



MPLS VPN over mGRE

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The MPLS VPN over mGRE feature overcomes the requirement that a carrier support multiprotocol label switching (MPLS) by allowing you to provide MPLS connectivity between networks that are connected by IP-only networks. This allows MPLS label switched paths (LSPs) to use generic routing encapsulation (GRE) tunnels to cross routing areas, autonomous systems, and internet service providers (ISPs). When MPLS VPNs are configured over multipoint GRE (mGRE) you can deploy layer-3 (L3) provider edge (PE) based virtual private network (VPN) services using a standards-based IP core. This allows you to provision the VPN services without using the overlay method.

You can configure mGRE tunnels to create a multipoint tunnel network that overlays an IP backbone. This overlay connects PE routers to transport VPN traffic. In addition, when MPLS VPNs are configured over mGRE you can deploy L3 PE-based VPN services using a standards-based IP core. This allows you to provision the VPN services without using the overlay method. When MPLS VPN over mGRE is configured, the system uses IPv4-based mGRE tunnels to encapsulate VPN-labeled IPv4 and IPv6 packets between PEs.

- [Finding Feature Information, page 1](#)
- [Prerequisites for MPLS VPN over mGRE, page 2](#)
- [Restrictions for MPLS VPN over mGRE, page 2](#)
- [Information About MPLS VPN over mGRE, page 2](#)
- [How to Configure MPLS VPN over mGRE, page 4](#)
- [Configuration Examples for MPLS VPN over mGRE, page 12](#)
- [Additional References, page 14](#)
- [Feature Information for MPLS VPN over mGRE, page 15](#)

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

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Prerequisites for MPLS VPN over mGRE

Before you configure MPLS VPN with mGRE tunnels, ensure that the MPLS VPN is configured and working properly. See the "Configuring MPLS Layer 3 VPNs" module for information about setting up MPLS VPNs.

Restrictions for MPLS VPN over mGRE

- MPLS VPN over mGRE is supported on the Cisco 7600 series routers using the ES-40 line card and the SIP 400 line card as core facing cards.
- Tunnelled tag traffic must enter the router through a line card that supports MPLS VPN over mGRE.
- Each PE router supports one tunnel configuration only.
- MPLS VPN over mGRE does not support the transportation of multicast traffic between VPNs.
- When a GRE tunnel has the same destination address and source address as the mGRE, the tunnel gets route-cache switched.
- The packets that require fragmentation get route cache-switched.
- When an L3VPN profile is removed and added back, then you should clear the Border Gateway Protocol (BGP) using the **clear ip bgp soft** command.
- When an mGRE tunnel is created, a dummy tunnel is also created.
- The loopback or IP address used in the update source of the BGP configuration should be the same as that of the transport source of the L3VPN profile.
- mGRE is not stateful switchover (SSO) compliant. However, both mGRE and SSO coexist.
- mGRE and multicast distribution tree (MDT) tunnel should not be configured with the same loopback address.

The limitations for MPLS VPN over mGRE feature are as follows:

- - Not all GRE options are supported in the hardware (for example, GRE extended header and GRE key).
 - Checking identical VLANs (Internet Control Message Protocol [ICMP] redirect) is not supported on the tunnels.
 - Features such as unicast reverse path forwarding (uRPF) and BGP policy accounting are not supported on the tunnels.

Information About MPLS VPN over mGRE

- [MPLS VPN over mGRE, page 2](#)

MPLS VPN over mGRE

GRE is a point-to-point tunneling protocol where two peers form the endpoints of the tunnel. It is designed to encapsulate network-layer packets inside IP tunneling packets. mGRE is a similar protocol with a single endpoint at one side of the tunnel connected to multiple endpoints at the other side of the tunnel. The mGRE tunnel provides a common link between branch offices that connect to the same VPN. Because

mGRE is a point-to-multipoint model, fully meshed GRE tunnels are not required to interconnect MPLS VPN PE devices.

MPLS is a widely deployed VPN internet architecture. MPLS requires that all core routers in the network support MPLS. This feature is useful in networks where the service provider uses a backbone carrier to provide connectivity.

The MPLS VPN over mGRE feature overcomes the requirement of carrier support MPLS by allowing you to provide MPLS connectivity between networks that are connected by IP-only networks. This allows MPLS LSPs to use GRE tunnels to cross routing areas, autonomous systems, and ISPs.

When MPLS VPNs are configured over mGRE you can deploy L3 PE-based VPN services using a standards-based IP core. This allows you to provision the VPN services without using LSP or a Label Distribution Protocol (LDP). The system uses IPv4-based mGRE tunnels to encapsulate VPN-labeled IPv4 and IPv6 packets between PEs.

The MPLS VPN over mGRE feature also allows you to deploy existing MPLS VPN LSP-encapsulated technology concurrently with MPLS VPN over mGRE and enables the system to determine which encapsulation method is used to route specific traffic. The ingress PE router determines which encapsulation technology to use when a packet is sent to the remote PE router.

This section includes information on the following topics on MPLS VPN over mGRE feature:

- [Route Maps, page 3](#)
- [Tunnel Endpoint Discovery and Forwarding, page 3](#)
- [Tunnel Decapsulation, page 4](#)
- [Tunnel Source, page 4](#)
- [IPv6 VPN, page 4](#)

Route Maps

By default, VPN traffic is sent using an LSP. The MPLS VPN over mGRE feature uses user-defined route maps to determine which VPN prefixes are reachable over an mGRE tunnel and which VPN prefixes are reachable using an LSP. The route map is applied to advertisements for VPNv4 and VPNv6 address families. The route map uses a next hop tunnel table to determine the encapsulation method for the VPN traffic.

To route traffic over the mGRE tunnel, the system creates an alternative address space that shows that all next hops are reached by encapsulating the traffic in an mGRE tunnel. To configure a specific route to use an mGRE tunnel, the user adds an entry for that route to the route map. The new entry remaps the Network Layer Reachability Information (NLRI) of the route to the alternative address space. If there is no remap entry in the route map for a route, then traffic on that route is forwarded over an LSP.

When the user configures MPLS VPN over mGRE, the system automatically provisions the alternative address space, normally held in the tunnel-encapsulated virtual routing and forwarding (VRF) instance. To ensure that all traffic reachable through the address space is encapsulated in an mGRE tunnel, the system installs a single default route out of a tunnel. The system also creates a default tunnel on the route map. The user can attach this default route map to the appropriate BGP updates.

Tunnel Endpoint Discovery and Forwarding

In order for the MPLS VPN over mGRE feature to function correctly, the system must be able to discover the remote PEs in the system and construct tunnel forwarding information for these remote PEs. In addition the system must be able to detect when a remote PE is no longer valid and remove the tunnel forwarding information for that PE.

If an ingress PE receives a VPN advertisement over BGP, it uses the route target attributes (which it inserts into the VRF) and the MPLS VPN label from the advertisement, to associate the prefixes with the appropriate customer. The next hop of the inserted route is set to the NLRI of the advertisement.

The advertised prefixes contain information about remote PEs in the system (in the form of NLRIs), and the PE uses this information to notify the system when an NLRI becomes active or inactive. The system uses this notification to update the PE forwarding information.

When the system receives notification of a new remote PE, it adds the information to the tunnel endpoint database, which causes the system to create an adjacency associated with the tunnel interface. The adjacency description includes information on the encapsulation and other processing that the system must perform to send encapsulated packets to the new remote PE.

The adjacency information is placed into the tunnel encapsulated VRF. When a user remaps a VPN NLRI to a route in the VRF (using the route map), the system links the NLRI to the adjacency; therefore the VPN is linked to a tunnel.

Tunnel Decapsulation

When the egress PE receives a packet from a tunnel interface that uses the MPLS VPN over mGRE feature, the PE decapsulates the packet to create a VPN label tagged packet, and sends the packet to the MPLS forwarding (MFI) code.

Tunnel Source

The MPLS VPN over mGRE feature uses a single tunnel configured as an mGRE tunnel to configure a system with a large number of endpoints (remote PEs). To identify the origin of tunnel-encapsulated packets, the system uses the tunnel source information.

At the transmitting (ingress) PE, when a VPN packet is sent to a tunnel, the tunnel destination is the NLRI. At a receiving (egress) PE, the tunnel source is the address that the packets encapsulated in the mGRE tunnel are received on. Therefore, at the egress PE the packet destination must match the NLRI from the local PE.

IPv6 VPN

If the advertising PE router has an IPv6 address then the NLRI must also be an IPv6 address (regardless of the network between the PEs). If the network between the PEs is IPv4 based, the system creates the IPv6 address of the advertising PE using an IPv4 mapped address in the following form: ::FFFF:IPv4-PE-address. The receiving PE sets the next hop for the VPN tag IPv6 prefixes to the IPv4 address embedded in the IPv6 NLRI. This enables the PE to link VPNv6 traffic to an LSP or an mGRE tunnel in the same way it maps VPNv4 traffic.

When a PE receives VPNv6 updates, it applies the IPv6 route map. The MPLS VPN over mGRE feature uses the IPv6 route map to set the next hop information in the Tunnel_Encap VRF.

How to Configure MPLS VPN over mGRE

To deploy MPLS VPN over mGRE tunnels, you create a VRF instance, enable and configure L3 VPN encapsulation, link the route map to the application template, and set up the BGP VPNv4 and VPNv6 exchange so that updates are filtered through the route map.

- [Configuring an L3VPN Encapsulation Profile, page 5](#)
- [Configuring BGP and Route Maps, page 6](#)

Configuring an L3VPN Encapsulation Profile

This section describes how to configure an L3VPN encapsulation profile.



Note

Transport protocols such as IPv6, MPLS, IP, and Layer 2 Tunneling Protocol version 3 (L2TPv3) can also be used in this configuration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l3vpn encapsulation ip *profile-name***
4. **transport ipv4 [source *interface-type interface-number*]**
5. **protocol gre [key *gre-key*]**
6. **end**
7. **show l3vpn encapsulation ip *profile-name***

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	l3vpn encapsulation ip <i>profile-name</i> Example: Router(config)# l3vpn encapsulation ip tunnel encap	Enters L3 VPN encapsulation configuration mode to create the tunnel.

Command or Action	Purpose
<p>Step 4 <code>transport ipv4 [source <i>interface-type interface-number</i>]</code></p> <p>Example:</p> <pre>Router(config-l3vpn-encap-ip)# transport ipv4 source loopback 0</pre>	<p>(Optional) Specifies IPv4 transport source mode and defines the transport source interface.</p> <ul style="list-style-type: none"> • If you use the transport ipv4 source <i>interface-type interface-number</i> command, make sure that the specified source address is used as the next hop in BGP updates advertised by the PE. • If you do not use this command, the bgp update source or bgp next-hop command is automatically used as the tunnel source.
<p>Step 5 <code>protocol gre [key <i>gre-key</i>]</code></p> <p>Example:</p> <pre>Router(config-l3vpn-encap-ip)# protocol gre key 1234</pre>	<p>Specifies GRE as the tunnel mode and sets the GRE key.</p>
<p>Step 6 <code>end</code></p> <p>Example:</p> <pre>Router(config-l3vpn-encap-ip)# end</pre>	<p>Exits L3 VPN encapsulation configuration mode and returns to privileged EXEC mode.</p>
<p>Step 7 <code>show l3vpn encapsulation ip <i>profile-name</i></code></p> <p>Example:</p> <pre>Router# show l3vpn encapsulation ip tunnel encap</pre>	<p>(Optional) Displays the profile health and the underlying tunnel interface.</p>

Configuring BGP and Route Maps

Perform this task to configure BGP and route maps. The following steps also enable you to link the route map to the application template and set up the BGP VPNv4 and VPNv6 exchange so that the updates are filtered through the route map.

SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp *as-number*
4. bgp log-neighbor-changes
5. neighbor *ip-address* remote-as *as-number*
6. neighbor *ip-address* update-source *interface name*
7. address-family ipv4
8. no synchronization
9. redistribute connected
10. neighbor *ip-address* activate
11. no auto-summary
12. exit
13. address-family vpnv4
14. neighbor *ip-address* activate
15. neighbor *ip-address* send-community both
16. neighbor *ip-address* route-map *map-name* in
17. exit
18. address-family vpnv6
19. neighbor *ip-address* activate
20. neighbor *ip-address* send-community both
21. neighbor *ip-address* route-map *map-name* in
22. exit
23. route-map *map-tag* permit *position*
24. set ip next-hop encapsulate l3vpn *profile-name*
25. set ipv6 next-hop encapsulate l3vpn *profile-name*
26. exit
27. exit

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable	Enables privileged EXEC mode.
	Example: Router> enable	<ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	router bgp <i>as-number</i> Example: Router(config)# router bgp 100	Specifies the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along, and enters router configuration mode.
Step 4	bgp log-neighbor-changes Example: Router(config-router)# bgp log-neighbor-changes	Enables logging of BGP neighbor resets.
Step 5	neighbor <i>ip-address</i> remote-as <i>as-number</i> Example: Router(config-router)# neighbor 209.165.200.225 remote-as 100	Adds an entry to the BGP or multiprotocol BGP neighbor table.
Step 6	neighbor <i>ip-address</i> update-source <i>interface name</i> Example: Router(config-router)# neighbor 209.165.200.225 update-source loopback 0	Allows BGP sessions to use any operational interface for TCP connections.
Step 7	address-family ipv4 Example: Router(config-router)# address-family ipv4	Enters address family configuration mode to configure routing sessions that use IPv4 address prefixes.
Step 8	no synchronization Example: Router(config-router-af)# no synchronization	Enables the Cisco IOS software to advertise a network route without waiting for an IGP.

Command or Action	Purpose
<p>Step 9 redistribute connected</p> <p>Example:</p> <pre>Router(config-router-af)# redistribute connected</pre>	<p>Redistributes routes from one routing domain into another routing domain and allows the target protocol to redistribute routes learned by the source protocol and connected prefixes on those interfaces over which the source protocol is running.</p>
<p>Step 10 neighbor ip-address activate</p> <p>Example:</p> <pre>Router(config-router-af)# neighbor 209.165.200.225 activate</pre>	<p>Enables the exchange of information with a BGP neighbor.</p>
<p>Step 11 no auto-summary</p> <p>Example:</p> <pre>Router(config-router-af)# no auto-summary</pre>	<p>Disables automatic summarization and sends subprefix routing information across classful network boundaries.</p>
<p>Step 12 exit</p> <p>Example:</p> <pre>Router(config-router-af)# exit</pre>	<p>Exits address family configuration mode.</p>
<p>Step 13 address-family vpnv4</p> <p>Example:</p> <pre>Router(config-router)# address-family vpnv4</pre>	<p>Enters address family configuration mode to configure routing sessions, such as BGP, that use standard VPNv4 address prefixes.</p>
<p>Step 14 neighbor ip-address activate</p> <p>Example:</p> <pre>Router(config-router-af)# neighbor 209.165.200.225 activate</pre>	<p>Enables the exchange of information with a BGP neighbor.</p>
<p>Step 15 neighbor ip-address send-community both</p> <p>Example:</p> <pre>Router(config-router-af)# neighbor 209.165.200.225 send-community both</pre>	<p>Specifies that a communities attribute, for both standard and extended communities, should be sent to a BGP neighbor.</p>

Command or Action	Purpose
<p>Step 16 <code>neighbor ip-address route-map map-name in</code></p> <p>Example:</p> <pre>Router(config-router-af)# neighbor 209.165.200.225 route-map SELECT_UPDATE_FOR_L3VPN in</pre>	Applies the named route map to the incoming route.
<p>Step 17 <code>exit</code></p> <p>Example:</p> <pre>Router(config-router-af)# exit</pre>	Exits address family configuration mode.
<p>Step 18 <code>address-family vpnv6</code></p> <p>Example:</p> <pre>Router(config-router)# address-family vpnv6</pre>	Enters address family configuration mode to configure routing sessions, such as BGP, that use VPNv6 address prefixes.
<p>Step 19 <code>neighbor ip-address activate</code></p> <p>Example:</p> <pre>Router(config-router-af)# neighbor 209.165.200.252 activate</pre>	Enables the exchange of information with a BGP neighbor.
<p>Step 20 <code>neighbor ip-address send-community both</code></p> <p>Example:</p> <pre>Router(config-router-af)# neighbor 209.165.200.252 send-community both</pre>	Specifies that a communities attribute, for both standard and extended communities, should be sent to a BGP neighbor.
<p>Step 21 <code>neighbor ip-address route-map map-name in</code></p> <p>Example:</p> <pre>Router(config-router-af)# neighbor 209.165.200.252 route-map SELECT_UPDATE_FOR_L3VPN in</pre>	Applies the named route map to the incoming route.
<p>Step 22 <code>exit</code></p> <p>Example:</p> <pre>Router(config-router-af)# exit</pre>	Exits address family configuration mode.

Command or Action	Purpose
<p>Step 23 <code>route-map map-tag permit position</code></p> <p>Example:</p> <pre>Router(config-router)# route-map SELECT_UPDATE_FOR_L3VPN permit 10</pre>	<p>Enters route-map configuration mode and defines the conditions for redistributing routes from one routing protocol into another.</p> <ul style="list-style-type: none"> • The redistribute router configuration command uses the specified map tag to reference this route map. Multiple route maps may share the same map tag name. • If the match criteria are met for this route map, the route is redistributed as controlled by the set actions. • If the match criteria are not met, the next route map with the same map tag is tested. If a route passes none of the match criteria for the set of route maps sharing the same name, it is not redistributed by that set. • The <i>position</i> argument indicates the position a new route map will have in the list of route maps already configured with the same name.
<p>Step 24 <code>set ip next-hop encapsulate l3vpn profile-name</code></p> <p>Example:</p> <pre>Router(config-route-map)# set ip next-hop encapsulate l3vpn my profile</pre>	<p>Indicates that output IPv4 packets that pass a match clause of the route map are sent to the VRF for tunnel encapsulation.</p>
<p>Step 25 <code>set ipv6 next-hop encapsulate l3vpn profile-name</code></p> <p>Example:</p> <pre>Router(config-route-map)# set ip next-hop encapsulate l3vpn tunnel encap</pre>	<p>Indicates that output IPv6 packets that pass a match clause of the route map are sent to the VRF for tunnel encapsulation.</p>
<p>Step 26 <code>exit</code></p> <p>Example:</p> <pre>Router(config-route-map)# exit</pre>	<p>Exits route-map configuration mode and enters global configuration mode.</p>
<p>Step 27 <code>exit</code></p> <p>Example:</p> <pre>Router(config)# exit</pre>	<p>Exits global configuration mode.</p>

Configuration Examples for MPLS VPN over mGRE

- [Example Verifying The MPLS VPN over mGRE Configuration](#), page 12
- [Example Configuration Sequence For MPLS VPN over mGRE](#), page 12

Example Verifying The MPLS VPN over mGRE Configuration

Use the following examples to verify that the configuration is working properly:

Cisco Express Forwarding (CEF) Switching

You can verify that CEF switching is working as expected:

```
Router# show ip cef vrf Customer_A tunnel 0

209.165.200.250
/24
    nexthop 209.165.200.251 Tunnel0 label 16
```

Endpoint Creation

You can verify the tunnel endpoint that has been created:

```
Router# show tunnel endpoints tunnel 0

Tunnel0 running in multi-GRE/IP mode
Endpoint transport 209.165.200.251 Refcount 3 Base 0x2AE93F0 Create Time 00:00:42
overlay 209.165.200.254 Refcount 2 Parent 0x2AE93F0 Create Time 00:00:42
```

Adjacency

You can verify that the corresponding adjacency has been created:

```
Router# show adjacency tunnel 0

Protocol Interface          Address
IP         Tunnel0                    209.165.200.251(4)
TAG        Tunnel0                    209.165.200.251(3)
```

Profile Health

You can use **show l3vpn encapsulation profile-name** command to get information on the basic state of the application. The output of this command provides you details on the references to the underlying tunnel.

```
Router# show l3vpn encapsulation ip tunnel encap
Profile: tunnel encap
transport ipv4 source Auto: Loopback0
protocol gre
Tunnel Tunnel0 Created [OK]
Tunnel Linestate [OK]
Tunnel Transport Source (Auto) Loopback0 [OK]
```

Example Configuration Sequence For MPLS VPN over mGRE

This example shows the configuration sequence for MPLS VPN over mGRE:

```
vrf definition Customer A
rd 100:110
```

```

route-target export 100:1000
route-target import 100:1000
!
address-family ipv4
exit-address-family
!
address-family ipv6
exit-address-family
!
!
ip cef
!
ipv6 unicast-routing
ipv6 cef
!
!
l3vpn encapsulation ip sample profile name
transport source loopback 0
protocol gre key 1234
!
!
interface Loopback0
ip address 209.165.200.252 255.255.255.224
ip router isis
!
interface Serial2/0
vrf forwarding Customer A
ip address 209.165.200.253 255.255.255.224
ipv6 address 3FFE:1001::/64 eui-64
no fair-queue
serial restart-delay 0
!
router bgp 100
bgp log-neighbor-changes
neighbor 209.165.200.254 remote-as 100
neighbor 209.165.200.254 update-source Loopback0
!
address-family ipv4
no synchronization
redistribute connected
neighbor 209.165.200.254 activate
no auto-summary
exit-address-family
!
address-family vpv4
neighbor 209.165.200.254 activate
neighbor 209.165.200.254 send-community both
neighbor 209.165.200.254 route-map SELECT_UPDATE_FOR_L3VPN in
exit-address-family
!
address-family vpv6
neighbor 209.165.200.254 activate
neighbor 209.165.200.254 send-community both
neighbor 209.165.200.254 route-map SELECT_UPDATE_FOR_L3VPN in
exit-address-family
!
address-family ipv4 vrf Customer A
no synchronization
redistribute connected
exit-address-family
!
address-family ipv6 vrf Customer A
redistribute connected
no synchronization
exit-address-family
!
!
route-map SELECT_UPDATE_FOR_L3VPN permit 10
set ip next-hop encapsulate sample profile name
set ipv6 next-hop encapsulate sample profile name

```

Additional References

Related Documents

Related Topic	Document Title
Configuring MPLS Layer 3 VPNs	<i>Cisco IOS Multiprotocol Label Switching Configuration Guide</i>
Dynamic Layer 3 VPNs with multipoint GRE tunnels	<i>Cisco IOS Interface and Hardware Component Configuration Guide</i>
Cisco Express Forwarding	<i>Cisco IOS IP Switching Configuration Guide</i>
Generic routing encapsulation	<i>Cisco IOS Interface and Hardware Component Configuration Guide</i>

Standards

Standard	Title
None	--

MIBs

MIB	MIBs Link
IETF-PPVPN-MPLS-VPN-MIB	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
RFC 2547	<i>BGP/MPLS VPNs</i>
RFC 2784	<i>Generic Routing Encapsulation (GRE)</i>
RFC 2890	Key Sequence Number Extensions to GRE
RFC 4023	Encapsulating MPLS in IP or Generic Routing Encapsulation
RFC 4364	<i>BGP/MPLS IP Virtual Private Networks (VPNs)</i>

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.	http://www.cisco.com/cisco/web/support/index.html
To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.	
Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	

Feature Information for MPLS VPN over mGRE

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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Table 1 Feature Information for MPLS VPN over mGRE

Feature Name	Releases	Feature Information
MPLS VPN over mGRE	12.2(33)SRE 15.1(2)T	<p>This feature provides support to carry MPLS Layer 3 VPN traffic over mGRE. This feature also supports SIP-400 and ES-40 on Cisco 7600 series routers.</p> <p>The following commands were introduced or modified by this feature: l3vpn encapsulation ip protocol gre , show l3vpn encapsulation ip , transport ipv4,set ip next-hop , set ipv6 next-hop.</p>

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