CHAPTER 35

Configuring IPsec Network Security

IP security (IPsec) protocol is a framework of open standards that provides data confidentiality, data integrity, and data authentication between participating peers. It is developed by the Internet Engineering Task Force (IETF). IPsec provides security services at the IP layer, including protecting one or more data flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host. The overall IPsec implementation is the latest version of RFC 2401. Cisco NX-OS IPsec implements RFC 2402 through RFC 2410.

IPsec uses the Internet Key Exchange (IKE) protocol to handle protocol and algorithm negotiation and to generate the encryption and authentication keys used by IPsec. While IKE can be used with other protocols, its initial implementation is with the IPsec protocol. IKE provides authentication of the IPsec peers, negotiates IPsec security associations, and establishes IPsec keys. IKE uses RFCs 2408, 2409, 2410, and 2412, and additionally implements the draft-ietf-ipsec-ikev2-16.txt draft.

The term IPsec is sometimes used to describe the entire protocol of IPsec data services and IKE security protocols and is other times used to describe only the data services.

This chapter includes the following topics:

Information About IPsec Network Security

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flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host. The overall IPsec implementation is the latest version of RFC 2401. Cisco NX-OS IPsec implements RFC 2402 through RFC 2410.

IPsec uses the Internet Key Exchange (IKE) protocol to handle protocol and algorithm negotiation and to generate the encryption and authentication keys used by IPsec. While IKE can be used with other protocols, its initial implementation is with the IPsec protocol. IKE provides authentication of the IPsec peers, negotiates IPsec security associations, and establishes IPsec keys. IKE uses RFCs 2408, 2409, 2410, and 2412, and additionally implements the draft-ietf-ipsec-ikev2-16.txt draft.

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).

Note IPsec is not supported by the Cisco Fabric Switch for HP c-Class BladeSystem and the Cisco Fabric Switch for IBM BladeCenter.

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IPsec provides the following network security services. In general, the local security policy dictates the use of one or more of these services between two participating IPsec devices:

- Data confidentiality—The IPsec sender can encrypt packets before transmitting 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 is dependent upon the data integrity service.
- Anti-replay protection—The IPsec receiver can detect and reject replayed packets.

Note The term *data authentication* is generally used to mean data integrity and data origin authentication. Within this chapter it also includes anti-replay services, unless otherwise specified.

With IPsec, data can be transmitted across a public network without fear of observation, modification, or spoofing. This enables applications such as Virtual Private Networks (VPNs), including intranets, extranets, and remote user access.

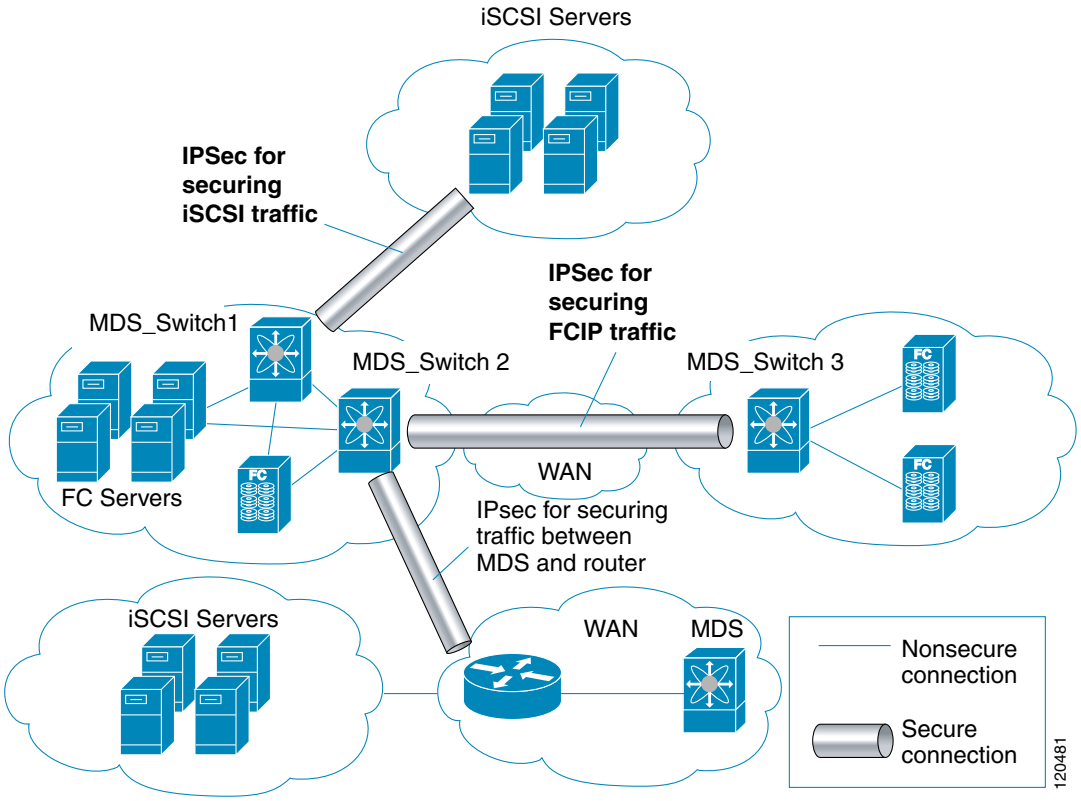
IPsec as implemented in Cisco NX-OS software supports the Encapsulating Security Payload (ESP) protocol. This protocol encapsulates the data to be protected and provides data privacy services, optional data authentication, and optional anti-replay services.

Note The Encapsulating Security Payload (ESP) protocol is a header inserted into an existing TCP/IP packet, the size of which depends on the actual encryption and authentication algorithms negotiated. To avoid fragmentation, the encrypted packet fits into the interface maximum transmission unit (MTU). The path MTU calculation for TCP takes into account the addition of ESP headers, plus the outer IP header in tunnel mode, for encryption. The MDS switches allow 100 bytes for packet growth for IPsec encryption.

Note When using IPsec and IKE, each Gigabit Ethernet interface on the IPS module (either on 14+2 LC or 18+4 LC) must be configured in its own IP subnet. If there are multiple Gigabit Ethernet interfaces configured with IP address or network-mask in the same IP subnet, IKE packets may not be sent to the right peer and thus IPsec tunnel will not come up.

Figure 35-1 shows different IPsec scenarios.

Figure 35-1 FCIP and iSCSI Scenarios Using MPS-14/2 Modules



This section includes the following topics:

- About IKE section, page 35-218
- IPsec Compatibility section, page 35-218
- IPsec and IKE Terminology section, page 35-219
- Supported IPsec Transforms and Algorithms section, page 35-220
- Supported IKE Transforms and Algorithms section, page 35-220
- About IPsec Digital Certificate Support section, page 35-221
- About IKE Initialization section, page 35-224
- About the IKE Domain section, page 35-224
- About IKE Tunnels section, page 35-224
- About IKE Policy Negotiation section, page 35-224
- Optional IKE Parameter Configuration section, page 35-225

About IKE

IKE automatically negotiates IPsec security associations and generates keys for all switches using the IPsec feature. Specifically, IKE provides these benefits:

- Allows you to refresh IPsec SAs.
- Allows IPsec to provide anti-replay services.
- Supports a manageable, scalable IPsec configuration.
- Allows dynamic authentication of peers.

IKE is not supported on the Cisco Fabric Switch for HP c-Class BladeSystem and the Cisco Fabric Switch for IBM BladeSystem.

IPsec Compatibility

IPsec features are compatible with the following Cisco MDS 9000 Family hardware:

- Cisco 18/4-port Multi-Service Module (MSM-18/4) modules and MDS 9222i Module-1 modules.
- Cisco 14/2-port Multiprotocol Services (MPS-14/2) modules in Cisco MDS 9200 Switches or Cisco MDS 9500 Directors
- Cisco MDS 9216i Switch with the 14/2-port multiprotocol capability in the integrated supervisor module. Refer to the *Cisco MDS 9200 Series Hardware Installation Guide* for more information on the Cisco MDS 9216i Switch.
- The IPsec feature is not supported on the management interface.

IPsec features are compatible with the following fabric setup:

- Two connected Cisco MDS 9200 Switches or Cisco MDS 9500 Directors running Cisco MDS SAN-OS Release 2.0(1b) or later, or Cisco NX-OS Release 4.1(1).
- A Cisco MDS 9200 Switches or Cisco MDS 9500 Directors running Cisco MDS SAN-OS Release 2.0(1b) or later, or Cisco NX-OS Release 4.1(1) connected to any IPsec compliant device.
- The following features are not supported in the Cisco NX-OS implementation of the IPsec feature:
  - Authentication Header (AH)
  - Transport mode
  - Security association bundling

- Manually configuring security associations
- Per host security association option in a crypto map
- Security association idle timeout
- Dynamic crypto maps

Note Any reference to crypto maps in this document, only refers to static crypto maps.

IPsec and IKE Terminology

The terms used in this chapter are explained in this section.

- Security association (SA)— An agreement between two participating peers on the entries required to encrypt and decrypt IP packets. Two SAs are required for each peer in each direction (inbound and outbound) to establish bidirectional communication between the peers. Sets of bidirectional SA records are stored in the SA database (SAD). IPsec uses IKE to negotiate and bring up SAs. Each SA record includes the following information:
  - Security parameter index (SPI)—A number which, together with a destination IP address and security protocol, uniquely identifies a particular SA. When using IKE to establish the SAs, the SPI for each SA is a pseudo-randomly derived number.
  - Peer—A switch or other device that participates in IPsec. For example, a Cisco MDS switch or other Cisco routers that support IPsec.
  - Transform—A list of operations done to provide data authentication and data confidentiality. For example, one transform is the ESP protocol with the HMAC-MD5 authentication algorithm.
  - Session key—The key used by the transform to provide security services.
  - Lifetime—A lifetime counter (in seconds and bytes) is maintained from the time the SA is created. When the time limit expires the SA is no longer operational and, if required, is automatically renegotiated (rekeyed).
  - Mode of operation—Two modes of operation are generally available for IPsec: tunnel mode and transport mode. The Cisco NX-OS implementation of IPsec only supports the tunnel mode. The IPsec tunnel mode encrypts and authenticates the IP packet, including its header. The gateways encrypt traffic on behalf of the hosts and subnets.
    The Cisco NX-OS implementation of IPsec does not support transport mode.

  Note The term *tunnel mode* is different from the term *tunnel*, which is used to indicate a secure communication path between two peers, such as two switches connected by an FCIP link.

- Anti-replay—A security service where the receiver can reject old or duplicate packets to protect itself against replay attacks. IPsec provides this optional service by use of a sequence number combined with the use of data authentication.
- Data authentication—Data authentication can refer either to integrity alone or to both integrity and authentication (data origin authentication is dependent on data integrity).
  - Data integrity—Verifies that data has not been altered.
  - Data origin authentication—Verifies that the data was actually sent by the claimed sender.
- Data confidentiality—A security service where the protected data cannot be observed.

- Data flow—A grouping of traffic, identified by a combination of source address and mask or prefix, destination address mask or prefix length, IP next protocol field, and source and destination ports, where the protocol and port fields can have any of these values. Traffic matching a specific combination of these values is logically grouped together into a data flow. A data flow can represent a single TCP connection between two hosts, or it can represent traffic between two subnets. IPsec protection is applied to data flows.
- Perfect forward secrecy (PFS)—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.
- Security Policy Database (SPD)—An ordered list of policies applied to traffic. A policy decides if a packet requires IPsec processing, if it should be allowed in clear text, or if it should be dropped.
  - The IPsec SPDs are derived from user configuration of crypto maps.
  - The IKE SPD is configured by the user.

Supported IPsec Transforms and Algorithms

The component technologies implemented for IPsec include the following transforms:

- Advanced Encrypted Standard (AES) is an encryption algorithm. It implements either 128 or 256 bits using Cipher Block Chaining (CBC) or counter mode.
- Data Encryption Standard (DES) is used to encrypt packet data and implements the mandatory 56-bit DES-CBC. CBC requires an initialization vector (IV) to start encryption. The IV is explicitly given in the IPsec packet.
- Triple DES (3DES) is a stronger form of DES with 168-bit encryption keys that allow sensitive information to be transmitted over untrusted networks.

Note Cisco NX-OS images with strong encryption are subject to United States government export controls, and have a limited distribution. Images to be installed outside the United States require an export license. Customer orders might be denied or subject to delay due to United States government regulations. Contact your sales representative or distributor for more information, or send e-mail to export@cisco.com.

- Message Digest 5 (MD5) is a hash algorithm with the HMAC variant. HMAC is a keyed hash variant used to authenticate data.
- Secure Hash Algorithm (SHA-1) is a hash algorithm with the Hash Message Authentication Code (HMAC) variant.
- AES-XCBC-MAC is a Message Authentication Code (MAC) using the AES algorithm.

Supported IKE Transforms and Algorithms

The component technologies implemented for IKE include the following transforms:

- Diffie-Hellman (DH) is a public-key cryptography protocol that allows two parties to establish a shared secret over an unsecure communications channel. Diffie-Hellman is used within IKE to establish session keys. Group 1 (768-bit), Group 2 (1024-bit), and Group 5 (1536-bit) are supported.
- Advanced Encrypted Standard (AES) is an encryption algorithm. It implements either 128 bits using Cipher Block Chaining (CBC) or counter mode.

- Data Encryption Standard (DES) is used to encrypt packet data and implements the mandatory 56-bit DES-CBC. CBC requires an initialization vector (IV) to start encryption. The IV is explicitly given in the IPsec packet.
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- Secure Hash Algorithm (SHA-1) is a hash algorithm with the Hash Message Authentication Code (HMAC) variant.
- The switch authentication algorithm uses the preshared keys based on the IP address

About IPsec Digital Certificate Support

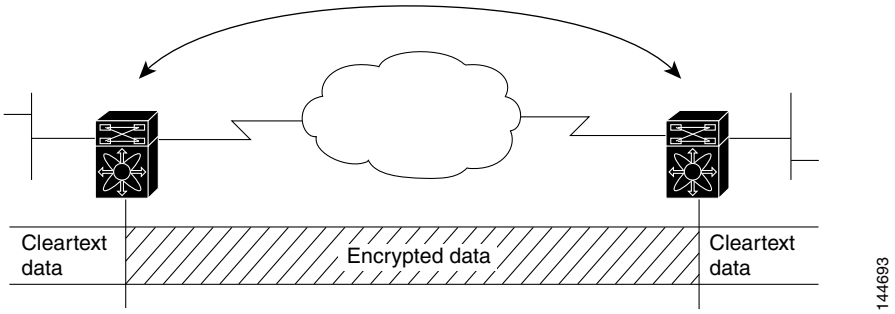
This section describes the advantages of using certificate authorities (CAs) and digital certificates for authentication.

Implementing IPsec Without CAs and Digital Certificates

Without a CA and digital certificates, enabling IPsec services (such as encryption) between two Cisco MDS switches requires that each switch has the key of the other switch (such as an RSA public key or a shared key). You must manually specify either the RSA public keys or preshared keys on each switch in the fabric using IPsec services. Also, each new device added to the fabric will require manual configuration of the other switches in the fabric to support secure communication. Each (see Figure 35-2) switch uses the key of the other switch to authenticate the identity of the other switch; this authentication always occurs when IPsec traffic is exchanged between the two switches.

If you have multiple Cisco MDS switches in a mesh topology and want to exchange IPsec traffic passing among all of those switches, you must first configure shared keys or RSA public keys among all of those switches.

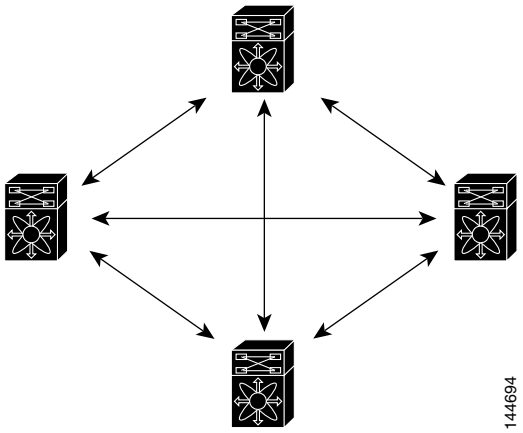
Figure 35-2 Two IPsec Switches Without CAs and Digital Certificates



Every time a new switch is added to the IPsec network, you must configure keys between the new switch and each of the existing switches. (In Figure 35-3, four additional two-part key configurations are required to add a single encrypting switch to the network).

Consequently, the more devices that require IPsec services, the more involved the key administration becomes. This approach does not scale well for larger, more complex encrypting networks.

Figure 35-3 Four IPsec Switches Without a CA and Digital Certificates

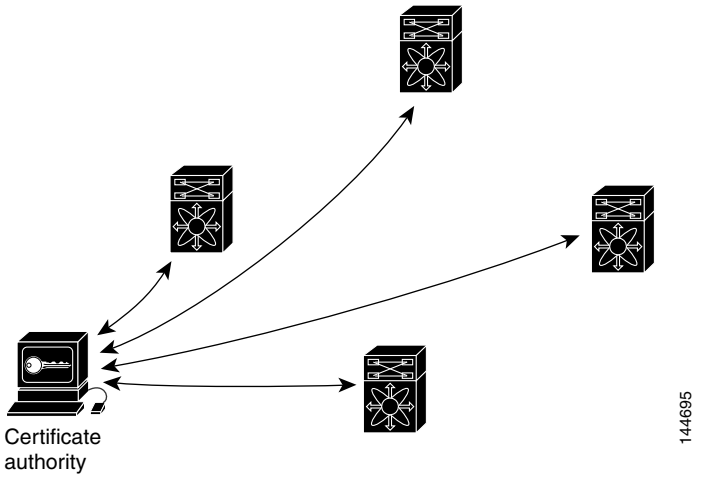


Implementing IPsec with CAs and Digital Certificates

With CA and digital certificates, you do not have to configure keys between all the encrypting switches. Instead, you individually enroll each participating switch with the CA, requesting a certificate for the switch. When this has been accomplished, each participating switch can dynamically authenticate all the other participating switches. When two devices want to communicate, they exchange certificates and digitally sign data to authenticate each other. When a new device is added to the network, you simply enroll that device with a CA, and none of the other devices needs modification. When the new device attempts an IPsec connection, certificates are automatically exchanged and the device can be authenticated.

Figure 35-4 shows the process of dynamically authenticating the devices.

Figure 35-4 Dynamically Authenticating Devices with a CA



To add a new IPsec switch to the network, you need only configure that new switch to request a certificate from the CA, instead of making multiple key configurations with all the other existing IPsec switches.

How CA Certificates Are Used by IPsec Devices

When two IPsec switches want to exchange IPsec-protected traffic passing between them, they must first authenticate each other—otherwise, IPsec protection cannot occur. The authentication is done with IKE.

IKE can use two methods to authenticate the switches, using preshared keys without a CA and using RSA key-pairs with a CA. Both methods require that keys must be preconfigured between the two switches.

Without a CA, a switch authenticates itself to the remote switch using either RSA-encrypted preshared keys.

With a CA, a switch authenticates itself to the remote switch by sending a certificate to the remote switch and performing some public key cryptography. Each switch must send its own unique certificate that was issued and validated by the CA. This process works because the certificate of each switch encapsulates the public key of the switch, each certificate is authenticated by the CA, and all participating switches recognize the CA as an authenticating authority. This scheme is called IKE with an RSA signature.

Your switch can continue sending its own certificate for multiple IPsec sessions, and to multiple IPsec peers until the certificate expires. When the certificate expires, the switch administrator must obtain a new one from the CA.

CAs can also revoke certificates for devices that will no longer participate in IPsec. Revoked certificates are not recognized as valid by other IPsec devices. Revoked certificates are listed in a certificate revocation list (CRL), which each peer may check before accepting a certificate from another peer.

Certificate support for IKE has the following considerations:

- The switch FQDN (host name and domain name) must be configured before installing certificates for IKE.
- Only those certificates that are configured for IKE or general usage are used by IKE.
- The first IKE or general usage certificate configured on the switch is used as the default certificate by IKE.
- The default certificate is for all IKE peers unless the peer specifies another certificate.

- If the peer asks for a certificate which is signed by a CA that it trusts, then IKE uses that certificate, if it exists on the switch, even if it is not the default certificate.
- If the default certificate is deleted, the next IKE or general usage certificate, if any exists, is used by IKE as the default certificate.
- Certificate chaining is not supported by IKE.
- IKE only sends the identity certificate, not the entire CA chain. For the certificate to be verified on the peer, the same CA chain must also exist there.

About IKE Initialization

The IKE feature must first be enabled and configured so the IPsec feature can establish data flow with the required peer. DCNM-SAN initializes IKE when you first configure it.

You cannot disable IKE if IPsec is enabled. If you disable the IKE feature, the IKE configuration is cleared from the running configuration.

About the IKE Domain

You must apply the IKE configuration to an IPsec domain to allow traffic to reach the supervisor module in the local switch. DCNM-SAN sets the IPsec domain automatically when you configure IKE.

About IKE Tunnels

An IKE tunnel is a secure IKE session between two endpoints. IKE creates this tunnel to protect IKE messages used in IPsec SA negotiations.

Two versions of IKE are used in the Cisco NX-OS implementation.

- IKE version 1 (IKEv1) is implemented using RFC 2407, 2408, 2409, and 2412.
- IKE version 2 (IKEv2) is a simplified and more efficient version and does not interoperate with IKEv1. IKEv2 is implemented using the draft-ietf-ipsec-ikev2-16.txt draft.

About IKE Policy Negotiation

To protect IKE negotiations, each IKE negotiation begins with a common (shared) IKE policy. An IKE policy defines a combination of security parameters to be used during the IKE negotiation. By default, no IKE policy is configured. You must create IKE policies at each peer. This policy states which security parameters will be used to protect subsequent IKE negotiations and mandates how peers are authenticated. You can create multiple, prioritized policies at each peer to ensure that at least one policy will match a remote peer's policy.

You can configure the policy based on the encryption algorithm (DES, 3DES, or AES), the hash algorithm (SHA or MD5), and the DH group (1, 2, or 5). Each policy can contain a different combination of parameter values. A unique priority number identifies the configured policy. This number ranges from 1 (highest priority) to 255 (lowest priority). You can create multiple policies in a switch. If you need to connect to a remote peer, you must ascertain that at least one policy in the local switch contains the identical parameter values configured in the remote peer. If several policies have identical parameter configurations, the policy with the lowest number is selected.

Table 35-1 provides a list of allowed transform combinations.

Table 35-1 IKE Transform Configuration Parameters

Parameter	Accepted Values	Keyword	Default Value
encryption algorithm	56-bit DES-CBC	**des**	**3des**
	168-bit DES	**3des**	
	128-bit AES	**aes**	
hash algorithm	SHA-1 (HMAC variant)	**sha**	**sha**
	MD5 (HMAC variant)	**md5**	
authentication method	Preshared keys	Not configurable	Preshared keys
DH group identifier	768-bit DH	**1**	**1**
	1024-bit DH	**2**	
	1536-bit DH	**5**	

The following table lists the supported and verified settings for IPsec and IKE encryption authentication algorithms on the Microsoft Windows and Linux platforms:

Platform	IKE	IPsec
Microsoft iSCSI initiator, Microsoft IPsec implementation on Microsoft Windows 2000 platform	3DES, SHA-1 or MD5, DH group 2	3DES, SHA-1
Cisco iSCSI initiator, Free Swan IPsec implementation on Linux platform	3DES, MD5, DH group 1	3DES, MD5

Note When you configure the hash algorithm, the corresponding HMAC version is used as the authentication algorithm.

When the IKE negotiation begins, IKE looks 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 other peer's received policies. The remote peer checks each of its policies in order of its priority (highest priority first) until a match is found.

A match is found when the two peers have the same encryption, hash algorithm, authentication algorithm, and DH group values. If a match is found, IKE completes the security negotiation and the IPsec SAs are created.

If an acceptable match is not found, IKE refuses negotiation and the IPsec data flows will not be established.

Optional IKE Parameter Configuration

You can optionally configure the following parameters for the IKE feature:

- The lifetime association within each policy—The lifetime ranges from 600 to 86,400 seconds. The default is 86,400 seconds (equals one day). The lifetime association within each policy is configured when you are creating an IKE policy. See the "Configuring an IKE Policy" section on page 35-240.
- The keepalive time for each peer if you use IKEv2—The keepalive ranges from 120 to 86,400 seconds. The default is 3,600 seconds (equals one hour).
- The initiator version for each peer—IKE v1 or IKE v2 (default). Your choice of initiator version does not affect interoperability when the remote device initiates the negotiation. Configure this option if the peer device supports IKEv1 and you can play the initiator role for IKE with the specified device. Use the following considerations when configuring the initiator version with FCIP tunnels:
  - If the switches on both sides of an FCIP tunnel are running MDS SAN-OS Release 3.0(1) or later, or Cisco NX-OS 4.1(1) you must configure initiator version IKEv1 on both sides of an FCIP tunnel to use only IKEv1. If one side of an FCIP tunnel is using IKEv1 and the other side is using IKEv2, the FCIP tunnel uses IKEv2.
  - If the switch on one side of an FCIP tunnel is running MDS SAN-OS Release 3.0(1) or later, or Cisco NX-OS 4.1(1b) and the switch on the other side of the FCIP tunnel is running MDS SAN-OS Release 2.x, configuring IKEv1 on either side (or both) results in the FCIP tunnel using IKEv1.

Note Only IKE v1 is supported to build IPsec between 2.x and 3.x MDS switches.

Caution You may need to configure the initiator version even when the switch does not behave as an IKE initiator under normal circumstances. Always using this option guarantees a faster recovery of traffic flows in case of failures.

Tip The keepalive time only applies to IKEv2 peers and not to all peers.

Note When IPsec implementations in the host prefer to initiate the IPsec rekey, be sure to configure the IPsec lifetime value in the Cisco MDS switch to be higher than the lifetime value in the host.

About Crypto IPv4-ACLs

IP access control lists (IPv4-ACLs) provide basic network security to all switches in the Cisco MDS 9000 Family. IPv4 IP-ACLs restrict IP-related traffic based on the configured IP filters. See Chapter 34, "Configuring IPv4 and IPv6 Access Control Lists ." for details on creating and defining IPv4-ACLs.

In the context of crypto maps, IPv4-ACLs are different from regular IPv4-ACLs. Regular IPv4-ACLs determine what traffic to forward or block at an interface. For example, IPv4-ACLs can be created to protect all IP traffic between subnet A and subnet Y or Telnet traffic between host A and host B.

Crypto IPv4-ACLs are used to define which IP traffic requires crypto protection and which traffic does not.

Crypto IPv4-ACLs associated with IPsec crypto map entries have four primary functions:

- Select outbound traffic to be protected by IPsec (permit = protect).

- Indicate the data flow to be protected by the new SAs (specified by a single permit entry) when initiating negotiations for IPsec SAs.
- Process inbound traffic to filter out and discard traffic that should have been protected by IPsec.
- Determine whether or not to accept requests for IPsec SAs on behalf of the requested data flows when processing IKE negotiation from the IPsec peer.

Tip If you want some traffic to receive one type of IPsec protection (for example, encryption only) and other traffic to receive a different type of IPsec protection (for example, both authentication and encryption), create two IPv4-ACLs. Use both IPv4-ACLs in different crypto maps to specify different IPsec policies.

Note IPsec does not support IPv6-ACLs.

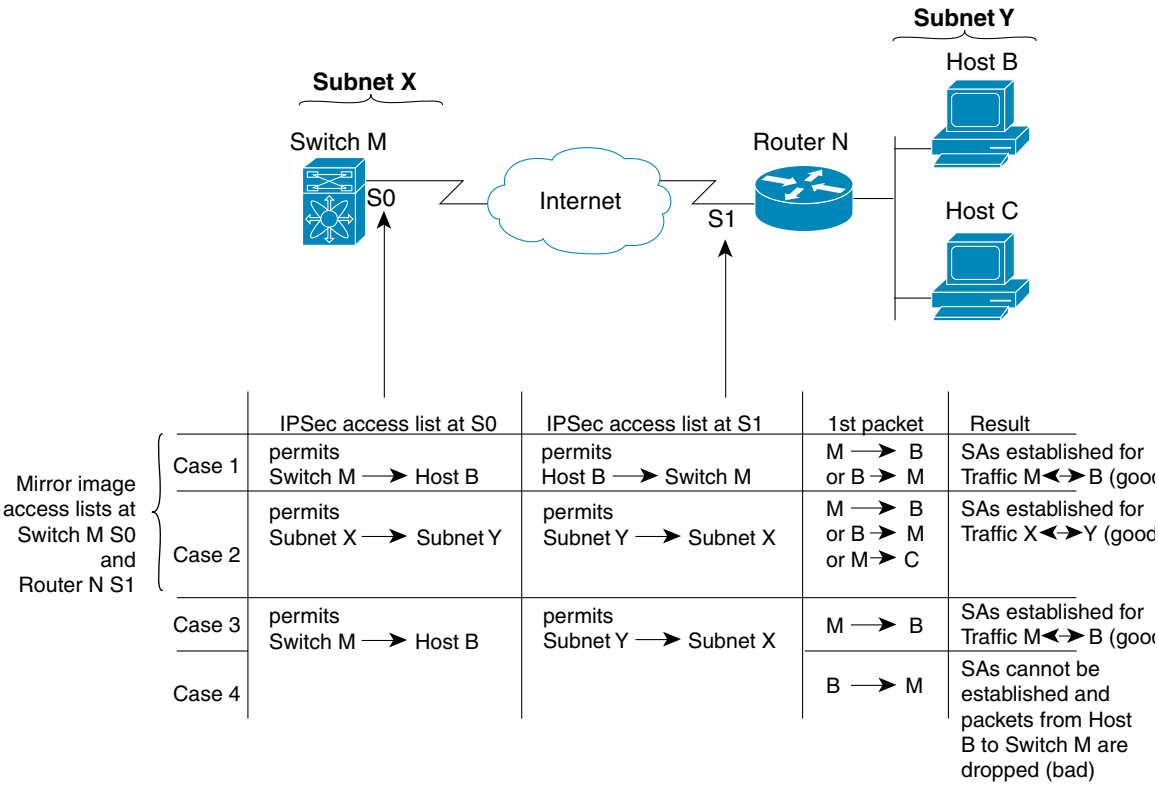
Mirror Image Crypto IPv4-ACLs

For every crypto IPv4-ACL specified for a crypto map entry defined at the local peer, define a mirror image crypto IPv4-ACL at the remote peer. This configuration ensures that IPsec traffic applied locally can be processed correctly at the remote peer.

Tip The crypto map entries themselves must also support common transforms and must refer to the other system as a peer.

Figure 35-5 shows some sample scenarios with and without mirror image IPv4-ACLs.

Figure 35-5 IPsec Processing of Mirror Image Configuration



As Figure 35-5 indicates, IPsec SAs can be established as expected whenever the two peers' crypto IPv4-ACLs are mirror images of each other. However, an IPsec SA can be established only some of the time when the IPv4-ACLs are not mirror images of each other. This can happen in the case when an entry in one peer's IPv4-ACL is a subset of an entry in the other peer's IPv4-ACL, such as shown in cases 3 and 4 of Figure 35-5. IPsec SA establishment is critical to IPsec. Without SAs, IPsec does not work, causing any packets matching the crypto IPv4-ACL criteria to be silently dropped instead of being forwarded with IPsec security.

In case 4, an SA cannot be established because SAs are always requested according to the crypto IPv4-ACLs at the initiating packet's end. In case 4, router N requests that all traffic between subnet X and subnet Y be protected, but this is a superset of the specific flows permitted by the crypto IPv4-ACL at switch M so the request is not permitted. Case 3 works because switch M's request is a subset of the specific flows permitted by the crypto IPv4-ACL at router N.

Because of the complexities introduced when crypto IPv4-ACLs are not configured as mirror images at peer IPsec devices, we strongly encourage you to use mirror image crypto IPv4-ACLs.

The any Keyword in Crypto IPv4-ACLs

Tip We recommend that you configure mirror image crypto IPv4-ACLs for use by IPsec and that you avoid using the **any** option.

The **any** keyword in a permit statement is discouraged when you have multicast traffic flowing through the IPsec interface. This configuration can cause multicast traffic to fail.

The **permit any** statement causes all outbound traffic to be protected (and all protected traffic sent to the peer specified in the corresponding crypto map entry) and requires protection for all inbound traffic. Then, all inbound packets that lack IPsec protection are silently dropped, including packets for routing protocols, NTP, echo, echo response, and so forth.

You need to be sure you define which packets to protect. If you must use **any** in a permit statement, you must preface that statement with a series of deny statements to filter out any traffic (that would otherwise fall within that permit statement) that you do not want to be protected.

About Transform Sets in IPsec

A transform set represents a certain combination of security protocols and algorithms. During the IPsec security association negotiation, the peers agree to use a particular transform set for protecting a particular data flow.

You can specify multiple transform sets, and then specify one or more of these transform sets in a crypto map entry. The transform set defined in the crypto map entry is used in the IPsec security association negotiation to protect the data flows specified by that crypto map entry's access list.

During IPsec security association negotiations with IKE, the peers search for a transform set that is the same at both peers. When such a transform set is found, it is selected and applied to the protected traffic as part of both peers' IPsec security associations.

Tip If you change a transform set definition, the change is only applied to crypto map entries that reference the transform set. The change is not applied to existing security associations, but used in subsequent negotiations to establish new security associations. If you want the new settings to take effect sooner, you can clear all or part of the security association database.

Note When you enable IPsec, the Cisco NX-OS software automatically creates a default transform set (ipsec_default_tranform_set) using AES-128 encryption and SHA-1 authentication algorithms.

Table 35-2 provides a list of allowed transform combinations for IPsec.

Table 35-2 IPsec Transform Configuration Parameters

Parameter	Accepted Values	Keyword
encryption algorithm	56-bit DES-CBC	**esp-des**
	168-bit DES	**esp-3des**
	128-bit AES-CBC	**esp-aes 128**
	128-bit AES-CTR[1]	**esp-aes 128 ctr**
	256-bit AES-CBC	**esp-aes 256**
	256-bit AES-CTR[1]	**esp-aes 256 ctr**
hash/authentication algorithm[1] (optional)	SHA-1 (HMAC variant)	**esp-sha1-hmac**
	MD5 (HMAC variant)	**esp-md5-hmac**
	AES-XCBC-MAC	**esp-aes-xcbc-mac**

1. If you configure the AES counter (CTR) mode, you must also configure the authentication algorithm.

The following table lists the supported and verified settings for IPsec and IKE encryption authentication algorithms on the Microsoft Windows and Linux platforms:

Platform	IKE	IPsec
Microsoft iSCSI initiator, Microsoft IPsec implementation on Microsoft Windows 2000 platform	3DES, SHA-1 or MD5, DH group 2	3DES, SHA-1
Cisco iSCSI initiator, Free Swan IPsec implementation on Linux platform	3DES, MD5, DH group 1	3DES, MD5

About Crypto Map Entries

Once you have created the crypto IPv4-ACLs and transform sets, you can create crypto map entries that combine the various parts of the IPsec SA, including the following:

- The traffic to be protected by IPsec (per the crypto IPv4-ACL). A crypto map set can contain multiple entries, each with a different IPv4-ACL.
- The granularity of the flow to be protected by a set of SAs.
- The IPsec-protected traffic destination (who the remote IPsec peer is).
- The local address to be used for the IPsec traffic (applying to an interface).
- The IPsec security to be applied to this traffic (selecting from a list of one or more transform sets).
- Other parameters to define an IPsec SA.

Crypto map entries with the same crypto map name (but different map sequence numbers) are grouped into a crypto map set.

When you apply a crypto map set to an interface, the following events occur:

- A security policy database (SPD) is created for that interface.
- All IP traffic passing through the interface is evaluated against the SPD.

If a crypto map entry sees outbound IP traffic that requires protection, an SA is negotiated with the remote peer according to the parameters included in the crypto map entry.

The policy derived from the crypto map entries is used during the negotiation of SAs. If the local switch initiates the negotiation, it will use the policy specified in the crypto map entries to create the offer to be sent to the specified IPsec peer. If the IPsec peer initiates the negotiation, the local switch checks the policy from the crypto map entries and decides whether to accept or reject the peer's request (offer).

For IPsec to succeed between two IPsec peers, both peers' crypto map entries must contain compatible configuration statements.

SA Establishment Between Peers

When two peers try to establish an SA, they must each have at least one crypto map entry that is compatible with one of the other peer's crypto map entries.

For two crypto map entries to be compatible, they must at least meet the following criteria:

- The crypto map entries must contain compatible crypto IPv4-ACLs (for example, mirror image IPv4-ACLs). If the responding peer entry is in the local crypto, the IPv4-ACL must be permitted by the peer's crypto IPv4-ACL.
- The crypto map entries must each identify the other peer or must have auto peer configured.
- If you create more than one crypto map entry for a given interface, use the seq-num of each map entry to rank the map entries: the lower the seq-num, the higher the priority. At the interface that has the crypto map set, traffic is evaluated against higher priority map entries first.
- The crypto map entries must have at least one transform set in common, where IKE negotiations are carried out and SAs are established. During the IPsec SA negotiation, the peers agree to use a particular transform set when protecting a particular data flow.

When a packet matches a permit entry in a particular IPv4-ACL, the corresponding crypto map entry is tagged, and the connections are established.

About SA Lifetime Negotiation

You can override the global lifetime values (size and time) by configuring an SA-specific lifetime value.

To specify SA lifetime negotiation values, you can optionally configure the lifetime value for a specified crypto map. If you do, this value overrides the globally set values. If you do not specify the crypto map specific lifetime, the global value (or global default) is used.

See the "Global Lifetime Values" section on page 35-233 for more information on global lifetime values.

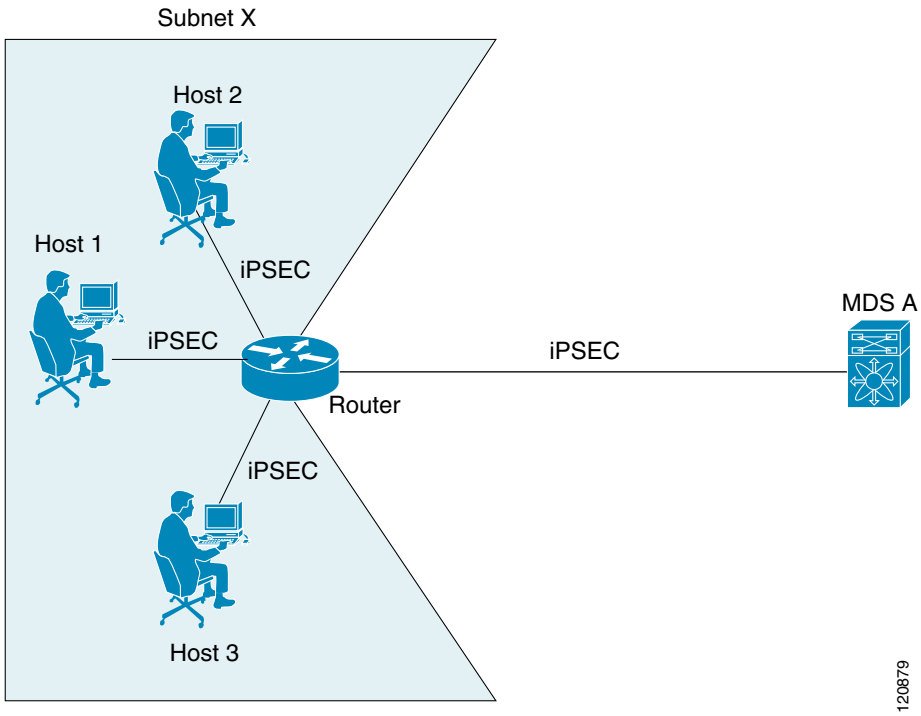
About the AutoPeer Option

Setting the peer address as **auto-peer** in the crypto map indicates that the destination endpoint of the traffic should be used as the peer address for the SA. Using the same crypto map, a unique SA can be set up at each of the endpoints in the subnet specified by the crypto map's IPv4-ACL entry. Auto-peer simplifies configuration when traffic endpoints are IPsec capable. It is particularly useful for iSCSI, where the iSCSI hosts in the same subnet do not require separate configuration.

Figure 35-6 shows a scenario where the auto-peer option can simplify configuration. Using the auto-peer option, only one crypto map entry is needed for all the hosts from subnet X to set up SAs with the switch. Each host will set up its own SA, but will share the crypto map entry. Without the auto-peer option, each host needs one crypto map entry.

See the "Sample iSCSI Configuration" section on page 35-260 for more details.

Figure 35-6 iSCSI with End-to-End IPsec Using the auto-peer Option



About Perfect Forward Secrecy

To specify SA lifetime negotiation values, you can also optionally configure the perfect forward secrecy (PFS) value in the crypto map.

The PFS feature is disabled by default. If you set the PFS group, you can set one of the DH groups: 1, 2, 5, or 14. If you do not specify a DH group, the software uses group 1 by default.

About Crypto Map Set Interface Application

You need to apply a crypto map set to each interface through which IPsec traffic will flow. Applying the crypto map set to an interface instructs the switch to evaluate all the interface's traffic against the crypto map set and to use the specified policy during connection or SA negotiation on behalf of the traffic to be protected by crypto.

You can apply only one crypto map set to an interface. You can apply the same crypto map to multiple interfaces. However, you cannot apply more than one crypto map set to each interface.

IPsec Maintenance

Certain configuration changes will only take effect when negotiating subsequent security associations. If you want the new settings to take immediate effect, you must clear the existing security associations so that they will be reestablished with the changed configuration. If the switch is actively processing IPsec traffic, it is desirable to clear only the portion of the security association database that would be

affected by the configuration changes (that is, clear only the security associations established by a given crypto map set). Clearing the full security association database should be reserved for large-scale changes, or when the router is processing very little other IPsec traffic.

Tip You can obtain the SA index from the output of the **show crypto sa domain interface gigabitethernet** *slot/port* command.

Use the following command to clear part of the SA database.

```
switch# clear crypto sa domain ipsec interface gigabitethernet 2/1 inbound sa-index 1
```

Global Lifetime Values

If you have not configured a lifetime in the crypto map entry, the global lifetime values are used when negotiating new IPsec SAs.

You can configure two lifetimes: timed or traffic-volume. An SA expires after the first of these lifetimes is reached. The default lifetimes are 3,600 seconds (one hour) and 450 GB.

If you change a global lifetime, the new lifetime value will not be applied to currently existing SAs, but will be used in the negotiation of subsequently established SAs. If you wish to use the new values immediately, you can clear all or part of the SA database.

Assuming that the particular crypto map entry does not have lifetime values configured, when the switch requests new SAs it will specify its global lifetime values in the request to the peer; it will use this value as the lifetime of the new SAs. When the switch receives a negotiation request from the peer, it uses the value determined by the IKE version in use:

- If you use IKEv1 to set up IPsec SAs, the SA lifetime values are chosen to be the smaller of the two proposals. The same values are programmed on both the ends of the tunnel.
- If you use IKEv2 to set up IPsec SAs, the SAs on each end have their own set up of lifetime values and thus the SAs on both sides expire independently.

The SA (and corresponding keys) will expire according to whichever comes sooner, either after the specified amount of time (in seconds) has passed or after the specified amount of traffic (in bytes) has passed.

A new SA is negotiated before the lifetime threshold of the existing SA is reached to ensure that negotiation completes before the existing SA expires.

The new SA is negotiated when one of the following thresholds is reached (whichever comes first):

- 30 seconds before the lifetime expires or
- Approximately 10% of the lifetime in bytes remain

If no traffic has passed through when the lifetime expires, a new SA is not negotiated. Instead, a new SA will be negotiated only when IPsec sees another packet that should be protected.

Prerequisites for IPsec

To use the IPsec feature, you need to perform the following tasks:

- Obtain the ENTERPRISE_PKG license (see the *Cisco MDS 9000 Family NX-OS Licensing Guide*).

- Configure IKE as described in the "About IKE Initialization" section on page 35-224.

Guidelines and Limitations

The following are the guidelines and limitations for IPsec network security:

- Crypto IPv4-ACL Guidelines section, page 35-234
- Crypto Map Configuration Guidelines section, page 35-235

Crypto IPv4-ACL Guidelines

Follow these guidelines when configuring IPv4-ACLs for the IPsec feature:

- The Cisco NX-OS software only allows name-based IPv4-ACLs.
- When an IPv4-ACL is applied to a crypto map, the following options apply:
  - Permit—Applies the IPsec feature to the traffic.
  - Deny—Allows clear text (default).

Note IKE traffic (UDP port 500) is implicitly transmitted in clear text.

- The IPsec feature only considers the source and destination IPv4 addresses and subnet masks, protocol, and single port number. There is no support for IPv6 in IPsec.

Note The IPsec feature does not support port number ranges and ignores higher port number field, if specified.

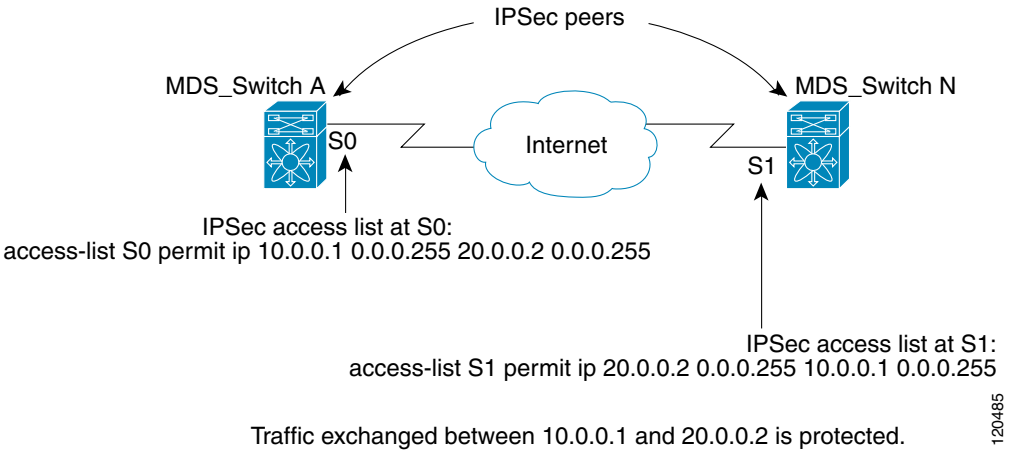
- The permit option causes all IP traffic that matches the specified conditions to be protected by crypto, using the policy described by the corresponding crypto map entry.
- The deny option prevents traffic from being protected by crypto. The first deny statement causes the traffic to be in clear text.
- The crypto IPv4-ACL you define is applied to an interface after you define the corresponding crypto map entry and apply the crypto map set to the interface.
- Different IPv4-ACLs must be used in different entries of the same crypto map set.
- Inbound and outbound traffic is evaluated against the same outbound IPv4-ACL. Therefore, the IPv4-ACL's criteria is applied in the forward direction to traffic exiting your switch, and the reverse direction to traffic entering your switch.
- Each IPv4-ACL filter assigned to the crypto map entry is equivalent to one security policy entry. The IPsec feature supports up to 120 security policy entries for each MPS-14/2 module and Cisco MDS 9216i Switch.
- IPsec protection (see Figure 35-7) is applied to traffic between switch interface S0 (IPv4 address 10.0.0.1) and switch interface S1 (IPv4 address 20.0.0.2) as the data exits switch A's S0 interface enroute to switch interface S1. For traffic from 10.0.0.1 to 20.0.0.2, the IPv4-ACL entry on switch A is evaluated as follows:
  - source = IPv4 address 10.0.0.1

- dest = IPv4 address 20.0.0.2

For traffic from 20.0.0.2 to 10.0.0.1, that same IPv4-ACL entry on switch A is evaluated as follows:

- source = IPv4 address 20.0.0.2
- dest = IPv4 address 10.0.0.1

Figure 35-7 IPsec Processing of Crypto IPv4-ACLs



- If you configure multiple statements for a given crypto IPv4-ACL that is used for IPsec, the first permit statement that is matched is used to determine the scope of the IPsec SA. Later, if traffic matches a different permit statement of the crypto IPv4-ACL, a new, separate IPsec SA is negotiated to protect traffic matching the newly matched IPv4-ACL statement.
- Unprotected inbound traffic that matches a permit entry in the crypto IPv4-ACL for a crypto map entry flagged as IPsec is dropped, because this traffic was expected to be protected by IPsec.
- You can use the **show ip access-lists** command to view all IP-ACLs. The IP-ACLs used for traffic filtering purposes are also used for crypto.
- For IPsec to interoperate effectively with Microsoft iSCSI initiators, specify the TCP protocol and the local iSCSI TCP port number (default 3260) in the IPv4-ACL. This configuration ensures the speedy recovery of encrypted iSCSI sessions following disruptions such as Gigabit Ethernet interfaces shutdowns, VRRP switchovers, and port failures.
- The following example of a IPv4-ACL entry shows that the MDS switch IPv4 address is 10.10.10.50 and remote Microsoft host running encrypted iSCSI sessions is 10.10.10.16:

```
switch(config)# ip access-list aclmsiscsi2 permit tcp 10.10.10.50 0.0.0.0 range port
3260 3260 10.10.10.16 0.0.0.0
```

Crypto Map Configuration Guidelines

When configuring crypto map entries, follow these guidelines:

- The sequence number for each crypto map decides the order in which the policies are applied. A lower sequence number is assigned a higher priority.
- Only one IPv4-ACL is allowed for each crypto map entry (the IPv4-ACL itself can have multiple permit or deny entries).

- When the tunnel endpoint is the same as the destination address, you can use the auto-peer option to dynamically configure the peer.
- For IPsec to interoperate effectively with Microsoft iSCSI initiators, specify the TCP protocol and the local iSCSI TCP port number (default 3260) in the IPv4-ACL. This configuration ensures the speedy recovery of encrypted iSCSI sessions following disruptions such as Gigabit Ethernet interfaces shutdowns, VRRP switchovers, and port failures.

Default Settings

Table 35-3 lists the default settings for IKE parameters.

Table 35-3 Default IKE Parameters

Parameters	Default
IKE	Disabled.
IKE version	IKE version 2.
IKE encryption algorithm	3DES.
IKE hash algorithm	SHA.
IKE authentication method	Not configurable (uses preshared Preshared keys).
IKE DH group identifier	Group 1.
IKE lifetime association	86,400 00 seconds (equals 24 hours).
IKE keepalive time for each peer (v2)	3,600 seconds (equals 1 hour).

Table 35-4 lists the default settings for IPsec parameters.

Table 35-4 Default IPsec Parameters

Parameters	Default
IPsec	Disabled.
Applying IPsec to the traffic.	Deny—allowing clear text.
IPsec PFS	Disabled.
IPsec global lifetime (traffic-volume)	450 Gigabytes.
IPsec global lifetime (time)	3,600 seconds (one hour).

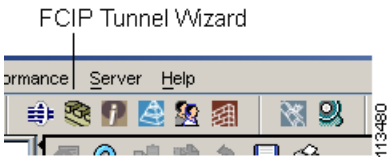
Enabling IPsec Using FCIP Wizard

DCNM-SAN simplifies the configuration of IPsec and IKE by enabling and configuring these features as part of the FCIP configuration using the FCIP Wizard.

To enable IPsec using the FCIP Wizard, follow these steps:

Step 1 Click the FCIP Wizard icon in the toolbar.

Figure 35-8 FCIP Wizard



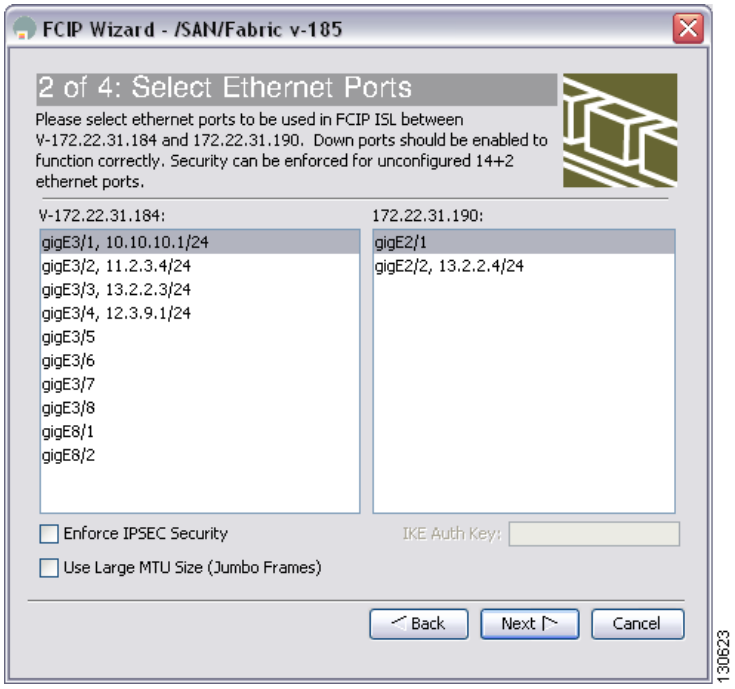
Step 2 Choose the switches that act as end points for the FCIP link and click **Next**.

Note These switches must have MPS-14/2 modules installed to configure IPsec on this FCIP link.

Step 3 Choose the Gigabit Ethernet ports on each MPS-14/2 module that will form the FCIP link.

Step 4 Check the **Enforce IPSEC Security** check box and set IKE Auth Key (see Figure 35-9).

Figure 35-9 Enabling IPsec on an FCIP Link



Step 5 Click **Next**. In the Specify Tunnel Properties dialog box, you see the TCP connection characteristics.

Step 6 Set the minimum and maximum bandwidth settings and round-trip time for the TCP connections on this FCIP link. Click the **Measure** button to measure the round-trip time between the Gigabit Ethernet endpoints.

Step 7 Check the **Enable Write Acceleration** check box to enable FCIP write acceleration on this FCIP link.

Step 8 Check the **Enable Optimum Compression** check box to enable IP compression on this FCIP link.

Step 9 Click **Next** to configure the FCIP tunnel parameters.

Step 10 Set the Port VSAN for nontrunk/auto and allowed VSAN list for the trunk tunnel. Choose a **Trunk Mode** for this FCIP link. See the *IP Services Configuration Guide*, *Cisco DCNM for SAN*.

Step 11 Click **Finish** to create this FCIP link or click **Cancel** to exit the FCIP Wizard without creating an FCIP link.

To verify that IPsec and IKE are enabled, follow these steps:

Step 1 Expand **Switches > Security** and then select **IPSEC** in the Physical Attributes pane.

Step 2 The **Control** tab is the default. Verify that the switches you want to modify for IPSec are enabled in the Status column.

Step 3 Expand **Switches > Security,** and then select **IKE** in the Physical Attributes pane.

Step 4 The **Control** tab is the default. Verify that the switches you want to modify for IKE are enabled in the Status column.

Configuring IPsec and IKE Manually

This section describes how to manually configure IPsec and IKE.

If you are not using the FCIP Wizard, see "Enabling IPsec Using FCIP Wizard" section on page 35-236.

IPsec provides secure data flows between participating peers. Multiple IPsec data flows can exist between two peers to secure different data flows, with each tunnel using a separate set of SAs.

Prerequisites

After you have completed IKE configuration, configure IPsec.

To configure IPsec in each participating IPsec peer, follow these steps:

Step 1 Identify the peers for the traffic to which secure tunnels should be established.

Step 2 Configure the transform set with the required protocols and algorithms.

Step 3 Create the crypto map and apply access control lists (IPv4-ACLs), transform sets, peers, and lifetime values as applicable.

Step 4 Apply the crypto map to the required interface.

This section includes the following topics:

Using IPsec

To use the IPsec feature, follow these steps:

Step 1 Obtain the ENTERPRISE_PKG license to enable IPsec for iSCSI and to enable IPsec for FCIP. See the *Cisco MDS 9000 Family NX-OS Licensing Guide* for more information.

Step 2 Configure IKE as described in the "Configuring IPsec and IKE Manually" section on page 35-238.

Note The IPsec feature inserts new headers in existing packets (see the Cisco MDS 9000 Family NX-OS IP Services Configuration Guide See *IP Services Configuration Guide, Cisco DCNM for SAN* for more information).

Enabling IKE

To enable IKE, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# feature crypto ike`	Enables the IKE feature.
	`switch(config)# no feature crypto ike`	Disables (default) the IKE feature. **Note** You must disable IPsec before you can disable the IKE feature.

Configuring the IKE Domain

You must apply the IKE configurations to an IPsec domain to allow traffic to reach the supervisor module in the local switch.

To configure the IPsec domain, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto ike domain ipsec` `switch(config-ike-ipsec)#`	Allows IKE configurations for IPsec domains.

Configuring an IKE Policy

To configure the IKE negotiation parameters, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto ike domain ipsec` `switch(config-ike-ipsec)#`	Allows IPsec domains to be configured in this switch.
Step 3	`switch(config-ike-ipsec)# identity address`	Configures the identity mode for the IKE protocol to use the IP address (default).
	`switch(config-ike-ipsec)# identity hostname`	Configures the identity mode for the IKE protocol to use the fully-qualified domain name (FQDN). **Note** The FQDN is required for using RSA signatures for authentication.
	`switch(config-ike-ipsec)# no identity`	Reverts to the default identity mode (**address**).
Step 4	`switch(config-ike-ipsec)# key switch1 address 10.10.1.1`	Associates a preshared key with the IP address of a peer.
	`switch(config-ike-ipsec)# no key switch1 address 10.10.1.1`	Deletes the association of a preshared key and the IP address of a peer.
	`switch(config-ike-ipsec)# key switch1 hostname switch1.cisco.com`	Associates a preshared key with the FQDN of a peer. **Note** To use the FQDN, you must configure the switch name and domain name on the peer.
	`switch(config-ike-ipsec)# no key switch1 hostname switch1.cisco.com`	Deletes the association of a preshared key and the IP address of a peer.
Step 5	`switch(config-ike-ipsec)# policy 1` `switch(config-ike-ipsec-policy)#`	Specifies the policy to configure.
	`switch(config-ike-ipsec)# no policy 1`	Deletes the specified policy.
Step 6	`switch(config-ike-ipsec-policy)# encryption des`	Configures the encryption policy.
	`switch(config-ike-ipsec-policy)# no encryption des`	Defaults to 3DES encryption.
Step 7	`switch(config-ike-ipsec-policy)# group 5`	Configures the DH group.
	`switch(config-ike-ipsec-policy)# no group 5`	Defaults to DH group 1.
Step 8	`switch(config-ike-ipsec-policy)# hash md5`	Configures the hash algorithm.
	`switch(config-ike-ipsec-policy)# no hash md5`	Defaults to SHA.

	Command	Purpose
Step 9	`switch(config-ike-ipsec-policy)# authentication pre-share`	Configures the authentication method to use the preshared key (default).
	`switch(config-ike-ipsec-policy)# authentication rsa-sig`	Configures the authentication method to use the RSA signature. **Note** To use RSA signatures for authentication you must configure identity authentication mode using the FQDN (see Step 3).
	`switch(config-ike-ipsec-policy)# no authentication`	Reverts to the default (**pre-share**).

To configure the IKE policy negotiation parameters, follow these steps:

Step 1 Expand **Switches > Security,** and then select **IKE**.

Step 2 Click the **Policies** tab.

You see the existing IKE polices in the Information pane.

Step 3 Click **Create Row** to create an IKE policy.

Step 4 Enter the **Priority** for this switch. You can enter a value from one through 255, one being the highest.

Step 5 Select appropriate values for the encryption, hash, authentication, and DHGroup fields.

Step 6 Enter the lifetime for the policy. You can enter a lifetime from 600 to 86400 seconds.

Step 7 Click **Create** to create this policy, or click **Close** to discard any unsaved changes.

Configuring the Lifetime Association for a Policy

To configure the lifetime association for each policy, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto ike domain ipsec` `switch(config-ike-ipsec)#`	Allows IPsec domains to be configured in this switch.
Step 3	`switch(config-ike-ipsec)# policy 1` `switch(config-ike-ipsec-policy)#`	Specifies the policy to configure.
Step 4	`switch(config-ike-ipsec-policy) lifetime seconds 6000`	Configures a lifetime of 6,000 seconds.
	`switch(config-ike-ipsec-policy)# no lifetime seconds 6000`	Deletes the configured lifetime value and defaults to 86,400 seconds.

Configuring the Keepalive Time for a Peer

To configure the keepalive time for each peer, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto ike domain ipsec` `switch(config-ike-ipsec)#`	Allows IPsec domains to be configured in this switch.
Step 3	`switch(config-ike-ipsec)# keepalive 60000`	Configures the keepalive time for all peers to be 60,000 seconds.
	`switch(config-ike-ipsec)# no keepalive 60000`	Deletes the configured keepalive time and defaults to 3,600 seconds.

To configure the keepalive time for each peer, follow these steps:

Step 1 Expand **Switches > Security**, and then select **IKE**.

Step 2 Click the **Global** tab.

Step 3 Enter a value (in seconds) in the **KeepAliveInterval (sec)**. The keepalive interval in seconds is used by the IKE entity on the managed device with all the peers for the DOI corresponding to this conceptual row.

Step 4 Click **Apply Changes** to save your changes.

Configuring the Initiator Version

To configure the initiator version using IPv4, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto ike domain ipsec` `switch(config-ike-ipsec)#`	Allows IPsec domains to be configured in this switch.
Step 3	`switch(config-ike-ipsec)# initiator version 1 address 10.10.10.1`	Configures the switch to use IKEv1 when initiating IKE with device 10.10.10.0 **Note** IKE supports IPv4 addresses, not IPv6 addresses.
	`switch(config-ike-ipsec)# no initiator version 1 address 10.10.10.1`	Defaults to IKEv2 for the specified device.
	`switch(config-ike-ipsec)# no initiator version 1`	Defaults to IKEv2 for all devices.

To configure the initiator version, follow these steps:

Step 1 Expand **Switches > Security,** and then select **IKE**.

Step 2 Click the **Initiator Version** tab.

You see the existing initiator versions for the peers in the Information pane.

Step 3 Click **Create Row** to create an initiator version.

Step 4 Select the Switches for the remote peer for which this IKE protocol initiator is configured.

Step 5 Enter the IP address of the remote peer.

IKEv1 represents the IKE protocol version used when connecting to a remote peer.

Step 6 Click **Create** to create this initiator version or click **Close** to discard any unsaved changes.

Clearing IKE Tunnels or Domains

If an IKE tunnel ID is not specified for the IKE configuration, you can clear all existing IKE domain connections by issuing the **clear crypto ike domain ipsec sa** command in EXEC mode.

```
switch# clear crypto ike domain ipsec sa
```

Caution When you delete all the SAs within a specific IKEv2 tunnel, then that IKE tunnel is automatically deleted.

If an SA is specified for the IKE configuration, you can clear the specified IKE tunnel ID connection by issuing the **clear crypto ike domain ipsec sa** *IKE_tunnel-ID* command in EXEC mode.

```
switch# clear crypto ike domain ipsec sa 51
```

Caution When you delete the IKEv2 tunnel, the associated IPsec tunnel under that IKE tunnel is automatically deleted.

To clear all the IKE tunnels or domains, follow these steps:

Step 1 Expand **Switches > Security,** and then select **IKE** in the Physical Attributes pane.

Step 2 Click the **Tunnels** tab in the Information pane.

You see the IKE tunnels.

Step 3 Click the **Action** column and select **Clear** to clear the tunnel.

Refreshing SAs

Use the **crypto ike domain ipsec rekey IPv4-ACL**-*index* command to refresh the SAs after performing IKEv2 configuration changes.

To refresh the SAs after changing the IKEv2 configuration, follow these steps:

Step 1 Expand **Switches** > **Security,** and then select **IKE** in the Physical Attributes pane.

Step 2 Click the **Pre-Shared AuthKey** tab in the Information pane.

Step 3 Click **Refresh Values**.

Configuring Crypto

This sections includes the following topics:

Creating Crypto IPv4-ACLs

To create IPv4-ACLs, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# ip access-list List1 permit ip 10.1.1.100 0.0.0.255 11.1.1.100 0.0.0.255`	Permits all IP traffic from and to the specified networks.

Note The **show ip access-list** command does not display the crypto map entries. Use the **show crypto map** command to display the associated entries.

Add permit and deny statements as appropriate (see Chapter 34, "Configuring IPv4 and IPv6 Access Control Lists .'). Each permit and deny specifies conditions to determine which IP packets must be protected.

Configuring Transform Sets

To configure transform sets, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto transform-set domain ipsec test esp-3des esp-md5-hmac`	Configures a transform set called test specifying the 3DES encryption algorithm and the MD5 authentication algorithm. Refer to Table 35-2 to verify the allowed transform combinations.
	`switch(config)# no crypto transform-set domain ipsec test esp-3des esp-md5-hmac`	Deletes the applied transform set.
	`switch(config)# crypto transform-set domain ipsec test esp-3des`	Configures a transform set called test specifying the 3DES encryption algorithm. In this case, the default no authentication is performed.
	`switch(config)# no crypto transform-set domain ipsec test esp-3des`	Deletes the applied transform set.

To configure transform sets, follow these steps:

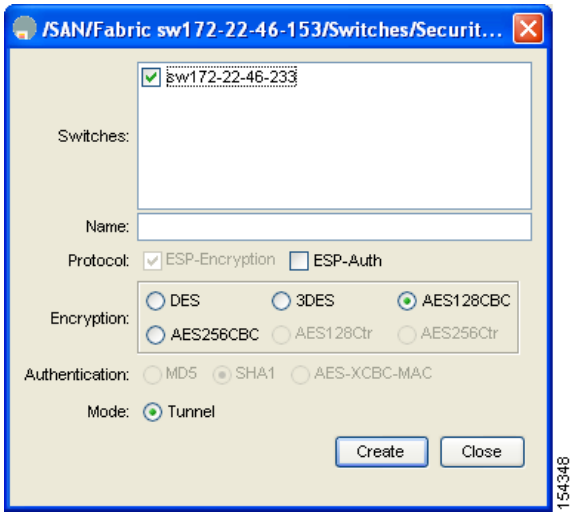
Step 1 Expand **Switches > Security,** and then select **IPSec** in the Physical Attributes pane.

Step 2 Click the **Transform Set** tab in the Information pane.

Step 3 Click **Create Row**.

You see the Create IPSEC dialog box shown in Figure 35-10.

Figure 35-10 Create IPSEC



Step 4 Select the switches that you want to create a transform set for in the Create Transform Set dialog box.

Step 5 Assign a name and protocol for the transform set.

Step 6 Select the encryption and authentication algorithm. See Table 35-2 to verify the allowed transform combinations.

Step 7 Click **Create** to create the transform set or you click **Close**.

Creating Crypto Map Entries

Note If the peer IP address specified in the crypto map entry is a VRRP IP address on a remote Cisco MDS switch, ensure that the IP address is created using the **secondary** option (see the *Cisco MDS 9000 Family NX-OS IP Services Configuration Guide* for more information).

To create mandatory crypto map entries, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto map domain ipsec SampleMap 31` `ips-hac1(config-crypto-map-ip)#`	Places you in the crypto map configuration mode for the entry named SampleMap with 31 as its sequence number.
	`switch(config)# no crypto map domain ipsec SampleMap 3`	Deletes the specified crypto map entry.
	`switch(config)# no crypto map domain ipsec SampleMap`	Deletes the entire crypto map set called SampleMap.
Step 3	`switch(config-crypto-map-ip)# match address SampleAcl`	Names an ACL to determine which traffic should be protected and not protected by IPsec in the context of this crypto map entry.
	`switch(config-crypto-map-ip)# no match address SampleAcl`	Deletes the matched address.
Step 4	`switch(config-crypto-map-ip)# set peer 10.1.1.1`	Configures a specific peer IPv4 address. **Note** IKE only supports IPv4 addresses, not IPv6 addresses.
Step 5	`switch(config-crypto-map-ip)# no set peer 10.1.1.1`	Deletes the configured peer.
Step 6	`switch(config-crypto-map-ip)# set transform-set SampleTransform1 SampleTransmfor2`	Specifies which transform sets are allowed for the specified crypto map entry or entries. List multiple transform sets in order of priority (highest priority first).
	`switch(config-(crypto-map-ip))# no set transform-set`	Deletes the association of all transform sets (regardless of you specifying a transform set name).

To create mandatory crypto map entries, follow these steps:

Step 1 Expand **Switches > Security,** and then select **IPSEC** in the Physical Attributes pane.

Step 2 Click the **CryptoMap Set Entry** tab.

Step 3 (Optional) Click **Create Row** to create a crypto map entry.

Step 4 Select the switch that you want to configure or modify. If you are creating a crypto map, set the setName and priority for this crypto map.

Step 5 Select the IPv4-ACL Profile and TransformSetIdList from the drop-down list for this crypto map.

Step 6 (Optional) Check the **AutoPeer** check box or set the peer address if you are creating a crypto map. See the "About the AutoPeer Option" section on page 35-231.

Step 7 Choose the appropriate PFS selection. See the "About Perfect Forward Secrecy" section on page 35-232.

Step 8 Supply the Lifetime and LifeSize. See the "About SA Lifetime Negotiation" section on page 35-231.

Step 9 Click **Create** if you are creating a crypto map, or click **Apply Changes** if you are modifying an existing crypto map.

Setting the SA Lifetime

To set the SA lifetime for a specified crypto map entry, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto map domain ipsec SampleMap 31` `switch(config-crypto-map-ip)#`	Enters crypto map configuration submode for the entry named SampleMap with 31 as its sequence number.
Step 3	`switch(config-crypto-map-ip)# set security-association lifetime seconds 8640`	Specifies an SA lifetime for this crypto map entry using different IPsec SA lifetimes than the global lifetimes for the crypto map entry.
	`switch(config-crypto-map-ip)# no set security-association lifetime seconds 8640`	Deletes the entry-specific configuration and reverts to the global settings.
Step 4	`switch(config-crypto-map-ip)# set security-association lifetime gigabytes 4000`	Configures the traffic-volume lifetime for this SA to time out after the specified amount of traffic (in gigabytes) have passed through the FCIP link using the SA. The lifetime ranges from 1 to 4095 gigabytes.

To set the SA lifetime for a specified crypto map entry, follow these steps:

Step 1 Expand **Switches > Security** and then select **IPSEC** in the Physical Attributes pane.

Step 2 Click the **CryptoMap Set Entry** tab.

Step 3 Scroll to the right half of the dialog box.

Step 4 Double-click and modify the value in the **Life Time(sec)** column.

Step 5 Click **Apply Changes** to save your changes.

Configuring Perfect Forward Secrecy

To configure the PFS value, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto map domain ipsec SampleMap 31` `ips-hac1(config-crypto-map-ip)#`	Places you in the crypto map configuration mode for the entry named SampleMap with 31 as its sequence number.
Step 3	`switch(config-crypto-map-ip)# set pfs group 2`	Specifies that IPsec should ask for PFS when requesting new SAs for this crypto map entry, or should demand PFS in requests received from the IPsec peer.
	`switch(config-crypto-map-ip)# no set pfs`	Deletes the configured DH group and reverts to the factory default of disabling PFS.

To configure the PFS value, follow these steps:

Step 1 Expand **Switches > Security** and then select **IPSEC** in the Physical Attributes pane.

Step 2 Click the **CryptoMap Set Entry** tab.

Step 3 From the drop-down list in the PFS column select the appropriate value.

Step 4 Click **Apply Changes** to save your changes.

Applying a Crypto Map Set

To apply a crypto map set to an interface, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# interface gigabitethernet 4/1` `switch(config-if)#`	Selects the required Gigabit Ethernet interface (and subinterface, if required) to which the IPsec crypto map is to be applied.
Step 3	`switch(config-if)# crypto map domain ipsec cm10`	Applies the crypto map set to the selected interface.
Step 4	`switch(config-if)# no crypto map domain ipsec`	Deletes the crypto map that is currently applied to this interface.

To apply a crypto map set to an interface, follow these steps:

Step 1 Expand **Switches > Security,** and then select **IPSEC** in the Physical Attributes pane.

Step 2 Click the **Interfaces** tab.

Step 3 Select the switch and interface you want to configure.

Step 4 Enter the name of the crypto map that you want to apply to this interface in the CryptomapSetName field.

Step 5 Click **Create** to apply the crypto map to the selected interface or click **Close** to exit the dialog box without applying the crypto map.

Configuring Global Lifetime Values

To configure global SA lifetimes, follow these steps:

	Command	Purpose
Step 1	`switch# config terminal` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# crypto global domain ipsec security-association lifetime seconds 86400`	Configures the global timed lifetime for IPsec SAs to time out after the specified number of seconds have passed. The global lifetime ranges from 120 to 86400 seconds.
	`switch(config)# no crypto global domain ipsec security-association lifetime seconds 86400`	Reverts to the factory default of 3,600 seconds.
Step 3	`switch(config)# crypto global domain ipsec security-association lifetime gigabytes 4000`	Configures the global traffic-volume lifetime for IPsec SAs to time out after the specified amount of traffic (in gigabytes) has passed through the FCIP link using the SA. The global lifetime ranges from 1 to 4095 gigabytes.
	`switch(config)# crypto global domain ipsec security-association lifetime kilobytes 2560`	Configures the global traffic-volume lifetime in kilobytes. The global lifetime ranges from 2560 to 2147483647 kilobytes.
	`switch(config)# crypto global domain ipsec security-association lifetime megabytes 5000`	Configures the global traffic-volume lifetime in megabytes. The global lifetime ranges from 3 to 4193280 megabytes.
	`switch(config)# no crypto global domain ipsec security-association lifetime megabytes`	Reverts to the factory default of 450 GB regardless of what value is currently configured.

To configure global SA lifetimes, follow these steps:

Step 1 Choose **Switches > Security,** and then select **IPSEC** in the Physical Attributes pane.

Step 2 You see the IPsec configuration in the Information pane.

Step 3 Click the **Global** tab.

Step 4 Double-click and edit the value in the **Life Time(sec)** column.

Step 5 Click **Apply Changes** to save your changes.

Verifying IPsec Configuration

To display IPsec configuration information, perform one of the following tasks:

Command	Purpose
show crypto ike domain ipsec-1	Displays the Parameters Configured for Each IKE Policy.
show crypto ike domain ipsec initiator	Displays the Initiator Configuration.
show crypto ike domain ipsec key	Displays the Key Configuration.
show crypto ike domain ipsec policy 1	Displays the Currently Established Policies for IKE.
show crypto ike domain ipsec sa	Displays the Currently Established SAs for IKE.
show ip access-list acl10	Displays Information for the Specified ACL.
show crypto transform-set domain ipsec	Displays the Transform Set Configuration.
show crypto map domain ipsec	Displays All Configured Crypto Maps.
show crypto map domain ipsec interface gigabitethernet 4/1	Displays the Crypto Map Information for a Specific Interface.
show crypto map domain ipsec tag cm100	Displays the Specified Crypto Map Information.
show crypto sad domain ipsec interface gigabitethernet 4/1	Displays SA Association for the Specified Interface.
show crypto sad domain ipsec	Displays All SA Associations.
show crypto spd domain ipsec	Displays Information About the Policy Database.
show crypto spd domain ipsec interface gigabitethernet 4/2	Displays SPD Information for a Specific Interface.
show iscsi session detail	Displays Detailed iSCSI Session Information for a Specific Interface.
show interface fcip 1	Displays FCIP Information for a Specific Interface.
show crypto global domain ipsec	Displays the Global IPsec Statistics for the Switch.
show crypto global domain ipsec interface gigabitethernet 3/1	Displays the IPsec Statistics for the Specified Interface.
show crypto global domain ipsec security-association lifetime	Displays the Global SA Lifetime Values.

For detailed information about the fields in the output from these commands, refer to the *Cisco DC-OS Command Reference*.

- "Displaying IKE Configurations" section on page 35-251
- "Displaying IPsec Configurations" section on page 35-251

Displaying IKE Configurations

You can verify the IKE information by using the **show** set of commands. See Examples 35-1 to 35-5.

Example 35-1 Displays the Parameters Configured for Each IKE Policy

```
switch# show crypto ike domain ipsec
keepalive 60000
```

Example 35-2 Displays the Initiator Configuration

```
switch# show crypto ike domain ipsec initiator
initiator version 1 address 1.1.1.1
initiator version 1 address 1.1.1.2
```

Example 35-3 Displays the Key Configuration

```
switch# show crypto ike domain ipsec key
key abcdefgh address 1.1.1.1
key bcdefghi address 1.1.2.1
```

Example 35-4 Displays the Currently Established Policies for IKE

```
switch# show crypto ike domain ipsec policy 1
Priority 1, auth pre-shared, lifetime 6000 secs, encryption 3des, hash md5, DH group 5
Priority 3, auth pre-shared, lifetime 86300 secs, encryption aes, hash sha1, DH group 1
```

Example 35-5 Displays the Currently Established SAs for IKE

```
switch# show crypto ike domain ipsec sa
Tunn    Local Addr          Remote Addr        Encr     Hash    Auth Method     Lifetime
------------------------------------------------------------------------------------------
1*      172.22.31.165[500]  172.22.31.166[500] 3des     sha1    preshared key   86400
2       172.22.91.174[500]  172.22.91.173[500] 3des     sha1    preshared key   86400
------------------------------------------------------------------------------------------
NOTE: tunnel id ended with * indicates an IKEv1 tunnel
```

Displaying IPsec Configurations

You can verify the IPsec information by using the **show** set of commands. See Examples 35-6 to 35-19.

Example 35-6 Displays Information for the Specified ACL

```
switch# show ip access-list acl10
ip access-list acl10 permit ip 10.10.10.0 0.0.0.255 10.10.10.0 0.0.0.255 (0 matches)
```

In Example 35-6, the display output match is only displayed of an interface (not the crypto map) meets this criteria.

Example 35-7 Displays the Transform Set Configuration

```
switch# show crypto transform-set domain ipsec
Transform set: 3des-md5 {esp-3des esp-md5-hmac}
    will negotiate {tunnel}
Transform set: des-md5 {esp-des esp-md5-hmac}
```

```
    will negotiate {tunnel}
Transform set: test {esp-aes-128-cbc esp-md5-hmac}
    will negotiate {tunnel}
```

Example 35-8 Displays All Configured Crypto Maps

```
switch# show crypto map domain ipsec
Crypto Map "cm10" 1 ipsec
        Peer = Auto Peer
        IP ACL = acl10
            permit ip 10.10.10.0 255.255.255.0 10.10.10.0 255.255.255.0
        Transform-sets: 3des-md5, des-md5,
        Security Association Lifetime: 4500 megabytes/3600 seconds
        PFS (Y/N): N
        Interface using crypto map set cm10:
            GigabitEthernet4/1
Crypto Map "cm100" 1 ipsec
        Peer = Auto Peer
        IP ACL = acl100
            permit ip 10.10.100.0 255.255.255.0 10.10.100.0 255.255.255.0
        Transform-sets: 3des-md5, des-md5,
        Security Association Lifetime: 4500 megabytes/3600 seconds
        PFS (Y/N): N
        Interface using crypto map set cm100:
            GigabitEthernet4/2
```

Example 35-9 Displays the Crypto Map Information for a Specific Interface

```
switch# show crypto map domain ipsec interface gigabitethernet 4/1
Crypto Map "cm10" 1 ipsec
        Peer = Auto Peer
        IP ACL = acl10
            permit ip 10.10.10.0 255.255.255.0 10.10.10.0 255.255.255.0
        Transform-sets: 3des-md5, des-md5,
        Security Association Lifetime: 4500 megabytes/120 seconds
        PFS (Y/N): N
        Interface using crypto map set cm10:
            GigabitEthernet4/1
```

Example 35-10 Displays the Specified Crypto Map Information

```
switch# show crypto map domain ipsec tag cm100
Crypto Map "cm100" 1 ipsec
        Peer = Auto Peer
        IP ACL = acl100
            permit ip 10.10.100.0 255.255.255.0 10.10.100.0 255.255.255.0
        Transform-sets: 3des-md5, des-md5,
        Security Association Lifetime: 4500 megabytes/120 seconds
        PFS (Y/N): N
        Interface using crypto map set cm100:
            GigabitEthernet4/2
```

Example 35-11 Displays SA Association for the Specified Interface

```
switch# show crypto sad domain ipsec interface gigabitethernet 4/1
interface: GigabitEthernet4/1
    Crypto map tag: cm10, local addr. 10.10.10.1
```

```
    protected network:
    local ident (addr/mask): (10.10.10.0/255.255.255.0)
    remote  ident (addr/mask): (10.10.10.4/255.255.255.255)
    current_peer: 10.10.10.4
      local crypto endpt.: 10.10.10.1, remote crypto endpt.: 10.10.10.4
      mode: tunnel, crypto algo: esp-3des, auth algo: esp-md5-hmac
     current outbound spi: 0x30e000f (51249167), index: 0
      lifetimes in seconds:: 120
      lifetimes in bytes:: 423624704
     current inbound spi: 0x30e0000 (51249152), index: 0
      lifetimes in seconds:: 120
      lifetimes in bytes:: 423624704
```

Example 35-12 Displays All SA Associations

```
switch# show crypto sad domain ipsec
interface: GigabitEthernet4/1
    Crypto map tag: cm10, local addr. 10.10.10.1
    protected network:
    local  ident (addr/mask): (10.10.10.0/255.255.255.0)
    remote  ident (addr/mask): (10.10.10.4/255.255.255.255)
    current_peer: 10.10.10.4
      local crypto endpt.: 10.10.10.1, remote crypto endpt.: 10.10.10.4
      mode: tunnel, crypto algo: esp-3des, auth algo: esp-md5-hmac
     current outbound spi: 0x30e000f (51249167), index: 0
      lifetimes in seconds:: 120
      lifetimes in bytes:: 423624704
     current inbound spi: 0x30e0000 (51249152), index: 0
      lifetimes in seconds:: 120
      lifetimes in bytes:: 423624704
```

Example 35-13 Displays Information About the Policy Database

```
switch# show crypto spd domain ipsec
Policy Database for interface: GigabitEthernet4/1, direction: Both
#   0:      deny  udp any port eq 500 any
#   1:      deny  udp any any port eq 500
#   2:      permit ip 10.10.10.0 255.255.255.0 10.10.10.0 255.255.255.0
#  63:      deny  ip any any
Policy Database for interface: GigabitEthernet4/2, direction: Both
#   0:      deny  udp any port eq 500 any <----------------------UDP default entry
#   1:      deny  udp any any port eq 500 <---------------------- UDP default entry
#   3:      permit ip 10.10.100.0 255.255.255.0 10.10.100.0 255.255.255.0
#  63:      deny  ip any any <---------------------------------------- Clear text default entry
```

Example 35-14 Displays SPD Information for a Specific Interface

```
switch# show crypto spd domain ipsec interface gigabitethernet 4/2
Policy Database for interface: GigabitEthernet3/1, direction: Both
#   0:      deny  udp any port eq 500 any
#   1:      deny  udp any any port eq 500
#   2:      permit ip 10.10.10.0 255.255.255.0 10.10.10.0 255.255.255.0
# 127:      deny  ip any any
```

Example 35-15 Displays Detailed iSCSI Session Information for a Specific Interface

```
switch# show iscsi session detail
```

```
Initiator iqn.1987-05.com.cisco:01.9f39f09c7468 (ips-host16.cisco.com)
    Initiator ip addr (s): 10.10.10.5
  Session #1 (index 24)
    Discovery session, ISID 00023d000001, Status active

  Session #2 (index 25)
    Target ibm1
    VSAN 1, ISID 00023d000001, TSIH 0, Status active, no reservation
    Type Normal, ExpCmdSN 42, MaxCmdSN 57, Barrier 0
    MaxBurstSize 0, MaxConn 1, DataPDUInOrder Yes
    DataSeqInOrder Yes, InitialR2T Yes, ImmediateData No
    Registered LUN 0, Mapped LUN 0
    Stats:
      PDU: Command: 41, Response: 41
      Bytes: TX: 21388, RX: 0
    Number of connection: 1
    Connection #1
      iSCSI session is protected by IPSec <----------The iSCSI session protection status
      Local IP address: 10.10.10.4, Peer IP address: 10.10.10.5
      CID 0, State: Full-Feature
      StatSN 43, ExpStatSN 0
      MaxRecvDSLength 131072, our_MaxRecvDSLength 262144
      CSG 3, NSG 3, min_pdu_size 48 (w/ data 48)
      AuthMethod none, HeaderDigest None (len 0), DataDigest None (len 0)
      Version Min: 0, Max: 0
      FC target: Up, Reorder PDU: No, Marker send: No (int 0)
      Received MaxRecvDSLen key: Yes
```

Example 35-16 Displays FCIP Information for a Specific Interface

```
switch# show interface fcip 1
fcip1 is trunking
    Hardware is GigabitEthernet
    Port WWN is 20:50:00:0d:ec:08:6c:c0
    Peer port WWN is 20:10:00:05:30:00:a7:9e
    Admin port mode is auto, trunk mode is on
    Port mode is TE
    Port vsan is 1
    Speed is 1 Gbps
    Trunk vsans (admin allowed and active) (1)
    Trunk vsans (up)                       (1)
    Trunk vsans (isolated)                 ()
    Trunk vsans (initializing)             ()
    Using Profile id 1  (interface GigabitEthernet2/1)
    Peer Information
      Peer Internet address is 10.10.11.1 and port is 3225
    FCIP tunnel is protected by IPSec <----------The FCIP tunnel protection status
    Write acceleration mode is off
    Tape acceleration mode is off
    Tape Accelerator flow control buffer size is 256 KBytes
    IP Compression is disabled
    Special Frame is disabled
    Maximum number of TCP connections is 2
    Time Stamp is disabled
    QOS control code point is 0
    QOS data code point is 0
    B-port mode disabled
    TCP Connection Information
      2 Active TCP connections
        Control connection: Local 10.10.11.2:3225, Remote 10.10.11.1:65520
        Data connection: Local 10.10.11.2:3225, Remote 10.10.11.1:65522
      2 Attempts for active connections, 0 close of connections
```

```
    TCP Parameters
      Path MTU 1400 bytes
      Current retransmission timeout is 200 ms
      Round trip time: Smoothed 2 ms, Variance: 1
      Advertized window: Current: 124 KB, Maximum: 124 KB, Scale: 6
      Peer receive window: Current: 123 KB, Maximum: 123 KB, Scale: 6
      Congestion window: Current: 53 KB, Slow start threshold: 48 KB
      Current Send Buffer Size: 124 KB, Requested Send Buffer Size: 0 KB
      CWM Burst Size: 50 KB
    5 minutes input rate 128138888 bits/sec, 16017361 bytes/sec, 7937 frames/sec
    5 minutes output rate 179275536 bits/sec, 22409442 bytes/sec, 46481 frames/sec
      10457037 frames input, 21095415496 bytes
         308 Class F frames input, 32920 bytes
         10456729 Class 2/3 frames input, 21095382576 bytes
         9907495 Reass frames
         0 Error frames timestamp error 0
      63792101 frames output, 30250403864 bytes
         472 Class F frames output, 46816 bytes
         63791629 Class 2/3 frames output, 30250357048 bytes
         0 Error frames
```

Example 35-17 Displays the Global IPsec Statistics for the Switch

```
switch# show crypto global domain ipsec
IPSec global statistics:
        Number of crypto map sets: 3
        IKE transaction stats: 0 num, 256 max
        Inbound SA stats: 0 num
        Outbound SA stats: 0 num
```

Example 35-18 Displays the IPsec Statistics for the Specified Interface

```
switch# show crypto global domain ipsec interface gigabitethernet 3/1
IPSec interface statistics:
        IKE transaction stats: 0 num
        Inbound SA stats: 0 num, 512 max
        Outbound SA stats: 0 num, 512 max
```

Example 35-19 Displays the Global SA Lifetime Values

```
switch# show crypto global domain ipsec security-association lifetime
Security Association Lifetime: 450 gigabytes/3600 seconds
```

Configuration Examples for IPsec

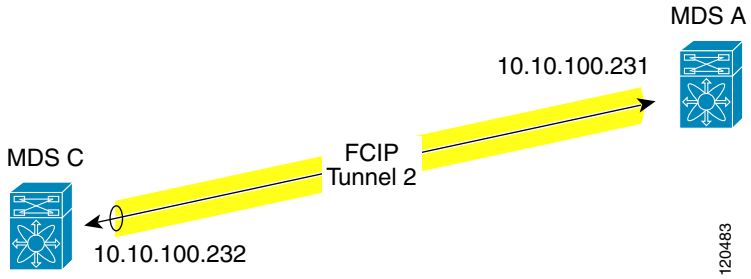
The following are the configuration examples for IPsec:

- "Sample FCIP Configuration" section on page 35-255
- "Sample iSCSI Configuration" section on page 35-260

Sample FCIP Configuration

Figure 35-11 focuses on implementing IPsec for one FCIP link (Tunnel 2). Tunnel 2 carries encrypted data between MDS A and MDS C.

Figure 35-11 IP Security Usage in an FCIP Scenario



To configure IPsec for the FCIP scenario shown in Figure 35-11, follow these steps:

Step 1 Enable IKE and IPsec in Switch MDS A.

```
sw10.1.1.100# conf t
sw10.1.1.100(config)# feature crypto ike
sw10.1.1.100(config)# feature crypto ipsec
```

Step 2 Configure IKE in Switch MDS A.

```
sw10.1.1.100(config)# crypto ike domain ipsec
sw10.1.1.100(config-ike-ipsec)# key ctct address 10.10.100.232
sw10.1.1.100(config-ike-ipsec)# policy 1
sw10.1.1.100(config-ike-ipsec-policy)# encryption 3des
sw10.1.1.100(config-ike-ipsec-policy)# hash md5
sw10.1.1.100(config-ike-ipsec-policy)# end
sw10.1.1.100#
```

Step 3 Configure the ACLs in Switch MDS A.

```
sw10.1.1.100# conf t
sw10.1.1.100(config)# ip access-list acl1 permit tcp 10.10.100.231 0.0.0.0 10.10.100.232
0.0.0.0
```

Step 4 Configure the transform set in Switch MDS A.

```
sw10.1.1.100(config)# crypto transform-set domain ipsec tfs-02 esp-aes 128 esp-sha1-hmac
```

Step 5 Configure the crypto map in Switch MDS A.

```
sw10.1.1.100(config)# crypto map domain ipsec cmap-01 1
sw10.1.1.100(config-crypto-map-ip)# match address acl1
sw10.1.1.100(config-crypto-map-ip)# set peer 10.10.100.232
sw10.1.1.100(config-crypto-map-ip)# set transform-set tfs-02
sw10.1.1.100(config-crypto-map-ip)# set security-association lifetime seconds 120
sw10.1.1.100(config-crypto-map-ip)# set security-association lifetime gigabytes 3000
sw10.1.1.100(config-crypto-map-ip)# set pfs group5
sw10.1.1.100(config-crypto-map-ip)# end
sw10.1.1.100#
```

Step 6 Bind the interface to the crypto map set in Switch MDS A.

```
sw10.1.1.100# conf t
sw10.1.1.100(config)# int gigabitethernet 7/1
sw10.1.1.100(config-if)# ip addr 10.10.100.231 255.255.255.0
sw10.1.1.100(config-if)# crypto map domain ipsec cmap-01
sw10.1.1.100(config-if)# no shut
sw10.1.1.100(config-if)# exit
sw10.1.1.100(config)#
```

Step 7 Configure FCIP in Switch MDS A.

```
sw10.1.1.100(config)# feature fcip
sw10.1.1.100(config)# fcip profile 2
sw10.1.1.100(config-profile)# ip address 10.10.100.231
sw10.1.1.100(config-profile)# int fcip 2
sw10.1.1.100(config-if)# peer-info ipaddr 10.10.100.232
sw10.1.1.100(config-if)# use-profile 2
sw10.1.1.100(config-if)# no shut
sw10.1.1.100(config-if)# end
sw10.1.1.100#
```

Step 8 Verify the configuration in Switch MDS A.

```
sw10.1.1.100# show crypto global domain ipsec security-association lifetime
Security Association Lifetime: 4500 megabytes/3600 seconds

sw10.1.1.100# show crypto map domain ipsec
Crypto Map "cmap-01" 1 ipsec
        Peer = 10.10.100.232
        IP ACL = acl1
            permit ip 10.10.100.231 255.255.255.255 10.10.100.232 255.255.255.255
        Transform-sets: tfs-02,
        Security Association Lifetime: 3000 gigabytes/120 seconds
        PFS (Y/N): Y
         PFS Group: group5
Interface using crypto map set cmap-01:
    GigabitEthernet7/1

sw10.1.1.100# show crypto transform-set domain ipsec
Transform set: tfs-02 {esp-aes 128 esp-sha1-hmac}
    will negotiate {tunnel}

sw10.1.1.100# show crypto spd domain ipsec
Policy Database for interface: GigabitEthernet7/1, direction: Both
#   0:      deny  udp any port eq 500 any
#   1:      deny  udp any any port eq 500
#   2:      permit ip 10.10.100.231 255.255.255.255 10.10.100.232 255.255.255.255
#  63:      deny  ip any any

sw10.1.1.100# show crypto ike domain ipsec
keepalive 3600

sw10.1.1.100# show crypto ike domain ipsec key
key ctct address 10.10.100.232

sw10.1.1.100# show crypto ike domain ipsec policy
Priority 1, auth pre-shared, lifetime 86300 secs, encryption 3des, hash md5, DH group 1
```

Step 9 Enable IKE and IPsec in Switch MDS C.

```
sw11.1.1.100# conf t
sw11.1.1.100(config)# feature crypto ike
sw11.1.1.100(config)# feature crypto ipsec
```

Step 10 Configure IKE in Switch MDS C.

```
sw11.1.1.100(config)# crypto ike domain ipsec
sw11.1.1.100(config-ike-ipsec)# key ctct address 10.10.100.231
sw11.1.1.100(config-ike-ipsec)# policy 1
sw11.1.1.100(config-ike-ipsec-policy)# encryption 3des
sw11.1.1.100(config-ike-ipsec-policy)# hash md5
sw11.1.1.100(config-ike-ipsec-policy)# exit
sw11.1.1.100(config-ike-ipsec)# end
sw11.1.1.100#
```

Step 11 Configure the ACLs in Switch MDS C.

```
sw11.1.1.100# conf t
sw11.1.1.100(config)# ip access-list acl1 permit ip 10.10.100.232 0.0.0.0 10.10.100.231
0.0.0.0
```

Step 12 Configure the transform set in Switch MDS C.

```
sw11.1.1.100(config)# crypto transform-set domain ipsec tfs-02 esp-aes 128 esp-sha1-hmac
```

Step 13 Configure the crypto map in Switch MDS C.

```
sw11.1.1.100(config)# crypto map domain ipsec cmap-01 1
sw11.1.1.100(config-crypto-map-ip)# match address acl1
sw11.1.1.100(config-crypto-map-ip)# set peer 10.10.100.231
sw11.1.1.100(config-crypto-map-ip)# set transform-set tfs-02
sw11.1.1.100(config-crypto-map-ip)# set security-association lifetime seconds 120
sw11.1.1.100(config-crypto-map-ip)# set security-association lifetime gigabytes 3000
sw11.1.1.100(config-crypto-map-ip)# set pfs group5
sw11.1.1.100(config-crypto-map-ip)# exit
sw11.1.1.100(config)#
```

Step 14 Bind the interface to the crypto map set in Switch MDS C.

```
sw11.1.1.100(config)# int gigabitethernet 1/2
sw11.1.1.100(config-if)# ip addr 10.10.100.232 255.255.255.0
sw11.1.1.100(config-if)# crypto map domain ipsec cmap-01
sw11.1.1.100(config-if)# no shut
sw11.1.1.100(config-if)# exit
sw11.1.1.100(config)#
```

Step 15 Configure FCIP in Switch MDS C.

```
sw11.1.1.100(config)# feature fcip
sw11.1.1.100(config)# fcip profile 2
sw11.1.1.100(config-profile)# ip address 10.10.100.232
sw11.1.1.100(config-profile)# int fcip 2
sw11.1.1.100(config-if)# peer-info ipaddr 10.10.100.231
sw11.1.1.100(config-if)# use-profile 2
sw11.1.1.100(config-if)# no shut
sw11.1.1.100(config-if)# exit
sw11.1.1.100(config)# exit
```

Step 16 Verify the configuration in Switch MDS C.

```
sw11.1.1.100# show crypto global domain ipsec security-association lifetime
Security Association Lifetime: 4500 megabytes/3600 seconds

sw11.1.1.100# show crypto map domain ipsec
Crypto Map "cmap-01" 1 ipsec
        Peer = 10.10.100.231
        IP ACL = acl1
            permit ip 10.10.100.232 255.255.255.255 10.10.100.231 255.255.255.255
        Transform-sets: tfs-02,
        Security Association Lifetime: 3000 gigabytes/120 seconds
        PFS (Y/N): Y
         PFS Group: group5
Interface using crypto map set cmap-01:
    GigabitEthernet1/2

sw11.1.1.100# show crypto spd domain ipsec
Policy Database for interface: GigabitEthernet1/2, direction: Both
#   0:      deny  udp any port eq 500 any
#   1:      deny  udp any any port eq 500
```

```
#   2:      permit ip 10.10.100.232 255.255.255.255 10.10.100.231 255.255.255.255
#  63:      deny  ip any any

sw11.1.1.100# show crypto sad domain ipsec
interface: GigabitEthernet1/2
    Crypto map tag: cmap-01, local addr. 10.10.100.232
    protected network:
    local  ident (addr/mask): (10.10.100.232/255.255.255.255)
    remote  ident (addr/mask): (10.10.100.231/255.255.255.255)
    current_peer: 10.10.100.231
      local crypto endpt.: 10.10.100.232, remote crypto endpt.: 10.10.100.231
      mode: tunnel, crypto algo: esp-3des, auth algo: esp-md5-hmac
     current outbound spi: 0x38f96001 (955867137), index: 29
      lifetimes in seconds:: 120
      lifetimes in bytes:: 3221225472000
     current inbound spi: 0x900b011 (151040017), index: 16
      lifetimes in seconds:: 120
      lifetimes in bytes:: 3221225472000

sw11.1.1.100# show crypto transform-set domain ipsec
Transform set: tfs-02 {esp-aes 128 esp-sha1-hmac}
    will negotiate {tunnel}

sw11.1.1.100# show crypto ike domain ipsec
keepalive 3600

sw11.1.1.100# show crypto ike domain ipsec key

key ctct address 10.10.100.231

sw11.1.1.100# show crypto ike domain ipsec policy
Priority 1, auth pre-shared, lifetime 86300 secs, encryption 3des, hash md5, DH
group 1

sw11.1.1.100# show crypto ike domain ipsec sa
Tunn    Local Addr          Remote Addr         Encr    Hash    Auth Method     Lifetime
-----------------------------------------------------------------------------------------
1*      10.10.100.232[500]  10.10.100.231[500]  3des    md5     preshared key   86300
-----------------------------------------------------------------------------------------
NOTE: tunnel id ended with * indicates an IKEv1 tunnel
```

Step 17 Verify the configuration in Switch MDS A.

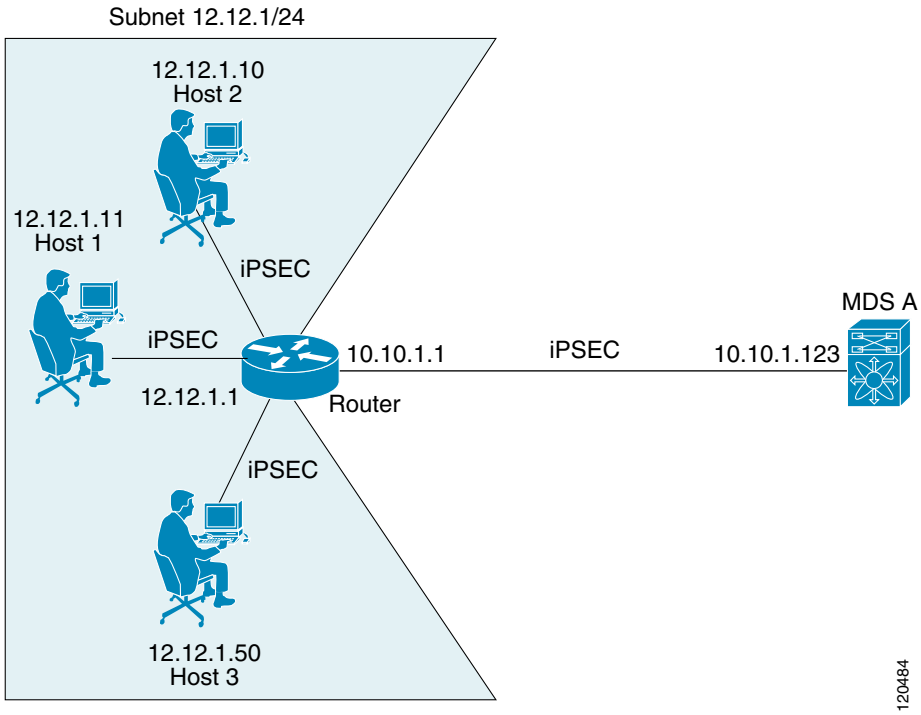
```
sw10.1.1.100# show crypto sad domain ipsec
interface: GigabitEthernet7/1
    Crypto map tag: cmap-01, local addr. 10.10.100.231
    protected network:
    local  ident (addr/mask): (10.10.100.231/255.255.255.255)
    remote  ident (addr/mask): (10.10.100.232/255.255.255.255)
    current_peer: 10.10.100.232
      local crypto endpt.: 10.10.100.231, remote crypto endpt.: 10.10.100.232
      mode: tunnel, crypto algo: esp-3des, auth algo: esp-md5-hmac
     current outbound spi: 0x900b01e (151040030), index: 10
      lifetimes in seconds:: 120
      lifetimes in bytes:: 3221225472000
     current inbound spi: 0x38fe700e (956198926), index: 13
      lifetimes in seconds:: 120
      lifetimes in bytes:: 3221225472000

sw10.1.1.100# show crypto ike domain ipsec sa
Tunn Local Addr          Remote Addr         Encr  Hash  Auth Method   Lifetime
-------------------------------------------------------------------------------
   1 10.10.100.231[500]  10.10.100.232[500]  3des  md5   preshared key    86300
```

You have now configured IPsec in both switches MDS A and MDS C.

Sample iSCSI Configuration

Figure 35-12 focuses on the iSCSI session between MDS A and the hosts in subnet 12.12.1/24. Using the **auto-peer** option, when any host from the subnet 12.12.1.0/24 tries to connect to the MDS switch's Gigabit Ethernet port 7/1, an SA is created between the hosts and the MDS switch. With auto-peer, only one crypto map is necessary to create SAs for all the hosts in the same subnet. Without auto-peer, you need one crypto map entry per host.

Figure 35-12 iSCSI with End-to-End IPsec



To configure IPsec for the iSCSI scenario shown in Figure 35-12, follow these steps:

Step 1 Configure the ACLs in Switch MDS A.

```
sw10.1.1.100# conf t
sw10.1.1.100(config)# ip access-list acl1 permit tcp 10.10.1.0 0.0.0.255 range port 3260
3260 12.12.1.0 0.0.0.255
```

Step 2 Configure the transform set in Switch MDS A.

```
sw10.1.1.100(config)# crypto transform-set domain ipsec tfs-01 esp-3des esp-md5-hmac
```

Step 3 Configure the crypto map in Switch MDS A.

```
sw10.1.1.100(config)# crypto map domain ipsec cmap-01 1
sw10.1.1.100(config-crypto-map-ip)# match address acl1
sw10.1.1.100(config-crypto-map-ip)# set peer auto-peer
```

```
sw10.1.1.100(config-crypto-map-ip)# set transform-set tfs-01
sw10.1.1.100(config-crypto-map-ip)# end
sw10.1.1.100#
```

Step 4 Bind the interface to the crypto map set in Switch MDS A.

```
sw10.1.1.100# conf t
sw10.1.1.100(config)# int gigabitethernet 7/1
sw10.1.1.100(config-if)# ip address 10.10.1.123 255.255.255.0
sw10.1.1.100(config-if)# crypto map domain ipsec cmap-01
sw10.1.1.100(config-if)# no shut
sw10.1.1.100(config-if)# end
sw10.1.1.100#
```

You have now configured IPsec in MDS A using the Cisco MDS IPsec and iSCSI features.

Field Descriptions for IPsec

The following are the field descriptions for IPsec.

IPsec

Field	Description
Interface, CryptomapName	The binding of cryptomap sets to the interfaces of the managed entity.

IKE Global

Field	Description
RemIdentity	Displays the keepalive interval in seconds used by the IKE entity on the managed device with all the peers for the DOI corresponding to this conceptual row.
Key	Displays the type of keepalives to be used by the IKE entity on the managed device with all the peers for the DOI corresponding to this conceptual row.

IKE Pre-Shared AuthKey

Field	Description
KeepAliveInterval (sec)	The Phase 1 ID identity of the peer for which this pre-shared key is configured on the local entity.
IdentityType	The pre-shared authorization key used in authenticating the peer corresponding to this conceptual row.

IKE Policies

Field	Description
Priority	The priority of this ISAKMP policy entry. The policy with lower value would take precedence over the policy with higher value in the same DOI.
Encr	The encryption transform specified by this ISAKMP policy specification. The Internet Key Exchange (IKE) tunnels setup using this policy item would use the specified encryption transform to protect the ISAKMP PDUs.
Hash	The hash transform specified by this ISAKMP policy specification. The IKE tunnels setup using this policy item would use the specified hash transform to protect the ISAKMP PDUs.
Auth	The peer authentication method specified by this ISAKMP policy specification. If this policy entity is selected for negotiation with a peer, the local entity would authenticate the peer using the method specified by this object.
DHGroup	Specifies the Oakley group used for Diffie Hellman exchange in the Main Mode. If this policy item is selected to negotiate Main Mode with an IKE peer, the local entity chooses the group specified by this object to perform Diffie Hellman exchange with the peer.
Lifetime (sec)	Specifies the lifetime in seconds of the IKE tunnels generated using this policy specification.

IKE Initiator Version

Field	Description
Address	The address of the remote peer corresponding to this conceptual row. This object cannot be modified while the corresponding value of cicIkeCfgInitiatorStatus is equal to active.
Version	The IKE protocol version used when connecting to a remote peer specified in cicIkeCfgInitiatorPAddr. This object cannot be modified while the corresponding value of cicIkeCfgInitiatorStatus is equal to active.

IKE Tunnels

Field	Description
LocalAddress	The address of the local endpoint for the Phase-1 tunnel.
RemoteAddresss	The address of the remote endpoint of the Phase-1 tunnel.

Field	Description
AuthMethod	The authentication method used in Phase-1 negotiations on the control tunnel corresponding to this conceptual row.
Action	The action to be taken on this tunnel. If clear, then this tunnel is cleared. If re-key, then re-keying is forced on this tunnel. The value none would be returned on doing read of this object.

IPSEC Global

Field	Description
Lifetime (sec)	The default lifetime (in seconds) assigned to an IPsec tunnel as a global policy (maybe overridden in specific cryptomap definitions).
Lifesize (KB)	The default life size in KB assigned to an IPsec tunnel as a global policy (unless overridden in cryptomap definition).

IPSEC Transform Set

Field	Description
Id	This is the sequence number of the transform set that uniquely identifies the transform set. Distinct transform sets must have distinct sequence numbers.
Protocol	Represents the suite of Phase-2 security protocols of this transform set.
ESP Encryption	Represents the transform used for ESP encryption.
ESP Authentication	Represents the transform used to implement integrity check with ESP protocol.
Mode	Represents the encapsulation mode of the transform set.

IPSEC CryptoMap Set Entry

Field	Description
IpFilter	Specifies an IP protocol filter to be secured using this cryptomap entry. When it has a value of zero-length string, it is not valid/applicable.
TransformSetIdList	The list of cipsXformSetId that are members of this CipsStaticCryptomapEntry. The value of this object is a concatenation of zero ormore 4-octet strings, where each 4-octet string contains a 32-bit cipsXformSetId value in network byte order. A zero length string value means this list has no members.
AutoPeer	If true the destination address is taken as the peer address, while creating the tunnel.

Field	Description
Peer Address	The IP address of the peer to which this cryptomap entry is currently connected.
PFS	Identifies whether the tunnels instantiated due to this policy item should use Perfect Forward Secrecy (PFS) and if so, what group of Oakley they should use.
LifeTime	Specifies the lifetime of the IPsec Security Associations (SA) created using this IPsec policy entry.
Lifesize Value	Identifies the life size (maximum traffic in bytes that may be carried) of the IPSec SAs created using this IPSec policy entry. When a Security Association (SA) is created using this IPsec policy entry, its life size takes the value of this object.

IPSEC Interfaces

Field	Description
CryptomapName	The index of the static cryptomap table. The value of the string is the name string assigned by the NMS when defining a cryptomap set.
InterfaceList	Interfaces belong to the cryptomap.

IPSEC Tunnels

Field	Description
Local Address	The IP address of the local endpoint for the IPsec Phase-2 tunnel.
RemoteAdddress	The type of the IP address of the remote endpoint for the IPsec Phase-2 tunnel.
ESP Encryption	The encryption algorithm used by the outbound security association of the IPsec Phase-2 tunnel.
ESP Encryption KeySize	The key size in bits of the negotiated key to be used with the algorithm denoted by ceipSecTunOutSaEncryptAlgo. For DES and 3DES the key size is respectively 56 and 168. For AES, this will denote the negotiated key size.
ESP Authentication	The authentication algorithm used by the inbound encapsulation security protocol (ESP) security association of the IPsec Phase-2 tunnel.
LifeSize (KB)	The negotiated life size of the IPSEC Phase-2 tunnel in kilobytes.
LifeTime (sec)	The negotiated lifetime of the IPSEC Phase-2 tunnel in seconds. If the tunnel was setup manually, the value of this MIB element should be 0.
Action	The status of the MIB table row.