Cisco Service Control MPLS/VPN Solution Guide

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Cisco Service Control MPLS/VPN Solution Guide

CONTENTS

About This Guide

Revised: May 30, 2007, OL-8822-03

This preface describes who should read the *Cisco Service Control MPLS/VPN User Guide*, how it is organized, and its document conventions.

This introduction provides information about the following topics:

- Audience
- Document Revision History
- Organization
- Related Publications
- Document Conventions
- Obtaining Documentation, Obtaining Support, and Security Guidelines

Audience

This guide is for experienced network administrators who are responsible for configuring and maintaining the Service Control MPLS/VPN solution.

Document Revision History

Table 1

Cisco Service Control Release	Part Number	Publication Date
Release 3.0.5	OL-8822-03	November, 2006

Description of Changes

Minor change regarding PE router with multiple IP interfaces (see How to Define the PE Routers).

Table 2

Cisco Service Control Release	Part Number	Publication Date
Release 3.0.3	OL-8822-02	May, 2006

Description of Changes

Various minor changes.

Table 3

Cisco Service Control Release	Part Number	Publication Date
Release 3.0	OL-8822-01	December, 2005

Description of Changes

Created the *Cisco Service Control MPLS/VPN Solution Guide* .

Organization

The major sections of this guide are as follows:

Table 4

Chapter	Title	Description
Chapter 1	Introduction to the Service Control MPLS/VPN Solution	General introduction to the Service Control MPLS/VPN solution, when it is used, and the benefits of its use.
Chapter 2	Overview of the Service Control Solution for MPLS/VPN Networks	Overview of how the Service Control MPLS/VPN solution works.
Chapter 3	Configuring MPLS/VPN Support	Explanation of how to configure the Service Control MPLS/VPN solution.
Chapter 4	Managing MPLS/VPN Support	Explanation of how to manage and monitor the Service Control MPLS/VPN solution.

Related Publications

The following documentation contains additional information regarding the components of the Service Control MPLS/VPN solution:

- For further information regarding general configuration of the Cisco Service Control solution, refer to the *Cisco Service Control Engine (SCE) Software Configuration Guide* .
- For further information regarding the Service Control CLI and a complete listing of all CLI commands, refer to the *Cisco Service Control Engine (SCE) CLI Command Reference* .
- For further information regarding the configuration and maintenance of the Subscriber Manager, refer to the *Cisco Service Control Management Subscriber Manager User Guide* .

In addition, the extensive features and functionality of the SCE platform and the software running on are documented in the following resources:

- For complete installation information, including initial configuration, refer to the relevant installation guide:

- *Cisco SCE 2000 4xGBE Installation and Configuration Guide*
- *Cisco SCE 2000 4/8xFE Installation and Configuration Guide*
- *Cisco SCE 1000 2xGBE Installation and Configuration Guide*

Note Note You can access Cisco software configuration and hardware installation and maintenance documentation on the World Wide Web at the Cisco Website. Translated documentation is available at the International Cisco Website

- For initial installation and startup information, refer to the relevant quick start guide:
  - *Cisco SCE 2000 4xGBE Quick Start Guide*
  - *Cisco SCE 2000 4/8xFE Quick Start Guide*
  - *Cisco SCE 1000 2xGBE Quick Start Guide*
- For international agency compliance, safety, and statutory information for wide-area network (WAN) interfaces for the SCE platform, refer to the regulatory and safety information document:
  - *Regulatory Compliance and Safety Information for the Cisco Service Control Engine (SCE)*
- To view Cisco documentation or obtain general information about the documentation, refer to the following sources:
  - Obtaining Documentation, Obtaining Support, and Security Guidelines
  - The Cisco Information Packet that shipped with your SCE 2000 platform.

Document Conventions

This guide uses the following conventions:

- **Bold** is used for commands, keywords, and buttons.
- *Italics* are used for command input for which you supply values.
- `Screen` font is used for examples of information that are displayed on the screen.
- **`Bold screen`** font is used for examples of information that you enter.
- Vertical bars (|) indicate separate alternative, mutually exclusive elements.
- Square brackets ([ ]) indicate optional elements.
- Braces ({}) indicate a required choice.
- Braces within square brackets ([{}]) indicate a required choice within an optional element.

Note Means *reader take note*. Notes contain helpful suggestions or references to material not covered in the guide.

Timesaver Means the *described action saves time*. You can save time by performing the action described in the paragraph.

Caution Means *reader be careful*. In this situation, you might do something that could result in equipment damage or loss of data.

Warning **Means *danger*. You are in a situation that could cause bodily injury. Before you work on any equipment, you must be aware of the hazards involved with electrical circuitry and familiar with standard practices for preventing accidents. To see translated versions of warnings, refer to the *Regulatory Compliance and Safety Information* document that accompanied the device.**

Obtaining Documentation, Obtaining Support, and Security Guidelines

For information on obtaining documentation, obtaining support, providing documentation feedback, security guidelines, and also recommended aliases and general Cisco documents, see the monthly *What's New in Cisco Product Documentation*, which also lists all new and revised Cisco technical documentation, at:

http://www.cisco.com/en/US/docs/general/whatsnew/whatsnew.html

CHAPTER 1

Introduction to the Service Control MPLS/VPN Solution

This module explains how the Cisco Service Control MPLS/VPN solution was developed to solve the challenges faced by ISPs offering MPLS/VPN services.

- Cisco Service Control MPLS/VPN: the Challenge and the Solution

Cisco Service Control MPLS/VPN: the Challenge and the Solution

- Overview
- The Challenge
- The Cisco MPLS-VPN Service Control Solution
- Benefits for Service Providers

Overview

Cisco offers a Service Control solution that is applicable for service providers who are either currently offering MPLS-VPN services to their customers, or planning to introduce such a service in the near-future. This service targets providers offering enterprise-focused solutions as well as those who are involved in offering MPLS-VPN services to their SOHO customers. This state-of-the-art solution allows complete visibility into the applications and services in MPLS-VPN tunnels for subscriber-based usage monitoring and billing, and leveraged for capacity control and for differentiation of service levels as well.

This solution incorporates the ability to monitor and control all the traffic in an MPLS-VPN tunnel as belonging to a single subscriber entity, including traffic with private non-routable IP addresses. Its advanced functionality facilitates the implementation the Cisco Service Control solution in MPLS-VPN environments, and the suite of capabilities that the solution provides.

The Challenge

Service providers that offer MPLS-VPN services are challenged in their ability to leverage their investment in the MPLS-VPN infrastructure. This lack of control hampers their ability to both reduce total cost of ownership and increase per customer revenue, aggregate revenue, and profitability.

These service providers need to:

- Implement usage monitoring and trend analysis for the traffic of MPLS-VPN tunnels to improve existing business models and develop new ones.
- Launch new service packages and billing plans enabled by granular subscriber usage information per service and application for the traffic inside MPLS-VPN tunnels.
- Control the traffic inside MPLS-VPN tunnels by de-prioritizing some of the traffic that the MPLS-VPN customers consider less important, while prioritizing business-critical traffic and providing network-based services such as content-filtering, security phishing prevention, and other such services.

The Cisco MPLS-VPN Service Control Solution

In the Cisco MPLS-VPN Service Control solution, Cisco has managed to overcome the technical challenge of classifying flows with private non-routable IP addresses into the correct MPLS-VPN that these flows are part of. The challenge originates from the fact that the SCE platform may have been incorrectly classifying the packets of these flows. The Cisco MPLS-VPN solution implements a unique learning algorithm that can successfully and reliably correctly classify multiple flows in multiple MPLS-VPN tunnels, even if they have the same private IP address.

The Cisco MPLS-VPN Service Control solution:

- Closes the loop between the Service Control engine and the PE routers that manage the allocation of MPLS tags to MPLS-VPN tunnels.
- Overcomes the challenge of correct classification of flows with private non-routable source-IP addresses.

Benefits for Service Providers

With the Cisco Service Control MPLS-VPN solution, service providers can benefit from granular per subscriber and per application usage reports. This granularity allows for complete per subscriber and per application layer-7 visibility of the manner in which their MPLS-VPN subscribers are using the service provider's network. These reports can, for example, show:

- The HTTP hosts or RTSP streaming hosts that are most popular for each subscriber
- The bandwidth per service consumed by a MPLS-VPN subscriber over a predefined time period
- An extensive variety of usage reports available as part of the Cisco Service Control solution

These reports can be used by the service provider's network teams for capacity planning, and by the marketing teams for planning and rolling out new "tiers of service" packages.

As well as the data records that enable these reports, the solution generates data records that can be forwarded to mediation and billing systems and used for implementation of granular usage-based billing.

Service providers can also benefit from the Service Control MPLS-VPN solution by using the SCE platforms as network enforcement devices for a variety of per network-based services, such as:

- Mission-critical traffic prioritization – the SCE platform can be used for prioritizing the Oracle or Citrix traffic that flows between the branches of the MPLS-VPN customer.
- Implementing various types of managed services – the solution can be used to create services designed to increase employee productivity, such as the creation of a network-based content filtering service. The deployment, management, and ongoing administration of this suite of services can be easily controlled using a standard WEB interface.

This flexibility not only provides an extremely attractive return on investment, but protects your investment as your needs for network and application infrastructure evolves.

Using the Service Control infrastructure to create these next-generation services provides the path to enhanced customer revenue streams, differentiated service offerings, and a cost structure commensurate with the required business model.

CHAPTER 2

Overview of the Service Control Solution for MPLS/VPN Networks

Service Control in the MPLS/VPN Environment

MPLS/VPN networks are very complex and contain many routing protocols and many different levels of addressing and control. In addition, the various VPNs may use overlapping IP addresses (private IPs).

The SCE platform makes a distinction between identical IP addresses that come from different VPNs, and maps them into subscribers according to the MPLS labels attached to the packets. This involves various mechanisms in all levels of the system.

The following assumptions and requirements allow the SCE platform to operate in an MPLS/VPN environment:

- The MPLS/VPN architecture is according to RFC-2547.
- The specific type of encapsulation used is the MPLS shim header over Ethernet (described in RFC-3032).
- There are two levels of MPLS labels.
  - External labels — Used for transport over the service provider MPLS core network.
  - Internal labels (BGP labels) — Used to identify the VPNs connected to each edge router, and typically controlled by the BGP protocol.
- All IP addresses in one VPN are treated as a single subscriber.
- The MPLS/VPN solution contains the SCE platform and the SM. The SM acts as a BGP peer for the PE routers in the service provider network, and communicates the BGP information to the SCE platform as subscriber information.

Note The MPLS/VPN solution supports the existence of non-VPN subscribers concurrently with the MPLS/VPN subscribers (see Non-VPN Subscribers).

Definitions and Acronyms

The following table defines important terms and acronyms.

Table 2-1 MPLS/VPN Terms and Acronyms

Term or Acronym	Definition
PE (Provider Edge router)	A router at the edge of the service provider network. The PE routers are the ones that connect to the customers, and maintain the VPNs
P (Provider router)	A router in the core of the service provider network. P routers only forward MPLS packets, regardless of VPNs.
VPN (Virtual Private Network)	In the Service Control context, a VPN is the part of the VPN that resides in a specific site. This is the subscriber of the solution
BGP LEG	A software module that resides on the SM server and generates BGP-related login events. The BGP LEG communicates with the BGP routers (PEs) and passes the relevant updates to the SM software, which generates login events to the SCE platform for the updated VPN subscribers.
Upstream	Traffic coming from the PE router and going into the P router
Downstream	Traffic coming from the P router and going into the PE router
RD (Route Distinguisher)	Used to uniquely identify the same network/mask from different VRFs (such as, 10.0.0.0/8 from VPN A and 10.0.0.0/8 from VPN B)
RT (Route Target)	Used by the routing protocols to control import and export policies, to build arbitrary VPN topologies for customers
VRF (Virtual Routing and Forwarding instance)	Mechanism used to build per-interface routing tables. Each PE has several VRFs, one for each site it connects to. This is how the private IPs remain unique.

What are the Challenges for Service Control for MPLS/VPN Support?

- Private IP addresses cause flows to look the same except for their MPLS labels.

- The MPLS labels are different in each direction, and must be matched.
- An entire VPN must be accounted as one subscriber. The problem is how to detect that a flow belongs to a certain VPN.
- In the downstream direction there is no external label. We must be able to understand the VPN information from the internal label + the MAC address of the PE.

How MPLS/VPN Support Works

Service Control supports two mechanisms that make MPLS/VPN support work:

- Flow detection – This is the job of the SCE platform, to match upstream and downstream traffic to identify flows.
- Subscriber detection – This is the job of the SM, to match downstream labels with the VPN to identify the subscriber entity.
- Flow Detection
- Subscriber Detection
- How the Service Control MPLS/VPN Solution Works

Flow Detection

Flow detection is the process of deciding which packets belong to the same flow. This relates to the first two challenges listed:

- Private IP addresses cause flows to look the same except for their MPLS labels.
- The MPLS labels are different in each direction, and must be matched.

Flow detection is based on the MPLS labels, extending the basic 5 tuple that SCOS uses to identify flows, and taking into account the fact that in MPLS, the packet is labeled differently in each direction.

Since MPLS traffic is unidirectional, each direction is classified separately by the SCE platform, using the following:

- Downstream – the BGP label and the MAC address of the PE (only one label that is relevant to the classification)

  Downstream labels are learned from the control plane (BGP).
- Upstream – the combination of the external label, the BGP label, and the MAC address of the P router (two labels that are relevant to the classification)

  Upstream labels are learned from the data plane.

Subscriber Detection

- What is a VPN Subscriber?
- SM and Subscriber Detection

What is a VPN Subscriber?

As in other modes of operation, in MPLS/VPN each flow belongs to a certain subscriber. A VPN subscriber is a customer of the Service Provider, who pays for the VPN service. All traffic of that VPN customer is aggregated into a single VPN subscriber for Service Control.

SM and Subscriber Detection

The network configuration that provides the division into VPN subscribers is controlled by the SM. The network-wide value that describes a VPN most closely is either the Route Target or the Route Distinguisher:

- The administrator configures the SM to detect VPN subscribers, according to selected attribute (RT or RD) (see How to Configure the SM for MPLS/VPN Support.)
- The network operator provides the SCE platform with a mapping between RT values and VPN subscriber names. (See How to Manage MPLS/VPN Support via SM CLU)

The relevant module in the Subscriber Manager server (SM) is the BGP-LEG. The BGP-LEG is added to the BGP neighborhood for obtaining the information on the MPLS labels. The local PEs are configured to add the BGP-LEG as a BGP peer.

- BGP-LEG gets MP-BGP messages from the PEs with the allocated labels per VPN and forwards them to the SM module.

The SM updates each SCE platform with the mapping of MPLS labels to VPN subscribers.

How the Service Control MPLS/VPN Solution Works

- How the Service Control MPLS/VPN Solution Works: A Summary
- SCE Platform Tasks in the MPLS/VPN Solution
- BGP LEG Tasks in the MPLS/VPN Solution
- SM Tasks in the MPLS/VPN Solution

How the Service Control MPLS/VPN Solution Works: A Summary

- The SM is configured with the VPNs that should be managed.

  A VPN is identified by the RD / RT and the PE.
- The BGP-LEG updates the SM with the MPLS labels.
- The SM pushes the VPN subscriber to the SCE platform with the downstream MPLS labels of the VPN.
- The SCE platform resolves the PE MAC addresses and updates its tables with the new information.
- The SCE platform learns the upstream labels, including the P MAC address.
- The SCE platform provides the regular services to the VPN subscriber (BW management, reports, etc.)

SCE Platform Tasks in the MPLS/VPN Solution

- Matching upstream to downstream labels

  - Mappings of downstream labels to VPN subscribers are received from the SM
  - Upstream labels are learned from the data
- The MAC addresses of the PEs are used to distinguish downstream labels of different PEs
- After the learning period, each flow is classified as belonging to one of the VPN subscribers
- The SCE platform runs the SCA-BB application for the network flows, which are classified to VPN subscribers, thus providing subscriber aware service control and reporting

BGP LEG Tasks in the MPLS/VPN Solution

- The BGP LEG is a software module that runs on the SM server
- The LEG maintains a BGP session with a list of PEs
- After the sessions establishment, the LEG propagates MP-BGP route-updates from the PEs to the SM module

SM Tasks in the MPLS/VPN Solution

- The VPNs are stored in the SM database as VPN subscribers.
- A VPN subscriber is a group of VPN sites.
- Each VPN site is defined by:
  - The IP address of the loopback interface of the PE router.
  - The RD or RT that identifies the VPN within the PE router.
- The SM receives updates from the BGP LEG, and updates the VPN subscriber information with the new MPLS labels.
- The relevant SCE platforms that will get the MPLS updates are defined by the VPN subscriber domain

Service Control MPLS/VPN Concepts

- Non-VPN Subscribers
- Bypassing Unknown VPNs
- Additional MPLS Pattern Support
- VPN Identifier (RD or RT)

Non-VPN Subscribers

The MPLS/VPN solution supports the existence of non-VPN (regular IP) subscribers concurrently with the MPLS/VPN subscribers, with the following limitations and requirements:

- The SM must work in "push" mode.
- Non-VPN subscribers cannot have MPLS/VPN mappings.
- VLAN subscribers are NOT supported at the same time as MPLS/VPN subscribers.

In typical MPLS/VPN networks, traffic that does not belong to any VPN is labeled with a single MPLS label in the upstream direction, which is used for routing. The downstream direction of such flows typically contains no label, due to penultimate hop popping.

The SCE platform uses the one or more labels upstream and no label downstream definition to identify non-VPN flows. Classification and traffic processor load balancing on these flows is performed according to the IP header, rather than the label.

This process requires learning of the upstream labels in use for such flows, and is done using the flow detection mechanism described above (see Flow Detection).

Bypassing Unknown VPNs

In an MPLS network, there may be many VPNs crossing the SCE platform, only a small number of which require service control functionality. It is necessary for the SCE platform to recognize which VPNs are not managed.

- The SCE platform automatically bypasses any VPN that is not configured in the SM
- The VPNs are bypassed by the SCE platform without any service

Note that the label limit of 57,344 different labels includes labels from the bypassed VPNs.

Each bypassed VPN entry, both upstream and downstream, is removed from the database after a set period of time (10 minutes). If the entry is still used in the traffic, it will be re-learnt. This allows the database to remain clean, even if the labels are reused by the routers for different VPNs.

In the **show bypassed VPNs** command, the age is indicated with each label - the length of time since it was learned.

Additional MPLS Pattern Support

The MPLS/VPN solution was designed to provide DPI services in MPLS/VPN network. These networks use BGP protocol as the control plane for the VPNs and LDP protocol for routing. There are complex networks where the MPLS infrastructure is used not only for VPN and routing, but also for other features such as traffic engineering (TE) and better fail-over. These features are usually enabled per VRF in the PE.

The Service Control MPLS/VPN solution does not support VPNs that use other MPLS-related features. Features such as MPLS-TE or MPLS-FRR (Fast Reroute) are not supported. VPNs for which these features are enabled can be automatically bypassed in the system, but are not allowed to be configured in the SM as serviced VPNs. Configuration of these VPNs in the SM might cause misclassification due to label aliasing.

The following list describes the labels combinations that are supported by the SCE platform and how each combination is interpreted by the platform:

- One or more labels upstream, no labels downstream:

  Assumed to be non-VPN (see Non-VPN Subscribers).

  The SCE platform treats the following IP flows as non-VPN flows, and ignores their labels.
- One label upstream, one label downstream:

  Assumed to be VPN traffic, in which the P router happens to be the last hop in the upstream.

The label in the downstream is treated as a BGP label, like the regular case. If the BGP label is known from the SM, then the flow is assigned to the correct subscriber, otherwise, it is treated as a bypassed VPN.

- Two labels upstream, one label downstream:

  This is the typical configuration of the system. Of the two upstream labels, one is for BGP and one for LDP. The downstream label is for BGP only

- More than two labels upstream, or more than one label downstream:

  These combinations occur when other MPLS-related features are enabled for the VPN. Such VPNs are not supported and should not be configured in the SM. However, they can be bypassed in the SCE platform without any service and without harming the service for other VPNs.

VPN Identifier (RD or RT)

Either the Route Distinguisher (RD) attribute or the Route Target (RT) attribute can be used to identify the VPN subscriber. It is required to decide which attribute best reflects the VPN subscriber partitioning, and configure the system accordingly. Note that the configuration is global for all the subscribers, that is, all subscribers must be identified by the same attribute.

The Route Distinguisher (RD) is generally used to distinguish the distinct VPN routes of separate customers who connect to the provider, so in most cases the RD is a good partition for the subscribers in the network. Since the RD is an identifier of the local VRF, and not the target VRF, it can be used to distinguish between VPN sites that transfer information to a common central entity (for example a central bank, IRS, Port Authority, etc.).

The Route Target (RT) is used to define the destination VPN site. Though it is not intuitive to define the VPN subscriber based on its destination route, it might be easier in some cases. For example, if all the VPN sites that communicate to a central bank should be treated as a single subscriber, consider using the RT as the VPN identifier.

It is important to note that this configuration is global. Therefore, if at some point in time, any VPN subscriber would have to be defined by RD, then all the other VPN subscribers must be defined by RD as well. This is a point to consider when designing the initial deployment

Service Control MPLS/VPN Requirements

- Topology
- Capacity
- Limitations

Topology

Following are the general topology requirements for MPLS/VPN support:

- The SCE platform is placed in the network between the P routers (Provider MPLS core) and the PE (Provider Edge) routers.
- The subscriber side of the SCE platform is connected toward the PE router.
- The network side of the SCE platform is connected toward the P router.

- The BGP LEG is installed on the SM, and is placed somewhere in the network.

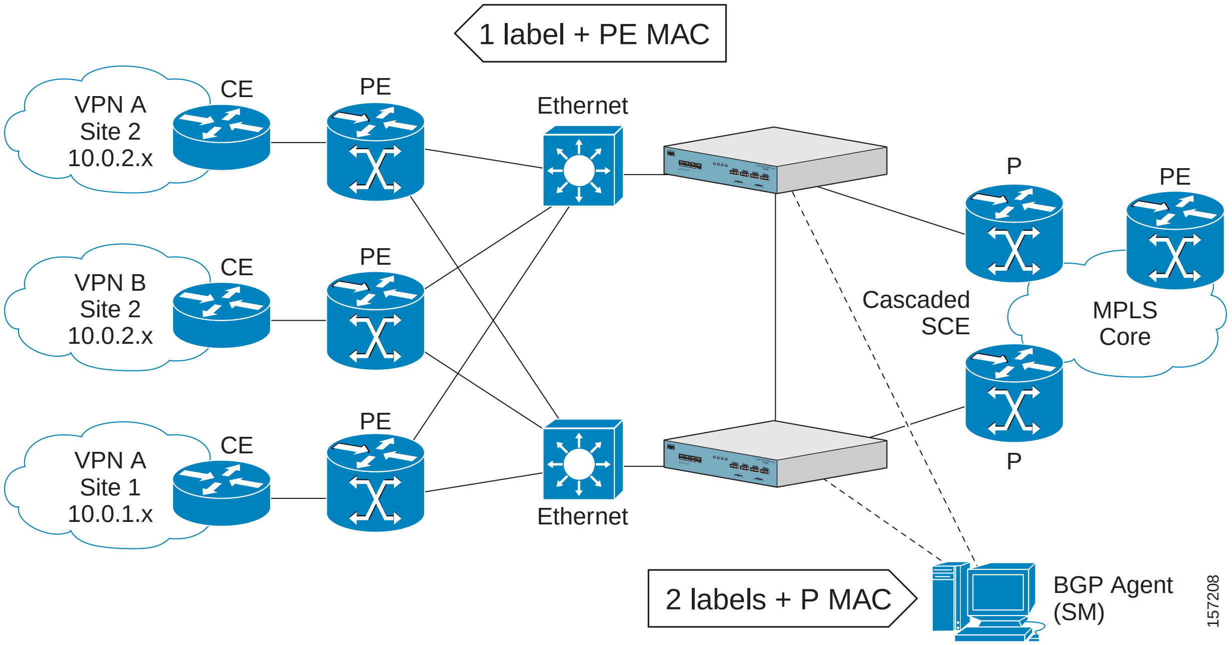
  It speaks with the SCE platform through the management IP.

In a cascade installation:

- The two SCE platforms are connected to each other via the cascade interfaces.
- The data link between the P and the PE is connected via the other interfaces on each SCE platform, as described above:
  - Subscriber side of each SCE platform connected toward the PE router
  - Network side of each SCE platform connected toward the P router

The following drawing depicts a typical cascade installation.

Figure 2-1



Capacity

The system supports:

- 2015 MPLS/VPN subscribers
- 57,344 different labels (including upstream and downstream, and including the bypassed VPNs)
- 256 PEs per SCE platform
- 4 interfaces per PE

Limitations

Mutuallyexclusive system modes

When the system works in MPLS/VPN mode, the following modes are not supported:

- Other tunneling modes (MPLS/TE, L2TP, VLAN classify, etc…).
- TCP Bypass-establishment
- DDoS
- Flow Filter TOS rules – When the MPLS/VPN feature is activated, the flow filter mode is automatically switched to tunnel-id. When the feature is de-activated, the flow filter mode remains tunnel-id.

  This provides easy configuration of MPLS/VPN. To assure correct and consistent configuration of the TOS/Tunnel-ID mode, the system does not allow configuration of TOS based rules when in tunnel-ID and vice versa

Number of MPLS labels

- The choice of the unique VPN site must be based on the BGP label only. The BGP label must be the innermost label.
- The MPLS/VPN solution supports various combinations of labels. See Additional MPLS Pattern Support .
- The system does not support VPNs for which other MPLS-related features, such as MPLS-TE or MPLS-FRR, are enabled.

Subscriber-related limitations

The following subscriber-related limitations exist in the current solution:

- The SM must be configured to operate in Push mode.
- VLAN subscribers cannot be used.
- Two sites of the same VPN must be aggregated into one subscriber if the following conditions are both true:
  - They are both connected to the same SCE platform
  - They both communicate with a common remote site using the same upstream labels and P router.

TCP related Requirements

- Number of Upstream TCP Flows – There must be enough TCP flows opening from the subscriber side on each PE-PE route in each period of time. The higher the rate of TCP flows from the subscriber side, the higher the accuracy of the mechanism can be.

CHAPTER 3

Configuring MPLS/VPN Support

This module explains how to configure MPLS/VPN support. Both the SCE platform and the SM must be properly configured.

- Configuring the MPLS Environment
- How to Configure the SCE Platform for MPLS/VPN Support
- How to Configure the SM for MPLS/VPN Support

Configuring the MPLS Environment

In order for MPLS/VPN support to function, the environment must be configured correctly, specifically the following are required:

- All other tunneling protocols must be configured to the default mode.
- VLAN support must be configured to the default mode.
- The MPLS auto-learning mechanism must be enabled.

How to Check the Running Configuration

Check the running configuration to verify no user-configured values appear for tunneling protocols or VLAN support, indicating that they are all in default mode.

Step 1 From the SCE# prompt, type `show running-config` and press Enter.

Displays the running configuration.

Step 2 Check that no VLAN or L2TP configuration appears.

How to Configure the MPLS Environment

If either VLAN or tunneling support is in default mode, skip the relevant step in the following procedure.

Step 1 From the SCE(config if)# prompt, type `default vlan` and press Enter.

Configures VLAN support to default mode.

Step 2 From the SCE(config if)# prompt, type `no IP-tunnel` and press Enter.

Disables all other tunneling protocol support.

Note All subscribers with tunnel mappings must be cleared to change the tunneling mode. If the connection with the SM is down, use the **no subscriber all with-tunnel-mappings** CLI command.

Step 3 From the SCE(config if)# prompt, type `MPLS VPN auto-learn` and press Enter.

Enables the MPLS auto-learning mechanism.

How to Configure the SCE Platform for MPLS/VPN Support

- About Configuring the SCE Platform for MPLS/VPN Support
- How to Define the PE Routers
- How to Configure the MAC Resolver
- How to Monitor the MAC Resolver

About Configuring the SCE Platform for MPLS/VPN Support

There are three main steps to configure the SCE platform for MPLS/VPN support:

1. Correctly configure the MPLS tunneling environment, disabling all other tunneling protocols, as well as disabling VLAN support (see How to Configure the MPLS Environment)
2. Define all PE routers, specifying the relevant interface IP addresses necessary for MAC resolution (see How to Define the PE Routers.)
3. Configure the MAC resolver (see How to Configure the MAC Resolver.)

How to Define the PE Routers

- Options
- How to Add a PE Router
- How to Remove PE Routers

Options

The following options are available:

- **PE-ID** — IP address that identifies the PE router.
- **interface-ip** — Interface IP address for the PE router. This is used for MAC resolution.
  - At least one interface IP address must be defined per PE router.
  - Multiple interface IP addresses may be defined for one PE router.

  – In the case where the PE router has multiple IP interfaces sharing the same MAC address, it is sufficient to configure just one of the PE interfaces

- **vlan** — A VLAN tag can optionally be provided for each interface IP.

Two interfaces cannot be defined with the same IP address, even if they have different VLAN tags. If such a configuration is attempted, it will simply update the VLAN tag information for the existing PE interface.

How to Add a PE Router

Each PE router that has managed MPLS/VPN subscribers behind it must be defined using the following CLI command.

Step 1 From the SCE(config if)# prompt, type `MPLS VPN PE-ID` *pe-id*`interface-IP` *interface-ip* `[vlan` *vlan*`][Interface-IP` *interface-ip* `[vlan` *vlan*`]]` and press Enter.

Defines the PE router with optional VLAN tag and optional additional IP addresses.

How to Remove PE Routers

- About Removing PE Routers
- How to Remove a Specified PE Router
- How to Remove All PE Routers
- How to Remove a Specified Interface from a PE Router

About Removing PE Routers

Use these commands to remove one or all defined PE routers.

Please note the following:

- You cannot remove a PE if it retains any MPLS mappings. You must logout the VPN before removing the router it uses.
- Removing the last interface of a PE router removes the router as well. Therefore, you must logout the relevant VPN to remove the last interface.
- Likewise, all MPLS VPNs must be logged out before using the no PE-Database command below, since it removes all PE routers.

How to Remove a Specified PE Router

Step 1 From the SCE(config if)# prompt, type `no MPLS VPN PE-ID` *pe-id* and press Enter.

Removes the specified PE router.

How to Remove All PE Routers

Step 1 From the SCE(config if)# prompt, type `no MPLS VPN PE-Database` and press Enter.

Removes all configured PR routers.

How to Remove a Specified Interface from a PE Router

Step 1 From the SCE(config if)# prompt, type `no MPLS VPN PE-ID` *pe-id*`interface-IP` *interface-ip* and press Enter.

Removes the specified interface from the PE router definition. The PE router itself is not removed.

How to Configure the MAC Resolver

- About the MAC Resolver
- Options
- How to Add a Static IP Address
- How to Remove a Static IP Address

About the MAC Resolver

The MAC resolver allows the SCOS to find the MAC address associated with a specific IP address. The MAC resolver must be configured when the SCE platform operates in MPLS/VPN mode, to translate the IP addresses of the provider edge router interfaces to their respective MAC addresses.

The MPLS/VPN mode needs the MAC resolver, as opposed to the standard ARP protocol, because ARP is used by the management interface, while MPLS/VPN uses the traffic interfaces of the SCE platform, which ARP does not include.

The MAC resolver database holds the IP addresses registered by the clients to be resolved. The IP addresses of the routers are added to and removed from the database in either of two modes:

- Dynamic mode (default)

  In this mode, the system listens to ARP messages of the configured PE interfaces, and this way it stays updated with their MAC addresses. There is no configuration required when operating in dynamic mode.

  – Benefit: it works even if the MAC address of the PE interface changes.
- Drawback: depending on the specific network topology, the MAC resolution convergence time may be undesirably long.
- Static mode

  In this mode, the MAC address of each PE router must be explicitly defined by the user.

  – Benefit: no initial delay until IP addresses converge.

  – Drawback: PE interface is not automatically updated via ARP updates; therefore it doesn't automatically support cases where the MAC address changes on the fly.

  However, for statically configured MAC addresses, a user log message appears when the system detects that the MAC address changed. This can be used by the operator to configure the new address.

These two modes can function simultaneously; therefore selected PE routers can be configured statically, while the rest are resolved dynamically

For more information regarding the MAC resolver, refer to the *Cisco Service Control Engine Software Configuration Guide*.

Options

The following options are available:

- **ip address** — The IP address entry to be added to or removed from the database.
- **vlan tag** — VLAN tag that identifies the VLAN that carries this IP address (if applicable).
- **mac address** — MAC address assigned to the IP address, in xxxx.xxxx.xxxx format.

How to Add a Static IP Address

Step 1 From the SCE(config if)# prompt, type `mac-resolver arp` *ip_address*`[vlan` *vlan_tag*`]` *mac_address* andpress Enter.

Adds the specified IP address and MAC address pair to the MAC resolver database.

How to Remove a Static IP Address

Step 1 From the SCE(config if)# prompt, type `no mac-resolver arp` *ip_address*`[vlan` *vlan_tag*`]` *mac_address* and press Enter.

Removes the specified IP address and MAC address pair to the MAC resolver database.

How to Monitor the MAC Resolver

Use this command to see a listing of all IP addresses and corresponding MAC addresses currently registered in the MAC resolver database.

Step 1 From the SCE# prompt, type `show interface linecard 0 mac-resolver arp` and press Enter.

Displays a listing of all IP addresses and corresponding MAC addresses currently registered in the MAC resolver database.

How to Configure the SM for MPLS/VPN Support

- Configuring the SM for MPLS/VPN Support
- How to Edit the SM Configuration File

Configuring the SM for MPLS/VPN Support

There are two main steps to configure the SM for MPLS/VPN support:

Step 1 Edit the *p3sm.cfg* configuration file to specify the field in the BGP messages that should be used by the SM for MPLS-VPN identification.

See How to Edit the SM Configuration File

Step 2 Install and configure the BGP LEG

Refer to the *Cisco SCM SM MPLS/VPN BGP LEG Reference Guide* .

How to Edit the SM Configuration File

The SM configuration file, *p3sm.cfg* , must be configured to specify the field in the BGP messages that should be used by the SM for MPLS-VPN identification.

- How to Configure the SM for MPLS/VPN Support
- How to Configure the SM for Troubleshooting MPLS/VPN Support

How to Configure the SM for MPLS/VPN Support

Step 1 Add the following section to the *p3sm.cfg* configuration file:

```
# The following parameter enables SM operation with MPLS-VPN support.
[MPLS-VPN]
# The following parameter determines field in the BGP messages that should be used
# for MPLS-VPN identification, in correlation to the MPLS-VPN mappings that were
# previously set to the SM.
# possible values: "rd" or "rt".
# (default: rt)
vpn_id=rt
```

How to Configure the SM for Troubleshooting MPLS/VPN Support

An optional parameter may be turned on to facilitate troubleshooting the BGP LEG installation. This parameter turns on detailed logging of messages received from the BGP LEG. It should only be turned on when necessary for troubleshooting and should always be turned off for normal operation of the system.

Step 1 Add the following section to the *p3sm.cfg* configuration file:

```
# The following parameter turns on detailed logging of messages received from the BGP LEG
# should be changed to true only during troubleshooting
# (default: false)
log_all=true
```

CHAPTER 4

Managing MPLS/VPN Support

This module explains how to manage MPLS/VPN support.

- How to Manage MPLS/VPN Support via SNMP
- How to Monitor MPLS/VPN Support via SCE Platform CLI
- How to Manage MPLS/VPN Support via SM CLU

How to Manage MPLS/VPN Support via SNMP

SNMP support for MPLS/VPN auto-learn is provided in two ways:

- MPLS/VPN MIB Objects
- MPLS/VPN Traps

MPLS/VPN MIB Objects

The mplsVpnAutoLearnGrp MIB object group (pcubeSEObjs 17) contains information regarding MPLS/VPN auto-learning.

The objects in the mplsVpnAutoLearnGrp provide the following information:

- maximum number of mappings
- allowed current number of mappings

For more information, see the "Proprietary MIB Reference" in the *Cisco Service Control Engine Software Configuration Guide.*

MPLS/VPN Traps

There is one MPLS/VPN-related trap:

- *mplsVpnTotalHWMappingsThresholdExceeded* (pcubeSeEvents 45)

To provide online notification of a resource deficiency, when the system reaches a level of 80% utilization of the hardware MPLS/VPN mappings, a warning message appears in the user log, and this SNMP trap is sent.

Both the warning and the trap are sent for each 100 mappings that are added after the threshold has been exceeded.

How to Monitor MPLS/VPN Support via SCE Platform CLI

The following sections describe functions you can perform using the SCE platform CLI:

- How to Display Subscriber Mappings
- How to Clear Subscriber Mappings
- How to Monitor Subscriber Counters
- How to Monitor MPLS/VPN Counters
- How to Monitor the PE Routers
- How to Monitor Bypassed VPNs
- How to Monitor Non-VPN Mappings

How to Display Subscriber Mappings

Use the following Viewer commands to display subscriber mappings. The following sections provide more information about the command displays:

- How to Display All MPLS/VPN Mappings for a Specified Subscriber
- How to Display Only the number of MPLS/VPN Mappings for a Specified Subscriber
- How to Display the Name of the Subscriber who has a Specified Downstream Mapping
- How to Display the Mappings of Upstream Labels that Belong to Non-VPN Flows

How to Display All MPLS/VPN Mappings for a Specified Subscriber

Step 1 From the SCE# prompt, type `show interface linecard 0 subscriber name` *name*`mappings` and press Enter.

The keyword " *mappings*" limits the output to the MPLS/VPN mapping information only. If the keyword is not used, all subscriber information is displayed, including the mappings.

Displaying All MPLS/VPN Mappings for a Specified Subscriber: Example

```
SCE# show interface linecard 0 subscriber name  SubscriberX_1122334455 mappings
Subscriber 'SubscriberX_1122334455' mappings:
Downstream MPLS Mappings:
PE-ID = 1.1.1.1 Mpls Label = 30
PE-ID = 1.1.1.1 Mpls Label = 256
PE-ID = 1.1.1.1 Mpls Label = 2
PE-ID = 1.1.1.1 Mpls Label = 3
PE-ID = 1.1.1.1 Mpls Label = 4
=====>Total Downstream Mappings: 5
Upstream MPLS Mappings:
Upstream MPLS label: (MAC = 00:50:04:b9:c8:a0 BGP label = 0x14, LDP Label = 0xa)
=====>Total Upstream Mappings: 1
```

How to Display Only the number of MPLS/VPN Mappings for a Specified Subscriber

Step 1 From the SCE# prompt, type `show interface linecard 0 subscriber name` *name*`mappings |include Total` and press Enter.

Displaying Only the number of MPLS/VPN Mappings for a Specified Subscriber: Example

```
SCE# show interface linecard 0 subscriber name  SubscriberX_1122334455 mappings
Subscriber 'SubscriberX_1122334455' mappings:
=====>Total Downstream Mappings: 5
=====>Total Upstream Mappings: 1
```

How to Display the Name of the Subscriber who has a Specified Downstream Mapping

Step 1 From the SCE# prompt, type `show interface linecard 0 subscriber mapping MPLS-VPN PE-ID` *pe-id*`BGP-label` *label*and press Enter.

How to Display the Mappings of Upstream Labels that Belong to Non-VPN Flows

Step 1 From the SCE# prompt, type `show interface linecard 0 MPLS-VPN non-VPN-mappings` and press Enter.

How to Clear Subscriber Mappings

Use this command to remove all learned upstream labels of a specified VPN subscriber.

Step 1 From the SCE(config if)# prompt, type `no subscriber name` *name*`mapping upstream mpls all` and press Enter.

This command, in effect, causes early label aging. Clearing the mappings allows relearning; labels will probably be quickly relearned after they have been cleared. Therefore, this command is useful when you want to update the mappings without waiting for the standard aging period.

How to Monitor Subscriber Counters

Use the following Viewer command to display subscriber counters, including those related to MPLS/VPN mappings.

- About Subscriber Counters
- Monitoring Subscriber Counters: Example

About Subscriber Counters

When MPLS/VPN subscribers are enabled, the following related counters appear in addition to the basic subscriber counters:

- MPLS/VPN subscribers:
  - Current number of MPLS/VPN subscribers
  - Maximum number of MPLS/VPN subscribers
- MPLS/VPN subscribers are also counted in the general subscribers counters, but the general subscribers maximum number does not apply to MPLS/VPN subscribers, which have a smaller maximum number.
- MPLS/VPN mappings:
  - Current number of used MPLS/VPN mappings
  - Maximum number of MPLS/VPN mappings
- Note that these values reflect the total number of mappings, not just the mappings used by MPLS/VPN subscribers. Bypassed VPNs also consume MPLS/VPN mappings.

Step 1 From the SCE# prompt, type **show interface linecard 0 subscriber db counters** and press Enter.

Monitoring Subscriber Counters: Example

```
SCE#show interface linecard 0 subscriber db counters
Current values:
===============
Subscribers: 2 used out of 99999 max.
Introduced subscribers: 2.
Anonymous subscribers: 0.
Subscribers with mappings: 2 used out of 99999 max.
IP mappings: 0 used.MPLS/VPN subscribers are enabled. MPLS/VPN mappings: 2 used out of
57344 max.  MPLS/VPN subscribers: 2 used out of 2015 max.
Subscribers with open sessions: 0.
Subscribers with TIR mappings: 0.
Sessions mapped to the default subscriber: 0.
Peak values:
============
Peak number of subscribers with mappings: 2
Peak number occurred at: 14:56:55 ISR MON November 7 2005
Peak number cleared at: 13:29:39 ISR MON November 7 2005
Event counters:
===============
Subscriber introduced: 2.
Subscriber pulled: 0.
Subscriber aged: 0.
Pull-request notifications sent: 0.
State notifications sent: 0.
Logout notifications sent: 0.
Subscriber mapping TIR contradictions: 0
```

Note The maximum number of subscribers when MPLS/VPN support is enabled is actually the maximum noted in the MPLS/VPN subscribers line (2015), rather than the maximum noted in the first line

How to Monitor MPLS/VPN Counters

Use the following Viewer command to display MPLS/VPN information.

Step 1 From the SCE# prompt, type `show interface linecard 0 mpls vpn` and press Enter.

Monitoring MPLS/VPN Counters: Example

```
SCE#show interface linecard 0 mpls vpn
MPLS/VPN auto-learn mode is enabled.
MPLS/VPN subscribers: 0 used out of 2015 max
Total HW MPLS/VPN mappings utilization: 0 used out of 57344 max
MPLS/VPN mappings are divided as follows:
    downstream VPN subscriber mappings: 0
    upstream VPN subscriber mappings: 0
    non-vpn upstream mappings: 0
    downstream bypassed VPN mappings: 0
    upstream bypassed VPN mappings: 0
```

How to Monitor the PE Routers

Use the following Viewer commands to monitor PE routers. These commands provide the following information:

- How to Display the Configuration of all Currently Defined PE Routers
- How to Display the Configuration of a Specified PE Router

How to Display the Configuration of all Currently Defined PE Routers

Step 1 From the SCE# prompt, type `show interface linecard 0 MPLS VPN PE-Database` and press Enter.

How to Display the Configuration of a Specified PE Router

Step 1 From the SCE# prompt, type `show interface linecard 0 MPLS VPN PE-Database PE-ID` *pe-id*and press Enter.

How to Monitor Bypassed VPNs

- How to Display the Currently Bypassed VPNs
- How to Remove all Learned Bypassed VPNs

How to Display the Currently Bypassed VPNs

Step 1 From the SCE# prompt, type `show interface linecard 0 MPLS VPN Bypassed-VPNs` and press Enter.

How to Remove all Learned Bypassed VPNs

Step 1 From the SCE# prompt, type `clear interface linecard 0 MPLS VPN Bypassed-VPNs` and press Enter.

How to Monitor Non-VPN Mappings

- How to Display Non-VPN Mappings
- How to Remove all Learned non-VPN Mappings

How to Display Non-VPN Mappings

Step 1 From the SCE# prompt, type s `how interface linecard 0 MPLS VPN non-VPN-mappings` and press Enter.

How to Remove all Learned non-VPN Mappings

Step 1 From the SCE# prompt, type `clear interface linecard 0 MPLS VPN non-VPN-mappings` and press Enter.

How to Manage MPLS/VPN Support via SM CLU

The SM CLU allows you to do the following:

- Add, remove, and display MPLS/VPN mappings for a specified subscriber (VPN)
- Clear all MPLS/VPN mappings from the SM database

Options

Use the **p3subs** utility to manage subscriber MPLS/VPN mappings.

The following options are available:

- **Subscriber-Name** — The name assigned to the VPN when it was added as a subscriber.

- **RT@PE-IP** — The mapping to be assigned to the subscriber/VPN. Multiple mappings can be specified using a comma.
  - **RT** = the route target of the VPN, specified using the ASN:n notation or the IP:n notation

  Note that the Route Distinguisher may be specified rather than the route target
  - PE-IP = the loopback IP of the PE router connected to that VPN

How to Manage Individual Subscriber MPLS/VPN Mappings

p3subs

Step 1 From the shell prompt, type a command having the following general format: **p3subs** *operation*--subscriber= *Subscriber-Name***--mpls-vpn=** *RT@PE-IP* `[--additive-mapping]`

The following tables present all the **p3subs** operations relevant to managing mappings.

Table 4-1 p3subs Mapping Operations

Operation	Description
--set	Add/update a subscriber. If the mapping exists, replaces the existing mapping, unless the additive-mapping option is used.
--remove-all-mappings	Removes all the mappings of specified subscriber.
--remove-mappings	Removes specified mapping of specified subscriber.

Table 4-2 p3subs Mapping Options

Options	Description
--additive-mapping	Adds the specified mappings to the existing ones (instead of replacing the existing mappings when this option is not used). Used with the set operation.

How to Monitor Subscriber MPLS/VPN Mappings

Step 1 From the shell prompt, type the following command: **p3subs --show-all-mappings --subscriber=** *Subscriber-Name*

How to Manage the SM Database MPLS/VPN Mappings

p3subsdb

Use the **p3subsdb** utility to remove the SM database MPLS/VPN mappings for all subscribers.

Step 1 From the shell prompt, type the following command: **p3subsdb --remove-all-mpls-vpn**