Dynamic Multipoint VPN Configuration Guide, Cisco IOS Release 15S

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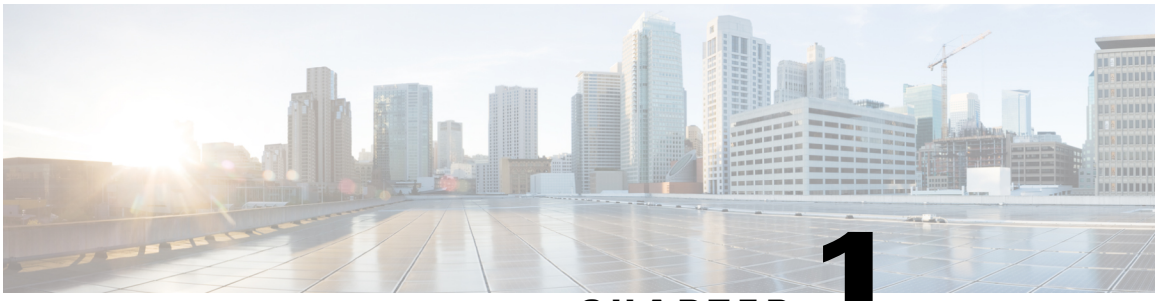


CHAPTER 1

Dynamic Multipoint VPN

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).

Note Security threats, as well as the cryptographic technologies to help protect against them, are constantly changing. For more information about the latest Cisco cryptographic recommendations, see the Next Generation Encryption (NGE) white paper.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and 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.

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 [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

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-recir**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)

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)

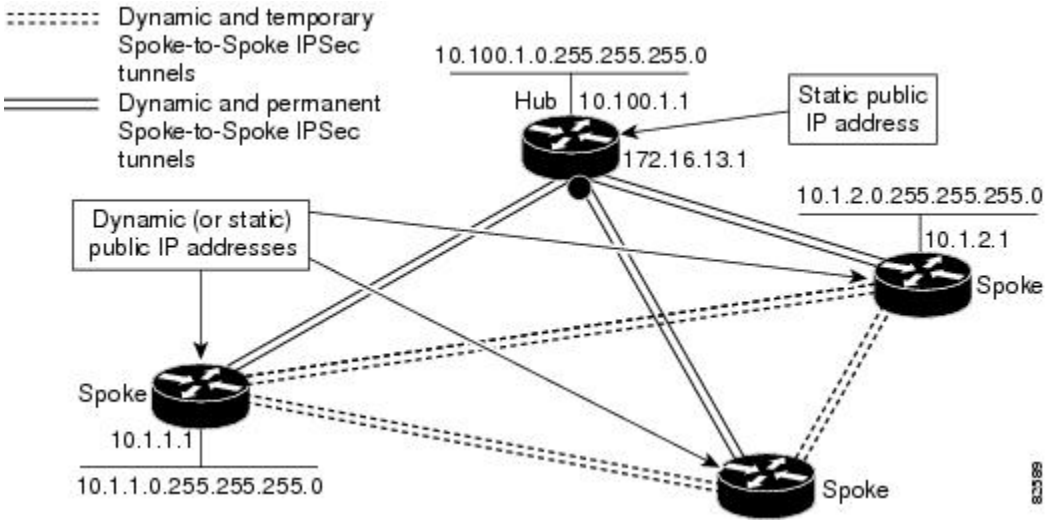
The Dynamic Multipoint VPN (DMVPN) feature combines GRE tunnels, IPsec encryption, and NHRP routing to provide users an ease of configuration via crypto profiles--which override the requirement for defining static crypto maps--and dynamic discovery of tunnel endpoints.

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.

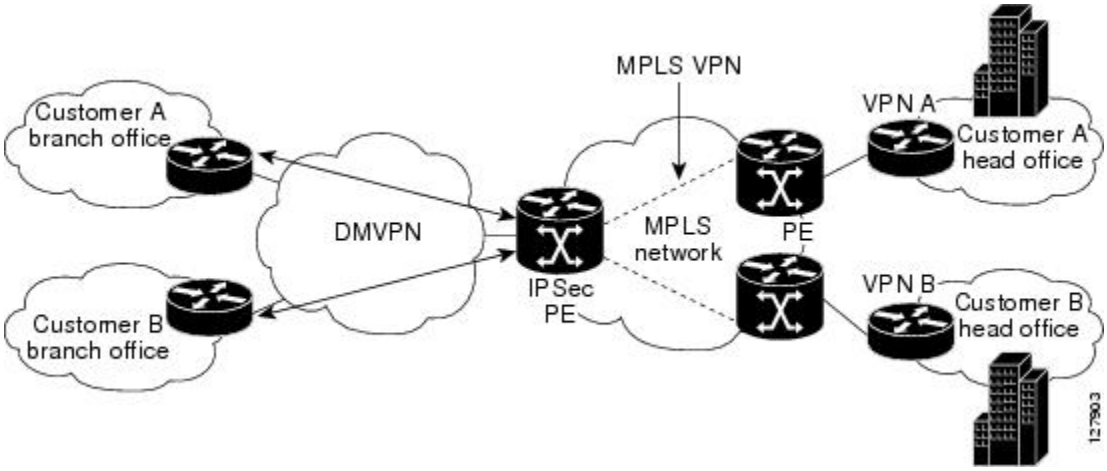
For information about configuring the forwarding of clear-text data IP packets into a VRF, see the section "Configuring the Forwarding of Clear-Text Data IP Packets into a VRF." For information about configuring

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

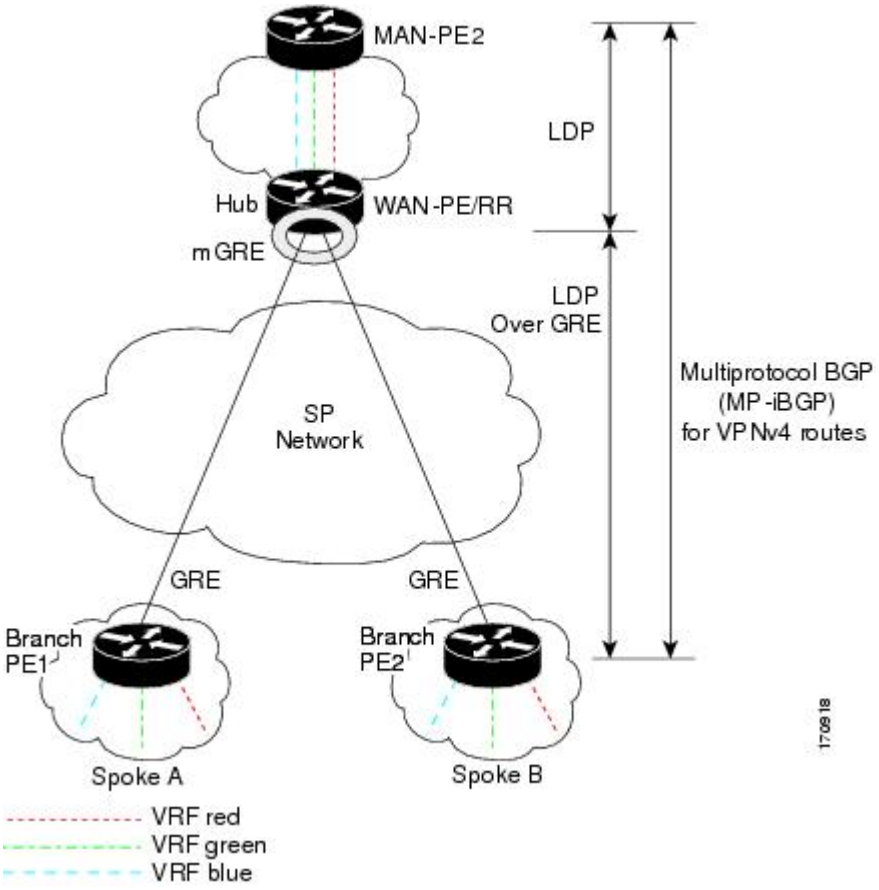


DMVPN--Enabling Traffic Segmentation Within DMVPN

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.

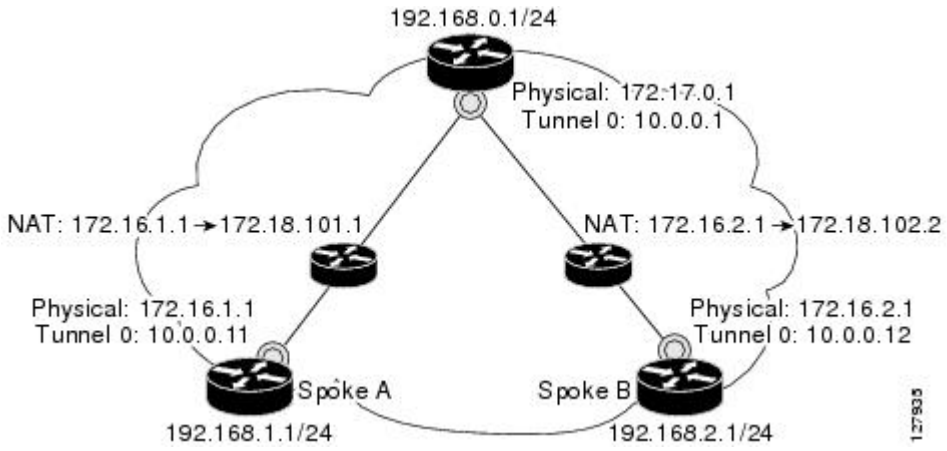
Also added in Cisco IOS Releases 12.3(9a) and 12.3(11)T is the capability to have the hub DMVPN router behind static NAT. This was a change in the ISAKMP NAT-T support. For this functionality to be used, all the DMVPN spoke routers and hub routers must be upgraded, and IPsec must use transport mode.

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 preforming 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

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.

Note Security threats, as well as the cryptographic technologies to help protect against them, are constantly changing. For more information about the latest Cisco cryptographic recommendations, see the Next Generation Encryption (NGE) white paper.

Before You Begin

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** | **group14** | **group15** | **group16** | **group19** | **group2** | **group20** | **group24** | **group5**]

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	**crypto ipsec profile** *name*
	
	Example:
	
	`Router(config)#`
	`crypto ipsec profile vpnprof`
		Defines the IPsec parameters that are to be used for IPsec encryption between “spoke and hub” and “spoke and spoke” routers.
		
		This command enters crypto map configuration mode.
		
		• The *name* argument specifies the name of the IPsec profile.

Step 4	**set transform-set** *transform-set-name*
	
	Example:
	
	`Router(config-crypto-map)# set`
	`transform-set trans2`
		Specifies which transform sets can be used with the IPsec profile.
		
		• The *transform-set-name* argument specifies the name of the transform set.

Step 5	**set identity**
	
	Example:
	
	`Router(config-crypto-map)# set`
	`identity`
		(Optional) Specifies identity restrictions to be used with the IPsec profile.

Step 6	**set security association lifetime** {**seconds** *seconds* | **kilobytes** *kilobytes*}
	
	Example:
	
	`Router(config-crypto-map)# set`
	`security association lifetime seconds`
	`1800`
		(Optional) Overrides the global lifetime value for the IPsec profile.
		
		• The **seconds** *seconds* option specifies the number of seconds a security association will live before expiring; the **kilobytes** *kilobytes*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 *seconds* argument is 3600 seconds.

Step 7	**set pfs** [**group1** | **group14** | **group15** | **group16** | **group19** | **group2** | **group20** | **group24** | **group5**]
	
	Example:
	
	`Router(config-crypto-map)# set pfs`
	`group14`
		(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 Diffie-Hellman (DH) group, **group1** will be enabled.
		
		• **1—**768-bit DH (No longer recommended.)
		
		• **2—**1024-bit DH (No longer recommended)

	Command or Action	Purpose
		• **5—**1536-bit DH (No longer recommended) • **14—**Specifies the 2048-bit DH group. • **15—**Specifies the 3072-bit DH group. • **16—**Specifies the 4096-bit DH group. • **19—**Specifies the 256-bit elliptic curve DH (ECDH) group. • **20—**Specifies the 384-bit ECDH group. • **24—**Specifies the 2048-bit DH/DSA group.

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	**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 tunnel** *number* **Example:** `Router(config)# interface tunnel 5`	Configures a tunnel interface and enters interface configuration mode • The *number* 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	**ip address** *ip-address mask* *secondary* **Example:** `Router(config-if)# ip address 10.0.0.1 255.255.255.0`	Sets a primary or secondary IP address for the tunnel interface. **Note** All hubs and spokes that are in the same DMVPN network must be addressed in the same IP subnet.

	Command or Action	Purpose
Step 5	**ip mtu** *bytes* **Example:** `Router(config-if)# ip mtu 1400`	Sets the maximum transmission unit (MTU) size, in bytes, of IP packets sent on an interface.
Step 6	**ip nhrp authentication** *string* **Example:** `Router(config-if)# ip nhrp authentication donttell`	Configures the authentication string for an interface using NHRP. **Note** The NHRP authentication string must be set to the same value on all hubs and spokes that are in the same DMVPN network.
Step 7	**ip nhrp map multicast dynamic** **Example:** `Router(config-if)# ip nhrp map multicast dynamic`	Allows NHRP to automatically add spoke routers to the multicast NHRP mappings.
Step 8	**ip nhrp network-id** *number* **Example:** `Router(config-if)# ip nhrp network-id 99`	Enables NHRP on an interface. • The *number* argument specifies a globally unique 32-bit network identifier from a nonbroadcast multiaccess (NBMA) network. The range is from 1 to 4294967295.
Step 9	**tunnel source** {*ip-address* | *type number*} **Example:** `Router (config-if)# tunnel source Ethernet0`	Sets source address for a tunnel interface.
Step 10	**tunnel key** *key-number* **Example:** `Router (config-if)# tunnel key 100000`	(Optional) Enables an ID key for a tunnel interface. • The *key-number* argument specifies a number from 0 to 4,294,967,295 that identifies the tunnel key. **Note** The key number must be set to the same value on all hubs and spokes that are in the same DMVPN network. **Note** This command should not be configured if you are using a Cisco 6500 or Cisco 7600 platform.
Step 11	**tunnel mode gre multipoint** **Example:** `Router(config-if)# tunnel mode gre multipoint`	Sets the encapsulation mode to mGRE for the tunnel interface.
Step 12	**tunnel protection ipsec profile** *name*	Associates a tunnel interface with an IPsec profile.

	Command or Action	Purpose
	Example: `Router(config-if)# tunnel protection ipsec profile vpnprof`	• The *name* argument specifies the name of the IPsec profile; this value must match the *name* specified in the **crypto ipsec profile** *name*command.
Step 13	**bandwidth** *kbps* **Example:** `Router(config-if)# bandwidth 1000`	Sets the current bandwidth value for an interface to higher-level protocols. • The *kbps* argument specifies the bandwidth in kilobits per second. The default value is 9. The recommend bandwidth value is 1000 or greater. 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.
Step 14	**ip tcp adjust-mss** *max-segment-size* **Example:** `Router(config-if)# ip tcp adjust-mss 1360`	Adjusts the maximum segment size (MSS) value of TCP packets going through a router. • The *max-segment-size* argument specifies the maximum segment size, in bytes. The range is from 500 to 1460. 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.
Step 15	**ip nhrp holdtime** *seconds* **Example:** `Router(config-if)# ip nhrp holdtime 450`	Changes the number of seconds that NHRP NBMA addresses are advertised as valid in authoritative NHRP responses. • The *seconds* 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.
Step 16	**delay** *number* **Example:** `Router(config-if)# delay 1000`	(Optional) Used to change the EIGRP routing metric for routes learned over the tunnel interface. • The *number* 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	**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.

	Command or Action	Purpose
Step 3	**interface tunnel** *number* **Example:** `Router(config)# interface tunnel 5`	Configures a tunnel interface and enters interface configuration mode. • The *number* 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	**ip address** *ip-address mask secondary* **Example:** `Router(config-if)# ip address 10.0.0.2 255.255.255.0`	Sets a primary or secondary IP address for the tunnel interface. **Note** All hubs and spokes that are in the same DMVPN network must be addressed in the same IP subnet.
Step 5	**ip mtu** *bytes* **Example:** `Router(config-if)# ip mtu 1400`	Sets the MTU size, in bytes, of IP packets sent on an interface.
Step 6	**ip nhrp authentication** *string* **Example:** `Router(config-if)# ip nhrp authentication donttell`	Configures the authentication string for an interface using NHRP. **Note** The NHRP authentication string be set to the same value on all hubs and spokes that are in the same DMVPN network.
Step 7	ip nhrp map *hub-tunnel-ip-address hub-physical-ip-address* **Example:** `Router(config-if)# ip nhrp map 10.0.0.1 172.17.0.1`	Statically configures the IP-to-NBMA address mapping of IP destinations connected to an MBMA network. • *hub-tunnel-ip-address* --Defines the NHRP server at the hub, which is permanently mapped to the static public IP address of the hub. • *hub-physical-ip-address* --Defines the static public IP address of the hub.
Step 8	**ip nhrp map multicast** *hub-physical-ip-address* **Example:** `Router(config-if)# ip nhrp map multicast 172.17.0.1`	Enables the use of a dynamic routing protocol between the spoke and hub, and sends multicast packets to the hub router.
Step 9	**ip nhrp nhs** *hub-tunnel-ip-address* **Example:** `Router(config-if)# ip nhrp nhs 10.0.0.1`	Configures the hub router as the NHRP next-hop server.
Step 10	**ip nhrp network-id** *number*	Enables NHRP on an interface.

	Command or Action	Purpose
	Example: `Router(config-if)# ip nhrp network-id 99`	• The *number* argument specifies a globally unique 32-bit network identifier from a NBMA network. The range is from 1 to 4294967295.
Step 11	**tunnel source** {*ip-address* | *type number*} **Example:** `Router (config-if)# tunnel source Ethernet0`	Sets the source address for a tunnel interface.
Step 12	**tunnel key** *key-number* **Example:** `Router (config-if)# tunnel key 100000`	(Optional) Enables an ID key for a tunnel interface. • The *key-number* 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. **Note** This command should not be configured if you are using a Cisco 6500 or Cisco 7600 platform.

Step 13	Do one of the following:
	• **tunnel mode gre multipoint**
	• **tunnel destination** *hub-physical-ip-address*
	Example:
	`Router(config-if)# tunnel mode gre multipoint`
	Example:
	`Router(config-if)# tunnel destination 172.17.0.1`
		Sets the encapsulation mode to mGRE for the tunnel interface.
		Use this command if data traffic can use dynamic spoke-to-spoke traffic.
		Specifies the destination for a tunnel interface.
		Use this command if data traffic can use hub-and-spoke tunnels.

Step 14	**tunnel protection ipsec profile** *name* **Example:** `Router(config-if)# tunnel protection ipsec profile vpnprof`	Associates a tunnel interface with an IPsec profile. • The *name* argument specifies the name of the IPsec profile; this value must match the *name* specified in the **crypto ipsec profile** *name*command.
Step 15	**bandwidth** *kbps*	Sets the current bandwidth value for an interface to higher-level protocols.

	Command or Action	Purpose
	Example: `Router(config-if)# bandwidth 1000`	• The *kbps* argument specifies the bandwidth in kilobits per second. The default value is 9. The recommend bandwidth value is 1000 or greater. 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.
Step 16	**ip tcp adjust-mss** *max-segment-size* **Example:** `Router(config-if)# ip tcp adjust-mss 1360`	Adjusts the maximum segment size (MSS) value of TCP packets going through a router. • The *max-segment-size* argument specifies the maximum segment size, in bytes. The range is from 500 to 1460. 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.
Step 17	**ip nhrp holdtime** *seconds* **Example:** `Router(config-if)# ip nhrp holdtime 450`	Changes the number of seconds that NHRP NBMA addresses are advertised as valid in authoritative NHRP responses. • The *seconds* 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.
Step 18	**delay** *number* **Example:** `Router(config-if)# delay 1000`	(Optional) Used to change the EIGRP routing metric for routes learned over the tunnel interface. • The *number* 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 date 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	**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 *type number* **Example:** `Router (config)# interface tunnel0`	Configures an interface type and enters interface configuration mode.
Step 4	**ip vrf forwarding** *vrf-name* **Example:** `Router (config-if)# ip vrf forwarding BLUE`	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 *type number* **Example:** `Router (config)# interface tunnel0`	Configures an interface type and enters interface configuration mode.
Step 4	**tunnel vrf** *vrf-name* **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

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 *type number* **Example:** `Router (config)# interface tunnel0`	Configures an interface type and enters interface configuration mode.
Step 4	**mpls ip** **Example:** `Router (config-if)# mpls ip`	Enables MPLS tagging of packets on the specified tunnel interface.

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
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	**router bgp** **Example:** `Router (config)# router bgp`	Enters BGP configuration mode.
Step 4	**neighbor** *ipaddress* **remote-as** *as* **-** *number* **Example:** `Router (config)# neighbor 10.0.0.11 remote-as 1`	Adds an entry to the BGP or multiprotocol BGP neighbor table.

	Command or Action	Purpose
Step 5	**neighbor** *ipaddress* **update-source** *interface* **Example:** `Router (config)# neighbor 10.10.10.11 update-source Tunnel1`	Configures the Cisco IOS software to allow BGP sessions to use any operational interface for TCP connections.
Step 6	**address-family vpnv4** **Example:** `Router (config)# address-family vpnv4`	Enters address family configuration mode to configure a routing session using Virtual Private Network (VPN) Version 4 address prefixes.
Step 7	**neighbor** *ipaddress* **activate** **Example:** `Router (config)# neighbor 10.0.0.11 activate`	Enables the exchange of information with a BGP neighbor.
Step 8	**neighbor** *ipaddress* **send-community extended** **Example:** `Router (config)# neighbor 10.0.0.11 send-community extended`	Specifies that extended community attributes should be sent to a BGP neighbor.
Step 9	**neighbor** *ipaddress* **route-reflector-client** **Example:** `Router (config)# neighbor 10.0.0.11 route-reflector-client`	Configures the router as a BGP route reflector and configures the specified neighbor as its client.
Step 10	**neighbor** *ipaddress* **route-map nexthop out** **Example:** `Router (config)# neighbor 10.0.0.11 route-map nexthop out`	Forces all traffic to be routed via the hub.
Step 11	**exit-address-family** **Example:** `Router (config)# exit-address-family`	Exits the address family configuration mode for VPNv4.
Step 12	**address-family ipv4** *vrf-name* **Example:** `Router (config)# address-family ipv4 vrf red`	Enters address family configuration mode to configure a routing session using standard IP Version 4 address prefixes.

	Command or Action	Purpose
Step 13	**redistribute connected** **Example:** `Router (config)# redistribute connected`	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:** `Router (config)# route-map nexthop permit 10`	Enters route map configuration mode to configure the next-hop that will be advertised to the spokes.
Step 15	**set ip next-hop** *ipaddress* **Example:** `Router (config)# set ip next-hop 10.0.0.1`	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 vpnv4**
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. • 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** *ipaddress* **remote-as** *as* **-** *number* **Example:** `Router (config)# neighbor 10.0.0.1 remote-as 1`	Adds an entry to the BGP or multiprotocol BGP neighbor table.
Step 5	**neighbor** *ipaddress* **update-source** *interface* **Example:** `Router (config)# neighbor 10.10.10.1 update-source Tunnel1`	Configures the Cisco IOS software to allow BGP sessions to use any operational interface for TCP connections.
Step 6	**address-family vpnv4** **Example:** `Router (config)# address-family vpnv4`	Enters address family configuration mode to configure a routing session using Virtual Private Network (VPN) Version 4 address prefixes.
Step 7	**neighbor** *ipaddress* **activate** **Example:** `Router (config)# neighbor 10.0.0.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 8	**neighbor** *ipaddress* **send-community extended** **Example:** `Router (config)# neighbor 10.0.0.1 send-community extended`	Specifies that extended community attributes should be sent to a BGP neighbor.

	Command or Action	Purpose
Step 9	**exit-address-family** **Example:** `Router (config)# exit-address-family`	Exits the address family configuration mode.
Step 10	**address-family ipv4** *vrf-name* **Example:** `Router (config)# address-family ipv4 vrf red`	Enters address family configuration mode to configure a routing session using standard IP Version 4 address prefixes.
Step 11	**redistribute connected** **Example:** `Router (config)# redistribute connected`	Redistributes routes that are established automatically by virtue of having enabled IP on an interface from one routing domain into another routing domain.
Step 12	**exit-address-family** **Example:** `Router (config)# exit-address-family`	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:

Note Security threats, as well as the cryptographic technologies to help protect against them, are constantly changing. For more information about the latest Cisco cryptographic recommendations, see the Next Generation Encryption (NGE) white paper.

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-aes ,
        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: 16 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# s**how 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

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

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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco47 address 0.0.0.0
!
crypto ipsec transform-set trans2 esp-aes esp-sha-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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco47 address 0.0.0.0
!
crypto ipsec transform-set trans2 esp-aes esp-sha-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 Spoke1
!
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 Tunnel1
   ! 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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-aes
 mode transport
crypto ipsec profile prof
 set transform-set t1
interface Tunnel1
 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 Tunnel1
 neighbor 10.0.0.12 remote-as 1
 neighbor 10.0.0.12 update-source Tunnel1
 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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-aes
 mode transport
crypto ipsec profile prof
 set transform-set t1
interface Tunnel1
 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 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
```

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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-aes
 mode transport
crypto ipsec profile prof
 set transform-set t1
interface Tunnel1
 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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-aes
 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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-aes
 mode transport
```

```
crypto ipsec profile prof
 set transform-set t1
interface Tunnel1
 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
 encr aes
 authentication pre-share
 group 14
crypto isakmp key cisco address 0.0.0.0 0.0.0.0
crypto ipsec transform-set t1 esp-aes
 mode transport
crypto ipsec profile prof
 set transform-set t1
interface Tunnel1
 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, Tunnel1 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
                               Sent       Rcvd
  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
Configuring Dynamic Multipoint VPN	Configuring Dynamic Multipoint VPN
Configuring NHRP	Configuring NHRP
NHRP commands	Cisco IOS IP Addressing Services Command Reference

RFCs

RFC	Title
RFC 2332	*NBMA Next Hop Resolution Protocol (NHRP)*

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
Mangeability Enhancements for DMVPN	12.4(9)T	DMVPN session manageabilty was expanded with DMVPN specific commands for debugging, show output, session and counter control, and system log information. The following sections provide information about this feature: • Troubleshooting Dynamic Multipoint VPN (DMVPN) 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**.
DMVPN Phase 2	12.2(18)SXE 12.3(9)a 12.3(8)T1	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. In Release 12.2(18)SXE, support was added for the Cisco Catalyst 6500 series switch and the Cisco 7600 series router.
--	12.3(6) 12.3(7)T	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 Release12.3(6) or 12.3(7)T. The enhancements added in Cisco IOS Release 12.3(6) were integrated into Cisco IOS Release 12.3(7)T.

Feature Name	Releases	Feature Information
Dynamic Multipoint VPN (DMVPN) Phase 1	12.2(13)T	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).

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.

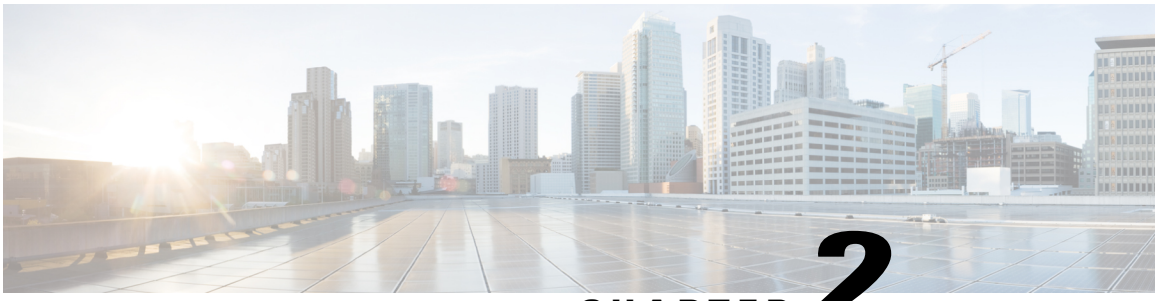
PFS --Perfect Forward Secrecy. A cryptographic characteristic associated with a derived shared secret value. With PFS, if one key is compromised, previous and subsequent keys are not compromised, because subsequent keys are not derived from previous keys.

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. One example of a transform is ESP with the 256-bit AES encryption algorithm and the AH 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.



CHAPTER 2

IPv6 over DMVPN

This document describes how to implement the Dynamic Multipoint VPN for IPv6 feature, which 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 the Next Hop Resolution Protocol (NHRP). In Dynamic Multipoint Virtual Private Network (DMVPN) for IPv6, the public network (the Internet) is a pure IPv4 network, and the private network (the intranet) is IPv6 capable.

IPv6 support on DMVPN was extended to the public network (the Internet) facing the Internet service provider (ISP). The IPv6 transport for DMVPN feature builds IPv6 WAN-side capability into NHRP tunnels and the underlying IPsec encryption, and enables IPv6 to transport payloads on the Internet.

The IPv6 transport for DMVPN feature is enabled by default. You need not upgrade your private internal network to IPv6 for the IPv6 transport for DMVPN feature to function. You can have either IPv4 or IPv6 addresses on your local networks.

Note Security threats, as well as the cryptographic technologies to help protect against them, are constantly changing. For more information about the latest Cisco cryptographic recommendations, see the Next Generation Encryption (NGE) white paper.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and 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.

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 IPv6 over DMVPN

- One of the following protocols must be enabled for DMVPN for IPv6 to work: Border Gateway Protocol (BGP), Enhanced Interior Gateway Routing Protocol (EIGRP), On-Demand Routing (ODR), Open Shortest Path First (OSPF), and Routing Information Protocol (RIP).
- Every IPv6 NHRP interface is configured with one IPv6 unicast address. This address can be a globally reachable or unique local address.
- Every IPv6 NHRP interface is configured with one IPv6 link-local address that is unique across all DMVPN hosts in the DMVPN cloud (that is, the hubs and spokes).

Information About IPv6 over DMVPN

DMVPN for IPv6 Overview

The DMVPN feature combines NHRP routing, multipoint generic routing encapsulation (mGRE) tunnels, and IPsec encryption to provide users 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 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 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--An mGRE tunnel interface allows a single GRE interface to support multiple IPsec tunnels and simplifies the size and complexity of the configuration.
- IPsec encryption--An IPsec tunnel interface facilitates for the protection of site-to-site IPv6 traffic with native encapsulation.

In DMVPN for IPv6, the public network (the Internet) is a pure IPv4 network, and the private network (the intranet) is IPv6 capable. The intranets could be a mix of IPv4 or IPv6 clouds connected to each other using DMVPN technologies, with the underlying carrier being a traditional IPv4 network.

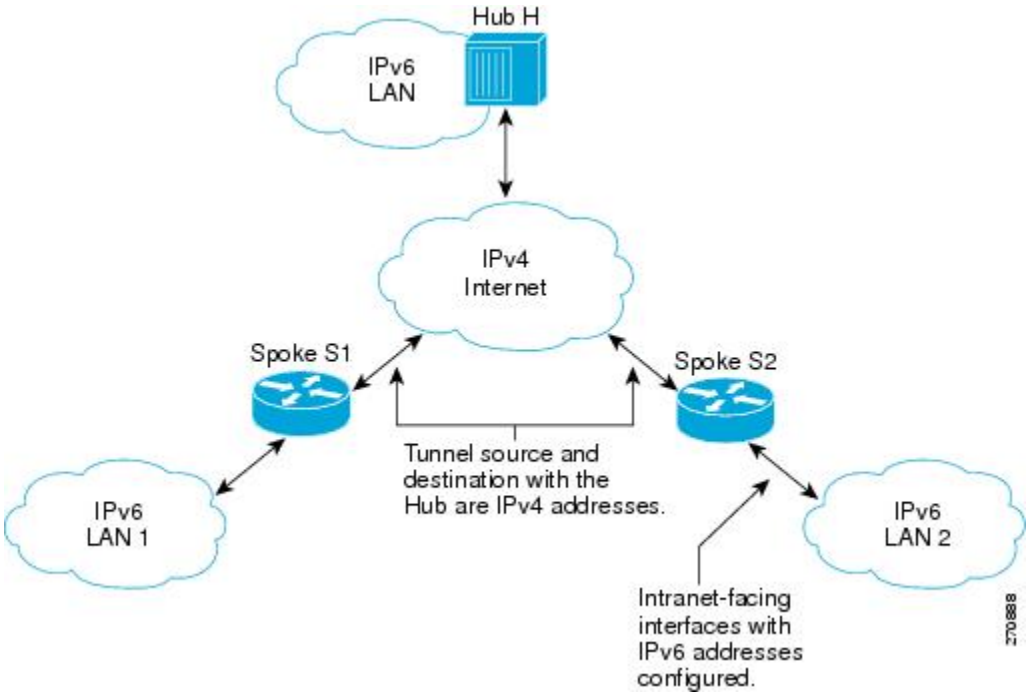
NHRP Routing

The NHRP protocol resolves a given intranet address (IPv4 or IPv6) to an Internet address (IPv4 nonbroadcast multiaccess [NBMA] address).

In the figure below, the intranets that are connected over the DMVPN network are IPv6 clouds, and the Internet is a pure IPv4 cloud. Spokes S1 and S2 are connected to Hub H over the Internet using a statically configured

tunnel. The address of the tunnel itself is the IPv6 domain, because it is another node on the intranet. The source and destinations address of the tunnel (the mGRE endpoints), however, are always in IPv4, in the Internet domain. The mGRE tunnel is aware of the IPv6 network because the GRE passenger protocol is an IPv6 packet, and the GRE transport (or carrier) protocol is an IPv4 packet.

Figure 5: IPv6 Topology That Triggers NHRP



When an IPv6 host in LAN L1 sends a packet destined to an IPv6 host in LAN L2, the packet is first routed to the gateway (which is Spoke S1) in LAN L1. Spoke S1 is a dual-stack device, which means both IPv4 and IPv6 are configured on it. The IPv6 routing table in S1 points to a next hop, which is the IPv6 address of the tunnel on Spoke S2. This is a VPN address that must be mapped to an NBMA address, triggering NHRP.

IPv6 NHRP Redirect and Shortcut Features

When IPv6 NHRP redirect is enabled, NHRP examines every data packet in the output feature path. If the data packet enters and leaves on the same logical network, NHRP sends an NHRP traffic indication message to the source of the data packet. In NHRP, a logical network is identified by the NHRP network ID, which groups multiple physical interfaces into a single logical network.

When IPv6 NHRP shortcut is enabled, NHRP intercepts every data packet in the output feature path. It checks to see if there is an NHRP cache entry to the destination of the data packet and, if yes, it replaces the current output adjacency with the one present in the NHRP cache. The data packet is therefore switched out using the new adjacency provided by NHRP.

IPv6 Routing

NHRP is automatically invoked for mGRE tunnels carrying the IPv6 passenger protocol. When a packet is routed and sent to the switching path, NHRP looks up the given next hop and, if required, initiates an NHRP

resolution query. If the resolution is successful, NHRP populates the tunnel endpoint database, which in turn populates the Cisco Express Forwarding adjacency table. The subsequent packets are Cisco Express Forwarding switched if Cisco Express Forwarding is enabled.

IPv6 Addressing and Restrictions

IPv6 allows multiple unicast addresses on a given IPv6 interface. IPv6 also allows special address types, such as anycast, multicast, link-local addresses, and unicast addresses.

DMVPN for IPv6 has the following addressing restrictions:

- Every IPv6 NHRP interface is configured with one IPv6 unicast address. This address can be a globally reachable or unique local address.
- Every IPv6 NHRP interface is configured with one IPv6 link-local address that is unique across all DMVPN hosts in the DMVPN cloud (that is, the hubs and spokes).
  - If no other tunnels on the device are using the same tunnel source, then the tunnel source address can be embedded into an IPv6 address.
  - If the device has only one DMVPN IPv6 tunnel, then manual configuration of the IPv6 link-local address is not required. Instead, use the **ipv6 enable** command to autogenerate a link-local address.
  - If the device has more than one DMVPN IPv6 tunnel, then the link-local address must be manually configured using the **ipv6 address fe80::2001 link-local** command.

How to Configure IPv6 over DMVPN

Configuring an IPsec Profile in DMVPN for IPv6

Note Security threats, as well as the cryptographic technologies to help protect against them, are constantly changing. For more information about the latest Cisco cryptographic recommendations, see the Next Generation Encryption (NGE) white paper.

The IPsec profile shares most 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 You Begin

Before configuring an IPsec profile, you must do the following:

- Define a transform set by using the **crypto ipsec transform-set** command.
- Make sure that the Internet Security Association Key Management Protocol (ISAKMP) profile is configured with default ISAKMP settings.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto identity** *name*
4. **exit**
5. **crypto ipsec profile** *name*
6. **set transform-set** *transform-set-name*
7. **set identity**
8. **set security-association lifetime seconds** *seconds* | **kilobytes** *kilobytes*
9. **set pfs** [**group1** | **group14** | **group15** | **group16** | **group19** | **group2** | **group20** | **group24** | **group5**]
10. end

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto identity** *name* **Example:** `Device(config)# crypto identity device1`	Configures the identity of the device with a given list of distinguished names (DNs) in the certificate of the device.
Step 4	**exit** **Example:** `Device(config-crypto-identity)# exit`	Exits crypto identity configuration mode and enters global configuration mode.
Step 5	**crypto ipsec profile** *name* **Example:** `Device(config)# crypto ipsec profile example1`	Defines the IPsec parameters that are to be used for IPsec encryption between "spoke and hub" and "spoke and spoke" routers. This command places the device in crypto map configuration mode.

	Command or Action	Purpose
Step 6	**set transform-set** *transform-set-name* **Example:** `Device(config-crypto-map)# set transform-set example-set`	Specifies which transform sets can be used with the IPsec profile.
Step 7	**set identity** **Example:** `Device(config-crypto-map)# set identity router1`	(Optional) Specifies identity restrictions to be used with the IPsec profile.
Step 8	**set security-association lifetime seconds** *seconds* | **kilobytes** *kilobytes* **Example:** `Device(config-crypto-map)# set security-association lifetime seconds 1800`	(Optional) Overrides the global lifetime value for the IPsec profile.
Step 9	**set pfs** [**group1** | **group14** | **group15** | **group16** | **group19** | **group2** | **group20** | **group24** | **group5**] **Example:** `Device(config-crypto-map)# set pfs group14`	(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 Diffie-Hellman (DH) group, **group1** will be enabled. • **1—**768-bit DH (No longer recommended.) • **2—**1024-bit DH (No longer recommended) • **5—**1536-bit DH (No longer recommended) • **14—**Specifies the 2048-bit DH group. • **15—**Specifies the 3072-bit DH group. • **16—**Specifies the 4096-bit DH group. • **19—**Specifies the 256-bit elliptic curve DH (ECDH) group. • **20—**Specifies the 384-bit ECDH group. • **24—**Specifies the 2048-bit DH/DSA group.
Step 10	end **Example:** `Device(config-crypto-map)# end`	Exits crypto map configuration mode and returns to privileged EXEC mode.

Configuring the Hub for IPv6 over DMVPN

Perform this task to configure the hub device for IPv6 over DMVPN for mGRE and IPsec integration (that is, associate the tunnel with the IPsec profile configured in the previous procedure).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *number*
4. **ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits* / *prefix-length*
5. **ipv6 address** *ipv6-address* / *prefix-length* **link-local**
6. **ipv6 mtu** *bytes*
7. **ipv6 nhrp authentication** *string*
8. **ipv6 nhrp map multicast dynamic**
9. **ipv6 nhrp network-id** *network-id*
10. **tunnel source** *ip-address* | *ipv6-address* | *interface-type interface-number*
11. **tunnel mode** {**aurp** | **cayman** | **dvmrp** | **eon** | **gre**| **gre multipoint**[**ipv6**] | **gre ipv6** | **ipip decapsulate-any**] | **ipsec ipv4** | **iptalk** | **ipv6**| **ipsec ipv6** | **mpls** | **nos** | **rbscp**
12. Do one of the following:
    - **tunnel protection ipsec profile** *name* [**shared**]
    - **tunnel protection psk** *key*
13. **bandwidth** {*kbps* | **inherit** [*kbps*] | **receive** [*kbps*]}
14. **ipv6 nhrp holdtime** *seconds*
15. end

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface tunnel** *number* **Example:** `Device(config)# interface tunnel 5`	Configures a tunnel interface and enters interface configuration mode. • The number argument specifies the number of the tunnel interfaces that you want to create or configure. There is no limit on the number of tunnel interfaces you can create.
Step 4	**ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits* / *prefix-length* **Example:** `Device(config-if)# ipv6 address 2001:DB8:1:1::72/64`	Configures an IPv6 address based on an IPv6 general prefix and enables IPv6 processing on an interface.
Step 5	**ipv6 address** *ipv6-address* / *prefix-length* **link-local** **Example:** `Device(config-if)# ipv6 address fe80::2001 link-local`	Configures an IPv6 link-local address for an interface and enables IPv6 processing on the interface. • A unique IPv6 link-local address (across all DMVPN nodes in a DMVPN network) must be configured.
Step 6	**ipv6 mtu** *bytes* **Example:** `Device(config-if)# ipv6 mtu 1400`	Sets the maximum transmission unit (MTU) size of IPv6 packets sent on an interface.
Step 7	**ipv6 nhrp authentication** *string* **Example:** `Device(config-if)# ipv6 nhrp authentication examplexx`	Configures the authentication string for an interface using the NHRP. **Note** The NHRP authentication string must be set to the same value on all hubs and spokes that are in the same DMVPN network.
Step 8	**ipv6 nhrp map multicast dynamic** **Example:** `Device(config-if)# ipv6 nhrp map multicast dynamic`	Allows NHRP to automatically add routers to the multicast NHRP mappings. **Note** Effective with Cisco IOS XE Denali 16.3 **ipv6 nhrp map multicast dynamic** is enabled by default.
Step 9	**ipv6 nhrp network-id** *network-id* **Example:** `Device(config-if)# ipv6 nhrp network-id 99`	Enables the NHRP on an interface. Effective with Cisco IOS XE Denali 16.3 **ipv6 nhrp network-id** is enabled by default.
Step 10	**tunnel source** *ip-address* | *ipv6-address* | *interface-type interface-number*	Sets the source address for a tunnel interface.

	Command or Action	Purpose
	Example: `Device(config-if)# tunnel source ethernet 0`	
Step 11	**tunnel mode** {**aurp** | **cayman** | **dvmrp** | **eon** | **gre**| **gre multipoint**[**ipv6**] | **gre ipv6** | **ipip decapsulate-any**] | **ipsec ipv4** | **iptalk** | **ipv6**| **ipsec ipv6** | **mpls** | **nos** | **rbscp** **Example:** `Device(config-if)# tunnel mode gre multipoint`	Sets the encapsulation mode to mGRE for the tunnel interface.

Step 12	Do one of the following:
	• **tunnel protection ipsec profile** *name* [**shared**]
	• **tunnel protection psk** *key*
	Example:
	`Router(config-if)# tunnel protection ipsec profile vpnprof`
	Example:
	`Router(config-if)# tunnel protection psk test1`
		Associates a tunnel interface with an IPsec profile.
		• The *name* argument specifies the name of the IPsec profile; this value must match the *name* specified in the **crypto ipsec profile** *name*command.
		or
		Simplifies the tunnel protection configuration for pre-shared key (PSK) by creating a default IPsec profile.

Step 13	**bandwidth** {*kbps* | **inherit** [*kbps*] | **receive** [*kbps*]} **Example:** `Device(config-if)# bandwidth 1200`	Sets the current bandwidth value for an interface to higher-level protocols. • The *bandwidth-size* argument specifies the bandwidth in kilobits per second. The default value is 9. The recommended bandwidth value is 1000 or greater.
Step 14	**ipv6 nhrp holdtime** *seconds* **Example:** `Device(config-if)# ipv6 nhrp holdtime 3600`	Changes the number of seconds that NHRP NBMA addresses are advertised as valid in authoritative NHRP responses.
Step 15	end **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring the NHRP Redirect and Shortcut Features on the Hub

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel number**
4. **ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits* / *prefix-length*
5. Do one of the following:
   - **ipv6 nhrp redirect** [**timeout** *seconds*]
   - **ipv6 nhrp redirect** [**interest** *acl*]
6. **ipv6 nhrp shortcut**
7. end

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel number** **Example:** `Device(config)# interface tunnel 5`	Configures a tunnel interface and enters interface configuration mode. • The number argument specifies the number of the tunnel interfaces that you want to create or configure. There is no limit on the number of tunnel interfaces you can create.
Step 4	**ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits* / *prefix-length* **Example:** `Device(config-if)# ipv6 address 2001:DB8:1:1::72/64`	Configures an IPv6 address based on an IPv6 general prefix and enables IPv6 processing on an interface.
Step 5	Do one of the following:	Enables NHRP redirect.

	Command or Action	Purpose

	• **ipv6 nhrp redirect** [**timeout** *seconds*]
	• **ipv6 nhrp redirect** [**interest** *acl*]
	Example:
	`Device(config-if)# ipv6 nhrp redirect`
	Example:
	`Device(config-if)# ipv6 nhrp redirect interest`
		or
		Enables the user to specify an ACL.
		Note You must configure the **ipv6 nhrp redirect** command on a hub.

Step 6	**ipv6 nhrp shortcut** **Example:** `Device(config-if)# ipv6 nhrp shortcut`	Enables NHRP shortcut switching. • You must configure the **ipv6 nhrp shortcut** command on a spoke. **Note** Effective with Cisco IOS XE Denali 16.3 **ipv6 nhrp shortcut** is enabled by default.
Step 7	end **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring the Spoke for IPv6 over DMVPN

Perform this task to configure the spoke for IPv6 over DMVPN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *number*
4. **ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits* / *prefix-length*
5. **ipv6 address** *ipv6-address* / *prefix-length* **link-local**
6. **ipv6 mtu** *bytes*
7. **ipv6 nhrp authentication** *string*
8. **ipv6 nhrp map** *ipv6-address nbma-address*
9. **ipv6 nhrp map multicast** *ipv4-nbma-address*
10. **ipv6 nhrp nhs** *ipv6- nhs-address*
11. **ipv6 nhrp network-id** *network-id*
12. **tunnel source** *ip-address* | *ipv6-address* | *interface-type interface-number*
13. Do one of the following:
    - **tunnel mode** {**aurp** | **cayman** | **dvmrp** | **eon** | **gre**| **gre multipoint** [**ipv6**] | **gre ipv6** | **ipip decapsulate-any**] | **ipsec ipv4** | **iptalk** | **ipv6**| **ipsec ipv6** | **mpls** | **nos** | **rbscp**
    - **tunnel destination** {*host-name* | *ip-address* | *ipv6-address*}
14. Do one of the following:
    - **tunnel protection ipsec profile** *name* [**shared**]
    - **tunnel protection psk** *key*
15. **bandwidth** {**interzone** | **total** | **session**} {**default** | **zone** *zone-name*} *bandwidth-size*
16. **ipv6 nhrp holdtime** *seconds*
17. end

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface tunnel** *number* **Example:** `Device(config)# interface tunnel 5`	Configures a tunnel interface and enters interface configuration mode. • The *number* argument specifies the number of the tunnel interfaces that you want to create or configure. There is no limit on the number of tunnel interfaces you can create.
Step 4	**ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits* / *prefix-length* **Example:** `Device(config-if) ipv6 address 2001:DB8:1:1::72/64`	Configures an IPv6 address based on an IPv6 general prefix and enables IPv6 processing on an interface.
Step 5	**ipv6 address** *ipv6-address* / *prefix-length* **link-local** **Example:** `Device(config-if)# ipv6 address fe80::2001 link-local`	Configures an IPv6 link-local address for an interface and enables IPv6 processing on the interface. • A unique IPv6 link-local address (across all DMVPN nodes in a DMVPN network) must be configured.
Step 6	**ipv6 mtu** *bytes* **Example:** `Device(config-if)# ipv6 mtu 1400`	Sets the MTU size of IPv6 packets sent on an interface.
Step 7	**ipv6 nhrp authentication** *string* **Example:** `Device(config-if)# ipv6 nhrp authentication examplexx`	Configures the authentication string for an interface using the NHRP. **Note** The NHRP authentication string must be set to the same value on all hubs and spokes that are in the same DMVPN network.
Step 8	**ipv6 nhrp map** *ipv6-address nbma-address* **Example:** `Device(config-if)# ipv6 nhrp map 2001:DB8:3333:4::5 10.1.1.1`	Statically configures the IPv6-to-NBMA address mapping of IPv6 destinations connected to an NBMA network. **Note** Only IPv4 NBMA addresses are supported, not ATM or Ethernet addresses.
Step 9	**ipv6 nhrp map multicast** *ipv4-nbma-address* **Example:** `Device(config-if)# ipv6 nhrp map multicast 10.11.11.99`	Maps destination IPv6 addresses to IPv4 NBMA addresses.

	Command or Action	Purpose
Step 10	**ipv6 nhrp nhs** *ipv6- nhs-address* **Example:** `Device(config-if)# ipv6 nhrp nhs 2001:0DB8:3333:4::5 2001:0DB8::/64`	Specifies the address of one or more IPv6 NHRP servers.
Step 11	**ipv6 nhrp network-id** *network-id* **Example:** `Device(config-if)# ipv6 nhrp network-id 99`	Enables the NHRP on an interface. **Note** Effective with Cisco IOS XE Denali 16.3 **ipv6 nhrp network-id** is enabled by default.
Step 12	**tunnel source** *ip-address* | *ipv6-address* | *interface-type interface-number* **Example:** `Device(config-if)# tunnel source ethernet 0`	Sets the source address for a tunnel interface.

Step 13	Do one of the following:
	• **tunnel mode** {**aurp** | **cayman** | **dvmrp** | **eon** | **gre**| **gre multipoint** [**ipv6**] | **gre ipv6** | **ipip decapsulate-any**] | **ipsec ipv4** | **iptalk** | **ipv6**| **ipsec ipv6** | **mpls** | **nos** | **rbscp**
	• **tunnel destination** {*host-name* | *ip-address* | *ipv6-address*}
	Example:
	`Device(config-if)# tunnel mode gre multipoint`
	Example:
	`Device(config-if)# tunnel destination 10.1.1.1`
		Sets the encapsulation mode to mGRE for the tunnel interface.
		• Use the **tunnel mode** command if data traffic can use dynamic spoke-to-spoke traffic.
		or
		Specifies the destination for a tunnel interface.
		• Use the **tunnel destination** command if data traffic can use hub-and-spoke tunnels.

Step 14	Do one of the following: • **tunnel protection ipsec profile** *name* [**shared**] • **tunnel protection psk** *key* **Example:** `Router(config-if)# tunnel protection ipsec profile vpnprof`	Associates a tunnel interface with an IPsec profile. • The *name* argument specifies the name of the IPsec profile; this value must match the *name* specified in the **crypto ipsec profile** *name*command. or Simplifies the tunnel protection configuration for pre-shared key (PSK) by creating a default IPsec profile.

	Command or Action	Purpose
	Example: `Router(config-if)# tunnel protection psk test1`	
Step 15	**bandwidth** {**interzone** | **total** | **session**} {**default** | **zone** *zone-name*} *bandwidth-size* **Example:** `Device(config-if)# bandwidth total 1200`	Sets the current bandwidth value for an interface to higher-level protocols. • The *bandwidth-size* argument specifies the bandwidth in kilobits per second. The default value is 9. The recommended bandwidth value is 1000 or greater. • The bandwidth setting for the spoke need not equal the bandwidth setting for the DMVPN hub. It is usually easier if all of the spokes use the same or similar value.
Step 16	**ipv6 nhrp holdtime** *seconds* **Example:** `Device(config-if)# ipv6 nhrp holdtime 3600`	Changes the number of seconds that NHRP NBMA addresses are advertised as valid in authoritative NHRP responses.
Step 17	end **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Verifying DMVPN for IPv6 Configuration

SUMMARY STEPS

1. **enable**
2. **show dmvpn** [**ipv4** [**vrf** *vrf-name*] | **ipv6** [**vrf** *vrf-name*]] [**debug-condition** | [**interface tunnel** *number* | **peer** {**nbma** *ip-address* | **network** *network-mask* | **tunnel** *ip-address*}] [**static**] [**detail**]]
3. **show ipv6 nhrp** [**dynamic** [*ipv6-address*] | **incomplete** | **static**] [*address* | *interface*] [**brief** | **detail**] [**purge**]
4. **show ipv6 nhrp multicast** [*ipv4-address* | *interface* | *ipv6-address*]
5. **show ip nhrp multicast** [*nbma-address* | *interface*]
6. **show ipv6 nhrp summary**
7. **show ipv6 nhrp traffic** [*interface***tunnel** *number*
8. **show ip nhrp shortcut**
9. **show ip route**
10. **show ipv6 route**
11. **show nhrp debug-condition**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show dmvpn** [**ipv4** [**vrf** *vrf-name*] | **ipv6** [**vrf** *vrf-name*]] [**debug-condition** | [**interface tunnel** *number* | **peer** {**nbma** *ip-address* | **network** *network-mask* | **tunnel** *ip-address*}] [**static**] [**detail**]] **Example:** `Device# show dmvpn 2001:0db8:1:1::72/64`	Displays DMVPN-specific session information.
Step 3	**show ipv6 nhrp** [**dynamic** [*ipv6-address*] | **incomplete** | **static**] [*address* | *interface*] [**brief** | **detail**] [**purge**] **Example:** `Device# show ipv6 nhrp`	Displays NHRP mapping information.
Step 4	**show ipv6 nhrp multicast** [*ipv4-address* | *interface* | *ipv6-address*]	Displays NHRP multicast mapping information.

	Command or Action	Purpose
	Example: `Device# show ipv6 nhrp multicast`	
Step 5	**show ip nhrp multicast** [*nbma-address* | *interface*] **Example:** `Device# show ip nhrp multicast`	Displays NHRP multicast mapping information.
Step 6	**show ipv6 nhrp summary** **Example:** `Device# show ipv6 nhrp summary`	Displays NHRP mapping summary information.
Step 7	**show ipv6 nhrp traffic** [*interface***tunnel** *number* **Example:** `Device# show ipv6 nhrp traffic`	Displays NHRP traffic statistics information.
Step 8	**show ip nhrp shortcut** **Example:** `Device# show ip nhrp shortcut`	Displays NHRP shortcut information.
Step 9	**show ip route** **Example:** `Device# show ip route`	Displays the current state of the IPv4 routing table.
Step 10	**show ipv6 route** **Example:** `Device# show ipv6 route`	Displays the current contents of the IPv6 routing table.
Step 11	**show nhrp debug-condition** **Example:** `Device# show nhrp debug-condition`	Displays the NHRP conditional debugging information.

Monitoring and Maintaining DMVPN for IPv6 Configuration and Operation

SUMMARY STEPS

1. **enable**
2. **clear dmvpn session** [**interface tunnel** *number* | **peer** {*ipv4-address* | *fqdn-string* | *ipv6-address*} | **vrf** *vrf-name*] [**static**]
3. **clear ipv6 nhrp** [*ipv6-address* | **counters**
4. **debug dmvpn** {**all** | **error** | **detail** | **packet**} {**all** | *debug-type*}
5. **debug nhrp** [**cache** | **extension** | **packet** | **rate**]
6. **debug nhrp condition** [**interface tunnel** *number* | **peer** {**nbma** {*ipv4-address* | *fqdn-string* | *ipv6-address*} | **tunnel** {*ip-address* | *ipv6-address*}} | **vrf** *vrf-name*]
7. **debug nhrp error**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**clear dmvpn session** [**interface tunnel** *number*	**peer** {*ipv4-address*	*fqdn-string*	*ipv6-address*}	**vrf** *vrf-name*] [**static**] **Example:** `Device# clear dmvpn session`	Clears DMVPN sessions.
Step 3	**clear ipv6 nhrp** [*ipv6-address*	**counters** **Example:** `Device# clear ipv6 nhrp`	Clears all dynamic entries from the NHRP cache.
Step 4	**debug dmvpn** {**all**	**error**	**detail**	**packet**} {**all**	*debug-type*} **Example:** `Device# debug dmvpn`	Displays debug DMVPN session information.
Step 5	**debug nhrp** [**cache**	**extension**	**packet**	**rate**] **Example:** `Device# debug nhrp ipv6`	Enables NHRP debugging.

	Command or Action	Purpose
Step 6	**debug nhrp condition** [**interface tunnel** *number* | **peer** {**nbma** {*ipv4-address* | *fqdn-string* | *ipv6-address*} | **tunnel** {*ip-address* | *ipv6-address*}} | **vrf** *vrf-name*] **Example:** `Device# debug nhrp condition`	Enables NHRP conditional debugging.
Step 7	**debug nhrp error** **Example:** `Device# debug nhrp ipv6 error`	Displays NHRP error-level debugging information.

Examples

Sample Output for the debug nhrp Command

The following sample output is from the **debug nhrp**command with the **ipv6** keyword:

```
Device# debug nhrp ipv6
Aug  9 13:13:41.486: NHRP: Attempting to send packet via DEST
   - 2001:DB8:3c4d:0015:0000:0000:1a2f:3d2c/32
Aug  9 13:13:41.486: NHRP: Encapsulation succeeded.
Aug  9 13:13:41.486: NHRP: Tunnel NBMA addr 11.11.11.99
Aug  9 13:13:41.486: NHRP: Send Registration Request via Tunnel0 vrf 0, packet size: 105
Aug  9 13:13:41.486: src: 2001:DB8:3c4d:0015:0000:0000:1a2f:3d2c/32,
          dst: 2001:DB8:3c4d:0015:0000:0000:1a2f:3d2c/32
Aug  9 13:13:41.486: NHRP: 105 bytes out Tunnel0
Aug  9 13:13:41.486: NHRP: Receive Registration Reply via Tunnel0 vrf 0, packet size: 125
```

Configuration Examples for IPv6 over DMVPN

Example: Configuring an IPsec Profile

```
Device(config)# crypto identity router1

Device(config)# crypto ipsec profile example1
Device(config-crypto-map)# set transform-set example-set
Device(config-crypto-map)# set identity router1

Device(config-crypto-map)# set security-association lifetime seconds 1800

Device(config-crypto-map)# set pfs group14
```

Example: Configuring the Hub for DMVPN

```
Device# configure terminal
Device(config)# interface tunnel 5

Device(config-if)# ipv6 address 2001:DB8:1:1::72/64
Device(config-if)# ipv6 address fe80::2001 link-local
Device(config-if)# ipv6 mtu 1400
Device(config-if)# ipv6 nhrp authentication examplexx
Device(config-if)# ipv6 nhrp map multicast dynamic
Device(config-if)# ipv6 nhrp network-id 99
Device(config-if)# tunnel source ethernet 0
Device(config-if)# tunnel mode gre multipoint
Device(config-if)# tunnel protection ipsec profile example_profile
Device(config-if)# bandwidth 1200
Device(config-if)# ipv6 nhrp holdtime 3600
```

The following sample output is from the **show dmvpn** command, with the **ipv6** and **detail** keywords, for the hub:

```
Device# show dmvpn ipv6 detail

Legend: Attrb --> S - Static, D - Dynamic, I - Incomplete
        N - NATed, L - Local, X - No Socket
        # Ent --> Number of NHRP entries with same NBMA peer
        NHS Status: E --> Expecting Replies, R --> Responding
        UpDn Time --> Up or Down Time for a Tunnel
==========================================================================

Interface Tunnel1 is up/up, Addr. is 10.0.0.3, VRF ""
   Tunnel Src./Dest. addr: 192.169.2.9/MGRE, Tunnel VRF ""
   Protocol/Transport: "multi-GRE/IP", Protect "test_profile"
Type:Hub, Total NBMA Peers (v4/v6): 2
    1.Peer NBMA Address: 192.169.2.10
        Tunnel IPv6 Address: 2001::4
        IPv6 Target Network: 2001::4/128
        # Ent: 2, Status: UP, UpDn Time: 00:01:51, Cache Attrib: D
Type:Hub, Total NBMA Peers (v4/v6): 2
    2.Peer NBMA Address: 192.169.2.10
        Tunnel IPv6 Address: 2001::4
        IPv6 Target Network: FE80::2/128
        # Ent: 0, Status: UP, UpDn Time: 00:01:51, Cache Attrib: D
Type:Hub, Total NBMA Peers (v4/v6): 2
    3.Peer NBMA Address: 192.169.2.11
Tunnel IPv6 Address: 2001::5
        IPv6 Target Network: 2001::5/128
        # Ent: 2, Status: UP, UpDn Time: 00:26:38, Cache Attrib: D
Type:Hub, Total NBMA Peers (v4/v6): 2
    4.Peer NBMA Address: 192.169.2.11
        Tunnel IPv6 Address: 2001::5
        IPv6 Target Network: FE80::3/128
        # Ent: 0, Status: UP, UpDn Time: 00:26:38, Cache Attrib: D
Pending DMVPN Sessions:

Interface: Tunnel1
  IKE SA: local 192.169.2.9/500 remote 192.169.2.10/500 Active
  Crypto Session Status: UP-ACTIVE
  fvrf: (none), Phase1_id: 192.169.2.10
  IPSEC FLOW: permit 47 host 192.169.2.9 host 192.169.2.10
        Active SAs: 2, origin: crypto map
   Outbound SPI : 0x BB0ED02, transform : esp-aes esp-sha-hmac
    Socket State: Open

Interface: Tunnel1
  IKE SA: local 192.169.2.9/500 remote 192.169.2.11/500 Active
  Crypto Session Status: UP-ACTIVE
  fvrf: (none), Phase1_id: 192.169.2.11
  IPSEC FLOW: permit 47 host 192.169.2.9 host 192.169.2.11
```

```
        Active SAs: 2, origin: crypto map
    Outbound SPI : 0xB79B277B, transform : esp-aes esp-sha-hmac
     Socket State: Open
```

Example: Configuring the Spoke for DMVPN

```
Device# configure terminal
Device(config)# crypto ikev2 keyring DMVPN
Device(config)# peer DMVPN
Device(config)# address 0.0.0.0 0.0.0.0
Device(config)# pre-shared-key cisco123
Device(config)# peer DMVPNv6
Device(config)# address ::/0
Device(config)# pre-shared-key cisco123v6
Device(config)# crypto ikev2 profile DMVPN
Device(config)# match identity remote address 0.0.0.0
Device(config)# match identity remote address ::/0
Device(config)# authentication local pre-share
Device(config)# authentication remote pre-share
Device(config)# keyring DMVPN
Device(config)# dpd 30 5 on-demand
Device(config)# crypto ipsec transform-set DMVPN esp-aes esp-sha-hmac
Device(config)# mode transport
Device(config)# crypto ipsec profile DMVPN
Device(config)# set transform-set DMVPN
Device(config)# set ikev2-profile DMVPN
Device(config)# interface tunnel 5

Device(config-if)# bandwidth 1000
Device(config-if)# ip address 10.0.0.11 255.255.255.0
Device(config-if)# ip mtu 1400
Device(config-if)# ip nhrp authentication test
Device(config-if)# ip nhrp network-id 100000
Device(config-if)# ip nhrp nhs 10.0.0.1 nbma 2001:DB8:0:FFFF:1::1 multicast
Device(config-if)# vip nhrp shortcut
Device(config-if)# delay 1000
Device(config-if)# ipv6 address 2001:DB8:0:100::B/64
Device(config-if)# ipv6 mtu 1400
Device(config-if)# ipv6 nd ra mtu suppress
Device(config-if)# no ipv6 redirects
Device(config-if)# ipv6 eigrp 1
Device(config-if)# ipv6 nhrp authentication testv6
Device(config-if)# ipv6 nhrp network-id 100006
Device(config-if)# ipv6 nhrp nhs 2001:DB8:0:100::1 nbma 2001:DB8:0:FFFF:1::1 multicast
Device(config-if)# ipv6 nhrp shortcut
Device(config-if)# tunnel source Ethernet0/0
Device(config-if)# tunnel mode gre multipoint ipv6
Device(config-if)# tunnel key 100000
Device(config-if)# end
.
.
```

The following sample output is from the **show dmvpn** command, with the **ipv6** and **detail** keywords, for the spoke:

```
Legend: Attrb --> S - Static, D - Dynamic, I - Incomplete
        N - NATed, L - Local, X - No Socket
        # Ent --> Number of NHRP entries with same NBMA peer
        NHS Status: E --> Expecting Replies, R --> Responding
        UpDn Time --> Up or Down Time for a Tunnel
==========================================================================

Interface Tunnel1 is up/up, Addr. is 10.0.0.1, VRF ""
   Tunnel Src./Dest. addr: 192.169.2.10/MGRE, Tunnel VRF ""
   Protocol/Transport: "multi-GRE/IP", Protect "test_profile"

IPv6 NHS: 2001::6 RE
Type:Spoke, Total NBMA Peers (v4/v6): 1
```

```
    1.Peer NBMA Address: 192.169.2.9
        Tunnel IPv6 Address: 2001::6
        IPv6 Target Network: 2001::/112
        # Ent: 2, Status: NHRP, UpDn Time: never, Cache Attrib: S

IPv6 NHS: 2001::6 RE
Type:Unknown, Total NBMA Peers (v4/v6): 1
    2.Peer NBMA Address: 192.169.2.9
        Tunnel IPv6 Address: FE80::1
        IPv6 Target Network: FE80::1/128
        # Ent: 0, Status: UP, UpDn Time: 00:00:24, Cache Attrib: D

Pending DMVPN Sessions:

Interface: Tunnel1
  IKE SA: local 192.169.2.10/500 remote 192.169.2.9/500 Active
  Crypto Session Status: UP-ACTIVE
  fvrf: (none), Phase1_id: 192.169.2.9
  IPSEC FLOW: permit 47 host 192.169.2.10 host 192.169.2.9
        Active SAs: 2, origin: crypto map
   Outbound SPI : 0x6F75C431, transform : esp-aes esp-sha-hmac
    Socket State: Open
```

Example: Configuring the NHRP Redirect and Shortcut Features on the Hub

```
Device(config)# interface tunnel 5
Device(config-if)# ipv6 address 2001:DB8:1:1::72/64

Device(config-if)# ipv6 nhrp redirect

Device(config-if)# ipv6 nhrp shortcut
```

Example: Configuring NHRP on the Hub and Spoke

Hub

```
Device# show ipv6 nhrp

2001::4/128 via 2001::4
   Tunnel1 created 00:02:40, expire 00:00:47
   Type: dynamic, Flags: unique registered used
   NBMA address: 192.169.2.10
2001::5/128 via 2001::5
   Tunnel1 created 00:02:37, expire 00:00:47
   Type: dynamic, Flags: unique registered used
   NBMA address: 192.169.2.11
FE80::2/128 via 2001::4
   Tunnel1 created 00:02:40, expire 00:00:47
   Type: dynamic, Flags: unique registered used
   NBMA address: 192.169.2.10
FE80::3/128 via 2001::5
   Tunnel1 created 00:02:37, expire 00:00:47
   Type: dynamic, Flags: unique registered used
   NBMA address: 192.169.2.11
```

Spoke

```
Device# show ipv6 nhrp

2001::8/128
   Tunnel1 created 00:00:13, expire 00:02:51
   Type: incomplete, Flags: negative
   Cache hits: 2
2001::/112 via 2001::6
```

```
   Tunnel1 created 00:01:16, never expire
   Type: static, Flags: used
   NBMA address: 192.169.2.9
FE80::1/128 via FE80::1
   Tunnel1 created 00:01:15, expire 00:00:43
   Type: dynamic, Flags:
   NBMA address: 192.169.2.9
```

Additional References

Related Documents

Related Topic	Document Title
IPv6 addressing and connectivity	*IPv6 Configuration Guide*
Dynamic Multipoint VPN	*Dynamic Multipoint VPN Configuration Guide*
Cisco IOS commands	Master Command List, All Releases
IPv6 commands	*IPv6 Command Reference*
Cisco IOS IPv6 features	IPv6 Feature Mapping
Recommended cryptographic algorithms	Next Generation Encryption

Standards and RFCs

Standard/RFC	Title
RFCs for IPv6	*IPv6 RFcs*

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

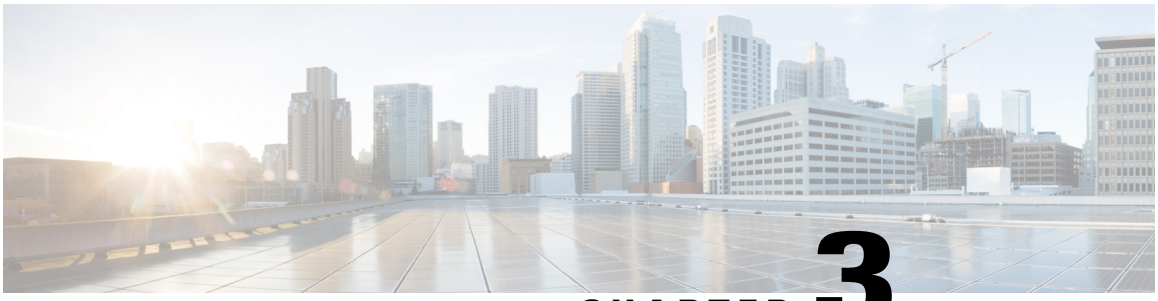
Feature Information for IPv6 over DMVPN

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 2: Feature Information for IPv6 over DMVPN

Feature Name	Releases	Feature Information
IPv6 Transport for DMVPN	15.3(1)S	The IPv6 transport for DMVPN feature builds IPv6 WAN-side capability into NHRP tunnels and the underlying IPsec encryption, and enables IPv6 to transport payloads on the Internet. The IPv6 transport for DMVPN feature is enabled by default. No new commands were introduced or modifed.



CHAPTER 3

DMVPN Tunnel Health Monitoring and Recovery

The Dynamic Multipoint VPN Tunnel Health Monitoring and Recovery feature enhances the ability of the system to monitor and report Dynamic Multipoint VPN (DMVPN) events. It includes support for Simple Network Management Protocol (SNMP) Next Hop Resolution Protocol (NHRP) notifications for critical DMVPN events and support for DMVPN syslog messages. It also enables the system to control the state of the tunnel interface based on the health of the DMVPN tunnels.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and 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.

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 DMVPN Tunnel Health Monitoring and Recovery

SNMP NHRP notifications

- SNMP is enabled in the system.
- Generic SNMP configurations for Get and Set operations and for notifications are implemented in the system.
- All relevant NHRP traps are enabled.

Restrictions for DMVPN Tunnel Health Monitoring and Recovery

MIB SNMP

- SNMP SET UNDO is not supported.
- The MIB Persistence feature that enables the MIB-SNMP data to persist across reloads is not supported. However, a virtual persistence for the MIB notification control object happens, because that information is also captured via the configuration command line interface (CLI).
- Notifications and syslogs are not virtual routing and forwarding (VRF)-aware.
- The Rate Limit Exceeded notification does not differentiate between the IPv4 or IPv6 protocol type.

Interface State Control

- Interface state control can be configured on leaf spoke nodes only.
- Interface state control supports IPv4 only.

Information About DMVPN Tunnel Health Monitoring and Recovery

NHRP Extension MIB

The NHRP Extension MIB module comprises objects that maintain redirect-related statistics for both clients and servers, and for the following SNMP notifications for critical DMVPN events:

- A spoke perceives that a hub has gone down. This can occur even if the spoke was not previously registered with the hub.
- A spoke successfully registers with a hub.

- A hub perceives that a spoke has gone down.
- A hub perceives that a spoke has come up.
- A spoke or hub perceives that another NHRP peer, not related by an NHRP registration, has gone down. For example, a spoke-spoke tunnel goes down.
- A spoke or hub perceives that another NHRP peer, not related by an NHRP registration, has come up. For example, a spoke-spoke tunnel comes up.
- The rate limit set for NHRP packets on the interface is exceeded.

The agent implementation of the MIB provides a means to enable and disable specific traps, from either the network management system or the CLI.

DMVPN Syslog Messages

The DMVPN syslog feature provides syslog messages for the following events:

- All next-hop state change events. For example, when the system declares that a Next Hop Server (NHS), Next Hop Client (NHC), or a Next Hop Peer (NHP) is up or down. The severity level for these messages is set to critical.
- NHRP resolution events. For example, when a spoke sends a resolution to a remote spoke, or when an NHRP resolution times out without receiving a response. The severity level for these messages is set to informational.
- DMVPN cryptography events. For example, when a DMVPN socket entry changes from open to closed, or from closed to open. The severity level for these messages is set to notification.
- NHRP error notifications. For example, when an NHRP registration or resolution event fails, when a system check event fails, or when an NHRP encapsulation error occurs, an NHRP error notification is displayed. The severity level for these messages is set to errors.
  A sample NHRP error message is given below:

  Received Error Indication from 209.165.200.226, code: administratively prohibited(4), (trigger src: 209.165.200.228 (nbma: 209.165.200.230) dst: 209.165.202.140), offset: 0, data: 00 01 08 00 00 00 00 00 00 FE 00 68 F4 03 00 34

  The error message includes the IP address of the node where the error originates, the source nonbroadcast multiaccess (NBMA), and the destination address.
- DMVPN error notifications. For example, when the NET_ID value is not configured, or when an NHRP multicast replication failure occurs. The severity level is set to notification for the unconfigured NET_ID value message, and set to errors if an NHRP multicast replication failure occurs.
- The rate limit set for NHRP packets on the interface is exceeded. This event occurs when the NHRP packets handled by the NHRP process exceeds the rate limit set on the interface. The severity level for this message is set to warning.

Interface State Control

The Interface State Control feature allows NHRP to control the state of the interface based on whether the tunnels on the interface are live. If NHRP detects that all NHSs configured on the interface are in the down

state, NHRP can change the interface state to down. However, if NHRP detects that any one of the NHSs configured on the interface is up, then it can change the state of the interface to up.

When the NHRP changes the interface state, other Cisco services can react to the state change, for example:

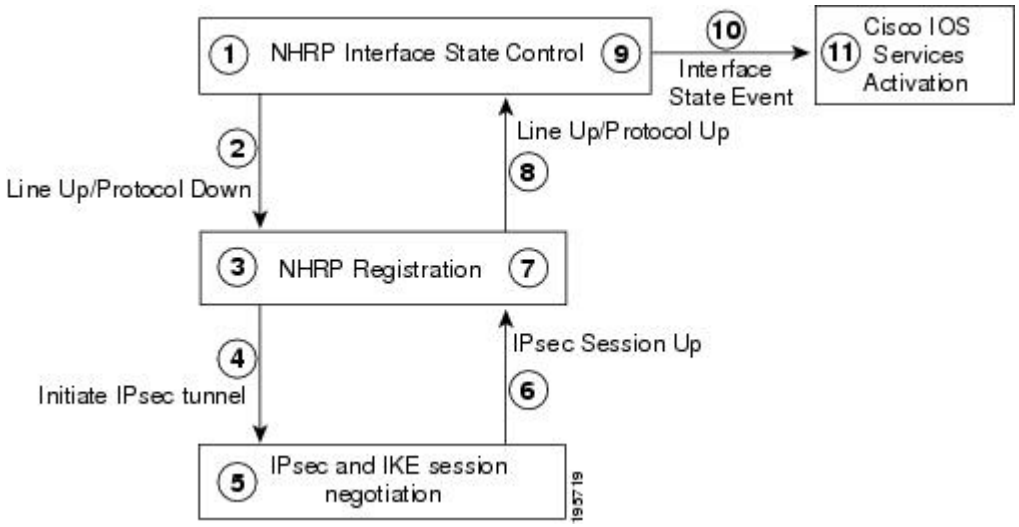
- If the interface state changes, the generic routing and encapsulation (GRE) interface generates IF-MIB notifications (traps) that report a LinkUp or LinkDown message. The system uses these traps to monitor the connectivity to the DMVPN cloud.
- If the interface state changes to down, the Cisco IOS backup interface feature can be initiated to allow the system to use another interface to provide an alternative path to the failed primary path.
- If the interface state changes to down, the system generates an update that is sent to all dynamic routing protocols. The Interface State Control feature a failover mechanism for dynamic routing when the multipoint GRE (mGRE) interface is down.
- If the interface state changes to down, the system clears any static routes that use the mGRE interface as the next hop. The Interface State Control feature provides a failover mechanism for routing when the mGRE interface is down.

The interface state control feature works on both point-to-point and mGRE interfaces.

Interface State Control Configuration Workflow

The diagram below illustrates how the system behaves when the Interface State Control feature is initialized.

Figure 6: Interface State Control Configuration Initialization Workflow



The Interface State Control initialization works as follows:

1 The Interface State Control feature is enabled on the GRE interface with NHRP configured.

2 The system reevaluates the protocol state and changes the state to line up and protocol down if none of the configured NHSs is responding.

3 The line up state change initiates the NHRP registration process.

4 The NHRP registration process initiates the IPsec tunnel.

5 The IPsec tunnel initiation starts the IPsec and IKE tunnel negotiation process.

6 On successful completion of the tunnel negotiation process, the system sends an IPsec Session Up message.

7 The NHRP registration process receives the IPsec Session Up message.

8 The NHRP registration process reports the line up and protocol up state to the GRE interface.

9 The GRE interface state changes to line up and protocol up.

10 The system reports the GRE interface state change to Cisco software.

11 The state change triggers Cisco services, such as interface event notifications, syslog events, DHCP renew, IP route refresh, and SNMP traps.

How to Configure DMVPN Tunnel Health Monitoring and Recovery

The DMVPN Tunnel Health Monitoring and Recovery feature allows you to configure SNMP NHRP notifications and interface states.

Configuring Interfaces to Generate SNMP NHRP Notifications

You can configure an interface so that SNMP NHRP traps are generated for NHRP events. In addition, you can configure the system to send the traps to particular trap receivers. To configure SNMP NHRP notifications on an interface, perform the steps in this section.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server community** *string* **rw**
4. **snmp-server enable traps nhrp nhs**
5. **snmp-server enable traps nhrp nhc**
6. **snmp-server enable traps nhrp nhp**
7. **snmp-server enable traps nhrp quota-exceeded**
8. **snmp-server host** *ip-address* **version** *snmpversion community-string*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Device> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**snmp-server community** *string* **rw** **Example:** `Device(config)# snmp-server community public rw`	Configures the community access string to permit access to the SNMP.
Step 4	**snmp-server enable traps nhrp nhs** **Example:** `Device(config)# snmp-server enable traps nhrp nhc`	Enables NHRP NHS notifications.
Step 5	**snmp-server enable traps nhrp nhc** **Example:** `Device(config)# snmp-server enable traps nhrp nhc`	Enables NHRP NHC notifications.
Step 6	**snmp-server enable traps nhrp nhp** **Example:** `Device(config)# snmp-server enable traps nhrp nhc`	Enables NHRP NHP notifications.
Step 7	**snmp-server enable traps nhrp quota-exceeded** **Example:** `Device(config)# snmp-server enable traps nhrp quota-exceeded`	Enables notifications for when the rate limit set on the NHRP packets is exceeded on the interface.
Step 8	**snmp-server host** *ip-address* **version** *snmpversion community-string* **Example:** `Device(config)# snmp-server host 192.40.3.130 version 2c public`	Specifies the recipient of an SNMP notification operation. • By default, SNMP notifications are sent as traps. • All NHRP traps are sent to the notification receiver with the IP address 192.40.3.130 using the community string public.

	Command or Action	Purpose
Step 9	**end** **Example:** `Device(config)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Troubleshooting Tips

Use the **debug snmp mib nhrp** command to troubleshoot SNMP NHRP notifications.

Configuring Interface State Control on an Interface

The Interface State Control feature enables the system to control the state of an interface based on whether the DMVPN tunnels connected to the interface are live or not. To configure interface state control on an interface, perform the steps in this section.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **if-state nhrp**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface** *type number* **Example:** `Device(config)# interface tunnel 1`	Configures an interface type and enters interface configuration mode.
Step 4	**if-state nhrp** **Example:** `Device(config-if)# if-state nhrp`	Enables NHRP to control the state of the tunnel interface.
Step 5	**end** **Example:** `Device(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Configuration Examples for DMVPN Tunnel Health Monitoring and Recovery

Example: Configuring SNMP NHRP Notifications

The following example shows how to configure SNMP NHRP notifications on a hub or spoke:

```
Device(config)# snmp-server community public rw
Device(config)# snmp-server enable traps nhrp nhs
Device(config)# snmp-server enable traps nhrp nhc
Device(config)# snmp-server enable traps nhrp nhp
Device(config)# snmp-server enable traps nhrp quota-exceeded
Device(config)# snmp-server host 209.165.200.226 version 2c public
```

Example: Configuring Interface State Control

The following example shows how to configure the Interface State Control feature for a spoke:

```
interface Tunnel 1
 ip address 209.165.200.228 255.255.255.0
 no ip redirects
 ip nhrp authentication cisco
 ip nhrp map 209.165.201.2 209.165.201.10
 ip nhrp map 209.165.201.3 209.165.201.11
 ip nhrp map multicast 209.165.201.10
 ip nhrp map multicast 209.165.201.11
 ip nhrp network-id 1
 ip nhrp holdtime 90
```

```
 ip nhrp nhs 209.165.201.3
 ip nhrp nhs 209.165.201.2
 ip nhrp shortcut
 if-state nhrp
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
 !
end
```

Additional References for DMVPN Tunnel Health Monitoring and Recovery

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
Dynamic Multipoint VPN information	"Dynamic Multipoint VPN (DMVPN)" module in the *Cisco IOS Security Configuration Guide: Secure Connectivity*
IKE configuration tasks such as defining an IKE policy	"Configuring Internet Key Exchange for IPsec VPNs" module in the *Cisco IOS Security Configuration Guide: Secure Connectivity*
IPsec configuration tasks	"Configuring Security for VPNs with IPsec" module in the *Cisco IOS Security Configuration Guide: Secure Connectivity*
System messages	*System Messages Guide*

Standards and RFCs

Standard/RFC	Title
RFC 2332	*NBMA Next Hop Resolution Protocol (NHRP)*
RFC 2677	*Definitions of Managed Objects for the NBMA Next Hop Resolution Protocol (NHRP)*

MIBs

MIB	MIBs Link
• CISCO-NHRP-EXT-MIB • NHRP-MIB	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

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 DMVPN Tunnel Health Monitoring and Recovery

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

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Table 3: Feature Information for Tunnel Health Monitoring and Recovery

Feature Name	Releases	Feature Information
DMVPN—Tunnel Health Monitoring and Recovery (Interface Line Control)		The DMVPN—Tunnel Health Monitoring and Recovery (Interface Line Control) feature enables NHRP to control the state of the tunnel interface based on the health of the DMVPN tunnels. The following command was introduced: **if-state nhrp**.