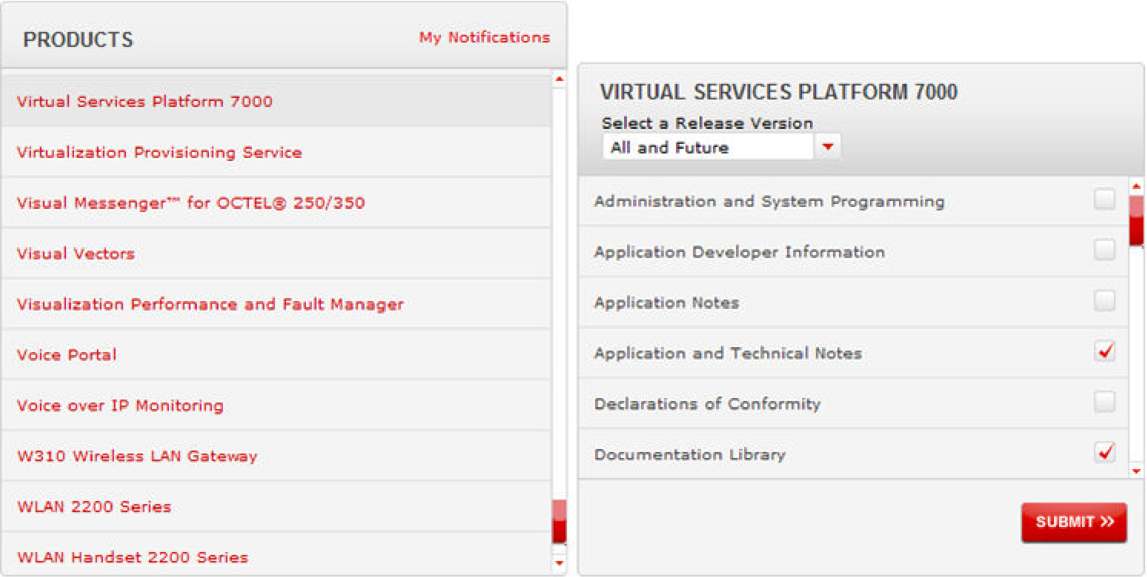

PRODUCTS

- Virtual Services Platform 7000
- Virtualization Provisioning Service
- Visual Messenger™ for OCTEL® 250/350
- Visual Vectors
- Visualization Performance and Fault Manager
- Voice Portal
- Voice over IP Monitoring
- W310 Wireless LAN Gateway
- WLAN 2200 Series
- WLAN Handset 2200 Series

VIRTUAL SERVICES PLATFORM 7000

Select a Release Version: All and Future

- □ Administration and System Programming
- □ Application Developer Information
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- ☑ Application and Technical Notes
- □ Declarations of Conformity
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Before you begin

- Download the documentation collection zip file to your local computer.
- You must have Adobe Acrobat or Adobe Reader installed on your computer.

Procedure

1. Extract the document collection zip file into a folder.
2. Navigate to the folder that contains the extracted files and open the file named <*product_name_release*>.pdx.

3. In the Search dialog box, select the option **In the index named** ***<product_name_release>*****.pdx**.
4. Enter a search word or phrase.
5. Select any of the following to narrow your search:
   - Whole Words Only
   - Case-Sensitive
   - Include Bookmarks
   - Include Comments
6. Click **Search**.

   The search results show the number of documents and instances found. You can sort the search results by Relevance Ranking, Date Modified, Filename, or Location. The default is Relevance Ranking.

Chapter 2: New in this release

The following sections detail what is new in *Network Design Reference for Avaya Virtual Services Platform 4000 Series*, NN46251-200.

VOSS 4.2.1

Features

See the following sections for information about feature-related changes.

Loop prevention and detection

For VOSS 4.2.1, references to Loop Detect have been removed from the section Loop prevention and detection on page 43. Avaya Virtual Services Platform 4000 Series uses Simple Loop Prevention Protocol (SLPP) as the solution to detect loops.

Related Links

New in this release on page 12

Other changes

The chapters “Software scaling capabilities” and “Supported standards, RFCs, and MIBs” are removed from this book for VOSS 4.2.1. For information about software scaling capabilities, see *Release Notes for VSP Operating System Software, NN47227-401*. For information about supported standards, RFCs, and MIBs, see *Administration for Avaya Virtual Services Platform 4000 Series, NN46251-600*.

Related Links

New in this release on page 12

VOSS 4.2

Features

See the following section for information about feature-related changes in VOSS 4.1.

Features for VSP Operating System Software (VOSS)4.1

- **IPv6**

  VSP 4000 VOSS 4.2 provides support for IPv6 routing. File Transfer Protocol (FTP), Trivial File Transfer Protocol (TFTP), Hypertext Transfer Protocol (HTTP) and Hypertext Transfer Protocol Secure (HTTPS) now support both IPv4 and IPv6 addresses, with no difference in functionality or configuration. VSP 4000 VOSS 4.1 supported IPv6 routing, but the feature is initially documented in the VSP 4000 VOSS 4.2 documentation suite. For more information about IPv6 routing, see *Configuring IPv6 Routing on VSP Operating System Software*, NN47227-507.

- **IPv6 routing between L2 VSN**

  IPv6 routing between L2 VSN (inter-VSN routing) allows configuration of any SPB IPv6 capable node to also provide Inter-ISID L2 VSN routing by adding an IPv6 interface to a port-less CVLAN. IPv6 Unicast traffic can then be routed anywhere in the SPB fabric on SPB-IPv6 capable nodes. VSP 4000 VOSS 4.1 supported IPv6 routing between L2 VSN, but the feature is initially documented in the VSP 4000 VOSS 4.2 documentation suite. For more information, see Implementation options on page 97.

- **IPv6 Shortcut routing**

  VOSS 4.1 adds support for IPv6 Shortcuts, which function in a very similar manner to IPv4 Shortcuts. Both types of Shortcuts use IS-IS as the Interior Gateway Protocol (IGP) and the link state packet (LSP) for reachability information. However, IPv4 Shortcuts use TLV 135 and IPv6 Shortcuts use TLV 236. All TLVs announced in the IS-IS LSPs are grafted onto the shortest path tree (SPT) as leaf nodes.

  IPv6 Shortcuts use some IPv4 Shortcuts functionality so IPv4 Shortcuts must be enabled before you enable IPv6 Shortcuts. For more information, see *Configuring IPv6 Routing on VSP Operating System Software*, NN47227-507 and *Configuring Avaya Fabric Connect on VSP Operating System Software*, NN47227-510.

- **IPv6 filters**

  VOSS 4.1 adds support for IPv6 ingress port/vlan security ACL/Filters. VSP 4000 supports a maximum of 256 IPv6 ingress port/vlan security ACL/Filters. IPv6 ingress QoS ACL/Filters and IPv6 egress security and QoS ACL/Filters are not supported. For more information, see *Configuration - QoS and ACL-Based Traffic Filtering Avaya Virtual Services Platform 4000 Series, NN46251-502*.

- **IP Multicast - PIM-SM**

  PIM-SM, as defined in RFC2362, supports multicast groups spread out across large areas of a company or the Internet. PIM-SM sends multicast traffic only to routers that specifically join a multicast group. This technique reduces traffic flow over WAN links and overhead costs for processing unwanted multicast packets. For more information, see *Configuring IP Multicast Routing Protocols on Avaya Virtual Services Platform 4000 Series , NN46251-504*.

- **RSMLT and SMLT with virtual IST**

  Split MultiLink Trunking (SMLT) provides subsecond failover when a switch fails. Routed Split MultiLink Trunking (RSMLT) permits rapid failover for core topologies by providing an active-active router concept to core SMLT networks. Virtual Inter-Switch Trunk (vIST) improves on this resiliency by using a virtualized IST channel through the SPBM Cloud.

  For more information, see Layer 2 switch clustering and SMLT on page 50, Layer 3 switch clustering and RSMLT on page 54, and Layer 3 switch clustering and multicast SMLT on page 62.

See the following section for information about feature-related changes in VOSS 4.2.

Features for VSP Operating System Software (VOSS) 4.2

- **Authentication and password enhancements**

  VOSS 4.2 supports authentication and password enhancements. After you enable enhanced secure mode, the system can supports role-based access levels, stronger password requirements, and stronger rules on password length, password complexity, password change intervals, password reuse, and password maximum age use.

  For more information, see Control plane security on page 154.

  For more information on system access security enhancements, see *Administration for Avaya Virtual Services Platform 4000 Series*, NN46251-600.

- **Enhanced secure mode**

  VOSS 4.2 adds support for the new **`boot config flags enhancedsecure-mode`** command. If you enable enhanced secure mode, the system can provide role-based access levels, strong password requirements, and strong rules on password length, password complexity, password change intervals, password reuse, and password maximum age use.

  For more information see:

  - Data plane security on page 151.
  - Control plane security on page 154.

  For additional information see the sections “Standard MIBs”, “Software scaling capabilities”, and Supported RFCs”in *Administration for Avaya Virtual Services Platform 4000 Series, NN46251-600*

- **load-encryption-module**

  VOSS 4.2 removes the **`load-encryption-module {3DES|AES|DES}`** command. The command is no longer required to load the security encryption image.

- **Secure Shell version 2 (SSHv2)**

  VOSS 4.2 updates Secure Shell implementation on the switch. The switch now supports only Secure Shell version 2 (SSHv2).

  SSHv2 also adds encryption support for MD5, SHA-1, and SHA-2.

  For more information, see Control plane security on page 154.

  For more information on SSHv2 conceptual information and configuration information, see *Administration for Avaya Virtual Services Platform 4000 Series*, NN46251-600.

- **Secure Copy (SCP)**

VOSS 4.2 does not support Secure Copy (SCP). For this release, use SFTP to transfer files securely. For more information, see the section “Security overview” in *Security for Avaya Virtual Services Platform 4000 Series, NN46251-601*.

- **SNMPv3**

  VOSS 4.2 updates SNMPv3 to support Federal Information Processing Standards (FIPS) 140-2. SNMPv3 supports the Advanced Encryption Standard (AES) and Data Encryption Standard (DES) encryption options and Message Digest algorithm 5 (MD5), Secure Hash Algorithm 1 (SHA-1) and SHA-2 authentication types.

  If you enable enhanced secure mode, the VSP switch does not support the default SNMPv1 and default SNMPv2 community strings, and default SNMPv3 user name. The individual in the administrator access level role can configure a non-default value for the community strings, and the VSP switch can continue to support SNMPv1 and SNMPv2. The individual in the administrator access level role can also configure a non-default value for the SNMPv3 user name and the VSP switch can continue to support SNMPv3.

  If you disable enhanced secure mode, the SNMPv1 and SNMPv2 support for community strings remains the same, and the default SNMPv3 user name remains the same. Enhanced secure mode is disabled by default.

  For more information, see Control plane security on page 154.

  For more information, see *Configuring Security on Avaya Virtual Services Platform 7200 Series and 8000 Series*, NN47227-601 and *Security for Avaya Virtual Services Platform 4000 Series*, NN46251-601.

Other changes

There are no other changes to this document for VOSS 4.2.

Chapter 3: Network design fundamentals

To efficiently and cost-effectively use Avaya Virtual Services Platform 4000 Series, you must properly design your network, which includes the following considerations:

- Reliability and availability
- Platform redundancy
- Desired level of redundancy

A robust network depends on the interaction between system hardware and software. System software can be divided into different functions as shown in the following figure.

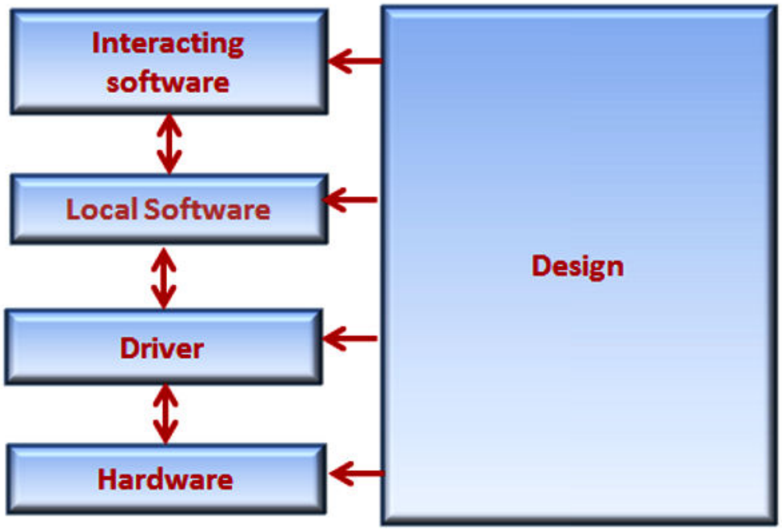


Figure 1: Hardware and software interaction

A driver is the lowest level of software that actually performs a function. Drivers reside on a single module and do not interact with other modules or external devices. Drivers are very stable.

Statically configured MultiLink Trunking (MLT) is a prime example of local software because it interacts with several modules within in the same device. No external interaction is needed, so you can easily test the function.

Interacting software is the most complex level of software because it depends on interaction with external devices. The Open Shortest Path First (OSPF) protocol is a good example of this software level. Interaction can occur between devices of the same type or with devices of other vendors than run a completely different implementation.

Based on network problem-tracking statistics, the following list is an approximate stability estimation model of a system that uses these components:

- Hardware and drivers represent a small portion of network problems.
- Local software represents a more significant share.
- Interacting software represents the vast majority of the reported issues.

Based on this model, network design attempts to off-load the interacting software level as much as possible to the other levels, especially to the hardware level. Avaya recommends that you follow these generic rules when you design networks:

1. Design networks as simply as possible.
2. Provide redundancy, but do not over-engineer your network.
3. Use a toolbox to design your network.
4. Design according to the product capabilities described in the latest release notes.
5. Follow the design rules provided in this document and also in the various configuration documents for the device.

Chapter 4: Hardware fundamentals and guidelines

This chapter provides general hardware guidelines to use the Avaya Virtual Services Platform 4000 Series in a network. Use the information in this chapter to help you during the hardware design and planning phase.

Supported hardware

VOSS 4.2.1 supports the following VSP 4000 Series models:

1. VSP 4850GTS Series: Includes the 4850GTS (AC), the 4850GTS-PWR+, and the 4850GTS-DC.
2. VSP 4450GSX Series: Includes the 4450GSX-DC, the 4450GSX-PWR+ and the TAA-compliant 4450GSX-PWR+ model.
3. VSP 4450GTX–HT–PWR+

Platform considerations

This section provides VSP 4000 platform power and cooling considerations. You must properly power and cool your device, or problems can result.

Platform power supplies

The VSP 4000 series switches support both AC and DC power supplies. One power supply is installed in the system.

You can install a redundant power supply to support additional power requirements or to provide power redundancy.

The following table describes the VSP 4000–compatible AC and DC power supplies and their part numbers (order codes). All the power supplies are EUED RoHS 5/6 compliant.

Note:

The 300W and 1000 W AC power supplies use the IEC 60320 C16 AC power cord connector.

Use the order codes to order a replacement for the primary PSU or to order a redundant PSU for your VSP 4000 system.

Table 1: Power supply order codes

VSP 4000 PSU	Usage	Part number (order code)
300 W AC power supply	For use in the ERS 4626GTS, VSP 4850GTS and WL8180, WL8180-16L wireless controllers.	AL1905?08-E5*
1000 W AC POE+ power supply	For use in VSP 4000 series PWR+ platforms including VSP 4450GSX–PWR+, and VSP 4850GTS-PWR+.	AL1905?21–E6*
300 W DC power supply	For use in the VSP 4850GTS-DC, VSP 4450GSX-DC, ERS5698TFD, 5650TD, and 5632FD. DC connector included.	AL1905005-E5
1000 W AC POE+ power supply	For use in the VSP 4000 4450GTX-HT-PWR+ model.	EC4005?03-E6*
*__Note:__ You must replace the seventh character (?) of the switch order number with the proper letter to indicate desired product nationalization. See the following for details: A: No power cord included. B: Includes European “Schuko” power cord common in Austria, Belgium, Finland, France, Germany, The Netherlands, Norway, and Sweden. C: Includes power cord commonly used in the United Kingdom and Ireland. D: Includes power cord commonly used in Japan. E: Includes North American power cord. F: Includes Australian power cord.		

Device cooling

VSP 4000 — device cooling

The VSP 4000 platform has an in-built cooling module that is not removable. Each cooling module includes four fans providing cooling from front to back. There are three 12-volt fans to maintain optimal operating temperature inside the box. The fans are also speed controlled, based on the temperature in the box, in order to minimize fan noise. Temperature sensors allow the fan speed controller to properly support the entire unit.

Caution:

Risk of electromagnetic interference:

This device is a Class A product. Operation of this equipment in a residential area is likely to cause harmful interference, in which case users are required to take appropriate measures necessary to correct the interference at their own expense.

Power specifications for VSP 4000 switches 4850GTS series and 4450GSX series

The following sections describe the regulatory AC and DC power specifications for the VSP 4000 series switches.

AC power specifications

The following table describes the regulatory AC power specifications for the 4850GTS series and the 4450GSX-PWR+ switches. The regulatory power specifications are based on the maximum rated capacity of the power supplies and are not based on typical power consumption, which is lower.

Table 2: AC power specifications for 4850GTS series

Specifications	4850GTS	4850GTS-PWR+
Input Current	5A/2.5 A	16.66A/8.33 A
Input Voltage (rms)	100 to 240 VAC at 50 to 60 Hz	100 to 240 VAC at 50 to 60 Hz
Power Consumption	Typical: 94.6 W Maximum: 140 W	• Without PoE+ - Typical: 107 W - Maximum: 145 W • With PoE+ - Typical power utilization depends on the number of ports using PoE+. - Maximum: 1705.2 W
Thermal Rating	323 BTU/hr maximum	508 BTU/hr maximum
Inrush Current	40 A maximum	70 A maximum
Turn on Condition	1 second maximum after application of AC power	1 second maximum after application of AC power
Important: 12–volt output rise time, from 10 to 90 percent, must be the maximum of 50 ms and monotonic under all defined input and output conditions.		
Efficiency	70 percent minimum	70 percent minimum

Table 3: AC power specifications for 4450GSX-PWR+

	4450GSX-PWR+
Input Current	16.66 A/8.33 A
Input Voltage (rms)	100 to 240 VAC at 50 to 60 Hz
Power Consumption	• Without PoE+ - Typical: 116 W - Maximum: 164.6 W • With PoE+ - Typical power utilization depends on the number of ports using PoE+. - Maximum: 553.4 W
Thermal Rating	508 BTU/hr maximum
Inrush Current	70 A maximum
Turn on Condition	1 second maximum after application of AC power
Efficiency	70 percent minimum
Important: 12–volt output rise time, from 10 to 90 percent, must be the maximum of 50 ms and monotonic under all defined input and output conditions.	

DC power specifications

The following table describes the DC power supply specifications for the 4850GTS-DC and the 4450GSX-DC models.

Table 4: DC power specifications

Specifications	**4850GTS-DC**	**4450GSX-DC**
Input current	25 A	25 A
Input voltage	12 V DC	12 V DC
Power consumption	• Typical: 94.6 W • Maximum: 140 W	• Typical: 116 W • Maximum: 164.6 W
Thermal rating	323 BTU/Hr	508 BTU/Hr

VSP 4000 power supply power specification

The VSP 4000 supports two external field-replaceable power supplies. One power supply ships with the chassis. You can install a secondary power supply to provide redundancy and load sharing, and to add Power over Ethernet Plus (PoE+) power budget on PWR+ models.

1000 W AC power supply

VSP 4000 PWR+ model (4450GSX-PWR+) supports dual 54 V 1000 W PoE+ AC power supplies.

Important:

Ensure that you use only 1000 W power supplies (both primary and secondary) on VSP 4000 PWR+ models.

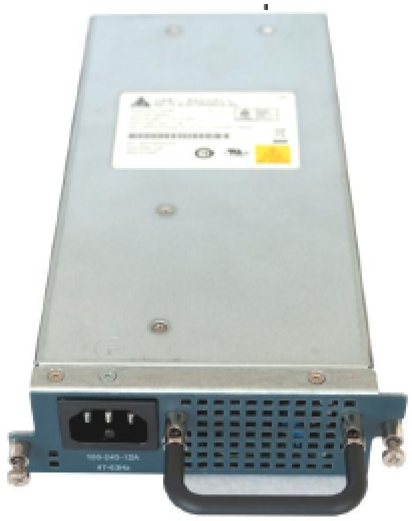


Figure 2: 1000 W AC power supply

300 W AC power supply

The Avaya VSP 4850GTS supports 300 W AC power supplies.

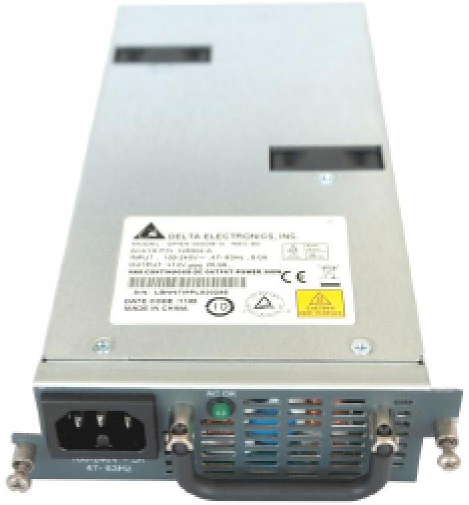


Figure 3: 300 W AC power supply

Connector

The 300 W and 1000 W AC power supplies use an IEC 60320 C16 AC power cord connector. The AC power cord is in close proximity to the hot-air exhaust, and supports high operating temperatures.

The 1000 W AC power supplies use an IEC 60320 C16 AC power cord connector. The AC power cord is in close proximity to the hot-air exhaust, and supports high operating temperatures.

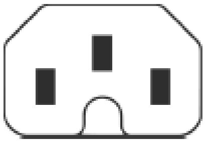


Figure 4: IEC 60320 C16 connector

Power over Ethernet Plus specifications

Table 5: Avaya VSP 4850GTS and 4850GTS-PWR+ models

Maximum PoE+ W	Average PoE+ W on 50 port model
855 W with one power supply 1855 W with two power supplies	15.4 W (802.3af) 17.8 W (802.3.at) — One power supply 32.4 W (802.3at) — Two power supplies

- VSP 4850GTS-PWR+ can support 802.3af 15.4 W on each port with one power supply installed. You can add a second power supply for redundancy.
- VSP 4850GTS-PWR+ can support 802.3at 32.4 W on each port with two power supplies installed. PoE+ power reduces to an average of 17.8W on each port with one power supply.

Table 6: Avaya VSP 4450GSX-PWR+ model

Maximum PoE+ W	Average PoE+ W on 12 ports
835 W with one power supply 1835 W with two power supplies	17.8 W or 32.4 W (802.3.at) — One power supply

- VSP 4450GSX-PWR+ can support 802.3af 17.8 W or 32.4 W on each port with one power supply installed. You can add a second power supply for redundancy.

Table 7: Avaya VSP 4450GTX-HT-PWR+ model

	0°C to 50°C	50°C to 70°C
1 PSU	860W	400W
2 PSU	1660W	832W
Avaya VSP 4450GTX-HT-PWR+ model with 1 PSU		
PoE support on	48 ports	23 ports

Table continues…

	0°C to 50°C	**50°C to 70°C**
PoE+ support on	26 ports	13 ports
Avaya VSP 4450GTX-HT-PWR+ model with 2 PSUs		
PoE support on	48 ports	48 ports
PoE+ support on	48 ports	26 ports

- VSP 4450GTX-HT-PWR+ can support 802.3af 17.8W or 32.4W on each port with one power supply installed. You can add a second power supply for redundancy.

DC power supply specifications

The following table describes the DC power supply specifications for the VSP 4000.

Table 8: DC power supply specifications

Description	DC-DC-12V-300 W
Output power	300 W
Input voltage	48 V DC
Input current	10 A
Output voltage	12 V DC
Output current	25 A

Hardware compatibility for VSP 4000

The following tables describe the Avaya Virtual Services Platform 4000 Series hardware.

Table 9: Hardware

Release	VSP 4000 model	Description	Part number
3.0	VSP 4850GTS	• 48 10/100/1000 BaseTX RJ-45 ports • two shared SFP ports • two 1/10GE SFP+ ports • Base Software License • one (of two) field replaceable 300W PSUs supplied with the chassis	EC4800x78-E6 **Note:** Replace the “x” with a country-specific power cord code. See the footnote for details.
3.0	VSP 4850GTS-PWR+	• 48 10/100/1000 802.3at PoE+ • two shared SFP ports	EC4800x88-E6

Table continues…

Release	VSP 4000 model	Description	Part number
		• two 1/10GE SFP+ ports • Base Software License • one (of two) field replaceable 1000W PSUs supplied with the chassis	**Note:** Replace the “x” with a country-specific power cord code. See the footnote for details.
3.0	VSP 4850GTS DC	• 48 10/100/1000 Base TX RJ-45 ports • two shared SFP ports • two 1/10GE SFP+ ports • one (of two) field replaceable 300W DC PSUs supplied with the chassis	EC4800078-E6
4.0	VSP 4450GSX-PWR+	• 12 10/100/1000 BASE TX RJ-45 ports with 802.3at PoE+ • 36 100/1000–Mbps SFP ports • Two 1/10G SFP+ ports with MACsec capable PHY • One (of two) field-replaceable 1000W PSUs supplied with the chassis	EC4400x05-E6 **Note:** Replace the “x” with a country-specific power cord code. See the footnote for details.
4.0.40	VSP 4450GTX-HT-PWR+	• 48 10/100/1000 Base TX RJ-45 ports with 802.3at PoE+ • two shared SFP ports • two 1/10GE SFP+ ports • Base Software License • one (of two) field replaceable 1000W PSUs supplied with the chassis	EC4400A03-E6
		• Same content as EC4400A03-E6 with a NA power cord.	EC4400E03-E6
4.0.50	VSP 4450GSX-DC	• 12 10/100/1000 BASE TX RJ-45 ports • 36 100/1000 Mbps SFP ports • two 1/10G SFP+ ports with MACsec capable PHY • one field-replaceable 300W DC PSU	EC4400004-E6
4.0.50	TAA-compliant VSP 4450GSX-PWR+	• 12 10/100/1000 BASE TX RJ-45 ports with 802.3at PoE+ • 36 100/1000–Mbps SFP ports	EC4400x05-E6GS

Table continues…

Release	VSP 4000 model	Description	Part number
		• Two 1/10G SFP+ ports with MACsec capable PHY • One (of two) field-replaceable 1000W PSUs supplied with the chassis	**Note:** Replace the “x” with a country-specific power cord code. See the footnote for details.
Note: The character (x) in the order number indicates the power cord code. Replace the “x” with the proper letter to indicate the desired product nationalization. See the following for details: “A”: No power cord included. “B”: Includes European “Schuko” power cord common in Austria, Belgium, Finland, France, Germany, The Netherlands, Norway, and Sweden. “C”: Includes power cord commonly used in the United Kingdom and Ireland. “D”: Includes power cord commonly used in Japan. “E”: Includes North American power cord. “F”: Includes Australian power cord.			

Supported optical devices

Use optical devices to achieve high-bit-rate communications and long transmission distances.

Important:

Avaya recommends using Avaya-branded SFP and SFP+ transceivers as they have been through extensive qualification and testing. Avaya is not responsible for issues related to non-Avaya branded SFP and SFP+ transceivers.

Small Form Factor Pluggable (SFP) transceivers

SFPs are hot-swappable input and output enhancement components designed to allow gigabit Ethernet ports to link with other gigabit Ethernet ports over various media types.

You can use various SFP (1 Gbps) and SFP+ (10 Gbps) to attain different line rates and reaches. The following table describes the SFPs including the reach provided by various SFPs.

Important:

The attainable cable length can vary depending on the quality of the fiber-optic cable used.

Small Form Factor Pluggable plus (SFP+) transceivers

SFP+ transceivers are hot-swappable input and output enhancement components that allow 10 gigabit connections. All Avaya SFP+ transceivers use Lucent connectors (LC) to provide precision keying and low interface losses.

For more information about SFP and SFP+ transceivers, including technical specifications and installation instructions, see *Installing Transceivers and Optical components on Avaya Virtual Services Platform 4000 Series*, NN46251-301.

Optical power considerations

When you connect the device to collocated equipment, ensure that enough optical attenuation exists to avoid overloading the receivers of each device. You must consider the minimum attenuation requirement based on the specifications of third-party equipment. For more information about minimum insertion losses for Avaya optical products, see *Installing Transceivers and Optical components on Avaya Virtual Services Platform 4000 Series*, NN46251-301.

Dispersion considerations for long reach

Precise engineering of transmission links is difficult; specifications and performance are often unknown, undocumented, or impractical to measure before equipment installation. Moreover, the skills required to perform rigorous link budget analysis are extensive. Fortunately, a simple, straightforward approach can assure robust link performance for most optical fiber systems in which you use Avaya switches and routers.

This method uses an optical power budget, the difference between transmitter power and receiver sensitivity, to determine whether the installed link can operate with low bit error ratio for extended periods. The power budget must accommodate the sum of link loss (that is, attenuation), dispersion, and system margin, described in the following paragraphs.

Link losses are the sum of cabled fiber loss, splices, and connectors, often with an allocation for additional connectors. Cabled fiber loss is wavelength and installation dependent, and is typically in the range of 0.20 to 0.5 dB/km. See the cable plant owner or operator for specifications of the cable you use, particularly if the available system margin is unsatisfactory. Engineered links require precise knowledge of the cable plant.

For long, high bit rate systems, pulse distortion, caused by the transmitter laser spectrum interaction with fiber chromatic dispersion, reduces receiver sensitivity. Transceivers for long reach single mode fiber systems have an associated maximum dispersion power penalty (DPP_{max}) specification, which applies to G.652 (dispersion unshifted) single mode fiber and the rated transceiver reach. The actual power penalty that you must use is

DPP_{budget} = [link length(km) / transceiver maximum reach (km)] * DPP_{max}

For example, if an 80 km transceiver is specified as having DPP < 3 dB, and if the actual link length will be 40 km, DPP_{budget} is one-half the maximum, or 1.5 dB.

Link operating margins are sometimes allocated for impairments such as aging, thermal, or other environmental effects. Because of the potentially large number of factors that can degrade performance, you can usually rely on statistics to represent these factors as a single margin value, in dB, to cover all effects. Margin is life and design dependent, but is typically 3.5 to 4.5 dB, minimum. Whether you require additional margin depends on the details, such as whether actual or specified transmitter power and receiver sensitivity are used. Avaya specifications represent worst-case values.

The sum of margin, dispersion power penalty, and passive cable plant losses must be less than the available power budget. Alternatively, if you calculate available power margin as the difference between the available budget and the sum of losses and dispersion, the margin can be more or less than required, which determines whether additional consideration is needed. If the power budget is exceeded or margin is insufficient, you can either use a transceiver rated for longer distance operation, or calculate budget and losses using actual values rather than specified limit values. Either method can improve the link budget by 4 to 5 dB or more.

10/100BASE-X and 1000BASE-TX reach

The following table lists maximum transmission distances for 10/100BASE-X and 1000BASE-TX Ethernet cables.

Table 10: Maximum cable distances

	10BASE-T	100BASE-TX	1000BASE-TX
IEEE standard	802.3 Clause 14	802.3 Clause 21	802.3 Clause 40
Data rate	10 Mbps	100 Mbps	1000 Mbps
Cat 5 UTP distance	100 m	100 m	100 Ω, 4 pair: 100 m

10/100/1000BASE-TX Auto-Negotiation recommendations

Auto-Negotiation lets devices share a link and automatically configures both devices so that they take maximum advantage of their abilities. Auto-Negotiation uses a modified 10BASE-T link integrity test pulse sequence to determine device ability.

The Auto-Negotiation feature allows the devices to switch between the various operational modes in an ordered fashion and allows management to select a specific operational mode. The Auto-Negotiation feature also provides a parallel detection (also called autosensing) function to allow the recognition of 10BASE-T, 100BASE-TX, 100BASE-T4, and 1000BASE-TX compatible devices, even if they do not support Auto-Negotiation. In this case, only the link speed is sensed; not the duplex mode. Avaya recommends the Auto-Negotiation configuration as shown in the following table, where A and B are two Ethernet devices.

Table 11: Recommended Auto-Negotiation configuration on 10/100/1000BASE-TX ports

Port on A	Port on B	Remarks	Recommendations
Auto-Negotiation enabled	Auto-Negotiation enabled	Ports negotiate on highest supported mode on both sides.	Avaya recommends that you use this configuration if

Table continues…

Port on A	Port on B	Remarks	Recommendations
			both ports support Auto-Negotiation mode.
Full-duplex	Full-duplex	Both sides require the same mode.	Avaya recommends that you use this configuration if you require full-duplex, but the configuration does not support Auto-Negotiation.

Auto-Negotiation cannot detect the identities of neighbors or shut down misconnected ports. Upper-layer protocols perform these functions.

Note:

The 10 GigabitEthernet fiber-based I/O module ports can operate at either 1 Gigabit per second (Gbps) or 10 Gbps, dependent upon the capabilities optical transceiver that you install.

This presents an ambiguity with respect to the autonegotiation settings of the port, while 1 Gigabit Ethernet (GbE) ports require autonegotiation; autonegotiation is not defined and is non-existent for 10 GbE ports.

For a 10GbE fiber-based I/O module, you have the capability to swap back-and-forth between 1 GbE and 10 GbE operation by simply swapping transceivers. To help with this transition between 1 GbE and 10 GbE port operation, Avaya allows you to configure autonegotiation when you install a 10 GbE transceiver, even though autonegotiation is not defined for 10GbE.

You can do this in anticipation of a port changeover from 10 GbE to 1 GbE. In this manner, you could essentially preconfigure a port in 1 GbE mode while the 10 GbE transceiver is still installed. The port is ready to go upon the changeover to the 1 GbE transceiver.

In addition, you can use a saved configuration file with autonegotiation enabled to boot a system with either 10 GbE or 1 GbE transceivers installed. If you install a 1 GbE transceiver, the system applies autonegotiation. If you install a 10 GbE transceiver, the system does not remove the autonegotiation settings from the configuration, but the system simply ignores the configuration because autonegotiation settings are irrelevant to a 10 GbE transceiver. The system preserves the saved configuration for autonegotiation when resaved no matter which speed of transceiver you install.

Auto MDIX

Automatic medium-dependent interface crossover (Auto-MDIX) automatically detects the need for a straight-through or crossover cable connection and configures the connection appropriately. This removes the need for crossover cables to interconnect switches and ensures either type of cable can be used. The speed and duplex setting of an interface must be set to Auto for Auto-MDIX to operate correctly.

CANA

Use Custom Auto-Negotiation Advertisement (CANA) to control the speed and duplex settings that the interface modules advertise during Auto-Negotiation sessions between Ethernet devices. Modules can only establish links using these advertised settings, rather than at the highest common supported operating mode and data rate.

Use CANA to provide smooth migration from 10/100 Mbps to 1000 Mbps on host and server connections. Using Auto-Negotiation only, the switch always uses the fastest possible data rates. In limited-uplink-bandwidth scenarios, CANA provides control over negotiated access speeds, and improves control over traffic load patterns.

You can use CANA only on 10/100/1000 Mbps RJ-45 ports. To use CANA, you must enable Auto-Negotiation.

Important:

If a port belongs to a MultiLink Trunking (MLT) group and you configure CANA on the port (that is, you configure an advertisement other than the default), you must apply the same configuration to all other ports of the MLT group (if they support CANA).

If a 10/100/1000 Mbps port that supports CANA is in a MLT group that has 10/100BASE-TX ports, or any other port type that does not support CANA, use CANA only if it does not conflict with MLT abilities.

Chapter 5: Optical routing design

The Avaya optical routing system uses coarse wavelength division multiplexing (CWDM) in a grid of eight optical wavelengths. Use the Avaya optical routing system to maximize bandwidth on a single optical fiber. This chapter provides optical routing system information that you can use to help design your network.

Optical routing system components

Small Form Factor Pluggable (SFP) transceivers transmit optical signals from gigabit Ethernet ports to multiplexers in a passive optical shelf.

Multiplexers combine multiple wavelengths traveling on different fibers onto a single fiber. At the receiver end of the link, demultiplexers separate the wavelengths and route them to different fibers, which terminate at separate CWDM devices. The following figure shows multiplexer and demultiplexer operations.

Important:

For clarity, the following figure shows a single fiber link with signals traveling in one direction only. A duplex connection requires communication in the reverse direction as well.

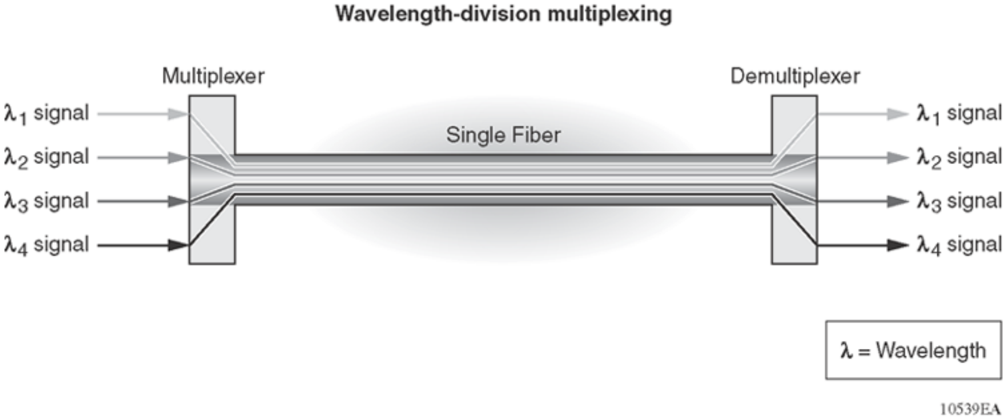


Figure 5: Wavelength division multiplexing

The Avaya optical routing system supports both ring and point-to-point configurations. The optical routing system includes the following parts:

- CWDM SFPs

- Optical add/drop multiplexers (OADM)
- Optical multiplexer/demultiplexers (OMUX)
- Optical shelf to house the multiplexers

OADMs drop or add a single wavelength from or to an optical fiber.

For the list of supported optical devices on the Avaya Virtual Services Platform 4000 Series platform for the current release, see Supported optical devices on page 26.

Chapter 6: Platform redundancy

This chapter includes recommendations to provide a fault-tolerant platform.

Power redundancy

The Avaya VSP 4000 series PWR+ models support dual 54V 1000W Power over Ethernet Plus (PoE+) AC power supplies. This model supports two external field-replaceable power supplies. You can install a secondary power supply to provide redundancy and load sharing, and add Power over Ethernet Plus (PoE+) power budget on PWR+ models.

The 1000 W AC power supplies use an IEC 60320 C16 AC power cord connector. The AC power cord is in close proximity to the hot-air exhaust, and supports high operating temperatures.

❗ **Important:**

Avaya recommends that power supplies use the same input voltage. Do not operate the chassis with power supplies under different input-voltage conditions. The product can function but Avaya does not support this configuration.

Table 12: Power over Ethernet Plus specifications

Model	Maximum PoE+ W	Average PoE+ W on 50 port models
Avaya VSP 4850GTS—PWR+ models	• 855 W with one power supply • 1855 W with two power supplies	• 15.4 W (802.3af) • 17.8 W (802.3at) — One power supply • 32.4 W (802.3at) — Two power supplies

The VSP 4850GTS-PWR+ can support 802.3af 15.4 W on each port with one power supply installed. PoE+ power reduces to an average of 17.8 W on each port with one power supply. It can support 802.3at 32.4 W on each port with two power supplies installed.

Table 13: Power over Ethernet Plus specifications for Avaya VSP 4450GSX-PWR+ model

	Maximum PoE+ W	Average PoE+ W on 12 ports
Avaya VSP 4450GSX-PWR+ models	835 W with one power supply	17.8 W or 32.4 W (802.3at) — One power supply

	Maximum PoE+ W	Average PoE+ W on 12 ports
	1835 W with two power supplies	

- VSP 4450GSX-PWR+ can support 802.3af 17.8 W or 32.4 W on each port with one power supply installed. You can add a second power supply for redundancy.

Table 14: Power over Ethernet Plus specifications for Avaya VSP 4450GTX-HT-PWR+ model

	0°C to 50°C	50°C to 70°C
1 PSU	860W	400W
2 PSU	1660W	832W
Avaya VSP 4450GTX-HT-PWR+ model with 1 PSU		
PoE support on	48 ports	23 ports
PoE+ support on	26 ports	13 ports
Avaya VSP 4450GTX-HT-PWR+ model with 2 PSUs		
PoE support on	48 ports	48 ports
PoE+ support on	48 ports	26 ports

- VSP 4450GTX-HT-PWR+ can support 802.3af 17.8W or 32.4W on each port with one power supply installed. You can add a second power supply for redundancy.

Input/output port redundancy

You can protect I/O ports using a link aggregation mechanism. MultiLink Trunking (MLT), which is compatible with 802.3ad static, provides a load sharing and failover mechanism to protect against module, port, fiber, or complete link failures.

You can use MLT with Link Access Control Protocol (LACP) disabled or use LACP enabled by itself.

Configuration redundancy

You can define primary and backup configuration file paths. This configuration protects against system failures. For example, the primary path can point to system flash memory and the backup path to the external Compact Flash card.

Link redundancy

Provide physical and link layer redundancy to eliminate a single point of failure in the network. For more information, see Link redundancy on page 36.

Chapter 7: Link redundancy

You can build link redundancy into your network to:

- Help eliminate a single point of failure in your network (provide physical and link layer redundancy)
- Prevent a service interruption caused by a faulty link (provide link layer redundancy)

This chapter explains the following design options that you can use to achieve link redundancy (provide alternate data paths) :

- Physical layer redundancy
- MultiLink Trunking
- 802.1ad-based link aggregation

Physical layer redundancy

To ensure that a faulty link does not cause a service interruption, you can provide physical layer redundancy in your network.

You can also configure the platform to detect link failures with, for example:

- Remote fault indication
- Virtual Link Aggregation Control Part (VLACP)

Gigabit Ethernet and remote fault indication

The 802.3z gigabit Ethernet standard defines remote fault indication (RFI) as part of the Auto-Negotiation function.

Because RFI is part of the Auto-Negotiation function, if you disable Auto-Negotiation, you automatically disable RFI.

The stations on both ends of a fiber pair use RFI to inform one another after a problem occurs on one of the fibers.

Avaya recommends that you enable Auto-Negotiation on gigabit Ethernet links when the devices on both ends of a fiber link support Auto-Negotiation because, without RFI support, if one of two unidirectional fibers that form the connection between the two platforms fails, the transmitting side cannot determine that the link is broken in one direction (see the following figure).

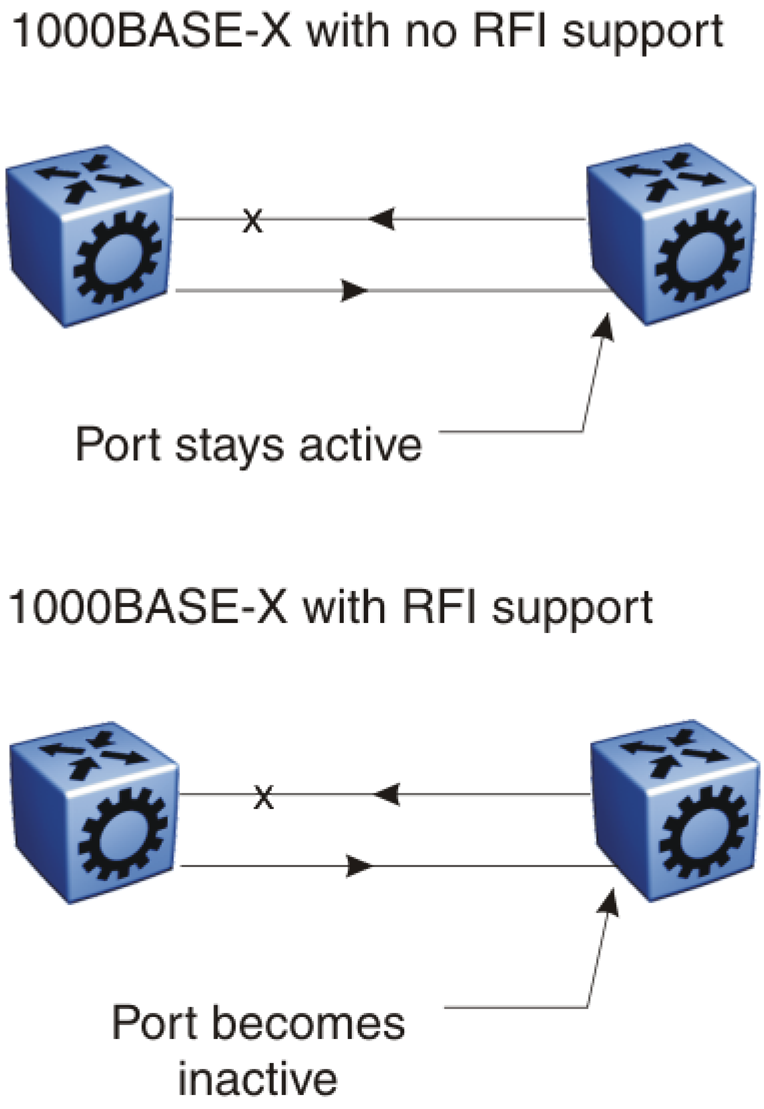


Figure 6: 1000BASE-X RFI

End-to-end fault detection and VLACP

Because remote fault indication (RFI) terminates at the next Ethernet hop, the device that uses only RFI cannot determine failures on an end-to-end basis over multiple hops.

However, you can use Virtual Link Aggregation Control Protocol (VLACP) to provide an end-to-end failure detection mechanism. You can configure VLACP on a port and enable it over single links or multilink trunks (MLT).

You can use VLACP with MLT to enhance its capabilities and provide quick failure detection. With VLACP, the device can detect far-end failures, which permits MLT to fail over properly when end-to-end connectivity is not guaranteed for some links in an aggregation group.

To minimize network outages, you can also use VLACP to switch traffic around entire network devices before Layer 3 protocols detect a network failure.

VLACP is an extension of the Link Aggregation Control Protocol (LACP) but LACP and VLACP are independent features.

VLACP does not perform link aggregation; it detects end-to-end link failures.

VLACP periodically checks the end-to-end condition of a point-to-point connection and it uses the hello mechanism of LACP to periodically send hello packets to ensure end-to-end communication.

If VLACP does not receive hello packets it transitions to a failure state, which indicates a service provider failure, and the port is disabled. The system sends VLACP trap messages to the management stations if the VLACP state changes. If the failure is local, the system generates only port linkdown or port linkup traps.

VLACP works for port-to-port communications only where a guarantee exists for a logical port-to-port match through the service provider.

VLACP does not work for port-to-multiport communications where no guarantee exists for a point-to-point match through the service provider.

Example:

When the enterprise networks connect the aggregated Ethernet trunk groups through a service provider network connection, far-end failures cannot be signaled with Ethernet-based functions that operate end-to-end through the service provider network. The multilink trunk (between enterprise switches S1 and S2) extends through the service provider network.

The following figure shows an MLT that operates with VLACP. VLACP can operate end-to-end, but you can also use it in a point-to-point link.

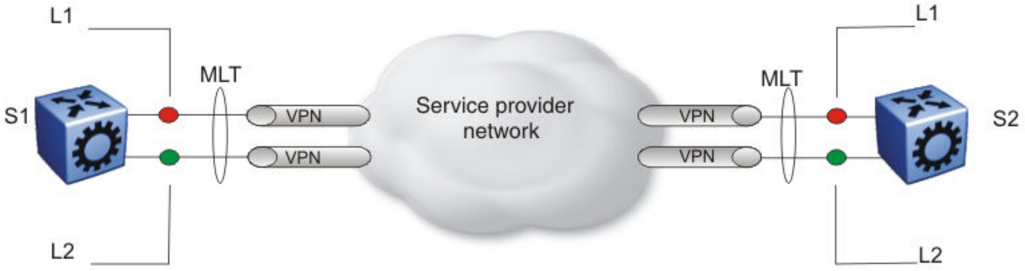


Figure 7: Problem description (1 of 2)

In the following figure, if the L2 link on S1 (S1/L2) fails, the link-down failure is not propagated over the service provider network to S2 and S2 continues to send traffic over the failed S2/L2 link.

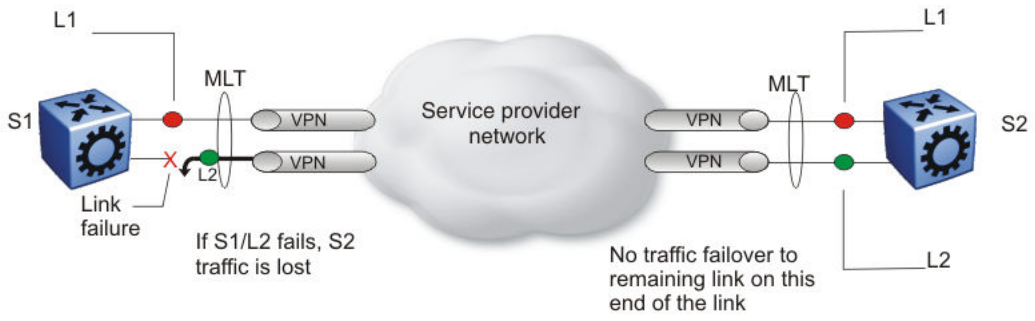

L1
MLT
S1
VPN
VPN
L2
Link failure
If S1/L2 fails, S2 traffic is lost
Service provider network
VPN
VPN
MLT
L1
S2
L2
No traffic failover to remaining link on this end of the link

Figure 8: Problem description (2 of 2)

However, if you use VLACP to detect far-end failures and allow MLT to fail over when end-to-end connectivity is not guaranteed for links in an aggregation group, VLACP prevents the failure scenario in the preceding figure.

Avaya recommends that you use the following guidelines for VLACP implementation:

- Do not use VLACP on configured LACP MLTs because LACP provides the same functionality as VLACP for link failure. Avaya Virtual Services Platform 4000 Series does not support VLACP and LACP on the same link.
- Use the following best practice standard settings for VLACP:
  - a short timer—no less than 500 milliseconds (ms)
  - a time-out scale of 5

  Tip:

  The VSP 4000 supports both faster timers and lower time-out scales, but if VLACP flapping occurs, increase the short timer and the time-out scale to their recommended values: 500 and 5, respectively. Although the software configuration supports VLACP short timers of less than 30 ms, the platform does not support using values less than 30 ms in practice. The shortest (fastest) supported VLACP timer is 30 ms with a time-out of 3, which achieves sub-100 ms failover.
- Do not configure VLACP timers to less than 100 ms if you plan to use a Layer 3 core with Equal Cost Multipath (ECMP).

  Note:

  This recommendation assumes a combination of basic Layer 2 and Layer 3 with Open Shortest Path First (OSPF). If you have more complex configurations, you can require higher timer values.
- Ensure that the VLACP configuration at the port level is consistent, that both sides of the point-to-point connection are either enabled or disabled. If a VLACP-enabled port does not receive a VLACP protocol data unit (PDU), it enters the disabled state. However, occasions exist when a VLACP-enabled port does not receive a VLACP PDU but remains in the forwarding state. You can avoid this situation with consistent port-level VLACP configuration.
- Configure VLACP on an individual port basis.

  The port can be either an individual port or an MLT member. Each VLACP-enabled port periodically sends VLACP PDUs. This action allows the exchange of VLACP PDUs from an end-to-end perspective. If a particular link does not receive VLACP PDUs, the platform shuts the link down after the expiry time-out occurs (time-out scale x periodic time). As a result of this action the ports stay in a disabled state.

MultiLink Trunking

Use MLT to provide link-layer redundancy. You can use MLT to provide alternate paths around failed links. When you configure MLT links, consider the following information:

- The device supports 24 MLT aggregation groups.
- Up to 8 ports can belong to a single MLT group.

MLT and LACP groups and port speed

Ensure that all ports that belong to the same MLT or LACP group use the same port speed, for example, 1 Gbps, even if you use Auto-Negotiation. The software does not enforce this requirement. Avaya recommends that you use Custom Auto-Negotiation Advertisement (CANA) to ensure proper speed negotiation in mixed-port-type scenarios.

To maintain Link Aggregation Group (LAG) stability during failover, use CANA: configure the advertised speed to be the same for all LACP links. For 10/100/1000 ports, ensure that CANA uses one particular setting, for example, 1000-full or 100-full. Otherwise, a remote device can restart Auto-Negotiation and the link can use a different capability.

Each port must use only one speed and duplex mode; all links in the up state are guaranteed to have the same capabilities. If you do not use Auto-Negotiation and CANA, you must use the same speed and duplex mode settings on all ports of the MLT.

Platform-to-platform MLT link recommendations

Avaya recommends that you connect physical connections in platform-to-platform MLT and link aggregation links in a specific order. To connect an MLT link between two platforms, connect the lower number port on one platform with the lower number port on the other platform. For example, to establish an MLT platform-to-platform link between ports 1/1 and 1/4 on platform A with ports 1/1 and 1/4 on platform B, do the following:

- Connect port 1/1 on platform A to port 1/1 on platform B
- Connect port 1/4 on platform A to port 1/4 on platform B

In VSP 4000, brouter ports do not support MLT. You cannot use brouter ports to connect two platforms with an MLT. An alternative is to use a Virtual Local Area Network (VLAN). This configuration option provides a routed VLAN with a single logical port or MLT. For more information about MLT configuration, see *Avaya Virtual Services Platform 4000 Series Configuration — Link Aggregation and MLT*, NN46251–503.

MLT and spanning tree protocols

The implementation of 802.1w (Rapid Spanning Tree Protocol—RSTP) and 802.1s (Multiple Spanning Tree Protocol—MSTP), provides a path cost calculation method. The following table provides the path costs associated with each interface type:

Table 15: Path cost for RSTP or MSTP mode

Link speed	Recommended path cost
Less than or equal 100 Kbps	200 000 000
1 Mbps	20 000 000
10 Mbps	2 000 000
100 Mbps	200 000
1 Gbps	20 000
10 Gbps	2000
100 Gbps	200
1 Tbps	20
10 Tbps	2

802.3ad-based link aggregation

Link aggregation provides link layer redundancy. Use IEEE 802.3ad-based link aggregation (IEEE 802.3 2002 clause 43) to aggregate one or more links together to form LAGs to allow a MAC client to treat the LAG as if it were a single link. Use link aggregation to increase aggregate throughput of the interconnection between devices and provide link redundancy. LACP can dynamically add or remove LAG ports, depending on their availability and states.

Although IEEE 802.3ad-based link aggregation and MLT provide similar services, MLT is statically defined. By contrast, IEEE 802.3ad-based link aggregation is dynamic and provides additional functionality.

LACP and MLT

When you configure standards-based link aggregation, you must enable the aggregatable parameter. This configuration creates a one-to-one mapping between the LACP aggregator and the specified MLT.

A newly created MLT or LAG adopts the VLAN membership of its member ports after the first port attaches to the aggregator associated with this LAG. After a port detaches from an aggregator, the port is deleted from the associated LAG port member list. After the last port member is deleted from the LAG, the LAG is deleted from all VLANs.

After you configure the MLT as aggregatable, you cannot add or delete ports or VLANs manually.

To enable tagging on ports that belong to a LAG, first disable LACP on the port, enable tagging on the port, and then enable LACP.

Important:

Enabling Intermediate System to Intermediate System (IS-IS) is not supported on LACP-based MLT.

LACP and spanning tree interaction

Only the physical link state or the LACP peer status affects the operation of LACP. When a link changes state between UP and DOWN, the LACP module receives notification. The spanning tree forwarding state does not affect the operation of the LACP module. LACP data units (LACPDU) can be sent even if the port is in spanning tree blocking state.

Configuration changes (such as speed and duplex mode) made to a LAG member port do not apply to all the member ports of the MLT. Instead, the changed port is removed from the LAG, and the corresponding aggregator and user is alerted.

In contrast to MLT, IEEE 802.3ad-based link aggregation does not require the system to replicate BPDUs over all ports in the trunk group.

LACP and minimum link

The minimum link function defines the minimum number of active links required for a LAG to remain in the forwarding state. You cannot configure the minimum link on VSP 4000. The minimum link value is always 1.

If the number of active links in a LAG is 0, the entire LAG is declared down and VSP 4000 informs the remote end of the LAG state by using an LACPDU.

Link aggregation group rules

Link aggregation is compatible with RSTP and MSTP. LAGs operate using the following rules:

- All ports in a LAG must operate in full-duplex mode.
- All ports in a LAG must use the same data rate.
- All ports in a LAG must be in the same VLANs.
- LAGs form using LACP.
- The platform supports a maximum of 128 LAGs.
- Each LAG supports a maximum of eight active links.

For LACP fundamentals and configuration procedures, see *Configuring Link Aggregation, MLT and SMLT on Avaya Virtual Services Platform 4000 Series*, NN46251-503.

Chapter 8: Layer 2 loop prevention

This chapter provides information about how to use bandwidth and network resources efficiently, and to prevent Layer 2 data loops.

Loop prevention and detection

In certain network designs, loops can form. For example, loops can form if you have incorrect configuration or cabling.

Avaya Virtual Services Platform 4000 Series uses Simple Loop Prevention Protocol (SLPP) as the solution to detect loops. SLPP performs the following functions:

- Detect the loop
- Automatically stop the loop
- Determine on which port the loop is occurring
- Shut down the port on which the loop is occurring

For more information about SLPP and loop detection, see *Configuring VLANs and Spanning Tree on Avaya Virtual Services Platform 4000 Series*, NN46251-500.

SLPP

Use SLPP to protect the network against Layer 2 loops. If you configure and enable SLPP, the switch sends a test packet to the VLAN. A loop is detected if the switch or a peer aggregation switch on the same VLAN receives the original packet. If the switch detects a loop, the switch disables the port. After the port is disabled, you must enable the port manually, or use port auto-enable to reenable the port after a predefined interval.

Loops can be introduced into the network in many ways. One way is through the loss of a multilink trunk configuration caused by user error or malfunction. This scenario does not introduce a broadcast storm, but because all MAC addresses are learned through the looping ports, Layer 2 MAC learning is significantly affected. Spanning tree protocols cannot always detect such a configuration issue, whereas SLPP reacts and disables the malfunctioning links, which minimizes the impact on the network.

SLPP configuration considerations and recommendations

SLPP uses an individual VLAN hello packet mechanism to detect network loops. Sending hello packets on an individual VLAN basis allows SLPP to detect VLAN-based network loops for untagged and tagged IEEE 802.1Q VLAN link configurations. You determine to which VLANs a switch sends SLPP test packets. All port members of the SLPP-enabled VLAN replicate the packets.

Use the information in this section to understand the considerations and recommendations to configure SLPP in your network:

- You must enable SLPP packet receive on each port to detect a loop.
- SLPP test packets (SLPP-PDU) are forwarded for each VLAN.
- SLPP-PDUs are automatically forwarded on VLAN ports configured for SLPP.
- The SLPP-PDU destination MAC address is the switch MAC address, with the multicast bit set; the source MAC address is the switch MAC address.

  Note:

  Avaya Virtual Services Platform 4000 Series SLPP design is different from that of Avaya Ethernet Routing Switch 8800/8600 SLPP. On the ERS 8800, the source MAC address is the switch *VLAN* MAC address.
- The SLPP-PDU is sent out as a multicast packet and is constrained to the VLAN on which it is sent.
- If an MLT port receives an SLPP-PDU, the port is removed from service.
- The originating CP receives the SLPP-PDU. All other switches treat the SLPP-PDU as a normal multicast packet, and forward it to the VLAN.
- SLPP is port-based; therefore, a port is disabled if it receives SLPP-PDU on one or more VLANs on a tagged port. For example, if the SLPP packet receive threshold is 5, a port is shut down if it receives five SLPP-PDUs from one or more VLANs on a tagged port.
- The switch does not act on SLPP packets other than on the SLPP packets that it transmits.
- For square and full-mesh configurations that use a routed core, create a separate core VLAN. Enable SLPP on the core VLAN and the square or full-mesh links between switch clusters. This configuration detects loops created in the core, and loops at the edge do not affect core ports.
- You can tune network failure behavior by selecting the number of SLPP packets that must be received before a switch takes action.

Avaya recommends the values in the following table.

Table 16: SLPP recommended values

Parameter	Configuration
Primary switch	
Packet Rx threshold	5
Transmission interval	500 milliseconds (ms) (default)
Secondary switch	
Packet Rx threshold	50
Transmission interval	500 ms (default)

VLACP

This feature provides an end-to-end failure-detection mechanism that prevents potential problems caused by misconfigurations in a switch cluster design.

Configure VLACP on an individual port basis. The system forwards traffic only across the uplinks when VLACP is operating correctly. You must configure the ports on each end of the link for

VLACP. VLACP takes the point-to-point hello mechanism of LACP and uses it to periodically send PDU packets to ensure end-to-end reachability and provide failure detection, across a Layer 2 domain. If one end of the link does not receive the VLACP PDUs, it logically disables that port and no traffic passes. This action ensures that even if no link exists on the port at the other end, and if it is not processing VLACP PDUs correctly, no traffic is sent. This function alleviates potential black hole situations by sending traffic only to ports that are functioning properly.

You can reduce VLACP timers to 400 milliseconds between two VSP 4000 systems. The timer provides approximately 1-second failure detection and switchover. When you configure VLACP, you must configure both ends of the link with the same multicast MAC address and timers. Most products in the Avaya Ethernet Switch and Ethernet Routing Switch line use the same timers, with the exception of the FastPeriodicTimer, which is 200 milliseconds on the Ethernet Routing Switch 8800, VSP 9000, and VSP 4000; and 500 milliseconds on all other switches.

SLPP example scenarios

The following examples illustrate some situations where Layer 2 loops can occur and how SLPP prevents loops in those cases.

Scenario 1: VSP 4000 as an edge router

Scenario 1 demonstrates a triangular setup with ERS 8800 switches as vIST peers, and VSP 4000 on the edge. From VSP 4000, there are four links that are part of the same MLT, with SLPP enabled on the VSP 4000 ports. Because the MLT ports are misconfigured, loops can occur. For example, port 1/1 on VSP 4000 can be part of the MLT, but on the ERS port, 2/1 is not part of the MLT, although they are on the same VLAN.

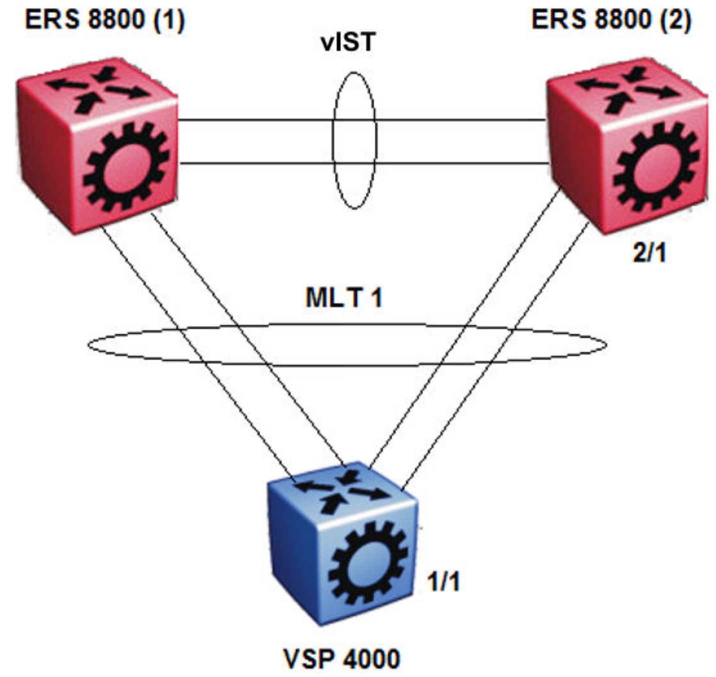


Figure 9: VSP 4000 as an edge router

SLPP PDUs are generated by VSP 4000. If there is a loop, the SLPP PDUs return to port 1/1. After the threshold value is reached, SLPP shuts the ports down.

Scenario 2: VSP 4000 as an edge router but with an additional link to the ERS 8800

Scenario 2 is similar to scenario 1 except that there is an additional link from ERS 8800 to VSP 4000 that is not part of MLT 1. The additional link is a member of the SLPP-enabled VLAN, and does not have to be directly connected from ERS 8800 to VSP 4000, but can be connected from other devices interconnected to the ERS 8800 and VSP 4000.

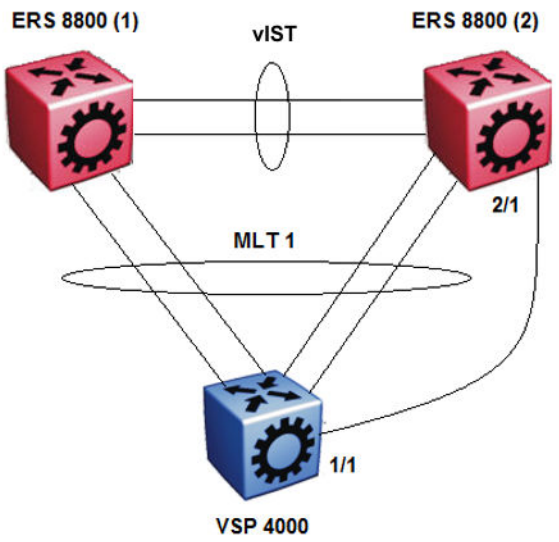


Figure 10: VSP 4000 as an edge router and with an additional link with ERS 8800

The SLPP PDUs generated by VSP 4000 return to the same device through the additional link. After the threshold value set on the SLPP-enabled ports is reached, the ports are shut down.

Scenario 3: VSP 4000 as a BEB connected to an edge router

In scenario 3, VSP 4000 acts as a Backbone Edge Bridge (BEB) and is connected to a BayStack device. SLPP is enabled on the user-network interface (UNI) ports of the VSP 4000. Because the MLT ports are misconfigured, loops can occur. For example, port 10 on BayStack is part of the MLT, but on VSP 4000 port 1/1 is not part of the MLT, but both devices are on the same VLAN.

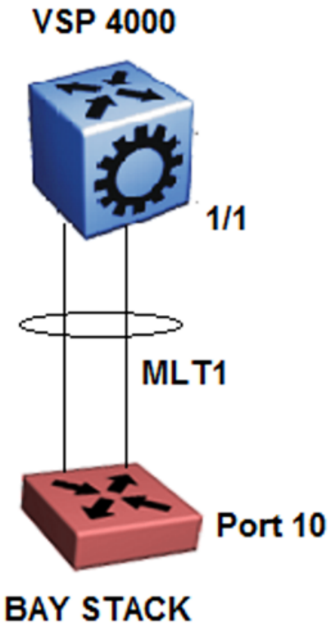


Figure 11: VSP 4000 as a BEB connected to an edge router

In this scenario, either SLPP or RSTP/MSTP can shut the ports down.

Scenario 4: Two VSP 4000 switches acting as BEBs

In scenario 4, there are two VSP 4000 devices that act as BEBs and are connected to each other through MLT, with two BayStack devices connected to each of the BEBs. The interface that connects the VSP 4000 interfaces is an Intermediate System to Intermediate System (IS-IS) interface with STP disabled. SLPP is enabled in the UNI ports of the VSP 4000. Because the link between the VSP 4000 uses IS-IS interfaces, and STP is disabled on these interfaces, STP may not be able to detect the loop.

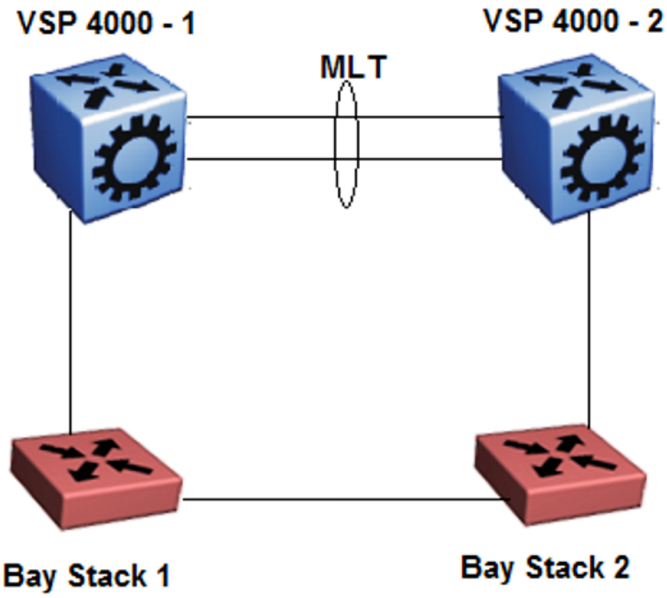


Figure 12: Two VSP 4000 switches acting as BEBs

The SLPP PDUs generated by the VSP 4000-1 return to itself through VSP 4000–2, Bay Stack 2, and Bay Stack 1. After reaching the threshold value, the SLPP shuts the port down, eliminating the loop.

Chapter 9: Layer 2 switch clustering and SMLT

Split MultiLink Trunking (SMLT) enables node redundancy by allowing aggregated link groups to be dual-homed across a pair of aggregating devices. This introduces an extra level of redundancy and failure protection. SMLT is introduced into existing subnetworks to provide this redundancy without the need to upgrade installed equipment. Bandwidth availability and network resiliency are improved by allowing all aggregation paths in a dual-homed configuration to be active and to forward traffic. In the event of a link failure, traffic failover is fast. An SMLT aggregation device pair uses a virtual interswitch trunk (vIST) to exchange information and appear as a single, logical path aggregation end point to dual-homed devices. vIST signalling protects against single points of failure such as link outages by detecting and modifying information about forwarding data paths.

The following sections describe SMLT and its implementation.

Related Links

Split MultiLink Trunk configuration on page 50

Split MultiLink Trunk configuration

SMLT improves Layer 2 resiliency by providing switch failure redundancy with subsecond failover in addition to standard MLT link failure protection and flexible bandwidth scaling functionality. Use SMLT to connect a device that supports link aggregation to two distinct SMLT endpoints to form a triangle. These SMLT switches form a switch cluster and are referred to as an vIST core switch pair.

Switch clusters are always formed as a pair but you can combine pairs of clusters in either a square or full-mesh fashion to increase the size and port density of the switch cluster.

SMLT and VLACP

Avaya recommends the use of Virtual Link Aggregation Control Protocol (VLACP) for all SMLT access links configured as MultiLink Trunks to ensure both end devices can communicate. Virtual Services Platform 4000 does not support LACP and VLACP on the same links simultaneously.

VLACP for SMLT also protects against CPU failures by causing traffic to switch or reroute to the SMLT peer if the CPU fails or stops responding.

The following table provides the recommended values for VLACP in an SMLT environment:

Table 17: Recommended VLACP values

Parameter	Value
SMLT access	
Timeout	Short
Timer	500ms
Timeout scale	5
VLACP MAC	01:80:C2:00:00:0F
SMLT core	
Timeout	Short
Timer	500ms
Timeout scale	5
VLACP MAC	01:80:C2:00:00:0F
vIST	
Timeout	Long
Timer	10000
Timeout scale	3
VLACP MAC	01:80:C2:00:00:0F

SMLT and loop prevention

SMLT-based network designs form physical loops for redundancy that logically do not function as loops. Under certain adverse conditions, loops can form, for example, if you use incorrect configurations or cabling.

The solution to detect loops is Simple Loop Prevention Protocol (SLPP). SLPP detects a loop and automatically stops the loop. SLPP determines on which port the loop occurs, and shuts down that port.

SMLT and Layer 3 traffic redundancy (VRRP and RSMLT)

VLANs that are part of an SMLT network can be routed on SMLT aggregation switches. Routing VLANs enables the SMLT edge network to connect to other Layer 3 networks. Virtual Router Redundancy Protocol (VRRP), which provides redundant default gateway configurations, additionally has BackupMaster capability. BackupMaster improves the Layer 3 capabilities of VRRP operating in conjunction with SMLT. Use a VRRP BackupMaster configuration with an SMLT configuration that currently uses VRRP.

Important:

Avaya strongly recommends using Routed SMLT (RSMLT) Layer 2 Edge configuration as a better alternative to SMLT with VRRP BackupMaster. Unless it is specifically required, use an RSMLT configuration.

RSMLT Layer 2 Edge configurations provide:

- Greater scalability — RSMLT scales to the maximum number of VLANs, while VRRP scales to 255 for each VRF and 512 for each system. VRRP IDs 1-255 are unique to each VLAN.

- Simpler configuration — A Routed SMLT Layer 2 Edge configuration only requires enabling RSMLT on a VLAN. VRRP requires virtual IP configuration along with other parameters.

For connections in pure Layer 3 configurations using a static or dynamic routing protocol, use a Layer 3 RSMLT configuration instead of SMLT with VRRP. RSMLT configuration provides faster failover than VRRP.

Important:

In an SMLT-VRRP environment that uses VRRP critical IP within both vIST core switches, routing between directly connected subnets ceases to work when connections from each of the switches to the exit router (the critical IP) fail. Do not configure VRRP critical IPs within SMLT or RSMLT environments because SMLT operation automatically provides the same level of redundancy.

Do not use VRRP BackupMaster and critical IP at the same time; use one or the other. Do not use VRRP in RSMLT environments.

The VRRP Master typically forwards traffic for a given subnet. Use BackupMaster on the SMLT aggregation switch with a destination routing table entry and the Backup VRRP switch also routes traffic. The VRRP BackupMaster uses the VRRP standardized backup switch state machine. This makes the VRRP BackupMaster compatible with standard VRRP. This capability prevents the traffic from edge switches from unnecessarily utilizing the vIST to deliver frames destined for a default gateway. In a traditional VRRP implementation, this operates only on one of the aggregation switches.

The BackupMaster switch routes all traffic received on the BackupMaster IP interface according to the switch routing table. The BackupMaster switch does not perform Layer 2 switching for the traffic to the VRRP Master.

Ensure that both SMLT aggregation switches can reach the same destinations using a given routing protocol. Configure individual VLAN IP addresses on both SMLT aggregation switches for routing purposes. Introduce an additional subnet on the vIST that has a shortest-route path to avoid issuing Internet Control Message Protocol (ICMP) redirect messages on the VRRP subnets. To reach the destination, ICMP redirect messages are issued if the router sends a packet back out through the same subnet on which it is received.

SMLT and IEEE 802.3ad interaction

Virtual Services Platform 4000 fully supports IEEE 802.3ad LACP on MLT and distributed MLT links. On a pair of SMLT switches:

- MLT peer and SMLT client devices can be network switches, a server, or a workstation that supports link bundling through IEEE 802.3ad.
- Multilink SMLT solutions support dual-homed connectivity for more than 350 attached devices, which allow dual-homed server farm solutions.

Only dual-homed devices benefit from LACP and SMLT interactivity.

SMLT and IEEE link aggregation supports all known SMLT scenarios where an IEEE 802.3ad SMLT pair can connect to SMLT clients or where two IEEE 802.3ad SMLT pairs can connect to each other in a square or full-mesh topology.

Known SMLT and LACP failure scenarios include

- wrong ports connected
- LACP is disabled on the SMLT edge switch

SMLT aggregation switches detect that aggregation is disabled on the SMLT client, thus no automatic link aggregation establishes until the configuration is resolved.

- Single CPU failure

  In this case, LACP on other switches detects the remote failure, and all links that connect to the failed system are removed from the link aggregation group. This process allows failure recovery to a different network path.

- LACP and VLACP cannot run on the same interfaces simultaneously.

SMLT and LACP System ID

The LACP SMLT System ID used by SMLT core aggregation switches is configurable. Configure the LACP SMLT system ID to be the base MAC address of one of the aggregate switches and include the SMLT-ID. Ensure that the same System ID is configured on both of the SMLT core aggregation switches.

The LACP System ID is the base MAC address of the switch, which is carried in Link Aggregation Control Protocol Data Units (LACPDU). When two links interconnect two switches running LACP, each switch is aware both links connect to the same remote device because the LACPDUs originate from the same System ID. If the links are enabled for aggregation using the same key, LACP can dynamically aggregate them into a LAG (MLT).

When SMLT is used between the two switches, they act as one logical device. Both aggregation switches must use the same LACP System ID over the SMLT links. This ensures the edge switch sees one logical LACP peer, and can aggregate uplinks towards the SMLT aggregation switches. This process automatically occurs over the vIST connection, where the base MAC address of one of the SMLT aggregation switches is chosen and used by both SMLT aggregation switches.

If the switch that owns that Base MAC address reboots, the vIST is no longer operational and the other switch reverts to using its own Base MAC address as the LACP System ID. This action causes all edge switches that run LACP to think their links are connected to a different switch. The edge switches stop forwarding traffic on their remaining uplinks until the aggregation can reform. Aggregation reformation can take several seconds. When the rebooted switch comes back online, the same actions occur and disrupt traffic twice. The solution to this situation is to statically configure the same SMLT System ID MAC address on both aggregation switches.

For more information about how to configure the LACP SMLT system ID, see *Configuring Link Aggregation, MLT, and SMLT on Avaya Virtual Services Platform 9000,* NN46250-503.

Related Links

Layer 2 switch clustering and SMLT on page 50

Chapter 10: Layer 3 switch clustering and RSMLT

This section describes designs for achieving network redundancy. Network redundancy minimizes failure and ensures a faulty switch does not interrupt service.

Related Links

Routed SMLT on page 54

Switch clustering topologies and interoperability with other products on page 61

Routed SMLT

Core network convergence time usually depends on the length of time a routing protocol requires to successfully converge. This convergence time can cause network interruptions that range from seconds to minutes depending on the specific routing protocol. Routed Split Multilink Trunking (RSMLT) allows rapid failover for core topologies by providing an active-active router concept to core SMLT networks. Virtual Services Platform 4000 supports RSMLT on SMLT triangles, squares, and SMLT full-mesh topologies that have routing enabled on the core VLANs. RSMLT provides redundancy as well. If a core router fails, RSMLT provides packet forwarding. This eliminates dropped packets during convergence.

Virtual Services Platform 4000 can use one of the following routing protocols to provide convergence:

- IP or IPv6 unicast static routes
- Routing Information Protocol version 1 (RIPv1) or version 2 (RIPv2) (IPv4)
- Open Shortest Path First (OSPF) and OSPFv3
- Border Gateway Protocol (BGP) (IPv4) and BGP+

SMLT and RSMLT operation

SMLT and RSMLT in Layer 2 and 3 environments on page 55 shows a typical redundant network with user aggregation, core, and server access layers. To minimize the creation of many IP subnets, one VLAN (VLAN 1, IP subnet A) spans all wiring closets. SMLT provides loop prevention and enables all links to forward to VLAN 1, IP Subnet A. RSMLT runs on the core.

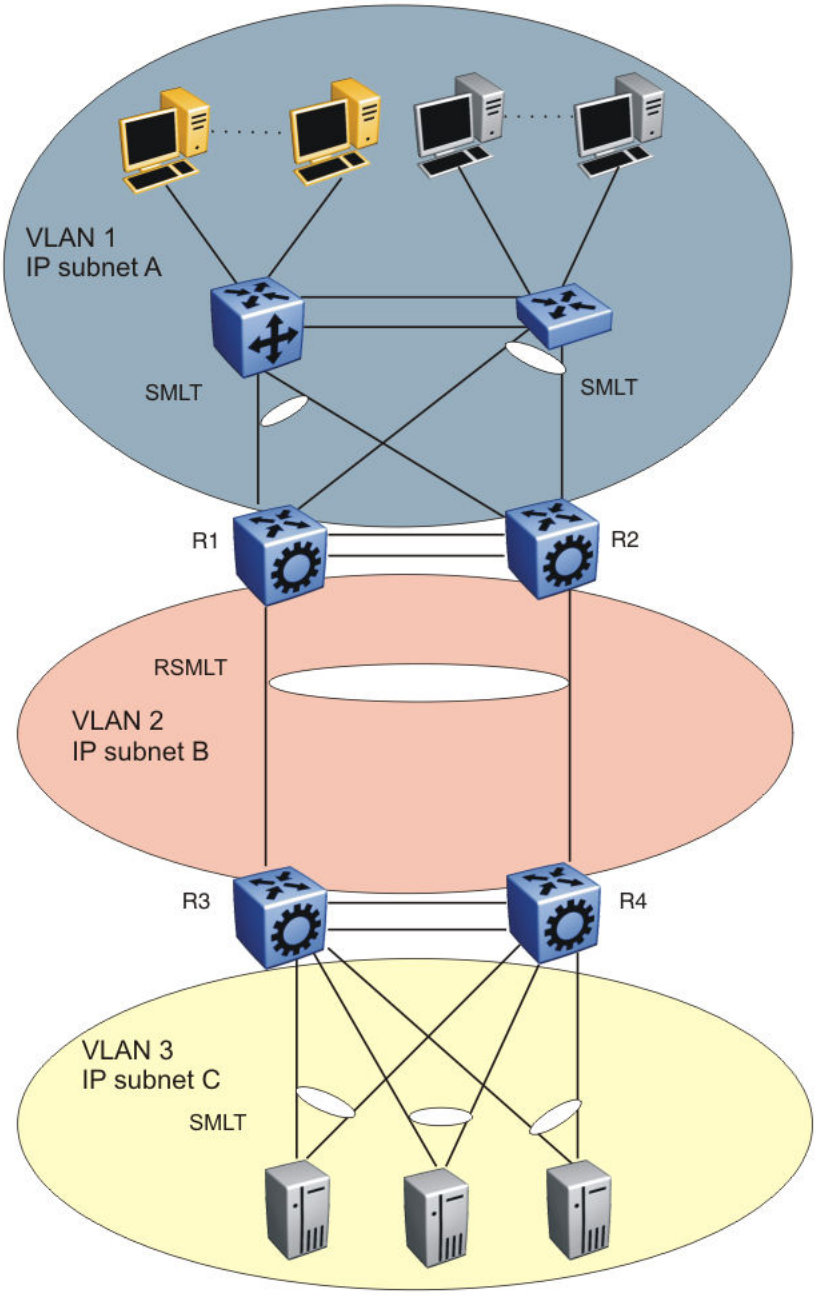


Figure 13: SMLT and RSMLT in Layer 2 and 3 environments

The aggregation layer switches are routing-enabled and provide active-active default gateway functions through RSMLT. Routers R1 and R2 forward traffic for IP subnet A. RSMLT provides both router and link failover. If the SMLT link between R2 and R4 breaks, the traffic fails over to R1.

For IP subnet A, Virtual Router Redundancy Protocol (VRRP) Backup-Master can provide the same functions as RSMLT, as long as an additional router is not connected to IP subnet A. In large scale environments, for example, more than 64 VRRP instances, Avaya recommends that you use RSMLT with RSMLT edge instead of VRRP.

RSMLT provides superior router redundancy in core networks (for example, IP subnet B) in which OSPF is used. Routers R1 and R2 provide router backup for each other—not only for the edge IP subnet A but also for the core IP subnet B. Similarly, routers R3 and R4 provide router redundancy for IP subnet C and also for core IP subnet B.

RSMLT router failure and recovery

This section describes the failure and recovery of router R1 in SMLT and RSMLT in Layer 2 and 3 environments on page 55.

R3 and R4 both use R1 as their next-hop to reach IP subnet A. Even though R4 sends packets to R2, these packets are routed directly to subnet A at R2. R3 sends packets towards R1; these packets are also sent directly to subnet A. After R1 fails, with the help of SMLT, all packets are directed to R2. R2 provides routing for R2 and R1.

After OSPF converges, R3 and R4 change their next-hop to R2 to reach IP subnet A. You can configure the hold-up timer (that is, the amount of time R2 routes for R1 in the event of failure) to a time period greater than the routing protocol convergence or to indefinite (that is, the pair always routes for each other). Avaya recommends that you configure the hold up and hold down timer to 1.5 times the convergence time of the network.

In an application where you use RSMLT at the edge instead of VRRP, Avaya recommends that you configure the hold-up timer value to indefinite.

After R1 restarts after a failure, it first becomes active as a VLAN bridge. Using the bridge forwarding table, packets destined to R1 are switched to R2 for as long as the hold-down timer value. These packets are routed at R2 for R1. Like VRRP, to converge routing tables, the hold-down timer value needs to be greater than the one required by the routing protocol.

After the hold-down time expires and the routing tables have converged, R1 starts routing packets for itself and also for R2. Therefore, it does not matter which one of the two routers is used as the next-hop from R3 and R4 to reach IP subnet A.

If you configure single-homed IP subnets on R1 or R2, Avaya recommends that you add another routed VLAN to the virtual interswitch trunks (vIST). As a traversal VLAN or subnet, this additional routed VLAN needs lower routing protocol metrics to avoid unnecessary Internet Control Message Protocol (ICMP) redirect generation messages. This recommendation also applies to VRRP implementations.

RSMLT guidelines

Use the following guidelines when you create RSMLT configurations:

- RSMLT is based on SMLT so all SMLT configuration rules apply. Enable RSMLT on the SMLT aggregation switches on an individual VLAN basis. The VLAN must be a member of SMLT links and the vIST trunk.
- The VLAN must be routable (IP address configured). On all four routers in a square or full-mesh topology, configure an Interior Routing Protocol, such as OSPF, although the protocol is independent from RSMLT.
- Routing protocols and static routes can be used with RSMLT.
- RSMLT pair switches provide backup for each other. As long as one of the two routers in an vIST pair is active, traffic forwarding is available for both next-hops.

For design examples using RSMLT, see the following sections.

RSMLT timer tuning

RSMLT enables a participating peer switch to act as a router for its peer by MAC address. This doubles router capacity and enables fast failover in the event of a peer switch failure. RSMLT provides hold-up and hold-down timer parameters to aid these functions.

The hold-up timer defines the length of time the RSMLT-peer switch routes for its peer after a peer switch failure. Configure the hold-up timer to at least 1.5 times greater than the routing protocol convergence time.

The RSMLT hold-down timer defines the length of time that the recovering switch remains in a non-Layer 3 forwarding mode for the MAC address of its peer. Configure the hold-down timer to at least 1.5 times greater than the routing protocol convergence time. The configuration of the hold-down timer gives RIP, OSPF or BGP time to build up the routing table before Layer 3 forwarding for the peer router MAC address begins again.

Important:

When using a Layer 3 SMLT client switch without a routing protocol, configure two static routes to point to both RSMLT switches or configure one static route. Configure the RSMLT hold-up timer to 9999 (infinity). Also configure the RSMLT hold-up timer to 9999 (infinity) for RSMLT Edge (Layer 2 RSMLT).

IPv6 differences

The following list identifies ways in which the IPv6 implementation of RSMLT differs from the IPv4 implementation of RSMLT.

- After the switch begins to forward traffic on behalf of the peer, duplicate address detection (DAD) is not executed for the IPv6 address of the peer. The implementation assumes that the peer IPv6 address is already known to be unique.
- An RSMLT switch installs a neighbor entry for the peer IPv6 address immediately after the peer disappearance is detected, possibly while a route for the peer still exists. This action can result in packets destined to the peer IPv6 address being delivered to the CP for a short period of time.
- You can not configure a vIST with IPv6 peer address
- In a dual-stack VLAN, adding or deleting IPv4 or IPv6 does not affect the RSMLT functionality of one another. If you add IPv4 or IPv6 to an existing IPv6 or IPv4 RSMLT VLAN, the RSMLT state for the protocol you add second will be the same as the previous RSMLT state.

Example: RSMLT redundant network with bridged and routed edge VLANs

Many Enterprise networks require the support of VLANs that span multiple wiring closets. VLANs are often local to wiring closets and routed towards the core. The following figure shows VLAN-10, which has all IP Deskphones as members and resides everywhere, while at the same time VLANs 20 and 30 are user VLANs that are routed through VLAN-40.

A combination of SMLT and RSMLT provide sub-second failover for all VLANs bridged or routed. VLAN-40 is RSMLT enabled that provides for the required redundancy. You can use unicast routing protocols—such as RIP, OSPF, or BGP—and routing convergence times do not impact the network convergence time provided by RSMLT.

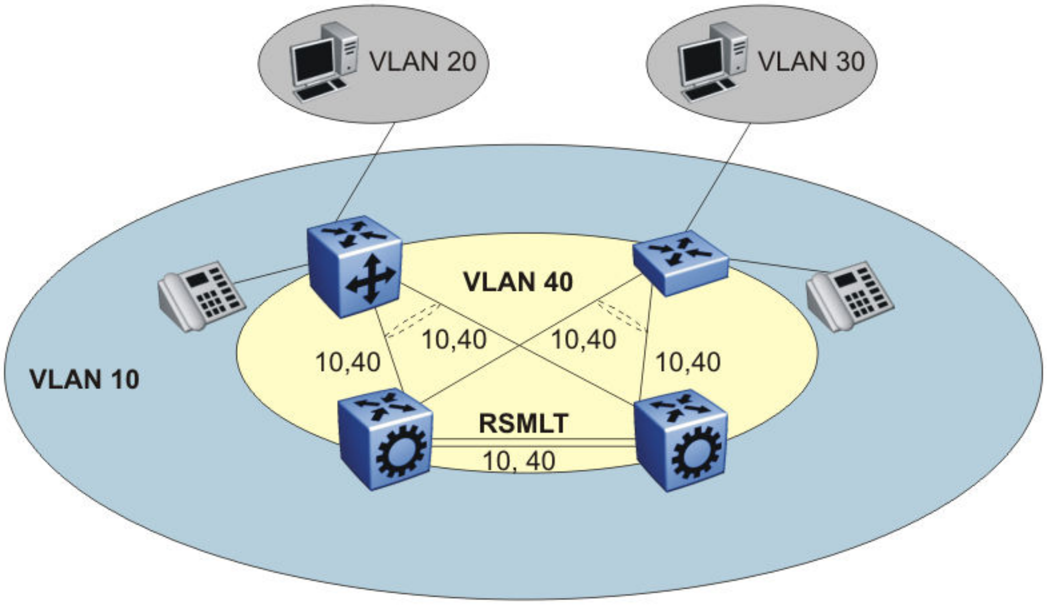


Figure 14: VLAN with all IP Deskphones as members

Example: RSMLT network with static routes at the access layer

Use default routes that point towards the RSMLT IP interfaces of the aggregation layer to achieve a robust redundant edge design, as shown in the following figure.

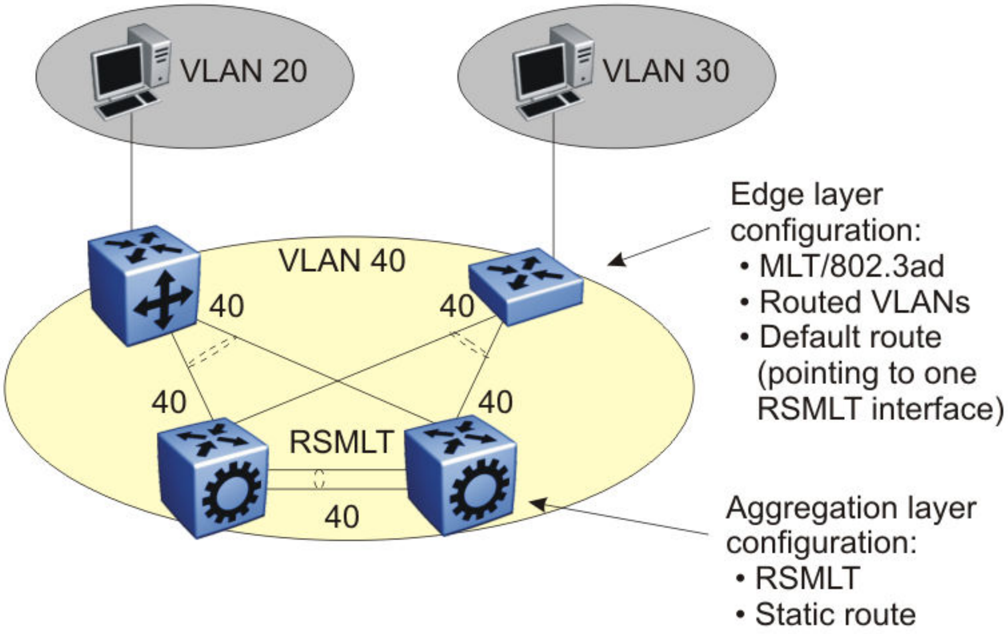

VLAN 20
VLAN 30
VLAN 40
40
40
40
40
RSMLT
40
Edge layer configuration:
• MLT/802.3ad
• Routed VLANs
• Default route (pointing to one RSMLT interface)
Aggregation layer configuration:
• RSMLT
• Static route

Figure 15: VLAN edge configuration

Example: RSMLT IPv6 network topology

The following figure shows a sample IPv6 RSMLT topology. The figure shows a typical redundant network example with user aggregation, core, and server access layers. To minimize the creation of many IPv6 prefixes, one VLAN (VLAN 1, IP prefix A) spans all wiring closets. RSMLT provides the loop-free topology. The aggregation layer switches are configured with routing enabled and provide active-active default gateway functionality through RSMLT.

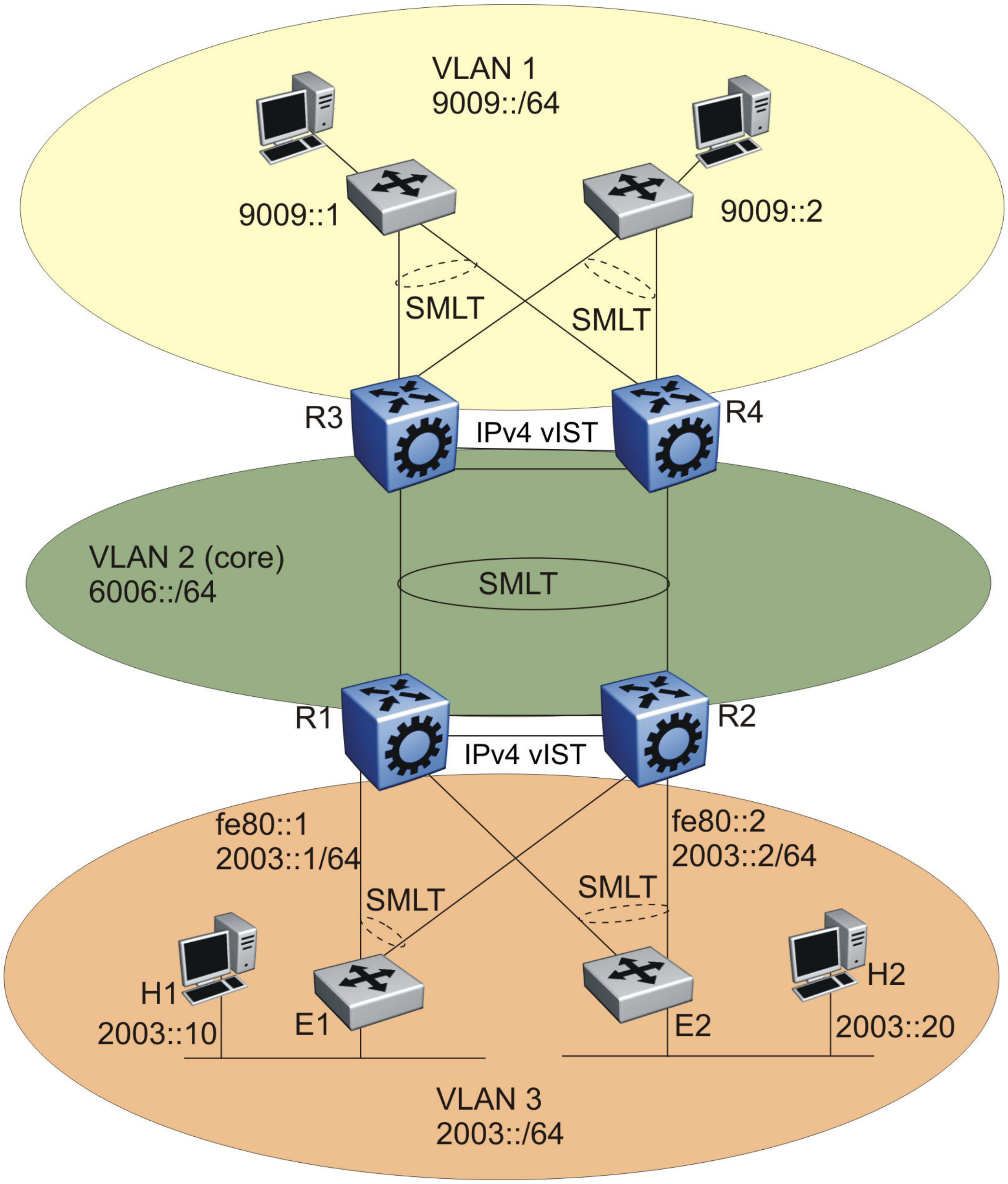


Figure 16: IPv6 RSMLT topology

In VLAN 3 of the preceding figure, routers R1 and R2 provide RSMLT-enabled IPv6 service to hosts H1 and H2. Router R1 is the default IPv6 router for H1 and R2 is the default router for H2. R1 uses the following configuration:

- link-local address of fe80::1
- global unicast address 2003::1

- routing prefix of 2003::/64

As a shorthand, the last two items in the preceding list are referred to as 2003::1/64.

R2 uses the following configuration:

- link-local address of fe80::1
- global unicast address and routing prefix if routing prefix of 2003::2/64.

Host H1 sends IPv6 traffic destined to VLAN 1 to the MAC address for R1. H2 sends traffic to the MAC address for R2. After an IPv6 packet destined to the MAC address of R1 is received at R2 on its SMLT links (the expected MLT behavior), R2 performs IPv6 forwarding on the packet and does not bridge it over the vIST. The same behavior occurs on R1.

At startup, R1 and R2 use the vIST link to exchange full configuration information that includes the MAC address for the IPv6 interfaces that reside on SMLT VLAN 3.

After R2 detects that the RSMLT in R1 transitions to the down state (for example, if R1 itself is down, the SMLT links are down, or the vIST link is down) R2 takes over IPv6 termination and IPv6 neighbor discovery on behalf of the IPv6 SMLT interface on R1. The following list shows the order of action in this situation:

1. After R2 detects the event, it transmits an unsolicited IPv6 neighbor advertisement for each IPv6 address configured on the SMLT link of R1 using the R1 MAC address (fe80::1 and 2003::1 in this example).
2. R2 transmits an unsolicited router advertisement for each of the R1 routing prefixes (unless the prefixes are configured as not advertised).
3. R2 responds to neighbor solicitations and, if the configuration allows, router advertisements on behalf of R1.
4. R2 terminates IPv6 traffic (such as ping requests) destined to the R1 SMLT IPv6 addresses.

After R1 RSMLT transitions back into the up state and the hold-down timer expires, R1 resumes IPv6 forwarding and R2 ceases to terminate IPv6 traffic on behalf of R1.

IPv6 provides a rich set of configuration options to advertise IPv6 routing prefixes (equivalent to IPv4 subnets) and to configure hosts on a link. You can configure a prefix to be or not be advertised, and to carry various flags or lifetime values. These parameters affect how hosts can automatically configure their IPv6 addresses and select their default routers. Most relevant from the RSMLT perspective is that an RSMLT node fully impersonates the peer IPv6 configuration and behavior on the SMLT link. The preceding network example illustrates one of the many possible deployment scenarios for IPv6 routers and hosts on a VLAN.

RSMLT provides both router failover and link failover. For example, if the SMLT link between R2 and R4 is broken, the traffic fails over to R1 as well.

Related Links

Layer 3 switch clustering and RSMLT on page 54

Switch clustering topologies and interoperability with other products

The switch clustering, unicast routing, and multicast routing configurations vary with switch type when using Ethernet Routing Switch products with Avaya Virtual Services Platform 4000. Use the supported topologies and features when you perform inter-product switch clustering. For more information see *Switch Clustering (SMLT/SLT/RSMLT/MSMLT) Supported Topologies and Interoperability with ERS 8800 / 5500 / 8300 / 1600*, NN48500-555. For specific design and configuration parameters see *The Large Campus Technical Solution Guide*, NN48500-575 and *Switch Clustering using Split-Multilink Trunking (SMLT) Technical Configuration Guide*, NN48500-518.

Related Links

Layer 3 switch clustering and RSMLT on page 54

Chapter 11: Layer 3 switch clustering and multicast SMLT

Switch clustering is the logical aggregation of two nodes to form one logical entity known as the switch cluster. The two peer nodes in a switch cluster connect using a virtual interswitch trunk (vIST). The vIST exchanges forwarding and routing information between the two peer nodes in the cluster. This section provides guidelines for switch clusters that use multicast and Split Multilink Trunking (SMLT).

Related Links

General guidelines on page 62
Multicast triangle topology on page 64
Square and full-mesh topology multicast guidelines on page 66
SMLT and multicast traffic issues on page 69

General guidelines

The following list identifies general guidelines to follow if you use multicast and switch clustering:

- Enable Protocol Independent Multicast - Sparse Mode (PIM-SM) on the vIST VLAN for fast recovery of multicast. A unicast routing protocol is not required.
- Enable Internet Group Management Protocol (IGMP) snooping and proxy on the edge switches.

The following figure shows multicast behavior in an SMLT environment. The configuration in the following figure provides fast failover if the switch or rendezvous point (RP) fails.

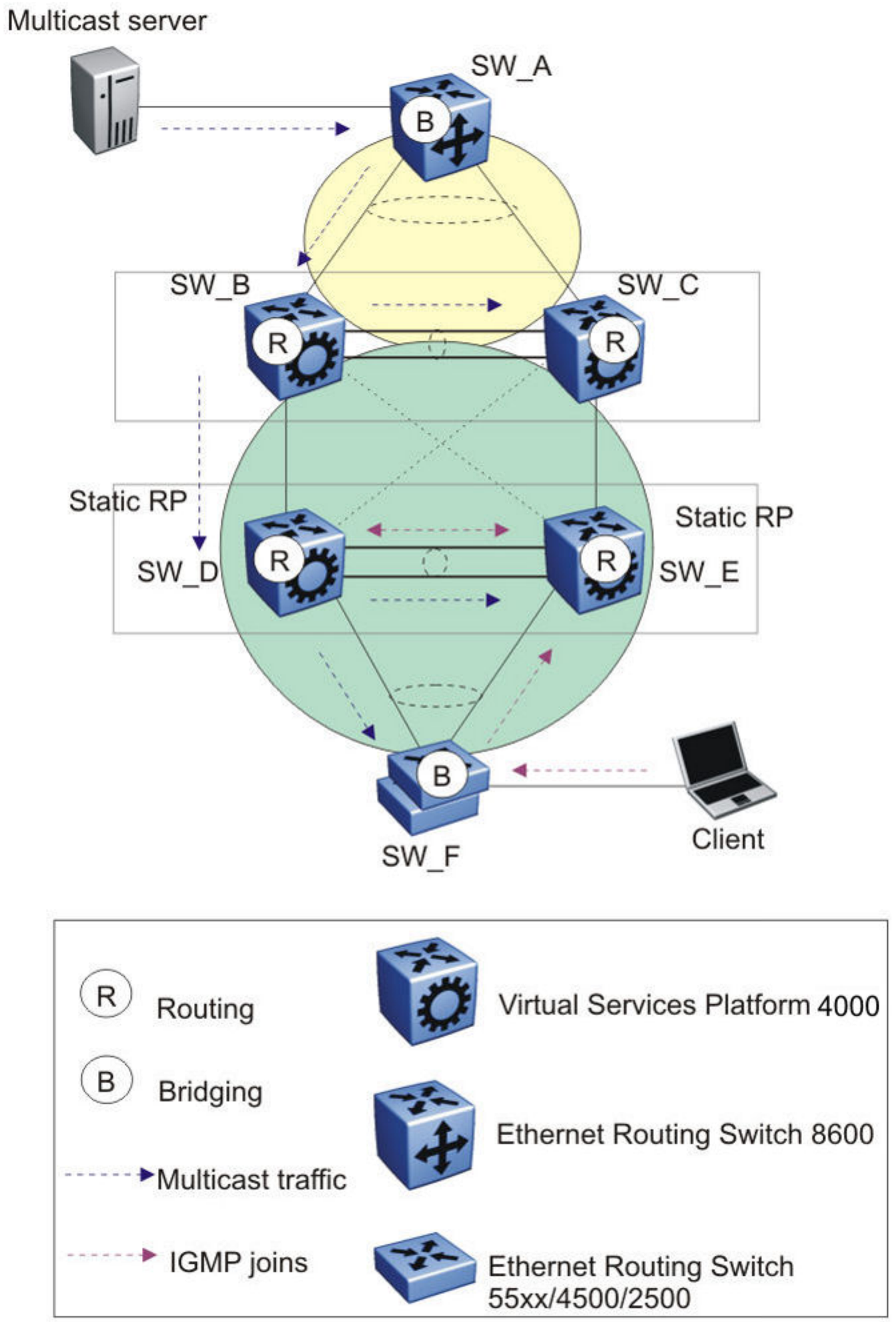


Figure 17: Multicast behavior in SMLT environment

In Multicast behavior in SMLT environment on page 63 the following actions occur:

1. The multicast server sends multicast data towards the source designated router (DR).
2. The source DR sends register messages with encapsulated multicast data towards the RP.
3. After the client sends IGMP membership reports towards the multicast router, the router creates a (*,G) entry.

4. The RP sends join messages towards the source DR on the reverse path.
5. After the source DR receives the join messages, it sends native multicast traffic.
6. After SW_B or SW_D receives multicast traffic from upstream, it forwards the traffic on the vIST as well as on the SMLT link. Other aggregation switches drop multicast traffic received over the vIST at egress. This action provides fast failover for multicast traffic. Both SW_D and SW_E (Aggregation switches) have similar (S,G) records.
7. In case of SW_D or RP failure, SW_B changes only the next-hop interface towards SW_E. Because the circuitless IP (CLIP) RP address is the same, SW_B does not flush (S,G) entries and achieves fast failover.

Related Links

Layer 3 switch clustering and multicast SMLT on page 62

Multicast triangle topology

A triangle design is an SMLT configuration that connects edge switches or SMLT clients to two aggregation switches. Connect the aggregation switches together with a vIST that carries all the SMLT trunks configured on the switches.

Virtual Services Platform 4000 supports the following triangle configurations:

- a configuration with Layer 3 PIM-SM routing on both the edge and aggregation switches
- a configuration with Layer 2 snooping on the client switches and Layer 3 routing with PIM-SM on the aggregation switches

To avoid using an external query device to provide correct handling and routing of multicast traffic to the rest of the network, use the triangle design with IGMP Snoop at the client switches. Use multicast routing at the aggregation switches as shown in the following figure.

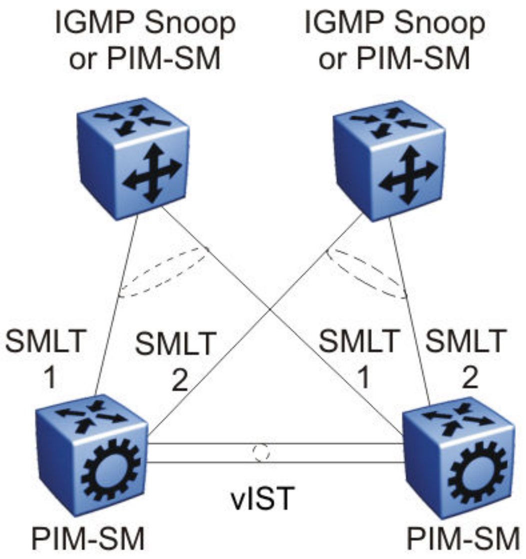


Figure 18: Multicast routing using PIM-SM

Client switches run IGMP Snoop or PIM-SM, and the aggregation switches run PIM-SM. This design is simple and, for the rest of the network, PIM-SM performs IP multicast routing. The aggregation switches are the query devices for IGMP, so an external query device is not required to activate IGMP membership. These switches also act as redundant switches for IP multicast.

Multicast data flows through the vIST link when receivers are learned on the client switch and senders are located on the aggregation switches, or when sourced data comes through the aggregation switches. This data is destined for potential receivers attached to the other side of the vIST. The data does not reach the client switches through the two aggregation switches because only the originating switch forwards the data to the client switch receivers.

Note:

Always place multicast receivers and senders on the core switches on VLANs different from those that span the vIST.

The following figure shows a switch clustering configuration with a single switch cluster core and dual-connected edge devices. This topology represents different VLANs spanning from each edge device and those VLANs routed at the switch cluster core. You can configure multiple VLANs on the edge devices, 802.1Q tagged to the switch cluster core.

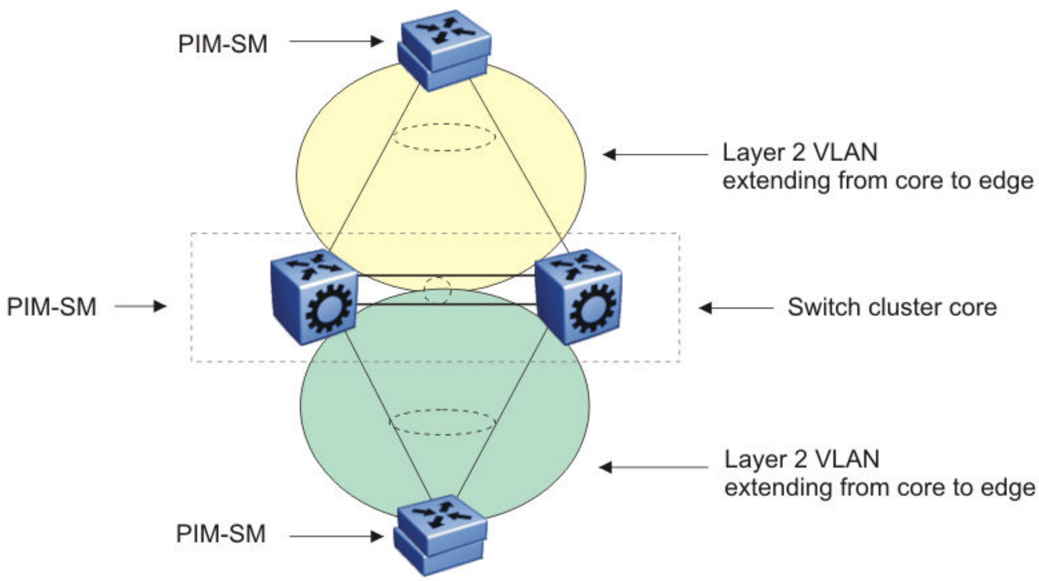

PIM-SM
Layer 2 VLAN extending from core to edge
PIM-SM
Switch cluster core
Layer 2 VLAN extending from core to edge
PIM-SM

Figure 19: Multicast SMLT triangle

Use an edge device that supports a form of link aggregation. Disable spanning tree on the link aggregation group on the edge devices. Enable either Virtual Router Redundancy Protocol (VRRP) BackupMaster or Routed SMLT (RSMLT) Layer 2 Edge on the switch cluster core.

Related Links

Layer 3 switch clustering and multicast SMLT on page 62

Square and full-mesh topology multicast guidelines

A square design connects a pair of aggregation switches to another pair of aggregation switches. A square design becomes a full-mesh design if the aggregation switches are connected in a full-mesh. Virtual Services Platform 4000 supports Layer 3 IP multicast (PIM-SM only) over a full-mesh SMLT or RSMLT configuration.

In a square design, configure all switches with PIM-SM. Place the bootstrap router (BSR) and RP in one of the four core switches; Avaya recommends that you place the RP closest to the source. If using PIM-SM over a square or full-mesh configuration, enable the **`multicast smlt-square`** flag.

The following three figures show switch clustering configurations with two-switch cluster cores and dual-connected edge devices.

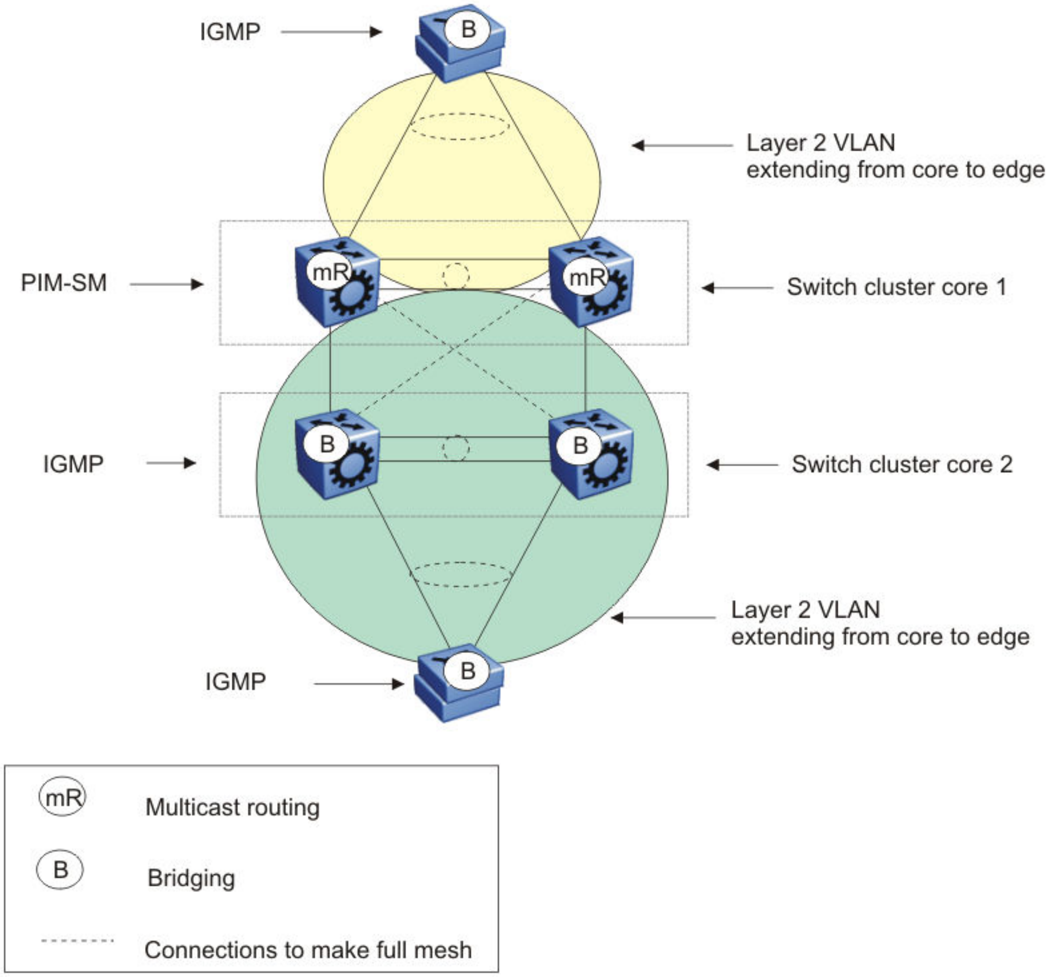


Figure 20: Multicast SMLT square 1

In the preceding figure, only one of the switch cluster cores performs Layer 3 multicast routing while the other is strictly Layer 2. Configure multiple VLANs on the edge devices, 802.1Q tagged to the switch cluster cores.

Use an edge device that supports a form of link aggregation. Disable spanning tree on the link aggregation group on the edge devices. Enable either the VRRP BackupMaster or RSMLT Layer 2 Edge on the switch cluster core.

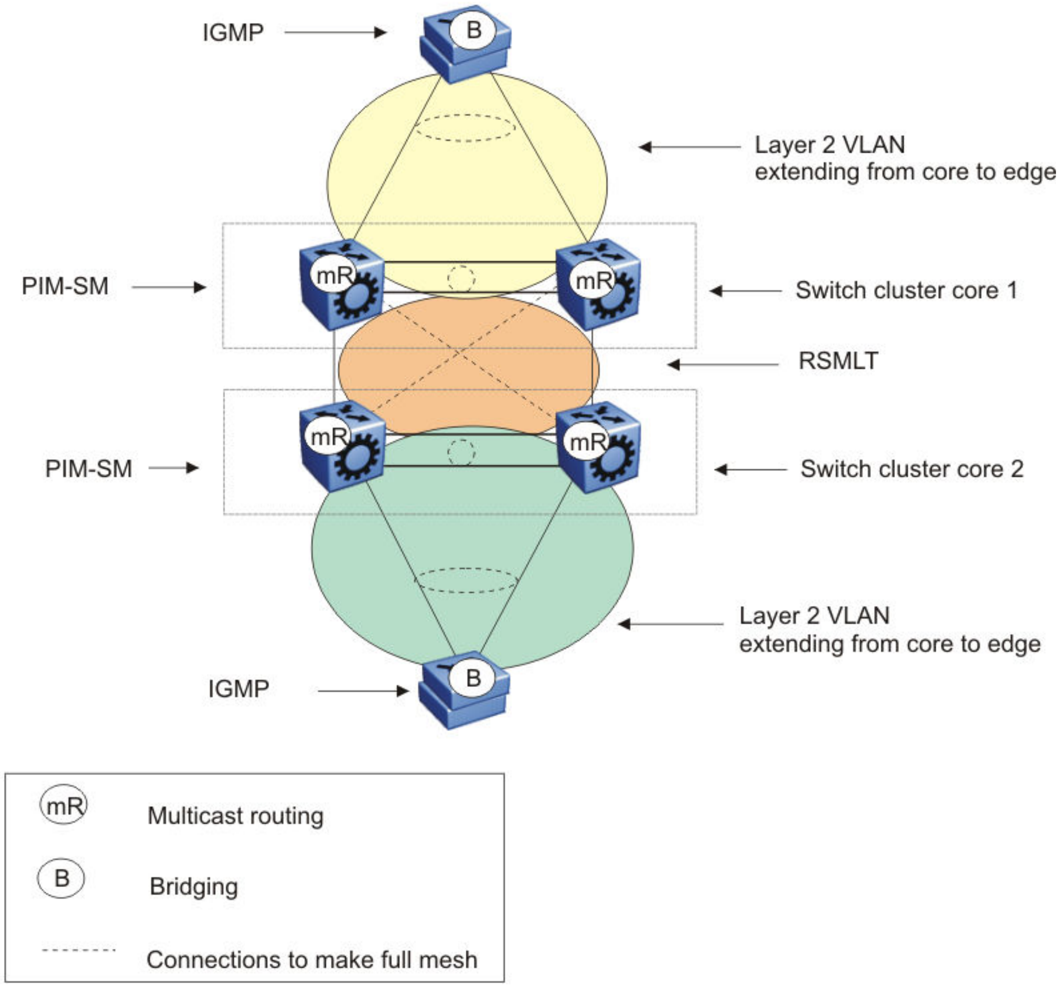


Figure 21: Multicast SMLT square 2

In the preceding figure, both of the switch cluster cores performs Layer 3 multicast routing, while the edge devices are Layer 2 IGMP.

Use an edge device that supports a form of link aggregation. Disable spanning tree on the link aggregation group on the edge devices. Enable either the VRRP BackupMaster or RSMLT Layer 2 Edge on the switch cluster cores. Do not enable VRRP on the RSMLT VLAN between switch cluster cores.

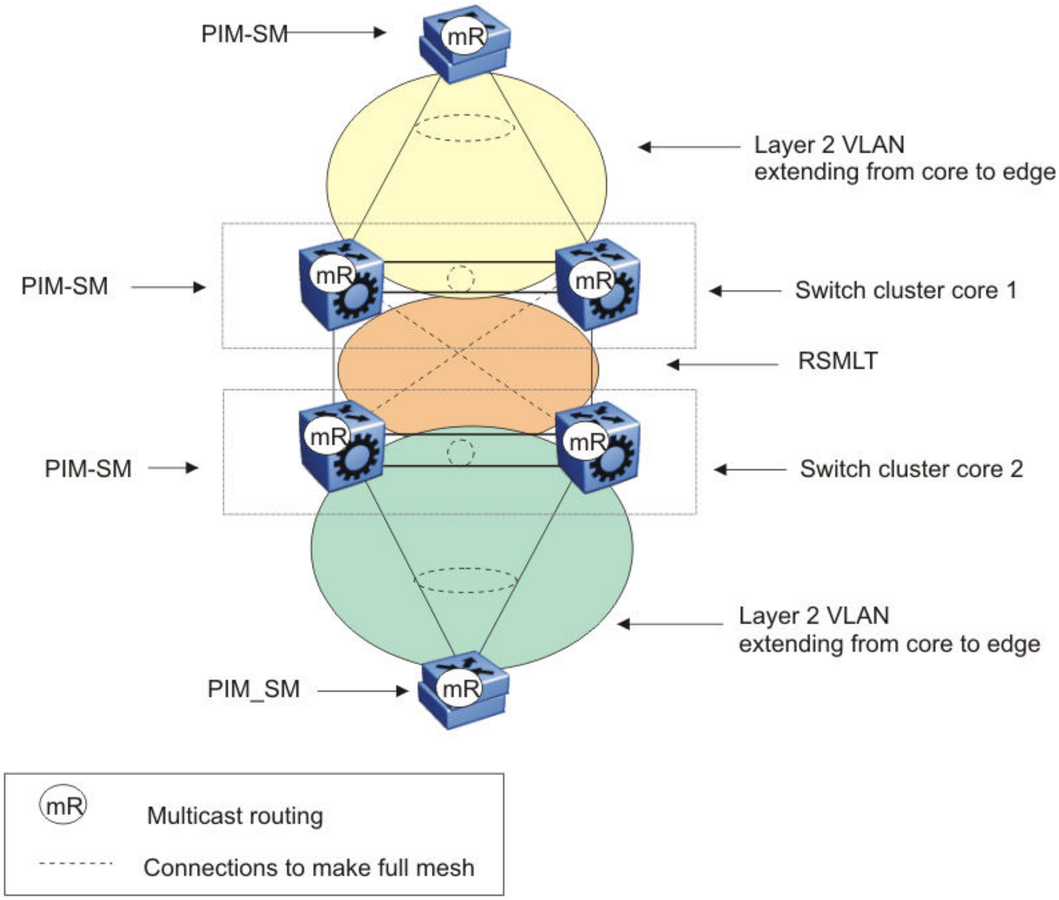


Figure 22: Multicast SMLT square 3

In the preceding figure, both of the switch cluster cores and the edge devices perform Layer 3 multicast routing.

Use an edge device that supports a form of link aggregation. Disable spanning tree on the link aggregation group on the edge devices. Enable either the VRRP BackupMaster or RSMLT Layer 2 Edge on the switch cluster cores. Do not enable VRRP on the RSMLT VLAN between switch cluster cores.

Related Links

Layer 3 switch clustering and multicast SMLT on page 62

SMLT and multicast traffic issues

If PIM-SM or other multicast protocols are used in an SMLT environment, enable the protocol on the vIST. Routing protocols in general are not run over an vIST but multicast routing protocols are an exception. When using PIM-SM and a unicast routing protocol, ensure the unicast route to the BSR and RP has PIM-SM active and enabled. If multiple OSPF paths exist and PIM-SM is not active on each pair, the BSR is learned on a path that does not have PIM-SM active. The following figure demonstrates this issue.

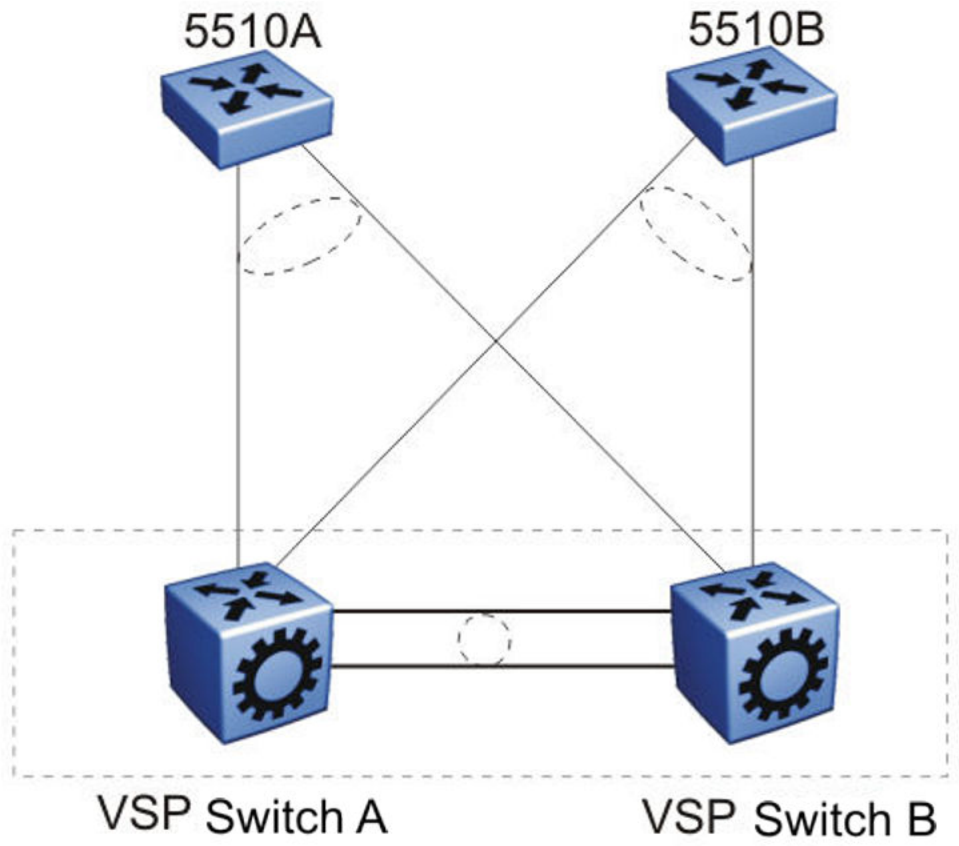


Figure 23: Unicast route example

The network configuration in the preceding figure is as follows:

- 5510A is on VLAN 101.
- 5510B is on VLAN 102.
- VSP Switch B is the BSR.
- VSP Switch A and VSP Switch B have OSPF enabled.
- PIM is enabled and active on VLAN 101.
- PIM is either disabled or passive on VLAN 102.

In this example, the unicast route table on VSP Switch A learns the BSR on VSP Switch B through VLAN 102 using OSPF. The BSR is either not learned or does not provide the RP to VSP Switch A.

Related Links

Layer 3 switch clustering and multicast SMLT on page 62

Chapter 12: Spanning tree

Spanning tree prevents loops in switched networks. Avaya Virtual Services Platform 4000 Series supports Rapid Spanning Tree Protocol (RSTP) and Multiple Spanning Tree Protocol (MSTP). This chapter describes issues to consider when you configure spanning tree protocols.

For more information about spanning tree protocols, see *Configuring VLANs and Spanning Tree on Avaya Virtual Services Platform 4000 Series*, NN46251-500.

Spanning tree and protection against isolated VLANs

Virtual Local Area Network (VLAN) isolation disrupts packet forwarding. The following figure illustrates the problem. Two VLANs (V1 and V2) connect four devices, and both VLANs are in the same spanning tree group. V2 includes three of the four devices, whereas V1 includes all four devices. After a spanning tree protocol detects a loop, it blocks the link with the highest link cost. In this case, the 100 Mbps link is blocked, which isolates a device in V2. To avoid this problem, either configure V2 on all four devices or use MSTP with a different Multiple Spanning Tree Instance (MSTI) for each VLAN.

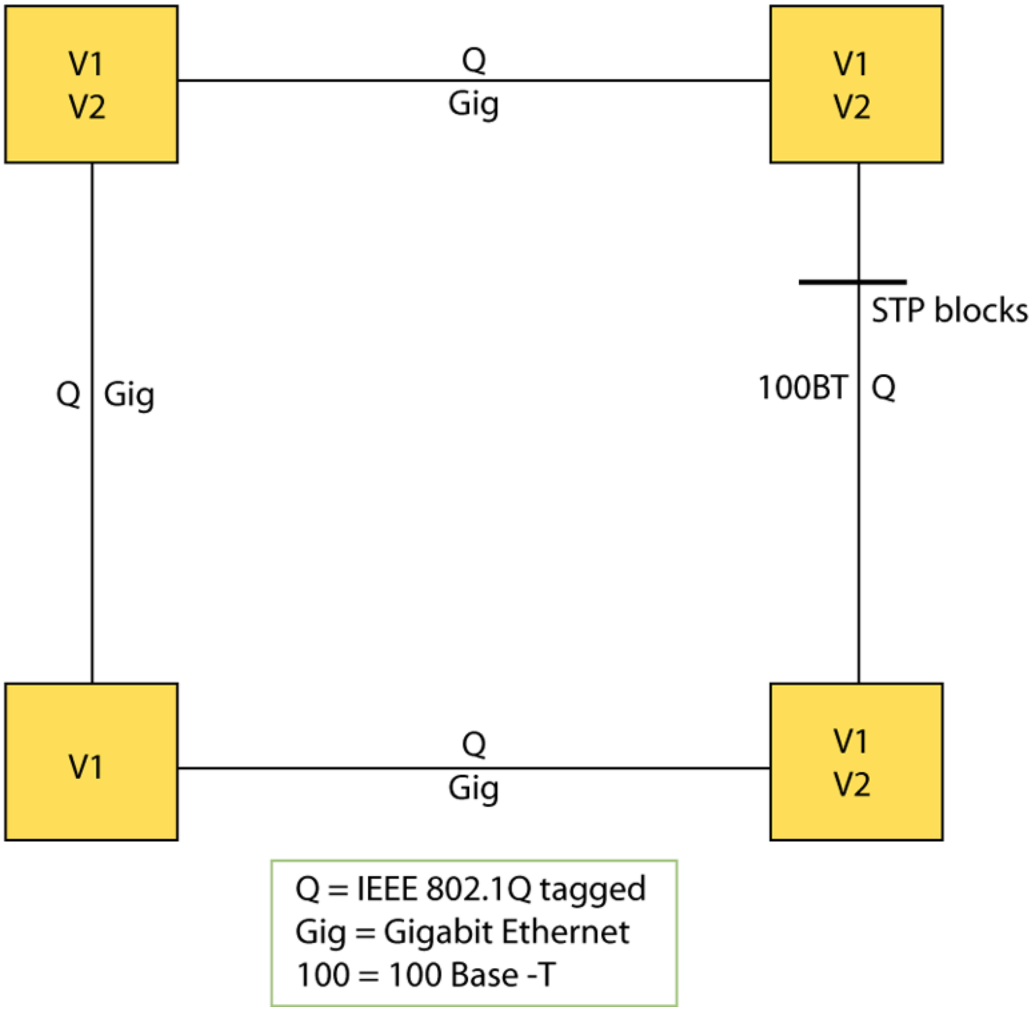


Figure 24: VLAN isolation

MSTP and RSTP considerations

The Spanning Tree Protocol (STP) provides loop protection and recovery, but it is slow to respond to a topology change in the network (for example, a dysfunctional link in a network). RSTP (IEEE 802.1w) and MSTP (IEEE 802.1s) reduce the recovery time after a network failure. RSTP and MSTP also maintain a backward compatibility with IEEE 802.1D. Typically, the recovery time of RSTP and MSTP is less than 1 second. RSTP and MSTP also reduce the amount of flooding in the network by enhancing the way that Topology Change Notification (TCN) packets are generated.

Use MSTP to configure MSTIs on the same switch. Each MSTI can include one or more VLANs.

In MSTP mode you can configure up to 64 instances. Instance 0 or Common and Internal Spanning Tree (CIST) is the default group, which includes default VLAN 1. Instances 1 to 63 are MSTIs.

RSTP and MSTP provide a global spanning tree parameter, called **`version`**, for backward compatibility with legacy STP. You can configure **`version`** to either STP-compatible mode, RSTP mode, or MSTP mode:

- An STP-compatible port transmits and receives only STP Bridge Protocol Data Units (BPDU). An RSTP or MSTP BPDU that the port receives in this mode is discarded.
- An RSTP or MSTP port transmits and receives only RSTP or MSTP BPDUs. If an RSTP or MSTP port receives an STP BPDU, it becomes an STP port. You must manually intervene to configure this port for RSTP or MSTP mode again. This process is called Port Protocol Migration.

You must be aware of the following recommendations before you implement MSTP or RSTP:

- The default mode is MSTP. A special boot configuration flag identifies the mode.
- You can lose your configuration if you change the spanning tree mode from MSTP to RSTP and the configuration file contains VLANs configured with MSTI greater than 0. RSTP only supports VLANs configured with the default instance 0.
- For best interoperability results, contact your Avaya representative.

Chapter 13: Layer 3 network design

This chapter describes Layer 3 design considerations that you need to understand to properly design an efficient and robust network.

VRF Lite

The Avaya Virtual Services Platform 4000 Series supports the Virtual Routing and Forwarding (VRF) Lite feature, which supports many virtual routers, each with its own routing domain. VRF Lite virtualizes the routing tables to form independent routing domains, which eliminates the need for multiple physical routers.

To use VRF Lite, you must use the Premier Software License.

For more information about VRF Lite, see *Configuration - IP Routing for Avaya Virtual Services Platform 4000 Series*, NN46251-505.

VRF Lite route redistribution

Using VRF Lite, VSP 4000 can function as many routers; each VRF routing engine works independently. Normally, no route leak occurs between different VRFs. Use the route redistribution option to facilitate the redistribution of routes. VRFs can redistribute Open Shortest Path First (OSPF), Routing Information Protocol (RIP), Border Gateway Protocol (BGP), direct routes, and static routes.

If you enable route redistribution between two VRFs, ensure that the IP addresses do not overlap. The software does not enforce this requirement.

VRF Lite capability and functionality

On a VRF instance, VRF Lite supports the following protocols: IP, Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), static routes, default routes, RIP, OSPF, external BGP (eBGP), route policies, Virtual Router Redundancy Protocol (VRRP), and the Dynamic Host Configuration Protocol/BootStrap Protocol relay agent.

The device uses VRF Lite to perform the following actions:

- Partition traffic and data, and represent an independent router in the network
- Provide virtual routers that are transparent to end users
- Support overlapping IP address spaces in separate VRFs
- Support addresses that are not restricted to the assigned address space given by host Internet Service Providers (ISP)
- Support eBGP

VRF Lite architecture examples

VRF Lite enables a router to act as many routers. This provides virtual traffic separation for each user and provides security. For example, you can use VRF Lite to:

- Provide different departments within a company with site-to-site connectivity as well as Internet access
- Provide centralized and shared access to data centers.

The following figure shows how VRF Lite can emulate VPNs.

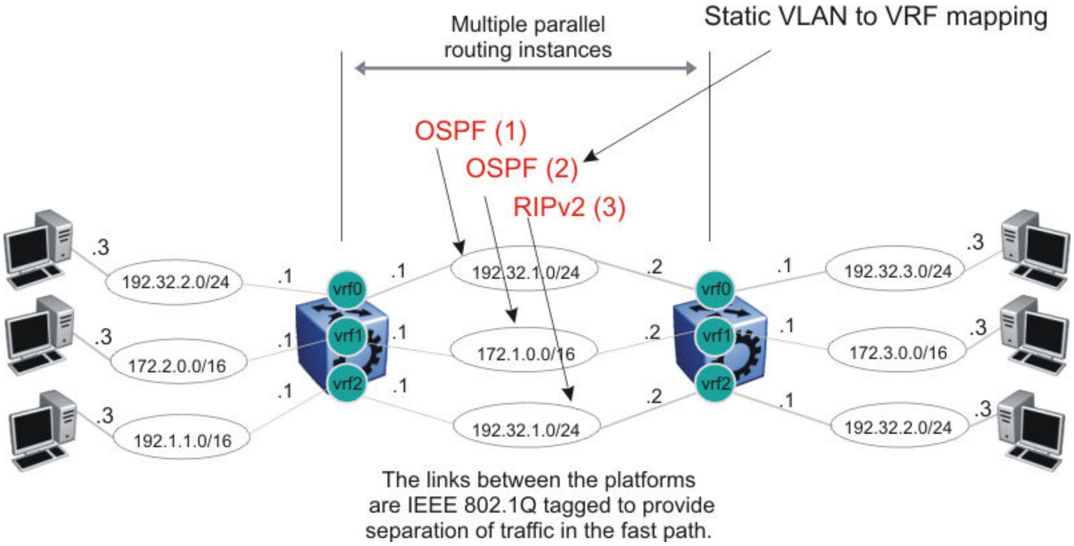


Figure 25: VRF Lite example

The following figure shows how VRFs can interconnect through an external firewall.

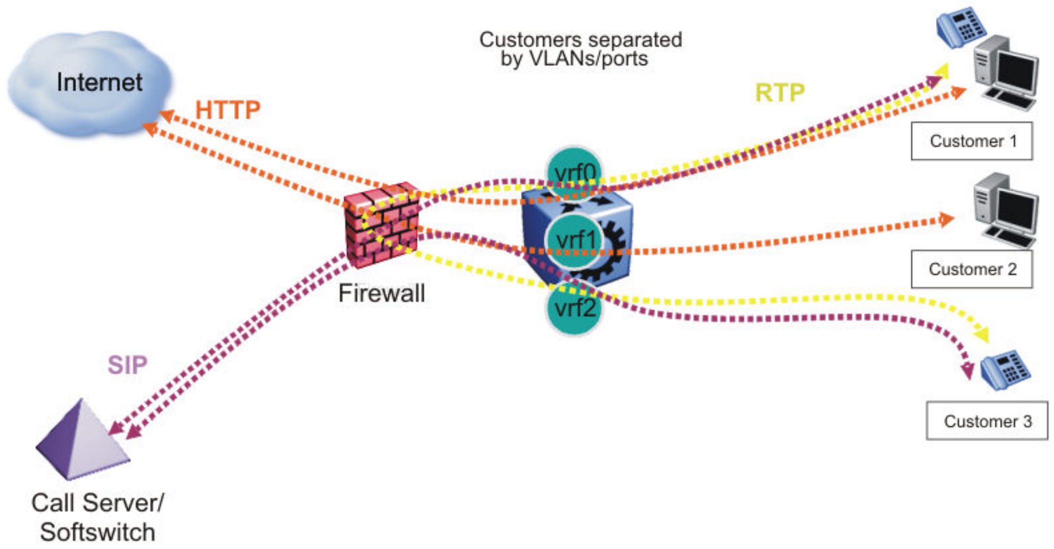


Figure 26: Inter-VRF forwarding based on external firewall

Although customer data separation into Layer 3 virtual routing domains is usually a requirement, sometimes customers must access a common network infrastructure. For example, they want to access the Internet, data storage, VoIP-PSTN, or call signaling services. To interconnect VRF instances, you can use an external firewall that supports virtualization, or use inter-VRF forwarding for specific services. Using the inter-VRF solution, you can use routing policies and static routes to inject IP subnets from one VRF instance to another, and filters to restrict access to certain protocols.

The following figure shows inter-VRF forwarding. In this solution, you can use routing policies to leak IP subnets from one VRF to another. You can use filters to restrict access to certain protocols. This configuration enables hub-and-spoke network designs, for example, for VoIP gateways.

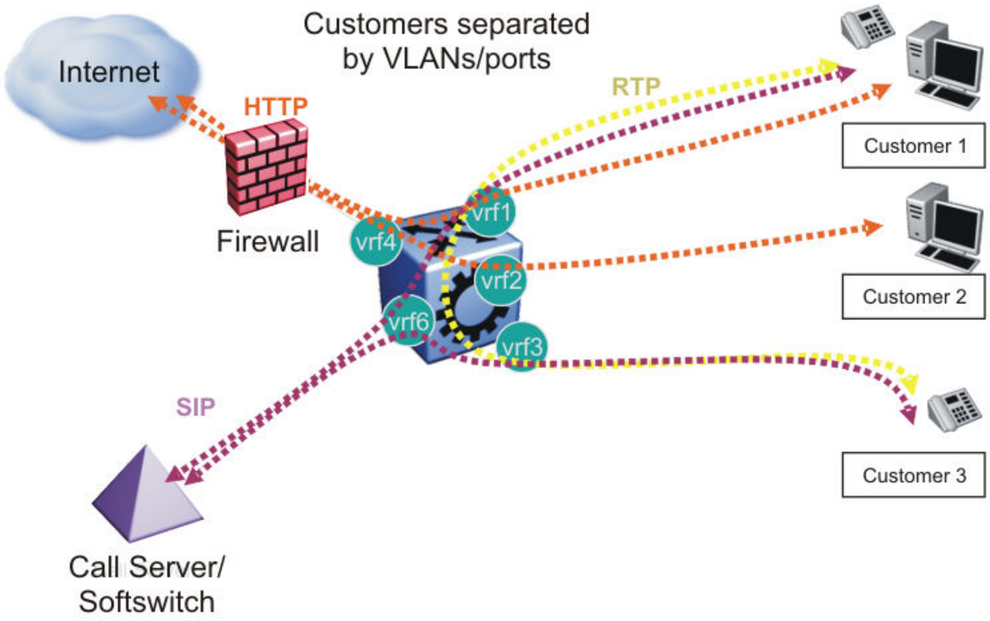


Figure 27: Inter VRF communication, internal inter-VRF forwarding

Virtual Router Redundancy Protocol

The Virtual Router Redundancy Protocol (VRRP) provides a backup router that takes over if a router fails, which is important if you must provide redundancy mechanisms.

VRRP guidelines

VRRP provides another layer of resiliency to your network design by providing default gateway redundancy for end users. If a VRRP-enabled router that connects to the default gateway fails, failover to the VRRP backup router ensures no interruption for end users who attempt to route from their local subnet.

Only the VRRP Master router forwards traffic for a given subnet. The backup VRRP router does not route traffic destined for the default gateway.

To allow both VRRP switches to route traffic, VSP 4000 has an extension to VRRP, the BackupMaster, that creates an active-active environment for routing. If you enable BackupMaster on the backup router, the backup router no longer switches traffic to the VRRP Master. Instead the

BackupMaster routes all traffic received on the BackupMaster IP interface according to the switch routing table.

Figure 28: VRRP with BackupMaster

Avaya recommends that you stagger VRRP instances on a network or subnet basis. The following figure shows the VRRP Masters and BackupMasters for two subnets. For more information about how to configure VRRP using the Avaya Command Line Interface (ACLI) and Enterprise Device Manager (EDM), see *Configuration - IP Routing for Avaya Virtual Services Platform 4000 Series*, NN46251-505.

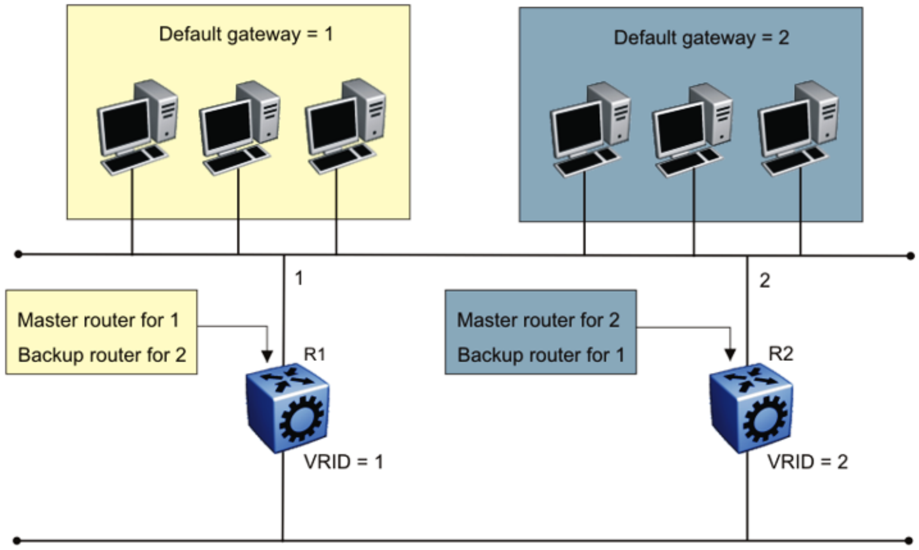


Figure 29: VRRP network configuration

The VRRP BackupMaster uses the VRRP standardized backup switch state machine. Thus, VRRP BackupMaster is compatible with standard VRRP.

Avaya recommends that you use the following best practices to implement VRRP:

- Do not configure the virtual address as a physical interface that is used on the routing switches. Instead, use a third address, for example:
  - Interface IP address of VLAN A on Switch 1 = x.x.x.2
  - Interface IP address of VLAN A on Switch 2 = x.x.x.3
  - Virtual IP address of VLAN A = x.x.x.1

  Note:

  Avaya does not support a VRRP virtual IP address that is the same as the local physical address of the device.
- Configure the VRRP holddown timer with enough time that the Interior Gateway Protocol (IGP) routing protocol has time to update the routing table. In some cases, configuring the VRRP

holddown timer to a minimum of 1.5 times the IGP convergence time is sufficient. For OSPF, Avaya recommends that you use a value of 90 seconds if you use the default OSPF timers.

- Implement VRRP BackupMaster for an active-active configuration (BackupMaster works across multiple switches that participate in the same VRRP domain).
- Configure VRRP priority as 200 to configure VRRP Master.
- Stagger VRRP Masters between switches in the core to balance the load between switches.
- If you implement VRRP Fast, you create additional control traffic on the network and also create a greater load on the CPU. To reduce the convergence time of VRRP, the VRRP Fast feature allows the modification of VRRP timers to achieve subsecond failover of VRRP. Without VRRP Fast, normal convergence time is approximately 3 seconds.
- Do not use VRRP BackupMaster and critical IP at the same time. Use one or the other.
- When you implement VRRP on multiple VLANs between the same switches, Avaya recommends that you configure a unique Virtual Router ID (VRID) on each VLAN.

VRRP and spanning tree

VSP 4000 can use one of two spanning tree protocols: Rapid Spanning Tree Protocol (RSTP) and Multiple Spanning Tree Protocol (MSTP).

VRRP protects clients and servers from link or aggregation switch failures. Configure the network to limit the amount of time a link is out of service during VRRP convergence. The following figure shows two possible configurations of VRRP and spanning tree; configuration A is optimal and configuration B is not.

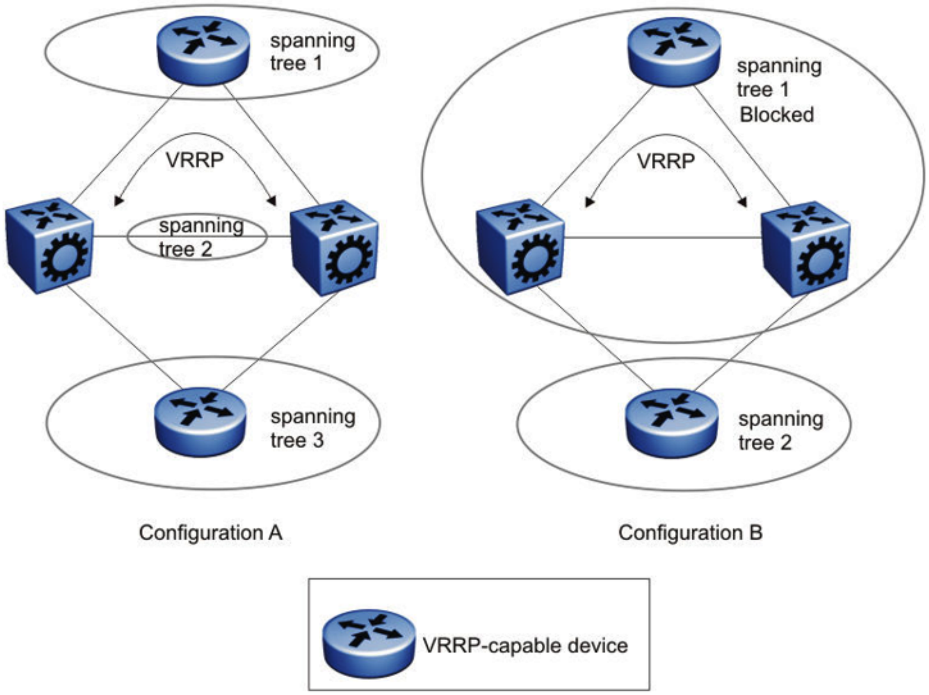


Figure 30: VRRP and STG configurations

In this figure, configuration A is optimal because VRRP convergence occurs within 2 to 3 seconds. In configuration A, three spanning tree instances exist and VRRP runs on the link between the two routers. Spanning tree instance 2 exists on the link between the two routers, which separates the link between the two routers from the spanning tree instances found on the other devices. All uplinks are active.

In configuration B, VRRP convergence takes between 30 and 45 seconds because it depends on spanning tree convergence. After initial convergence, spanning tree blocks one link (an uplink), so only one uplink is used. If an error occurs on the uplink, spanning tree reconverges, which can take up to 45 seconds. After spanning tree reconvergence, VRRP can take a few more seconds to fail over.

VRRP and ICMP redirect messages

You can use VRRP and Internet Control Message Protocol (ICMP) together. However, doing so can provide nonoptimal network performance.

Consider the network shown in the following figure. Traffic from the client on subnet 30.30.30.0, destined for the 10.10.10.0 subnet, is sent to routing switch 1 (VRRP Master). Routing switch 1 forwards this traffic on the same subnet to routing switch 2, where it is routed to the destination. With ICMP redirect enabled, for each packet received, routing switch 1 sends an ICMP redirect message to the client to inform it of a shorter path to the destination through routing switch 2.

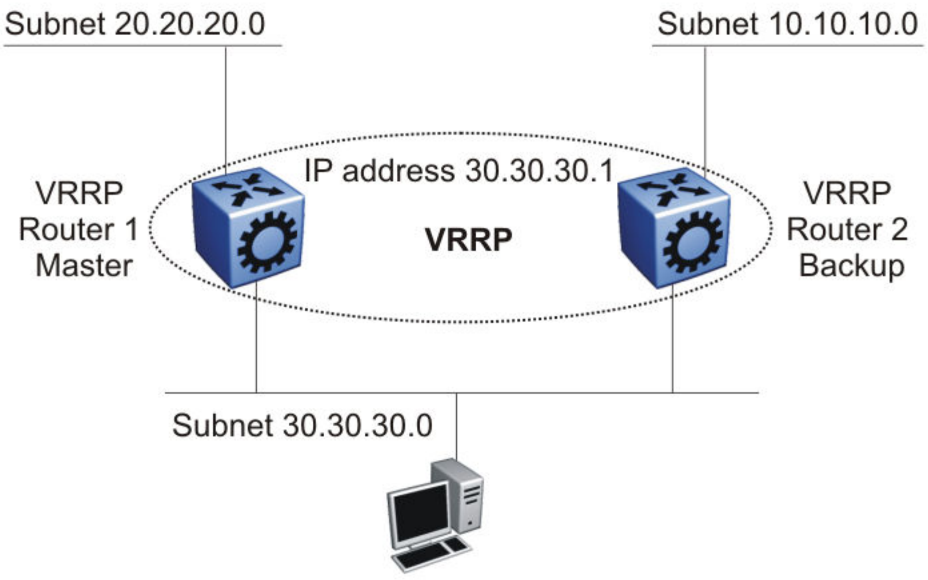


Figure 31: ICMP redirect messages

If network clients do not recognize ICMP redirect messages, disable ICMP redirect messages on VSP 4000 to avoid excessive ICMP redirect messages. Avaya recommends the network design shown in the following figure.

Ensure that the routing path to the destination through both routing switches has the same metric to the destination. One hop goes from 30.30.30.0 to 10.10.10.0 through routing switch 1 and routing switch 2.

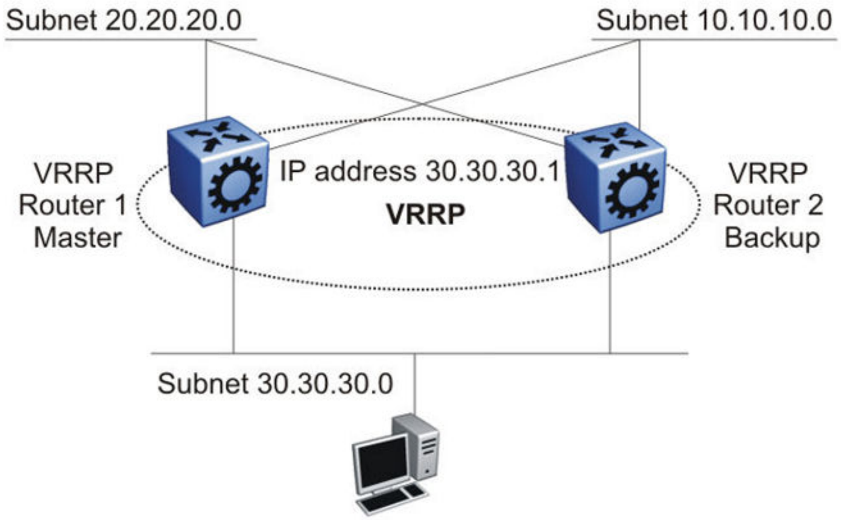


Figure 32: Avoiding excessive ICMP redirect messages without SMLT

Open Shortest Path First

Use OSPF to ensure that the switch can communicate with other OSPF routers. This section describes some general design considerations and presents a number of design scenarios for OSPF.

For more information about OSPF concepts and configuration, see *Configuring OSPF and RIP on Avaya Virtual Services Platform 4000 Series*, NN46251-506.

OSPF LSA limits

To determine OSPF link-state advertisement (LSA) limits:

1. Use the command **`show ip ospf area`** to determine the LSA_CNT and to obtain the number of LSAs for a given area.
2. Use the following formula to determine the number of areas. Ensure the total is less than 16,000 (16K):

   $$\sum \mathrm{Adj}_N * \mathrm{LSA\_CNT}_N < 16k$$

   N = 1 to the number of areas for each switch

   Adj_N = number of adjacencies for each Area N

   $\mathrm{LSA\_CNT}_N$ = number of LSAs for each Area N

For example, assume that a switch has a configuration of three areas with a total of 18 adjacencies and 1000 routes. This includes:

- 3 adjacencies with an LSA_CNT of 500 (Area 1)
- 10 adjacencies with an LSA_CNT of 1000 (Area 2)

- 5 adjacencies with an LSA_CNT of 200 (Area 3)

Calculate the number as follows:

3*500+10*1000+5*200=12.5K < 16K

This configuration ensures that the switch operates within accepted scalability limits.

OSPF design guidelines

Follow these additional OSPF guidelines:

- OSPF timers must be consistent across the entire network.
- Use OSPF area summarization to reduce routing table sizes.
- Use OSPF passive interfaces to reduce the number of active neighbor adjacencies.
- Use OSPF active interfaces only on intended route paths.

  Configure wiring-closet subnets as OSPF passive interfaces unless they form a legitimate routing path for other routes.
- Minimize the number of OSPF areas for each switch to avoid excessive shortest-path calculations.

  The switch executes the Djikstra algorithm for each area separately.
- Ensure that the OSPF dead interval is at least four times the OSPF hello-interval.
- Use MD5 authentication on untrusted OSPF links.
- Use stub or NSSAs as much as possible to reduce CPU overhead.

OSPF and CPU utilization

After you create an OSPF area route summary on an area border router, the summary route can attract traffic to the area border router for which the router does not have a specific destination route. Enabling ICMP unreachable-message generation on the switch can result in a high CPU utilization rate.

To avoid high CPU utilization, Avaya recommends that you use a black-hole static route configuration. The black-hole static route is a route (equal to the OSPF summary route) with a next hop of 255.255.255.255. This configuration ensures that all traffic that does not have a specific next-hop destination route is dropped.

OSPF network design examples

You can use OSPF routing in the core of a network. For more information, see Layer 1, 2, and 3 design examples on page 170.

The following figure describes a simple implementation of an OSPF network: enabling OSPF on two switches (S1 and S2) that are in the same subnet in one OSPF area.

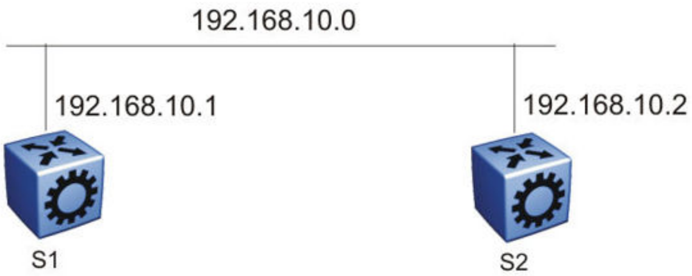


Figure 33: Example 1: OSPF on one subnet in one area

The routers in the preceding figure use the following configuration:

- S1 has an OSPF router ID of 1.1.1.1, and the OSPF port uses an IP address of 192.168.10.1.
- S2 has an OSPF router ID of 1.1.1.2, and the OSPF port uses an IP address of 192.168.10.2.

The general method to configure OSPF on each routing switch is:

1. Enable OSPF globally.
2. Enable IP forwarding on the switch.
3. Configure the IP address, subnet mask, and VLAN ID for the port.
4. Disable RIP on the port, if you do not need it.
5. Enable OSPF for the port.

After you configure S2, the two switches elect a designated router and a backup designated router. They exchange hello packets to synchronize their link state databases.

The following figure shows a configuration in which OSPF operates on three switches. OSPF performs routing on two subnets in one OSPF area. In this example, S1 directly connects to S2, and S3 directly connects to S2, but traffic between S1 and S3 is indirect, and passes through S2.

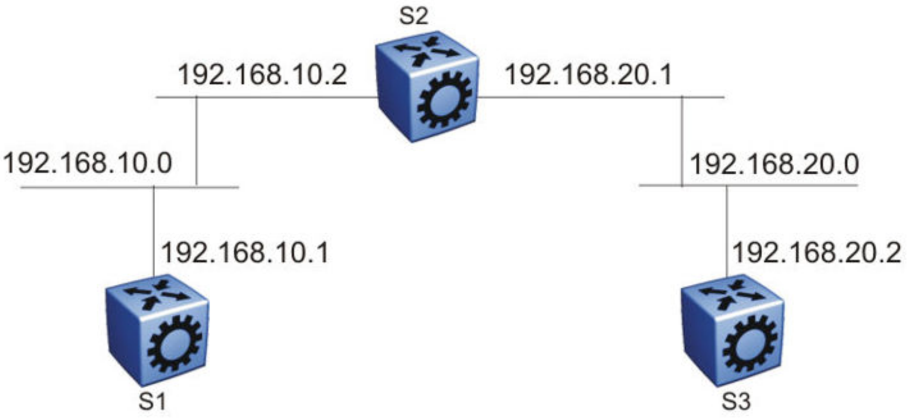


Figure 34: Example 2: OSPF on two subnets in one area

The routers in example 2 use the following configuration:

- S1 has an OSPF router ID of 1.1.1.1, and the OSPF port uses an IP address of 192.168.10.1.
- S2 has an OSPF router ID of 1.1.1.2, and two OSPF ports use IP addresses of 192.168.10.2 and 192.168.20.1.
- S3 has an OSPF router ID of 1.1.1.3, and the OSPF port uses an IP address of 192.168.20.2.

The general method to configure OSPF on each routing switch is:

1. Enable OSPF globally.
2. Insert IP addresses, subnet masks, and VLAN IDs for the OSPF ports on S1 and S3, and for the two OSPF ports on S2. The two ports on S2 enable routing and establish the IP addresses related to the two networks.
3. Enable OSPF for each OSPF port allocated with an IP address.

After you configure all three switches for OSPF, they elect a designated router and a backup designated router for each subnet and exchange hello packets to synchronize their link-state databases.

The following figure shows an example where OSPF operates on two subnets in two OSPF areas. S2 becomes the area border router for both networks.

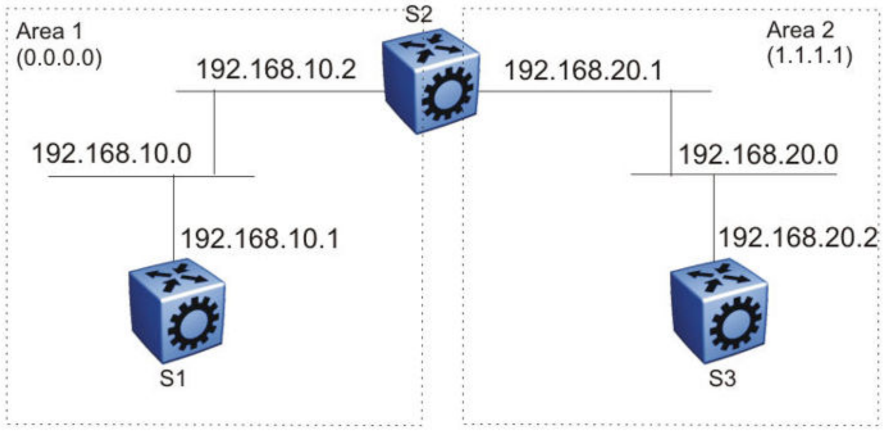


Figure 35: Example 3: OSPF on two subnets in two areas

The routers in scenario 3 use the following configuration:

- S1 has an OSPF router ID of 1.1.1.1. The OSPF port uses an IP address of 192.168.10.1, which is in OSPF area 1.
- S2 has an OSPF router ID of 1.1.1.2. One port uses an IP address of 192.168.10.2, which is in OSPF area 1. The second OSPF port on S2 uses an IP address of 192.168.20.1, which is in OSPF area 2.
- S3 has an OSPF router ID of 1.1.1.3. The OSPF port uses an IP address of 192.168.20.2, which is in OSPF area 2.

The general method to configure OSPF for this three-switch network is:

1. On all three switches, enable OSPF globally.

2. Configure OSPF on one network.

   On S1, insert the IP address, subnet mask, and VLAN ID for the OSPF port. Enable OSPF on the port. On S2, insert the IP address, subnet mask, and VLAN ID for the OSPF port in area 1, and enable OSPF on the port. Both routable ports belong to the same network. Therefore, by default, both ports are in the same area.

3. Configure three OSPF areas for the network.

4. Configure OSPF on two additional ports in a second subnet.

   Configure additional ports and verify that IP forwarding is enabled for each switch to ensure that routing can occur. On S2, insert the IP address, subnet mask, and VLAN ID for the OSPF port in area 2, and enable OSPF on the port. On S3, insert the IP address, subnet mask, and VLAN ID for the OSPF port, and enable OSPF on the port.

The three switches exchange hello packets.

In an environment with a mix of non-Avaya and Avaya switches and routers, you may need to manually modify the OSPF parameter RtrDeadInterval to 40 seconds.

Border Gateway Protocol

Use the Border Gateway Protocol (BGP) to ensure that the switch can communicate with other BGP routers on the Internet backbone. BGP is an exterior gateway protocol that exchanges network reachability information with other BGP systems in the same or other autonomous systems (AS). This network reachability information includes information about the AS list that the reachability information traverses. By using this information, you can prune routing loops and enforce policy decisions at the AS level.

BGP performs routing between two sets of routers that operate in different autonomous systems. An AS can use two kinds of BGP: internal BGP (iBGP), which refers to the protocol that BGP routers use within an autonomous system, and external BGP (eBGP), which refers to the protocol that BGP routers use across two different autonomous systems. BGP information is redistributed to Interior Gateway Protocols (IGP) that run in the autonomous system.

BGP version 4 (BGPv4) supports classless interdomain routing (CIDR). BGPv4 advertises the IP prefix and eliminates the concept of network class within BGP. BGPv4 can aggregate routes and AS paths. BGP aggregation does not occur when routes have different Multi-Exit Discriminators (MED) or next hops.

BGP Equal-Cost Multipath (ECMP) allows a BGP speaker to perform route balancing within an AS by using multiple equal-cost routes submitted to the routing table by OSPF or RIP. BGP performs load balancing on an individual-packet basis.

To control route propagation and filtering, RFC1772 and RFC2270 recommend that multihomed, nontransit autonomous systems not run BGPv4. To address the load sharing and reliability requirements of a multihomed user, use BGP between them.

For more information about BGP concepts and configuration, see *Configuring BGP on Avaya Virtual Services Platform 4000 Series*, NN46251-507.

BGP implementation guidelines

To successfully implement BGP in a VSP 4000 network, follow these guidelines:

- BGP does not operate with an IP router in nonforwarding (host-only) mode. Ensure that the routers with which you want BGP to operate are in forwarding mode.
- If you use BGP for a multihomed AS (one that contains more than a single exit point), Avaya recommends that you use OSPF for the IGP, and BGP for the sole exterior gateway protocol. Otherwise, use intra-AS iBGP routing.
- If OSPF is the IGP, use the default OSPF tag construction. The use of EGP or the modification of the OSPF tags makes network administration and proper configuration of BGP path attributes difficult.
- For routers that support both BGP and OSPF, you must configure the OSPF router ID and the BGP identifier to the same IP address. The BGP router ID automatically uses the OSPF router ID.
- In configurations where BGP speakers reside on routers that have multiple network connections over multiple IP interfaces (the typical case for iBGP speakers), consider using the address of the circuitless (virtual) IP interface as the local peer address. In this configuration, you ensure that BGP is reachable as long as an active circuit exists on the router.
- By default, BGP speakers do not advertise or inject routes into their IGP. You must configure route policies to enable route advertisement.
- Coordinate routing policies among all BGP speakers within an AS so that every BGP border router within an AS constructs the same path attributes for an external path.
- Configure accept and announce policies on all iBGP connections to accept and propagate all routes. Make consistent routing policy decisions on external BGP connections.
- Use the max-prefix parameter to limit the number of routes BGP imports from a peer. Use a configuration of 0 to accept an unlimited number of prefixes.
- You cannot enable or disable the MED selection process. BGP aggregation does not occur when routes have different MEDs or next hops.

BGP and OSPF interaction

RFC1745 defines the interaction between BGP and OSPF when OSPF is the IGP within an autonomous system. For routers that run both protocols, the OSPF router ID and the BGP ID must be the same IP address. You must configure a BGP route policy to allow BGP advertisement of OSPF routes.

Interaction between BGPv4 and OSPF includes the ability to advertise supernets to support CIDR. BGPv4 supports interdomain supernet advertisements; OSPF can carry supernet advertisements within a routing domain.

BGP and other vendor interoperability

BGP interoperability is compatible between VSP 4000, Cisco 6500 Software Release IOS 11.3, and Juniper M20 Software Release 5.3R2.4.

For more information about BGP, see *Configuring BGP on Avaya Virtual Services Platform 4000 Series*, NN46251-507.

BGP and Internet peering

By using BGP, you can perform Internet peering directly between VSP 4000 and another edge router. In such a scenario, you can use each VSP 4000 for aggregation and link it with a Layer 3 edge router, as shown in the following figure.

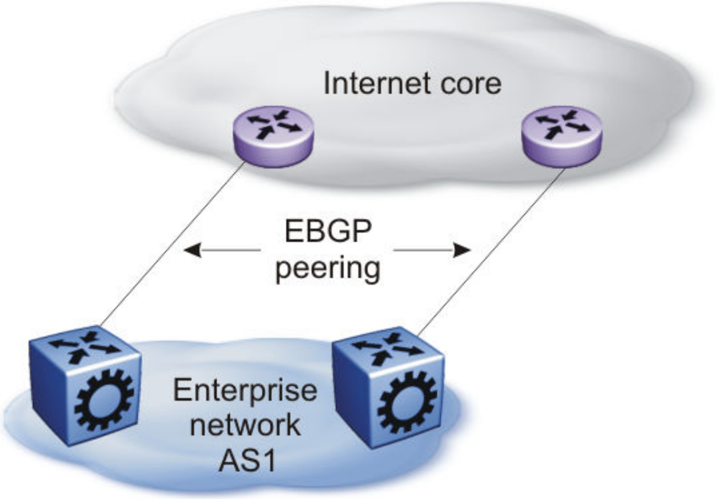


Figure 36: BGP and Internet peering

In cases where the Internet connection is single-homed, to reduce the size of the routing table, Avaya recommends that you advertise Internet routes as the default route to the IGP. The VSP 4000 supports a total of 16,000 eBGP routes. The maximum FIB size for IPv4 routes is also 16,000.

Routing domain interconnection with BGP

You can implement BGP so that autonomous routing domains, such as OSPF routing domains, connect. This connection allows the two different networks to begin communicating quickly over a common infrastructure, thus providing additional time to plan the IGP merger. Such a scenario is particularly effective when you need to merge two OSPF area 0.0.0.0s (see the following figure).

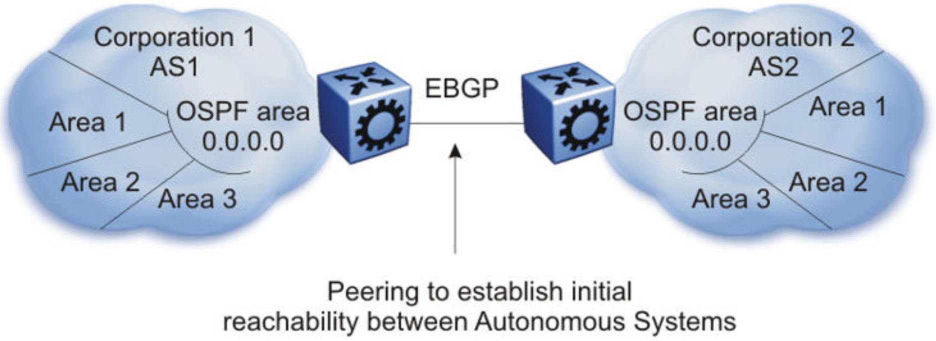


Figure 37: Routing domain interconnection with BGP

BGP and edge aggregation

You can perform edge aggregation with multiple point of presence or edge concentrations. VSP 4000 supports 12 pairs (peering services). You can use BGP to inject dynamic routes rather than using static routes or RIP (see the following figure).

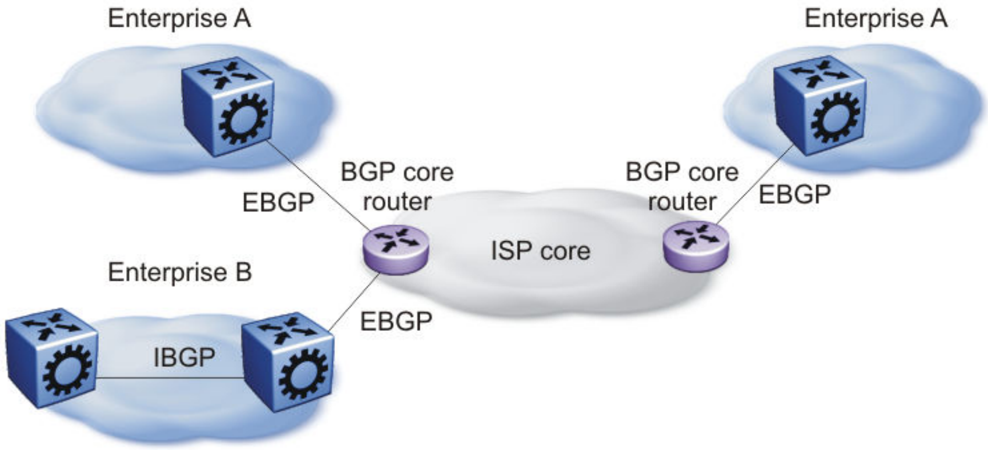


Figure 38: BGP and edge aggregation

BGP and ISP segmentation

You can use the platform as a peering point between different regions or ASs that belong to the same ISP. In such cases, you can define a region as an OSPF area, an AS, or a part of an AS.

You can divide the AS into multiple regions that each run different IGPs. Interconnect regions logically by using a full iBGP mesh. Each region then injects its IGP routes into iBGP and also injects a default route inside the region. For destinations that do not belong to the region, each region defaults to the BGP border router.

Use the community parameter to differentiate between regions. To provide Internet connectivity, this scenario requires you to make your Internet connections part of the central iBGP mesh (see the following figure).

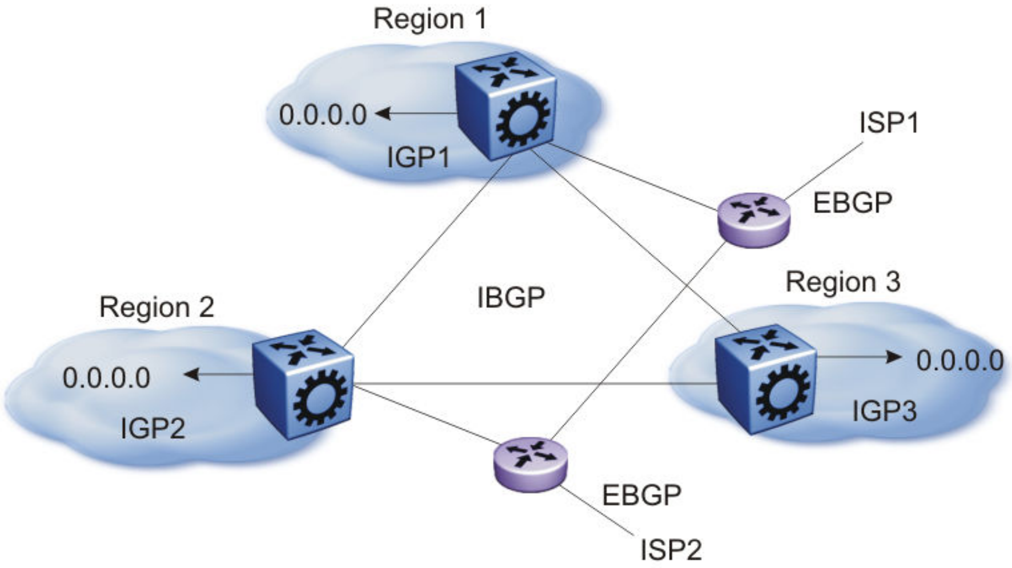


Figure 39: Multiple regions separated by iBGP

In the preceding figure, consider the following:

- The AS is divided into three regions that each run different and independent IGPs.
- Regions logically interconnect by using a full-mesh iBGP, which also provides Internet connectivity.
- Internal non-BGP routers in each region default to the BGP border router, which contains all routes.
- If the destination belongs to another region, the traffic is directed to that region; otherwise, the traffic is sent to the Internet connections according to BGP policies.

To configure multiple policies between regions, represent each region as a separate AS. Implement eBGP between ASs, and implement iBGP within each AS. In such instances, each AS injects its IGP routes into BGP, where they are propagated to all other regions and the Internet.

The following figure shows the use of eBGP to join several ASs.

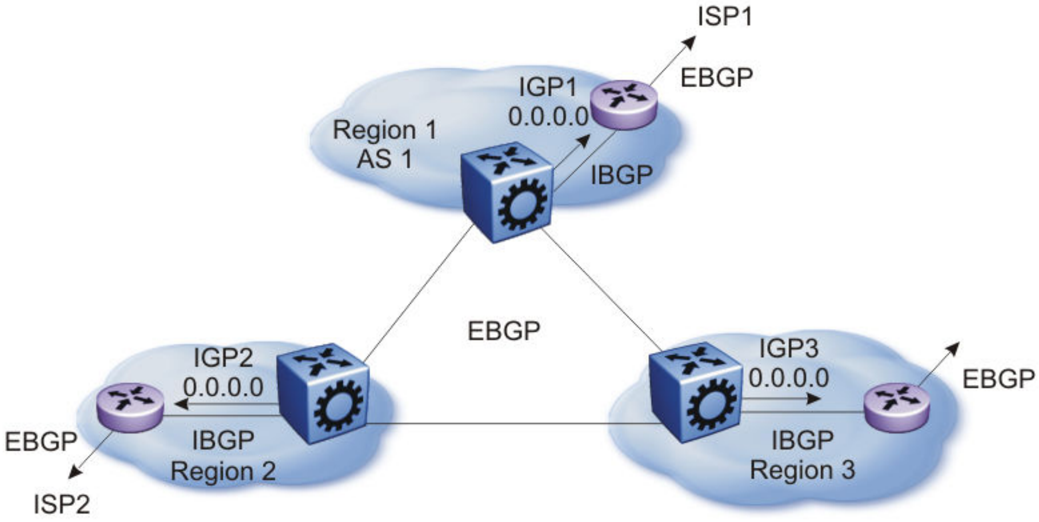


Figure 40: Multiple regions separated by eBGP

You can obtain AS numbers from the Inter-Network Information Center (NIC) or use private AS numbers. If you use private AS numbers, be sure to design your Internet connectivity carefully. For example, you can introduce a central, well-known AS to provide interconnections between all private ASs and the Internet. Before it propagates the BGP updates, this central AS strips the private AS numbers to prevent them from leaking to providers.

The following figure illustrates a design scenario in which you use multiple OSPF regions to enable peering with the Internet.

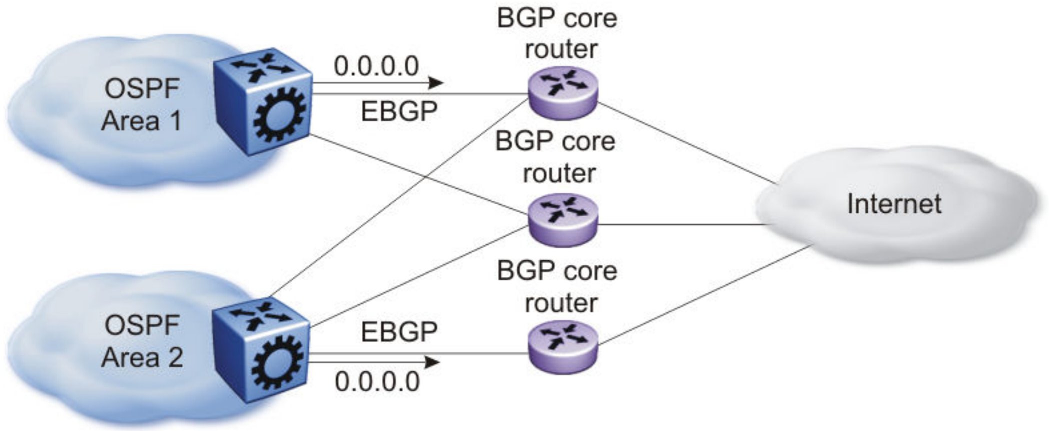


Figure 41: Multiple OSPF regions peering with the Internet

IP routed interface scaling

VSP 4000 supports up to 256 IP-routed interfaces.

When you configure a large number of IP-routed interfaces, use passive interfaces on most of the configured interfaces. You can make very few interfaces active.

IPv6

IPv6 provides high-performance, scalable Internet communications. Use the information in this section to help deploy IPv6 in your network. For configuration information, see *Configuring IPv6 Routing on VSP Operating System Software*, NN47227-507.

Design recommendations

Avaya Layer 2 and Layer 3 Ethernet switches support protocol-based IPv6 VLANs. To simplify network configuration with IPv6, Avaya recommends that you use protocol-based IPv6 VLANs from edge Layer 2 switches if you want to segregate all IPv6 traffic into a single VLAN at one switch or across a set of Layer 2 access switches. The core switch performs hardware-based IPv6 line-rate routing.

Transition mechanisms

The switch uses the following functions to help you transition your network from IPv4 to IPv6:

- Dual stack mechanism, where the IPv4 and IPv6 protocol stacks can communicate with both IPv6 and IPv4 devices.
- Tunneling, which involves the encapsulation of IPv6 packets to traverse IPv4 networks, and the decapsulation of IPv4 packets to traverse IPv6 networks.

Tunneling

The switch supports manually configured IPv6-in-IPv4 tunnels per RFC4213.

A manually-configured tunnel is equivalent to a permanent link between two IPv6 domains over an IPv4 backbone.

Use tunnels to provide stable, secure communications between two edge routers, an end system and an edge router, or to provide a connection to remote IPv6 networks.

Configure an IPv6 address on the tunnel interface.

Configure an IPv4 address on the tunnel source and destination.

Note:

The host or router at each end of the tunnel must be a dual-stack device.

The following figure demonstrates an IPv6 over IPv4 tunnel.

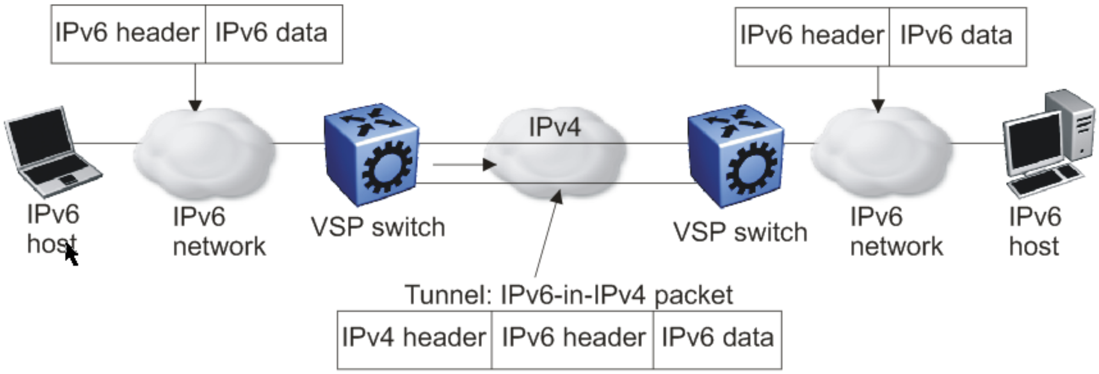


Figure 42: IPv6 over IPv4 tunneling

The tunnel in the preceding figure exists only between two VSP devices.

If you add new devices, you must configure additional tunnels.

VRRP

For IPv6 hosts on a LAN to learn about one or more default routers, IPv6-enabled routers send router advertisements using the IPv6 Neighbor Discovery (ND) protocol. The routers multicast these router advertisements every few minutes.

The ND protocol includes a mechanism called Neighbor Unreachability Detection to detect the failure of a neighbor node (router or host) or the failure of the forwarding path to a neighbor. Nodes can monitor the health of a forwarding path by sending unicast ND neighbor solicitation messages to the neighbor node. To reduce traffic, nodes only send neighbor solicitations to neighbors to which they are actively sending traffic, and only after the node receives no positive indication that the neighbors are up for a period of time. Using the default ND parameters, it takes a host approximately 38 seconds to learn that a router is unreachable before it switches to another default router. This delay is very noticeable and causes some transport protocol implementations to timeout.

While you can decrease the ND unreachability detection period by modifying the ND parameters, the lowest limit that can be achieved is 5 seconds, with the added downside of significantly increasing ND traffic, especially when many hosts try to determine the reachability of one of more routers.

To provide fast failover of a default router for IPv6 LAN hosts, the switch supports the Virtual Router Redundancy Protocol (VRRP) for IPv6

VRRP for IPv6 provides a faster switchover to an alternate default router than is possible using the ND protocol. With VRRP for IPv6, a backup router can take over for a failed default router in approximately 3 seconds (using default parameters). This failover is accomplished without host interaction and with a minimum amount of VRRP traffic.

IPv6 VRRP operation is similar to the IPv4 VRRP operation, including support for the holddown timer, critical IP, fast advertisements, and backup master. With backup master enabled, the backup switch routes all traffic according to its routing table. The backup master switch does not perform Layer 2 switching for the traffic to the VRRP master.

New to the IPv6 implementation of VRRP from the IPv4 implementation, you must specify a link-local address to associate with the virtual router. Optionally, you can also assign global unicast IPv6 addresses to associate with the virtual router. Network prefixes for the virtual router are derived from the global IPv6 addresses assigned to the virtual router.

VRRP backup master with triangular SMLT:

The standard implementation of VRRP supports one active master switch for each IPv6 subnet. All other VRRP interfaces in a network are in backup mode.

A deficiency occurs when VRRP-enabled switches use SMLT. If VRRP switches are aggregated into two SMLT switches, the end host traffic is load-shared on all uplinks to the aggregation switches (based on the Multilink Trunk [MLT] traffic distribution algorithm).

However, VRRP usually has only one active routing interface enabled. All other VRRP routers are in backup mode. Therefore, all traffic that reaches the backup VRRP router is forwarded over Virtual Inter-Switch Trunk (vIST) toward the master VRRP router. In this case, vIST potentially does not have enough bandwidth to carry all the aggregated traffic.

To resolve this issue, assign the backup router as the backup master router. The backup master router can actively load-share the routing traffic with a master router.

Because the two VRRP peer nodes exchange MAC address tables, the VRRP backup master can forward traffic directly, on behalf of the master router. The switch in the backup master state routes all traffic received on the backup master IP interface according to its routing table. The backup master switch does not perform Layer 2 switching for the traffic to the VRRP master.

If you enable SMLT on the backup master router, the incoming host traffic is forwarded over the SMLT links as usual.

Important:

Do not use VRRP backup master and critical IP at the same time. Use one or the other.

IPv6 VRRP and ICMP redirects:

In IPv6 networks, do not enable ICMP redirects on VRRP VLANs. If you enable this option (using the `ipv6 icmp redirect-msg` command), VRRP cannot function. The option is disabled by default.

Chapter 14: SPBM design guidelines

Shortest Path Bridging MAC (SPBM) is a next-generation virtualization technology that revolutionizes the design, deployment, and operations of enterprise edge campus core networks and data centers. The benefits of the technology are clearly evident in its ability to provide massive scalability while at the same time reducing the complexity of the network. SPBM makes network virtualization a much easier paradigm to deploy within the enterprise environment than other technologies.

This chapters provides design guidelines that illustrate the operational simplicity of SPBM. It also lists best practices to configure SPBM in your network. For more information about SPBM fundamental concepts, command structure, and basic configuration, see *Configuring Avaya Fabric Connect on VSP Operating System Software*, NN47227-510.

802.1aq standard

Avaya Virtual Services Platform 4000 Series supports the IEEE 802.1aq standard of SPBM. SPBM makes network virtualization easy to deploy within the enterprise environment by reducing the complexity of the network while at the same time providing greater scalability. This technology provides all the features and benefits required by carrier-grade deployments to the enterprise market without the complexity of alternative technologies traditionally used in carrier deployments, for example, Multiprotocol Label Switching (MPLS). SPBM integrates into a single control plane all the functions that MPLS requires multiple layers and protocols to support.

IS-IS

SPBM eliminates the need for multiple overlay protocols in the core of the network by reducing the core to a single Ethernet-based link-state protocol, Intermediate System to Intermediate System (IS-IS). IS-IS provides virtualization services, both Layer 2 and Layer 3, using a pure Ethernet technology base. SPBM also uses IS-IS to discover and advertise the network topology, which enables it to compute the shortest path to all nodes in the SPBM network.

Spanning Tree is a topology protocol that prevents loops but does not scale very well. Because SPBM uses IS-IS, which has its own mechanisms to prevent loops, SPBM does not have to use Spanning Tree to provide a loop-free Layer 2 domain.

SPBM uses the IS-IS shortest-path trees to populate forwarding tables for the individual backbone MAC (B-MAC) addresses of each participating node. Depending on the topology, SPBM supports as many Equal Cost Multipath trees as there are backbone VLAN IDs (B-VIDs) provisioned (with a maximum of 16 B-VIDs allowed by the standard and two allowed in this release) per IS-IS instance.

IS-IS interfaces operate in point-to-point mode only, which means that for any port or MLT interface where IS-IS is enabled, there can be only one IS-IS adjacency across that interface.

B-MAC

An SPBM backbone includes Backbone Edge Bridges (BEB) and Backbone Core Bridges (BCB). A BEB performs the same functionality as a BCB, but it also terminates one or more Virtual Service Networks (VSNs). A BCB does not terminate any VSNs. BCBs forward encapsulated VSN traffic based on the Backbone MAC Destination Address (B-MAC-DA). A BCB can access information to send that traffic to any Backbone Edge Bridges (BEBs) in the SPBM backbone.

To forward customer traffic across the service provider backbone, the BEB for the VSN encapsulates the customer Ethernet packet received at the edge into a Backbone MAC header using the 802.1ah MAC-in-MAC encapsulation. This encapsulation hides the customer MAC (C-MAC) address in a backbone MAC (B-MAC) address pair. MAC-in-MAC encapsulation defines a BMAC-DA and BMAC-SA to identify the backbone source and destination addresses. The originating node creates a MAC header for delivery from end to end. Intermediate BCB nodes within the SPBM backbone perform packet forwarding using BMAC-DA alone. When the packet reaches the intended egress BEB, the B-MAC header is removed and the original customer packet is forwarded.

I-SID

SPBM introduces a service instance identifier called I-SID. SPBM uses I-SIDs to separate services from the infrastructure. After you create an SPBM infrastructure, you can add additional services (such as VLAN extensions) by provisioning the endpoints only. The SPBM endpoints are BEBs, which mark the boundary between the core MAC-in-MAC SPBM domain and the edge customer 802.1Q domain. I-SIDs are provisioned on the BEBs to be associated with a particular service instance. In the SPBM core, the bridges are BCBs. BCBs forward encapsulated traffic based on the BMAC-DA.

The SPBM B-MAC header includes an I-SID. The length of the I-SID is 32 bits with a 24-bit ID. I-SIDs identify and transmit virtualized traffic in an encapsulated SPBM frame. These I-SIDs are used in a VSN for VLANs or VRFs across the MAC-in-MAC backbone:

- For a Layer 2 VSN, the I-SID is associated with a customer VLAN, which is then virtualized across the backbone. Layer 2 VSNs offer an any-any LAN service type. Layer 2 VSNs associate one VLAN per I-SID.
- For a Layer 2 VSN with multicast, the BEB associates a data I-SID with the multicast stream and a scope I-SID that defines the scope as a Layer 2 VSN. A multicast stream with a Layer 2 VSN scope can only transmit a multicast stream for the same Layer 2 VSN.
- For a Layer 3 VSN, the I-SID is associated with a customer VRF, which is also virtualized across the backbone. Layer 3 VSNs are always full-mesh topologies. Layer 3 VSNs associate one VRF per I-SID.
- For a Layer 3 VSN with multicast, the BEB associates a data I-SID with the multicast stream and a scope I-SID that defines the scope as a Layer 3 VSN. A multicast stream with a Layer 3 VSN scope can only transmit a multicast stream for the same Layer 3 VSN.
- For IP shortcuts with multicast, the BEB associates a data I-SID with the multicast stream and defines the scope as Layer 3 Global Routing Table (GRT). A multicast stream with a scope of Layer 3 GRT can only transmit a multicast stream for the Layer 3 GRT.

Encapsulating customer MAC addresses in backbone MAC addresses greatly improves network scalability (no end-user C-MAC learning is required in the core) and also significantly improves network robustness (loops have no effect on the backbone infrastructure).

The following figure shows the components of a basic SPBM architecture.

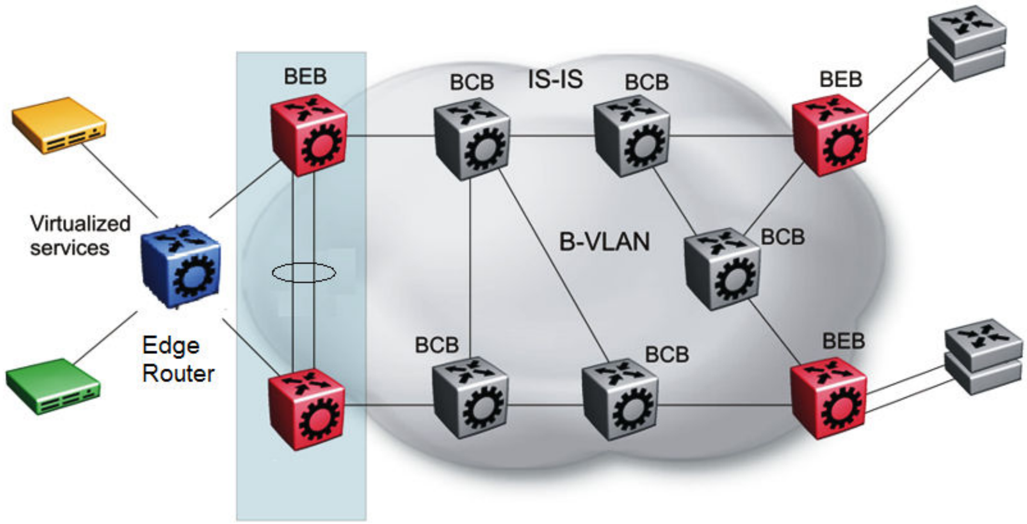


Figure 43: SPBM basic architecture

VLANs without member ports

The Avaya Ethernet Routing Switch 8800 manages VLANs without member ports differently than the Virtual Services Platform 9000 and Virtual Services Platform 4000.

- The Ethernet Routing Switch 8800 always designates the VLAN as operationally up if there is an attached I-SID.
- The Virtual Services Platform 9000 and Virtual Services Platform 4000 designate the VLAN as operationally up only if there is a matching I-SID in the SPBM network. For more information, see the following sections.

Ethernet Routing Switch 8800 implementation

If a VLAN has an IP address and is attached to an I-SID, the ERS 8800 designates that VLAN as operationally up whether it has a member port or not. When the VLAN is operationally up, the IP address of the VLAN will be in the routing table.

The ERS 8800 design behaves this way because the VLAN might be acting as an NNI in cases of Layer 2 Inter-VSN routing. If the VLAN was acting as a UNI interface, it would require a member port.

Virtual Services Platform 9000 and Virtual Services Platform 4000 implementation

If a VLAN is attached to an I-SID there must be another instance of that same I-SID in the SPBM network.

- If another instance of that I-SID exists, the device designates that VLAN as operationally up regardless of whether it has a member port or not.

When the VLAN is operationally up, the IP address of the VLAN will be in the routing table.

- If no matching instance of the I-SID exists in the SPBM network, then that VLAN has no reachable members and does not act as an NNI interface.

  The VLAN does not act as a UNI interface because it does not have a member port.

  Therefore, the device does not designate the VLAN as operationally up because the VLAN does not act as a UNI or an NNI interface.

If the device acts as a BCB with two VLANs configured and two I-SIDs, there must be a UNI side with the corresponding I-SID existing in the network.

If the device acts as both BEB and BCB, then there must be a member port in that VLAN to push out the UNI traffic.

Provisioning

This section summarizes how to provision SPBM. For information about specific configuration commands, see *Configuring Avaya Fabric Connect on VSP Operating System Software*, NN47227-510.

Infrastructure provisioning

Provisioning an SPBM core is as simple as enabling SPBM and IS-IS globally, and on all the IS-IS core Ethernet links on all the BCB and BEB nodes. The IS-IS protocol operates at Layer 2 so it does not need IP addresses configured on the links to form IS-IS adjacencies with neighboring switches (like OSPF does). You do not need to configure IP addresses on any of the core links. The encapsulation of customer MAC addresses in backbone MAC addresses greatly improves network scalability.

No flooding or learning of end-user MACs occurs in the backbone. This SPBM provisioning significantly improves network robustness, as customer-introduced network loops have no effect on the backbone infrastructure.

Service provisioning

Provision I-SIDs on a BEB to associate that BEB with a particular service instance. After you map the customer VLAN or VRF into an I-SID, any BEB that has the same I-SID configured can participate in the same Layer 2 or Layer 3 VSN. This same simplicity extends to provisioning the services to run above the SPBM backbone:

- To create a Layer 2 VSN, associate an I-SID number with an edge VLAN.
- To create a Layer 3 VSN, associate an I-SID number with a VRF and configure the desired IS-IS IP route redistribution within the newly created Layer 3 VSN.

Note:

No service provisioning is needed on the core BCB SPBM switches. This provides a robust carrier grade architecture where configuration on the core switches never needs to be updated when adding new services.

IP multicast over Fabric Connect

Provisioning IP multicast over Fabric Connect is as simple as enabling multicast over Fabric Connect on the BEBs. You do not need to enable IP multicast over Fabric Connect on the BCBs.

For Layer 2 VSN using IP multicast over Fabric Connect, configure Internet Group Management Protocol (IGMP) snooping on the VLAN that represents the Layer 2 VSN.

For Layer 3 VSNs using IP multicast over Fabric Connect, configure the Layer 3 VSN as a multicast VSN, and then enable IP multicast over Fabric Connect on each VLAN within the VRF to which IP multicast senders and receivers attach.

For IP shortcuts using IP multicast over Fabric Connect, enable IP multicast over Fabric Connect on each of the VLANs within the Global Routing Table (GRT) that need to support IP multicast traffic.

Implementation options

The SPBM architecture is architecturally simple and easy to provision, but it is not just for simple networks. SPBM supports multiple implementation options within the same network to meet the demands of the most complex network configurations. The following figure shows how SPBM supports multiple campus networks as well as multiple data centers.

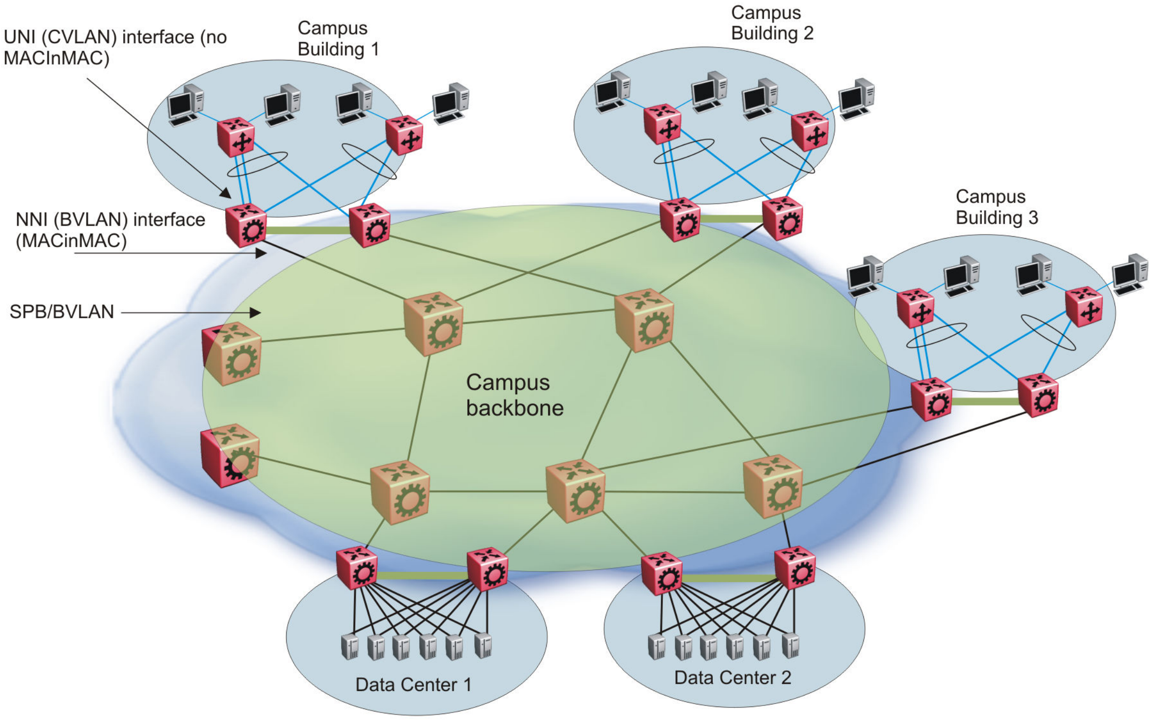


Figure 44: SPBM support for campus and data center architecture

Within the SPBM architecture, you can implement multiple options. The following figure shows all the options that SPBM supports.

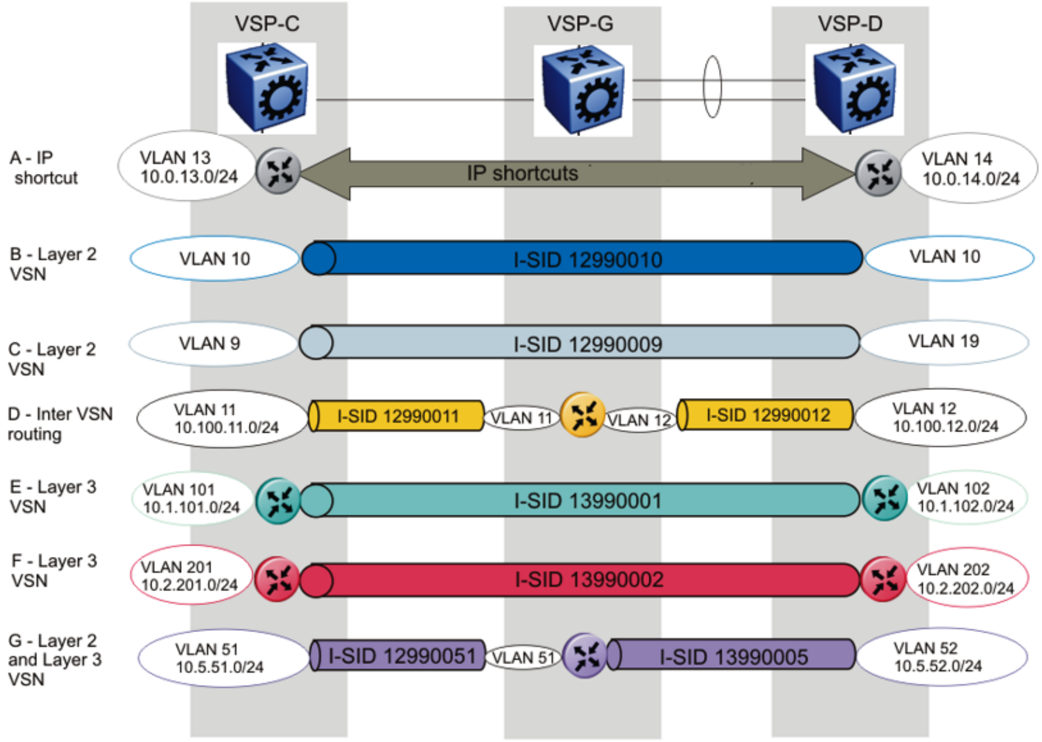


Figure 45: SPBM implementation options

The following sections describe the options that are illustrated in the preceding figure.

A—IP shortcut

IP shortcuts forward standard IP packets over IS-IS. This option enables you to forward IP over the SPBM core, which is a simpler method than traditional IP routing or MPLS. SPBM nodes propagate Layer 3 reachability as leaf information in the IS-IS link-state packets (LSP) using Extended IP reachability type-length-value (TLV) 135, which contains routing information such as neighbors and locally configured subnets. SPBM nodes that receive the reachability information use this information to populate the routes to the announcing nodes. All TLVs announced in the IS-IS LSPs are grafted onto the shortest-path tree (SPT) as leaf nodes.

An IP route lookup is only required once where the source BEB uses the routing table to identify the BEB closest to the destination subnet. All other nodes perform standard Ethernet switching based on the existing SPT. This scenario allows for end to end IP-over-Ethernet forwarding without the need for Address Resolution Protocol (ARP), flooding, or reverse learning. Because BCB SPBM nodes only forward on the MAC addresses that comprise the B-MAC header, and because unknown TLVs in IS-IS are relayed to the next hop but ignored locally, SPBM BCB nodes do not require information about IP subnets to forward IP traffic. Only BEBs generate and receive Extended IP reachability TLV to build the routing table; BCBs just relay the TLV to the next hop based on the SPT. In fact, the Extended IP reachabilty TLV is ignored on BCBs.

With IP shortcuts there are only two IP routing hops (ingress BEB and egress BEB) as the SPBM backbone acts as a virtualized switching backplane.

IP shortcuts do not require I-SID configuration. However, you must enable IP on IS-IS, and configure the IS-IS source address to match a circuitless or loopback IP address.

In Figure 45: SPBM implementation options on page 98, node VSP-G acts as a BCB for the service, and has no IP configuration.

B—Layer 2 VSN

A Layer 2 Virtual Services Network (VSN) bridges customer VLANs (C-VLANs) over the SPBM core infrastructure. A Layer 2 VSN associates a C-VLAN with an I-SID, which is then virtualized across the backbone. All VLANs in the network that share the same I-SID can participate in the same VSN. If you use Split MultiLink Trunking (SMLT) clusters or if you want IS-IS to distribute traffic across two equal-cost paths, then you need two backbone VLANs (B-VLAN) with a primary B-VLAN and a secondary B-VLAN. Otherwise, you need only a single B-VLAN.

One of the key advantages of the SPBM Layer 2 VSN is that network virtualization provisioning is achieved by configuring the edge of the network (BEBs) only. The intrusive core provisioning that other Layer 2 virtualization technologies require is not needed when new connectivity services are added to the SPBM network. For example, when new virtual server instances are created and need their own VLAN instances, they are provisioned at the network edge only and do not need to be configured throughout the rest of the network infrastructure.

Based on its I-SID scalability, this solution can scale much higher than any 802.1Q tagging-based solution. Also, because there is no need for Spanning Tree in the core, this solution does not need any core link provisioning for normal operation. Redundant connectivity between the C-VLAN domain and the SPBM infrastructure can be achieved by operating two SPBM switches in switch clustering (SMLT) mode. This allows the dual homing of any traditional link-aggregation-capable device into an SPBM network

In Figure 45: SPBM implementation options on page 98, nodes VSP-C and VSP-D act as BEBs for the VSN. Only these nodes have a MAC table or forwarding database for C-VLAN 10.

C—Layer 2 VSN with VLAN translation

Layer 2 VSNs with VLAN translation are basically the same as the Layer 2 VSNs, except that the BEBs on either end of the SPBM network belong to different VLANs. With this option, you can connect one VLAN to another VLAN. In Figure 45: SPBM implementation options on page 98, VLAN 9 connects to VLAN 19. The mechanism that connects them is that they use the same I-SID (12990009).

D—Inter-VSN routing

Inter-VSN routing allows routing between Layer 2 VLANs with different I-SIDs. You can use Inter-VSN routing to redistribute routes between Layer 2 VLANs. This option allows effective networking of multiple VSNs. Where you could use Layer 2 VSN with VLAN translation to interconnect VLANs, this option takes that concept one step further and allows you to interconnect VSNs. This option also provides the ability to route IP traffic on Layer 2 VSNs that enter on NNIs, which is especially useful for Layer 2 edge solutions.

As seen in Figure 45: SPBM implementation options on page 98, routing between VLANs 11 and 12 occurs on the SPBM core switch VSP-G shown in the middle of the figure. With Inter-VSN routing enabled, VSP-G transmits traffic between VLAN 11 (I-SID 12990011) and VLAN 12 (I-SID 12990012) on the VRF instance configured. Note that for these VSNs, node VSP-G acts as a BEB.

E—Layer 3 VSN

Layer 3 VSNs are very similar to Layer 2 VSNs. The difference between the two is that Layer 2 VSNs associate I-SIDs with VLANs. Layer 3 VSNs associate I-SIDs with VRFs. With the Layer 3 VSN option, all VRFs in the network that share the same I-SID can participate in the same VSN by advertising their reachable IP routes into IS-IS and installing IP routes learned from IS-IS. Suitable IP redistribution policies need to be defined to determine what IP routes a BEB will advertise to IS-IS.

As seen in Figure 45: SPBM implementation options on page 98, the green VRF on VSP-C is configured to advertise its local or direct IP routes into IS-IS within I-SID 13990001. The VRF on node VSP-D, which is also a member of the same I-SID, installs these IP routes in its VRF IP routing table with a next-hop B-MAC address of VSP-C. Therefore, when the VRF on node VSP-D needs to IP route traffic to the IP subnet off VSP-C, it performs a lookup in its IP routing table and applies a MAC-in- MAC encapsulation with B-MAC DA of VSP-C. The SPBM core ensures delivery to the egress BEB VSP-C where the encapsulation is removed and the packet is IP routed onward.

Note:

Like the IP shortcut service, there are only two IP routing hops (ingress BEB and egress BEB) as the SPBM backbone acts as a virtualized switching backplane.

F—Layer 3 VSN

Figure 45: SPBM implementation options on page 98 shows two VRFs (green and red) to illustrate that the BEBs can associate I-SIDs with multiple VRFs. The Layer 3 VSN option provides IP connectivity over SPBM for all of your VRFs.

G—Layer 2 VSN and Layer 3 VSN

Figure 45: SPBM implementation options on page 98 shows both a Layer 2 VSN and a Layer 3 VSN to show that you can configure both options on the same BEBs. This topology is simply made up of a number of BEBs that terminate VSNs of both types. This example illustrates the flexibility to extend one or more edge VLANs (using one or more Layer 2 VSNs) to use a default gateway that is deeper in the SPBM core. From here, traffic can then be IP routed onward as either nonvirtualized with IP shortcuts or, as shown in this example, with a virtualized Layer 3 VSN. Note that in this example the central node VSP-G is now also acting as BEB for both service types as it now maintains both a MAC table for the Layer 2 VSN it terminates, and an ARP cache and IP routing table for the Layer 3 VSN it also terminates.

Multiple tenants using different SPBM services

The following figure shows multiple tenants using different services within an SPBM metro network. In this network, you can use some or all of the SPBM implementation options to meet the needs of the community while maintaining the security of information within VLAN members.

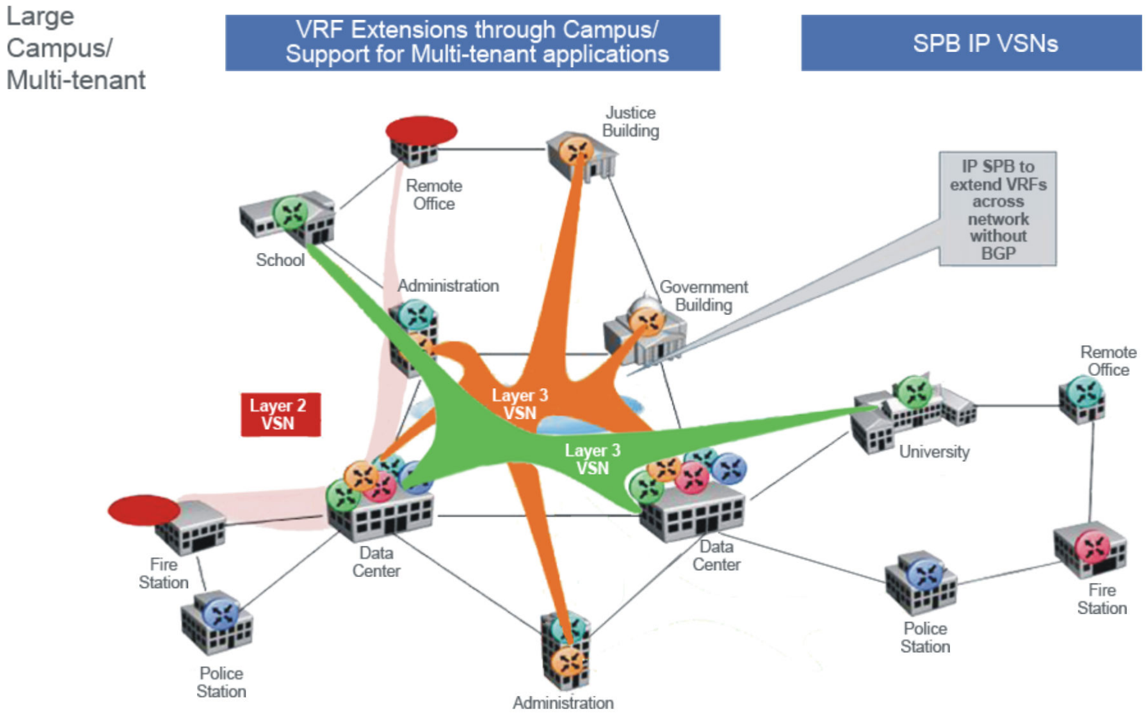


Figure 46: Multi-tenant SPBM metro network

To illustrate the versatility and robustness of SPBM even further, the following figure shows a logical view of multiple tenants in a ring topology. In this architecture, each tenant has its own domain where some users have VLAN requirements and are using Layer 2 VSNs and others have VRF requirements and are using Layer 3 VSNs. In all three domains, they can share data center resources across the SPBM network.

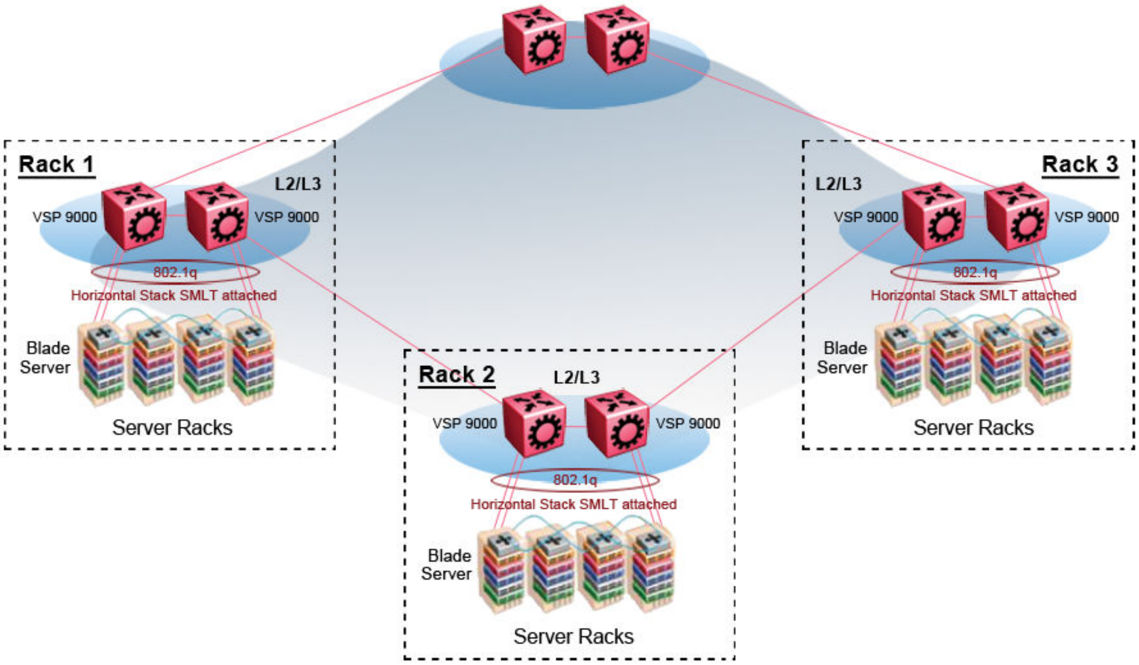


Figure 47: SPBM ring topology with shared data centers

Reference architectures

SPBM has a straightforward architecture that simply forwards encapsulated C-MACs across the backbone. Because the B-MAC header stays the same across the network, there is no need to swap a label or perform a route lookup at each node. This architecture allows the frame to follow the most efficient forwarding path from end to end.

The following reference architectures illustrate SPBM with multiple VSP and ERS systems in a network. For information about solution-specific architectures like Video Surveillance or Data Center implementation using the VSP 4000, see Solution specific reference architectures on page 115.

The following figure shows the MAC-in-MAC SPBM domain with BEBs on the boundary and BCBs in the core.

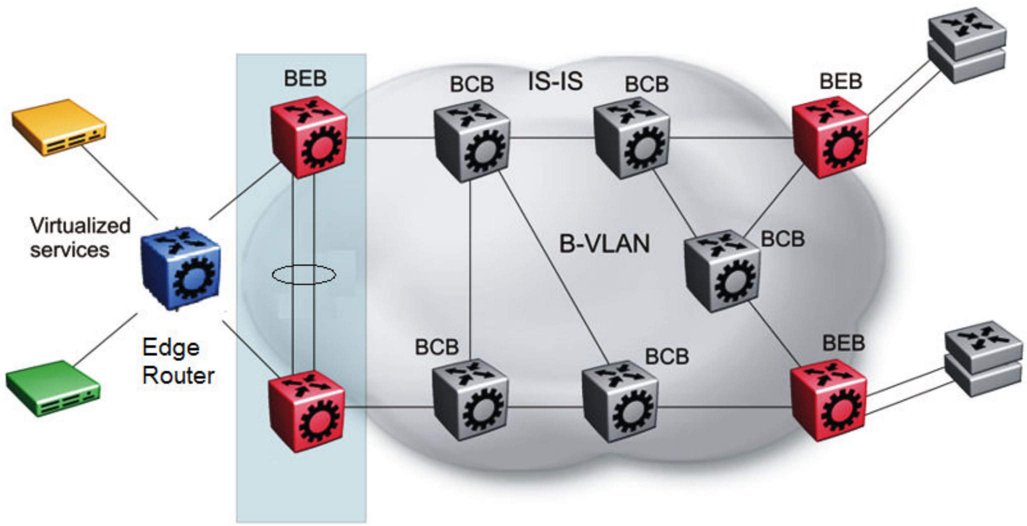


Figure 48: SPBM basic architecture

Provisioning an SPBM core is as simple as enabling SPBM and IS-IS globally on all the nodes and on the core facing links. To migrate an existing edge configuration into an SPBM network is just as simple.

The boundary between the MAC-in-MAC SPBM domain and the 802.1Q domain is handled by the BEBs. At the BEBs, VLANs or VRFs are mapped into I-SIDs based on the local service provisioning. Services (whether Layer 2 or Layer 3 VSNs) only need to be configured at the edge of the SPBM backbone (on the BEBs). There is no provisioning needed on the core SPBM nodes.

The following figure illustrates an existing edge that connects to an SPBM core.

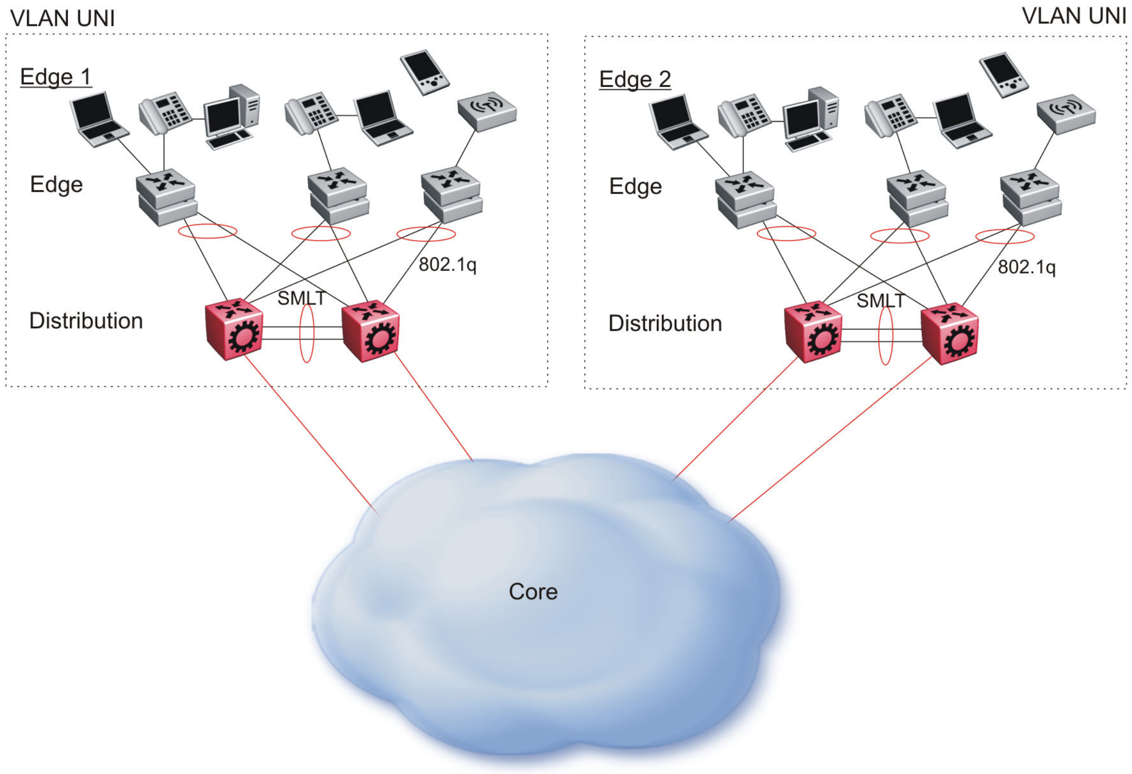


Figure 49: Access to the SPBM Core

For Layer 2 virtualized bridging (Layer 2 VSN), identify all the VLANs that you want to migrate into SPBM and assign them to an I-SID on the BEB.

For Layer 3 virtualized routing (Layer 3 VSN), map IPv4-enabled VLANs to VRFs, create an IP VPN instance on the VRF, assign an I-SID to the VRF, and then configure the desired IP redistribution of IP routes into IS-IS.

All BEBs that have the same I-SID configured can participate in the same VSN. That completes the configuration part of the migration and all the traffic flows return to normal operation.

SPBM on VSP 4000 supports the following traffic:

- Layer 2 bridged traffic (Layer 2 VSN)
- IPv4 unicast routed traffic on the Global Router (IP shortcuts)
- IPv4 unicast routed traffic using a VRF (Layer 3 VSN)
- IPv4 unicast routed traffic using different VSNs, which have different I-SIDs (Inter-VSN)
- Layer 2 IP multicast traffic in a bridged network (Layer 2 VSN with IP multicast over Fabric Connect)
- IPv4 multicast routed traffic on the Global Router (IP shortcuts with IP multicast over Fabric Connect)
- IPv4 multicast routed traffic using a VRF (Layer 3 VSN with IP multicast over Fabric Connect)

SMLT

If your existing edge configuration uses SMLT, you can maintain that SMLT-based resiliency for services configured on the vIST peer switches. SPBM requires that you upgrade both vIST peer to the current release and identify two VLANs to use as B-VLANs. SPBM then automatically creates a virtual backbone MAC for the vIST pair, and advertises it with IS-IS. By operating two SPBM switches in switch clustering (SMLT) mode, you can achieve redundant connectivity between the C-VLAN domain and the SPBM infrastructure. This configuration allows the dual homing of any traditional link aggregation capable device into an SPBM network.

SMLT with IP multicast over Fabric Connect

Layer 2 access switches use IGMP Snooping to prune multicast traffic. In IP multicast over Fabric Connect, BEBs are the IGMP queriers, therefore access switches forward multicast data from the senders as well as IGMP control messages from receivers to the BEBs.

1. When a sender transmits multicast data to the Layer 2 access switch that has an MLT to the switch cluster, the multicast data is hashed towards one or the other BEBs in the switch cluster.
2. The receiving BEB allocates a Data I-SID and sends a TLV update on the primary B-VLAN, to announce the availability of the stream to its neighbors.
3. The BEB propagates the TLV update through the SPBM fabric in an LSP, so all BEBs are aware of this stream availability.
4. The sender information is also synchronized over the vIST to the peer switch.
5. Then the peer switch allocates a Data I-SID for the multicast stream, and sends a TLV update on the secondary B-VLAN to announce the stream availability.

Campus architecture

For migration purposes, you can add SPBM to an existing network that has SMLT configured. In fact, if there are other protocols already running in the network, such as Open Shortest Path First (OSPF), you can leave them in place too. SPBM uses IS-IS, and operates independently from other protocols. However, Avaya recommends that you eventually eliminate SMLT in the core and eliminate other unnecessary protocols. This reduces the complexity of the network and makes it much simpler to maintain and troubleshoot.

Whether or not you configure SMLT in the core, the main point to remember is that SPBM separates services from the infrastructure. For example, in a large campus, a user may need access to other sites or data centers. With SPBM you can grant that access by associating the user to a specific I-SID. With this mechanism, the user can work without getting access to confidential information of another department.

The following figure depicts a topology where the BEBs in the edge and data center distribution nodes are configured in SMLT clusters. Prior to implementing SPBM, the core nodes would also have been configured as SMLT clusters. When migrating SPBM onto this network design, it is important to note that you can deploy SPBM over the existing SMLT topology without network interruption. After the SPBM infrastructure is in place, you can create VSN services over SPBM or migrate them from the previous end-to-end SMLT-based design.

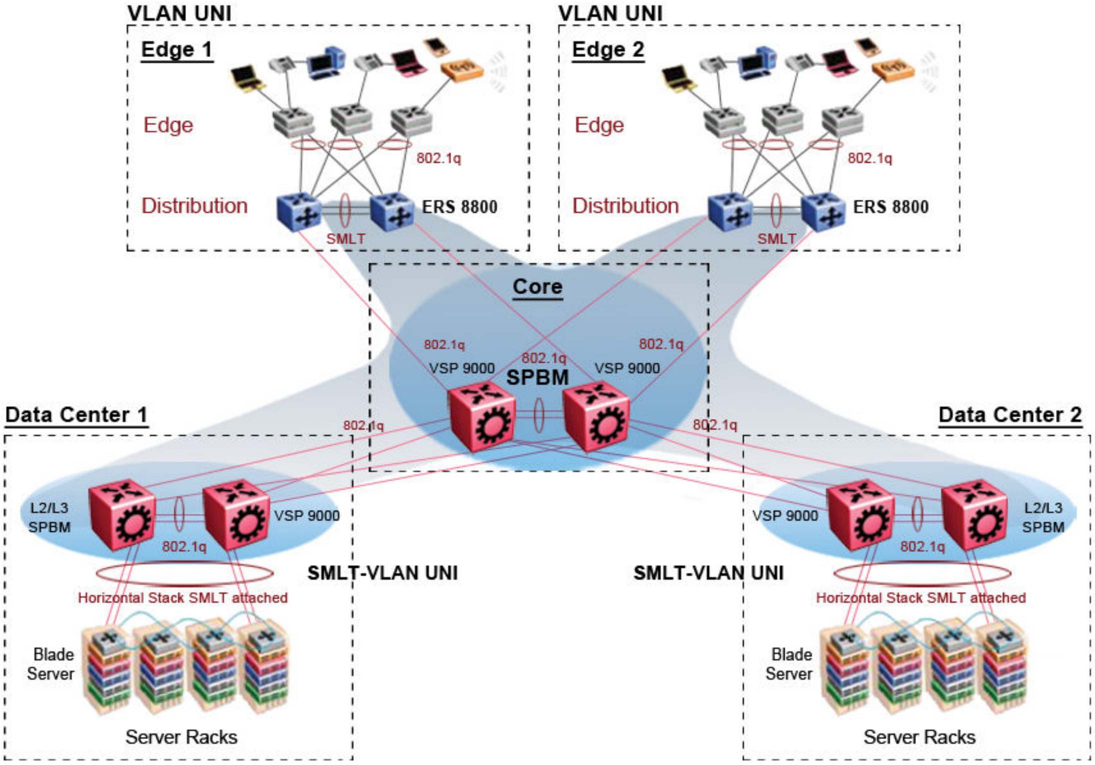


Figure 50: SPBM campus without SMLT

After you migrate all services to SPBM, the customer VLANs (C-VLANs) will exist only on the BEB SMLT clusters at the edge of the SPBM network. The C-VLANs will be assigned to an I-SID instance and then associated with either a VLAN in an Layer 2 VSN or terminated into a VRF in an Layer 3 VSN. You can also terminate the C-VLAN into the default router, which uses IP shortcuts to IP route over the SPBM core.

In an SPBM network design, the only nodes where it makes sense to have an SMLT cluster configuration is on the BEB nodes where VSN services terminate. These are the SPBM nodes where C-VLANs exist and these C-VLANs need to be redundantly extended to non-SPBM devices such as Layer 2 edge stackable switches. On the BCB core nodes where no VSNs are terminated and no Layer 2 edge stackables are connected, there is no longer any use for the SMLT clustering functionality. Therefore, in the depicted SPBM design, the SMLT/vIST configuration can be removed from the core nodes because they now act as pure BCBs that simply transport VSN traffic and the only control plane protocol they need to run is IS-IS.

Because SMLT BEB nodes exist in this design (the edge BEBs) and it is desirable to use equal cost paths to load balance VSN traffic across the SPBM core, all SPBM nodes in the network are configured with the same two B-VIDs.

Where Figure 50: SPBM campus without SMLT on page 106 shows the physical topology, the following two figures illustrate a logical rendition of the same topology. In both of the following figures, you can see that the core is almost identical. Because the SPBM core just serves as a transport mechanism that transmits traffic to the destination BEB, all the provisioning is performed at the edge.

In the data center, VLANs are attached to Inter-VSNs that transmit the traffic across the SPBM core between the data center on the left and the data center on the right. A common application of this service is VMotion moving VMs from one data center to another.

The following figure uses IP shortcuts that route VLANs. There is no I-SID configuration and no Layer 3 virtualization between the edge distribution and the core. This is normal IP forwarding to the BEB.

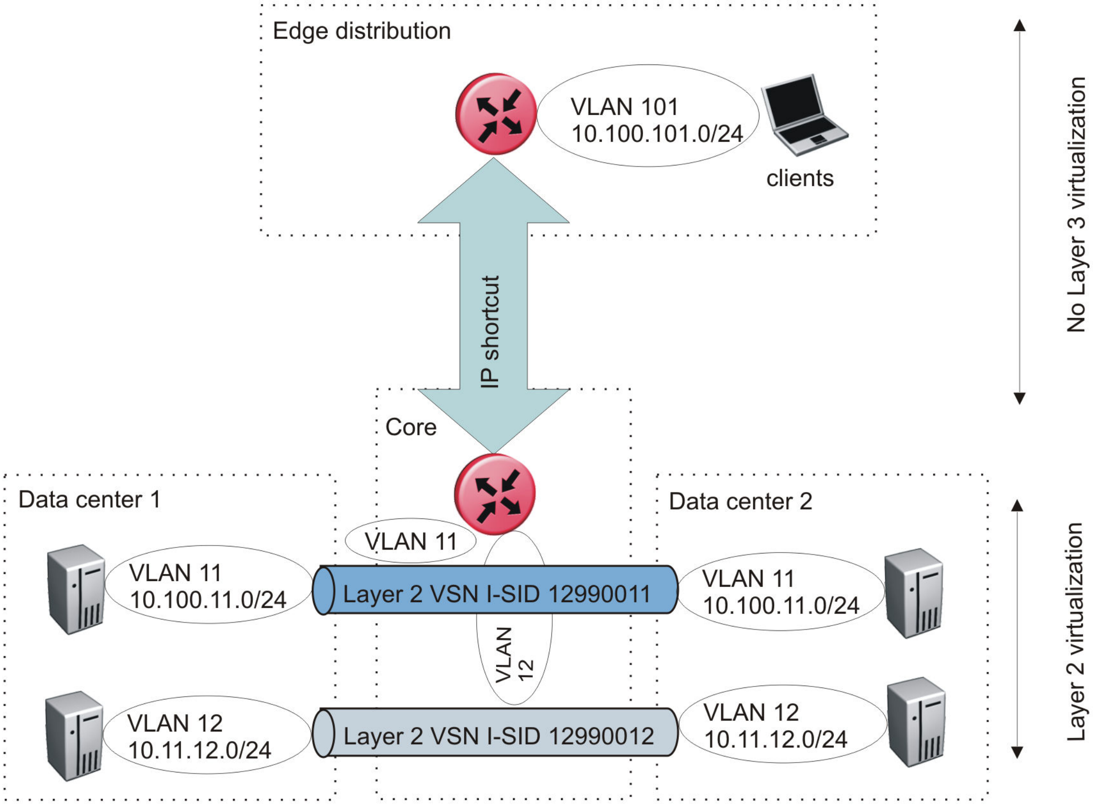


Figure 51: IP shortcut scenario to move traffic between data centers

The following figure uses Layer 3 VSNs to route VRFs between the edge distribution and the core. The VRFs are attached to I-SIDs and use Layer 3 virtualization.

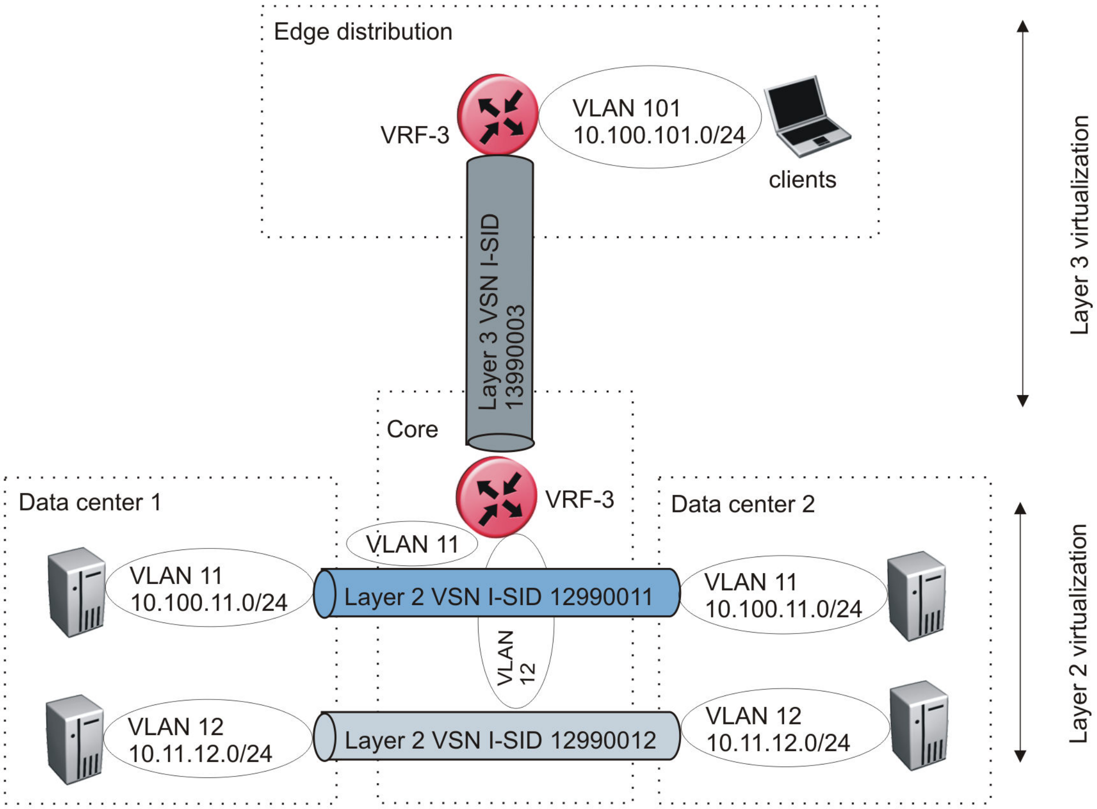


Figure 52: VRF scenario to move traffic between data centers

Multicast architecture

Networks today either have inefficient bridged IP multicast networks (Internet Group Management Protocol, or IGMP) or IP multicast networks that require multiple protocols that are complex to configure and operate. IP multicast over Fabric Connect builds on the simplicity of Avaya Fabric Connect using SPBM for the control plane with support for bridged and routed IP multicast traffic, without the inefficiencies or complexities that exist in other topologies today.

This functionality extends the SPBM IS-IS control plane to additionally exchange IP multicast stream advertisement and membership information, which means that you can use SPBM for Layer 2 (unicast, broadcast, multicast) virtualization as well as Layer 3 (unicast, multicast) routing and forwarding virtualization.

IP multicast over Fabric Connect supports three operational models:

1. Layer 2 Virtual Services Network with IGMP support on the access networks for optimized forwarding of IP multicast traffic in a bridged network (L2 VSN with multicast)
2. IP multicast routing support for Global Routing Table using Shortest Path Bridging (SPB) in the core (IP shortcuts with multicast)
3. Layer 3 Virtual Services Network with VRF based IP multicast routing support over SPB in the core and IGMP on the access (L3 VSN with multicast)

All multicast streams are constrained within the level in which they originate, which is called the scope level. In other words, if a sender transmits a multicast stream to a BEB on a C-VLAN with IP multicast over Fabric Connect enabled, only receivers that are part of the same Layer 2 VSN can receive that stream. Similarly, if a sender transmits a multicast stream to a BEB on a VLAN that is part of the Layer 3 VSN with IP multicast over Fabric Connect enabled, only receivers that are part of the same Layer 3 instance can receive that stream.

IP multicast over Fabric Connect uses BEBs to act as senders and receivers of data. After a BEB receives IP multicast data from a sender, a BEB allocates a data I-SID in the range of 16,000,000 to 16,512,000 for the stream. The stream is identified by the S,G,V tuple, which is the source IP address, group IP Address, and the stream is identified by the local VLAN on which the stream is received. The BEB also sends a TLV update to its neighbors to inform them of the presence of an IP multicast stream, along with identifying the sender. The BEB propagates the information through the SPBM cloud through IS-IS TLV updates in LSPs that result in a multicast tree being created for that stream.

IGMP handles group membership registration to enable members to receive data. IGMP snooping listens to conversations between hosts and routers, and maintains a table of links that require IP multicast streams.

The BEBs also act as IGMP queriers and send out periodic IGMP queries. The IGMP querier enables the creation of the link table. After a BEB receives an IGMP join message from a receiver, a BEB queries the IS-IS database to check if a sender exists for the requested stream within the scope of the receiver. If the requested stream does not exist, the IGMP information is kept, but no further action is taken. If the requested stream exists, the BEB sends an IS-IS TLV update to its neighbors to inform them of the presence of a receiver and this information is propagated through the SPBM cloud.

IS-IS acts dynamically using the TLV information it receives from BEBs that connect to the sender and the receivers to create a multicast tree between them.

The following figure shows how multicast senders and receivers connect to the SPBM cloud using BEBs.

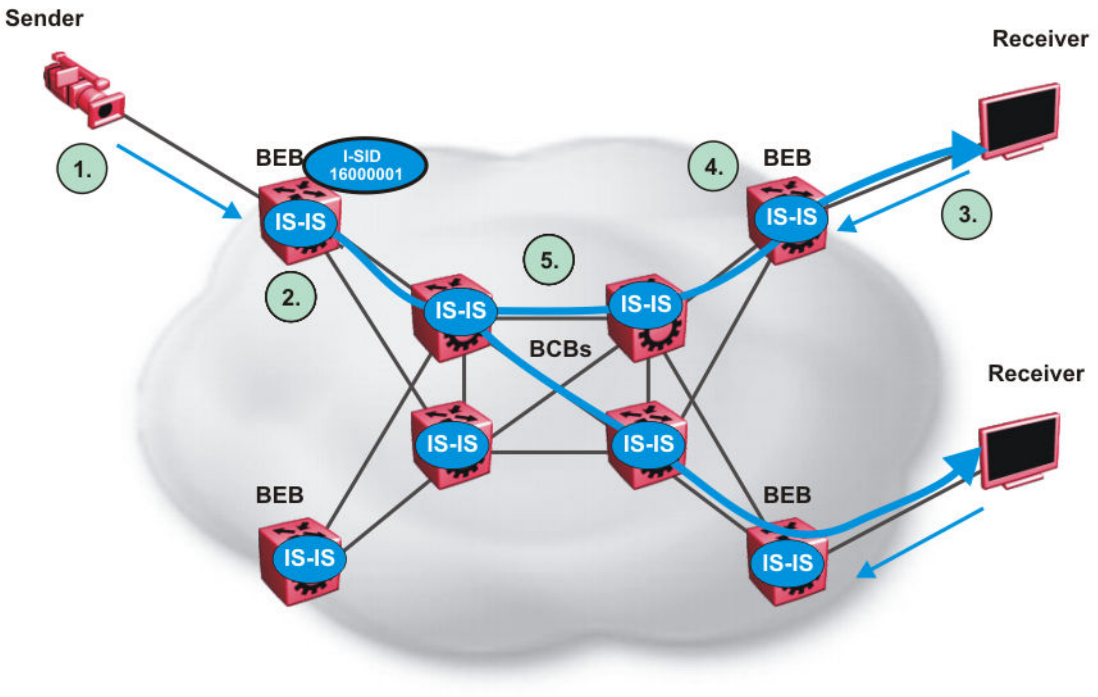


Figure 53: IP multicast over Fabric Connect streams

The following steps describe how multicast senders and receivers connect to the SPBM cloud using BEBs, as illustrated in the preceding figure:

1. The sender sends multicast traffic with group IP address 233.252.0.1.
2. After the BEB receives the IP multicast stream from the sender, the BEB allocates data I-SID 16000001 for the S,G multicast stream. The BEB sends a link-state packet with the Internet Protocol multicast (IPMC) TLV (for Layer 2 VSN and Layer 3 VSN) or Internet Protocol Virtual Private Network (IPVPN) TLV (for IP shortcuts for multicast) with the transmit bit set. The BEB also sends an IS-IS service identifier and unicast address sub-TLV (where the unicast address has the multicast bit set and the I-SID is the data I-SID).
3. The receiver sends a join request to group 233.252.0.1.
4. The BEB (acting as the IGMP querier) queries the IS-IS database to find all senders for group 233.252.0.1. If the group exists, the BEB sends an IS-IS service identifier and unicast address sub-TLV (where the unicast address has the multicast bit set and the nickname is the stream transmitter BEB and the I-SID is the data I-SID). If the requested stream does not exist, the BEB keeps the IGMP information, but no further action is taken.
5. IS-IS acts dynamically using the TLV information it receives from BEBs that connect to the sender and receivers to create a multicast tree between them, and the data starts flowing from the sender.

For conceptual and configuration information on IP multicast over Fabric Connect, see *Configuring Avaya Fabric Connect on VSP Operating System Software*, NN47227-510.

Large data center architecture

SPBM supports data centers with IP shortcuts, Layer 2 VSNs, or Layer 3 VSNs. If you use vMotion, you must use Layer 2 between data centers (Layer 2 VSN). With Layer 2 VSNs, you can add IP addresses to the VLAN on both data centers and run Virtual Router Redundancy Protocol (VRRP) between them to allow the ESX server to route to the rest of the network.

The following figure shows an SPBM topology of a large data center. This figure represents a full-mesh data center fabric using SPBM for storage over Ethernet. This topology is optimized for storage transport because traffic never travels more than two hops.

Note:

Avaya recommends that you use a two-tier, full-mesh topology for large data centers.

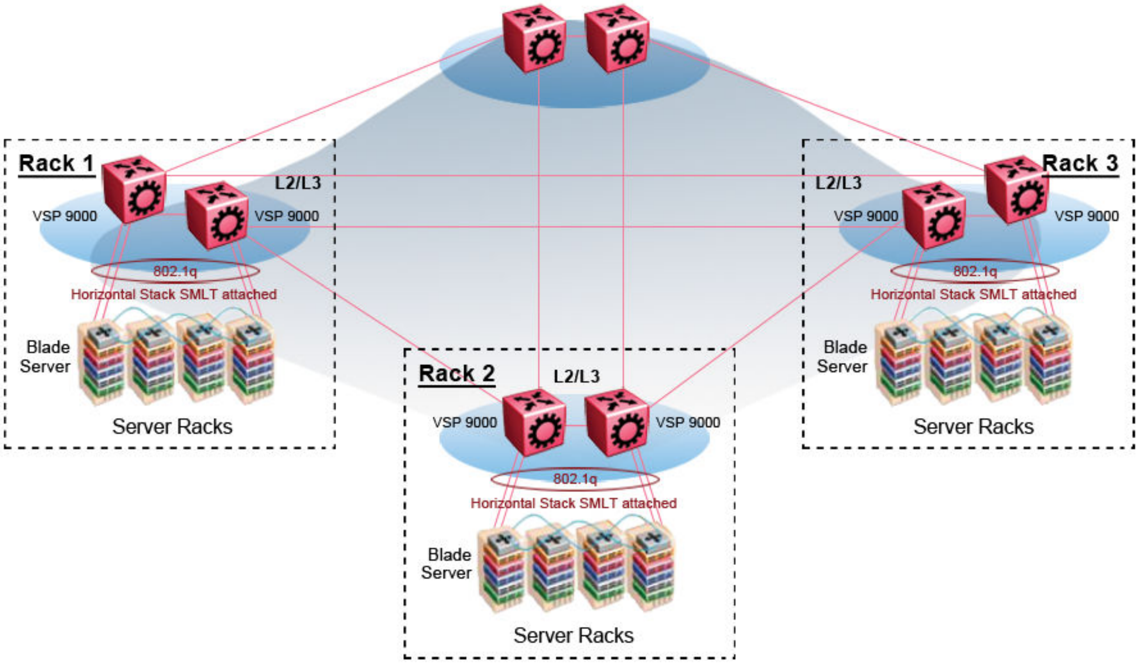


Figure 54: SPBM data center—full mesh

Traditional data center routing of VMs:

In a traditional data center configuration, the traffic flows into the network to a VM and out of the network in almost a direct path.

The following figure shows an example of a traditional data center with VRRP configured. Because end stations are often configured with a static default gateway IP address, a loss of the default gateway router causes a loss of connectivity to the remote networks. VRRP eliminates the single point of failure that can occur when the single static default gateway router for an end station is lost.

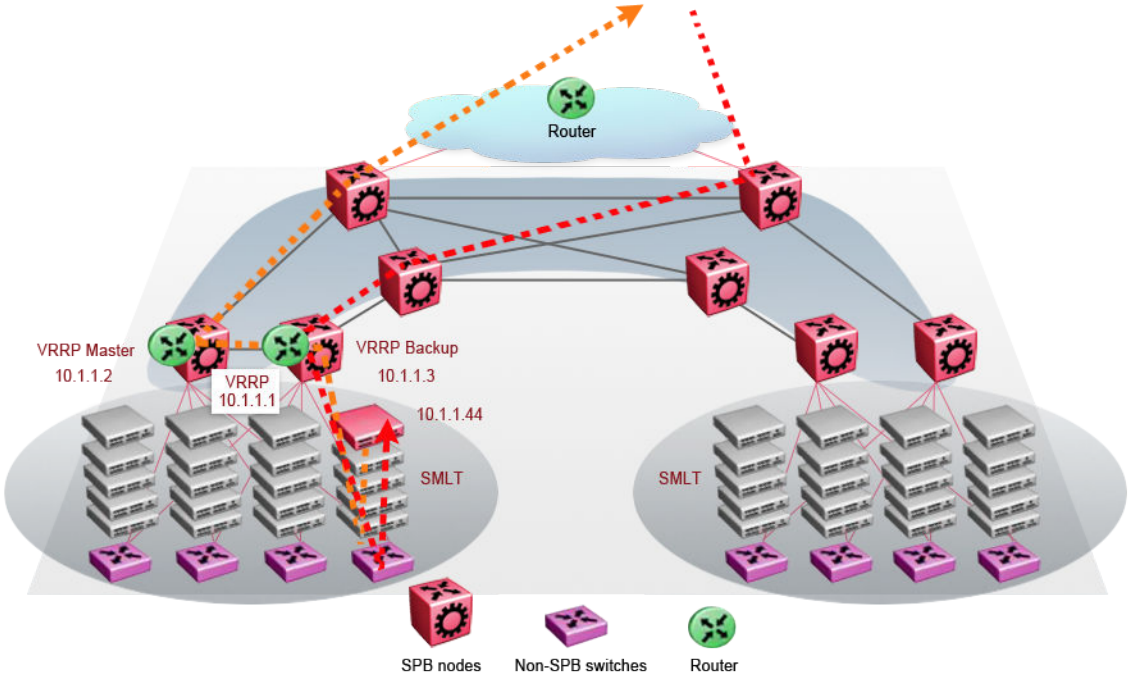


Figure 55: Traditional routing before moving VMs

A VM is a virtual server. When you move a VM, the virtual server is moved as is. This action means that the IP addresses of that server remain the same after the server is moved from one data center to the other. This in turn dictates that the same IP subnet (and hence VLAN) exist in both data centers.

In the following figure, the VM moved from the data center on the left to the data center on the right. To ensure a seamless transition that is transparent to the user, the VM retains its network connections through the default gateway. This method works, but it adds more hops to all traffic. As you can see in the figure, one VM move results in a complicated traffic path. Multiply this with many moves and soon the network look like a tangled mess that is very inefficient, difficult to maintain, and almost impossible to troubleshoot.

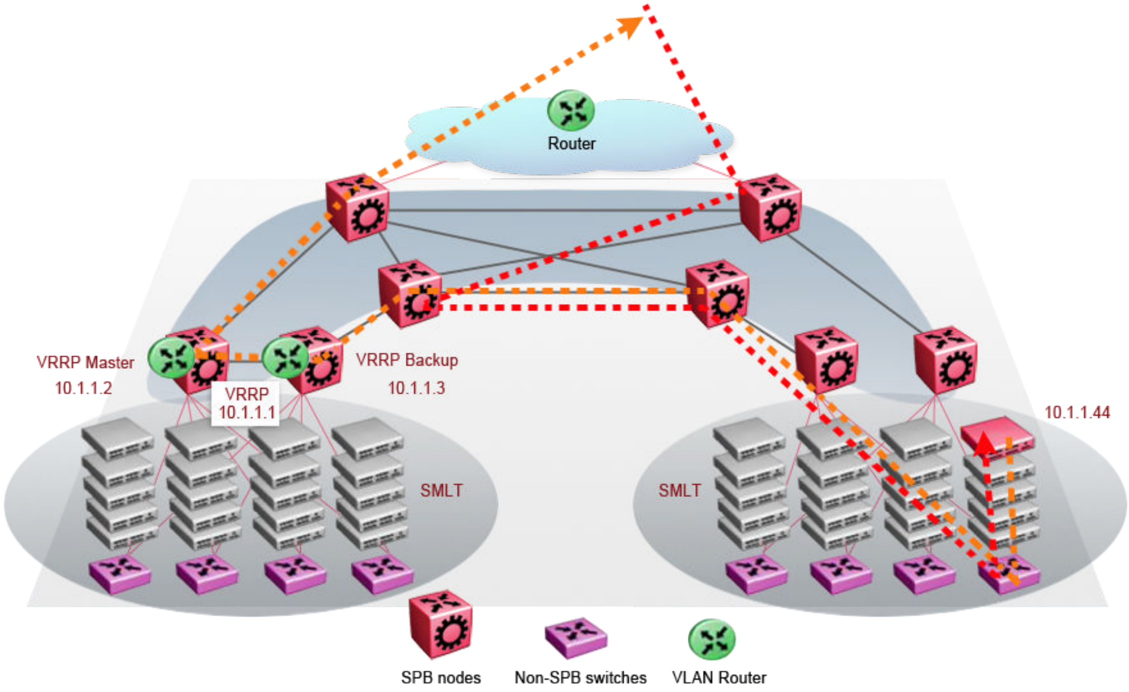


Figure 56: Traditional routing after moving VMs

Optimized data center routing of VMs:

Two features make a data center optimized:

- VLAN routers in the Layer 2 domain (green icons)
- VRRP BackupMaster

The VLAN routers use lookup tables to determine the best path to route incoming traffic (red dots) to the destination VM.

VRRP BackupMaster solves the problem of traffic congestion on the vIST. Because there can be only one VRRP Master, all other interfaces are in backup mode. In this case, all traffic is forwarded over the vIST link towards the primary VRRP switch. All traffic that arrives at the VRRP backup interface is forwarded, so there is not enough bandwidth on the vIST link to carry all the aggregated riser traffic. VRRP BackupMaster overcomes this issue by ensuring that the vIST trunk is not used in such a case for primary data forwarding. The VRRP BackupMaster acts as an IP router for packets destined for the logical VRRP IP address. All traffic is directly routed to the destined subnetwork and not through Layer 2 switches to the VRRP Master. This avoids potential limitation in the available vIST bandwidth.

The following figure shows a solution that optimizes your network for bidirectional traffic flows. However, this solution turns two SPBM BCB nodes into BEBs where MAC and ARP learning will be enabled on the Inter-VSN routing interfaces. If you do not care about top-down traffic flows, you can omit the Inter-VSN routing interfaces on the SPBM BCB nodes. This makes the IP routed paths top-down less optimal, but the BCBs remain pure BCBs, thus simplifying core switch configurations.

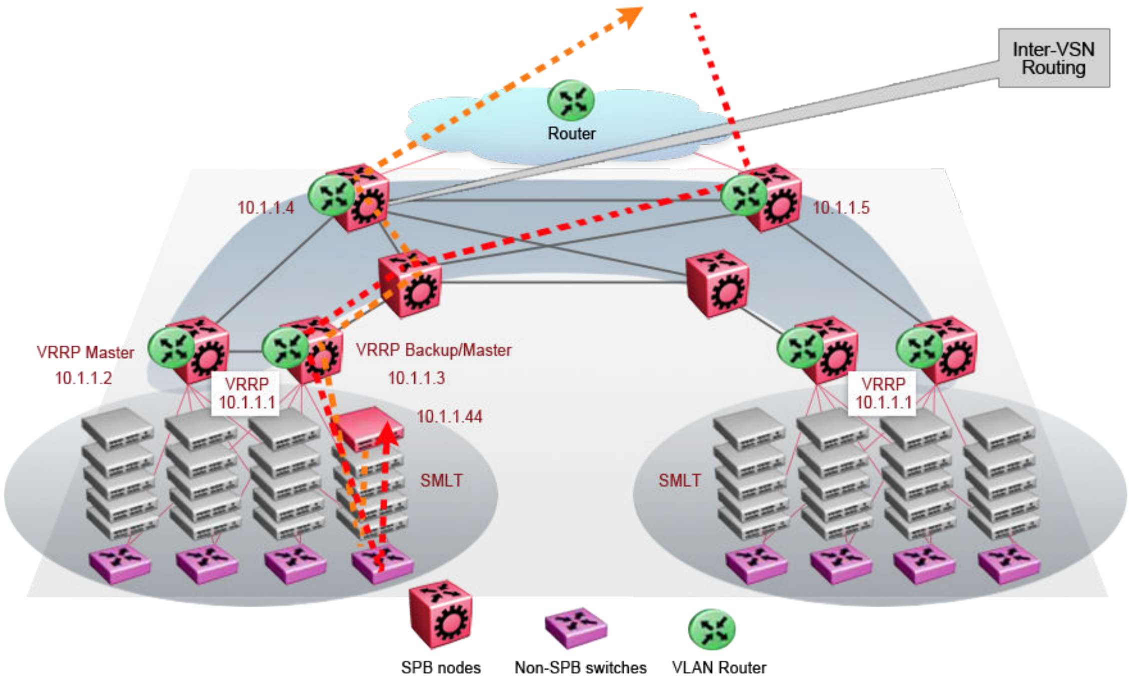


Figure 57: Optimized routing before moving VMs

In the traditional data center, chaos resulted after many VMs were moved. In an optimized data center as shown in the following figure, the incoming traffic enters the Layer 2 domain where an edge switch uses Inter-VSN routing to attach an I-SID to a VLAN. The I-SID bridges traffic directly to the destination. With VRRP BackupMaster, the traffic no longer goes through the default gateway; it takes the most direct route in and out of the network.

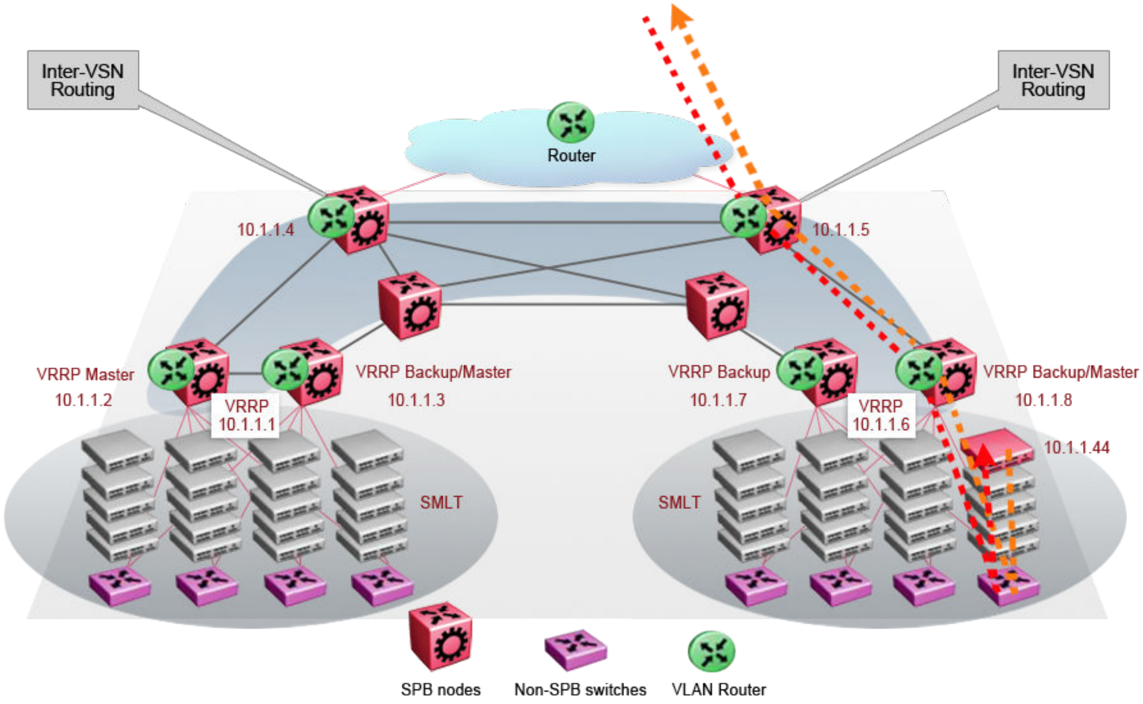


Figure 58: Optimized routing after moving VMs

Solution-specific reference architectures

The following sections describe solution-specific reference architectures, like for example for Video Surveillance or Data Center implementation, using the VSP 4000.

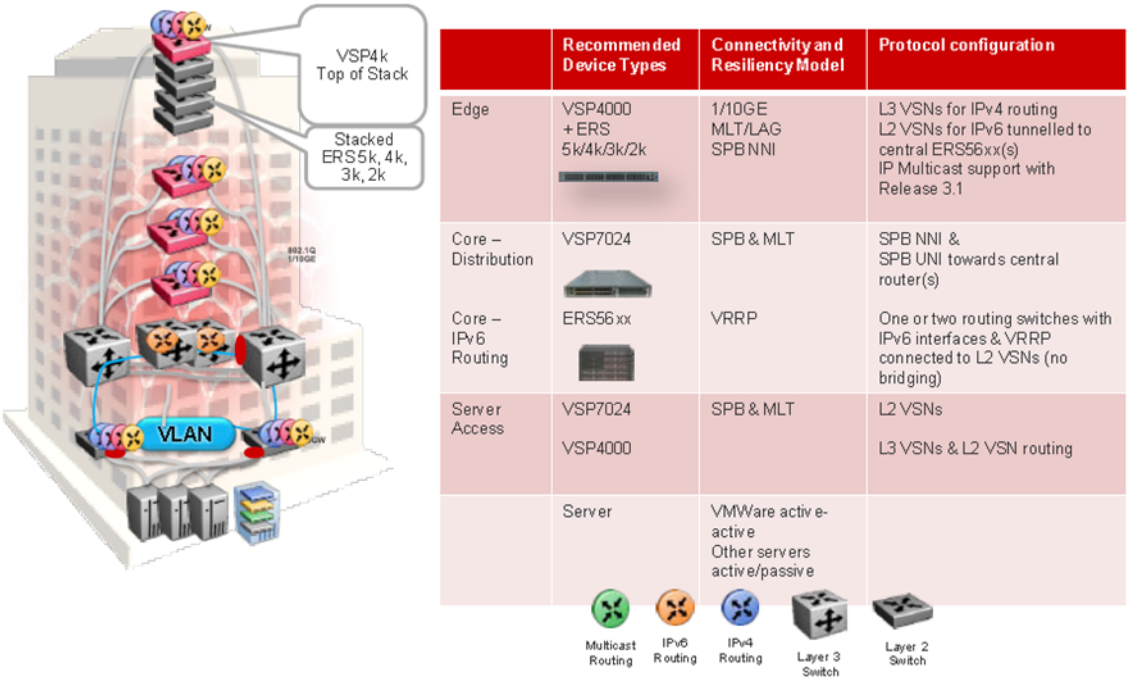
Multi-tenant — fabric connect

This fabric connect-based solution leverages the fabric capabilities of the VSP platforms: a VSP 7000 core and a VSP 4000 edge. This solution provides the ability to run up to 24 VRFs for each wiring closet and is well suited for multi-tenant applications. The zero-touch core is enabled by the fabric connect endpoint provisioning capabilities.

If this solution must support IPv6, then a central router-pair routes all IPv6 traffic. The IPv6 traffic is tunneled from each wiring closet to the IPv6 routers by extending Layer 2 VSNs to the q-tagged router interfaces.

Note:

IPv6 is not supported in the current release of VSP 4000.



	Recommended Device Types	Connectivity and Resiliency Model	Protocol configuration
Edge	VSP4000 + ERS 5k/4k/3k/2k	1/10GE MLT/LAG SPB NNI	L3 VSNs for IPv4 routing L2 VSNs for IPv6 tunnelled to central ERS56xx(s) IP Multicast support with Release 3.1
Core – Distribution	VSP7024	SPB & MLT	SPB NNI & SPB UNI towards central router(s)
Core – IPv6 Routing	ERS56xx	VRRP	One or two routing switches with IPv6 interfaces & VRRP connected to L2 VSNs (no bridging)
Server Access	VSP7024 VSP4000	SPB & MLT	L2 VSNs L3 VSNs & L2 VSN routing
	Server	VMWare active-active Other servers active/passive	

Figure 59: Small core — multi-tenant

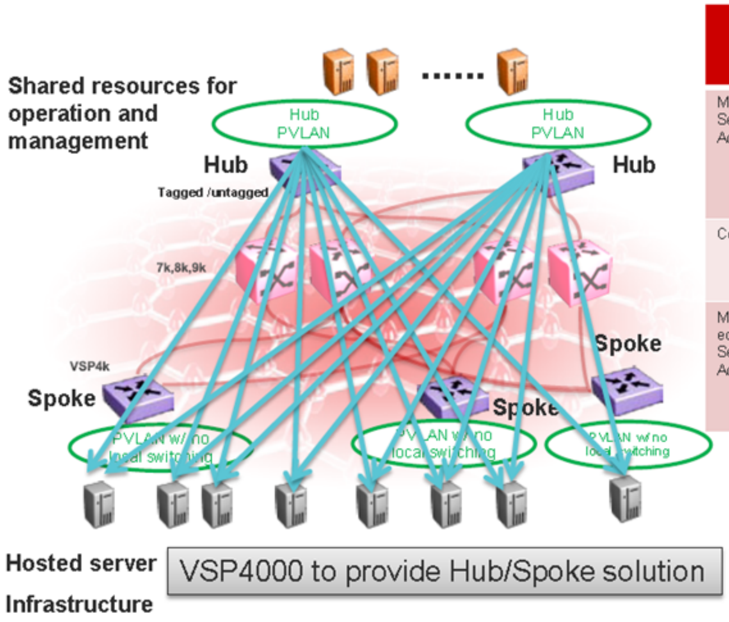
The following list outlines the benefits of the fabric connect-based solution:

- Endpoint provisioning
- Fast failover
- Simple to configure
- L2 and L3 virtualized

Hosted data center management solution — ETREE

In some hosted data center solutions, the hosting center operating company takes responsibility for managing customer servers. For this shared management, shown in the following figure, servers that control the operating system level of the production servers, such as the patch level, are deployed. Because customer production servers do not communicate with each other, a distributed private VLAN solution based on fabric connect is deployed to manage all production servers. This solution builds a distributed set of ETREEs for each management domain.

VSP 9000, ERS 8000, VSP 7000 as core and VSP 4000 as access, provide an elegant network-wide ETREE solution. Spokes, or managed servers, cannot communicate to each other over this network, but the shared management servers on the hub ports can access all spokes. Because of the Layer 2 – ETREE nature of this setup, the managed servers do not require any route entries, and only require one IP interface in this management private VLAN. This solution supports tagged and untagged physical and virtual (VM) servers.


Shared resources for operation and management
Hub PVLAN
Hub PVLAN
Hub
Hub
Tagged /untagged
7k,8k,9k
VSP4k
Spoke
Spoke
Spoke
PVLAN w/ no local switching
PVLAN w/ no local switching
PVLAN w/ no local switching
Hosted server Infrastructure
VSP4000 to provide Hub/Spoke solution

	Recom-mended Device Types	Connectivity and Resiliency Model	Protocol configura-tion
Mgmt Server Access	VSP7024/ VSP9000	SPB UNI/NNI MLT/LAG	SPB
Core	VSP7024/ VSP9000/ ERS8800	SPB NNI MLT	SPB
Managed Server Access	VSP4000	SPB-BEB MLT/LAG	SPB L2VSN ETREE

Figure 60: Data center hosting private VLAN

The following list outlines the benefits of the hosted data center management solution:

- Easy endpoint provisioning
- Optimal resiliency
- Secure tenant separation

Video surveillance — bridged

In a video surveillance solution, optimal traffic forwarding is a key requirement to ensure proper operation of the camera and recorder solutions. However, signaling is also important to ensure quick channel switching. This is achieved by deploying a fabric connect based IP multicast infrastructure that is optimized for multicast transport, so that the cameras can be selected quickly, and so that there is no unnecessary traffic sent across the backbone.

Fabric connect enables this solution with support for ERS 8000, VSP 7000, VSP 9000, and the VSP 4000 products.

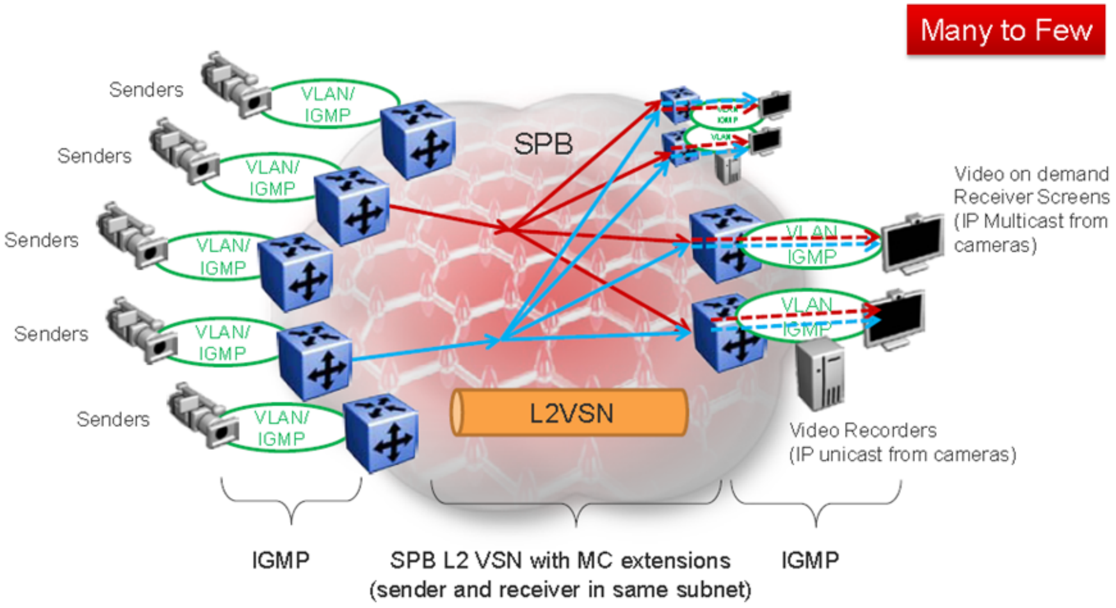

Many to Few
Senders
Senders
Senders
Senders
Senders
VLAN/ IGMP
VLAN/ IGMP
VLAN/ IGMP
VLAN/ IGMP
VLAN/ IGMP
SPB
L2VSN
VLAN IGMP
VLAN IGMP
Video on demand Receiver Screens (IP Multicast from cameras)
Video Recorders (IP unicast from cameras)
IGMP
SPB L2 VSN with MC extensions (sender and receiver in same subnet)
IGMP

Figure 61: Deployment scenario — bridged video surveillance and IP camera deployment for transportation, airports, and government

The following list outlines the benefits of the bridged video surveillance solution:

- Easy end-point provisioning
- sub second resiliency and mc forwarding
- secure tenant separation
- quick camera switching

Video surveillance — routed

In a video surveillance solution, optimal traffic forwarding is a key requirement to ensure proper operation of the camera and recorder solutions. However, signaling is also important to ensure quick channel switching. This is achieved by deploying an IP multicast infrastructure that is optimized for multicast transport, so that the cameras can be selected quickly, and so that there is no unnecessary traffic sent across the backbone. In the topology shown in the following figure, each camera is attached to its own IP subnet. In a larger topology, this can reduce network overhead. To increase network scalability, you can attach a set of cameras to a Layer 2 switch that has IGMP, and then connect the cameras to the fabric edge (BEB) which has a routing instance.

In many customer scenarios, surveillance must be separated from the rest of the infrastructure. This can be achieved by deploying a Layer 3 VSN for the surveillance traffic to keep the surveillance traffic isolated from any other tenant.

Fabric connect enables this solution with support for ERS 8000, VSP 7000, VSP 9000 and VSP 4000 products.

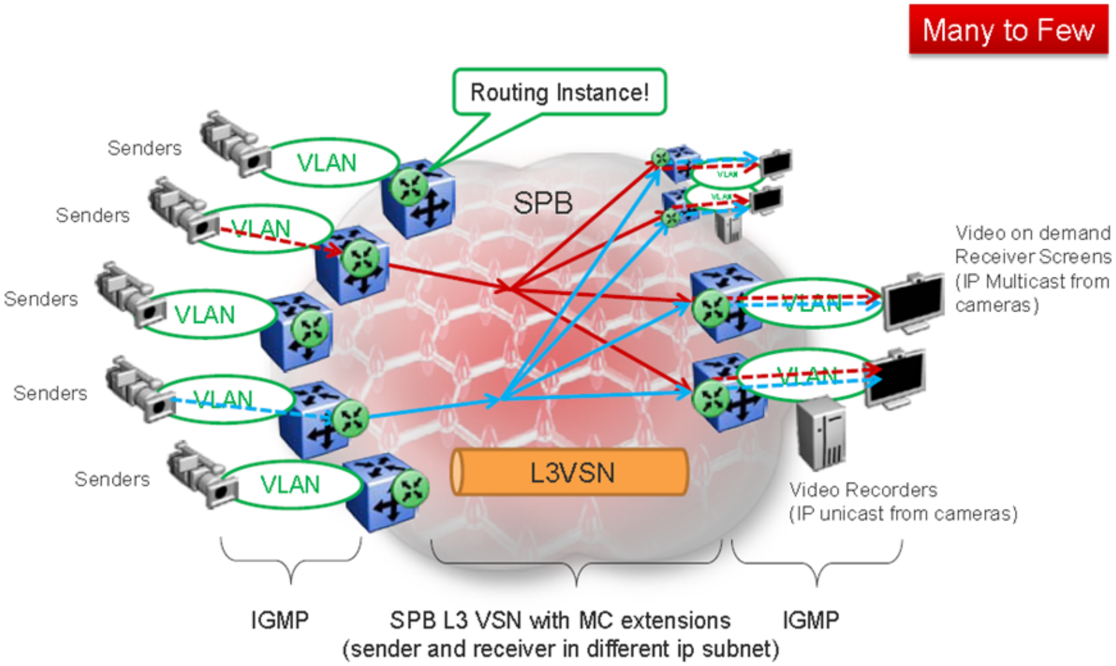

Many to Few
Routing Instance!
Senders
Senders
Senders
Senders
Senders
VLAN
VLAN
VLAN
VLAN
VLAN
SPB
L3VSN
VLAN
VLAN
Video on demand Receiver Screens (IP Multicast from cameras)
Video Recorders (IP unicast from cameras)
IGMP
SPB L3 VSN with MC extensions (sender and receiver in different ip subnet)
IGMP

Figure 62: Deployment scenario — Routed video surveillance and IP camera deployment for transportation, airports, and government

The following list outlines the benefits of the routed video surveillance solution:

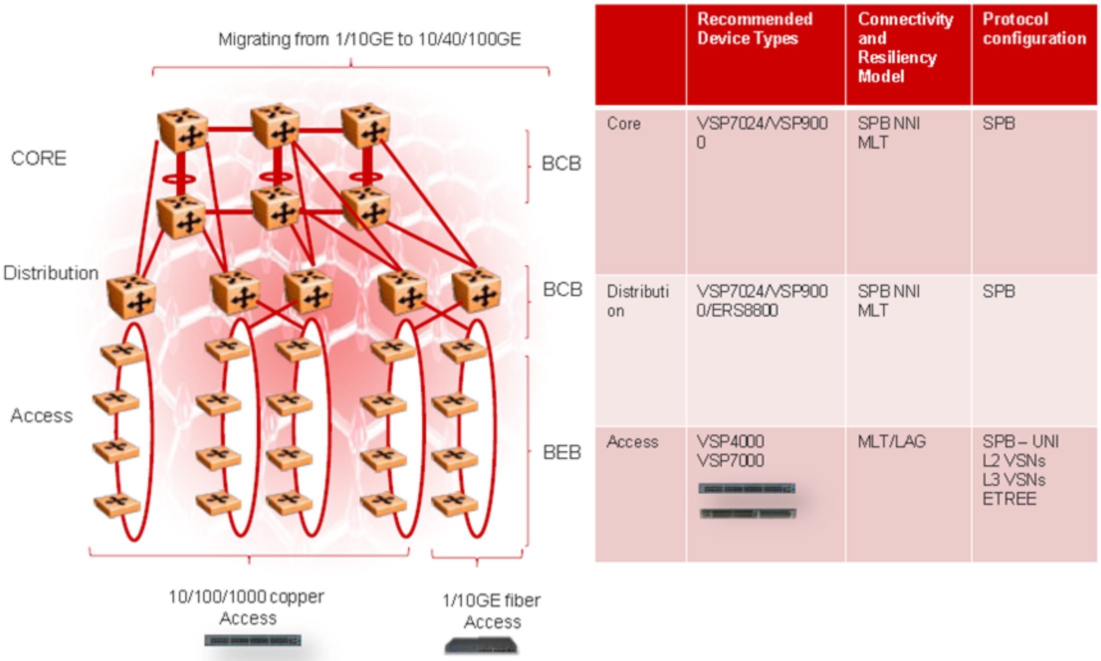
- Easy endpoint provisioning
- Optimal resiliency and mc forwarding
- Secure tenant separation
- Rapid channel/camera switching

Metro-Ethernet Provider solution

VSP 9000, ERS 8000, VSP 7000 and VSP 4000 provide an end-to-end Metro-Ethernet Provider solution. Leveraging fabric connect throughout the infrastructure enables a scalable and flexible wholesale provider infrastructure.

VSP 4000 switches are used as the access product, VSP 7000 switches build the distribution layer, and in large-scale solutions VSP 9000 can be leveraged to build the core of the network.

This use case extends the Transparent UNI functionality to transparently forward any customer VLAN across the services.



	Recommended Device Types	Connectivity and Resiliency Model	Protocol configuration
Core	VSP7024/VSP9000	SPB NNI MLT	SPB
Distribution	VSP7024/VSP9000/ERS8800	SPB NNI MLT	SPB
Access	VSP4000 VSP7000	MLT/LAG	SPB – UNI L2 VSNs L3 VSNs ETREE

Figure 63: Metro ring access solution

The following list outlines the benefits of the Metro-Ethernet Provider solution:

- Easy endpoint provisioning
- Optimal resiliency
- Secure tenant separation

Best practices

This section provides best practices to configure an SPBM network.

IS-IS

The following list identifies best practices for IS-IS:

- Avaya recommends that you change the IS-IS system ID from the default B-MAC value to a recognizable address to easily identify a switch. This change helps to recognize source and destination addresses for troubleshooting purposes.
    - If you leave the system ID as the default value (safe practice as it ensures no duplication in the network), it can be difficult to recognize the source and destination B-MAC for troubleshooting purposes.
    - If you do manually change the system ID, take the necessary steps to ensure no duplication exists in the network.
- Create two B-VLANs to allow load distribution over both B-VLANs. This configuration is required if you use SMLT. Even if you do not use SMLT in the network, this is still good

practice as adding a second B-VLAN to an existing configuration allows SPBM to load balance traffic across two equal-cost multipaths if the physical topology grants it.

- In a ring topology with OSPF and IS-IS configured in the core, a core link break causes slow convergence that can lead to SPBM Layer 2 traffic loss. If the last member link of an OSPF VLAN fails, it takes down the IP interface and OSPF reconverges. While OSPF reconverges, SPBM does not have access to the CPU, which causes traffic loss.

SPBM

The following list identifies best practices for SPBM:

- Use a different, easily recognizable IS-IS nickname on each switch.
- If you enable IP shortcuts, you must configure an IS-IS IP source address on the switch.

Physical or MLT links between IS-IS switches

Virtual Services Platform supports only a single port or single MLT between a pair of IS-IS switches. For example, if two individual ports exist between a pair of IS-IS switches, you can configure IS-IS on both the ports, but an IS-IS adjacency only forms on one of the links.

If you configure a single MLT between a pair of IS-IS switches, all ports in the MLT are used. You must configure the MLT before you enable IS-IS on the MLT.

CFM using manual mode configuration

Important:

Avaya recommends auto-configuration of CFM, which is simpler than the manual mode of configuration.

For more information about these commands, see *Commands Reference for Avaya Virtual Services Platform 4000 Series*, NN46251-104.

The following list identifies best practices for manual configuration of Connectivity Fault Management (CFM):

- The CFM domain name must be the same on all switches in an IS-IS area.
- The maintenance association must be the same on all switches in an IS-IS area.
- To use CFM testing over both B-VLANs, create two maintenance associations, one for each B-VLAN.
- You can configure the same maintenance domain intermediate points (MIP) on all switches in an IS-IS area or uniquely defined per switch.

  Important:

  You must configure the MIP at the same level as the Maintenance Association Endpoints (MEP) on all switches in the SPBM network.

Example of a configuration using best practices

```
spbm-id : 1
BVID #1 & BVID #2 : 4040, 4041 (ignore warning message when configuring)
nick-name : b:b0:<node-id>
MEP-id : md.ma.<node-id>
BMAC : 00:bb:00:00:<node-id>:00
VirtBMAC : 00:bb:00:00:<node-id>:ff
MD : spbm (level 4)
MA : 4040 & 4041
```

```
mep : <node-id>
mip : (level 4)
isis manual area : 49.0001
```

SPBM restrictions and limitations

This section describes the restrictions and limitations associated with SPBM on VSP 4000.

RSTP and MSTP

The following list identifies restrictions and limitations associated with RSTP and MSTP:

- RSTP mode does not support SPBM.
- Because Avaya supports non-SPBM C-VLANs to also span the SPBM network, MSTP can be provisioned in the network to provide loop-free connectivity for these non-SPBM C-VLANs. Because all ports on the VSP 4000 system including IS-IS enabled NNI ports belong to MSTP instance 0, Avaya recommends provisioning the non-SPBM C-VLANs in an MSTP instance other than 0.
- SPBM NNI ports are not part of the Layer 2 VSN C-VLAN, and BPDUs are not transmitted over the SPBM tunnel. SPBM can only guarantee loop-free topologies consisting of the NNI ports. Avaya recommends that you always use Simple Loop Prevention Protocol (SLPP) for loop prevention.

  Note:

  Avaya recommends that you deploy SLPP on C-VLANs to detect loops created by customers in their access networks. However, SLPP is not required on B-VLANs, and it is not supported. The B-VLAN active topology is controlled by IS-IS that has loop mitigation and prevention capabilities built into the protocol.
- SPB internally uses spanning tree group (STG) 63 or Multiple Spanning Tree Instance (MSTI) 62. STG 63 or MSTI 62 cannot be used by another VLAN or MSTI. For non-SPB customer networks, if you use STG 63 or MSTI 62 in the configuration, you must delete STG 63 or MSTI 62 before you can configure SPBM.
- You must configure SPBM B-VLANs on all devices in the same MSTP region. MSTP requires this configuration to generate the correct digest.

SPBM IS-IS

The following list identifies restrictions and limitations associated with SPBM IS-IS:

- The current release does not support IP over IS-IS as defined by RFC1195. IS-IS protocol is only to facilitate SPBM.
- The current release uses Level 1 IS-IS. The current release does not support Level 2 IS-IS. The ACLI command **`show isis int-l2-contl-pkts`** is not supported in the current release because the IEEE 802.1aq standard currently only defines the use of one hierarchy, Level 1.
- The IS-IS standard defines wide (32-bit) metrics and narrow (8-bits) metrics. The current release supports the wide metric.

Pay special attention to the expected scaling of routes in the network when you select configuration values for the **`isis l1-hello-interval`** and **`isis l1-hello-multiplier`** commands on IS-

IS interfaces. The default values for these commands work well for most networks, including those using moderately scaled routes. In highly scaled networks, you may need to configure higher values for these commands.

VLACP

VLACP is generally used when a repeater or switch exists between connected VSP 4000 switches to detect when a connection is not operational even when the link LED is lit.

SNMP traps

On each SPBM peer, if you configure the SPBM B-VLANs to use different VLAN IDs, for example, VLAN 10 and 20 on one switch, and VLAN 30 and 40 on the second, the system does not generate a trap message to alert of the mismatch because the two switches cannot receive control packets from one another. Configure the SPBM B-VLANs to use matching VLAN IDs.

I-SID filters

The current release does not support I-SID filters.

Single-homed T-UNI service on a vIST-enabled node

If you configure a T-UNI service as a single-homed service on a vIST-enabled node, you must configure the same ISID service without port/MLT being mapped to ISID, on the other vIST peer node. Failure to perform this configuration on the vIST peer node can result in the loss of traffic to the single-homed T-UNI service in various scenarios.

IP multicast over Fabric Connect restrictions

Review the following restrictions for the IP multicast over Fabric Connect feature.

IGMP

The BEB must be the only IGMP querier in the network. If the BEB receives an IGMP query from any other device, it causes unpredictable behavior, including traffic loss.

SPBM supports IGMP Snooping on a C-VLAN, but it does not support Protocol-Independent Multicast (PIM) on a C-VLAN. If you enable IGMP Snooping on a C-VLAN, then its operating mode is Layer 2 VSN with IP multicast over Fabric Connect.

You must enable Source-Specific Multicast (SSM) snoop before you configure IGMP version 3, and you must enable both SSM snoop and snooping for IGMPv3.

For IGMP Snooping, ensure that the IGMP version used by multicast hosts and other devices in the network is either the same as the IGMP version configured on the IGMP Snooping VLAN, or that compatibility mode is enabled.

SSM

If you delete any **`ssm-map`** in a static range group, the switch deletes the entire static range group. For example, create an ssm-map for 232.122.122.122 to 232.122.122.122.128 and after that configure this same range in a static group. If you delete any ssm-map between 232.122.122.122 and 232.122.122.128, the switch deletes the entire static range group.

Data I-SID

The BEB matches a single multicast stream to a particular data I-SID. As a result there is a one-to-one mapping between the source, group (S,G) pair to data I-SID for each BEB.

IP address

In this release, IP multicast over Fabric Connect supports only IPv4 multicast traffic.

Supported services

VSP 4000 does not support IP multicast over Fabric Connect routing on inter-VSN routing interfaces.

VSP 4000 supports the following modes of IP multicast over Fabric Connect:

- Layer 2 VSN multicast service — Multicast traffic remains within the same Layer 2 VSN across the SPBM cloud.
- Layer 3 VSN multicast service — Multicast traffic remains within the same Layer 3 VSN across the SPBM cloud.
- IP Shortcuts multicast service — Multicast traffic can cross VLAN boundaries but remains confined to the subset of VLANs with the Global Routing Table that have IP multicast over Fabric Connect enabled.

Chapter 15: IP multicast network design

Use multicast routing protocols to efficiently distribute a single data source among multiple users in the network. This section provides information about how to design networks that support IP multicast routing.

For more information about multicast routing, see *Configuring IP Multicast Routing Protocols on Avaya Virtual Services Platform 4000 Series* , NN46251-504.

For design guidelines on IP Multicast over Fabric Connect, see SPBM design guidelines on page 93.

For more conceptual and configuration information about IP Multicast over Fabric Connect, see *Configuring Avaya Fabric Connect on VSP Operating System Software*, NN47227-510.

Multicast and VRF-Lite

You can configure multicast routing support with the Virtual Routing and Forwarding (VRF) Lite feature. This feature is known as multicast virtualization.

Multicast virtualization enables multiple VRF routing instances on devices and supports various unicast routing protocols so that you can provide the services of many virtual routers from one physical device.

VRF-Lite configurations support IGMP.

Multicast virtualization provides support for:

- Virtualization of control and data plane
- Multicast routing table managers (MRTM)
- Virtualized IGMPv1, v2, and v3
- Support for overlapping multicast address spaces
- Support for the Global Router (VRF0)

Multicast and MultiLink Trunking considerations

Multicast traffic distribution is important because the bandwidth requirements can be substantial when a large number of streams are employed. Avaya Virtual Services Platform 4000 Series can distribute IP multicast streams over links of a multilink trunk using the following method.

Multicast flow distribution over MLT

MultiLink Trunking (MLT) distributes multicast streams over a multilink trunk based on the source MAC address and the destination MAC address. As a result, the load is distributed on different ports of the multilink trunk more evenly. This functionality is enabled by default on the VSP 4000 and cannot be manually configured.

Multicast scalability design rules

The following section lists the design rules to increase multicast route scaling.

Important:

Release 4.1 and higher of VSP 4000 supports the following:

- Protocol-Independent Multicast (PIM)
- Split MultiLink Trunking (SMLT) and Routed-SMLT (RSMLT)

Release 4.1 and higher of VSP 4000 does not support High Availability (HA).

Multicast scalability design rules

1. Whenever possible, use simple network designs that do not use VLANs that span several switches. Instead, use routed links to connect switches.
2. Whenever possible, group sources sending to the same group in the same subnet. Avaya Virtual Services Platform 4000 Series uses a single egress forwarding pointer for all sources in the same subnet sending to the same group. Be aware that these streams have separate hardware forwarding records on the ingress side.
3. Do not configure multicast routing on edge switch interfaces that do not contain multicast senders or receivers. By following this rule, you:
   - Provide secure control over multicast traffic that enters or exits the interface.
   - Reduce the load on the switch, as well as the number of routes. This improves overall performance and scalability.
4. Avoid initializing many (several hundred) multicast streams simultaneously. Initial stream setup is a resource-intensive task, and initializing a large number can increase the setup time. In some cases, this delay can result in stream loss.
5. Whenever possible, do not connect IP multicast sources and receivers by using VLANs that interconnect switches (see the following figure). In some cases, this can result in excessive hardware record use. By placing the source on the interconnected VLAN, traffic takes two paths to the destination, depending on the reverse path forwarding (RPF) checks and the shortest path to the source.

For example, if a receiver is on VLAN 1 on switch S1 and another receiver is on VLAN 2 on switch S1, traffic can be received from two different paths to the two receivers, which results in the use of two forwarding records. If the source on switch S2 is on a different VLAN than VLAN 3, traffic takes a single path to switch S1 where the receivers are located.

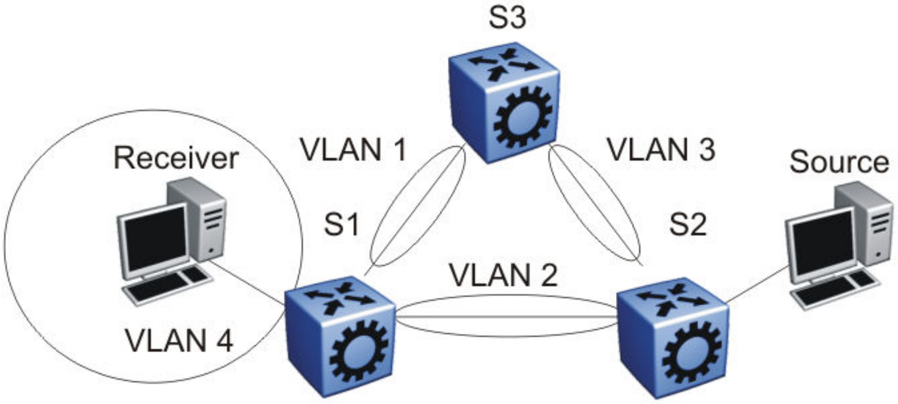


Figure 64: IP multicast sources and receivers on interconnected VLANs

6. Avaya recommends the use of Static group-range-to-rendezvous point (RP) mappings in an SMLT topology as opposed to RP set learning via the Bootstrap Router (BSR) mechanism. Static RP allows for faster convergence in box failure, reset, and HA failover scenarios; whereas there are inherent delays in the BSR mechanism as follows:

   - When a router comes back up after a failover or reset, to accept and propagate (*,g) Join requests from surrounding routers (either PIM Join messages or local IGMP membership reports) to the RP, a PIM router must determine the address of the RP for each group for which they desire (*,g) state. The PIM router needs information about the unicast route to the RP address. The route to the RP address is learned by using a unicast routing protocol such as OSPF, and the RP address is either statically configured or dynamically learned using the BSR mechanism.
   - When a system comes up after a reset or the standby CP becomes master after an HA failover, if the RP is not statically configured. It must wait for the BSR to select the RP from candidate RP routers, and then propagate the RP set hop-by-hop to all PIM routers. This must be done before a Join message can be processed. If the PIM router receives a Join message before it learns the RP set, the router drops the Join message and waits for another Join or Prune message to arrive before it creates the multicast router, and propagates the Join messages to the RP. The default Join/Prune timer is 60 seconds, and because of this and the delays inherent in BSR RP-set learning, significant multicast traffic interruptions can occur. If the RP is statically configured, the only delay is in the unicast routing table convergence and the arrival of the Join/Prune messages from surrounding boxes.

IP multicast address range restrictions

IP multicast routers use D class addresses, which range from 224.0.0.0 to 239.255.255.255. Although you can use subnet masks to configure IP multicast address ranges, the concept of subnets does not exist for multicast group addresses. Consequently, the usual unicast conventions —where you reserve the all 0s subnets, all 1s subnets, all 0s host addresses, and all 1s host addresses—do not apply.

Internet Assigned Numbers Authority (IANA) reserves addresses from 224.0.0.0 through 224.0.0.255 for link-local network applications. Multicast-capable routers do not forward packets with an address in this range. For example, Open Shortest Path First (OSPF) uses 224.0.0.5 and 224.0.0.6, and Virtual Router Redundancy Protocol (VRRP) uses 224.0.0.18 to communicate across local broadcast network segments.

IANA also reserves the range of 224.0.1.0 through 224.0.1.255 for well-known applications. IANA assigns these addresses to specific network applications. For example, the Network Time Protocol (NTP) uses 224.0.1.1, and Mtrace uses 224.0.1.32. RFC1700 contains a complete list of these reserved addresses.

Multicast addresses in the 232.0.0.0/8 (232.0.0.0 to 232.255.255.255) range are reserved only for source-specific multicast (SSM) applications, such as one-to-many applications. While this range is the publicly reserved range for SSM applications, private networks can use other address ranges for SSM.

Finally, addresses in the range 239.0.0.0/8 (239.0.0.0 to 239.255.255.255) are administratively scoped addresses; they are reserved for use in private domains. Do not advertise these addresses outside the private domain. This multicast range is analogous to the 10.0.0.0/8, 172.16.0.0/20, and 192.168.0.0/16 private address ranges in the unicast IP space.

In a private network, only assign multicast addresses from 224.0.2.0 through 238.255.255.255 to applications that are publicly accessible on the Internet. Assign addresses in the 239.0.0.0/8 range to multicast applications that are not publicly accessible.

Although you can use a multicast address you choose on your own private network, it is generally not good design practice to allocate public addresses to private network entities. Do not use public addresses for unicast host or multicast group addresses on private networks.

Multicast MAC address mapping considerations

Like IP, Ethernet has a range of multicast MAC addresses that natively support Layer 2 multicast capabilities. While IP has a total of 28 addressing bits available for multicast addresses, Ethernet has only 23 addressing bits assigned to IP multicast. The Ethernet multicast MAC address space is much larger than 23 bits, but only a subrange of that larger space is allocated to IP multicast. Because of this difference, 32 IP multicast addresses map to one Ethernet multicast MAC address.

IP multicast addresses map to Ethernet multicast MAC addresses by placing the low-order 23 bits of the IP address into the low-order 23 bits of the Ethernet multicast address 01:00:5E:00:00:00. Thus, more than one multicast address maps to the same Ethernet address (see the following figure). For example, all 32 addresses 224.1.1.1, 224.129.1.1, 225.1.1.1, 225.129.1.1, 239.1.1.1, 239.129.1.1 map to the same 01:00:5E:01:01:01 multicast MAC address.

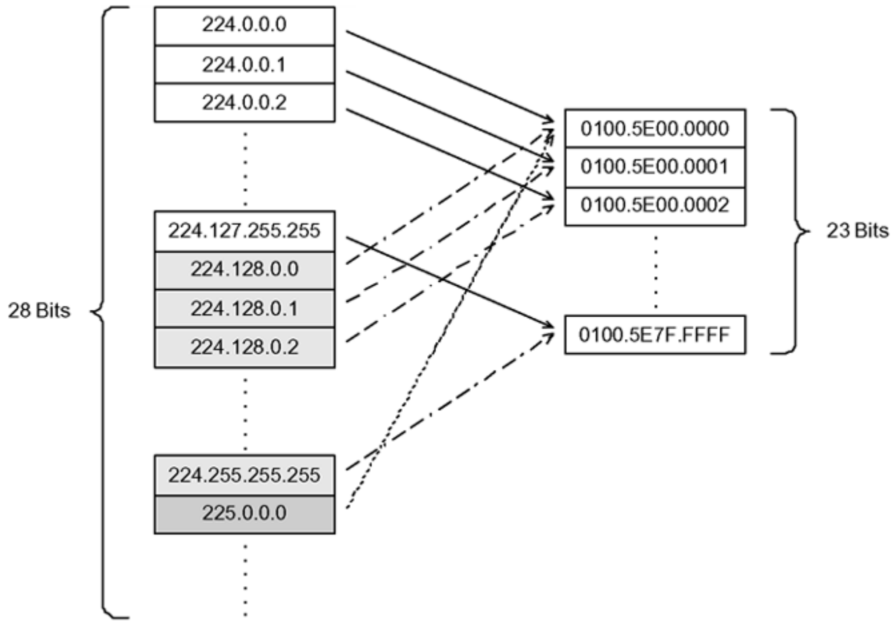


Figure 65: Multicast IP address to MAC address mapping

Most Ethernet switches handle Ethernet multicast by mapping a multicast MAC address to multiple switch ports in the MAC address table. Therefore, when you design the group addresses for multicast applications, take care to efficiently distribute streams only to hosts that are receivers. VSP 4000 switches IP multicast data based on the IP multicast address, not the MAC address, and thus, does not have this issue.

As an example, consider two active multicast streams using addresses 239.1.1.1 and 239.129.1.1. Suppose that two Ethernet hosts, receiver A and receiver B, connect to ports on the same switch and only want the stream addressed to 239.1.1.1. Suppose also that two other Ethernet hosts, receiver C and receiver D, also connect to the ports on the same switch as receiver A and B, and want to receive the stream addressed to 239.129.1.1. If the switch uses the Ethernet multicast MAC address to make forwarding decisions, then all four receivers receive both streams—even though each host only wants one stream. This transmission increases the load on both the hosts and the switch. To avoid this extra load, Avaya recommends that you manage the IP multicast group addresses used on the network.

VSP 4000 does not forward IP multicast packets based on multicast MAC addresses—even when bridging VLANs at Layer 2. Thus, the platform does not encounter this problem. Instead, the platform internally maps IP multicast group addresses to the ports that contain group members.

When an IP multicast packet is received, the lookup is based on the IP group address, regardless of whether the VLAN is bridged or routed. While the problem described in the previous example does not affect the VSP 4000, other switches in the network may be affected. This problem is particularly true of pure Layer 2 switches.

In a network that includes non-VSP 4000 equipment, the easiest way to ensure that this issue does not arise is to use only a consecutive range of IP multicast addresses that correspond to the lower-order 23 bits of that range. For example, use an address range from 239.0.0.0 through 239.127.255.255. A group address range of this size can still easily accommodate the needs of even the largest private enterprise.

Dynamic multicast configuration changes

Avaya recommends that you not perform dynamic multicast configuration changes when multicast streams flow in a network. For example, do not change the routing protocol that runs on an interface, or the IP address, or the subnet mask for an interface until multicast traffic ceases.

For such changes, Avaya recommends that you temporarily stop all multicast traffic. If the changes are necessary and you have no control over the applications that send multicast data, you can disable the multicast routing protocols before you perform the change. For example, consider disabling multicast routing before making interface address changes. In all cases, these changes result in traffic interruptions because they affect neighbor-state machines and stream-state machines.

In addition, Avaya recommends that when removing port members of an MLT group you first disable the ports. Changing the group set without first shutting the ports down can result in high-CPU utilization and processing in a scaled multicast environment due to the necessary hardware reprogramming on the multicast records.

IGMPv3 backward compatibility

IGMPv3 for PIM is backward compatible with IGMPv1/v2. According to RFC3376, the multicast router with IGMPv3 can use one of two methods to handle older query messages:

- If an older version of IGMP is present on the router, the querier must use the lowest version of IGMP present on the network.
- If a router that is not explicitly configured to use IGMPv1 or IGMPv2, detects an IGMPv1 query or IGMPv2 general query, it logs a rate-limited warning.

You can configure the IGMP version of an interface to version 3 regardless of the PIM or snooping mode.

You can configure whether the switch downgrades the version of IGMP to handle older query messages. If the switch downgrades, the host with IGMPv3 only capability does not work. If you do not configure the switch to downgrade the version of IGMP, the switch logs a warning.

Note:

If you enable the explicit host tracking option on an IGMPv3 interface, you cannot downgrade to IGMPv1 or IGMPv2. You must disable explicit host tracking to downgrade the IGMP version.

IGMP Layer 2 Querier

In a multicast network, if you only need to use Layer 2 switching for the multicast traffic, you do not need multicast routing. However, you must have an IGMP querier on the network for multicast traffic to flow from sources to receivers. A multicast router normally provides the IGMP querier function. You can use the IGMP Layer 2 querier to provide a querier on a Layer 2 network without a multicast router.

The Layer 2 querier function originates queries for multicast receivers, and processes the responses accordingly. On the connected Layer 2 VLANs, IGMP snoop continues to provide services as normal. IGMP snoop responds to queries and identifies receivers for the multicast traffic.

You must enable Layer 2 querier and configure an IP address for the querier before it can originate IGMP query messages. If a multicast router exists on the network, VSP 4000 automatically disables the Layer 2 querier.

In a Layer 2 multicast network, enable Layer 2 querier on only one of the switches in the VLAN. A Layer 2 multicast domain supports only one Layer 2 querier. No querier election exists.

For more information about how to configure IGMP Layer 2 querier, see *Configuring IP Multicast Routing Protocols on Avaya Virtual Services Platform 4000 Series* , NN46251-504.

TTL in IP multicast packets

Avaya Virtual Services Platform 4000 Series treats multicast data packets with a time-to-live (TTL) of 1 as expired packets and sends them to the CPU before dropping them. To avoid this issue, ensure that the originating application uses a hop count large enough to enable the multicast stream to traverse the network and reach all destinations without reaching a TTL of 1. Avaya recommends that you use a TTL value of 33 or 34 to minimize the effect of looping in an unstable network.

Multicast MAC filtering

Certain network applications, such as the Microsoft Network Load Balancing solution, require multiple hosts to share a multicast MAC address. Instead of flooding all ports in the VLAN with this multicast traffic, you can use Multicast MAC filtering to forward traffic to a configured subset of the ports in the VLAN. This multicast MAC address is not an IP multicast MAC address.

At a minimum, map the multicast MAC address to a set of ports within the VLAN. In addition, if traffic is routed on the local VSP 4000, you must configure an Address Resolution Protocol (ARP) entry to map the shared unicast IP address to the shared multicast MAC address. You must configure an ARP entry because the hosts can also share a virtual IP address, and packets addressed to the virtual IP address need to reach each host.

Avaya recommends that you limit the number of such configured multicast MAC addresses to a maximum of 100. This number is related to the maximum number of possible VLANs you can configure, because for every multicast MAC filter that you configure the maximum number of configurable VLANs reduces by one. Similarly, configuring large numbers of VLANs reduces the maximum number of configurable multicast MAC filters downward from 100.

Although you can configure addresses starting with 01.00.5E, which are reserved for IP multicast address mapping, do not enable IP multicast with streams that match the configured addresses. This configuration can result in incorrect IP multicast forwarding and incorrect multicast MAC filtering.

Guidelines for multicast access policies

Use the following guidelines when you configure multicast access policies:

- Use masks to specify a range of hosts. For example, 10.177.10.8 with a mask of 255.255.255.248 matches hosts addresses 10.177.10.8 through 10.177.10.15. The host subnet address and the host mask must be equal to the host subnet address. An easy way to determine this is to ensure that the mask has an equal or fewer number of trailing zeros than the host subnet address. For example, 3.3.0.0/255.255.0.0 and 3.3.0.0/255.255.255.0 are valid. However, 3.3.0.0/255.0.0.0 is not.
- Apply receive-access policies to all eligible receivers on a segment. Otherwise, one host joining a group makes that multicast stream available to all.
- Receive access policies are initiated after the switch receives reports with addresses that match the filter criteria.
- Transmit access policies apply after the switch receives the first packet of a multicast stream.

Multicast access policies can apply to a routed PIM interface if Internet Group Management Protocol (IGMP) reports the reception of multicast traffic.

The following rules and limitations apply to IGMP access policy parameters when you use them with IGMP instead of PIM:

- The static member parameter applies to IGMP snooping and PIM on both interconnected links and edge ports.
- The Static Not Allowed to Join parameter applies to IGMP snooping and PIM on both interconnected links and edge ports.
- For multicast access control, the denyRx parameter applies to IGMP snooping and PIM. The DenyTx and DenyBoth parameters apply only to IGMP snooping.

Split-subnet and multicast

The split-subnet issue arises when you divide a subnet into two unconnected sections in a network. This division results in the production of erroneous routing information about how to reach the hosts on that subnet. The split-subnet problem applies to all types of traffic, but it has a larger impact on a PIM-SM network.

To avoid the split-subnet problem in PIM networks, ensure that the RP router is not in a subnet that can become a split subnet. Also, avoid having receivers on this subnet. Because the RP is an entity that must be reached by all PIM-enabled switches with receivers in a network, placing the RP on a split-subnet can impact the whole multicast traffic flow. Traffic can be affected even for receivers and senders that are not part of the split-subnet.

Protocol Independent Multicast-Sparse Mode guidelines

Protocol Independent Multicast-Sparse Mode (PIM-SM) uses an underlying unicast routing information base to perform multicast routing. PIM-SM builds unidirectional shared trees rooted at a RP router for each group and can also create shortest-path trees for each source.

PIM-SM and PIM-SSM scalability

Values for VSP 4000 active and passive interface scaling can be found in *Release Notes for VSP Operating System Software*, NN47227-401.

The current release does not support virtualized PIM. PIM is supported in the Global Routing Table only.

Interfaces that run PIM must also use a unicast routing protocol (PIM uses the unicast routing table), which puts stringent requirements on the system. With a high number of interfaces, take special care to reduce the load on the system.

Use few active IP routed interfaces. You can use IP forwarding without a routing protocol enabled on the interfaces, and enable only one or two with a routing protocol. You can configure proper routing by using IP routing policies to announce and accept routes on the switch. Use PIM passive interfaces on the majority of interfaces.

Important:

> Refer to *Release Notes for VSP Operating System Software*, NN47227-401 for maximum values for total PIM interfaces and active interfaces. If you configure the maximum amount of active interfaces, all remaining interfaces must be passive.

When you use PIM-SM, the number of routes can scale up to the unicast route limit because PIM uses the unicast routing table to make forwarding decisions. For higher route scaling, Avaya recommends that you use OSPF rather than Routing Information Protocol (RIP).

As a general rule, a well-designed network does not have many routes in the routing table. For PIM to work properly, ensure that all subnets configured with PIM are reachable and that PIM uses the information in the unicast routing table. For the RPF check, to correctly reach the source of any multicast traffic, PIM requires the unicast routing table. For more information, see PIM network with non-PIM interfaces on page 143.

PIM general requirements

Avaya recommends that you design simple PIM networks where VLANs do not span several switches.

PIM relies on unicast routing protocols to perform its multicast forwarding. As a result, include in your PIM network design, a unicast design where the unicast routing table has a route to every source and receiver of multicast traffic, as well as a route to the RP router and Bootstrap router (BSR) in the network. Ensure that the path between a sender and receiver contains PIM-enabled interfaces. Receiver subnets are not always required in the routing table.

Avaya recommends that you follow these guidelines:

- Ensure that every PIM-SM domain is configured with an RP, either by static definition or via BSR.
- Ensure that every group address used in multicast applications has an RP in the network.
- As a redundancy option, you can configure several RPs for the same group in a PIM domain.
- As a load sharing option, you can have several RPs in a PIM-SM domain map to different groups.
- In order to configure an RP to cover the entire multicast range, configure an RP to use the IP address of 224.0.0.0 and the mask of 240.0.0.0.
- Configure an RP to handle a range of multicast groups by using the mask parameter. For example, an entry for group value of 224.1.1.0 with a mask of 255.255.255.192 covers groups 224.1.1.0 to 224.1.1.63.
- In a PIM domain with both static and dynamic RP switches, you cannot configure one of the (local) interfaces for the static RP switches as the RP. For example, in the following scenario:

  (static RP switch) Sw1 ------ Sw2 (BSR/Cand-RP1) -----Sw3

  You cannot configure one of the interfaces on switch Sw1 as static RP because the BSR cannot learn this information and propagate it to Sw2 and Sw3. PIM requires that you consistently configure RP on all the routers of the PIM domain, so you can only add the remote interface Candidate-RP1 (Cand-RP) to the static RP table on Sw1.
- If a switch needs to learn an RP-set, and has a unicast route to reach the BSR through this switch, you cannot enable or configure static RP on a switch in a mixed mode of candidate RP and static RP switches. For examples, see the following two figures.

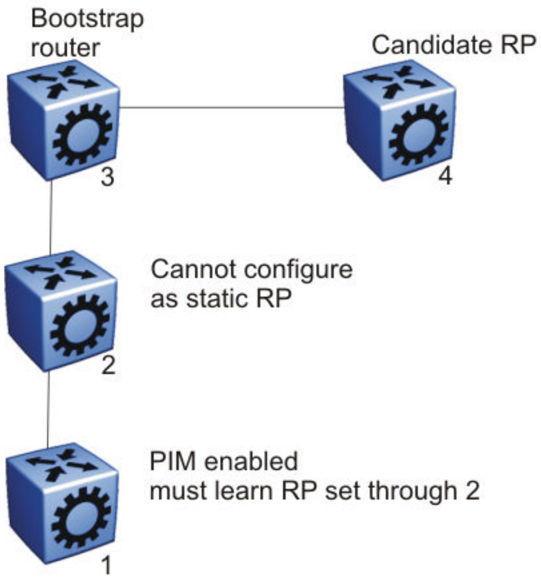

Bootstrap router
Candidate RP
3
4
Cannot configure as static RP
2
PIM enabled must learn RP set through 2
1

Figure 66: Example 1

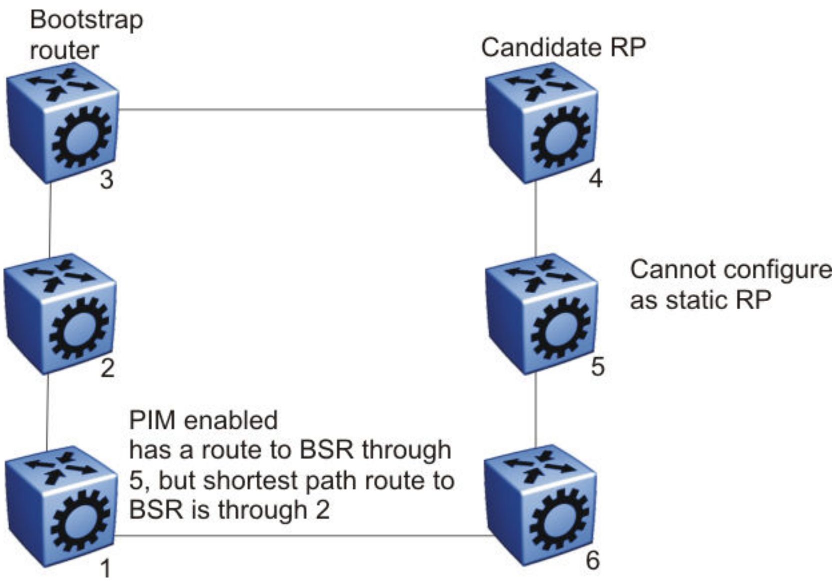

Bootstrap router
Candidate RP
3
4
Cannot configure as static RP
2
5
PIM enabled has a route to BSR through 5, but shortest path route to BSR is through 2
1
6

Figure 67: Example 2

PIM and shortest path tree switchover

When an IGMP receiver joins a multicast group, PIM on the leaf router first joins the shared tree. After the first packet is received on the shared tree, the router uses the source address information in the packet to immediately switch over to the shortest path tree (SPT).

To guarantee a simple, yet high-performance implementation of PIM-SM, the switch does not support a threshold bit rate in relation to SPT switchover. Intermediate routers (that is, not directly connected IGMP hosts) do not switch over to the SPT until directed to do so by the leaf routers.

Other vendors can offer a configurable threshold, such as a certain bit rate at which the SPT switchover occurs. Regardless of their implementation, no interoperability issues with Virtual Services Platform 4000 result. Switching to and from the shared and shortest path trees is independently controlled by each downstream router. Upstream routers relay joins and prunes upstream hop-by-hop, building the desired tree as they go. Because a PIM-SM compatible router already supports shared and shortest path trees, no compatibility issues arise from the implementation of configurable switchover thresholds.

PIM traffic delay and SMLT peer reboot

PIM uses a designated router (DR) to forward data to receivers on the DR VLAN. The DR is the router with the highest IP address on a LAN. If this router is down, the router with the next highest IP address becomes the DR. However, if the VLAN is an SMLT VLAN, the DR is not a factor in determining which switch forwards the data down to the receiver. Either aggregate switch can forward data to the receiver, because the switches act as one. The switch that forwards depends on where the source is located (on another SMLT/vIST link or on a non-SMLT/non-vIST link) and whether either side of the receiver SMLT link is up or down. If the forwarder switch is rebooted, traffic loss occurs until protocol convergence is completed.

Consider the following cases:

- If the source is on an SMLT link that is not the receiver SMLT, the switch that directly received the data on its side of the source SMLT link forwards it down to the receiver on the receiver SMLT regardless of which switch is the DR for the receiver VLAN. The forwarding switch sends a copy of the data over the vIST link to the peer switch, which drops the data because it knows that the remote SMLT is up and therefore the remote peer has already forwarded the data. If the forwarding switch goes down, the other switch receives the data directly over its source SMLT link and takes over forwarding to the receivers. After the original switch comes back up, the original switch again receives the data directly over its source SMLT. The original switch may not be ready to forward the data because of the protocol reconvergence, so the original switch loses traffic until reconvergence is complete.

- If the source is not learned on another SMLT link or the vIST link on each aggregate switch; they have a route to the source which is not on an SMLT or across the vIST. The switches must choose which one forwards the data down the receiver SMLT link; which one is the designated forwarder, so that duplicate data does not occur. The highest IP address is the designated forwarder. If the designated forwarder becomes disabled, the other takes over. When it is reenabled, the other switch sees that it is no longer the highest IP address and it sees that the remote SMLT link comes up. The other switch then assumes that the vIST peer is capable of being the designated forwarder and it stops forwarding down to the receivers. If the original switch is not ready to forward the data due to reconvergence, traffic loss occurs.

In either case, configuring a static RP helps the situation. To avoid this traffic delay, a workaround is to configure a static RP on the peer SMLT switches. This configuration avoids the process of selecting an active RP router from the list of candidate RPs, and also of dynamically learning about RPs through the BSR mechanism. Then, when the DR comes back, traffic resumes as soon as OSPF converges. This workaround reduces the traffic delay.

Circuitless IP for PIM-SM

Use CLIP to configure a resilient RP and BSR for a PIM network. When you configure an RP or BSR on a regular interface, if it becomes nonoperational, the RP and BSR also become nonoperational. This status results in the election of other redundant RPs and BSRs, and can disrupt IP multicast traffic flow in the network. As a best practice for multicast networks design, always configure the RP and BSR on a CLIP interface to prevent a single interface failure from causing these entities to fail.

Avaya also recommends that you configure redundant RPs and BSRs on different switches and that these entities be on CLIP interfaces. For the successful setup of multicast streams, ensure that a unicast route exists to all CLIP interfaces from all locations in the network. A unicast route is mandatory because, for proper RP learning and stream setup on the shared RP tree, every switch in the network needs to reach the RP and BSR. You can use PIM-SM CLIP interfaces only for RP and BSR configurations, and are not intended for other purposes.

It is not recommended to have non-SMLT IGMP leaf ports on a VSP router configured to be one of the redundant RP CLIP devices. It is possible that these IGMP hosts can become isolated from the multicast data stream(s).

If you configure dual-redundant RPs (vIST peers with the same CLIP interface IP address used for the RP), the topology in the following figure does not work in link-failure scenarios. Use caution if you design a network with this topology where the vIST peers are PIM enabled, and the source and receiver edges are Layer 2.

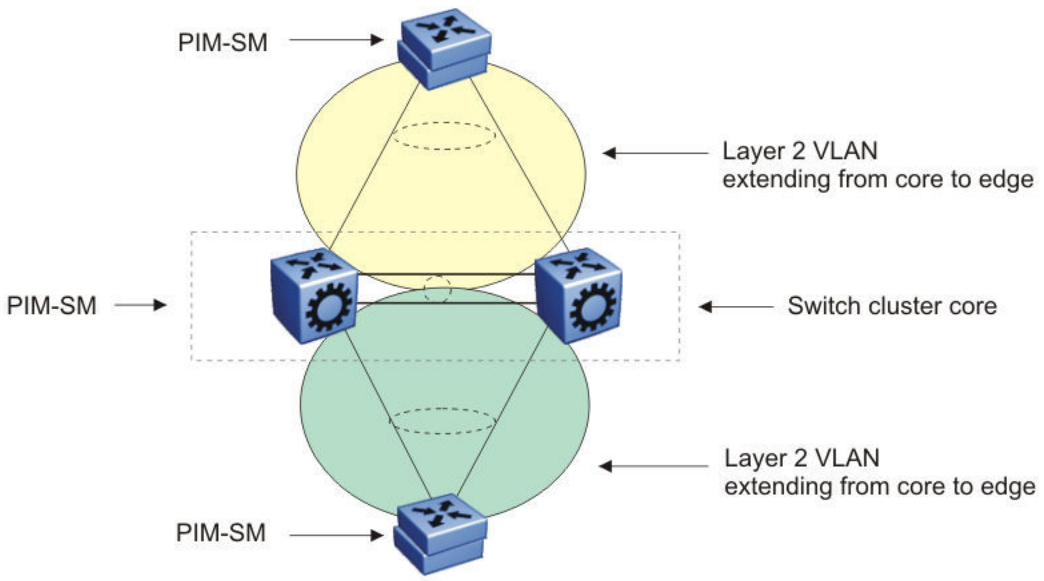


Figure 68: Multicast SMLT triangle

Consider an example where one of the peers, vIST-A, is the PIM DR for the source VLAN, and the source data is hashed to vIST-A from the Layer 2 source edge. vIST-A forwards traffic to the receiver edge using the SMLT link from vIST-A to the receiver edge. If the SMLT link fails, vIST-A does not forward traffic over the vIST link to vIST-B, and the receiver edge does receive the data.

In this topology, the receiver edge sends an IGMP membership report for a group, which is recorded on both vIST peers as an IGMP LEAF on the receiver SMLT port on the receiver VLAN.

Because both of the vIST peers are the RP for the group, they do not send a (*,g) PIM JOIN message toward the other RP. The (*,g) PIM mroute does not record the vIST port as a JOIN port on either vIST device. The PIM (*,g) mroute records only a LEAF on the SMLT receiver port.

Because the source is local (Layer 2 edge), there is no PIM (s,g) JOIN message toward the source and the (s,g) PIM mroute does not record the vIST port as a JOIN port on either vIST device. The PIM (s,g) mroute records only a LEAF on the SMLT receiver port.

If the source is hashed to vIST-A, the PIM DR for the incoming VLAN, traffic is forwarded to the receiver correctly. vIST-A does not forward traffic over the vIST to vIST-B, because no JOIN exists on the vIST port. If the receiver SMLT link from the vIST-A peer is down, the traffic is not forwarded to vIST-B, and is not received by the receiver edge. Traffic resumes after the link is restored. If the source data hashes to the non-DR peer, vIST-B, no problem occurs because the non-DR always forwards traffic to the DR.

A similar situation exists in this topology when vIST-A is both the RP and the DR for the Layer 2 receiver edge. The vIST port is not in the outgoing port list because there is no JOIN message from the peer toward the source (which is not PIM enabled). Therefore, if the SMLT link from vIST-A to the receiver edge is down, the system does not forward traffic to the peer vIST-B and down to the receiver.

You can avoid the preceding problems with this topology by performing one of the following actions:

- Enable PIM on the source edge.

  The vIST peers send PIM joins toward the source and the JOIN is recorded on the vIST port for the (s,g). Data is forwarded to the peer.

- Do not configure dual redundant RPs.

  One vIST peer is the RP for a group.
- Do not configure one vIST peer as both the DR for the source VLAN and the RP for the receiver group.

  The system forwards the traffic to the RP or to the DR, depending on which peer receives the source, and, if the SMLT link to the receiver goes down there will be no data loss.

PIM-SM and static RP

Use static RP to provide security, interoperability, and redundancy for PIM-SM multicast networks. Consider if the administrative ease derived from using dynamic RP assignment is worth the security risks involved. For example, if an unauthorized user connects a PIM-SM router that advertises itself as a candidate RP (C-RP), it can possibly take over new multicast streams that otherwise distribute through an authorized RP. If security is important, use static RP assignment.

You can use the static RP feature in a PIM environment with devices that run legacy PIM-SMv1 and auto-RP (a proprietary protocol that Virtual Services Platform 4000 does not support). For faster convergence, you can also use static RP in a PIM-SMv2 environment. If you configure static RP with PIM-SMv2, the BSR is not active.

Static RP and auto-RP

Some legacy PIM-SMv1 networks use the auto-RP protocol. Auto-RP is a Cisco proprietary protocol that provides equivalent functionality to the standard Virtual Services Platform 4000 PIM-SM RP and BSR. You can use the static RP feature to interoperate in this environment. For example, in a mixed-vendor network, you can use auto-RP among routers that support the protocol, while other routers use static RP. In such a network, ensure that the static RP configuration mimics the information that is dynamically distributed to guarantee that multicast traffic is delivered to all parts of the network.

In a mixed auto-RP and static RP network, ensure that Virtual Services Platform 4000 does not serve as an RP because it does not support the auto-RP protocol. In this type of network, the RP must support the auto-RP protocol.

Static RP and RP redundancy

You can provide RP redundancy through static RPs. To ensure consistency of RP selection, implement the same static RP configuration on all PIM-SM routers in the network. In a mixed vendor network, ensure that the same RP selection criteria is used among all routers. For example, to select the active RP for each group address, the switch uses a hash algorithm defined in the PIM-SMv2 standard. If a router from another vendor selects the active RP based on the lowest IP address, then the inconsistency prevents stream delivery to certain routers in the network.

If a group address-to-RP discrepancy occurs among PIM-SM routers, network outages occur. Routers that are unaware of the true RP cannot join the shared tree and cannot receive the multicast stream.

Failure detection of the active RP is determined by the unicast routing table. As long as the RP is considered reachable from a unicast routing perspective, the local router assumes that the RP is fully functional and attempts to join the shared tree of that RP.

The following figure shows a hierarchical OSPF network where a receiver is in a totally stubby area. If RP B fails, PIM-SM router A does not switch over to RP C because the injected default route in the unicast routing table indicates that RP B is still reachable.

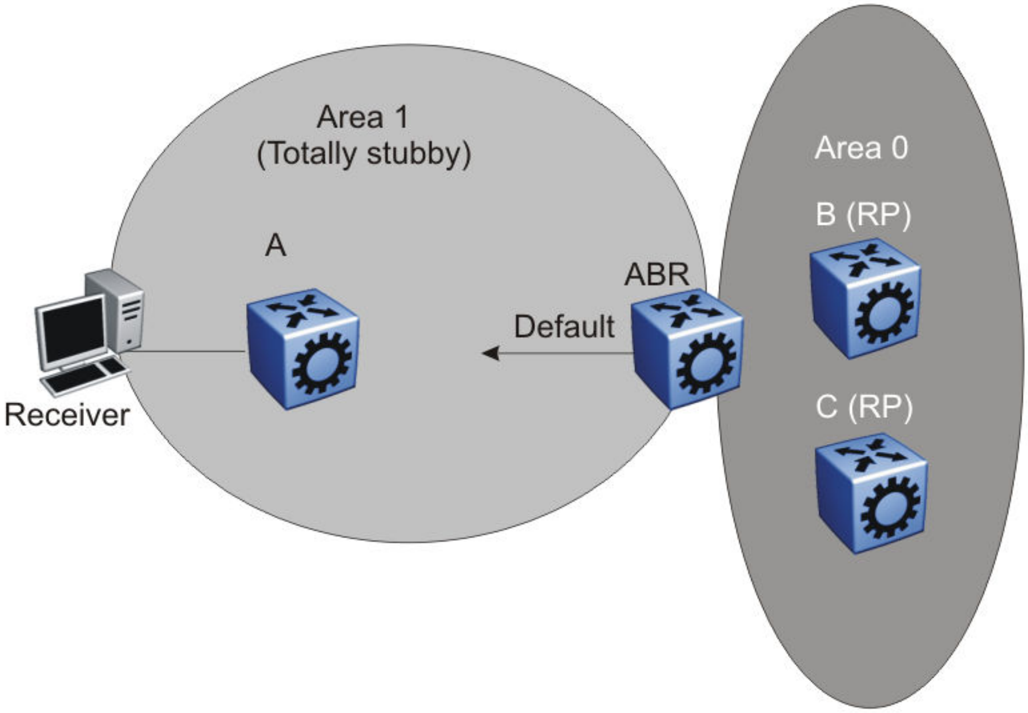


Figure 69: RP failover with default unicast routes

Because failover is determined by unicast routing behavior, carefully consider the unicast routing design, as well as the IP address you select for the RP. Static RP failover performance depends on the convergence time of the unicast routing protocol. For quick convergence, Avaya recommends that you use a link state protocol, such as OSPF. For example, if you use RIP as the routing protocol, an RP failure can take minutes to detect. Depending on the application, this situation can be unacceptable.

Static RP failover time does not affect routers that have already switched over to the SPT; failover time only affects newly-joining routers.

Unsupported static RP configurations

If you use static RP, you disable dynamic RP learning. The following figure shows an unsupported configuration for static RP. In this example because of inter-operation between static RP and dynamic RP, no RP exists at switch 2. However, (S,G) creation and deletion occurs every 210 seconds at switch 16.

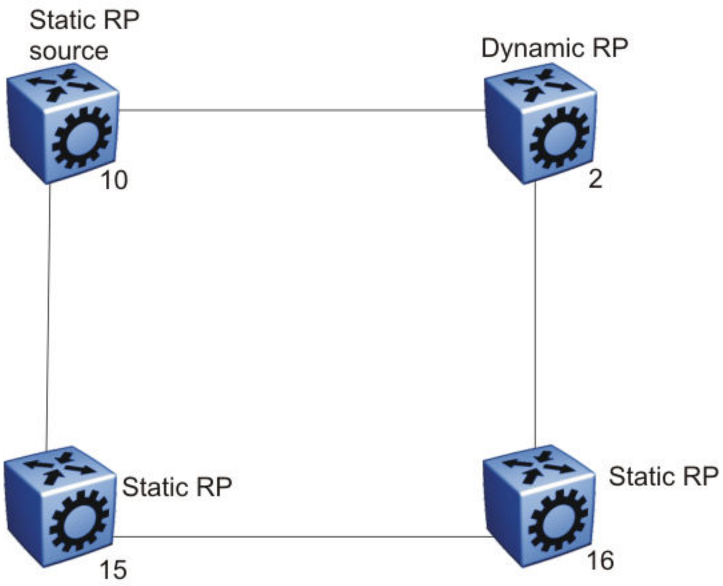


Figure 70: Unsupported static RP configuration

Switches 10, 15, and 16 use static RP, whereas switch 2 uses dynamic RP. The source is at switch 10, and the receivers are switches 15 and 16. The RP is at switch 15 locally. The receiver on switch 16 cannot receive packets because its SPT goes through switch 2.

Switch 2 is in a dynamic RP domain, so it cannot learn about the RP on switch 15. However, (S, G) records are created and deleted on switch 16 every 210 seconds.

Rendezvous point router considerations

You can place an RP on a switch when VLANs extend over several switches. However, when you use PIM-SM, Avaya recommends that you not span VLANs on more than two switches.

Avaya recommends the use of Static group-range-to-RP mappings in an SMLT topology as opposed to RP set learning via the Bootstrap Router (BSR) mechanism. Static RP allows for faster convergence in box failure, reset and HA failover scenarios, whereas there are inherent delays in the BSR mechanism as follows:

- When a router comes back up after a failover or reset, to accept and propagate (*,g) join requests from surrounding routers (either PIM join messages or local IGMP membership reports) to the RP, a PIM router must determine the address of the RP for each group for which they desire (*,g) state. The PIM router must know the unicast route to the RP address. The route to the RP address is learned by using a unicast routing protocol such as OSPF, and the RP address is either statically configured or dynamically learned using the BSR mechanism.
- When a box comes up after a reset, if the RP is not statically configured, it must wait for the BSR to select the RP from candidate RP routers, and then propagate the RP set hop-by-hop to all PIM routers. This must be done before a join message can be processed. If the PIM router receives a join message before it learns the RP set, it drops the join message, and the router waits for another join or prune message to arrive before it creates the multicast route and propagates the join message to the RP. The default Join/Prune timer is 60 seconds, and because of this and the delays inherent in BSR RP-set learning, significant multicast traffic interruptions can occur. If the RP is statically configured, the only delay is in the unicast routing table convergence and the arrival of the Join/Prune messages from surrounding boxes.

PIM-SM design and the BSR hash algorithm

To optimize the flow of traffic down the shared trees in a network that uses a BSR to dynamically advertise candidate RPs, consider the hash function. The BSR uses the hash function to assign multicast group addresses to each C-RP.

The BSR distributes the hash mask used to compute the RP assignment. For example, if two RPs are candidates for the range 239.0.0.0 through 239.0.0.127, and the hash mask is 255.255.255.252, that range of addresses is divided into groups of four consecutive addresses and assigned to one or the other C-RP.

The following figure illustrates a suboptimal design where Router A sends traffic to a group address assigned to RP D. Router B sends traffic assigned to RP C. RP C and RP D serve as backups for each other for those group addresses. To distribute traffic, it is desirable that traffic from Router A use RP C and that traffic from Router B use RP D.

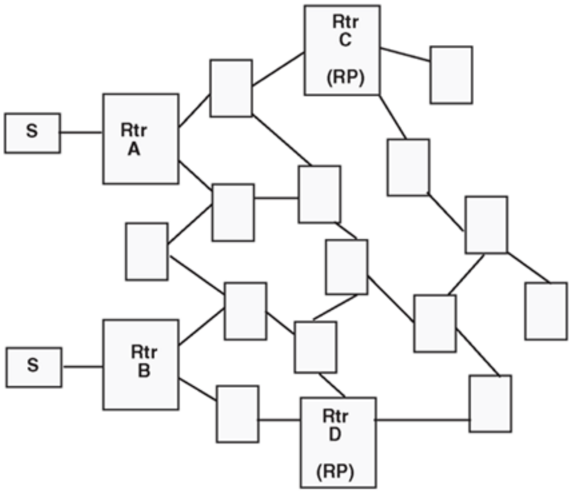


Figure 71: Example multicast network

While still providing redundancy in the case of an RP failure, you can ensure that the optimal shared tree is used by using the following methods.

1. Use the hash algorithm to proactively plan the group-address-to-RP assignment.

   Use this information to select the multicast group address for each multicast sender on the network and to ensure optimal traffic flows. This method is helpful for modeling more complex redundancy and failure scenarios, where each group address has three or more C-RPs.

2. Allow the hash algorithm to assign the blocks of addresses on the network, and then view the results using the command `show ip pim active-rp` .

   Use the command output to assign multicast group addresses to senders that are located near the indicated RP. The limitation to this approach is that while you can easily determine the current RP for a group address, the backup RP is not shown. If more than one backup for a group address exists, the secondary RP is not obvious. In this case, use the hash algorithm to reveal which of the remaining C-RPs take over for a particular group address in the event of primary RP failure.

The hash algorithm works as follows:

1. For each C-RP router with matching group address ranges, a hash value is calculated according to the formula:

   Hash value [G, M, C(i)] = {1 103 515 245 * [(1 103 515245 * (G&M) +12 345) XOR C(i)] + 12 345} mod 2^31

   The hash value is a function of the group address (G), the hash mask (M), and the IP address of the C-RP C(i). The expression (G&M) guarantees that blocks of group addresses hash to the same value for each C-RP, and that the size of the block is determined by the hash mask.

   For example, if the hash mask is 255.255.255.248, the group addresses 239.0.0.0 through 239.0.0.7 yield the same hash value for a given C-RP. Thus, the block of eight addresses are assigned to the same RP.

2. The C-RP with the highest resulting hash value is chosen as the RP for the group. In the event of a tie, the C-RP with the highest IP address is chosen.

   This algorithm runs independently on all PIM-SM routers so that every router has a consistent view of the group-to-RP mappings.

Candidate RP considerations

The C-RP priority parameter determines an active RP for a group. The hash values for different RPs are only compared for RPs with the highest priority. Among the RPs with the highest priority value and the same hash value, the C-RP with the highest RP IP address is chosen as the active RP.

You cannot configure the C-RP priority. Each RP has a default C-RP priority value of 0, and the algorithm uses the RP if the group address maps to the grp-prefix that you configure for that RP. If a different router in the network has a C-RP priority value greater than 0, the switch uses this part of the algorithm in the RP election process.

Currently, you cannot configure the hash mask used in the hash algorithm. Unless you configure a different PIM BSR in the network with a nondefault hash mask value, the default hash mask of 255.255.255.252 is used. Static RP configurations do not use the BSR hash mask; they use the default hash mask.

For example:

RP1 = 128.10.0.54 and RP2 = 128.10.0.56. The group prefix for both RPs is 238.0.0.0/255.0.0.0. Hash mask = 255.255.255.252.

The hash function assigns the groups to RPs in the following manner:

The group range 238.1.1.40 to 238.1.1.51 (12 consecutive groups) maps to 128.10.0.56. The group range 238.1.1.52 to 238.1.1.55 (4 consecutive groups) maps to 128.10.0.54. The group range 238.1.1.56 to 238.1.1.63 (8 consecutive groups) maps to 128.10.0.56.

PIM-SM receivers and VLANs

Some designs cause unnecessary traffic flow on links in a PIM-SM domain. In these cases, traffic is not duplicated to the receivers, but wastes bandwidth.

The following figure shows such a situation. Switch B is the DR between switches A and B. Switch C is the RP. A receiver R is on the VLAN (V1) that connects switches A and B. A source sends multicast data to the receiver.

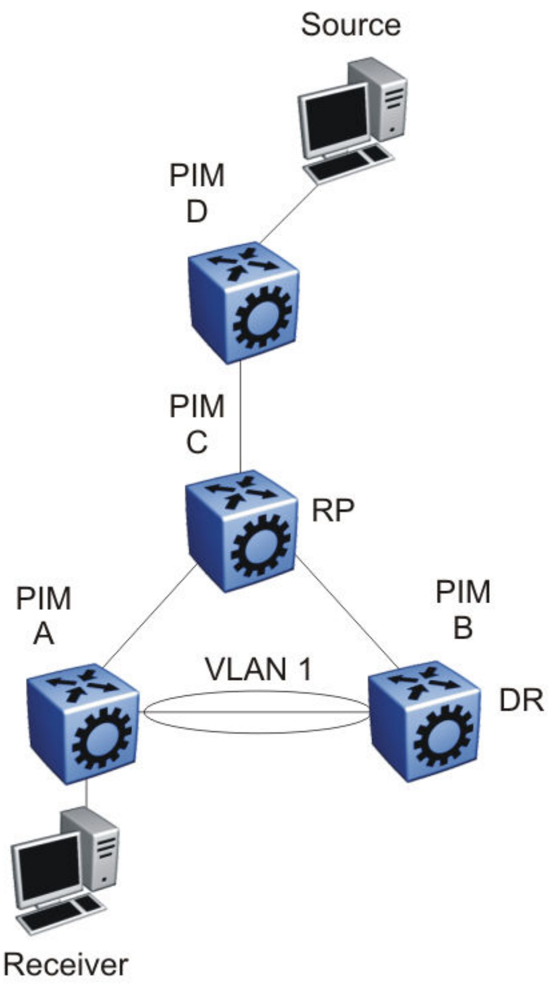


Figure 72: Receivers on interconnected VLANs

IGMP reports that the messages that the receiver sends are forwarded to the DR, and both A and B create (*,G) records. Switch A receives duplicate data through the path from C to A, and through the second path from C to B to A. Switch A discards the data on the second path (assuming the upstream source is A to C).

To avoid this waste of resources, Avaya recommends that you do not place receivers on V1. This configuration guarantees that no traffic flows between B and A for receivers attached to A. In this case, the existence of the receivers is only learned through PIM join messages to the RP [for (*,G)] and of the source through SPT joins.

PIM network with non-PIM interfaces

For proper multicast traffic flow in a PIM-SM domain, as a general rule, enable PIM-SM on all interfaces in the network (even if paths exist between all PIM interfaces). Enable PIM on all interfaces because PIM-SM relies on the unicast routing table to determine the path to the RP, BSR, and multicast sources. Ensure that all routers on these paths have PIM-SM enabled interfaces.

The following figure provides an example of this situation. If A is the RP, then initially the receiver receives data from the shared tree path (that is, through switch A).

If the shortest path from C to the source is through switch B, and the interface between C and B does not have PIM-SM enabled, then C cannot switch to the SPT. C discards data that comes through the shared path tree (that is, through A). The simple workaround is to enable PIM on VLAN1 between C and B.

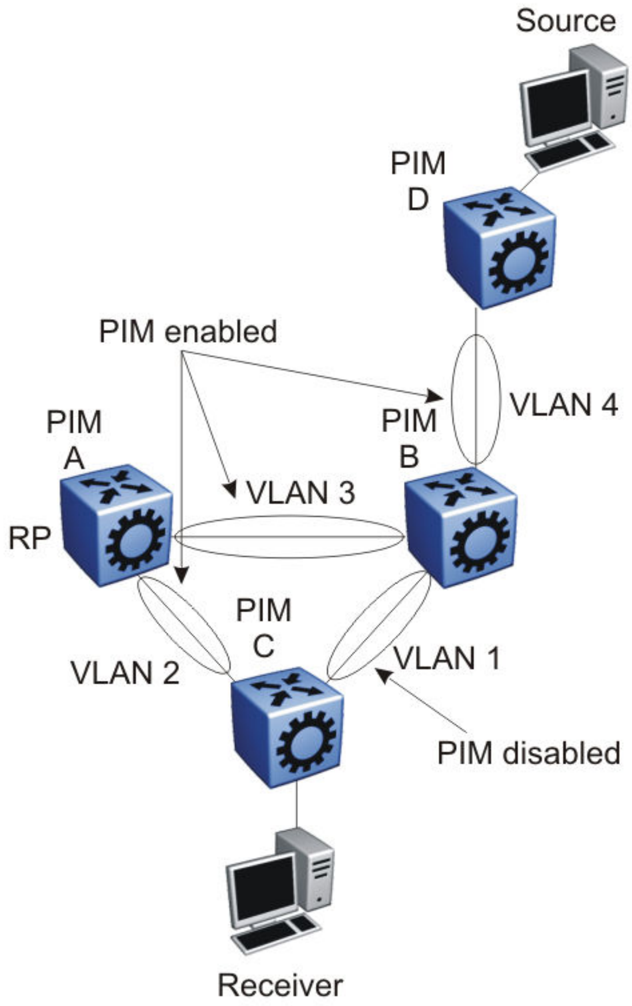


Figure 73: PIM network with non-PIM interfaces

Source filtering

The system can report interest in receiving packets from *only* a specific source address (INCLUDE), from all *but* specific source addresses (EXCLUDE), or sent to specific multicast addresses. IGMPv3 interacts with PIM-SM, PIM-SSM, and snooping to provide source filtering. For more information, see *Configuring IP Multicast Routing Protocols on Avaya Virtual Services Platform 9000,* NN46250-504.

Protocol Independent Multicast-Source Specific Multicast guidelines

PIM-Source Specific Multicast (SSM) is a one-to-many model that uses a subset of the PIM-SM features. In this model, members of an SSM group can only receive multicast traffic from a specific source or sources, which is more efficient and puts less load on multicast routing devices.

IGMPv3 supports PIM-SSM by enabling a host to selectively request traffic from individual sources within a multicast group. The system can report interest in receiving packets from only specific source addresses (INCLUDE). IGMPv3 interacts with PIM-SM, PIM-SSM, and snooping to provide source filtering.

IGMPv2 SSM extensions

Virtual Services Platform 4000 processes messages according to the following rules:

- After IGMPv3 receives an IGMPv2 report in the SSM range, the system translates the report to an IGMPv3 report message.
- After an IGMPv2 router sends queries on an IGMPv3 interface, the switch downgrades this interface to IGMPv2 (backward compatibility).

  This can cause traffic interruption, but the switch recovers quickly.

PIM-SSM design considerations

Use the following information when you design an SSM network:

- If you configure SSM, it affects SSM groups only. The switch handles other groups in sparse mode (SM) if a valid RP exists on the network.
- You can configure PIM-SSM only on switches at the edge of the network. Core switches use PIM-SM if they do not have receivers for SSM groups.
- For networks where group addresses are already in use, you can change the SSM range to match the groups.
- One switch has a single SSM range.
- You can have different SSM ranges on different switches.

  Configure the core switches that relay multicast traffic so that they cover all of these groups in their SSM range, or use PIM-SM.
- One group in the SSM range can have multiple sources for a given SSM group.

For more information about multicast concepts and configuration, see *Configuring IP Multicast Routing Protocols on Avaya Virtual Services Platform 4000 Series* , NN46251-504.

Multicast for multimedia

Avaya Virtual Services Platform 4000 Series provides a flexible and scalable multicast implementation for multimedia applications. Several features are dedicated to multimedia applications and in particular to television distribution.

Join and leave performance

For TV applications, you can attach several TVs directly, or through an IGMP-capable Ethernet switch, to the VSP 4000. Base this implementation on IGMP; the set-top boxes use IGMP reports to join a TV channel and IGMP leaves to exit the channel. After a viewer changes channels, an IGMPv2 leave for the old channel (multicast group) is issued, and a membership report for the new channel is sent. If viewers change channels continuously, the number of joins and leaves can become large, particularly if many viewers attach to the switch.

VSP 4000 supports more than a thousand joins and leaves per second, which is well adapted to TV applications.

Important:

For IGMPv3, Avaya recommends that you ensure a join rate of 1000 per second or less. This ensures the timely processing of join requests.

If you use the IGMP proxy functionality at the receiver edge, you reduce the number of IGMP reports received by VSP 4000. This provides better overall performance and scalability.

Fast Leave

IGMP Fast Leave supports two modes of operation: single-user mode and multiple-user mode.

In single-user mode, if more than one member of a group is on the port and one of the group members leaves the group, everyone stops receiving traffic for this group. A group-specific query is not sent before the effective leave takes place.

Multiple-user mode allows several users on the same port or VLAN. If one user leaves the group and other receivers exist for the same stream, the stream continues. The switch tracks the number of receivers that join a given group. For multiple-user mode to operate properly, do not suppress reports. This ensures that the switch properly tracks the correct number of receivers on an interface.

The Fast Leave feature is particularly useful in IGMP-based TV distribution where only one receiver of a TV channel connects to a port. If a viewer changes channels quickly, you create considerable bandwidth savings if you use Fast Leave.

You can implement Fast Leave on a VLAN and port combination; a port that belongs to two different VLANs can have Fast Leave enabled on one VLAN (but not on the other). Thus, with the Fast Leave feature enabled, you can connect several devices on different VLANs to the same port. This strategy does not affect traffic after one device leaves a group to which another device subscribes. For example, you can use this feature when two TVs connect to a port through two set-top boxes, even if you use the single-user mode.

To use Fast Leave, you must first enable explicit host tracking. IGMP uses explicit host tracking to track all source and group members. Explicit host tracking is disabled by default. For configuration information, see *Configuring IP Multicast Routing Protocols on Avaya Virtual Services Platform 4000 Series* , NN46251-504.

Last member query interval tuning

If an IGMPv2 host leaves a group, it notifies the router by using a leave message. Because of the IGMPv2 report suppression mechanism, the router cannot access information of other hosts that require the stream. Thus, the router broadcasts a group-specific query message with a maximum response time equal to the last member query interval (LMQI).

Because this timer affects the latency between the time that the last member leaves and the time the stream actually stops, you must properly tune this parameter. This timer can especially affect TV delivery or other large-scale, high-bandwidth multimedia applications. For instance, if you assign a value that is too low, this can lead to a storm of membership reports if a large number of hosts are subscribed. Similarly, assigning a value that is too high can cause unwanted high-bandwidth stream propagation across the network if users change channels rapidly. Leave latency also depends on the robustness value, so a value of 2 equates to a leave latency of twice the LMQI.

Determine the proper LMQI value for your particular network through testing. If a very large number of users connect to a port, assigning a value of 3 can lead to a storm of report messages after a group-specific query is sent. Conversely, if streams frequently start and stop in short intervals, as in a TV delivery network, assigning a value of 10 can lead to frequent congestion in the core network.

Another performance-affecting factor that you need to be aware of is the error rate of the physical medium. For links that have high packet loss, you can find it necessary to adjust the robustness variable to a higher value to compensate for the possible loss of IGMP queries and reports.

In such cases, leave latency is adversely affected as numerous group-specific queries are unanswered before the stream is pruned. The number of unanswered queries is equal to the robustness variable (default 2). The assignment of a lower LMQI can counterbalance this effect. However, if you configure the LMQI too low, it can actually exacerbate the problem by inducing storms of reports on the network. LMQI values of 3 and 10, with a robustness value of 2, translate to leave latencies of 6/10 of a second and 2 seconds, respectively.

When you choose an LMQI, consider all of these factors to determine the best configuration for the given application and network. Test that value to ensure that it provides the best performance.

Important:

In networks that have only one user connected to each port, Avaya recommends that you use the Fast Leave feature instead of LMQI, because no wait is required before the stream stops. Similarly, the robustness variable does not affect the Fast Leave feature, which is an additional benefit for links with high loss.

Chapter 16: System and network stability and security

Use the information in this chapter to design and implement a secure network.

You must provide security mechanisms to prevent your network from attack. If links become congested due to attacks, you can immediately halt end-user services. During the design phase, study availability issues for each layer.

To provide additional network security, you can use the Avaya Virtual Services Platform 9000 or your own high-performance stateful firewalls.

DoS protection mechanisms

Several internal mechanisms and features protect Avaya Virtual Services Platform 4000 Series against Denial-of-Service (DoS) attacks.

Broadcast and multicast rate limiting

To protect the switch and other devices from excessive broadcast traffic, you can use broadcast and multicast rate limiting on an individual-port basis.

For more information about how to configure the rate limits for broadcast or multicast packets on a port, see *Configuration - QoS and ACL-Based Traffic Filtering Avaya Virtual Services Platform 4000 Series*, NN46251-502.

Directed broadcast suppression

You can enable or disable forwarding for directed broadcast traffic on an IP-interface basis. A directed broadcast is a frame sent to the subnet broadcast address on a remote IP subnet. By disabling or suppressing directed broadcasts on an interface, you cause all frames sent to the subnet broadcast address for a local router interface to be dropped. Directed broadcast suppression protects hosts from possible DoS attacks.

To prevent the flooding of other networks with DoS attacks, such as the Smurf attack, VSP 4000 is protected by directed broadcast suppression. This feature is enabled by default. Avaya recommends that you not disable it.

For more information about directed broadcast suppression, see *Security for Avaya Virtual Services Platform 4000 Series*, NN46251-601.

Prioritization of control traffic

VSP 4000 uses a sophisticated prioritization scheme to schedule control packets on physical ports. This scheme involves two levels with both hardware and software queues to guarantee proper handling of control packets regardless of the switch load. In turn, this scheme guarantees the stability of the network. Prioritization also guarantees that applications that use many broadcasts are handled with lower priority.

You cannot view, configure, or modify control-traffic queues.

ARP request threshold recommendations

The Address Resolution Protocol (ARP) request threshold defines the maximum number of outstanding unresolved ARP requests. The default value for this function is 500 ARP requests. To avoid excessive amounts of subnet scanning that a virus can cause, Avaya recommends that you change the ARP request threshold to a value between 100 and 50. This configuration protects the CPU from causing excessive ARP requests, protects the network, and lessens the spread of the virus to other PCs. The following list provides further recommended ARP threshold values:

- Default: 500
- Severe conditions: 50
- Continuous scanning conditions: 100
- Moderate: 200
- Relaxed: 500

For more information about how to configure the ARP threshold, see *Configuration - IP Routing for Avaya Virtual Services Platform 4000 Series*, NN46251-505.

Multicast Learning Limitation

The Multicast Learning Limitation feature protects the CPU from multicast data packet bursts generated by malicious applications. If more than a certain number of multicast streams enter the CPU through a port during a sampling interval, the port is shut down until the user or administrator takes the appropriate action.

For more information, see *Configuring IP Multicast Routing Protocols on Avaya Virtual Services Platform 4000 Series* , NN46251-504.

Damage prevention

To further reduce the chance that unauthorized users can use your network to damage other existing networks, take the following actions:

1. Prevent IP spoofing.

   You can use the spoof-detect feature.
2. Prevent the use of the network as a broadcast amplification site.
3. To block illegal IP addresses, enable the **`hsecure`** flag (High Secure mode).

   For more information, see *Security for Avaya Virtual Services Platform 4000 Series*, NN46251-601.

4. Prevent unknown devices from influencing the spanning tree topology.

Packet spoofing

You can stop spoofed IP packets by configuring the switch to forward only IP packets that contain the correct source IP address of your network. By denying all invalid source IP addresses, you minimize the chance that your network is the source of a spoofed DoS attack.

A spoofed packet is one that comes from the Internet into your network with a source address equal to one of the subnet addresses on your network. The source address belongs to one of the address blocks or subnets on your network. To provide spoofing protection, you can use a filter that examines the source address of all outside packets. If that address belongs to an internal network or a firewall, the packet is dropped.

To prevent DoS attack packets that come from your network with valid source addresses, you need to know the IP network blocks in use. You can create a generic filter that:

- Permits valid source addresses
- Denies all other source addresses

To do so, configure an ingress filter that drops all traffic based on the source address that belongs to your network.

If you do not know the address space completely, it is important that you at least deny private (see RFC1918) and reserved source IP addresses. The following table lists the source addresses to filter.

Table 18: Source addresses to filter

Address	Description
0.0.0.0/8	Historical broadcast. High Secure mode blocks addresses 0.0.0.0/8 and 255.255.255.255/16. If you enable this mode, you do not need to filter these addresses.
10.0.0.0/8	RFC1918 private network
127.0.0.0/8	Loopback
169.254.0.0/16	Link-local networks
172.16.0.0/12	RFC1918 private network
192.0.2.0/24	TEST-NET
192.168.0.0/16	RFC1918 private network
224.0.0.0/4	Class D multicast
240.0.0.0/5	Class E reserved
248.0.0.0/5	Unallocated
255.255.255.255/32	Broadcast1

You can also enable the spoof-detect feature on a port.

For more information about the spoof-detect feature, see*Configuring VLANs and Spanning Tree on Avaya Virtual Services Platform 4000 Series*, NN46251-500.

High Secure mode

To ensure that VSP 4000 does not route packets with an illegal source address of 255.255.255.255 (RFC1812 Section 4.2.2.11 and RFC971 Section 3.2), you can enable High Secure mode.

By default, this feature is disabled. After you enable this flag, the feature applies to all ports.

For more information about High Secure mode, see *Security for Avaya Virtual Services Platform 4000 Series*, NN46251-601.

Data plane security

Data plane security mechanisms include the Extended Authentication Protocol (EAP) 802.1x, VLANs, filters, routing policies, and routing protocol protection.

To protect the network from inside threats, the switch supports the 802.1x standard.

EAP separates user authentication from device authentication.

If you enable EAP, end-users must securely log on to the network before they can obtain access to a resource.

Interaction between 802.1x and Optivity Policy Server v4.0

User-based networking links EAP authorization to individual user-based security policies based on individual policies. As a result, network managers can define corporate policies and configure them on an individual port basis. This configuration provides additional security based on a logon and password.

The Avaya Optivity Policy Server supports 802.1x EAP authentication against Remote Authentication Dial-in User Service (RADIUS) and other authentication, authorization, and accounting (AAA) repositories. This support authenticates the user, grants access to specific applications, and provides real time policy provisioning capabilities to mitigate the penetration of unsecured devices.

The following figure shows the interaction between 802.1x and Optivity Policy Server. First, the user initiates a logon from a user access point and receives a request/identify request from the switch (EAP access point). The user receives a network logon. Prior to Dynamic Host Configuration Protocol (DHCP), the user does not have network access because the EAP access point port is in EAP blocking mode. The user provides logon credentials to the EAP access point using the Extensible Authentication Protocol Over LAN (EAPoL). The client PC is both a RADIUS peer user and an EAP supplicant.

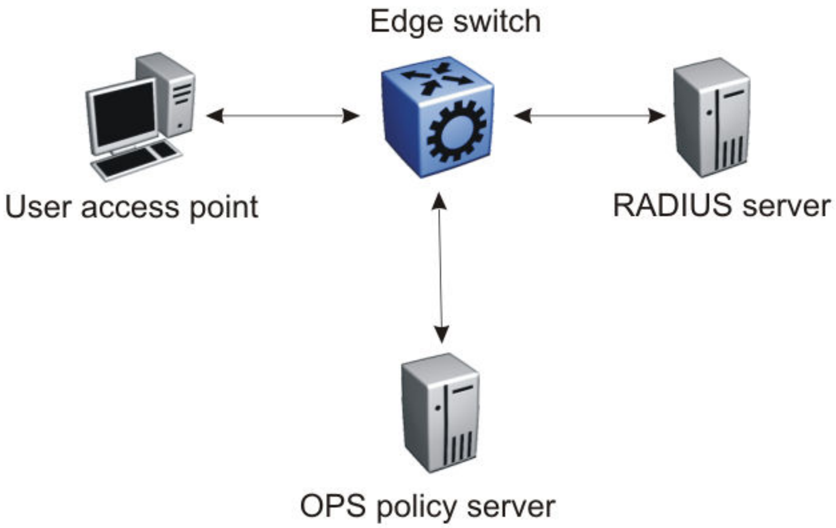


Figure 74: 802.1x and OPS interaction

Virtual Services Platform 4000 includes software support for the Preside (Funk) and Microsoft IAS RADIUS servers. Additional RADIUS servers that support the EAP standard are also compatible with Virtual Services Platform 4000. For more information, contact your Avaya representative.

802.1x and the LAN Enforcer or Avaya Health Agent

The Sygate LAN Enforcer or the Avaya Health Agent enables Virtual Services Platform 4000 to use the 802.1x standard to ensure that a user who connects from inside a corporate network is legitimate. The LAN Enforcer or Health Agent also checks the endpoint security posture, including anti-virus, firewall definitions, Windows registry content, and specific file content (plus date and size). Noncompliant systems that attempt to obtain switch authentication can be placed in a remediation VLAN, where updates can be pushed to the internal user, and users can subsequently attempt to join the network again.

VLANs and traffic isolation

You can use Avaya Virtual Services Platform 4000 Series to build secure VLANs. If you configure port-based VLANs, each VLAN is completely separate from the others. VSP 4000 supports the IEEE 802.1Q specification for tagging frames and coordinating VLANs across multiple switches.

VSP 4000 analyzes each packet independently of preceding packets. This mode, as opposed to the cache mode that other vendors use, allows complete traffic isolation.

For more information about VLANs, see *Configuring VLANs and Spanning Tree on Avaya Virtual Services Platform 4000 Series*, NN46251-500.

Management of access policies

At Layer 2, VSP 4000 provides the following security mechanisms:

- Access policies

  If you enable access policies globally, the system creates a default policy (1) that allows File Transfer Protocol (FTP), Hypertext Transfer Protocol (HTTP), Telnet, and Secure Shell (SSH). If you enable access policies globally but disable the default policy, the system denies FTP, HTTP, rlogin, SSH, Simple Network Management Protocol (SNMP), Telnet, and Trivial FTP (TFTP).

The **access-strict** parameter ties to the **accesslevel** parameter. If you enable **access-strict**, the access policy looks at the **accesslevel** parameter, and only applies to that access level. Use the following configuration as an example:

```
VSP-9012:1(config)#show access-policy

  AccessPolicyEnable: off

                  Id: 1
                Name: default
        PolicyEnable: false
                Mode: allow
             Service: ftp|http|telnet|ssh
          Precedence: 128
         NetAddrType: any
             NetAddr: N/A
             NetMask: N/A
     TrustedHostAddr: N/A
 TrustedHostUserName: none
         AccessLevel: readOnly
        AccessStrict: false
               Usage: 0
```

If you disable **access-strict** (false), the policy looks at the value for **accesslevel**, and then the system applies the policy to anyone with equivalent rights or higher. In this example, all levels include read-only so the default policy applies to l1, l2, l3, rw, ro, and rwa. If you enable **access-strict**, the system applies the policy only to ro.

Note:

If you configure the access policy mode to **deny**, the system checks the mode and service, and if they match the system denies the connection. With the access policy mode configured to **deny**, the system does not check **accesslevel** or **access-strict** information. If you configure the access policy mode to allow, the system continues to check the **accesslevel** and **access-strict** information.

For SNMP and access policies, you must apply the service to the access policy. The only choice is SNMPv3 but this parameter applies to all versions of SNMP. The additional command **access-policy <1-65535> snmp-group WORD<1-32> <snmpv1|snmpv2|usm>** applies the policy to the SNMP community or the SNMP group.

Note:

If you enable enhanced secure mode, the system can provide role-based access levels, strong password requirements, and strong rules on password length, password complexity, password change intervals, password reuse, and password maximum age use. For more information, see *Administration for Avaya Virtual Services Platform 4000 Series*, NN46251-600.

- Filters

  ACL filters are used by individual VLANs to filter out packets based on source MAC, destination MAC and other criteria.

  For more information about these filters, see *Configuration - QoS and ACL-Based Traffic Filtering Avaya Virtual Services Platform 4000 Series*, NN46251-502.

- Limited MAC learning

This feature limits the number of forwarding database (FDB) entries learned on a particular port to a user-specified value. After the number of learned FDB entries reaches the maximum limit, the switch drops packets with unknown source MAC addresses.

Note:

The current release of the VSP 4000 allows you to enable limit-learning on a port and configure the maximum number of MAC entries on this port.

```
VSP-switch(config-if)#mac-security limit-learning ?
  enable     Enable limit-learning on this port
  max-addrs  Set the maximum number of entries on this port
```

Security at Layer 3: filtering

At Layer 3 and higher, VSP 4000 provides enhanced filtering capabilities as part of its security strategy to protect the network from different attacks.

VSP 4000 supports advanced filters based on Access Control Lists (ACL).

Customer Support Bulletins (CSBs) are available on the Avaya Technical Support website to provide information and configuration examples about how to block some attacks.

Routing protocol security

You can protect OSPF and BGP updates with a Message Digest 5 (MD5) key on each interface. At most, you can configure two MD5 keys for each interface. You can also use multiple MD5 key configurations for MD5 transitions without bringing down an interface.

For more information, see *Configuring OSPF and RIP on Avaya Virtual Services Platform 4000 Series*, NN46251-506 and *Configuring BGP on Avaya Virtual Services Platform 4000 Series*, NN46251-507.

Control plane security

The control plane physically separates management traffic using the in-band interface. The control plane facilitates High Secure mode, management access control, access policies, authentication, SSH and Secure Copy, and SNMP.

Management port

Avaya Virtual Services Platform 4000 Series requires one port to be configured as the management port. This port separates user traffic from management traffic in highly sensitive environments, such as brokerages and insurance agencies. By using this dedicated network (see Figure 75: Dedicated Ethernet management link on page 155) to manage the switch, and by configuring access policies (if you enable routing), you can manage the switch in a secure fashion. You can also use terminal servers to access the console port on the CP module (see Figure 76: Terminal server access on page 155).

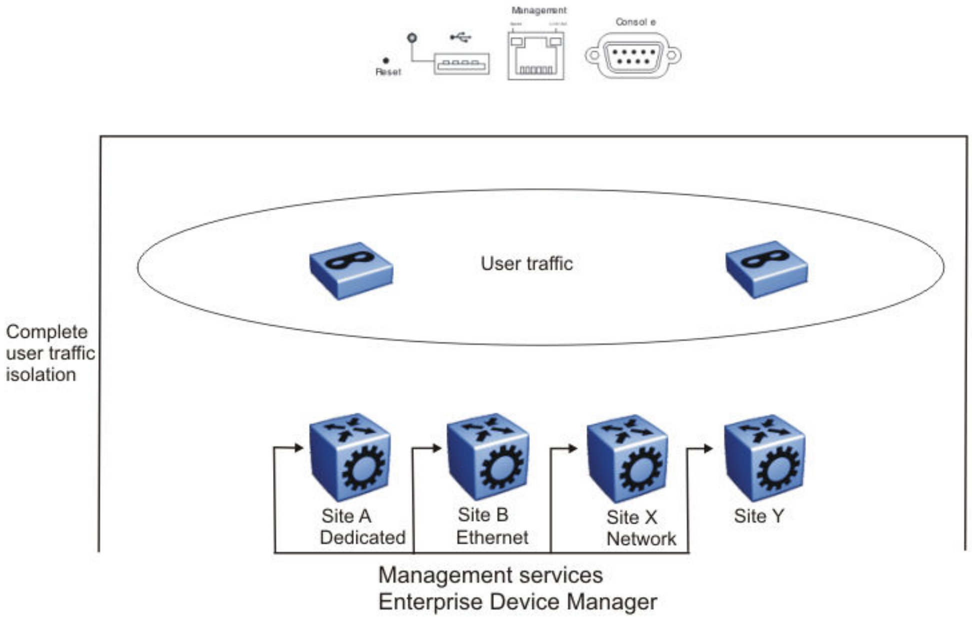


Figure 75: Dedicated Ethernet management link

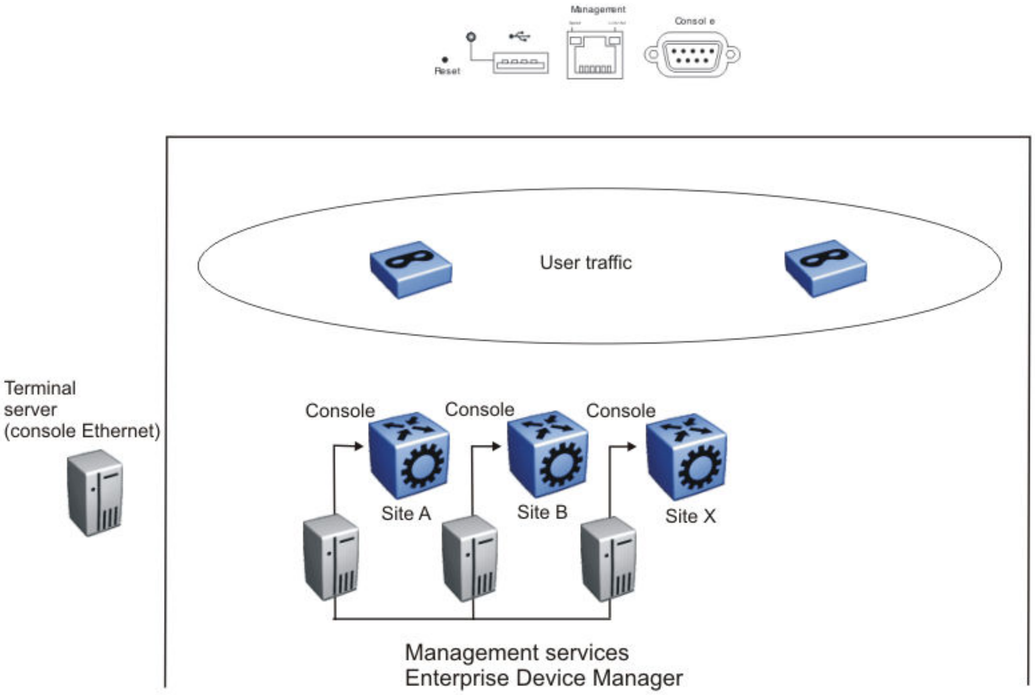


Figure 76: Terminal server access

If you must access the switch, Avaya recommends that you use the console port. The switch is always reachable, even if an issue occurs with the in-band network management interface.

Management access control

The following table shows management access levels. For more information, see *Security for Avaya Virtual Services Platform 4000 Series*, NN46251-601.

Note:

If you enable enhanced secure mode, the following access levels do not apply. If enhanced secure mode is enabled, the system supports role-based access levels. For more information on enhanced secure mode, see *Administration for Avaya Virtual Services Platform 4000 Series*, NN46251-600. Enhanced secure mode is disabled by default.

Table 19: Management access levels

Access level	Description
Read only	Use this level to view the device configuration. You cannot change the configuration.
Layer 1 Read Write	Use this level to view switch configuration and status information and change only physical port parameters.
Layer 2 Read Write	Use this level to view and edit device configuration related to Layer 2 (bridging) functionality. The Layer 3 configuration, for example, OSPF and DHCP, are not accessible. You cannot change the security and password configuration.
Layer 3 Read Write	Use this level to view and edit device configuration related to Layer 2 (bridging) and Layer 3 (routing). You cannot change the security and password configuration.
Read Write	Use this level to view and edit most device configuration. You cannot change the security and password configuration.
Read Write All	Use this level to do everything. You have all the privileges of read-write access and the ability to change the security configuration. The security configuration includes access passwords and the web-based management user names and passwords. Read-Write-All (RWA) is the only level from which you can modify usernames, passwords, and SNMP community strings, with the exception of the RWA community string, which cannot be changed.

High Secure mode

Use High Secure to disable all unsecured applications and daemons, for example, FTP, TFTP, and rlogin. Avaya strongly recommends that you do not use unsecured protocols. See also High Secure mode on page 151.

Use Secure File Transfer Protocol (SFTP) rather than FTP or TFTP.

Enhanced secure mode

If you enable enhanced secure mode, the system can provide role-based access levels, strong password requirements, and strong rules on password length, password complexity, password change intervals, password reuse, and password maximum age use. For more information, see *Administration for Avaya Virtual Services Platform 4000 Series*, NN46251-600.

Security and access policies

Access policies permit secure switch access by specifying a list of IP addresses or subnets that can manage the switch for a specific daemon, such as Telnet, SNMP, HTTP, SSHv2, TFTP, FTP, RSH, and rlogin. Rather than using a management VLAN that is spread out among all of the switches in the network, you can build a full Layer 3 routed network and securely manage the switch with one of the in-band IP addresses attached to one of the VLANs (see the following figure).

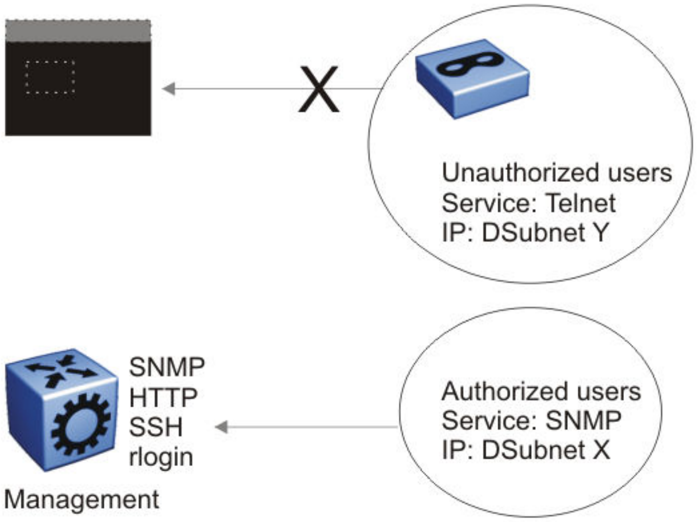


Figure 77: Access levels

Avaya recommends that you use access policies for in-band management to secure access to the switch. By default, all services are denied. You must enable the default policy or enable a custom policy to provide access. A lower precedence takes higher priority if you use multiple policies. Preference 120 has priority over preference 128.

RADIUS authentication

You can enforce access control by using Remote Authentication Dial-in User Service (RADIUS). RADIUS provides a high degree of security against unauthorized access and centralizes the knowledge of security access based on a client and server architecture. The database within the RADIUS server stores pertinent information about clients, users, passwords, and access privileges including the use of the shared secret.

When the switch acts as a Network Access Server, it operates as a RADIUS client. The switch is responsible for passing user information to the designated RADIUS servers. Because the switch operates in a LAN environment, it allows user access through Telnet, rlogin, and console logon.

You can configure a list of up to 10 RADIUS servers on the switch. If the first server is unavailable, VSP 4000 tries the second, and so on, until it establishes a successful connection.

RADIUS authentication supports: WEB, CLI, or SNMP. You can configure a list of up to 10 RADIUS servers for all three methods combined. If you configure six servers for SNMP, you can configure four servers for the other methods.

You can use the RADIUS server as a proxy for stronger authentication (see the following figure), such as:

- SecurID cards
- Kerberos
- other systems like Terminal Access Controller Access-Control System Plus (TACACS+)

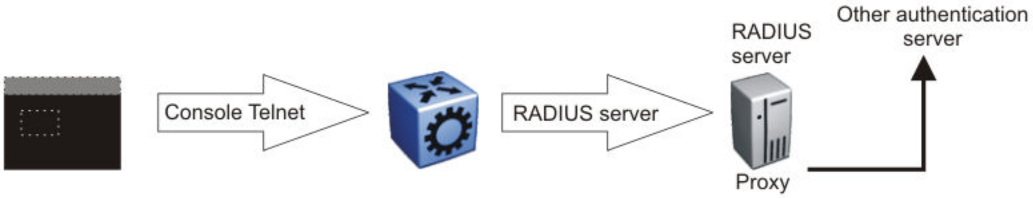


Figure 78: RADIUS server as proxy for stronger authentication

You must configure each RADIUS client to contact the RADIUS server. When you configure a client to work with a RADIUS server, complete the following configurations:

- Enable RADIUS.
- Provide the IP address of the RADIUS server.
- Ensure that the shared secret matches what is defined in the RADIUS server.
- Provide the attribute value.
- Provide the use-by value.

  The use-by value can be CLI, SNMP, or IGMP, or EAPoL.
- Indicate the order of priority in which the RADIUS server is used. (Order is essential when more than one RADIUS server exists in the network.)
- Specify the User Datagram Protocol (UDP) port that the client and server use during the authentication process. The UDP port between the client and the server must have the same or equal value. For example, if you configure the server with UDP 1812, the client must use the same UDP port value.

Other customizable RADIUS parameters require careful planning and consideration, for example, switch timeout and retry. Use the switch timeout to define the number of seconds before the authentication request expires. Use the retry parameter to indicate the number of retries the server accepts before sending an authentication request failure.

Avaya recommends that you use the default value in the attribute-identifier field. If you change the default value, you must alter the dictionary on the RADIUS server with the new value. To configure the RADIUS feature, you require Read-Write-All access to the switch.

For more information about RADIUS, see *Security for Avaya Virtual Services Platform 4000 Series*, NN46251-601.

Encryption of control plane traffic

Control-plane traffic encryption involves Secure Shell (SSHv2), SFTP, and Simple Network Management Protocol (SNMPv3).

Use SSH to conduct secure communications over a network between a server and a client. The switch supports only the server mode (supply an external client to establish communication). The server mode supports SSHv2. SSHv1 is not supported.

The SSH protocol offers:

- Authentication—SSHv2 determines identities. During the logon process, the SSH client asks for digital proof of the identity of the user.
- Encryption—SSHv2 uses encryption algorithms to scramble data. This data is rendered unintelligible except to the intended receiver.
- Integrity—SSHv2 guarantees that data is transmitted from the sender to the receiver without alteration. If a third party captures and modifies the traffic, SSH detects this alteration.

VSP 4000 supports:

- SSH version 2 with password and Digital Signature Algorithm (DSA) authentication. SSH version 1 is not supported.
- Digital Encryption Standard (DES)
- Advanced Encryption Standard (AES)

SNMP header network address

You can direct an IP header to have the same source address as the management virtual IP address for self-generated UDP packets. If you configure a management virtual IP address and enable the **`udpsrc-by-vip`** flag, the network address in the SNMP header is always the management virtual IP address. This configuration is true for all traps routed out on the I/O ports or on the out-of-band management Ethernet port.

SNMPv3 support

SNMP version 1 and version 2 are not secure because communities are not encrypted.

Avaya strongly recommends that you use SNMP version 3. SNMPv3 provides stronger authentication services and the encryption of data traffic for network management.

If you enable enhanced secure mode, the VSP switch does not support the default SNMPv1 and default SNMPv2 community strings, and default SNMPv3 user name. The individual in the administrator access level role can configure a non-default value for the community strings, and the VSP switch can continue to support SNMPv1 and SNMPv2. The individual in the administrator access level role can also configure a non-default value for the SNMPv3 user name and the VSP switch can continue to support SNMPv3.

If you disable enhanced secure mode, the SNMPv1 and SNMPv2 support for community strings remains the same, and the default SNMPv3 user name remains the same. Enhanced secure mode is disabled by default.

Other security equipment

Avaya offers other devices that increase the security of your network.

For sophisticated state-aware packet filtering (real stateful inspection), you can add an external firewall to the architecture. State-aware firewalls can recognize and track application flows that use not only static TCP and UDP ports, like Telnet or HTTP, but also applications that create and use dynamic ports, such as FTP, and audio and video streaming. For every packet, the state-aware firewall finds a matching flow and conversation.

The following figure shows a typical configuration used in firewall load balancing.

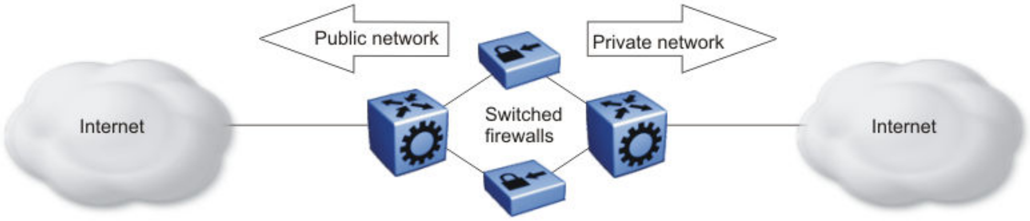


Figure 79: Firewall load balancing configuration

Use this configuration to redirect incoming and outgoing traffic to a group of firewalls and to automatically load balance across multiple firewalls. The benefits of such a configuration are:

- Increased firewall performance
- Reduced response time
- Redundant firewalls ensure Internet access

Virtual private networks (VPN) replace the physical connection between the remote client and access server with an encrypted tunnel over a public network. VPN technology employs IP security (IPsec) and the Secure Sockets Layer (SSL) services.

Several Avaya products support IPsec and SSL, including Avaya VPN Gateway and Secure Router.

Additional information

The following organizations provide the most up-to-date information about network security attacks and recommendations about good practices:

- The Center of Internet Security Expertise (CERT)
- The Research and Education Organization for Network Administrators and Security Professionals (SANS)
- The Computer Security Institute (CSI)

Chapter 17: QoS design guidelines

This chapter provides design guidelines to provide Quality of Service (QoS) to user traffic on the network.

For more information about fundamental QoS mechanisms and how to configure QoS, see *Configuration - QoS and ACL-Based Traffic Filtering Avaya Virtual Services Platform 4000 Series*, NN46251-502.

QoS mechanisms

Avaya Virtual Services Platform 4000 Series has a solid, well-defined architecture to handle QoS in an efficient and effective manner. The following sections briefly describe several QoS mechanisms that the platform uses.

QoS classification and mapping

VSP 4000 provides a hardware-based QoS platform through hardware packet classification. Packet classification is based on the examination of the QoS fields within the Ethernet packet, primarily the Differentiated Services Code Point (DSCP) and the 802.1p fields.

You can configure ingress interfaces in one of two ways. In the first type of configuration, the interface does not classify traffic, but it forwards the traffic based on the packet markings. This mode of operation applies to trusted interfaces (core port mode) because the DSCP or 802.1p field is trusted to be correct, and the edge switch performs the mapping without classification.

In the second type of configuration, the interface classifies traffic as it enters the port, and marks the packet for further treatment as it traverses VSP 4000 network. This mode of operation applies to untrusted interfaces (access port mode) because the DSCP or 802.1p field is not trusted to be correct.

VSP 4000 assigns an internal QoS level to each packet that enters a port.

The Avaya QoS strategy simplifies QoS implementation by providing a mapping of various traffic types and categories to a Class of Service. These service classes are termed Avaya Service Classes (ASC). The following table provides a summary of the mappings and their typical traffic types.

Table 20: Traffic categories and ASC mappings

Traffic category		Application example	ASC
Network Control		Alarms and heartbeats	Critical
		Routing table updates	Network
Real-Time, Delay Intolerant		IP telephony; interhuman communication	Premium
Real-Time, Delay Tolerant		Video conferencing; interhuman communication.	Platinum
		Audio and video on demand; human-host communication	Gold
NonReal-Time Mission Critical	Interactive	eBusiness (B2B, B2C) transaction processing	Silver
	NonInteractive	Email; store and forward	Bronze
NonReal Time, NonMission Critical		FTP; best effort	Standard
		PointCast; Background/standby	Custom/ best effort

QoS and filters

Filters help you provide QoS by permitting or dropping traffic based on the parameters you configure. You can use filters to mark packets for specific treatment.

Typically, filters act as firewalls or are used for Layer 3 redirection. In more advanced cases, traffic filters can identify Layer 3 and Layer 4 traffic streams. The filters cause the streams to be re-marked and classified to attain a specific QoS level at both Layer 2 (802.1p) and Layer 3 (DSCP).

Traffic filtering is a key QoS feature. VSP 4000, by default, determines incoming packet 802.1p or DiffServ markings, and forwards traffic based on their assigned QoS levels. However, situations exist where the markings are incorrect, or the originating user application does not have 802.1p or DiffServ marking capabilities. Also, you can give a higher priority to select users (executive class). In these situations, use filters to prioritize specific traffic streams.

You can use filters to assign QoS levels to devices and applications. To help you decide whether to use a filter, key questions include:

1. Does the user or application have the ability to mark QoS information on data packets?
2. Is the traffic source trusted? Are the QoS levels configured appropriately for each data source?

   Users can maliciously configure QoS levels on their devices to take advantage of higher priority levels.
3. Do you want to prioritize traffic streams?

This decision-making process is outlined in the following figure.

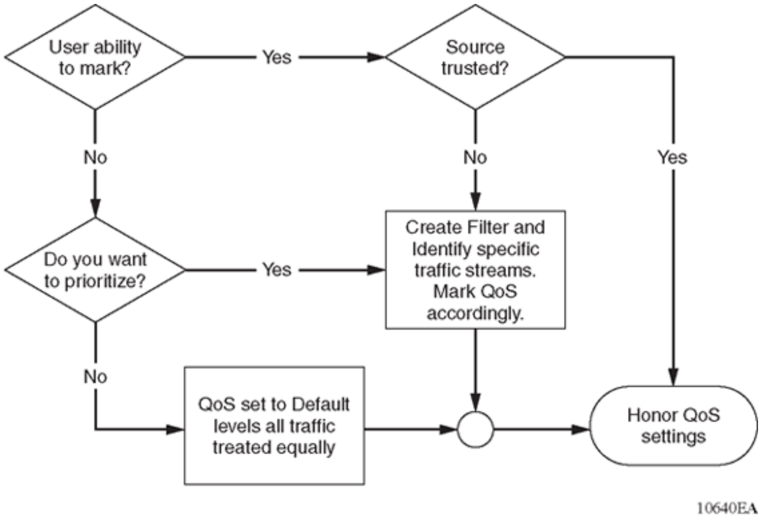

User ability to mark?
Yes
Source trusted?
No
No
Yes
Create Filter and Identify specific traffic streams. Mark QoS accordingly.
Do you want to prioritize?
Yes
No
QoS set to Default levels all traffic treated equally
Honor QoS settings
10640EA

Figure 80: Filter decision-making process

Configure filters through the use of Access Control Lists (ACL) and Access Control Entries (ACE), which are implemented in hardware. An ACL can include both security and QoS type ACEs. The platform supports 2048 ACLs and 1000 ACEs for each ACL to a maximum of 16,000 ACEs for each plaform.

Note:

VSP 4000 supports a maximum of 256 IPv6 ingress port/vlan security ACL/Filters. IPv6 ingress QoS ACL/Filters and IPv6 egress security and QoS ACL/Filters are not supported.

The following steps summarize the filter configuration process:

1. Determine your desired match fields.
2. Create an ACL.
3. Create an ACE within the ACL.
4. Configure the desired precedence, traffic type, and action.

   You determine the traffic type by creating an ingress or egress ACL.
5. Modify the parameters for the ACE.

Policing and shaping

As part of the filtering process, you can police ingress traffic. Policing is performed according to the traffic filter profile assigned to the traffic flow. For enterprise networks, policing ensures that traffic flows conform to the criteria assigned by network managers.

Traffic policers identify traffic using a traffic policy. Traffic that conforms to this policy is guaranteed for transmission, whereas nonconforming traffic is considered to be in violation. Traffic policers drop packets if traffic is excessive, or remark the DSCP or 802.1p markings by using filter actions. With VSP 4000, you can define multiple actions in case of traffic violation.

For service providers, policing at the network edge provides different bandwidth options as part of a service-level agreement (SLA). For example, in an enterprise network, you can police the traffic rate from one department to give critical traffic unlimited access to the network. In a service provider network, you can control the amount of traffic customers send to ensure that they comply with their SLA. Policing ensures that users do not exceed their traffic contract for a QoS level.

VSP 4000 supports two-rate, three-color marking for policers as described in RFC2698. Policers mark packets as Green, Yellow, or Red. Red packets are dropped automatically. Out of profile packets cannot be re-marked to a lower QoS level.

The system can perform rate metering only on a Layer 3 basis.

Traffic shapers buffer and delay violating traffic. These operations occur at the egress level. VSP 4000 supports traffic shaping at the port level.

QoS interface considerations

Four QoS interface types are explained in detail in the following sections. You can configure an interface as trusted or untrusted, and for bridging or routing operations. Use these parameters to properly apply QoS to network traffic.

Trusted and untrusted interfaces

You can configure an interface as trusted (core) or untrusted (access). The default is trusted (core).

Use trusted interfaces (core) to mark traffic in a specific way, and to ensure that packets are treated according to the service level of those markings. Use a core interface if you need control over network traffic prioritization. For example, use 802.1p-bits to apply desired class of service (CoS) attributes to the packets before they are forwarded to the access node. You can also classify other protocol types ahead of IP packets.

A core port preserves the DSCP and 802.1p-bits markings. The device uses these values to assign a corresponding QoS level to the packets.

Use an access port to control the classification and mapping of traffic for delivery through the network. Untrusted interfaces require you to configure filter sets to classify and re-mark ingress traffic. For untrusted interfaces in the packet forwarding path, the DSCP is mapped to an IEEE 802.1p user priority field in the IEEE 802.1Q frame, and both of these fields are mapped to an IP Layer 2 drop precedence value that determines the forwarding treatment at each network node along the path. Traffic that enters an access port is re-marked with the appropriate DSCP and 802.1p markings, and given an internal QoS level. The switch performs this re-marking based on the filters and traffic policies that you configure.

The following logical table shows how the system performs ingress mappings for data packets and for control packets not destined for the Control Processor (CP).

Table 21: Data packet ingress mapping

Enable DiffServ	Access DiffServ	802.1p Override	Routed Packet	Tagged Ingress Packet	Internal QoS Derived From	Egress Packet DSCP Derived from	Egress Packet 802.1p Derived from
1	0, L3T=1	0, L2T=1	1	1	DSCP	Stays untouched	iQoS

Table continues…

Enable DiffServ	Access DiffServ	802.1p Override	Routed Packet	Tagged Ingress Packet	Internal QoS Derived From	Egress Packet DSCP Derived from	Egress Packet 802.1p Derived from
1	0, L3T=1	0, L2T=1	0	1	.1p	Stays untouched	iQoS
1	0, L3T=1	0, L2T=1	X	0	DCSP	Stays untouched	iQoS
1	1, L3T=0	0, L2T=1	X	1	.1p	iQoS	iQoS
1	1, L3T=0	0, L2T=1	X	0	Port QoS	iQoS	iQoS
0	X, L3T=0	0, L2T=1	X	1	.1p	Stays untouched	iQoS
0	X, L3T=0	0, L2T=1	X	0	Port QoS	Stays untouched	iQoS
1	0, L3T=1	1, L2T=0	X	X	DSCP	Stays untouched	iQoS
1	1, L3T=0	1, L2T=0	X	X	Port QoS	iQoS	iQoS

Bridged and routed traffic

In a service provider network, access nodes use VSP 4000 for bridging. In this case, VSP 4000 uses DiffServ to manage network traffic and resources, but some QoS features are unavailable in the bridging mode of operation.

In an enterprise network, access nodes use VSP 4000 for bridging, and core nodes use it for routing. For bridging, ingress traffic is mapped from the 802.1p-bit marking to a QoS level. For routing, ingress traffic is mapped from the DSCP marking to the appropriate QoS level.

802.1p and 802.1Q recommendations

In a network, to map the 802.1p user priority bits, use 802.1Q-tagged encapsulation on customer-premises equipment (CPE). You require encapsulation because VSP 4000 does not provide classification when it operates in bridging mode.

To ensure consistent Layer 2 QoS boundaries within the service provider network, you must use 802.1Q encapsulation to connect a CPE directly to VSP 4000 access node. If you do not require packet classification, use Avaya Ethernet Routing Switch 5600 to connect to the access node. In this case, configure the traffic classification functions in the Avaya Ethernet Routing Switch 5600.

At the egress access node, packets are examined to determine if their IEEE 802.1p or DSCP values must be re-marked before leaving the network. Upon examination, if the packet is a tagged packet, the IEEE 802.1p tag is configured based on the QoS level-to-IEEE 802.1p-bit mapping. For bridged packets, the DSCP is re-marked based on the QoS level.

Network congestion and QoS design

When you provide QoS in a network, one of the major elements you must consider is congestion, and the traffic management behavior during congestion. Congestion in a network is caused by many different conditions and events, including node failures, link outages, broadcast storms, and user traffic bursts.

At a high level, three main types or stages of congestion exist:

1. No congestion
2. Bursty congestion
3. Severe congestion

In a noncongested network, QoS actions ensure that delay-sensitive applications, such as real-time voice and video traffic, are sent before lower-priority traffic. The prioritization of delay-sensitive traffic is essential to minimize delay and reduce or eliminate jitter, which has a detrimental impact on these applications.

A network can experience momentary bursts of congestion for various reasons, such as network failures, rerouting, and broadcast storms. Avaya Virtual Services Platform 4000 Series has sufficient capacity to handle bursts of congestion in a seamless and transparent manner. If the burst is not sustained, the traffic management and buffering process on the switch allows all the traffic to pass without loss.

Severe congestion is defined as a condition where the network or certain elements of the network experience a prolonged period of sustained congestion. Under such congestion conditions, congestion thresholds are reached, buffers overflow, and a substantial amount of traffic is lost.

After the switch detects severe congestion, Avaya Virtual Services Platform 4000 Series discards traffic based on drop precedence values. This mode of operation ensures that high-priority traffic is not discarded before lower-priority traffic.

When you perform traffic engineering and link capacity analysis for a network, the standard design rule is to design the network links and trunks for a maximum average-peak utilization of no more than 80%. This value means that the network peaks to up to 100% capacity, but the average-peak utilization does not exceed 80%. The network is expected to handle momentary peaks above 100% capacity.

QoS examples and recommendations

The sections that follow present QoS network scenarios for bridged and routed traffic over the core network.

Bridged traffic

If you bridge traffic over the core network, you keep customer VLANs separate (similar to a Virtual Private Network). Normally, a service provider implements VLAN bridging (Layer 2) and no routing. In this case, the 802.1p-bit marking determines the QoS level assigned to each packet. If DiffServ is active on core ports, the level of service received is based on the highest of the DiffServ or 802.1p settings.

The following cases provide sample QoS design guidelines you can use to provide and maintain high service quality in a network.

If you configure a core port, you assume that, for all incoming traffic, the QoS value is properly marked. All core switch ports simply read and forward packets; they are not re-marked or reclassified. All initial QoS markings are performed at the customer device or on the edge devices.

The following figure illustrates the actions performed on three different bridged traffic flows (that is VoIP, video conference, and email) at access and core ports throughout the network.

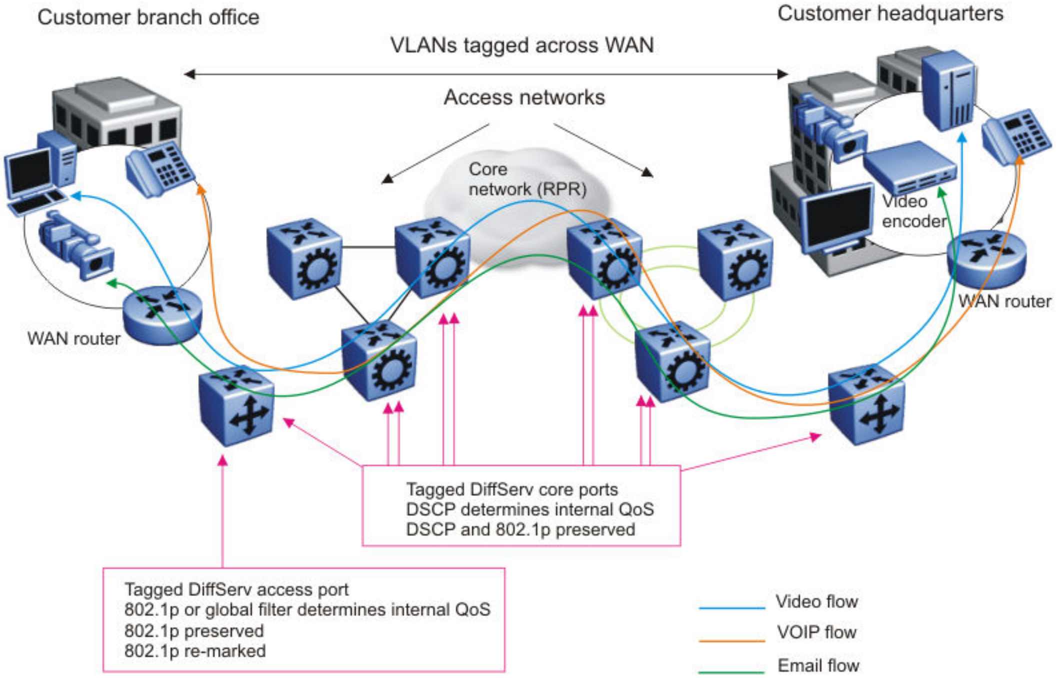


Figure 81: Trusted bridged traffic

For bridged, untrusted traffic, if you configure the port to access, mark and prioritize traffic on the access node using global filters. Reclassify the traffic to ensure it complies with the class of service specified in the SLA.

For Resilient Packet Ring (RPR) interworking, you can assume that, for all incoming traffic, the QoS configuration is properly marked by the access nodes. The core switch ports, configured as core or trunk ports, perform the RPR interworking. These ports preserve the DSCP marking and re-mark the 802.1p bit to match the 802.1p bit of the RPR. The following figure shows the actions performed on three different traffic flows (VoIP, video conference, and email) over an RPR core network.

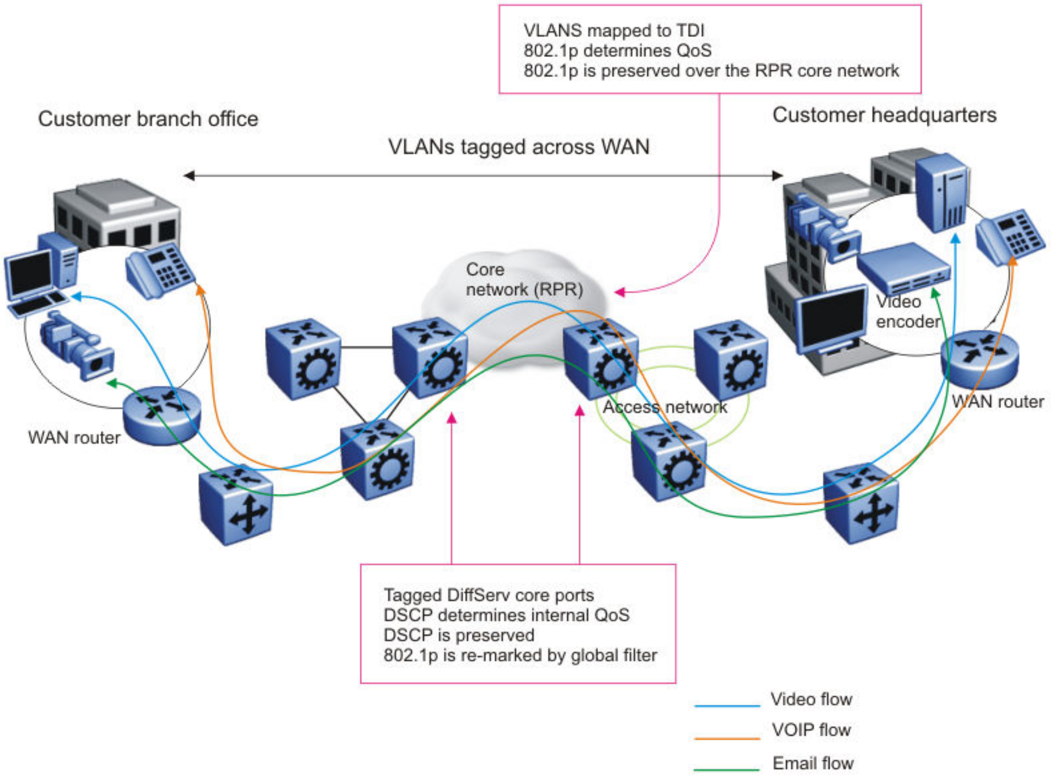


Figure 82: RPR QoS internetworking

Routed traffic

If you route traffic over the core network, VLANs are not kept separate.

If you configure the port to core, you assume that, for all incoming traffic, the QoS configuration is properly marked. All core switch ports simply read and forward packets. The switch does not re-mark or classify the packets. The customer device or the edge devices perform all initial QoS markings.

The following figure shows the actions performed on three different routed traffic flows (that is VoIP, video conference, and email) at access and core ports throughout the network.

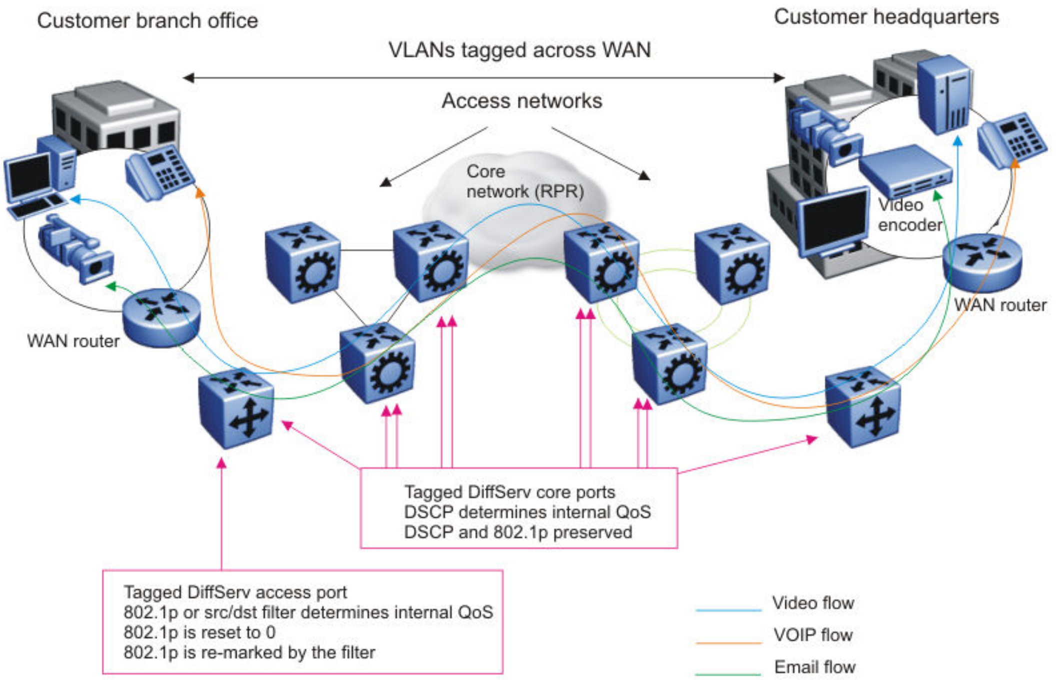

Customer branch office
Customer headquarters
VLANs tagged across WAN
Access networks
Core network (RPR)
Video encoder
WAN router
WAN router
Tagged DiffServ core ports
DSCP determines internal QoS
DSCP and 802.1p preserved
Tagged DiffServ access port
802.1p or src/dst filter determines internal QoS
802.1p is reset to 0
802.1p is re-marked by the filter
Video flow
VOIP flow
Email flow

Figure 83: Trusted routed traffic

For routed, untrusted traffic, in an access node, packets that enter through a tagged or untagged access port exit through a tagged or untagged core port.

Chapter 18: Layer 1, 2, and 3 design examples

This chapter provides examples to help design your network. Layer 1 examples deal with the physical network layouts. Layer 2 examples map Virtual Local Area Networks (VLAN) on top of the physical layouts. Layer 3 examples show the routing instances that Avaya recommends to optimize IP for network redundancy.

Layer 1 example

This section describes a Layer 1 network design example that focuses primarily on the physical network layout. In this example, an Avaya Virtual Services Platform 4000 Series switch can function as an access switch.

Layer 1: Design example

This example uses double physical links and distributed MultiLink Trunking (DMLT) to provide a redundant network.

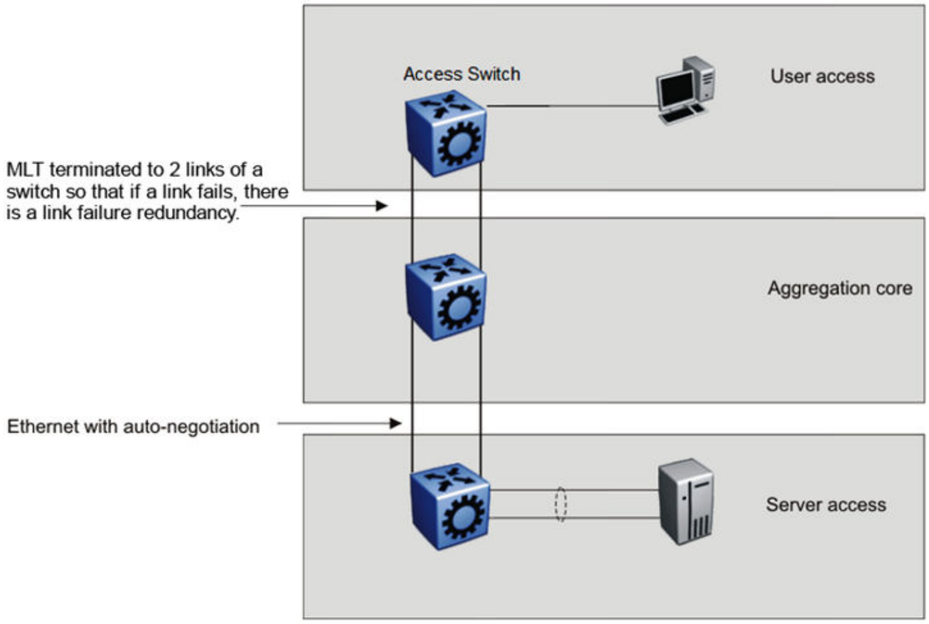

Access Switch
User access
MLT terminated to 2 links of a switch so that if a link fails, there is a link failure redundancy.
Aggregation core
Ethernet with auto-negotiation
Server access

Figure 84: Layer 1 design example

Layer 2 example

This section describes a Layer 2 network design example that maps VLANs over the physical network layout.

Layer 2: Design example

The following example shows a redundant device network that uses one VLAN for all switches. To support multiple VLANs, you need 802.1Q tagging on the links with trunks.

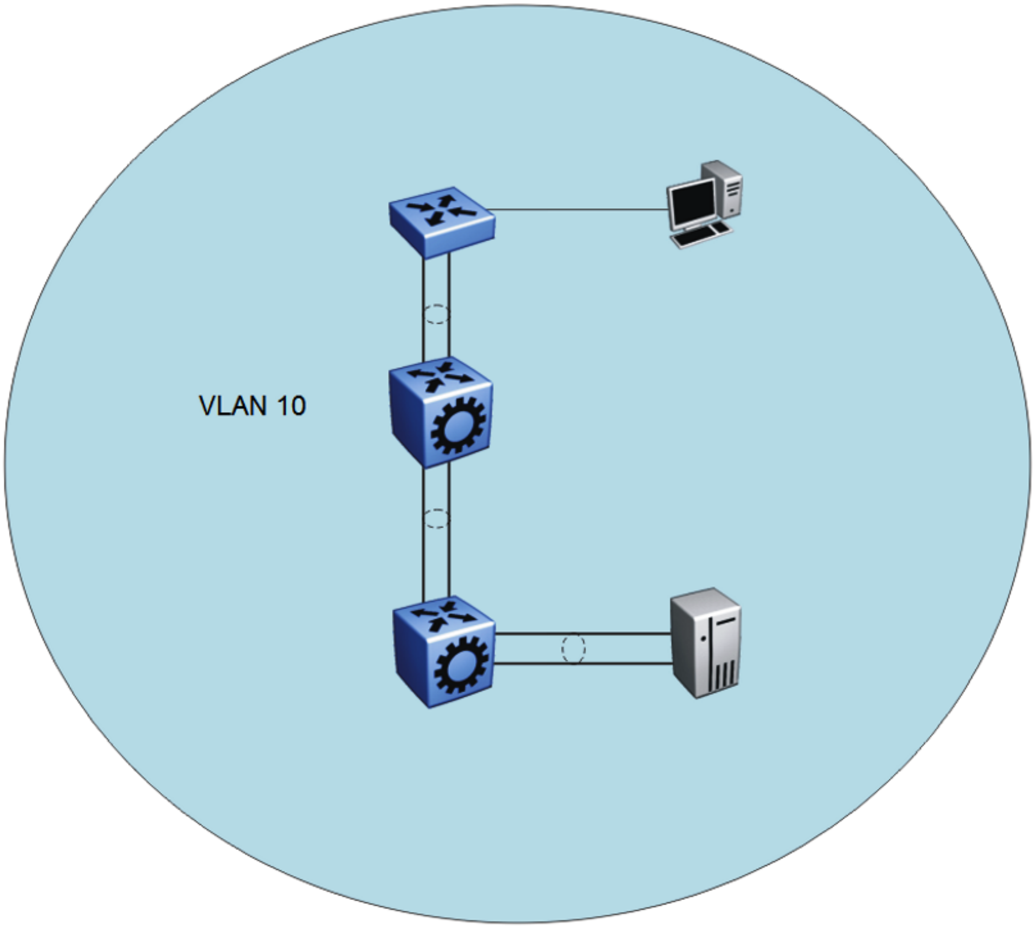


Figure 85: Layer 2 design example

Layer 3 example

This section describes a Layer 3 network design example that shows the routing instances that Avaya recommends you use to optimize IP for network redundancy.

Layer 3: Design example

The example in the following figure uses redundant links.

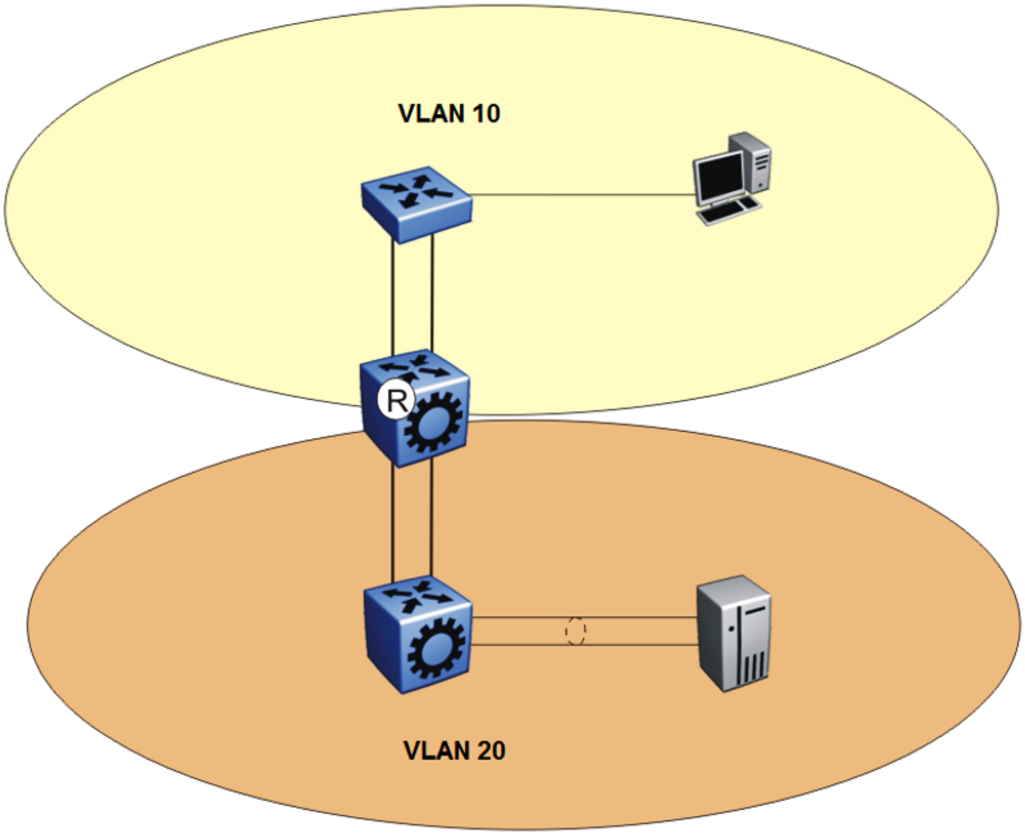


Figure 86: Layer 3 design example

Glossary

Backbone Core Bridge (BCB)
Backbone Core Bridges (BCBs) form the core of the SPBM network. The BCBs are SPBM nodes that do not terminate the VSN services. BCBs forward encapsulated VSN traffic based on the Backbone MAC Destination Address (B-MAC-DA). A BCB can access information to send that traffic to any Backbone Edge Bridges (BEBs) in the SPBM backbone.

Backbone Edge Bridge (BEB)
Backbone Edge Bridges (BEBs) are SPBM nodes where Virtual Services Networks (VSNs) terminate. BEBs handle the boundary between the core MAC-in-MAC Shortest Bath Bridging MAC (SPBM) domain and the edge customer 802.1Q domain. A BEB node performs 802.1ah MAC-in-MAC encapsulation and decapsulation for the Virtual Services Network (VSN).

Backbone MAC (B-MAC)
Provider Backbone Bridging (PBB) MAC-in-MAC encapsulation encapsulates customer MAC addresses in Backbone MAC (B-MAC) addresses. MAC-in-MAC encapsulation defines a BMAC-DA and BMAC-SA to identify the backbone source and destination addresses. The originating node creates a MAC header that SPBM uses for delivery from end to end. As the MAC header stays the same across the network, no need exists to swap a label or perform a route lookup at each node, allowing the frame to follow the most efficient forwarding path end to end. In Shortest Path Bridging MAC (SPBM), each node has a System ID, which is used in the topology announcement. This same System ID also serves as the switch Backbone MAC address (B-MAC), which is used as the source and destination MAC address in the SPBM network.

Backbone VLAN identifier (B-VID)
The Backbone VLAN identifier (B-VID) indicates the Shortest Path Bridging MAC (SPBM) B-VLAN associated with the SPBM instance.

bit error rate (BER)
The ratio of the number of bit errors to the total number of bits transmitted in a specific time interval.

coarse wavelength division multiplexing (CWDM)
A technology that uses multiple optical signals with different wavelengths to simultaneously transmit in the same direction over one fiber, and then separates by wavelength at the distant end.

Connectivity Fault Management (CFM)
Connectivity Fault Management is a mechanism to debug connectivity issues and to isolate faults within the Shortest Path Bridging MAC (SPBM) network. CFM operates at Layer 2 and provides the equivalent of ping and traceroute. IEEE 802.1ag Connectivity Fault Management (CFM) divides or

separates a network into administrative domains called Maintenance Domains (MD).

Customer MAC (C-MAC)

For customer MAC (C-MAC) addresses, which is customer traffic, to forward across the service provider back, SPBM uses IEEE 802.1ah Provider Backbone Bridging MAC-in-MAC encapsulation. The system encapsulates C-MAC addresses within a backbone MAC (B-MAC) address pair made up of a BMAC destination address (BMAC-DA) and a BMAC source address (BMAC-SA).

dense wavelength division multiplexing (DWDM)

A technology that uses many optical signals (16 or more) with different wavelengths to simultaneously transmit in the same direction across one fiber, and then separate by wavelength at the distant end.

Designated Intermediate System (DIS)

A Designated Intermediate System (DIS) is the designated router in Intermediate System to Intermediate System (IS-IS) terminology. You can modify the priority to affect the likelihood of a router being elected the designated router. The higher the priority, the more likely the router is to be elected as the DIS. If two routers have the same priority, the router with the highest MAC address (Sequence Number Packet [SNP] address) is elected as the DIS.

Global routing engine (GRE)

The base router or routing instance 0 in the Virtual Routing and Forwarding (VRF).

Intermediate System to Intermediate System (IS-IS)

Intermediate System to Intermediate System(IS-IS) is a link-state, interior gateway protocol. ISO terminology refers to routers as Intermediate Systems (IS), hence the name Intermediate System to Intermediate System (IS-IS). IS-IS operation is similar to Open Shortest Path First (OSPF).

In Shortest Path Bridging MAC (SPBM) networks, IS-IS discovers network topology and builds shortest path trees between network nodes that IS-IS uses for forwarding unicast traffic and determining the forwarding table for multicast traffic. SPBM employs IS-IS as the interior gateway protocol and implements additional Type-Length-Values (TLVs) to support additional functionality.

Internet Protocol Security (IPsec)

Internet Protocol security (IPsec) is a set of security protocols and cryptographic algorithms that protect communication in a network. Use IPsec in scenarios where you need to encrypt packets between two hosts, two routers, or a router and a host.

jitter

The delay variance between received packets. Packets may not arrive at the destination address in consecutive order, or on a timely basis, and the signal can vary from its original reference timing. This distortion damages multimedia traffic.

last member query interval (LMQI)
The time between when the last Internet Group Management Protocol (IGMP) member leaves the group and the stream stops.

latency
The time between when a node sends a message and receipt of the message by another node; also referred to as propagation delay.

Layer 1
Layer 1 is the Physical Layer of the Open System Interconnection (OSI) model. Layer 1 interacts with the MAC sublayer of Layer 2, and performs character encoding, transmission, reception, and character decoding.

Layer 2
Layer 2 is the Data Link Layer of the OSI model. Examples of Layer 2 protocols are Ethernet and Frame Relay.

Layer 2 Virtual Services Network
The Layer 2 Virtual Services Network (L2 VSN) feature provides IP connectivity over SPBM for VLANs. Backbone Edge Bridges (BEBs) handle Layer 2 virtualization. At the BEBs you map the end-user VLAN to a Service Instance Identifier (I-SID). BEBs that have the same I-SID configured can participate in the same Layer 2 Virtual Services Network (VSN).

Layer 3
Layer 3 is the Network Layer of the OSI model. An example of a Layer 3 protocol is Internet Protocol (IP).

Layer 3 Virtual Services Network
The Layer 3 Virtual Services Network (L3 VSN) feature provides IP connectivity over SPBM for VRFs. Backbone Edge Bridges (BEBs) handle Layer 3 virtualized. At the BEBs through local provisioning, you map the end-user IP enabled VLAN or VLANs to a Virtualized Routing and Forwarding (VRF) instance. Then you map the VRF to a Service Instance Identifier (I-SID). VRFs that have the same I-SID configured can participate in the same Layer 3 Virtual Service Network (VSN).

Layer 4
The Transport Layer of the OSI model. An example of a Layer 4 protocol is Transmission Control Protocol (TCP).

Link Aggregation Control Protocol (LACP)
A protocol that exists between two endpoints to bundle links into an aggregated link group for bandwidth increase and link redundancy.

Link Aggregation Control Protocol Data Units (LACPDU)
Link aggregation control protocol data unit (LACPDU) is used for exchanging information among LACP-enabled devices.

link aggregation group (LAG)
A group that increases the link speed beyond the limits of one single cable or port, and increases the redundancy for higher availability.

link-state advertisement (LSA)
Packets that contain state information about directly connected links (interfaces) and adjacencies. Each Open Shortest Path First (OSPF) router generates the packets.

link-state database (LSDB) A database built by each OSPF router to store LSA information. The router uses the LSDB to calculate the shortest path to each destination in the autonomous system (AS), with itself at the root of each path.

load balancing The practice of splitting communication into two (or more) routes or servers.

MAC-in-MAC encapsulation MAC-in-MAC encapsulation defines a BMAC-DA and BMAC-SA to identify the backbone source and destination addresses. The originating node creates a MAC header that the device uses for delivery from end to end. As the MAC header stays the same across the network, there is no need to swap a label or do a route lookup at each node, allowing the frame to follow the most efficient forwarding path end to end.

management information base (MIB) The MIB defines system operations and parameters used for the Simple Network Management Protocol (SNMP).

multicast router discovery (MRDISC) Provides the automatic discovery of multicast-capable routers. By listening to multicast router discovery messages, Layer 2 devices can determine where to send multicast source data and Internet Group Management Protocol (IGMP) host membership reports.

multihomed AS An autonomous system that has multiple connections to one or more autonomous systems and does not carry transit traffic.

multiplexing Carriage of multiple channels over a single transmission medium; a process where a dedicated circuit is shared by multiple users. Typically, data streams intersperse on a bit or byte basis (time division), or separate by different carrier frequencies (frequency division).

next hop The next hop to which a packet can be sent to advance the packet to the destination.

not so stubby area (NSSA) Prevents the flooding of external link-state advertisements (LSA) into the area by providing them with a default route. An NSSA is a configuration of the Open Shortest Path First (OSPF) protocol.

out of band (OOB) Network dedicated for management access to chassis.

packet loss Expressed as a percentage of packets dropped over a specified interval. Keep packet loss to a minimum to deliver effective IP telephony and IP video services.

policing Ensures that a traffic stream follows the domain service-provisioning policy or service-level agreement (SLA).

Protocol Data Units (PDUs) A unit of data that is specified in a protocol of a specific layer and that consists of protocol-control information of the specific layer and possibly user data of that layer.

Provider Backbone Bridge (PBB)

To forward customer traffic across the service-provider backbone, SPBM uses IEEE 802.1ah Provider Backbone Bridging (PBB) MAC-in-MAC encapsulation, which hides the customer MAC (C-MAC) addresses in a backbone MAC (B-MAC) address pair. MAC-in-MAC encapsulation defines a BMAC-DA and BMAC-SA to identify the backbone source and destination addresses.

quality of service (QoS)

QoS features reserve resources in a congested network, allowing you to configure a higher priority for certain devices. For example, you can configure a higher priority for IP deskphones, which need a fixed bit rate and split the remaining bandwidth between data connections if calls in the network are more important than the file transfers.

Read Write All (RWA)

An access class that lets users access all menu items and editable fields.

remote login (rlogin)

An application that provides a terminal interface between hosts (usually UNIX) that use the TCP/IP network protocol. Unlike Telnet, rlogin assumes the remote host is, or behaves like, a UNIX host.

remote monitoring (RMON)

A remote monitoring standard for Simple Network Management Protocol (SNMP)-based management information bases (MIB). The Internetwork Engineering Task Force (IETF) proposed the RMON standard to provide guidelines for remote monitoring of individual LAN segments.

resilient packet ring (RPR)

A shared packet edge ring connection, where both paths around the ring carry traffic, which allows double bandwidth on each ring.

reverse path forwarding (RPF)

Prevents a packet from forging its source IP address. Typically, the system examines and validates the source address of each packet.

route flapping

An instability that is associated with a prefix, where the associated prefix routes can exhibit frequent changes in availability over a period of time.

routing policy

A form of routing that is influenced by factors other than the default algorithmically best route, such as the shortest or quickest path.

Secure Shell (SSH)

SSH uses encryption to provide security for remote logons and data transfer over the Internet.

Secure Sockets Layer (SSL)

An Internet security encryption and authentication protocol for secure point-to-point connections over the Internet and intranets, especially between clients and servers.

Service Instance Identifier (I-SID)

The SPBM B-MAC header includes a Service Instance Identifier (I-SID) with a length of 24 bits. SPBM uses this I-SID to identify and transmit any virtualized traffic in an encapsulated SPBM frame. SPBM uses I-SIDs to virtualize VLANs (Layer 2 Virtual Services Network [VSN]) or VRFs (Layer 3 Virtual Services Network [VSN]) across the MAC-in-MAC backbone. With Layer 2 VSNs, you associate the I-SID with a customer VLAN, which is then virtualized across the backbone. With Layer 3 VSNs, you associate the I-SID with a customer VRF, which is also virtualized across the backbone.

service level agreement (SLA)

A service contract that specifies the forwarding service that traffic receives.

Shortest Path Bridging (SPB)

Shortest Path Bridging is a control Link State Protocol that provides a loop-free Ethernet topology. There are two versions of Shortest Path Bridge: Shortest Path Bridging VLAN and Shortest Path Bridging MAC. Shortest Path Bridging VLAN uses the Q-in-Q frame format and encapsulates the source bridge ID into the VLAN header. Shortest Path Bridging MAC uses the 802.1 ah MAC-in-MAC frame format and encapsulates the source bridge identifier into the B-MAC header.

Shortest Path Bridging MAC (SPBM)

Shortest Path Bridging MAC (SPBM) uses the Intermediate-System-to-Intermediate-System (IS-IS) link-state routing protocol to provide a loop-free Ethernet topology that creates a shortest-path topology from every node to every other node in the network based on node MAC addresses. SPBM uses the 802.1ah MAC-in-MAC frame format and encapsulates the source bridge identifier into the B-MAC header. SPBM eliminates the need for multiple overlay protocols in the core of the network by reducing the core to a single Ethernet-based link-state protocol, which can provide virtualization services, both layer 2 and layer 3, using a pure Ethernet technology base.

shortest path tree (SPT)

Creates a direct route between the receiver and the source for group members in a Protocol Independent Multicast-Sparse Mode (PIM-SM) domain.

Simple Loop Prevention Protocol (SLPP)

Simple Hello Protocol that prevents loops in a Layer 2 network (VLAN).

single-mode fiber (SMF)

One of the various light waves transmitted in an optical fiber. Each optical signal generates many modes, but in single-mode fiber only one mode is transmitted. Transmission occurs through a small diameter core (approximately 10 micrometers), with a cladding that is 10 times the core diameter. These fibers have a potential bandwidth of 50 to 100 gigahertz (GHz) per kilometer.

Small Form Factor Pluggable (SFP)

A hot-swappable input and output enhancement component used with Avaya products to allow gigabit Ethernet ports to link with other gigabit Ethernet ports over various media types.

Small Form Factor Pluggable plus (SFP+)

SFP+ transceivers are similar to SFPs in physical appearance but SFP+ transceivers provide Ethernet at 10 gigabits per second (Gbps).

spanning tree
A simple, fully-connected active topology formed from the arbitrary physical topology of connected bridged Local Area Network components by relaying frames through selected bridge ports. The protocol parameters and states that are used and exchanged to facilitate the calculation of the active topology and to control the bridge relay function.

Spanning Tree Group (STG)
A collection of ports in one spanning-tree instance.

SysAdmin, Audit, Network, Security (SANS) Institute
The research and education organization for network administrators and security professionals.

time-to-live (TTL)
The field in a packet used to determine the valid duration for the packet. The TTL determines the packet lifetime. The system discards a packet with a TTL of zero.

traffic engineering
A method that guarantees performance in a network.

Trivial File Transfer Protocol (TFTP)
A protocol that governs transferring files between nodes without protection against packet loss.

trunk
A logical group of ports that behaves like a single large port.

unshielded twisted pair (UTP)
A cable with one or more pairs of twisted insulated copper conductors bound in a single plastic sheath.

User Datagram Protocol (UDP)
In TCP/IP, a packet-level protocol built directly on the Internet Protocol layer. TCP/IP host systems use UDP for application-to-application programs.

user-based security model (USM)
A security model that uses a defined set of user identities for authorized users on a particular Simple Network Management Protocol (SNMP) engine.

view-based access control model (VACM)
Provides context, group access, and group security levels based on a predefined subset of management information base (MIB) objects.

Virtual Link Aggregation Control Protocol (VLACP)
Virtual Link Aggregation Control Protocol (VLACP) is a Layer 2 handshaking protocol that can detect end-to-end failure between two physical Ethernet interfaces.

Virtual Router Redundancy Protocol (VRRP)
A protocol used in static routing configurations, typically at the edge of the network. This protocol operates on multiple routers on an IP subnet and elects a primary gateway router. When the primary router fails, a backup router is quickly available to take its place.

Voice over IP (VOIP) The technology that delivers voice information in digital form in discrete packets using the Internet Protocol (IP) rather than the traditional circuit-committed protocols of the public switched telephone network (PSTN).

wavelength division multiplexing (WDM) Simultaneously transmits many colors (wavelengths) of laser light down the same optical fiber to increase the amount of transferred information.

wiring closet A central termination area for telephone or network cabling or both.