IPsec VPN High Availability Enhancements

The IPsec VPN High Availability Enhancements feature: Reverse Route Injection (RRI) and Hot Standby Router Protocol (HSRP) with IPsec. When used together, these two features provide you with a simplified network design for VPNs and reduced configuration complexity on remote peers when defining gateway lists.

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 at the end of this module.

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.

Information About IPsec VPN High Availability Enhancements

Reverse Route Injection

Reverse Route Injection (RRI) simplifies network design for Virtual Private Networks (VPNs) in which there is a requirement for redundancy or load balancing. RRI works with both dynamic and static crypto maps.

RRI provides the following benefits:

- Enables routing of IPsec traffic to a specific VPN headend device in environments that have multiple (redundant) VPN headend devices.
- Ensures predictable failover time of remote sessions between headend devices when using IKE keepalives, especially in environments in which remote device route flapping is common (not taking into consideration the effects of route convergence, which may vary depending on the routing protocol used and the size of the network).
- Eliminates the need for the administration of static routes on upstream devices, as routes are dynamically learned by these devices.

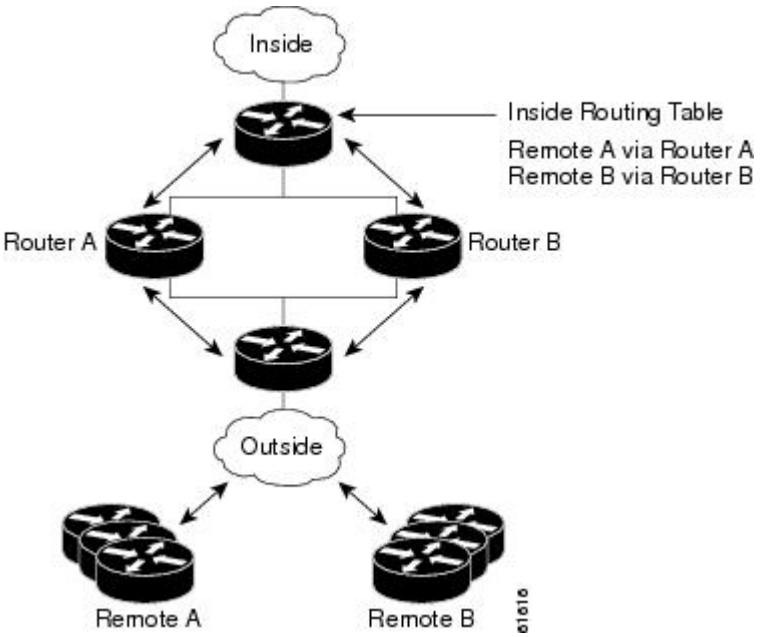
In the dynamic case, as remote peers establish IPsec security associations (SAs) with an RRI-enabled router, a static route is created for each subnet or host protected by that remote peer. For static crypto maps, a static route is created for each destination of an extended access list rule. When RRI is used on a static crypto map with an access control list (ACL), routes will always exist, even without the negotiation of IPsec SAs.

Note The use of any keyword in ACLs with RRI is not supported.

When routes are created, they are injected into any dynamic routing protocol and distributed to surrounding devices. This traffic flows, requiring IPsec to be directed to the appropriate RRI router for transport across the correct SAs to avoid IPsec policy mismatches and possible packet loss.

The figure below shows an RRI configuration functionality topology. Remote A is being serviced by Router A and Remote B connected to Router B, providing load balancing across VPN gateways at the central site. RRI on the central site devices ensures that the other router on the inside of the network can automatically make the correct forwarding decision. RRI also eliminates the need to administer static routes on the inside router.

Figure 1: Topology Showing Reverse Route Injection Configuration Functionality



Hot Standby Router Protocol and IPsec

Hot Standby Router Protocol (HSRP) provides high network availability by routing IP traffic from hosts on Ethernet networks without relying on the availability of any single router. HSRP is particularly useful for hosts that do not support a router discovery protocol, such as ICMP Router Discovery Protocol (IRDP) and do not have the functionality to switch to a new router when their selected router reloads or loses power. Without this functionality, a router that loses its default gateway because of a router failure cannot communicate with the network.

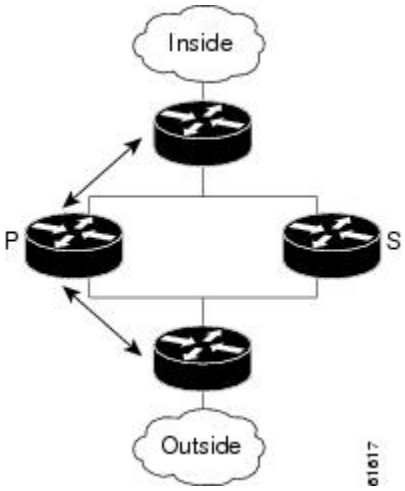
HSRP is configurable on LAN interfaces using standby command-line interface (CLI) commands. You can to use the standby IP address from an interface as the local IPsec identity or local tunnel endpoint.

By using the standby IP address as the tunnel endpoint, failover can be applied to VPN routers by using HSRP. Remote VPN gateways connect to the local VPN router via the standby address that belongs to the active device in the HSRP group. In the event of failover, the standby device takes over ownership of the standby IP address and begins to service remote VPN gateways.

Failover can be applied to VPN routers through the use of HSRP. Remote VPN gateways connect to the local VPN router through the standby address that belongs to the active device in the HSRP group. This functionality reduces configuration complexity on remote peers with respect to defining gateway lists, because only the HSRP standby address needs to be defined.

The figure below shows the enhanced HSRP functionality topology. Traffic is serviced by the active Router P, which is the active device in the standby group. In the event of failover, traffic is diverted to Router S, which is the original standby device. Router S assumes the role of the new active router and takes ownership of the standby IP address.

Figure 2: Topology Showing Hot Standby Router Protocol Functionality



Note In case of a failover, HSRP does not facilitate IPsec state information transference between VPN routers. This means that without this state transference, SAs to remotes will be deleted, requiring Internet Key Exchange (IKE) and IPsec SAs to be reestablished. To make IPsec failover more efficient, it is recommended that IKE keepalives be enabled on all routers.

How to Configure IPsec VPN High Availability Enhancements

Configuring Reverse Route Injection on a Dynamic Crypto Map

Dynamic crypto map entries, like regular static crypto map entries, are grouped into sets. A set is a group of dynamic crypto map entries all with the same dynamic map name, but each with a different dynamic sequence number. Each member of the set may be configured for RRI.

To create a dynamic crypto map entry and enable RRI, perform the steps in this section.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto dynamic-map** *map-name seq-num*
4. **set transform-set**
5. **reverse-route**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**crypto dynamic-map** *map-name seq-num* **Example:** `Router(config)# crypto dynamic-map mymap`	Creates a dynamic crypto map entry and enters crypto map configuration mode.
Step 4	**set transform-set** **Example:** `Router(config-crypto-m)#set transform-set`	Specifies which transform sets are allowed for the crypto map entry. Lists multiple transform sets in order of priority (highest priority first). This entry is the only configuration statement required in dynamic crypto map entries.
Step 5	**reverse-route** **Example:** `Router(config-crypto-m)#reverse-route`	Creates source proxy information.

Configuring Reverse Route Injection on a Static Crypto Map

Before configuring RRI on a static crypto map, note that:

- Routes are not created based on access list 102, as reverse-route is not enabled on mymap 2. RRI is not enabled by default and is not displayed in the router configuration.
- Enable a routing protocol to distribute the VPN routes to upstream devices.
- If Cisco Express Forwarding (CEF) is run on a VPN router configured for RRI, adjacencies need to be formed for each RRI injected network through the next hop device. As the next hop is not explicitly defined in the routing table for these routes, proxy-ARP should be enabled on the next hop router, which allows the CEF adjacency to be formed using the Layer 2 addresses of that device. In cases where there are many RRI injected routes, adjacency tables may become quite large, as an entry is created for each device from each of the subnets represented by the RRI route.

To add RRI to a static crypto map set, perform the steps in this section.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto map** *map-name seq-num* **ipsec-isakmp**
4. **set peer** *ip-address*
5. **reverse-route**
6. **match address**
7. **set transform-set** *transform-set-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**crypto map** *map-name seq-num* **ipsec-isakmp** **Example:** `Router(config)#crypto map mymap 3 ipsec-isakmp`	Adds a dynamic crypto map set to a static crypto map set and enters interface configuration mode.
Step 4	**set peer** *ip-address* **Example:** `Router(config-if)#set peer 209.165.200.248`	Specifies an IPsec peer IP address in a crypto map entry.

	Command or Action	Purpose
Step 5	**reverse-route** **Example:** `Router (config-if)#reverse-route`	Creates dynamic static routes based on crypto access control lists (ACLs).
Step 6	**match address** **Example:** `Router(config-if)# match address`	Specifies an extended access list for a crypto map entry.
Step 7	**set transform-set** *transform-set-name* **Example:** `Router (config-if)# set transform-set my_t_set1`	Specifies which transform sets are allowed for the crypto map entry. List multiple transform sets in order of priority (highest priority first).

Configuring HSRP with IPsec

When configuring HSRP with IPsec, the following conditions may apply:

- When HSRP is applied to a crypto map on an interface, the crypto map must be reapplied if the standby IP address or the standby name is changed on that interface.
- If HSRP is applied to a crypto map on an interface, and you delete the standby IP address or the standby name from that interface, the crypto tunnel endpoint is reinitialized to the actual IP address of that interface.
- If you add the standby IP address and the standby name to an interface with the requirement IPsec failover, the crypto map must be reapplied with the appropriate redundancy information.
- Standby priorities should be equal on active and standby routers. If they are not, the higher priority router takes over as the active router. If the old active router comes back up and immediately assumes the active role before having time to report itself, standby and sync connections will be dropped.
- The IP addresses on the HSRP-tracked interfaces on the standby and active routers should both be either lower or higher on one router than the other. In the case of equal priorities (an HA requirement), HSRP will assign the active state-based IP address. If an addressing scheme exists so that the public IP address of router A is lower than the public IP address of router B, but the opposite is true for their private interfaces, an active/standby-standby/active split condition could exist, which will break connectivity.

Note To configure HSRP without IPsec, refer to the "Configuring IP Services" module in the *IP Application Services Configuration Guide*.

To apply a crypto map set to an interface, perform the steps in this section.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **interface** *type slot / port*
4. **standby name** *group-name*
5. **standby ip** *ip-address*
6. **crypto map** *map-name* **redundancy** [*standby-name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router#configure terminal`	Enters global configuration mode.
Step 3	**interface** *type slot / port* **Example:** `Router(config)#interface GigabitEthernet 0/0`	Specifies an interface and enters interface configuration mode.
Step 4	**standby name** *group-name* **Example:** `Router(config-if)#standby name mygroup`	Specifies the standby group name.
Step 5	**standby ip** *ip-address* **Example:** `Router(config-if)#standby ip 209.165.200.249`	Specifies the IP address of the standby groups • This command is required for one device in the group.
Step 6	**crypto map** *map-name* **redundancy** [*standby-name*] **Example:** `Router (config-if)#crypto map mymap redundancy`	Specifies the IP redundancy address as the tunnel endpoint for IPsec.

Verifying VPN IPsec Crypto Configuration

SUMMARY STEPS

1. **enable**
2. **show crypto ipsec transform-set**
3. **show crypto map** [**interface** *interface* | **tag** *map-name*]

4. **show crypto ipsec sa** [**map** *map-name* | **address** | **identity**] [**detail**]
5. **show crypto dynamic-map** [**tag** *map-name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show crypto ipsec transform-set** **Example:** `Router#show crypto ipsec transform-set`	Displays the transform set configuration.
Step 3	**show crypto map** [**interface** *interface*	**tag** *map-name*] **Example:** `Router#show crypto map tag mycryptomap`	Displays your crypto map configuration.
Step 4	**show crypto ipsec sa** [**map** *map-name*	**address**	**identity**] [**detail**] **Example:** `Router#show crypto ipsec sa address detail`	Displays information about IPsec SAs.
Step 5	**show crypto dynamic-map** [**tag** *map-name*] **Example:** `Router#show crypto dynamic-map tag mymap`	Displays information about dynamic crypto maps.

Configuration Examples for IPsec VPN High Availability Enhancements

Example: Configuring Reverse Route Injection on a Dynamic Crypto Map

In the following example, using the **reverse-route** command in the definition of the dynamic crypto map template ensures that routes are created for any remote proxies (subnets or hosts), protected by the connecting remote IPsec peers.

```
crypto dynamic mydynmap 1
 set transform-set my-transform-set
 reverse-route
```

This template is then associated with a “parent” crypto map statement and then applied to an interface.

```
crypto map mymap 3 ipsec-isakmp dynamic mydynmap
 interface FastEthernet 0/0
 crypto map mymap
```

Example: Configuring Reverse Route Injection on a Static Crypto Map

RRI is a good solution for topologies that require encrypted traffic to be diverted to a VPN router and all other traffic to a different router. In these scenarios, RRI eliminates the need to manually define static routes on devices.

RRI is not required if a single VPN router is used, and all traffic passes through the VPN router during its path in to and out of the network.

If you choose to manually define static routes on the VPN router for remote proxies and have these routes permanently installed in the routing table, RRI should not be enabled on the crypto map instance that covers the same remote proxies. In this case, there is no possibility of user-defined static routes being removed by RRI.

Routing convergence can affect the success of a failover based on the routing protocol used to advertise routes (link state versus periodic update). We recommend that a link state routing protocol such as OSPF be used to help speed convergence time by ensuring that routing updates are sent as soon as a change in routing state is detected.

In the following example, RRI is enabled for mymap 1, but not for mymap 2. Upon the application of the crypto map to the interface, a route is created based on access-list 101 analogous to the following:

```
IP route 172.17.11.0 255.255.255.0 FastEthernet 0/0
crypto map mymap 1 ipsec-isakmp
 set peer 172.17.11.1
 reverse-route
 set transform-set my-transform-set
 match address 101
crypto map mymap 2 ipsec-isakmp
 set peer 10.1.1.1
 set transform-set my-transform-set
 match address 102
access-list 101 permit ip 192.168.1.0 0.0.0.255 172.17.11.0 0.0.0.255
access-list 102 permit ip 192.168.1.0 0.0.0.255 10.0.0.0 0.0.255.255
interface FastEthernet 0/0
 crypto map mymap
```

Example: Configuring HSRP with IPsec

The following example shows how all remote VPN gateways connect to the router via 192.168.0.3. The crypto map on the interface binds this standby address as the local tunnel endpoint for all instances of the crypto map named *mymap* and at the same time ensures that HSRP failover is facilitated between an active and standby device belonging to the same standby group named group1.

Note that RRI also provides the ability for only the active device in the HSRP group to be advertising itself to inside devices as the next hop VPN gateway to the remote proxies. If there is a failover, routes are deleted on the formerly active device and created on the newly active device.

```
crypto map mymap 1 ipsec-isakmp
 set peer 10.1.1.1
 reverse-route
```

```
 set transform-set esp-aes-sha
 match address 102
Interface FastEthernet 0/0
 ip address 192.168.0.2 255.255.255.0
 standby name group1
 standby ip 192.168.0.3
 crypto map mymap redundancy group1
access-list 102 permit ip 192.168.1.0 0.0.0.255 10.0.0.0 0.0.255.255
```

The standby name needs to be configured on all devices in the standby group, and the standby address needs to configured on at least one member of the group. If the standby name is removed from the router, the IPsec SAs will be deleted. If the standby name is added again, regardless of whether the same name or a different name is used, the crypto map (using the redundancy option) will have to be reapplied to the interface.

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
Configuring HSRP without IPsec	"Configuring IP Services" module in the *IP Application Services Configuration Guide*
Configuring stateful failover for IP security (IPsec)	"Stateful Failover for IPsec" module in the *Security Configuration Guide: Secure Connectivity*
Recommended cryptographic algorithms	Next Generation Encryption

MIBs

MIB	MIBs Link
None	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

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 IPsec VPN High Availability Enhancements

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 IPsec VPN High Availability Enhancements

Feature Name	Releases	Feature Information
IPsec VPN High Availability Enhancements	Cisco IOS XE 3.1.0S	The IPsec VPN High Availability Enhancements feature consists of two features:Reverse Route Injection (RRI) and Hot Standby Router Protocol (HSRP) with IPsec. When used together, these two features provide you with a simplified network design for VPNs and reduced configuration complexity on remote peers when defining gateway lists. The following commands were introduced or modified: **crypto map** (interface IPsec), **reverse-route**.