



Dynamic Multipoint VPN

Last Updated: April 12, 2012

The Dynamic Multipoint VPN (DMVPN) feature allows users to better scale large and small IP Security (IPsec) Virtual Private Networks (VPNs) by combining generic routing encapsulation (GRE) tunnels, IPsec encryption, and Next Hop Resolution Protocol (NHRP).

- [Finding Feature Information, page 1](#)
- [Prerequisites for Dynamic Multipoint VPN \(DMVPN\), page 1](#)
- [Restrictions for Dynamic Multipoint VPN \(DMVPN\), page 2](#)
- [Information About Dynamic Multipoint VPN \(DMVPN\), page 3](#)
- [How to Configure Dynamic Multipoint VPN \(DMVPN\), page 10](#)
- [Configuration Examples for Dynamic Multipoint VPN \(DMVPN\) Feature, page 31](#)
- [Additional References, page 45](#)
- [Feature Information for Dynamic Multipoint VPN \(DMVPN\), page 47](#)
- [Glossary, page 49](#)

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for Dynamic Multipoint VPN (DMVPN)

- Before a multipoint GRE (mGRE) and IPsec tunnel can be established, you must define an Internet Key Exchange (IKE) policy by using the **crypto isakmp policy** command.
- For the NAT-Transparency Aware enhancement to work, you must use IPsec transport mode on the transform set. Also, even though NAT-Transparency can support two peers (IKE and IPsec) being translated to the same IP address (using the User Datagram Protocol [UDP] ports to differentiate them



Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

[that is, Peer Address Translation (PAT)], this functionality is not supported for DMVPN. All DMVPN spokes must have a unique IP address after they have been NAT translated. They can have the same IP address before they are NAT translated.

- To enable 2547oDMPVN--Traffic Segmentation Within DMVPN you must configure multiprotocol label switching (MPLS) by using the **mpls ip** command.

Restrictions for Dynamic Multipoint VPN (DMVPN)

- If you use the Dynamic Creation for Spoke-to-Spoke Tunnels benefit of this feature, you must use IKE certificates or wildcard preshared keys for Internet Security Association Key Management Protocol (ISAKMP) authentication.



Note

It is highly recommended that you do not use wildcard preshared keys because the attacker will have access to the VPN if one spoke router is compromised.

- GRE tunnel keepalives (that is, the **keepalive** command under a GRE interface) are not supported on point-to-point or multipoint GRE tunnels in a DMVPN Network.
- For best DMVPN functionality, it is recommended that you run the latest Cisco IOS software Release 12.4 mainline, 12.4T, or 12.2(18)SXF.
- If one spoke is behind one NAT device and another different spoke is behind another NAT device, and Peer Address Translation (PAT) is the type of NAT used on both NAT devices, then a session initiated between the two spokes cannot be established.

One example of a PAT configuration on a NAT interface is:

```
ip nat inside source list nat_acl interface FastEthernet0/1 overload
```

- [DMVPN Support on the Cisco 6500 and Cisco 7600, page 2](#)

DMVPN Support on the Cisco 6500 and Cisco 7600

Blade-to-Blade Switchover on the Cisco 6500 and Cisco 7600

- DMVPN does not support blade-to-blade switchover on the Cisco 6500 and Cisco 7600.

Cisco 6500 or Cisco 7600 As a DMVPN Hub

- A Cisco 6500 or Cisco 7600 that is functioning as a DMVPN hub cannot be located behind a NAT router.
- If a Cisco 6500 or Cisco 7600 is functioning as a DMVPN hub, the spoke behind NAT must be a Cisco 6500 or Cisco 7600, respectively, or the router must be upgraded to Cisco IOS software Release 12.3(11)T02 or a later release.

Cisco 6500 or Cisco 7600 As a DMVPN Spoke

- If a Cisco 6500 or Cisco 7600 is functioning as a spoke, the hub cannot be behind NAT.

- If a Cisco 6500 or Cisco 7600 is functioning as a DMVPN spoke behind NAT, the hub must be a Cisco 6500 or Cisco 7600, respectively, or the router must be upgraded to Cisco IOS Release 12.3(11)T02 or a later release.

DMVPN Hub or Spoke Supervisor Engine

- Only a Supervisor Engine 720 can be used as a DMVPN hub or spoke. A Supervisor Engine 2 cannot be used.

Encrypted Multicast with GRE

- Encrypted Multicast with GRE is not supported on the Cisco 6500 nor on the Cisco 7600.

mGRE Interfaces

- If there are two mGRE interfaces on the same DMVPN node and they both do not have a tunnel key, the two mGRE interfaces must each have a unique tunnel source address (or interface) configured.
- On the Cisco 6500 and Cisco 7600, each GRE interface (multipoint or point-to-point) must have a unique tunnel source address (or interface).
- The following commands are not supported under mGRE with DMVPN: **ip tcp adjust-mss**, **qos pre-classify tunnel vrf**, **tunnel path-mtu-discovery**, and **tunnel vrf**.

Quality of Service (QoS)

- You cannot use QoS for DMVPN packets on a Cisco 6500 or Cisco 7600.

Tunnel Key

- The use of a tunnel key on a GRE (multipoint or point-to-point) interface is not supported in the hardware switching ASICs on the Cisco 6500 and Cisco 7600 platforms. If a tunnel key is configured, throughput performance is greatly reduced.
- In Cisco IOS Release 12.3(11)T3 and Release 12.3(14)T, the requirement that a mGRE interface must have a tunnel key was removed. Therefore, in a DMVPN network that includes a Cisco 6500 or Cisco 7600 as a DMVPN node, you should remove the tunnel key from all DMVPN nodes in the DMVPN network, thus preserving the throughput performance on the Cisco 6500 and Cisco 7600 platforms.
- If the tunnel key is not configured on any DMVPN node within a DMVPN network, it must not be configured on all DMVPN nodes with the DMVPN network.

VRF-Aware DMVPN Scenarios

- The **mls mpls tunnel-recirc** command must be configured on the provider equipment (PE) DMVPN hub if customer equipment (CE) DMVPN spokes need to “talk” to other CEs across the MPLS cloud.
- The mGRE interface should be configured with a large enough IP maximum transmission unit (1400 packets) to avoid having the route processor doing fragmentation.
- Enhanced Interior Gateway Routing Protocol (EIGRP) should be avoided.

Information About Dynamic Multipoint VPN (DMVPN)

- [Benefits of Dynamic Multipoint VPN \(DMVPN\)](#), page 4
- [Feature Design of Dynamic Multipoint VPN \(DMVPN\)](#), page 5

- [IPsec Profiles, page 6](#)
- [VRF Integrated DMVPN, page 6](#)
- [DMVPN--Enabling Traffic Segmentation Within DMVPN, page 7](#)
- [NAT-Transparency Aware DMVPN, page 8](#)
- [Call Admission Control with DMVPN, page 9](#)
- [NHRP Rate-Limiting Mechanism, page 10](#)

Benefits of Dynamic Multipoint VPN (DMVPN)

Hub Router Configuration Reduction

- Currently, for each spoke router, there is a separate block of configuration lines on the hub router that define the crypto map characteristics, the crypto access list, and the GRE tunnel interface. This feature allows users to configure a single mGRE tunnel interface, a single IPsec profile, and no crypto access lists on the hub router to handle all spoke routers. Thus, the size of the configuration on the hub router remains constant even if spoke routers are added to the network.
- DMVPN architecture can group many spokes into a single multipoint GRE interface, removing the need for a distinct physical or logical interface for each spoke in a native IPsec installation.

Automatic IPsec Encryption Initiation

- GRE has the peer source and destination address configured or resolved with NHRP. Thus, this feature allows IPsec to be immediately triggered for the point-to-point GRE tunneling or when the GRE peer address is resolved via NHRP for the multipoint GRE tunnel.

Support for Dynamically Addressed Spoke Routers

- When using point-to-point GRE and IPsec hub-and-spoke VPN networks, the physical interface IP address of the spoke routers must be known when configuring the hub router because IP address must be configured as the GRE tunnel destination address. This feature allows spoke routers to have dynamic physical interface IP addresses (common for cable and DSL connections). When the spoke router comes online, it will send registration packets to the hub router: within these registration packets, is the current physical interface IP address of this spoke.

Dynamic Creation for Spoke-to-Spoke Tunnels

- This feature eliminates the need for spoke-to-spoke configuration for direct tunnels. When a spoke router wants to transmit a packet to another spoke router, it can now use NHRP to dynamically determine the required destination address of the target spoke router. (The hub router acts as the NHRP server, handling the request for the source spoke router.) The two spoke routers dynamically create an IPsec tunnel between them so data can be directly transferred.

VRF Integrated DMVPN

- DMVPNs can be used to extend the Multiprotocol Label Switching (MPLS) networks that are deployed by service providers to take advantage of the ease of configuration of hub and spokes, to provide support for dynamically addressed customer premises equipment (CPEs), and to provide zero-touch provisioning for adding new spokes into a DMVPN.

Feature Design of Dynamic Multipoint VPN (DMVPN)

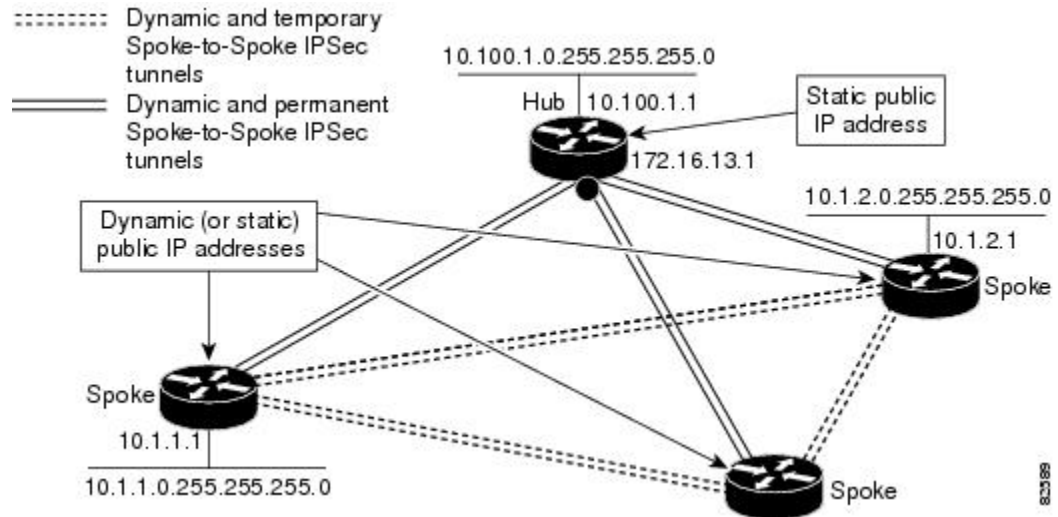
The Dynamic Multipoint VPN (DMVPN) feature combines GRE tunnels, IPsec encryption, and NHRP routing to provide users an ease of configuration via crypto profiles--which override the requirement for defining static crypto maps--and dynamic discovery of tunnel endpoints.

This feature relies on the following two Cisco enhanced standard technologies:

- NHRP--A client and server protocol where the hub is the server and the spokes are the clients. The hub maintains an NHRP database of the public interface addresses of the each spoke. Each spoke registers its real address when it boots and queries the NHRP database for real addresses of the destination spokes to build direct tunnels.
- mGRE Tunnel Interface --Allows a single GRE interface to support multiple IPsec tunnels and simplifies the size and complexity of the configuration.

The topology shown in the diagram below and the corresponding bullets explain how this feature works.

Figure 1 Sample mGRE and IPsec Integration Topology



- Each spoke has a permanent IPsec tunnel to the hub, not to the other spokes within the network. Each spoke registers as clients of the NHRP server.
- When a spoke needs to send a packet to a destination (private) subnet on another spoke, it queries the NHRP server for the real (outside) address of the destination (target) spoke.
- After the originating spoke “learns” the peer address of the target spoke, it can initiate a dynamic IPsec tunnel to the target spoke.
- The spoke-to-spoke tunnel is built over the multipoint GRE interface.
- The spoke-to-spoke links are established on demand whenever there is traffic between the spokes. Thereafter, packets can bypass the hub and use the spoke-to-spoke tunnel.



Note

After a preconfigured amount of inactivity on the spoke-to-spoke tunnels, the router will tear down those tunnels to save resources (IPsec security associations [SAs]).

IPsec Profiles

IPsec profiles abstract IPsec policy information into a single configuration entity, which can be referenced by name from other parts of the configuration. Therefore, users can configure functionality such as GRE tunnel protection with a single line of configuration. By referencing an IPsec profile, the user does not have to configure an entire crypto map configuration. An IPsec profile contains only IPsec information; that is, it does not contain any access list information or peering information.

VRF Integrated DMVPN

VPN Routing and Forwarding (VRF) Integrated DMVPN enables users to map DMVPN multipoint interfaces into MPLS VPNs. This mapping allows Internet service providers (ISPs) to extend their existing MPLS VPN services by mapping off-network sites (typically a branch office) to their respective MPLS VPNs. Customer equipment (CE) routers are terminated on the DMVPN PE router, and traffic is placed in the VRF instance of an MPLS VPN.

DMVPN can interact with MPLS VPNs in two ways:

- 1 The **ip vrf forwarding** command is used to inject the data IP packets (those packets inside the mGRE+IPsec tunnel) into the MPLS VPN. The **ip vrf forwarding** command is supported for DMVPN in Cisco IOS Release 12.3(6) and Release 12.3(7)T.
- 2 The **tunnel vrf** command is used to transport (route) the mGRE+IPsec tunnel packet itself within an MPLS VPN. The **tunnel vrf** command is supported in Cisco IOS Release 12.3(11)T but not in Cisco IOS Release 12.2(18)SXE.



Note

Clear-text data IP packets are forwarded in a VRF using the **ip vrf forwarding** command, and encrypted tunnel IP packets are forwarded in a VRF using the **tunnel vrf** command.

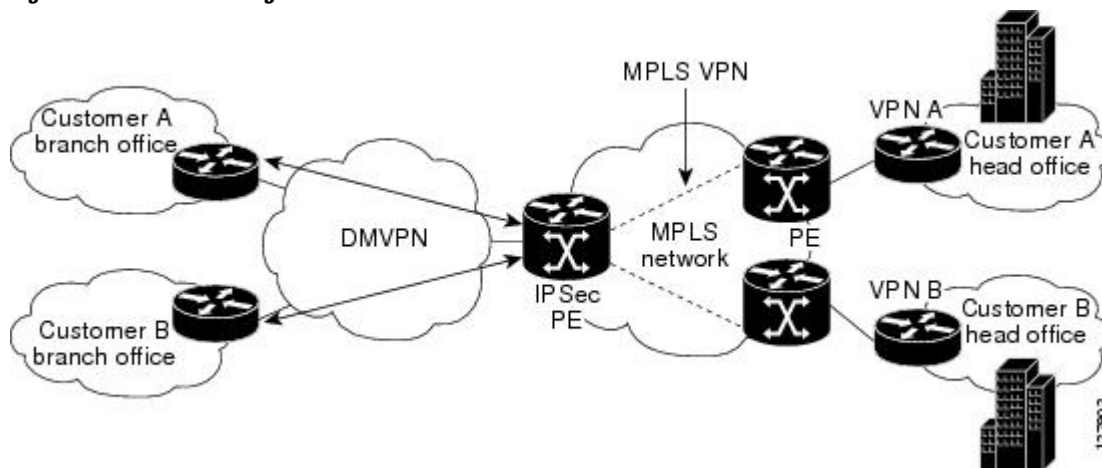
The **ip vrf forwarding** and **tunnel vrf** commands may be used at the same time. If they are used at the same time, the VRF name of each command may be the same or different.

For information about configuring the forwarding of clear-text data IP packets into a VRF, see the section “Configuring the Forwarding of Clear-Text Data IP Packets into a VRF.” For information about configuring the forwarding of encrypted tunnel packets into a VRF, see the section “Configuring the Forwarding of Encrypted Tunnel Packets into a VRF.”

For more information about configuring VRF, see reference in the “Related Documents” section.

The diagram below illustrates a typical VRF Integrated DMVPN scenario.

Figure 2 VRF Integrated DMVPN



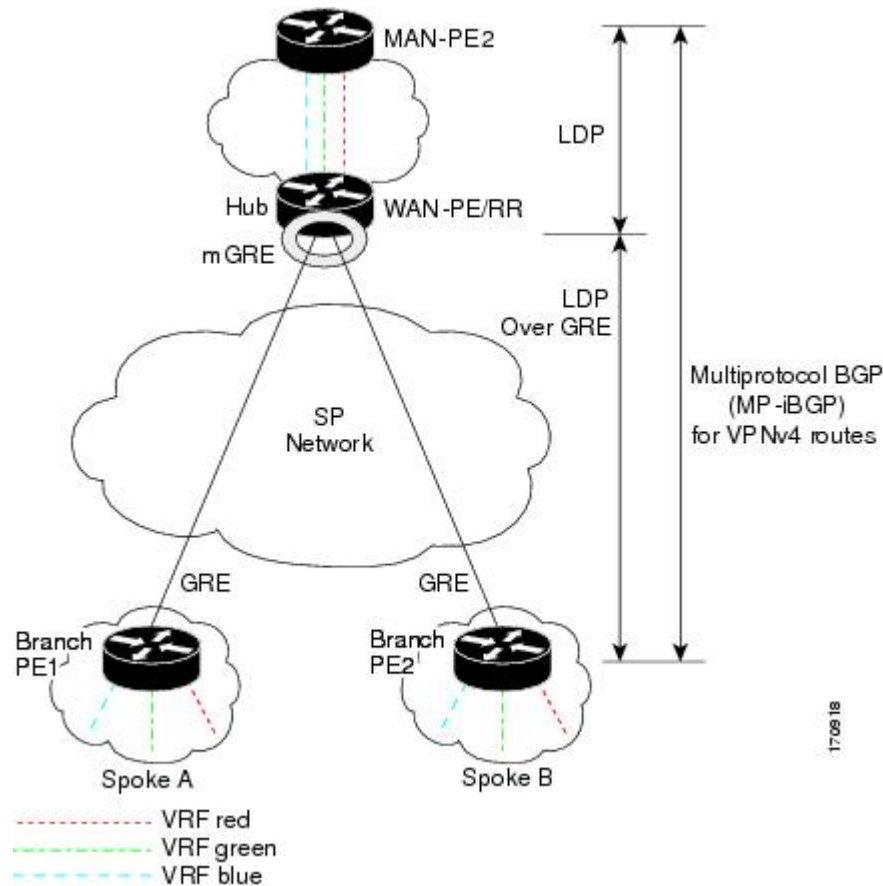
12.790.3

DMVPN--Enabling Traffic Segmentation Within DMVPN

Cisco IOS Release 12.4(11)T provides an enhancement that allows you to segment VPN traffic within a DMVPN tunnel. VRF instances are labeled, using MPLS, to indicate their source and destination.

The diagram below and the corresponding bullets explain how traffic segmentation within DMVPN works.

Figure 3 Traffic Segmentation with DMVPN



- The hub shown in the diagram is a WAN-PE and a route reflector, and the spokes (PE routers) are clients.
- There are three VRFs, designated “red,” “green,” and “blue.”
- Each spoke has both a neighbor relationship with the hub (multiprotocol Border Gateway Protocol [MP-iBGP] peering) and a GRE tunnel to the hub.
- Each spoke advertises its routes and VPNv4 prefixes to the hub.
- The hub sets its own IP address as the next-hop route for all the VPNv4 addresses it learns from the spokes and assigns a local MPLS label for each VPN when it advertises routes back to the spokes. As a result, traffic from Spoke A to Spoke B is routed via the hub.

An example illustrates the process:

- 1 Spoke A advertises a VPNv4 route to the hub, and applies the label X to the VPN.
- 2 The hub changes the label to Y when the hub advertises the route to Spoke B.

- 3 When Spoke B has traffic to send to Spoke A, it applies the *Y* label, and the traffic goes to the hub.
- 4 The hub swaps the VPN label, by removing the *Y* label and applying an *X* label, and sends the traffic to Spoke A.

NAT-Transparency Aware DMVPN

DMVPN spokes are often situated behind a NAT router (which is often controlled by the ISP for the spoke site) with the outside interface address of the spoke router being dynamically assigned by the ISP using a private IP address (per Internet Engineering Task Force [IETF] RFC 1918).

Prior to Cisco IOS Release 12.3(6) and 12.3(7)T, these spoke routers had to use IPsec tunnel mode to participate in a DMVPN network. In addition, their assigned outside interface private IP address had to be unique across the DMVPN network. Even though ISAKMP and IPsec would negotiate NAT-T and “learn” the correct NAT public address for the private IP address of this spoke, NHRP could only “see” and use the private IP address of the spoke for its mapping entries. Effective with the NAT-Transparency Aware DMVPN enhancement, NHRP can now learn and use the NAT public address for its mappings as long as IPsec transport mode is used (which is the recommend IPsec mode for DMVPN networks). The restriction that the private interface IP address of the spoke must be unique across the DMVPN network has been removed. It is recommended that all DMVPN routers be upgraded to the new code before you try to use the new functionality even though spoke routers that are not behind NAT do not need to be upgraded. In addition, you cannot convert upgraded spoke routers that are behind NAT to the new configuration (IPsec transport mode) until the hub routers have been upgraded.

Also added in Cisco IOS Releases 12.3(9a) and 12.3(11)T is the capability to have the hub DMVPN router behind static NAT. This was a change in the ISAKMP NAT-T support. For this functionality to be used, all the DMVPN spoke routers and hub routers must be upgraded, and IPsec must use transport mode.

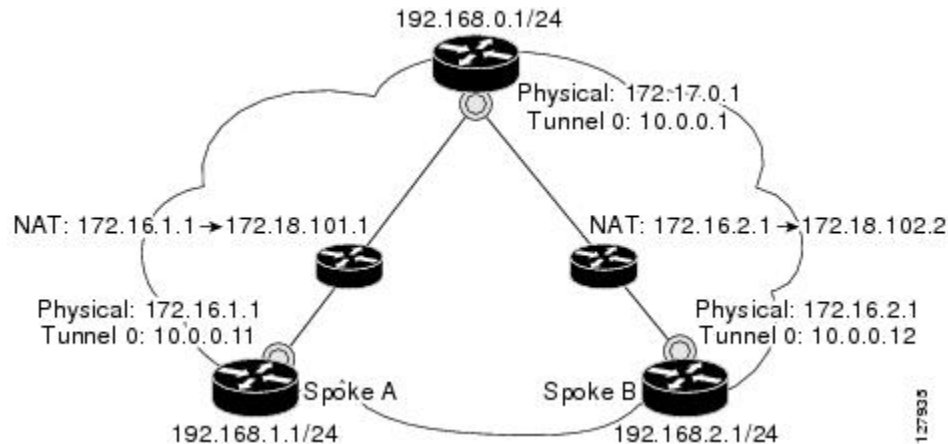
For these NAT-Transparency Aware enhancements to work, you must use IPsec transport mode on the transform set. Also, even though NAT-Transparency (IKE and IPsec) can support two peers (IKE and IPsec) being translated to the same IP address (using the UDP ports to differentiate them), this functionality is not supported for DMVPN. All DMVPN spokes must have a unique IP address after they have been NAT translated. They can have the same IP address before they are NAT translated.

The diagram below illustrates a NAT-Transparency Aware DMVPN scenario.

**Note**

In Cisco IOS Release 12.4(6)T or earlier, DMVPN spokes behind NAT will not participate in dynamic direct spoke-to-spoke tunnels. Any traffic to or from a spoke that is behind NAT will be forwarded using the DMVPN hub routers. DMVPN spokes that are not behind NAT in the same DMVPN network may create dynamic direct spoke-to-spoke tunnels between each other. In Cisco IOS Release 12.4(6)T or later releases, DMVPN spokes behind NAT will participate in dynamic direct spoke-to-spoke tunnels. The spokes must be behind NAT boxes that are performing NAT, not PAT. The NAT box must translate the spoke to the same outside NAT IP address for the spoke-spoke connections as the NAT box does for the spoke-hub connection. If there is more than one DMVPN spoke behind the same NAT box, then the NAT box must translate the DMVPN spokes to different outside NAT IP addresses. It is also likely that you may not be able to build a direct spoke-spoke tunnel between these spokes. If a spoke-spoke tunnel fails to form, then the spoke-spoke packets will continue to be forwarded via the spoke-hub-spoke path.

Figure 4 NAT-Transparency Aware DMVPN



Call Admission Control with DMVPN

In a DMVPN network, it is easy for a DMVPN router to become “overwhelmed” with the number of tunnels it is trying to build. Call Admission Control can be used to limit the number of tunnels that can be built at any one time, thus protecting the memory of the router and CPU resources.

It is most likely that Call Admission Control will be used on a DMVPN spoke to limit the total number of ISAKMP sessions (DMVPN tunnels) that a spoke router will attempt to initiate or accept. This limiting is accomplished by configuring an IKE SA limit under Call Admission Control, which configures the router to drop new ISAKMP session requests (inbound and outbound) if the current number of ISAKMP SAs exceeds the limit.

It is most likely that Call Admission Control will be used on a DMVPN hub to rate limit the number of DMVPN tunnels that are attempting to be built at the same time. The rate limiting is accomplished by configuring a system resource limit under Call Admission Control, which configures the router to drop new ISAKMP session requests (new DMVPN tunnels) when the system utilization is above a specified percentage. The dropped session requests allow the DMVPN hub router to complete the current ISAKMP session requests, and when the system utilization drops, it can process the previously dropped sessions when they are reattempted.

No special configuration is required to use Call Admission Control with DMVPN. For information about configuring Call Admission Control, see the reference in the section “Related Documents.”

NHRP Rate-Limiting Mechanism

NHRP has a rate-limiting mechanism that restricts the total number of NHRP packets from any given interface. The default values, which are set using the **ip nhrp max-send** command, are 100 packets every 10 seconds per interface. If the limit is exceeded, you will get the following system message:

```
%NHRP-4-QUOTA: Max-send quota of [int]pkts/[int]Sec. exceeded on [chars]
```

For more information about this system message, see the document 12.4T System Message Guide.

How to Configure Dynamic Multipoint VPN (DMVPN)

To enable mGRE and IPsec tunneling for hub and spoke routers, you must configure an IPsec profile that uses a global IPsec policy template and configure your mGRE tunnel for IPsec encryption. This section contains the following procedures:

- [Configuring an IPsec Profile, page 10](#)
- [Configuring the Hub for DMVPN, page 12](#)
- [Configuring the Spoke for DMVPN, page 16](#)
- [Configuring the Forwarding of Clear-Text Data IP Packets into a VRF, page 20](#)
- [Configuring the Forwarding of Encrypted Tunnel Packets into a VRF, page 21](#)
- [Configuring DMVPN--Traffic Segmentation Within DMVPN, page 21](#)
- [Troubleshooting Dynamic Multipoint VPN \(DMVPN\), page 28](#)

Configuring an IPsec Profile

The IPsec profile shares most of the same commands with the crypto map configuration, but only a subset of the commands are valid in an IPsec profile. Only commands that pertain to an IPsec policy can be issued under an IPsec profile; you cannot specify the IPsec peer address or the access control list (ACL) to match the packets that are to be encrypted.

Before configuring an IPsec profile, you must define a transform set by using the **crypto ipsec transform-set** command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto ipsec profile** *name*
4. **set transform-set** *transform-set-name*
5. **set identity**
6. **set security association lifetime** {**seconds** *seconds* | **kilobytes** *kilobytes*}
7. **set pfs** [**group1** | **group2**]

DETAILED STEPS

Command or Action	Purpose
<p>Step 1 enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables higher privilege levels, such as privileged EXEC mode.</p> <p>Enter your password if prompted.</p>
<p>Step 2 configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p>Step 3 crypto ipsec profile <i>name</i></p> <p>Example:</p> <pre>Router(config)# crypto ipsec profile vpnprof</pre>	<p>Defines the IPsec parameters that are to be used for IPsec encryption between “spoke and hub” and “spoke and spoke” routers.</p> <p>This command enters crypto map configuration mode.</p> <ul style="list-style-type: none"> The <i>name</i> argument specifies the name of the IPsec profile.
<p>Step 4 set transform-set <i>transform-set-name</i></p> <p>Example:</p> <pre>Router(config-crypto-map)# set transform-set trans2</pre>	<p>Specifies which transform sets can be used with the IPsec profile.</p> <ul style="list-style-type: none"> The <i>transform-set-name</i> argument specifies the name of the transform set.
<p>Step 5 set identity</p> <p>Example:</p> <pre>Router(config-crypto-map)# set identity</pre>	<p>(Optional) Specifies identity restrictions to be used with the IPsec profile.</p>
<p>Step 6 set security association lifetime {seconds <i>seconds</i> kilobytes <i>kilobytes</i>}</p> <p>Example:</p> <pre>Router(config-crypto-map)# set security association lifetime seconds 1800</pre>	<p>(Optional) Overrides the global lifetime value for the IPsec profile.</p> <ul style="list-style-type: none"> The seconds <i>seconds</i> option specifies the number of seconds a security association will live before expiring; the kilobytes <i>kilobytes</i> option specifies the volume of traffic (in kilobytes) that can pass between IPsec peers using a given security association before that security association expires. The default for the <i>seconds</i> argument is 3600 seconds.

Command or Action	Purpose
<p>Step 7 <code>set pfs [group1 group2]</code></p> <p>Example:</p> <pre>Router(config-crypto-map)# set pfs group2</pre>	<p>(Optional) Specifies that IPsec should ask for perfect forward secrecy (PFS) when requesting new security associations for this IPsec profile. If this command is not specified, the default (group1) will be enabled.</p> <ul style="list-style-type: none"> The group1 keyword specifies that IPsec should use the 768-bit Diffie-Hellman (DH) prime modulus group when performing the new DH exchange; the group2 keyword specifies the 1024-bit DH prime modulus group.

- [What to Do Next, page 12](#)

What to Do Next

Proceed to the following sections “Configuring the Hub for DMVPN” and “Configuring the Spoke for DMVPN.”

Configuring the Hub for DMVPN

To configure the hub router for mGRE and IPsec integration (that is, associate the tunnel with the IPsec profile configured in the previous procedure), use the following commands:



Note

NHRP network IDs are locally significant and can be different. It makes sense from a deployment and maintenance perspective to use unique **network ID** numbers (using the `ip nhrp network-id` command) across all routers in a DMVPN network, but it is not necessary that they be the same.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *number*
4. **ip address** *ip-address mask secondary*
5. **ip mtu** *bytes*
6. **ip nhrp authentication** *string*
7. **ip nhrp map multicast dynamic**
8. **ip nhrp network-id** *number*
9. **tunnel source** {*ip-address* | *type number*}
10. **tunnel key** *key-number*
11. **tunnel mode gre multipoint**
12. **tunnel protection ipsec profile** *name*
13. **bandwidth** *kbps*
14. **ip tcp adjust-mss** *max-segment-size*
15. **ip nhrp holdtime** *seconds*
16. **delay** *number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	<p>enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables higher privilege levels, such as privileged EXEC mode.</p> <p>Enter your password if prompted.</p>
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p>interface tunnel <i>number</i></p> <p>Example:</p> <pre>Router(config)# interface tunnel 5</pre>	<p>Configures a tunnel interface and enters interface configuration mode</p> <ul style="list-style-type: none"> • The <i>number</i> argument specifies the number of the tunnel interface that you want to create or configure. There is no limit on the number of tunnel interfaces you can create.

Command or Action	Purpose
<p>Step 4 <code>ip address <i>ip-address</i> <i>mask</i> <i>secondary</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.1 255.255.255.0</pre>	<p>Sets a primary or secondary IP address for the tunnel interface.</p> <p>Note All hubs and spokes that are in the same DMVPN network must be addressed in the same IP subnet.</p>
<p>Step 5 <code>ip mtu <i>bytes</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip mtu 1400</pre>	<p>Sets the maximum transmission unit (MTU) size, in bytes, of IP packets sent on an interface.</p>
<p>Step 6 <code>ip nhrp authentication <i>string</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp authentication donttell</pre>	<p>Configures the authentication string for an interface using NHRP.</p> <p>Note The NHRP authentication string must be set to the same value on all hubs and spokes that are in the same DMVPN network.</p>
<p>Step 7 <code>ip nhrp map multicast dynamic</code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp map multicast dynamic</pre>	<p>Allows NHRP to automatically add spoke routers to the multicast NHRP mappings.</p>
<p>Step 8 <code>ip nhrp network-id <i>number</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp network- id 99</pre>	<p>Enables NHRP on an interface.</p> <ul style="list-style-type: none"> The <i>number</i> argument specifies a globally unique 32-bit network identifier from a nonbroadcast multiaccess (NBMA) network. The range is from 1 to 4294967295.
<p>Step 9 <code>tunnel source {<i>ip-address</i> <i>type</i> <i>number</i>}</code></p> <p>Example:</p> <pre>Router (config-if)# tunnel source Ethernet0</pre>	<p>Sets source address for a tunnel interface.</p>

Command or Action	Purpose
<p>Step 10 <code>tunnel key <i>key-number</i></code></p> <p>Example:</p> <pre>Router (config-if)# tunnel key 100000</pre>	<p>(Optional) Enables an ID key for a tunnel interface.</p> <ul style="list-style-type: none"> The <i>key-number</i> argument specifies a number from 0 to 4,294,967,295 that identifies the tunnel key. <p>Note The key number must be set to the same value on all hubs and spokes that are in the same DMVPN network.</p> <p>Note This command should not be configured if you are using a Cisco 6500 or Cisco 7600 platform.</p>
<p>Step 11 <code>tunnel mode gre multipoint</code></p> <p>Example:</p> <pre>Router(config-if)# tunnel mode gre multipoint</pre>	<p>Sets the encapsulation mode to mGRE for the tunnel interface.</p>
<p>Step 12 <code>tunnel protection ipsec profile <i>name</i></code></p> <p>Example:</p> <pre>Router(config-if)# tunnel protection ipsec profile vpnprof</pre>	<p>Associates a tunnel interface with an IPsec profile.</p> <ul style="list-style-type: none"> The <i>name</i> argument specifies the name of the IPsec profile; this value must match the <i>name</i> specified in the crypto ipsec profile <i>name</i>command.
<p>Step 13 <code>bandwidth <i>kbps</i></code></p> <p>Example:</p> <pre>Router(config-if)# bandwidth 1000</pre>	<p>Sets the current bandwidth value for an interface to higher-level protocols.</p> <ul style="list-style-type: none"> The <i>kbps</i> argument specifies the bandwidth in kilobits per second. The default value is 9. The recommend bandwidth value is 1000 or greater. <p>Setting the bandwidth value to at least 1000 is critical if EIGRP is used over the tunnel interface. Higher bandwidth values may be necessary depending on the number of spokes supported by a hub.</p>
<p>Step 14 <code>ip tcp adjust-mss <i>max-segment-size</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip tcp adjust- mss 1360</pre>	<p>Adjusts the maximum segment size (MSS) value of TCP packets going through a router.</p> <ul style="list-style-type: none"> The <i>max-segment-size</i> argument specifies the maximum segment size, in bytes. The range is from 500 to 1460. <p>The recommended value is 1360 when the number of IP MTU bytes is set to 1400. With these recommended settings, TCP sessions quickly scale back to 1400-byte IP packets so the packets will “fit” in the tunnel.</p>
<p>Step 15 <code>ip nhrp holdtime <i>seconds</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp holdtime 450</pre>	<p>Changes the number of seconds that NHRP NBMA addresses are advertised as valid in authoritative NHRP responses.</p> <ul style="list-style-type: none"> The <i>seconds</i> argument specifies the time in seconds that NBMA addresses are advertised as valid in positive authoritative NHRP responses. The recommended value ranges from 300 seconds to 600 seconds.

Command or Action	Purpose
Step 16 <code>delay number</code> Example: <code>Router(config-if)# delay 1000</code>	(Optional) Used to change the EIGRP routing metric for routes learned over the tunnel interface. <ul style="list-style-type: none"> The <i>number</i> argument specifies the delay time in seconds. The recommend value is 1000.

Configuring the Spoke for DMVPN

To configure spoke routers for mGRE and IPsec integration, use the following commands.



Note

NHRP network IDs are locally significant and can be different. It makes sense from a deployment and maintenance perspective to use unique **network ID** numbers (using the **ip nhrp network-id** command) across all routers in a DMVPN network, but it is not necessary that they be the same.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel number**
4. **ip address ip-address mask secondary**
5. **ip mtu bytes**
6. **ip nhrp authentication string**
7. **ip nhrp map hub-tunnel-ip-address hub-physical-ip-address**
8. **ip nhrp map multicast hub-physical-ip-address**
9. **ip nhrp nhs hub-tunnel-ip-address**
10. **ip nhrp network-id number**
11. **tunnel source {ip-address | type number}**
12. **tunnel key key-number**
13. Do one of the following:
 - **tunnel mode gre multipoint**
 - **tunnel destination hub-physical-ip-address**
14. **tunnel protection ipsec profile name**
15. **bandwidth kbps**
16. **ip tcp adjust-mss max-segment-size**
17. **ip nhrp holdtime seconds**
18. **delay number**

DETAILED STEPS

	Command or Action	Purpose
Step 1	<p>enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables higher privilege levels, such as privileged EXEC mode.</p> <p>Enter your password if prompted.</p>
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p>interface tunnel <i>number</i></p> <p>Example:</p> <pre>Router(config)# interface tunnel 5</pre>	<p>Configures a tunnel interface and enters interface configuration mode.</p> <ul style="list-style-type: none"> The <i>number</i> argument specifies the number of the tunnel interface that you want to create or configure. There is no limit on the number of tunnel interfaces you can create.
Step 4	<p>ip address <i>ip-address mask secondary</i></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.2 255.255.255.0</pre>	<p>Sets a primary or secondary IP address for the tunnel interface.</p> <p>Note All hubs and spokes that are in the same DMVPN network must be addressed in the same IP subnet.</p>
Step 5	<p>ip mtu <i>bytes</i></p> <p>Example:</p> <pre>Router(config-if)# ip mtu 1400</pre>	<p>Sets the MTU size, in bytes, of IP packets sent on an interface.</p>
Step 6	<p>ip nhrp authentication <i>string</i></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp authentication donttell</pre>	<p>Configures the authentication string for an interface using NHRP.</p> <p>Note The NHRP authentication string be set to the same value on all hubs and spokes that are in the same DMVPN network.</p>

Command or Action	Purpose
<p>Step 7 <code>ip nhrp map <i>hub-tunnel-ip-address</i> <i>hub-physical-ip-address</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp map 10.0.0.1 172.17.0.1</pre>	<p>Statically configures the IP-to-NBMA address mapping of IP destinations connected to an NBMA network.</p> <ul style="list-style-type: none"> • <i>hub-tunnel-ip-address</i> --Defines the NHRP server at the hub, which is permanently mapped to the static public IP address of the hub. • <i>hub-physical-ip-address</i> --Defines the static public IP address of the hub.
<p>Step 8 <code>ip nhrp map multicast <i>hub-physical-ip-address</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp map multicast 172.17.0.1</pre>	<p>Enables the use of a dynamic routing protocol between the spoke and hub, and sends multicast packets to the hub router.</p>
<p>Step 9 <code>ip nhrp nhs <i>hub-tunnel-ip-address</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp nhs 10.0.0.1</pre>	<p>Configures the hub router as the NHRP next-hop server.</p>
<p>Step 10 <code>ip nhrp network-id <i>number</i></code></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp network- id 99</pre>	<p>Enables NHRP on an interface.</p> <ul style="list-style-type: none"> • The <i>number</i> argument specifies a globally unique 32-bit network identifier from a NBMA network. The range is from 1 to 4294967295.
<p>Step 11 <code>tunnel source {<i>ip-address</i> <i>type number</i>}</code></p> <p>Example:</p> <pre>Router (config-if)# tunnel source Ethernet0</pre>	<p>Sets the source address for a tunnel interface.</p>
<p>Step 12 <code>tunnel key <i>key-number</i></code></p> <p>Example:</p> <pre>Router (config-if)# tunnel key 100000</pre>	<p>(Optional) Enables an ID key for a tunnel interface.</p> <ul style="list-style-type: none"> • The <i>key-number</i> argument specifies a number from 0 to 4,294,967,295 that identifies the tunnel key. • The key number must be set to the same value on all hubs and spokes that are in the same DMVPN network. <p>Note This command should not be configured if you are using a Cisco 6500 or Cisco 7600 platform.</p>

Command or Action	Purpose
<p>Step 13 Do one of the following:</p> <ul style="list-style-type: none"> • tunnel mode gre multipoint • tunnel destination <i>hub-physical-ip-address</i> <p>Example:</p> <pre>Router(config-if)# tunnel mode gre multipoint</pre> <p>Example:</p> <pre>Router(config-if)# tunnel destination 172.17.0.1</pre>	<p>Sets the encapsulation mode to mGRE for the tunnel interface.</p> <p>Use this command if data traffic can use dynamic spoke-to-spoke traffic.</p> <p>Specifies the destination for a tunnel interface.</p> <p>Use this command if data traffic can use hub-and-spoke tunnels.</p>
<p>Step 14 tunnel protection ipsec profile <i>name</i></p> <p>Example:</p> <pre>Router(config-if)# tunnel protection ipsec profile vpnprof</pre>	<p>Associates a tunnel interface with an IPsec profile.</p> <ul style="list-style-type: none"> • The <i>name</i> argument specifies the name of the IPsec profile; this value must match the <i>name</i> specified in the crypto ipsec profile <i>name</i> command.
<p>Step 15 bandwidth <i>kbps</i></p> <p>Example:</p> <pre>Router(config-if)# bandwidth 1000</pre>	<p>Sets the current bandwidth value for an interface to higher-level protocols.</p> <ul style="list-style-type: none"> • The <i>kbps</i> argument specifies the bandwidth in kilobits per second. The default value is 9. The recommend bandwidth value is 1000 or greater. <p>The bandwidth setting for the spoke does not need to equal the bandwidth setting for the DMVPN hub. It is usually easier if all of the spokes use the same or similar value.</p>
<p>Step 16 ip tcp adjust-mss <i>max-segment-size</i></p> <p>Example:</p> <pre>Router(config-if)# ip tcp adjust- mss 1360</pre>	<p>Adjusts the maximum segment size (MSS) value of TCP packets going through a router.</p> <ul style="list-style-type: none"> • The <i>max-segment-size</i> argument specifies the maximum segment size, in bytes. The range is from 500 to 1460. <p>The recommended number value is 1360 when the number of IP MTU bytes is set to 1400. With these recommended settings, TCP sessions quickly scale back to 1400-byte IP packets so the packets will “fit” in the tunnel.</p>
<p>Step 17 ip nhrp holdtime <i>seconds</i></p> <p>Example:</p> <pre>Router(config-if)# ip nhrp holdtime 450</pre>	<p>Changes the number of seconds that NHRP NBMA addresses are advertised as valid in authoritative NHRP responses.</p> <ul style="list-style-type: none"> • The <i>seconds</i> argument specifies the time in seconds that NBMA addresses are advertised as valid in positive authoritative NHRP responses. The recommended value ranges from 300 seconds to 600 seconds.

Command or Action	Purpose
Step 18 <code>delay number</code> Example: <code>Router(config-if)# delay 1000</code>	(Optional) Used to change the EIGRP routing metric for routes learned over the tunnel interface. <ul style="list-style-type: none"> The <i>number</i> argument specifies the delay time in seconds. The recommend value is 1000.

Configuring the Forwarding of Clear-Text Data IP Packets into a VRF

To configure the forwarding of clear-text data IP packets into a VRF, perform the following steps. This configuration assumes that the VRF BLUE has already been configured.

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `interface type number`
4. `ip vrf forwarding vrf-name`

DETAILED STEPS

Command or Action	Purpose
Step 1 <code>enable</code> Example: <code>Router> enable</code>	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2 <code>configure terminal</code> Example: <code>Router# configure terminal</code>	Enters global configuration mode.
Step 3 <code>interface type number</code> Example: <code>Router (config)# interface tunnel0</code>	Configures an interface type and enters interface configuration mode.
Step 4 <code>ip vrf forwarding vrf-name</code> Example: <code>Router (config-if)# ip vrf forwarding BLUE</code>	Associates a VPN VRF with an interface or subinterface.

Configuring the Forwarding of Encrypted Tunnel Packets into a VRF

To configure the forwarding of encrypted tunnel packets into a VRF, perform the following steps. This configuration assumes that the VRF RED has already been configured.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface *type number***
4. **tunnel vrf *vrf-name***

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	interface <i>type number</i> Example: Router (config)# interface tunnel0	Configures an interface type and enters interface configuration mode.
Step 4	tunnel vrf <i>vrf-name</i> Example: Router (config-if)# tunnel vrf RED	Associates a VPN VRF instance with a specific tunnel destination, interface, or subinterface.

Configuring DMVPN--Traffic Segmentation Within DMVPN

There are no new commands to use for configuring traffic segmentation, but there are tasks you must complete in order to segment traffic within a DMVPN tunnel:

- [Prerequisites, page 22](#)
- [Enabling MPLS on the VPN Tunnel, page 22](#)
- [Configuring Multiprotocol BGP on the Hub Router, page 23](#)
- [Configuring Multiprotocol BGP on the Spoke Routers, page 25](#)

Prerequisites

The tasks that follow assume that the DMVPN tunnel and the VRFs “red” and “blue” have already been configured.

For information on configuring a DMVPN tunnel, see the Configuring the Hub for DMVPN task and the Configuring the Spoke for DMVPN. For details about VRF configuration, see the Configuring the Forwarding of Clear-Text Data IP Packets into a VRF task and the Configuring the Forwarding of Encrypted Tunnel Packets into a VRF task.

Enabling MPLS on the VPN Tunnel

Because traffic segmentation within a DMVPN tunnel depends upon MPLS, you must configure MPLS for each VRF instance in which traffic will be segmented. For detailed information about configuring MPLS, see *Cisco IOS Multiprotocol Label Switching Configuration Guide*, Release 12.4.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface *type number***
4. **mpls ip**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	interface <i>type number</i> Example: Router (config)# interface tunnel0	Configures an interface type and enters interface configuration mode.

Command or Action	Purpose
<p>Step 4 <code>mpls ip</code></p> <p>Example:</p> <pre>Router (config-if)# mpls ip</pre>	<p>Enables MPLS tagging of packets on the specified tunnel interface.</p>

Configuring Multiprotocol BGP on the Hub Router

You must configure multiprotocol iBGP (MP-iBGP) to enable advertisement of VPNv4 prefixes and labels to be applied to the VPN traffic. Use BGP to configure the hub as a route reflector. To force all traffic to be routed via the hub, configure the BGP route reflector to change the next hop to itself when it advertises VPNv4 prefixes to the route reflector clients (spokes).

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `router bgp`
4. `neighbor ipaddress remote-as as - number`
5. `neighbor ipaddress update-source interface`
6. `address-family vpnv4`
7. `neighbor ipaddress activate`
8. `neighbor ipaddress send-community extended`
9. `neighbor ipaddress route-reflector-client`
10. `neighbor ipaddress route-map nexthop out`
11. `exit-address-family`
12. `address-family ipv4 vrf-name`
13. `redistribute connected`
14. `route-map`
15. `set ip next-hop ipaddress`

DETAILED STEPS

Command or Action	Purpose
<p>Step 1 <code>enable</code></p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables higher privilege levels, such as privileged EXEC mode.</p> <ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	Enters global configuration mode.
Step 3	<p>router bgp</p> <p>Example:</p> <pre>Router (config)# router bgp</pre>	Enters BGP configuration mode.
Step 4	<p>neighbor <i>ipaddress</i> remote-as <i>as - number</i></p> <p>Example:</p> <pre>Router (config)# neighbor 10.0.0.11 remote-as 1</pre>	Adds an entry to the BGP or multiprotocol BGP neighbor table.
Step 5	<p>neighbor <i>ipaddress</i> update-source <i>interface</i></p> <p>Example:</p> <pre>Router (config)# neighbor 10.10.10.11 update-source Tunnell</pre>	Configures the Cisco IOS software to allow BGP sessions to use any operational interface for TCP connections.
Step 6	<p>address-family vpnv4</p> <p>Example:</p> <pre>Router (config)# address-family vpnv4</pre>	Enters address family configuration mode to configure a routing session using Virtual Private Network (VPN) Version 4 address prefixes.
Step 7	<p>neighbor <i>ipaddress</i> activate</p> <p>Example:</p> <pre>Router (config)# neighbor 10.0.0.11 activate</pre>	Enables the exchange of information with a BGP neighbor.
Step 8	<p>neighbor <i>ipaddress</i> send-community extended</p> <p>Example:</p> <pre>Router (config)# neighbor 10.0.0.11 send-community extended</pre>	Specifies that extended community attributes should be sent to a BGP neighbor.

	Command or Action	Purpose
Step 9	neighbor <i>ipaddress</i> route-reflector-client Example: <pre>Router (config)# neighbor 10.0.0.11 route-reflector-client</pre>	Configures the router as a BGP route reflector and configures the specified neighbor as its client.
Step 10	neighbor <i>ipaddress</i> route-map nexthop out Example: <pre>Router (config)# neighbor 10.0.0.11 route-map nexthop out</pre>	Forces all traffic to be routed via the hub.
Step 11	exit-address-family Example: <pre>Router (config)# exit-address-family</pre>	Exits the address family configuration mode for VPNv4.
Step 12	address-family ipv4 <i>vrf-name</i> Example: <pre>Router (config)# address-family ipv4 vrf red</pre>	Enters address family configuration mode to configure a routing session using standard IP Version 4 address prefixes.
Step 13	redistribute connected Example: <pre>Router (config)# redistribute connected</pre>	Redistributes routes that are established automatically by virtue of having enabled IP on an interface from one routing domain into another routing domain.
Step 14	route-map Example: <pre>Router (config)# route-map nexthop permit 10</pre>	Enters route map configuration mode to configure the next-hop that will be advertised to the spokes.
Step 15	set ip next-hop <i>ipaddress</i> Example: <pre>Router (config)# set ip next-hop 10.0.0.1</pre>	Sets the next hop to be the hub.

Configuring Multiprotocol BGP on the Spoke Routers

Multiprotocol-iBGP (MP-iBGP) must be configured on the spoke routers and the hub. Follow the steps below for each spoke router in the DMVPN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp**
4. **neighbor *ipaddress* remote-as *as - number***
5. **neighbor *ipaddress* update-source *interface***
6. **address-family vpvv4**
7. **neighbor *ipaddress* activate**
8. **neighbor *ipaddress* send-community extended**
9. **exit-address-family**
10. **address-family ipv4 *vrf-name***
11. **redistribute connected**
12. **exit-address-family**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables higher privilege levels, such as 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	router bgp Example: Router (config)# router bgp 1	Enters BGP configuration mode.
Step 4	neighbor <i>ipaddress</i> remote-as <i>as - number</i> Example: Router (config)# neighbor 10.0.0.1 remote-as 1	Adds an entry to the BGP or multiprotocol BGP neighbor table.

	Command or Action	Purpose
Step 5	neighbor <i>ipaddress</i> update-source <i>interface</i> Example: <pre>Router (config)# neighbor 10.10.10.1 update- source Tunnell</pre>	Configures the Cisco IOS software to allow BGP sessions to use any operational interface for TCP connections.
Step 6	address-family vpvv4 Example: <pre>Router (config)# address-family vpvv4</pre>	Enters address family configuration mode to configure a routing session using Virtual Private Network (VPN) Version 4 address prefixes.
Step 7	neighbor <i>ipaddress</i> activate Example: <pre>Router (config)# neighbor 10.0.0.1 activate</pre>	Enables the exchange of information with a BGP neighbor.
Step 8	neighbor <i>ipaddress</i> send-community extended Example: <pre>Router (config)# neighbor 10.0.0.1 send- community extended</pre>	Specifies that extended community attributes should be sent to a BGP neighbor.
Step 9	exit-address-family Example: <pre>Router (config)# exit-address-family</pre>	Exits the address family configuration mode.
Step 10	address-family ipv4 <i>vrf-name</i> Example: <pre>Router (config)# address-family ipv4 vrf red</pre>	Enters address family configuration mode to configure a routing session using standard IP Version 4 address prefixes.
Step 11	redistribute connected Example: <pre>Router (config)# redistribute connected</pre>	Redistributes routes that are established automatically by virtue of having enabled IP on an interface from one routing domain into another routing domain.

Command or Action	Purpose
Step 12 <code>exit-address-family</code> Example: <pre>Router (config)# exit-address-family</pre>	Exits the address family configuration mode. Note Repeat Steps 10-12 for each VRF.

Troubleshooting Dynamic Multipoint VPN (DMVPN)

After configuring DMVPN, to verify that DMVPN is operating correctly, to clear DMVPN statistics or sessions, or to debug DMVPN, you may perform the following optional steps:

SUMMARY STEPS

1. The **clear dmvpn session** command is used to clear DMVPN sessions.
2. The **clear dmvpn statistics** command is used to clear DMVPN related counters. The following example shows how to clear DMVPN related session counters for the specified tunnel interface:
3. The **debug dmvpn** command is used to debug DMVPN sessions. You can enable or disable DMVPN debugging based on a specific condition. There are three levels of DMVPN debugging, listed in the order of details from lowest to highest:
4. The **debug nhrp condition** command enables or disables debugging based on a specific condition. The following example shows how to enable conditional NHRP debugging:
5. The **debug nhrp error** command displays information about NHRP error activity. The following example shows how to enable debugging for NHRP error messages:
6. The **logging dmvpn** command is used to enable DMVPN system logging. The following command shows how to enable DMVPN system logging at the rate of 1 message every 20 seconds:
7. The **show crypto ipsec sa** command displays the settings used by the current SAs. The following example output shows the IPsec SA status of only the active device:
8. The **show crypto isakmp sa** command displays all current IKE SAs at a peer. For example, the following sample output is displayed after IKE negotiations have successfully completed between two peers.
9. The **show crypto map** command displays the crypto map configuration.
10. The **show dmvpn** command displays DMVPN specific session information. The following example shows example summary output:
11. The **show ip nhrp traffic** command displays NHRP statistics. The following example shows output for a specific tunnel, tunnel7:

DETAILED STEPS

- Step 1** The **clear dmvpn session** command is used to clear DMVPN sessions. The following example clears only dynamic DMVPN sessions:

```
Router# clear dmvpn session peer nbma
```

The following example clears all DMVPN sessions, both static and dynamic, for the specified tunnel:

Router# **clear dmvpn session interface tunnel 100 static**

Step 2 The **clear dmvpn statistics** command is used to clear DMVPN related counters. The following example shows how to clear DMVPN related session counters for the specified tunnel interface:

Router# **clear dmvpn statistics peer tunnel 192.0.2.3**

Step 3 The **debug dmvpn** command is used to debug DMVPN sessions. You can enable or disable DMVPN debugging based on a specific condition. There are three levels of DMVPN debugging, listed in the order of details from lowest to highest:

- Error level
- Detail level
- Packet level

The following example shows how to enable conditional DMVPN debugging that displays all error debugs for next hop routing protocol (NHRP), sockets, tunnel protection and crypto information:

Router# **debug dmvpn error all**

Step 4 The **debug nhrp condition** command enables or disables debugging based on a specific condition. The following example shows how to enable conditional NHRP debugging:

Router# **debug nhrp condition**

Step 5 The **debug nhrp error** command displays information about NHRP error activity. The following example shows how to enable debugging for NHRP error messages:

Router# **debug nhrp error**

Step 6 The **logging dmvpn** command is used to enable DMVPN system logging. The following command shows how to enable DMVPN system logging at the rate of 1 message every 20 seconds:

Router(config)# **logging dmvpn rate-limit 20**

The following example shows a sample system log with DMVPN messages:

Example:

```
%DMVPN-7-CRYPTO_SS: Tunnel101-192.0.2.1 socket is UP
%DMVPN-5-NHRP_NHS: Tunnel101 192.0.2.251 is UP
%DMVPN-5-NHRP_CACHE: Client 192.0.2.2 on Tunnel1 Registered.
%DMVPN-5-NHRP_CACHE: Client 192.0.2.2 on Tunnel101 came UP.
%DMVPN-3-NHRP_ERROR: Registration Request failed for 192.0.2.251 on Tunnel101
```

Step 7 The **show crypto ipsec sa** command displays the settings used by the current SAs. The following example output shows the IPsec SA status of only the active device:

Example:

```
Router#
show crypto ipsec sa active
interface: Ethernet0/0
  Crypto map tag: to-peer-outside, local addr 209.165.201.3
  protected vrf: (none)
  local ident (addr/mask/prot/port): (192.168.0.1/255.255.255.255/0/0)
  remote ident (addr/mask/prot/port): (172.16.0.1/255.255.255.255/0/0)
  current_peer 209.165.200.225 port 500
    PERMIT, flags={origin_is_acl,}
    #pkts encaps: 3, #pkts encrypt: 3, #pkts digest: 3
    #pkts decaps: 4, #pkts decrypt: 4, #pkts verify: 4
    #pkts compressed: 0, #pkts decompressed: 0
    #pkts not compressed: 0, #pkts compr. failed: 0
    #pkts not decompressed: 0, #pkts decompress failed: 0
    #send errors 0, #recv errors 0
```

```

local crypto endpt.: 209.165.201.3, remote crypto endpt.: 209.165.200.225
path mtu 1500, media mtu 1500
current outbound spi: 0xD42904F0(3559458032)
inbound esp sas:
  spi: 0xD3E9ABD0(3555306448)
    transform: esp-3des ,
    in use settings ={Tunnel, }
    conn id: 2006, flow_id: 6, crypto map: to-peer-outside
    sa timing: remaining key lifetime (k/sec): (4586265/3542)
    HA last key lifetime sent(k): (4586267)
    ike_cookies: 9263635C CA4B4E99 C14E908E 8EE2D79C
    IV size: 8 bytes
    replay detection support: Y
    Status: ACTIVE

```

Step 8 The **show crypto isakmp sa** command displays all current IKE SAs at a peer. For example, the following sample output is displayed after IKE negotiations have successfully completed between two peers.

Example:

```

Router# show crypto isakmp sa
dst          src          state          conn-id  slot
172.17.63.19 172.16.175.76 QM_IDLE        2        0
172.17.63.19 172.17.63.20 QM_IDLE        1        0
172.16.175.75 172.17.63.19 QM_IDLE        3        0

```

Step 9 The **show crypto map** command displays the crypto map configuration. The following sample output is displayed after a crypto map has been configured:

Example:

```

Router# show crypto map
Crypto Map "Tunnel5-head-0" 10 ipsec-isakmp
  Profile name: vpnprof
  Security association lifetime: 4608000 kilobytes/3600 seconds
  PFS (Y/N): N
  Transform sets={trans2, }
Crypto Map "Tunnel5-head-0" 20 ipsec-isakmp
  Map is a PROFILE INSTANCE.
  Peer = 172.16.175.75
  Extended IP access list
    access-list permit gre host 172.17.63.19 host 172.16.175.75
  Current peer: 172.16.175.75
  Security association lifetime: 4608000 kilobytes/3600 seconds
  PFS (Y/N): N
  Transform sets={trans2, }
Crypto Map "Tunnel5-head-0" 30 ipsec-isakmp
  Map is a PROFILE INSTANCE.
  Peer = 172.17.63.20
  Extended IP access list
    access-list permit gre host 172.17.63.19 host 172.17.63.20
  Current peer: 172.17.63.20
  Security association lifetime: 4608000 kilobytes/3600 seconds
  PFS (Y/N): N
  Transform sets={trans2, }
Crypto Map "Tunnel5-head-0" 40 ipsec-isakmp
  Map is a PROFILE INSTANCE.
  Peer = 172.16.175.76
  Extended IP access list
    access-list permit gre host 172.17.63.19 host 172.16.175.76
  Current peer: 172.16.175.76
  Security association lifetime: 4608000 kilobytes/3600 seconds
  PFS (Y/N): N
  Transform sets={trans2, }

```

```
Interfaces using crypto map Tunnel5-head-0:
Tunnel5
```

Step 10 The **show dmvpn** command displays DMVPN specific session information. The following example shows example summary output:

Example:

```
Router# show dmvpn
Legend: Attrb --> S - Static, D - Dynamic, I - Incomplete
        N - NATed, L - Local, X - No Socket
        # Ent --> Number of NHRP entries with same NBMA peer
! The line below indicates that the sessions are being displayed for Tunnel1.
! Tunnel1 is acting as a spoke and is a peer with three other NBMA peers.
Tunnel1, Type: Spoke, NBMA Peers: 3,
# Ent Peer NBMA Addr Peer Tunnel Add State UpDn Tm Attrb
-----
  2    192.0.2.21      192.0.2.116   IKE      3w0d D
  1    192.0.2.102      192.0.2.11   NHRP    02:40:51 S
  1    192.0.2.225      192.0.2.10   UP       3w0d S
Tunnel2, Type: Spoke, NBMA Peers: 1,
# Ent Peer NBMA Addr Peer Tunnel Add State UpDn Tm Attrb
-----
  1    192.0.2.25      192.0.2.171   IKE      never S
```

Step 11 The **show ip nhrp traffic** command displays NHRP statistics. The following example shows output for a specific tunnel, tunnel7:

```
Router# show ip nhrp traffic interface tunnel7
```

Example:

```
Tunnel7: Max-send limit:100Pkts/10Sec, Usage:0%
Sent: Total 79
    18 Resolution Request   10 Resolution Reply   42 Registration Request
     0 Registration Reply    3 Purge Request       6 Purge Reply
     0 Error Indication      0 Traffic Indication
Rcvd: Total 69
    10 Resolution Request   15 Resolution Reply   0 Registration Request
    36 Registration Reply    6 Purge Request       2 Purge Reply
     0 Error Indication      0 Traffic Indication
```

- [What to Do Next, page 31](#)

What to Do Next

If you have troubleshooted your DMVPN configuration and proceed to contact technical support, the **show tech-support** command includes information for DMVPN sessions. For more information, see the **show tech-support** command in the Cisco IOS Configuration Fundamentals Command Reference.

Configuration Examples for Dynamic Multipoint VPN (DMVPN) Feature

- [Example Hub Configuration for DMVPN, page 32](#)

- [Example Spoke Configuration for DMVPN, page 33](#)
- [Example VRF Aware DMVPN, page 33](#)
- [Example 2547oDMVPN with Traffic Segmentation \(with BGP only\), page 35](#)
- [Example 2547oDMVPN with Traffic Segmentation \(Enterprise Branch\), page 39](#)

Example Hub Configuration for DMVPN

In the following example, which configures the hub router for multipoint GRE and IPsec integration, no explicit configuration lines are needed for each spoke; that is, the hub is configured with a global IPsec policy template that all spoke routers can talk to. In this example, EIGRP is configured to run over the private physical interface and the tunnel interface.

```
crypto isakmp policy 1
  authentication pre-share
crypto isakmp key cisco47 address 0.0.0.0
!
crypto ipsec transform-set trans2 esp-des esp-md5-hmac
mode transport
!
crypto ipsec profile vpnprof
  set transform-set trans2
!
interface Tunnel0
  bandwidth 1000
  ip address 10.0.0.1 255.255.255.0
  ! Ensures longer packets are fragmented before they are encrypted; otherwise, the
  receiving router would have to do the reassembly.
  ip mtu 1400
  ! The following line must match on all nodes that "want to use" this mGRE tunnel:
  ip nhrp authentication donttell
  ! Note that the next line is required only on the hub.
  ip nhrp map multicast dynamic
  ! The following line must match on all nodes that want to use this mGRE tunnel:
  ip nhrp network-id 99
  ip nhrp holdtime 300
  ! Turns off split horizon on the mGRE tunnel interface; otherwise, EIGRP will not
  advertise routes that are learned via the mGRE interface back out that interface.
  no ip split-horizon eigrp 1
  ! Enables dynamic, direct spoke-to-spoke tunnels when using EIGRP.
  no ip next-hop-self eigrp 1
  ip tcp adjust-mss 1360
  delay 1000
  ! Sets IPsec peer address to Ethernet interface's public address.
  tunnel source Ethernet0
  tunnel mode gre multipoint
  ! The following line must match on all nodes that want to use this mGRE tunnel.
  tunnel key 100000
  tunnel protection ipsec profile vpnprof
!
interface Ethernet0
  ip address 172.17.0.1 255.255.255.0
!
interface Ethernet1
  ip address 192.168.0.1 255.255.255.0
!
router eigrp 1
  network 10.0.0.0 0.0.0.255
  network 192.168.0.0 0.0.0.255
!
```

For information about defining and configuring ISAKMP profiles, see the references in the “Related Documents” section.

Example Spoke Configuration for DMVPN

In the following example, all spokes are configured the same except for tunnel and local interface address, thereby, reducing necessary configurations for the user:

```
crypto isakmp policy 1
  authentication pre-share
crypto isakmp key cisco47 address 0.0.0.0
!
crypto ipsec transform-set trans2 esp-des esp-md5-hmac
  mode transport
!
crypto ipsec profile vpnprof
  set transform-set trans2
!
interface Tunnel0
  bandwidth 1000
  ip address 10.0.0.2 255.255.255.0
  ip mtu 1400
! The following line must match on all nodes that want to use this mGRE tunnel:
  ip nhrp authentication donttell
! Definition of NHRP server at the hub (10.0.0.1), which is permanently mapped to the
static public address of the hub (172.17.0.1).
  ip nhrp map 10.0.0.1 172.17.0.1
! Sends multicast packets to the hub router, and enables the use of a dynamic routing
protocol between the spoke and the hub.
  ip nhrp map multicast 172.17.0.1
! The following line must match on all nodes that want to use this mGRE tunnel:
  ip nhrp network-id 99
  ip nhrp holdtime 300
! Configures the hub router as the NHRP next-hop server.
  ip nhrp nhs 10.0.0.1
  ip tcp adjust-mss 1360
  delay 1000
  tunnel source Ethernet0
  tunnel mode gre multipoint
! The following line must match on all nodes that want to use this mGRE tunnel:
  tunnel key 100000
  tunnel protection ipsec profile vpnprof
!
! This is a spoke, so the public address might be dynamically assigned via DHCP.
interface Ethernet0
  ip address dhcp hostname Spokel
!
interface Ethernet1
  ip address 192.168.1.1 255.255.255.0
!
! EIGRP is configured to run over the inside physical interface and the tunnel.
router eigrp 1
  network 10.0.0.0 0.0.0.255
  network 192.168.1.0 0.0.0.255
```

Example VRF Aware DMVPN

When configuring VRF Aware DMVPN, you must create a separate DMVPN network for each VRF instance. In the following example, there are two DMVPN networks: BLUE and RED. In addition, a separate source interface has been used on the hub for each DMVPN tunnel--a must for Cisco IOS Release 12.2(18)SXE. For other Cisco IOS releases, you can configure the same tunnel source for both of the tunnel interfaces, but you must configure the **tunnel key** and **tunnel protection (tunnel protection ipsec profile {name} shared)** commands.

**Note**

If you use the **shared** keyword, then you should be running Cisco IOS Release 12.4(5) or Release 12.4(6)T, or a later release. Otherwise the IPsec/GRE tunnels under the two mGRE tunnel interfaces may not function correctly.

Hub Configuration

```
interface Tunnel0
! Note the next line.
 ip vrf forwarding BLUE
 bandwidth 1000
 ip address 10.0.0.1 255.255.255.0
 ip mtu 1436
 ! Note the next line.
 ip nhrp authentication BLUE!KEY
 ip nhrp map multicast dynamic
 ! Note the next line
 ip nhrp network-id 100000
 ip nhrp holdtime 600
 no ip split-horizon eigrp 1
 no ip next-hop-self eigrp 1
 ip tcp adjust-mss 1360
 delay 1000
 ! Note the next line.
 tunnel source Ethernet0
 tunnel mode gre multipoint
 tunnel protection ipsec profile vpnprof!
interface Tunnell
! Note the next line.
 ip vrf forwarding RED
 bandwidth 1000
 ip address 10.0.0.1 255.255.255.0
 ip mtu 1436
 ! Note the next line.
 ip nhrp authentication RED!KEY
 ip nhrp map multicast dynamic
 ! Note the next line.
 ip nhrp network-id 20000
 ip nhrp holdtime 600
 no ip split-horizon eigrp 1
 no ip next-hop-self eigrp 1
 ip tcp adjust-mss 1360
 delay 1000
 ! Note the next line.
 tunnel source Ethernet1
 tunnel mode gre multipoint
 tunnel protection ipsec profile vpnprof!
interface Ethernet0
 ip address 172.17.0.1 255.255.255.0
interface Ethernet1
 ip address 192.0.2.171 255.255.255.0
```

**Note**

For the hub configuration shown above, a separate DMVPN network is configured for each VPN. The NHRP network ID and authentication keys must be unique on the two mGRE interfaces.

EIGRP Configuration on the Hub

```
router eigrp 1
 auto-summary
 !
 address-family ipv4 vrf BLUE
 network 10.0.0.0 0.0.0.255
```

```

no auto-summary
autonomous-system 1
exit-address-family
!
address-family ipv4 vrf RED
network 10.0.0.0 0.0.0.255
no auto-summary
autonomous-system 1
exit-address-family

```

Spoke Configurations

Spoke 1:

```

interface Tunnel0
 bandwidth 1000
 ip address 10.0.0.2 255.255.255.0
 ip mtu 1436
 ! Note the next line.
 ip nhrp authentication BLUE!KEY
 ip nhrp map 10.0.0.1 172.17.0.1
 ip nhrp network-id 100000
 ip nhrp holdtime 300
 ip nhrp nhs 10.0.0.1
 ip tcp adjust-mss 1360
 delay 1000
 tunnel mode gre multipoint
 tunnel source Ethernet0
 tunnel destination 172.17.0.1
 tunnel protection ipsec profile vpnprof

```

Spoke 2:

```

interface Tunnel0
 bandwidth 1000
 ip address 10.0.0.2 255.255.255.0
 ip mtu 1436
 ip nhrp authentication RED!KEY
 ip nhrp map 10.0.0.1 192.0.2.171
 ip nhrp network-id 200000
 ip nhrp holdtime 300
 ip nhrp nhs 10.0.0.1
 ip tcp adjust-mss 1360
 delay 1000
 tunnel source Ethernet0
 tunnel destination 192.0.2.171
 tunnel protection ipsec profile vpnprof!

```

Example 2547oDMVPN with Traffic Segmentation (with BGP only)

The following example show a traffic segmentation configuration in which traffic is segmented between two spokes that serve as provider edge (PE) devices.

Hub Configuration

```

hostname hub-pe1
boot-start-marker
boot-end-marker
no aaa new-model
resource policy
clock timezone EST 0
ip cef
no ip domain lookup
!This section refers to the forwarding table for VRF blue:
ip vrf blue

```

```

rd 2:2
route-target export 2:2
route-target import 2:2
!This section refers to the forwarding table for VRF red:
ip vrf red
rd 1:1
route-target export 1:1
route-target import 1:1
mpls label protocol ldp
crypto isakmp policy 1
authentication pre-share
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-des
mode transport
crypto ipsec profile prof
set transform-set t1
interface Tunnell
ip address 10.9.9.1 255.255.255.0
no ip redirects
ip nhrp authentication cisco
ip nhrp map multicast dynamic
ip nhrp network-id 1
!The command below enables MPLS on the DMVPN network:
mpls ip
tunnel source Ethernet0/0
tunnel mode gre multipoint
tunnel protection ipsec profile prof
interface Loopback0
ip address 10.0.0.1 255.255.255.255
interface Ethernet0/0
ip address 172.0.0.1 255.255.255.0
!The multiprotocol BGP route reflector (the hub) configuration changes the next-hop
information to set itself as the next-hop and assigns a new VPN label for the prefixes
learned from the spokes and advertises the VPN prefix:
router bgp 1
no synchronization
bgp log-neighbor-changes
neighbor 10.0.0.11 remote-as 1
neighbor 10.0.0.11 update-source Tunnell
neighbor 10.0.0.12 remote-as 1
neighbor 10.0.0.12 update-source Tunnell
no auto-summary
address-family vpnv4
neighbor 10.0.0.11 activate
neighbor 10.0.0.11 send-community extended
neighbor 10.0.0.11 route-reflector-client
neighbor 10.0.0.11 route-map NEXTHOP out
neighbor 10.0.0.12 activate
neighbor 10.0.0.12 send-community extended
neighbor 10.0.0.12 route-reflector-client
neighbor 10.0.0.12 route-map NEXTHOP out
exit-address-family
address-family ipv4 vrf red
redistribute connected
no synchronization
exit-address-family
address-family ipv4 vrf blue
redistribute connected
no synchronization
exit-address-family
no ip http server
no ip http secure-server
!In this route map information, the hub sets the next hop to itself, and the VPN prefixes
are advertised:
route-map NEXTHOP permit 10
set ip next-hop 10.0.0.1
control-plane
line con 0
logging synchronous
line aux 0
line vty 0 4
no login
end

```

Spoke Configurations

Spoke 2

```

hostname spoke-pe2
boot-start-marker
boot-end-marker
no aaa new-model
resource policy
clock timezone EST 0
ip cef
no ip domain lookup
!This section refers to the forwarding table for VRF blue:
ip vrf blue
  rd 2:2
  route-target export 2:2
  route-target import 2:2
!This section refers to the forwarding table for VRF red:
ip vrf red
  rd 1:1
  route-target export 1:1
  route-target import 1:1
mpls label protocol ldp
crypto isakmp policy 1
  authentication pre-share
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-des
  mode transport
crypto ipsec profile prof
  set transform-set t1
interface Tunnell
  ip address 10.0.0.11 255.255.255.0
  no ip redirects
  ip nhrp authentication cisco
  ip nhrp map multicast dynamic
  ip nhrp map 10.0.0.1 172.0.0.1
  ip nhrp map multicast 172.0.0.1
  ip nhrp network-id 1
  ip nhrp nhs 10.0.0.1
!The command below enables MPLS on the DMVPN network:
mpls ip
  tunnel source Ethernet0/0
  tunnel mode gre multipoint
  tunnel protection ipsec profile prof
interface Loopback0
  ip address 10.9.9.11 255.255.255.255
interface Ethernet0/0
  ip address 172.0.0.11 255.255.255.0
!
!
interface Ethernet1/0
  ip vrf forwarding red
  ip address 192.168.11.2 255.255.255.0
interface Ethernet2/0
  ip vrf forwarding blue
  ip address 192.168.11.2 255.255.255.0
!The multiprotocol BGP route reflector (the hub) configuration changes the next-hop
information to set itself as the next-hop and assigns a new VPN label for the prefixes
learned from the spokes and advertises the VPN prefix:
router bgp 1
  no synchronization
  bgp log-neighbor-changes
  neighbor 10.0.0.1 remote-as 1
  neighbor 10.0.0.1 update-source Tunnell
  no auto-summary
  address-family vpnv4
  neighbor 10.0.0.1 activate
  neighbor 10.0.0.1 send-community extended
  exit-address-family
!
  address-family ipv4 vrf red
  redistribute connected

```

```

no synchronization
exit-address-family
!
address-family ipv4 vrf blue
redistribute connected
no synchronization
exit-address-family
no ip http server
no ip http secure-server
control-plane
line con 0
  logging synchronous
line aux 0
line vty 0 4
  no login
end

```

Spoke 3

```

hostname spoke-PE3
boot-start-marker
boot-end-marker
no aaa new-model
resource policy
clock timezone EST 0
ip cef
no ip domain lookup
!This section refers to the forwarding table for VRF blue:
ip vrf blue
  rd 2:2
  route-target export 2:2
  route-target import 2:2
!This section refers to the forwarding table for VRF red:
ip vrf red
  rd 1:1
  route-target export 1:1
  route-target import 1:1
mpls label protocol ldp
crypto isakmp policy 1
  authentication pre-share
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-des
  mode transport
crypto ipsec profile prof
  set transform-set t1
interface Tunnell
  ip address 10.0.0.12 255.255.255.0
  no ip redirects
  ip nhrp authentication cisco
  ip nhrp map multicast dynamic
  ip nhrp map 10.0.0.1 172.0.0.1
  ip nhrp map multicast 172.0.0.1
  ip nhrp network-id 1
  ip nhrp nhs 10.0.0.1
!The command below enables MPLS on the DMVPN network:
mpls ip
  tunnel source Ethernet0/0
  tunnel mode gre multipoint
  tunnel protection ipsec profile prof
!
interface Loopback0
  ip address 10.9.9.12 255.255.255.255
interface Ethernet0/0
  ip address 172.0.0.12 255.255.255.0
interface Ethernet1/0
  ip vrf forwarding red
  ip address 192.168.12.2 255.255.255.0
interface Ethernet2/0
  ip vrf forwarding blue
  ip address 192.168.12.2 255.255.255.0
!The multiprotocol BGP route reflector (the hub) configuration changes the next-hop
information to set itself as the next-hop and assigns a new VPN label for the prefixes

```

```

learned from the spokes and advertises the VPN prefix:
router bgp 1
  no synchronization
  bgp log-neighbor-changes
  neighbor 10.0.0.1 remote-as 1
  neighbor 10.0.0.1 update-source Tunnel1
  no auto-summary
  address-family vpnv4
  neighbor 10.0.0.1 activate
  neighbor 10.0.0.1 send-community extended
  exit-address-family
  address-family ipv4 vrf red
  redistribute connected
  no synchronization
  exit-address-family
  address-family ipv4 vrf blue
  redistribute connected
  no synchronization
  exit-address-family
no ip http server
no ip http secure-server
control-plane
line con 0
  logging synchronous
line aux 0
line vty 0 4
  no login
end

```

Example 2547oDMVPN with Traffic Segmentation (Enterprise Branch)

The following example shows a configuration for segmenting traffic between two spokes located at branch offices of an enterprise. In this example, EIGRP is configured to learn routes to reach BGP neighbors within the DMVPN.

Hub Configuration

```

hostname HUB
boot-start-marker
boot-end-marker
no aaa new-model
resource policy
clock timezone EST 0
ip cef
no ip domain lookup
!This section refers to the forwarding table for VRF blue:
ip vrf blue
  rd 2:2
  route-target export 2:2
  route-target import 2:2
!This refers to the forwarding table for VRF red:
ip vrf red
  rd 1:1
  route-target export 1:1
  route-target import 1:1
mpls label protocol ldp
crypto isakmp policy 1
  authentication pre-share
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-des
  mode transport
crypto ipsec profile prof
  set transform-set t1
interface Tunnel1
  ip address 10.0.0.1 255.255.255.0
  no ip redirects
  ip nhrp authentication cisco
  ip nhrp map multicast dynamic
  ip nhrp network-id 1

```

```

!EIGRP is enabled on the DMVPN network to learn the IGP prefixes:
no ip split-horizon eigrp 1
!The command below enables MPLS on the DMVPN network:
mpls ip
tunnel source Ethernet0/0
tunnel mode gre multipoint
tunnel protection ipsec profile prof
!This address is advertised by EIGRP and used as the BGP endpoint:
interface Loopback0
 ip address 10.9.9.1 255.255.255.255
interface Ethernet0/0
 ip address 172.0.0.1 255.255.255.0
!EIGRP is configured to learn the BGP peer addresses (10.9.9.x networks)
router eigrp 1
 network 10.9.9.1 0.0.0.0
 network 10.0.0.0 0.0.0.255
 no auto-summary
!The multiprotocol BGP route reflector (the hub) configuration changes the next-hop
information to set itself as the next-hop and assigns a new VPN label for the prefixes
learned from the spokes and advertises the VPN prefix:
router bgp 1
 no synchronization
 bgp router-id 10.9.9.1
 bgp log-neighbor-changes
 neighbor 10.9.9.11 remote-as 1
 neighbor 10.9.9.11 update-source Loopback0
 neighbor 10.9.9.12 remote-as 1
 neighbor 10.9.9.12 update-source Loopback0
 no auto-summary
 address-family vpnv4
 neighbor 10.9.9.11 activate
 neighbor 10.9.9.11 send-community extended
 neighbor 10.9.9.11 route-reflector-client
 neighbor 10.9.9.12 activate
 neighbor 10.9.9.12 send-community extended
 neighbor 10.9.9.12 route-reflector-client
 exit-address-family
 address-family ipv4 vrf red
 redistribute connected
 no synchronization
 exit-address-family
 address-family ipv4 vrf blue
 redistribute connected
 no synchronization
 exit-address-family
 no ip http server
 no ip http secure-server
 control-plane
 line con 0
 logging synchronous
 line aux 0
 line vty 0 4
 no login
 end

```

Spoke Configurations

Spoke 2

```

hostname Spoke2
boot-start-marker
boot-end-marker
no aaa new-model
resource policy
clock timezone EST 0
ip cef
no ip domain lookup
!This section refers to the forwarding table for VRF blue:
ip vrf blue
 rd 2:2
 route-target export 2:2

```



```

route-target import 2:2
!This section refers to the forwarding table for VRF red:
ip vrf red
  rd 1:1
  route-target export 1:1
  route-target import 1:1
mpls label protocol ldp
crypto isakmp policy 1
  authentication pre-share
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-des
  mode transport
crypto ipsec profile prof
  set transform-set t1
interface Tunnell
  ip address 10.0.0.11 255.255.255.0
  no ip redirects
  ip nhrp authentication cisco
  ip nhrp map multicast dynamic
  ip nhrp map 10.0.0.1 172.0.0.1
  ip nhrp map multicast 172.0.0.1
  ip nhrp network-id 1
  ip nhrp nhs 10.0.0.1
!The command below enables MPLS on the DMVPN network:
mpls ip
  tunnel source Ethernet0/0
  tunnel mode gre multipoint
  tunnel protection ipsec profile prof
!This address is advertised by EIGRP and used as the BGP endpoint:
interface Loopback0
  ip address 10.9.9.11 255.255.255.255
interface Ethernet0/0
  ip address 172.0.0.11 255.255.255.0
interface Ethernet1/0
  ip vrf forwarding red
  ip address 192.168.11.2 255.255.255.0
interface Ethernet2/0
  ip vrf forwarding blue
  ip address 192.168.11.2 255.255.255.0
!EIGRP is enabled on the DMVPN network to learn the IGP prefixes:
router eigrp 1
  network 10.9.9.11 0.0.0.0
  network 10.0.0.0 0.0.0.255
  no auto-summary
!The multiprotocol BGP route reflector (the hub) configuration changes the next-hop
information to set itself as the next-hop and assigns a new VPN label for the prefixes
learned from the spokes and advertises the VPN prefix:
router bgp 1
  no synchronization
  bgp router-id 10.9.9.11
  bgp log-neighbor-changes
  neighbor 10.9.9.1 remote-as 1
  neighbor 10.9.9.1 update-source Loopback0
  no auto-summary
  address-family vpnv4
  neighbor 10.9.9.1 activate
  neighbor 10.9.9.1 send-community extended
  exit-address-family
  address-family ipv4 vrf red
  redistribute connected
  no synchronization
  exit-address-family
  address-family ipv4 vrf blue
  redistribute connected
  no synchronization
  exit-address-family
no ip http server
no ip http secure-server
control-plane
line con 0
  logging synchronous
line aux 0
line vty 0 4

```

```
no login
end
```

Spoke 3

```
hostname Spoke3
boot-start-marker
boot-end-marker
no aaa new-model
resource policy
clock timezone EST 0
ip cef
no ip domain lookup
!This section refers to the forwarding table for VRF blue:
ip vrf blue
  rd 2:2
  route-target export 2:2
  route-target import 2:2
!This section refers to the forwarding table for VRF red:
ip vrf red
  rd 1:1
  route-target export 1:1
  route-target import 1:1
mpls label protocol ldp
crypto isakmp policy 1
  authentication pre-share
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-des
  mode transport
crypto ipsec profile prof
  set transform-set t1
interface Tunnell
  ip address 10.0.0.12 255.255.255.0
  no ip redirects
  ip nhrp authentication cisco
  ip nhrp map multicast dynamic
  ip nhrp map 10.0.0.1 172.0.0.1
  ip nhrp map multicast 172.0.0.1
  ip nhrp network-id 1
  ip nhrp nhs 10.0.0.1
!The command below enables MPLS on the DMVPN network:
mpls ip
  tunnel source Ethernet0/0
  tunnel mode gre multipoint
  tunnel protection ipsec profile prof
!This address is advertised by EIGRP and used as the BGP endpoint:
interface Loopback0
  ip address 10.9.9.12 255.255.255.255
interface Ethernet0/0
  ip address 172.0.0.12 255.255.255.0
interface Ethernet1/0
  ip vrf forwarding red
  ip address 192.168.12.2 255.255.255.0
interface Ethernet2/0
  ip vrf forwarding blue
  ip address 192.168.12.2 255.255.255.0
!EIGRP is enabled on the DMVPN network to learn the IGP prefixes:
router eigrp 1
  network 10.9.9.12 0.0.0.0
  network 10.0.0.0 0.0.0.255
  no auto-summary
!The multiprotocol BGP route reflector (the hub) configuration changes the next-hop
information to set itself as the next-hop and assigns a new VPN label for the prefixes
learned from the spokes and advertises the VPN prefix:
router bgp 1
  no synchronization
  bgp router-id 10.9.9.12
  bgp log-neighbor-changes
  neighbor 10.9.9.1 remote-as 1
  neighbor 10.9.9.1 update-source Loopback0
  no auto-summary
  address-family vpnv4
```

```

neighbor 10.9.9.1 activate
neighbor 10.9.9.1 send-community extended
exit-address-family
address-family ipv4 vrf red
redistribute connected
no synchronization
exit-address-family
address-family ipv4 vrf blue
redistribute connected
no synchronization
exit-address-family
no ip http server
no ip http secure-server
control-plane
line con 0
  logging synchronous
line aux 0
line vty 0 4
  no login
end

```

Sample Command Output: show mpls ldp bindings

```

Spoke2# show mpls ldp bindings
tib entry: 10.9.9.1/32, rev 8
  local binding: tag: 16
  remote binding: tsr: 10.9.9.1:0, tag: imp-null
tib entry: 10.9.9.11/32, rev 4
  local binding: tag: imp-null
  remote binding: tsr: 10.9.9.1:0, tag: 16
tib entry: 10.9.9.12/32, rev 10
  local binding: tag: 17
  remote binding: tsr: 10.9.9.1:0, tag: 17
tib entry: 10.0.0.0/24, rev 6
  local binding: tag: imp-null
  remote binding: tsr: 10.9.9.1:0, tag: imp-null
tib entry: 172.0.0.0/24, rev 3
  local binding: tag: imp-null
  remote binding: tsr: 10.9.9.1:0, tag: imp-null
Spoke2#

```

Sample Command Output: show mpls forwarding-table

```

Spoke2# show mpls forwarding-table

Local   Outgoing   Prefix           Bytes tag   Outgoing   Next Hop
tag     tag or VC  or Tunnel Id     switched   interface
16      Pop tag    10.9.9.1/32      0          Tu1        10.0.0.1
17      17         10.9.9.12/32     0          Tu1        10.0.0.1
18      Aggregate 192.168.11.0/24[V] \
0
19      Aggregate 192.168.11.0/24[V] \
0
Spoke2#

```

Sample Command Output: show ip route vrf red

```

Spoke2# show ip route vrf red
Routing Table: red
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is not set
B       192.168.12.0/24 [200/0] via 10.9.9.12, 00:00:02

```

```
C 192.168.11.0/24 is directly connected, Ethernet1/0
Spoke2#
```

Sample Command Output: show ip route vrf blue

```
Spoke2# show ip route vrf blue
Routing Table: blue
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is not set
B 192.168.12.0/24 [200/0] via 10.9.9.12, 00:00:08
C 192.168.11.0/24 is directly connected, Ethernet2/0
Spoke2#
Spoke2# show ip cef vrf red 192.168.12.0
192.168.12.0/24, version 5, epoch 0
0 packets, 0 bytes
 tag information set
   local tag: VPN-route-head
   fast tag rewrite with Tu1, 10.0.0.1, tags imposed: {17 18}
 via 10.9.9.12, 0 dependencies, recursive
   next hop 10.0.0.1, Tunnell via 10.9.9.12/32
   valid adjacency
   tag rewrite with Tu1, 10.0.0.1, tags imposed: {17 18}
Spoke2#
```

Sample Command Output: show ip bgp neighbors

```
Spoke2# show ip bgp neighbors

BGP neighbor is 10.9.9.1, remote AS 1, internal link
  BGP version 4, remote router ID 10.9.9.1
  BGP state = Established, up for 00:02:09
  Last read 00:00:08, last write 00:00:08, hold time is 180, keepalive interval is 60
seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                Sent          Rcvd
Opens:           1             1
Notifications:  0             0
Updates:         4             4
Keepalives:      4             4
Route Refresh:   0             0
Total:           9             9
  Default minimum time between advertisement runs is 0 seconds
  For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1/0
  Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member

                Sent          Rcvd
Prefix activity: ----          ----
Prefixes Current:    0             0
Prefixes Total:      0             0
Implicit Withdraw:   0             0
Explicit Withdraw:   0             0
Used as bestpath:    n/a           0
Used as multipath:   n/a           0
                   Outbound      Inbound
Local Policy Denied Prefixes: -----
Total:                0             0
```

```

Number of NLRIs in the update sent: max 0, min 0
For address family: VPNv4 Unicast
  BGP table version 9, neighbor version 9/0
Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member

Prefix activity:
  Prefixes Current:      2      2 (Consumes 136 bytes)
  Prefixes Total:       4      2
  Implicit Withdraw:    2      0
  Explicit Withdraw:    0      0
  Used as bestpath:     n/a     2
  Used as multipath:    n/a     0
                                Outbound  Inbound
Local Policy Denied Prefixes:
  ORIGINATOR loop:      n/a      2
  Bestpath from this peer: 4      n/a
  Total:                4      2
Number of NLRIs in the update sent: max 1, min 1
Connections established 1; dropped 0
Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled
Local host: 10.9.9.11, Local port: 179
Foreign host: 10.9.9.1, Foreign port: 12365
Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)
Event Timers (current time is 0x2D0F0):
Timer      Starts    Wakeups      Next
Retrans     6         0            0x0
TimeWait    0         0            0x0
AckHold     7         3            0x0
SendWnd     0         0            0x0
KeepAlive   0         0            0x0
GiveUp      0         0            0x0
PmtuAger    0         0            0x0
DeadWait    0         0            0x0
iss: 3328307266  snduna: 3328307756  sndnxt: 3328307756  sndwnd: 15895
irs: 4023050141  rcvnxt: 4023050687  rcvwnd: 16384  delrcvwnd: 0
SRTT: 165 ms, RTTO: 1457 ms, RTV: 1292 ms, KRTT: 0 ms
minRTT: 0 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs
IP Precedence value : 6
Datagrams (max data segment is 536 bytes):
Rcvd: 13 (out of order: 0), with data: 7, total data bytes: 545
Sent: 11 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with
data: 6, total data bytes: 489
Spoke2#

```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
Call Admission Control	Call Admission Control for IKE
GRE tunnel keepalive information	Generic Routing Encapsulation (GRE) Tunnel Keepalive, Cisco IOS Release 12.2(8)T

Related Topic	Document Title
IKE configuration tasks such as defining an IKE policy	The chapter “Configuring Internet Key Exchange for IPsec VPNs” in the Cisco IOS Security Configuration Guide: <i>Secure Connectivity</i>
IPsec configuration tasks	The chapter “Configuring Security for VPNs with IPsec” in the Cisco IOS Security Configuration Guide: <i>Secure Connectivity</i>
Configuring VRF-Aware IPsec	The chapter “VRF-Aware IPsec” in the Cisco IOS Security Configuration Guide: <i>Secure Connectivity</i>
Configuring MPLS	The chapter “Configuring Multiprotocol Label Switching” in the Cisco IOS Multiprotocol Label Switching Configuration Guide
Configuring BGP	The chapter “Cisco BGP Overview” in the <i>Cisco IOS IP Routing: BGP Protocols Configuration Guide</i>
System messages	System Message Guide
Defining and configuring ISAKMP profiles	“Certificate to ISAKMP Profile Mapping” chapter in the <i>Cisco IOS Security Configuration Guide: Secure Connectivity</i>

Standards

Standards	Title
None	--

MIBs

MIBs	MIBs Link
None	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

RFCs	Title
RFC 2547	BGP/MPLS VPNs

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Dynamic Multipoint VPN (DMVPN)

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 1 Feature Information for Dynamic Multipoint VPN (DMVPN)

Feature Name	Releases	Feature Information
DMVPN--Enabling Traffic Segmentation Within DMVPN	12.4(11)T	The 2547oDMVPN feature allows users to segment VPN traffic within a DMVPN tunnel by applying MPLS labels to VRF instances to indicate the source and destination of each VRF.

Feature Name	Releases	Feature Information
Manageability Enhancements for DMVPN	12.4(9)T	<p>DMVPN session manageability was expanded with DMVPN specific commands for debugging, show output, session and counter control, and system log information.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • Troubleshooting Dynamic Multipoint VPN (DMVPN) <p>The following commands were introduced or modified by this feature: clear dmvpn session, clear dmvpn statistics, debug dmvpn, debug nhrp condition, debug nhrp error, logging dmvpn, show dmvpn, show ip nhrp traffic.</p>
DMVPN Phase 2	12.2(18)SXE 12.3(9)a 12.3(8)T1	<p>DMVPN Spoke-to-Spoke functionality was made more production ready. If you are using this functionality in a production network, the minimum release is Release 12.3(9a) or Release 12.3(8)T1.</p> <p>In Release 12.2(18)SXE, support was added for the Cisco Catalyst 6500 series switch and the Cisco 7600 series router.</p>

Feature Name	Releases	Feature Information
--	12.3(6) 12.3(7)T	<p>Virtual Route Forwarding Integrated DMVPN and Network Address Translation-Transparency (NAT-T) Aware DMVPN enhancements were added. In addition, DMVPN Hub-to-Spoke functionality was made more production ready. If you are using this functionality in a production network, the minimum release requirement is Cisco IOS Release 12.3(6) or 12.3(7)T.</p> <p>The enhancements added in Cisco IOS Release 12.3(6) were integrated into Cisco IOS Release 12.3(7)T.</p>
Dynamic Multipoint VPN (DMVPN) Phase 1	12.2(13)T	<p>The Dynamic Multipoint VPN (DMVPN) feature allows users to better scale large and small IPsec Virtual Private Networks (VPNs) by combining generic routing encapsulation (GRE) tunnels, IP security (IPsec) encryption, and Next Hop Resolution Protocol (NHRP).</p>

Glossary

AM --aggressive mode. A mode during IKE negotiation. Compared to MM, AM eliminates several steps, making it faster but less secure than MM. Cisco IOS software will respond in aggressive mode to an IKE peer that initiates aggressive mode.

GRE --generic routing encapsulation. Tunnels that provide a specific pathway across the shared WAN and encapsulate traffic with new packet headers to ensure delivery to specific destinations. The network is private because traffic can enter a tunnel only at an endpoint. Tunnels do not provide true confidentiality (encryption does) but can carry encrypted traffic.

GRE tunneling can also be used to encapsulate non-IP traffic into IP and send it over the Internet or IP network. The Internet Package Exchange (IPX) and AppleTalk protocols are examples of non-IP traffic.

IKE --Internet Key Exchange. A hybrid protocol that implements Oakley key exchange and Skeme key exchange inside the ISAKMP framework. Although IKE can be used with other protocols, its initial implementation is with IPsec. IKE provides authentication of the IPsec peers, negotiates IPsec keys, and negotiates IPsec security associations.

IPsec --IP security. A framework of open standards developed by the Internet Engineering Task Force (IETF). IPsec provides security for transmission of sensitive information over unprotected networks such as

the Internet. IPsec acts at the network layer, protecting and authenticating IP packets between participating IPsec devices (“peers”), such as Cisco routers.

ISAKMP --Internet Security Association Key Management Protocol. A protocol framework that defines payload formats, the mechanics of implementing a key exchange protocol, and the negotiation of a security association.

MM --main mode. Mode that is slower than aggressive mode but more secure and more flexible than aggressive mode because it can offer an IKE peer more security proposals. The default action for IKE authentication (rsa-sig, rsa-encr, or preshared) is to initiate main mode.

NHRP --Next Hop Resolution Protocol. Routers, access servers, and hosts can use NHRP to discover the addresses of other routers and hosts connected to a NBMA network.

The Cisco implementation of NHRP supports the IETF draft version 11 of NBMA Next Hop Resolution Protocol (NHRP).

The Cisco implementation of NHRP supports IP Version 4, Internet Packet Exchange (IPX) network layers, and, at the link layer, ATM, Ethernet, SMDS, and multipoint tunnel networks. Although NHRP is available on Ethernet, NHRP need not be implemented over Ethernet media because Ethernet is capable of broadcasting. Ethernet support is unnecessary (and not provided) for IPX.

PFS --Perfect Forward Secrecy. A cryptographic characteristic associated with a derived shared secret value. With PFS, if one key is compromised, previous and subsequent keys are not compromised, because subsequent keys are not derived from previous keys.

SA --security association. Describes how two or more entities will utilize security services to communicate securely. For example, an IPsec SA defines the encryption algorithm (if used), the authentication algorithm, and the shared session key to be used during the IPsec connection.

Both IPsec and IKE require and use SAs to identify the parameters of their connections. IKE can negotiate and establish its own SA. The IPsec SA is established either by IKE or by manual user configuration.

transform --The list of operations done on a dataflow to provide data authentication, data confidentiality, and data compression. For example, one transform is the ESP protocol with the HMAC-MD5 authentication algorithm; another transform is the AH protocol with the 56-bit DES encryption algorithm and the ESP protocol with the HMAC-SHA authentication algorithm.

VPN --Virtual Private Network. A framework that consists of multiple peers transmitting private data securely to one another over an otherwise public infrastructure. In this framework, inbound and outbound network traffic is protected using protocols that tunnel and encrypt all data. This framework permits networks to extend beyond their local topology, while remote users are provided with the appearance and functionality of a direct network connection.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: www.cisco.com/go/trademarks. Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.

© 2012 Cisco Systems, Inc. All rights reserved.