# Implementing IPsec in IPv6 Security

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Cisco IOS IPv6 security features for your Cisco networking devices can protect your network against degradation or failure and also against data loss or compromise resulting from intentional attacks and from unintended but damaging mistakes by well-meaning network users.

Cisco IOS IPsec functionality provides network data encryption at the IP packet level, offering robust, standards-based security. IPsec provides data authentication and antireplay services in addition to data confidentiality services.

IPsec is a mandatory component of IPv6 specification. IPv6 IPsec tunnel mode and encapsulation is used to protect IPv6 unicast and multicast traffic. This document provides information about implementing IPsec in IPv6 security.



## 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 Implementing IPsec for IPv6 Security




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# IPsec for IPv6

IP Security, or IPsec, is a framework of open standards developed by the Internet Engineering Task Force (IETF) that provide 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. IPsec provides the following optional network security services. In general, local security policy will dictate the use of one or more of these services:

- Data confidentiality--The IPsec sender can encrypt packets before sending them across a network.
- Data integrity--The IPsec receiver can authenticate packets sent by the IPsec sender to ensure that the data has not been altered during transmission.
- Data origin authentication--The IPsec receiver can authenticate the source of the IPsec packets sent. This service depends upon the data integrity service.
- Antireplay--The IPsec receiver can detect and reject replayed packets.

With IPsec, data can be sent across a public network without observation, modification, or spoofing. IPsec functionality is similar in both IPv6 and IPv4; however, site-to-site tunnel mode only is supported in IPv6.

In IPv6, IPsec is implemented using the AH authentication header and the ESP extension header. The authentication header provides integrity and authentication of the source. It also provides optional protection against replayed packets. The authentication header protects the integrity of most of the IP header fields and authenticates the source through a signature-based algorithm. The ESP header provides confidentiality, authentication of the source, connectionless integrity of the inner packet, antireplay, and limited traffic flow confidentiality.

The Internet Key Exchange (IKE) protocol is a key management protocol standard that is used in conjunction with IPsec. IPsec can be configured without IKE, but IKE enhances IPsec by providing additional features, flexibility, and ease of configuration for the IPsec standard.

IKE is a hybrid protocol that implements the Oakley key exchange and Skeme key exchange inside the Internet Security Association Key Management Protocol (ISAKMP) framework (ISAKMP, Oakley, and Skeme are security protocols implemented by IKE) (see the figure below). This functionality is similar to the security gateway model using IPv4 IPsec protection.

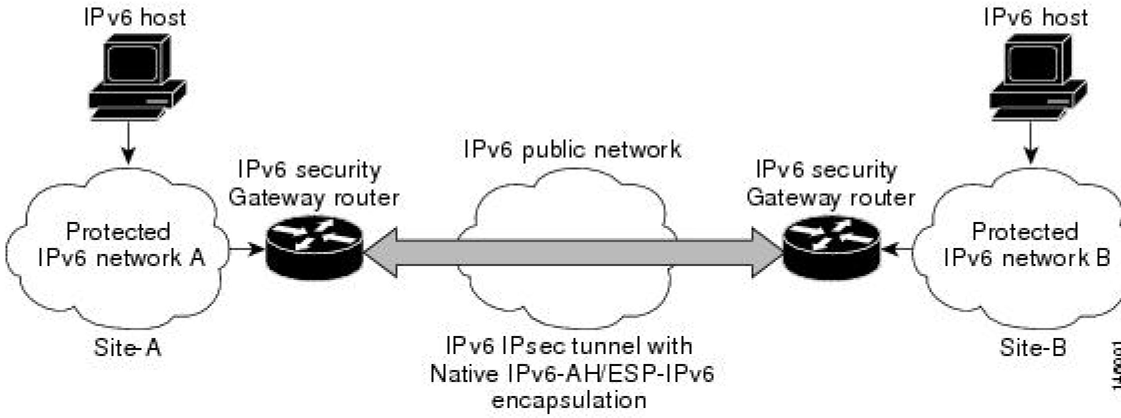


## IPv6 IPsec Site-to-Site Protection Using Virtual Tunnel Interface

The IPsec virtual tunnel interface (VTI) provides site-to-site IPv6 crypto protection of IPv6 traffic. Native IPv6 IPsec encapsulation is used to protect all types of IPv6 unicast and multicast traffic.

The IPsec VTI allows IPv6 routers to work as security gateways, establish IPsec tunnels between other security gateway routers, and provide crypto IPsec protection for traffic from internal networks when it is sent across the public IPv6 Internet (see the figure below). This functionality is similar to the security gateway model using IPv4 IPsec protection.

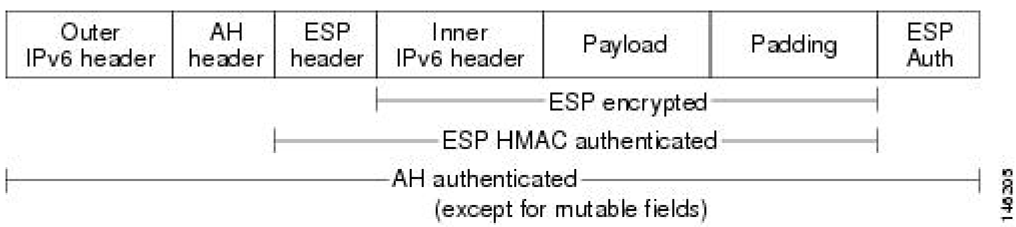
***Figure 1 IPsec Tunnel Interface for IPv6***




When the IPsec tunnel is configured, IKE and IPsec security associations (SAs) are negotiated and set up before the line protocol for the tunnel interface is changed to the UP state. The remote IKE peer is the same as the tunnel destination address; the local IKE peer will be the address picked from tunnel source interface which has the same IPv6 address scope as tunnel destination address.

The following figures shows the IPsec packet format.

***Figure 2 IPv6 IPsec Packet Format***




# IPv6 over IPv4 GRE Tunnel Protection

The IPv6 over IPv4 GRE tunnel protection feature allows both IPv6 unicast and multicast traffic to go through a protected GRE tunnel.

- GRE Tunnels with IPsec, page 3

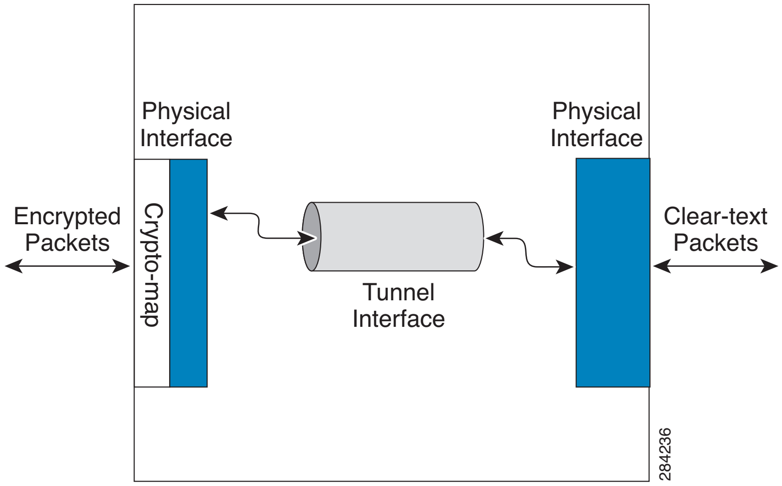
## GRE Tunnels with IPsec

Generic routing encapsulation (GRE) tunnels sometimes are combined with IPSec, because IPSec does not support IPv6 multicast packets. This function prevents dynamic routing protocols from running successfully over an IPSec VPN network. Because GRE tunnels do support IPv6 multicast , a dynamic routing protocol can be run over a GRE tunnel. Once a dynamic routing protocol is configured over a GRE tunnel, you can encrypt the GRE IPv6 multicast packets using IPSec.

IPSec can encrypt GRE packets using a crypto map or tunnel protection. Both methods specify that IPSec encryption is performed after GRE encapsulation is configured. When a crypto map is used, encryption is applied to the outbound physical interfaces for the GRE tunnel packets. When tunnel protection is used, encryption is configured on the GRE tunnel interface.

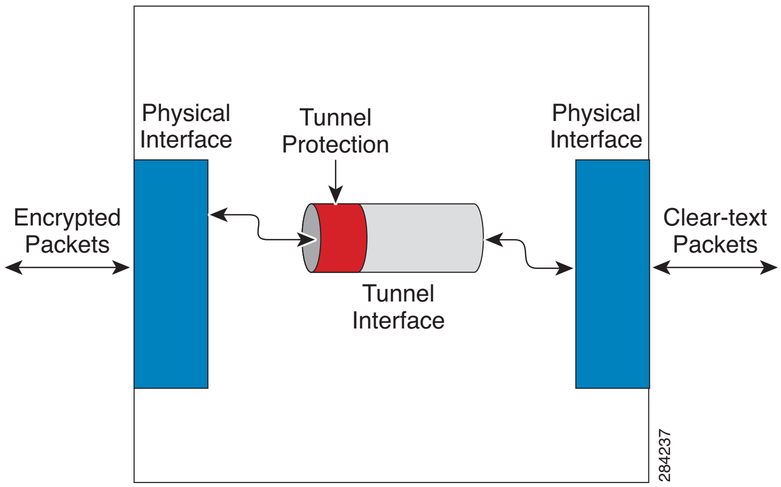
The following figure shows encrypted packets that enter a router through a GRE tunnel interface using a crypto map on the physical interface. Once the packets are decrypted and decapsulated, they continue to their IP destination as clear text.

*Figure 3* ***Using a Crypto Map to Configure IPv6 over IPv4 GRE Tunnel Encryption***




The following figure shows encryption using tunnel protection command on the GRE tunnel interface. The encrypted packets enter the router through the tunnel interface and are decrypted and decapsulated before they continue to their destination as clear text.

*Figure 4* ***Using Tunnel Protection to Configure IPv6 over IPv4 GRE Tunnel Encryption***




There are two key differences in using the crypto map and tunnel protection methods:

- The IPSec crypto map is tied to the physical interface and is checked as packets are forwarded out through the physical interface. At this point, the GRE tunnel has already encapsulated the packet.

- Tunnel protection ties the encryption functionality to the GRE tunnel and is checked after the packet is GRE encapsulated but before the packet is handed to the physical interface.

# How to Implement IPsec for IPv6 Security



## Configuring a VTI for Site-to-Site IPv6 IPsec Protection



### Defining an IKE Policy and a Preshared Key in IPv6

Because IKE negotiations must be protected, each IKE negotiation begins by agreement of both peers on a common (shared) IKE policy. This policy states which security parameters will be used to protect subsequent IKE negotiations and mandates how the peers are authenticated.

After the two peers agree upon a policy, the security parameters of the policy are identified by an SA established at each peer, and these SAs apply to all subsequent IKE traffic during the negotiation.

You can configure multiple, prioritized policies on each peer--each with a different combination of parameter values. However, at least one of these policies must contain exactly the same encryption, hash, authentication, and Diffie-Hellman parameter values as one of the policies on the remote peer. For each policy that you create, you assign a unique priority (1 through 10,000, with 1 being the highest priority).

**Note** If you are interoperating with a device that supports only one of the values for a parameter, your choice is limited to the value supported by the other device. Aside from this limitation, there is often a trade-off between security and performance, and many of these parameter values represent such a trade-off. You should evaluate the level of security risks for your network and your tolerance for these risks.

When the IKE negotiation begins, IKE searches for an IKE policy that is the same on both peers. The peer that initiates the negotiation will send all its policies to the remote peer, and the remote peer will try to find a match. The remote peer looks for a match by comparing its own highest priority policy against the policies received from the other peer. The remote peer checks each of its policies in order of its priority (highest priority first) until a match is found.

A match is made when both policies from the two peers contain the same encryption, hash, authentication, and Diffie-Hellman parameter values, and when the remote peer’s policy specifies a lifetime that is less than or equal to the lifetime in the policy being compared. (If the lifetimes are not identical, the shorter lifetime--from the remote peer’s policy--will be used.)

If a match is found, IKE will complete negotiation, and IPsec security associations will be created. If no acceptable match is found, IKE refuses negotiation and IPsec will not be established.

**Note** Depending on which authentication method is specified in a policy, additional configuration might be required. If a peer's policy does not have the required companion configuration, the peer will not submit the policy when attempting to find a matching policy with the remote peer.

You should set the ISAKMP identity for each peer that uses preshared keys in an IKE policy.

When two peers use IKE to establish IPsec SAs, each peer sends its identity to the remote peer. Each peer sends either its hostname or its IPv6 address, depending on how you have set the ISAKMP identity of the router.

By default, a peer's ISAKMP identity is the IPv6 address of the peer. If appropriate, you could change the identity to be the peer's hostname instead. As a general rule, set the identities of all peers the same way--either all peers should use their IPv6 addresses or all peers should use their hostnames. If some peers use their hostnames and some peers use their IPv6 addresses to identify themselves to each other, IKE negotiations could fail if the identity of a remote peer is not recognized and a DNS lookup is unable to resolve the identity.

Perform this task to create an IKE policy and a preshared key in IPv6.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto isakmp policy** *priority*
4. **authentication** {**rsa-sig** | **rsa-encr** | **pre-share**}
5. **hash** {**sha** | **md5**}
6. **group** {**1** | **2** | **5**}
7. **encryption** {**des** | **3des** | **aes** | **aes 192** | **aes 256**}
8. **lifetime** *seconds*
9. **exit**
10. **crypto isakmp key** password-type keystring *keystring {* **address** *peer-address*| **ipv6** {*ipv6-address* / *ipv6-prefix*} | **hostname** *hostname} [* **no-xauth** *]*
11. **crypto keyring** *keyring-name* [**vrf** *fvrf-name*]
12. **pre-shared-key** {**address** *address* [*mask*] | **hostname** *hostname* | **ipv6** {*ipv6-address* | *ipv6-prefix*}} **key** *key*

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br><br>**Example:**<br><br>`Router> enable` | Enables privileged EXEC mode.<br><br>• Enter your password if prompted. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 2** | **configure terminal**<br><br>**Example:**<br><br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **crypto isakmp policy** *priority*<br><br>**Example:**<br><br>`Router(config)# crypto isakmp policy 15` | Defines an IKE policy, and enters ISAKMP policy configuration mode.<br><br>• Policy number 1 indicates the policy with the highest priority. The smaller the *priority* argument value, the higher the priority. |
| **Step 4** | **authentication** {**rsa-sig** \| **rsa-encr** \| **pre-share**}<br><br>**Example:**<br><br>`Router(config-isakmp-policy)# authentication pre-share` | Specifies the authentication method within an IKE policy.<br><br>• The **rsa-sig** and **rsa-encr** keywords are not supported in IPv6. |
| **Step 5** | **hash** {**sha** \| **md5**}<br><br>**Example:**<br><br>`Router(config-isakmp-policy)# hash md5` | Specifies the hash algorithm within an IKE policy. |
| **Step 6** | **group** {**1** \| **2** \| **5**}<br><br>**Example:**<br><br>`Router(config-isakmp-policy)# group 2` | Specifies the Diffie-Hellman group identifier within an IKE policy. |
| **Step 7** | **encryption** {**des** \| **3des** \| **aes** \| **aes 192** \| **aes 256**}<br><br>**Example:**<br><br>`Router(config-isakmp-policy)# encryption 3des` | Specifies the encryption algorithm within an IKE policy. |
| **Step 8** | **lifetime** *seconds*<br><br>**Example:**<br><br>`Router(config-isakmp-policy)# lifetime 43200` | Specifies the lifetime of an IKE SA.<br><br>• Setting the IKE lifetime value is optional. |

| | Command or Action | Purpose |
|---|---|---|
| Step 9 | **exit**<br><br>**Example:**<br><br>`Router(config-isakmp-policy)# exit` | Exits ISAKMP policy configuration mode and enter global configuration mode. |
| Step 10 | **crypto isakmp key** password-type keystring *keystring {* **address** *peer-address*\| **ipv6** {*ipv6-address* / *ipv6-prefix*} \| **hostname** *hostname} [* **no-xauth** *]*<br><br>**Example:**<br><br>`Router(config)# crypto isakmp key 0 my-preshare-key-0 address ipv6 3ffe:1001::2/128` | Configures a preshared authentication key. |
| Step 11 | **crypto keyring** *keyring-name* [**vrf** *fvrf-name*]<br><br>**Example:**<br><br>`Router(config)# crypto keyring keyring1` | Defines a crypto keyring to be used during IKE authentication and enters config-keyring mode. |
| Step 12 | **pre-shared-key** {**address** *address* [*mask*] \| **hostname** *hostname* \| **ipv6** {*ipv6-address* \| *ipv6-prefix*}} **key** *key*<br><br>**Example:**<br><br>`Router (config-keyring)# pre-shared-key ipv6 3FFE: 2002::A8BB:CCFF:FE01:2C02/128` | Defines a preshared key to be used for IKE authentication. |

## Configuring ISAKMP Aggressive Mode

You likely do not need to configure aggressive mode in a site-to-site scenario. The default mode is typically used.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto isakmp peer** {**address** {*ipv4-address* | **ipv6** *ipv6-address ipv6-prefix-length*} | **hostname** *fqdn-hostname*}
4. **set aggressive-mode client-endpoint** {*client-endpoint* | **ipv6** *ipv6-address*}
5. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| Step 1 | **enable**<br><br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| Step 2 | **configure terminal**<br><br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| Step 3 | **crypto isakmp peer** {**address** {*ipv4-address* \| **ipv6** *ipv6-address ipv6-prefix-length*} \| **hostname** *fqdn-hostname*}<br><br>**Example:**<br>`Router(config)# crypto isakmp peer address ipv6 3FFE:2002::A8BB:CCFF:FE01:2C02/128` | Enables an IPsec peer for IKE querying for tunnel attributes. |
| Step 4 | **set aggressive-mode client-endpoint** {*client-endpoint* \| **ipv6** *ipv6-address*}<br><br>**Example:**<br>`Router(config-isakmp-peer)# set aggressive mode client-endpoint ipv6 3FFE:2002::A8BB:CCFF:FE01:2C02/128` | Defines the remote peer's IPv6 address, which will be used by aggressive mode negotiation. The remote peer's address is usually the client side's end-point address. |
| Step 5 | **end**<br><br>**Example:**<br>`Router(config-isakmp-peer)# end` | Exits crypto ISAKMP peer configuration mode and returns to privileged EXEC mode. |

## Defining an IPsec Transform Set and IPsec Profile

Perform this task to define an IPsec transform set. A transform set is a combination of security protocols and algorithms that is acceptable to the IPsec routers.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto ipsec transform-set** *transform-set-name transform1* [*transform2*] [*transform3*] [*transform4*]
4. **crypto ipsec profile** *name*
5. **set transform-set** *transform-set-name* [*transform-set-name2...transform-set-name6*

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| Step 1 | **enable**<br><br>**Example:**<br><br>`Router> enable` | Enables privileged EXEC mode.<br><br>• Enter your password if prompted. |
| Step 2 | **configure terminal**<br><br>**Example:**<br><br>`Router# configure terminal` | Enters global configuration mode. |
| Step 3 | **crypto ipsec transform-set** *transform-set-name transform1* [*transform2*] [*transform3*] [*transform4*]<br><br>**Example:**<br><br>`Router(config)# crypto ipsec transform-set myset0 ah-sha-hmac esp-3des` | Defines a transform set, and places the router in crypto transform configuration mode. |
| Step 4 | **crypto ipsec profile** *name*<br><br>**Example:**<br><br>`Router(config)# crypto ipsec profile profile0` | Defines the IPsec parameters that are to be used for IPsec encryption between two IPsec routers. |
| Step 5 | **set transform-set** *transform-set-name* [*transform-set-name2...transform-set-name6*]<br><br>**Example:**<br><br>`Router (config-crypto-transform)# set-transform-set myset0` | Specifies which transform sets can be used with the crypto map entry. |

## Defining an ISAKMP Profile in IPv6

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto isakmp profile** *profile-name* [**accounting** *aaalist*
4. **self-identity** {**address** | **address ipv6**] | **fqdn** | **user-fqdn** *user-fqdn*}
5. **match identity** {**group** *group-name* | **address** {*address* [*mask*] [*fvrf*] | **ipv6** *ipv6-address*} | **host** *host-name* | **host domain** *domain-name* | **user** *user-fqdn* | **user domain** *domain-name*}
6. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br><br>**Example:**<br><br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br><br>**Example:**<br><br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **crypto isakmp profile** *profile-name* [**accounting** *aaalist*<br><br>**Example:**<br><br>`Router(config)# crypto isakmp profile profile1` | Defines an ISAKMP profile and audits IPsec user sessions. |
| **Step 4** | **self-identity** {**address** \| **address ipv6**] \| **fqdn** \| **user-fqdn** *user-fqdn*}<br><br>**Example:**<br><br>`Router(config-isakmp-profile)# self-identity address ipv6` | Defines the identity that the local IKE uses to identify itself to the remote peer. |
| **Step 5** | **match identity** {**group** *group-name* \| **address** {*address* [*mask*] [*fvrf*] \| **ipv6** *ipv6-address*} \| **host** *host-name* \| **host domain** *domain-name* \| **user** *user-fqdn* \| **user domain** *domain-name*}<br><br>**Example:**<br><br>`Router(config-isakmp-profile)# match identity address ipv6 3FFE:`<br>`2002::A8BB:CCFF:FE01:2C02/128` | Matches an identity from a remote peer in an ISAKMP profile. |

| | Command or Action | Purpose |
|---|---|---|
| Step 6 | **end**<br><br>**Example:**<br>`Router(config-isakmp-profile)# end` | Exits ISAKMP profile configuration mode and returns to privileged EXEC mode. |

## Configuring IPv6 IPsec VTI

Use the **ipv6 unicast-routing** command to enable IPv6 unicast routing.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 unicast-routing**
4. **interface tunnel** *tunnel-number*
5. **ipv6 address** *ipv6-address/prefix*
6. **ipv6 enable**
7. **tunnel source** {*ip-address* | *ipv6-address* | *interface-type interface-number*}
8. **tunnel destination** {*host-name* | *ip-address* | *ipv6-address*}
9. **tunnel mode** {**aurp** | **cayman** | **dvmrp** | **eon** | **gre** | **gre multipoint** | **gre ipv6** | **ipip** [**decapsulate-any**] | **ipsec ipv4** | **iptalk** | **ipv6** | **ipsec ipv6** | **mpls** | **nos** | **rbscp**}
10. **tunnel protection ipsec profile** *name* [**shared**]
11. **end**

### DETAILED STEPS

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

| | Command or Action | Purpose |
|---|---|---|
| **Step 3** | **ipv6 unicast-routing**<br><br>**Example:**<br><br>`Router(config)# ipv6 unicast-routing` | Enables IPv6 unicast routing. You only need to enable IPv6 unicast routing once, not matter how many interface tunnels you want to configure. |
| **Step 4** | **interface tunnel** *tunnel-number*<br><br>**Example:**<br><br>`Router(config)# interface tunnel 0` | Specifies a tunnel interface and number, and enters interface configuration mode. |
| **Step 5** | **ipv6 address** *ipv6-address/prefix*<br><br>**Example:**<br><br>`Router(config-if)# ipv6 address 3FFE:C000:0:7::/64 eui-64` | Provides an IPv6 address to this tunnel interface, so that IPv6 traffic can be routed to this tunnel. |
| **Step 6** | **ipv6 enable**<br><br>**Example:**<br><br>`Router(config-if)# ipv6 enable` | Enables IPv6 on this tunnel interface. |
| **Step 7** | **tunnel source** {*ip-address* \| *ipv6-address* \| *interface-type interface-number*}<br><br>**Example:**<br><br>`Router(config-if)# tunnel source ethernet0` | Sets the source address for a tunnel interface. |
| **Step 8** | **tunnel destination** {*host-name* \| *ip-address* \| *ipv6-address*}<br><br>**Example:**<br><br>`Router(config-if)# tunnel destination 2001:DB8:1111:2222::1` | Specifies the destination for a tunnel interface. |
| **Step 9** | **tunnel mode** {**aurp** \| **cayman** \| **dvmrp** \| **eon** \| **gre** \| **gre multipoint** \| **gre ipv6** \| **ipip** [**decapsulate-any**] \| **ipsec ipv4** \| **iptalk** \| i**pv6** \| **ipsec ipv6** \| **mpls** \| **nos** \| **rbscp**}<br><br>**Example:**<br><br>`Router(config-if)# tunnel mode ipsec ipv6` | Sets the encapsulation mode for the tunnel interface. For IPsec, only the **ipsec ipv6** keywords are supported. |

| | Command or Action | Purpose |
|---|---|---|
| Step 10 | **tunnel protection ipsec profile** *name* [**shared**]<br><br>**Example:**<br><br>`Router(config-if)# tunnel protection ipsec profile profile1` | Associates a tunnel interface with an IPsec profile. IPv6 does not support the **shared** keyword. |
| Step 11 | **end**<br><br>**Example:**<br><br>`Router(config-if)# end` | Exits interface configuration mode and returns to privileged EXEC mode. |

# Verifying IPsec Tunnel Mode Configuration

### SUMMARY STEPS

1. **show adjacency** [**summary** [*interface-type interface-number*]] | [**prefix**] [**interface** *interface-number*] [**connectionid** *id*] [**link** {**ipv4**| **ipv6** | **mpls**}] [**detail**]
2. **show crypto engine** {**accelerator** | **brief** | **configuration** | **connections** [**active** | **dh** | **dropped-packet** | **show**] | **qos**}
3. **show crypto ipsec sa** [**ipv6**] [*interface-type interface-number*] [**detailed**]
4. **show crypto isakmp peer** [**config** | **detail**]
5. **show crypto isakmp policy**
6. **show crypto isakmp profile** [**tag** *profilename* | **vrf** *vrfname*]
7. **show crypto map** [**interface** *interface* | **tag** *map-name*]
8. **show crypto session** [**detail**] | [**local** *ip-address* [**port** *local-port*] | [**remote** *ip-address* [**port** *remote-port*]] | **detail**] | **fvfr** *vrf-name* | **ivrf** *vrf-name*]
9. **show crypto socket**
10. **show ipv6 access-list** [*access-list-name*]
11. **show ipv6 cef** [*ipv6-prefix* / *prefix-length*] | [*interface-type interface-number*] [**longer-prefixes** | **similar-prefixes** | **detail** | **internal** | **platform** | **epoch** | **source**]]
12. **show interface** *type number* **stats**

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **show adjacency** [**summary** [*interface-type interface-number*]] \| [**prefix**] [**interface** *interface-number*] [**connectionid** *id*] [**link** {**ipv4**\| **ipv6** \| **mpls**}] [**detail**]<br><br>**Example:**<br>`Router# show adjacency detail` | Displays information about the Cisco Express Forwarding adjacency table or the hardware Layer 3-switching adjacency table. |
| **Step 2** | **show crypto engine** {**accelerator** \| **brief** \| **configuration** \| **connections** [**active** \| **dh** \| **dropped-packet** \| **show**] \| **qos**}<br><br>**Example:**<br>`Router# show crypto engine connection active` | Displays a summary of the configuration information for the crypto engines. |
| **Step 3** | **show crypto ipsec sa** [**ipv6**] [*interface-type interface-number*] [**detailed**]<br><br>**Example:**<br>`Router# show crypto ipsec sa ipv6` | Displays the settings used by current SAs in IPv6. |
| **Step 4** | **show crypto isakmp peer** [**config** \| **detail**]<br><br>**Example:**<br>`Router# show crypto isakmp peer detail` | Displays peer descriptions. |
| **Step 5** | **show crypto isakmp policy**<br><br>**Example:**<br>`Router# show crypto isakmp policy` | Displays the parameters for each IKE policy. |
| **Step 6** | **show crypto isakmp profile** [**tag** *profilename* \| **vrf** *vrfname*]<br><br>**Example:**<br>`Router# show crypto isakmp profile` | Lists all the ISAKMP profiles that are defined on a router. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 7** | **show crypto map** [**interface** *interface* \| **tag** *map-name*]<br><br>**Example:**<br><br>`Router# show crypto map` | Displays the crypto map configuration.<br><br>The crypto maps shown in this command output are dynamically generated. The user does not have to configure crypto maps. |
| **Step 8** | **show crypto session** [**detail**] \| [**local** *ip-address* [**port** *local-port*] \| [**remote** *ip-address* [**port** *remote-port*]] \| **detail**] \| **fvfr** *vrf-name* \| **ivrf** *vrf-name*]<br><br>**Example:**<br><br>`Router# show crypto session` | Displays status information for active crypto sessions.<br><br>IPv6 does not support the **fvfr** or **ivrf** keywords or the *vrf-name* argument. |
| **Step 9** | **show crypto socket**<br><br>**Example:**<br><br>`Router# show crypto socket` | Lists crypto sockets. |
| **Step 10** | **show ipv6 access-list** [*access-list-name*]<br><br>**Example:**<br><br>`Router# show ipv6 access-list` | Displays the contents of all current IPv6 access lists. |
| **Step 11** | **show ipv6 cef** [*ipv6-prefix* / *prefix-length*] \| [*interface-type interface-number*] [**longer-prefixes** \| **similar-prefixes** \| **detail** \| **internal** \| **platform** \| **epoch** \| **source**]]<br><br>**Example:**<br><br>`Router# show ipv6 cef` | Displays entries in the IPv6 Forwarding Information Base (FIB). |
| **Step 12** | **show interface** *type number* **stats**<br><br>**Example:**<br><br>`Router# show interface fddi 3/0/0 stats` | Displays numbers of packets that were process switched, fast switched, and distributed switched. |

# Troubleshooting IPsec for IPv6 Configuration and Operation

### SUMMARY STEPS

1. **enable**
2. **debug crypto ipsec**
3. **debug crypto engine packet** [**detail**]

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| Step 1 | **enable**<br><br>**Example:**<br><br>`Router# enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| Step 2 | **debug crypto ipsec**<br><br>**Example:**<br><br>`Router# debug crypto ipsec` | Displays IPsec network events. |
| Step 3 | **debug crypto engine packet** [**detail**]<br><br>**Example:**<br><br>`Router# debug crypto engine packet` | Displays the contents of IPv6 packets.<br>**Caution** Using this command could flood the system and increase CPU usage if several packets are being encrypted. |

• Examples, page 17

## Examples

This section provides the following output examples:

### Sample Output from the show crypto ipsec sa Command

The following is sample output from the **show crypto ipsec sa**command:

```
Router# show crypto ipsec sa
interface: Tunnel0
     Crypto map tag: Tunnel0-head-0, local addr 3FFE:2002::A8BB:CCFF:FE01:9002
    protected vrf: (none)
    local  ident (addr/mask/prot/port): (::/0/0/0)
    remote ident (addr/mask/prot/port): (::/0/0/0)
    current_peer 3FFE:2002::A8BB:CCFF:FE01:2C02 port 500
      PERMIT, flags={origin_is_acl,}
     #pkts encaps: 133, #pkts encrypt: 133, #pkts digest: 133
     #pkts decaps: 133, #pkts decrypt: 133, #pkts verify: 133
     #pkts compressed: 0, #pkts decompressed: 0
     #pkts not compressed: 0, #pkts compr. failed: 0
     #pkts not decompressed: 0, #pkts decompress failed: 0
```

```
#send errors 60, #recv errors 0
 local crypto endpt.: 3FFE:2002::A8BB:CCFF:FE01:9002,
 remote crypto endpt.: 3FFE:2002::A8BB:CCFF:FE01:2C02
 path mtu 1514, ip mtu 1514
 current outbound spi: 0x28551D9A(676666778)
 inbound esp sas:
  spi: 0x2104850C(553944332)
    transform: esp-des ,
    in use settings ={Tunnel, }
    conn id: 93, flow_id: SW:93, crypto map: Tunnel0-head-0
    sa timing: remaining key lifetime (k/sec): (4397507/148)
    IV size: 8 bytes
    replay detection support: Y
    Status: ACTIVE
 inbound ah sas:
  spi: 0x967698CB(2524354763)
    transform: ah-sha-hmac ,
    in use settings ={Tunnel, }
    conn id: 93, flow_id: SW:93, crypto map: Tunnel0-head-0
    sa timing: remaining key lifetime (k/sec): (4397507/147)
    replay detection support: Y
    Status: ACTIVE
 inbound pcp sas:
 outbound esp sas:
  spi: 0x28551D9A(676666778)
    transform: esp-des ,
    in use settings ={Tunnel, }
    conn id: 94, flow_id: SW:94, crypto map: Tunnel0-head-0
    sa timing: remaining key lifetime (k/sec): (4397508/147)
    IV size: 8 bytes
    replay detection support: Y
    Status: ACTIVE
 outbound ah sas:
  spi: 0xA83E05B5(2822636981)
    transform: ah-sha-hmac ,
    in use settings ={Tunnel, }
    conn id: 94, flow_id: SW:94, crypto map: Tunnel0-head-0
    sa timing: remaining key lifetime (k/sec): (4397508/147)
    replay detection support: Y
    Status: ACTIVE
 outbound pcp sas:
```

### Sample Output from the show crypto isakmp peer Command

The following sample output shows peer descriptions on an IPv6 router:

```
Router# show crypto isakmp peer detail
Peer: 2001:DB8:0:1::1 Port: 500 Local: 2001:DB8:0:2::1
Phase1 id: 2001:DB8:0:1::1
flags:
NAS Port: 0 (Normal)
IKE SAs: 1 IPsec SA bundles: 1
last_locker: 0x141A188, last_last_locker: 0x0
last_unlocker: 0x0, last_last_unlocker: 0x0
```

### Sample Output from the show crypto isakmp profile Command

The following sample output shows the ISAKMP profiles that are defined on an IPv6 router:

```
Router# show crypto isakmp profile
ISAKMP PROFILE tom
Identities matched are:
ipv6-address 2001:DB8:0:1::1/32
Certificate maps matched are:
Identity presented is: ipv6-address fqdn
keyring(s): <none>
trustpoint(s): <all>
```

### Sample Output from the show crypto isakmp sa Command

The following sample output shows the SAs of an active IPv6 device. The IPv4 device is inactive.

```
Router# show crypto isakmp sa detail


Codes: C - IKE configuration mode, D - Dead Peer Detection

        K - Keepalives, N - NAT-traversal

        X - IKE Extended Authentication

        psk - Preshared key, rsig - RSA signature

        renc - RSA encryption

IPv4 Crypto ISAKMP SA


C-id  Local           Remote          I-VRF    Status Encr Hash Auth DH

Lifetime Cap.


IPv6 Crypto ISAKMP SA


  dst: 3FFE:2002::A8BB:CCFF:FE01:2C02

  src: 3FFE:2002::A8BB:CCFF:FE01:9002

  conn-id: 1001  I-VRF:          Status: ACTIVE Encr: des  Hash: sha  Auth:

psk

  DH: 1  Lifetime: 23:45:00 Cap: D    Engine-id:Conn-id = SW:1


  dst: 3FFE:2002::A8BB:CCFF:FE01:2C02

  src: 3FFE:2002::A8BB:CCFF:FE01:9002

  conn-id: 1002  I-VRF:          Status: ACTIVE Encr: des  Hash: sha  Auth: psk

  DH: 1  Lifetime: 23:45:01 Cap: D    Engine-id:Conn-id = SW:2
```

### Sample Output from the show crypto map Command

The following sample output shows the dynamically generated crypto maps of an active IPv6 device:

```
Router# show crypto map

Crypto Map "Tunnel1-head-0" 65536 ipsec-isakmp
        Profile name: profile0
        Security association lifetime: 4608000 kilobytes/300 seconds
        PFS (Y/N): N
```

```
        Transform sets={
                ts,
        }
Crypto Map "Tunnel1-head-0" 65537
        Map is a PROFILE INSTANCE.
        Peer = 2001:1::2
IPv6 access list Tunnel1-head-0-ACL (crypto)
    permit ipv6 any any (61445999 matches) sequence 1
        Current peer: 2001:1::2
        Security association lifetime: 4608000 kilobytes/300 seconds
        PFS (Y/N): N
        Transform sets={
          ts,
        }
        Interfaces using crypto map Tunnel1-head-0:
        Tunnel1
```

### Sample Output from the show crypto session Command

The following output from the show crypto session command provides details on currently active crypto sessions:

```
Router# show crypto session detail
Crypto session current status
Code: C - IKE Configuration mode, D - Dead Peer Detection K - Keepalives, N - NAT-
traversal, X - IKE Extended Authentication
Interface: Tunnel1
Session status: UP-ACTIVE
Peer: 2001:1::1 port 500 fvrf: (none) ivrf: (none)
       Phase1_id: 2001:1::1
       Desc: (none)
   IKE SA: local 2001:1::2/500
           remote 2001:1::1/500 Active
           Capabilities:(none) connid:14001 lifetime:00:04:32
   IPSEC FLOW: permit ipv6 ::/0 ::/0
         Active SAs: 4, origin: crypto map
         Inbound:  #pkts dec'ed 42641 drop 0 life (KB/Sec) 4534375/72
         Outbound: #pkts enc'ed 6734980 drop 0 life (KB/Sec) 2392402/72
```

# Configuration Examples for IPsec for IPv6 Security

- Example: Configuring a VTI for Site-to-Site IPv6 IPsec Protection, page 20

## Example: Configuring a VTI for Site-to-Site IPv6 IPsec Protection

```
crypto isakmp policy 1
  authentication pre-share
!
crypto isakmp key myPresharekey0 address ipv6 3FFE:2002::A8BB:CCFF:FE01:2C02/128
crypto isakmp keepalive 30 30
!
crypto ipsec transform-set 3des ah-sha-hmac esp-3des
!
crypto ipsec profile profile0
  set transform-set 3des
!
ipv6 cef
!
interface Tunnel0
  ipv6 address 3FFE:1001::/64 eui-64
  ipv6 enable
  ipv6 cef
  tunnel source Ethernet2/0
  tunnel destination 3FFE:2002::A8BB:CCFF:FE01:2C02
```

```
tunnel mode ipsec ipv6
tunnel protection ipsec profile profile0
```

# Additional References

### Related Documents

| Related Topic | Document Title |
|---|---|
| OSPFv3 authentication support with IPsec | Implementing OSPFv3 |
| IPsec VTI information | IPsec Virtual Tunnel Interface |
| IPv6 supported feature list | Start Here: Cisco IOS Software Release Specifics for IPv6 Features |
| IPv6 commands: complete command syntax, command mode, defaults, usage guidelines, and examples | *Cisco IOS IPv6 Command Reference* |
| IPv4 security configuration tasks | *Cisco IOS Security Configuration Guide* |
| IPv4 security commands: complete command syntax, command mode, defaults, usage guidelines, and examples | *Cisco IOS Security Command Reference* |

### Standards

| Standards | Title |
|---|---|
| No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature. | -- |

### MIBs

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

### RFCs

| RFCs | Title |
|---|---|
| RFC 2401 | *Security Architecture for the Internet Protocol* |

| RFCs | Title |
|---|---|
| RFC 2402 | *IP Authentication Header* |
| RFC 2404 | *The Use of Hash Message Authentication Code Federal Information Processing Standard 180-1 within Encapsulating Security Payload and Authentication Header* |
| RFC 2406 | *IP Encapsulating Security Payload (ESP)* |
| RFC 2407 | *The Internet Security Domain of Interpretation for ISAKMP* |
| RFC 2408 | *Internet Security Association and Key Management Protocol (ISAKMP)* |
| RFC 2409 | *Internet Key Exchange (IKE)* |
| RFC 2460 | *Internet Protocol, Version 6 (IPv6) Specification* |
| RFC 2474 | *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers* |
| RFC 3576 | *Change of Authorization* |
| RFC 4109 | *Algorithms for Internet Key Exchange version 1 (IKEv1)* |
| RFC 4302 | *IP Authentication Header* |
| RFC 4306 | *Internet Key Exchange (IKEv2) Protocol* |
| RFC 4308 | *Cryptographic Suites for IPsec* |

### 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 Implementing IPsec in IPv6 Security

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 Implementing IPsec in IPv6 Security***

| Feature Name | Releases | Feature Information |
|---|---|---|
| IPv6 IPsec VPN | Cisco IOS XE Release 2.4 | The following commands were introduced or modified: **authentication (IKE policy), crypto ipsec profile, crypto isakmp identity, crypto isakmp key, crypto isakmp peer, crypto isakmp policy, crypto isakmp profile, crypto keyring, debug crypto ipv6 ipsec, debug crypto ipv6 packet, deny (IPv6), encryption (IKE policy), group (IKE policy), hash (IKE policy), lifetime (IKE policy), match identity, permit (IPv6), pre-shared-key, self-identity, set aggressive-mode client-endpoint, set transform-set, show crypto engine, show crypto ipsec policy, show crypto ipsec sa, show crypto isakmp key, show crypto isakmp peers, show crypto isakmp policy, show crypto isakmp profile, show crypto map (IPsec), show crypto session, show crypto socket** |
| IPSec Virtual Tunnel Interface | Cisco IOS XE Release 2.4 | |
| IPv6 over v4 GRE Tunnel Protection | Cisco IOS XE Release 3.5S | |