Mobile IP Security

All registration messages between a mobile node and home agent are required to contain the Mobile-Home Authentication Extension (MHAE).

The integrity of the registration messages is protected by a shared 128-bit key between a mobile node and home agent. The keyed message digest algorithm 5 (MD5) in "prefix+suffix" mode is used to compute the authenticator value in the appended MHAE. Mobile IP also supports the hash-based message authentication code (HMAC-MD5). The receiver compares the authenticator value it computes over the message with the value in the extension to verify the authenticity.

Optionally, the Mobile-Foreign Authentication Extension and Foreign-Home Authentication Extension are appended to protect message exchanges between a mobile node and foreign agent and between a foreign agent and home agent, respectively.

Replay protection uses the identification field in the registration messages as a time stamp and sequence number. The home agent returns its time stamp to synchronize the mobile node for registration.

The Cisco IOS software allows the mobility keys to be stored on an authentication, authorization, and accounting (AAA) server that can be accessed using Terminal Access Controller Access Control System Plus (TACACS+) or Remote Authentication Dial-In User Service (RADIUS) protocols. You can restrict who is allowed to register by using registration filters.

For more information on security in a Mobile IP environment, refer to the "Configuring Mobile IP" chapter of the *Cisco IOS IP Configuration Guide*, Release 12.2.

AAA in the Mobile IP Environment

To configure AAA in the Mobile IP environment, use the following commands in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# aaa new-model`	Enables the AAA access control model.
Step 2	`Router(config)# aaa authorization ipmobile {tacacs+ | radius}`	Authorizes Mobile IP to retrieve security associations from the AAA server using TACACS+ or RADIUS.

Configuring RADIUS in the Mobile IP Environment

RADIUS is a method for defining the exchange of AAA information in the network. In the Cisco implementation, RADIUS clients run on Cisco routers and send authentication requests to a RADIUS server that contains all user authentication and network server access information. For detailed information about RADIUS configuration options, refer to the "Configuring RADIUS" chapter in the *Cisco IOS Security Configuration Guide*.

To configure RADIUS in the Mobile IP environment, use the following commands in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# radius-server host`	Specifies a RADIUS server host.
Step 2	`Router(config)# radius-server key`	Sets the authentication and encryption key for all RADIUS communications between the router and the RADIUS daemon.

Configuring TACACS+ in the Mobile IP Environment

Terminal Access Controller Access Control System Plus (TACACS+) is an authentication protocol that provides remote access authentication and related services, such as event logging. For detailed information about TACACS+ configuration options, refer to the "Configuring TACACS+" chapter in the *Cisco IOS Security Configuration Guide*.

To configure TACACS+ in the Mobile IP environment, use the following commands in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# tacacs-server host`	Specifies a TACACS+ server host.
Step 2	`Router(config)# tacacs-server key`	Sets the authentication encryption key used for all TACACS+ communications between the access server and the TACACS+ daemon.

Example of a AAA Server Configuration

In the following AAA server configuration, the home agent can use an AAA server for storing security associations. Mobile IP has been authorized using TACACS+ server to retrieve the security association information, which is used by the home agent to authenticate registrations. The **user** is the mobile node IP address. The syntax for the security association is spi#*num* = *string*, where *string* is the rest of the IP address. This format can be imported into a CiscoSecure server.

```
user = 20.0.0.1 {
    service = mobileip {
        set spi#0 = "spi 100 key hex 12345678123456781234567812345678"
"
    }
}
```

```
user = 20.0.0.2 {
    service = mobileip {
        set spi#0 = "spi 100 key hex 12345678123456781234567812345678"
    }
}

user = 20.0.0.3 {
    service = mobileip {
        set spi#0 = "spi 100 key hex 12345678123456781234567812345678"
    }
}
```

The following example shows how the home agent is configured to use the AAA server:

```
aaa new-model
aaa authorization ipmobile tacacs+
!
ip mobile home-agent
ip mobile network 20.0.0.0 255.0.0.0
ip mobile host 20.0.0.1 20.0.0.3 virtual-network 20.0.0.0 255.0.0.0 aaa
!
tacacs-server host 1.2.3.4
tacacs-server key cisco
```

IPSec in the Mobile IP Environment

Security associations establish trust between two devices in a peer-to-peer relationship. There are two types of security association. The first is Internet Key Exchange (IKE), which provides negotiation, peer authentication, key management, and key exchange. IKE provides a secure communication channel between two devices that is used to negotiate an encryption algorithm, a hash algorithm, an authentication method, and any relevant group information.

The second type of security association is called IPsec security association (IPsec SA). IPsec SA is unidirectional, thus requiring that separate IPsec SAs be established in each direction to provide non-repudiation, data integrity, and payload confidentiality. Non-repudiation is often necessary to verify that a transaction has taken place, such as a financial exchange between parties. Data integrity verifies that packets are not altered in transit by a third party. Payload confidentiality is provided by encryption.

It might be necessary to protect certain traffic on the mobile network. This is accomplished by enabling IPSec between the mobile access router and an IPSec gateway located behind the home agent. Since an IPSec tunnel is established within the Mobile IP tunnel, IKE renegotiation is unnecessary as the mobile access router moves about. The result is secure, scalable mobile networks based on standards.

The IPSec encryption algorithm that runs between the mobile access router and the IPSec gateway can either be Triple Data Encryption Standard (DES) or Advanced Encryption Standard (AES). Note that AES provides greater security than DES and is more efficient than 3DES.

IPSec Interoperability

IPsec sets up its peering between the egress interface of the encrypting router and any interface on the decrypting router. This relationship is hampered because the egress interface of a mobile access router changes based on available network connectivity. In addition, the egress interfaces might have non-routable IP addresses associated with them, which makes setting up an IPsec session impossible using the standard model.

To overcome the problems, all traffic must exit the same interface that will always be up and will always have a routable IP address. The method applied in this example is anchoring the IPsec session to the loopback interface on the mobile access router. The home address of the mobile access router should be configured on a loopback interface because loopback interfaces are software and are always up.

It is possible to forward traffic into a loopback interface. If the traffic is not destined for the IP address of the loopback, the traffic exits the interface and is looped back into the router. At this point, normal routing processes take delivery of the packet.

The only way to forward traffic out a loopback is with the **set interface** target of a **route map** command. Using the features of route maps and loopback interfaces, you can configure IPsec on a mobile access router. All traffic from the mobile network that needs to be encrypted is sent by a route map out the loopback and back in to the router for normal delivery. When the traffic exits the loopback interface, the crypto map is applied and traffic is encrypted as necessary. For traffic to the mobile access router, the ingress interface is the loopback interface that has the crypto map to decrypt any protected content.

In summary, the loopback interface is always up and not affected by the movement of the mobile access router (in which the interface or point of attachment changes dynamically). This provides the invariant endpoint of the IPSec connection. Thus, the IPSec connection is always *alive* in conjunction with mobility.

IPSec Gateway

The IPSec gateway might be any Cisco router with IPSec software and an IPSec-capable image that corresponds to the mobile access router. The IPSec gateway is not required to have the Mobile IP feature set, because it is not providing mobility service. Since this router is acting as an IPSec traffic aggregator, it is recommended that you install hardware accelerator modules in the connected device for better performance. Ideally, the IPSec gateway router is a Cisco 7200 Series router with an ISA/VPN Acceleration Module (VAM) card, or a Catalyst 6500 switch with an American Contractors Exchange (ACE) card.

Figure 9-1 IPSec Gateway Network Topology

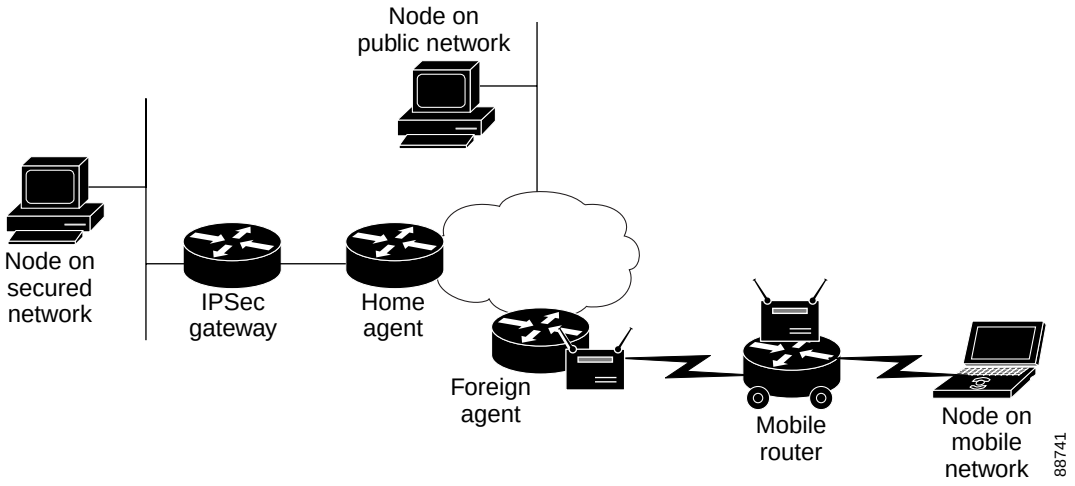
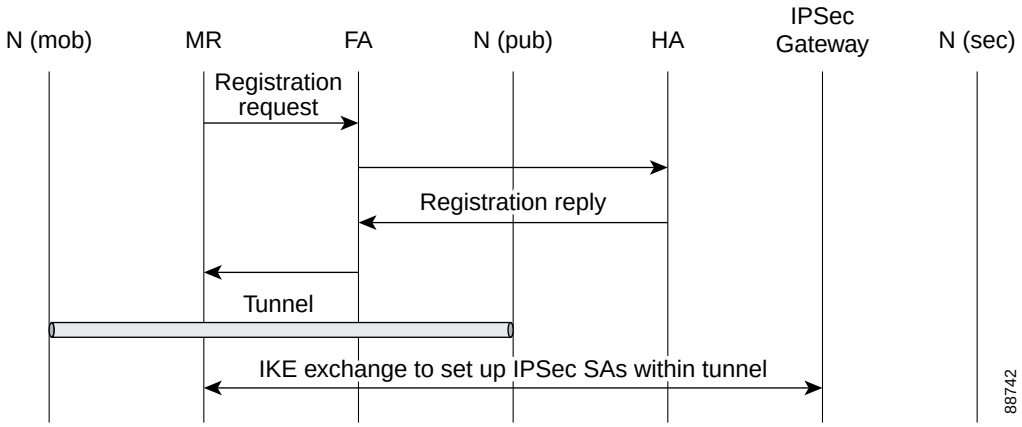


Figure 9-1 shows three types of nodes in the network topology: nodes on a mobile network, nodes on a secured network, and nodes on a public network. The mobile access router establishes an IPSec tunnel between it and the IPSec gateway to protect traffic to nodes on the secured network. Communications with nodes on the public network is not encrypted. The home agent and IPSec gateway must be deployed in the Demilitarized Zone (DMZ).

Figure 9-2 shows how a mobile access router sets up an IPSec tunnel with the IPSec gateway by exchanging IKE messages, which traverse the Mobile IP tunnel. The IPSec tunnel is established when traffic flows between a node on the secured network and a node on a mobile network.

Figure 9-2 IPSec Control Flow

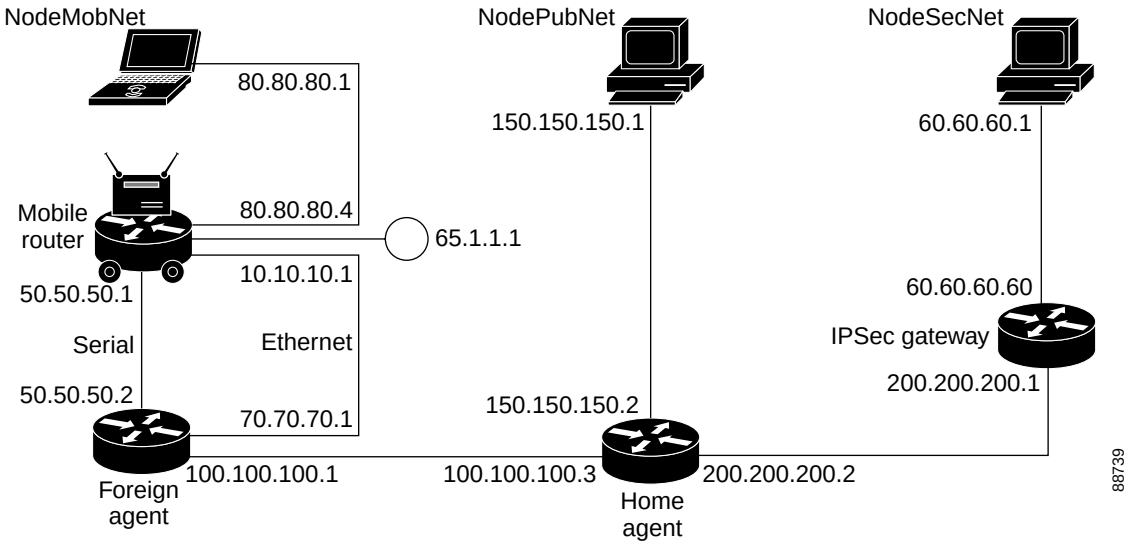


Data traffic can be categorized into either secure or public. Communications that must be protected are encrypted and wrapped in IPSec. Otherwise, packets are sent in the clear.

IPSec Configuration

This section contains configurations for the mobile access router, IPSec gateway, home agent, foreign agent, and mobile nodes in a specified network topology. Traffic is secured between the mobile access router network and networks in the home domain. The IPSec endpoints are the mobile access router and the IPSec Gateway located behind the home agent on the home network. The networks in the home domain in which protection is desired are placed behind the IPSec gateway.

Figure 9-3 IPSec Configuration Example



Example of IPSec Mobile Network Configuration

The mobile access router has one Ethernet interface on the mobile network and two interfaces, serial and Ethernet, connected to a foreign agent. The foreign agent is providing Mobile IP service only on the Ethernet interface, not on the serial interface.

The serial interface is a roaming interface with static collocated care-of-address. The roaming Ethernet interface is used to detect foreign agents. The other Ethernet interface is for the LAN on the mobile access router. All nodes on the mobile network use the mobile access router as the default gateway.

Note If the mobile access router has only one network interface, the mobile network and the roaming interface functions should be combined. If the mobile access router has multiple interfaces or VLANs, it should have a dedicated roaming interface and a mobile network interface.

The IPSec configuration must meet the following criteria:

- The mobile access router home address must be configured as a loopback address.
- The crypto map to encrypt traffic to the home network must be applied on the loopback interface (named *ToSecureNet* in the configuration example).
- The IPSec/IKE peer for the crypto configuration is the IPSec gateway IP address.
- On the inbound interface where the mobile access router networks are configured, a routemap must be applied to select the traffic to be encrypted (named *SecureNetPolicy* in the example configuration). This routemap sets the outbound interface to the loopback interface and forces crypto evaluation. This results in encryption if the traffic matches the crypto-map access control lists.
- The access control list must list the networks for which traffic must be encrypted. In the configuration example, the access control list is:

  ```
  access-list 155 permit ip 80.80.80.0 0.0.0.255 60.60.60.0 0.0.0.255
  ```

Since the source is 80.80.80.0/24, it corresponds to the mobile access router network connected on the Ethernet interface. The destination network is 60.60.60.0/24, which implies that all traffic towards 60.60.60.0/24 will be encrypted. Since communication with the network 60.60.60.0/24 is IPSec protected, this network is referred to as a *protected network*. All protected networks must be listed in the access control list. The last implicit entry in the access control list is *deny ip any any.* If the traffic does not match any of the previous entries and was not marked for encryption, the traffic is sent in clear.

Unprotected access is provided to all other (public) networks (those not listed the access control list with the permit clause). For example:

```
crypto isakmp policy 1
 hash md5
 authentication pre-share
 group 2
crypto isakmp key 1234567890 address 200.200.200.1
!
crypto isakmp peer address 200.200.200.1
!
crypto IPsec transform-set testtrans esp-des
!
!
crypto map ToSecureNet 10 IPsec-isakmp
 set peer 200.200.200.1
 set transform-set testtrans
 match address 155
!
```

```
interface Loopback1
 ip address 65.1.1.1 255.255.255.255
 crypto map ToSecureNet
!
interface Ethernet3/2
 ip address 10.10.10.1 255.255.255.0
 ip mobile router-service roam
!
interface Ethernet3/3
 ip address 80.80.80.4 255.255.255.0
 ip policy route-map SecureNetPolicy
!
interface Serial4/1
ip address 50.50.50.1 255.255.255.0
 ip mobile router-service roam
 ip mobile router-service collocated gateway 50.50.50.2
!
router mobile
!
ip local policy route-map SecureNetPolicy
!
ip mobile secure home-agent 100.100.100.3 spi 100 key hex 11223344556677881123344556677881
algorithm md5 mode prefix-suffix
ip mobile router
 address 65.1.1.1 255.0.0.0
 home-agent 100.100.100.3
 reverse-tunnel
!
access-list 155 permit ip 80.80.80.0 0.0.0.255 60.60.60.0 0.0.0.255
!
route-map SecureNetPolicy permit 10
 match ip address 155
 set interface Loopback1
```

Example of IPSec Gateway

The IPSec gateway IP address must be configured on a physical WAN interface of the mobile access router. Typically, this is the interface that receives traffic from and sends traffic to the home agent.

Home domain networks in which sensitive data requires encryption are located behind this gateway. Traffic between these networks and mobile access router networks is provided IPSec protection. The crypto map in sample configuration has the following access control list:

```
access-list 156 permit ip 60.60.60.0 0.0.0.255 80.80.80.0 0.0.0.255
```

This indicates that any traffic from protected network 60.60.60.0/24 that is going to mobile access router network 80.80.80.0/24 is selected for encryption and decryption. For example:

```
crypto isakmp policy 1
 hash md5
 authentication pre-share
 group 2
crypto isakmp key 1234567890 address 65.1.1.1
!
!
crypto IPsec transform-set testtrans esp-des
!
crypto map ToMobileNet 10 IPsec-isakmp
set peer 65.1.1.1
 set transform-set testtrans
 match address 156
!
interface Ethernet1/0/2
```

```
 ip address 200.200.200.1 255.255.255.0
 crypto map ToMobileNet
!
interface Ethernet1/0/3
 ip address 60.60.60.60 255.255.255.0
!
access-list 156 permit ip 60.60.60.0 0.0.0.255 80.80.80.0 0.0.0.255
```

Foreign Agent Example

To support mobile access router home domain network IPSec, no special configuration of the foreign agent is required. For example:

```
interface Serial1/2
 ip address 50.50.50.2 255.255.255.0
!
interface Ethernet3/1
 ip address 100.100.100.1 255.255.255.0
!
interface Ethernet3/3
 ip address 70.70.70.1 255.255.255.0
 ip irdp
 ip irdp maxadvertinterval 5
 ip irdp minadvertinterval 2
 ip irdp holdtime 15
 ip mobile foreign-service reverse-tunnel
!
router mobile
!
router rip
 redistribute mobile
 network 50.0.0.0
 network 70.0.0.0
 network 100.0.0.0
!
ip mobile foreign-agent care-of Ethernet3/1
```

Home Agent Example

Because the home agent does not participate in providing traffic protection, no special IPSec configuration is required at the home agent. The Mobile IP configurations are shown below:

```
interface Ethernet3/1
 ip address 100.100.100.3 255.255.255.0
!
interface Ethernet3/2
 ip address 200.200.200.2 255.255.255.0
!
interface Ethernet3/3
 ip address 150.150.150.2 255.255.255.0
!
router mobile
!
router rip
 redistribute mobile metric 1
 network 100.0.0.0
 network 150.150.150.0
 network 200.200.200.0
!
ip mobile home-agent
ip mobile virtual-network 65.0.0.0 255.0.0.0
ip mobile host 65.1.1.1 virtual-network 65.0.0.0 255.0.0.0
ip mobile mobile-networks 65.1.1.1
```

```
 description SecureTransport
 network 80.80.80.0 255.255.255.0
ip mobile secure host 65.1.1.1 spi 100 key hex 11223344556677881123344556677881 algorithm
md5 mode prefix-suffix
no ip mobile tunnel path-mtu-discovery
```

Node on Mobile Network Example

```
interface Ethernet3/3
 ip address 80.80.80.1 255.255.255.0
!
ip route 60.60.60.0 255.255.255.0 80.80.80.4
```

Node in Public Network Example

```
interface Ethernet1/1
 ip address 150.150.150.1 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 150.150.150.2
```

Node in Secure Network Example

```
interface Ethernet1/1
 ip address 60.60.60.1 255.255.255.0
!
ip route 0.0.0.0 0.0.0.0 60.60.60.60
```

Mobile Network Security Testing

From a node on the mobile network, you can ping a node in the protected network. You can ping from the protected network node to the mobile network node with same results. The first few packets might be dropped (due to ARP, IKE, or IPSec secure area setup). After the initial packet loss, ping should be successful.

IKE and IPSec security associations are established at mobile access router and IPSec Gateway. To see the IKE security association (SA) state, use the **show crypto** command. For example:

```
MobileRouter# show crypto isakmp sa
  f_vrf/i_vrf   dst            src             state       conn-id        slot
       /        200.200.200.1   65.1.1.1         QM_IDLE       3              0
```

After the security area has been established, the state is typically QM_IDLE.

To see the IPSec secure area, use the **show crypto ipsec sa** command:

```
MobileRouter#show crypto ipsec sa
interface: Loopback1
    Crypto map tag: ToSecureNet, local addr. 65.1.1.1
protected vrf:
   local  ident (addr/mask/prot/port): (80.80.80.0/255.255.255.0/0/0)
   remote ident (addr/mask/prot/port): (60.60.60.0/255.255.255.0/0/0)
   current_peer: 200.200.200.1:500
     PERMIT, flags={origin_is_acl,}
    #pkts encaps: 397876, #pkts encrypt: 397876, #pkts digest 0
    #pkts decaps: 397559, #pkts decrypt: 397559, #pkts verify 0
    #pkts compressed: 0, #pkts decompressed: 0
    #pkts not compressed: 0, #pkts compr. failed: 0
    #pkts not decompressed: 0, #pkts decompress failed: 0
    #send errors 1, #recv errors 0
```

```
     local crypto endpt.: 65.1.1.1, remote crypto endpt.: 200.200.200.1
     path mtu 1514, media mtu 1514
     current outbound spi: 21E53ABF

     inbound esp sas:
<snip>
```

Notice the **#pkts encaps** and **#pkts decaps** counters. To clear the counters, use the **clear crypto sa counters** command.

Ping from a mobile access router node to a node on the secured network (or vice versa), and look at the value of counters again. The counters should match the number of ping packets you sent.

Other methods for detecting the encryption activity:

- Use the **debug ip packet detail dump** command, and observe that the contents do not appear to be logical.
- Attach a sniffer (or Pagent device) between the mobile access router and the IPSec Gateway, and watch the packets on the wire.
- Measure the size of packets as seen by egress interfaces on the mobile access router, home agent and IPSec gateway.

To clear the IKE security associations, use the **clear crypto isakmp** command:

```
MobileRouter#clear crypto isakmp <0-32766>
```

where *<0-32766>* is the connection ID of the secure area.

To clear the IPSec security associations, use the **clear crypto sa** command:

```
MobileRouter#clear crypto sa [counters | map | peer | spi | vrf]
```

where:

counters resets the secure area counters
map clears all secure areas for a given crypto map
peer clears all secure areas for a given crypto peer
spi clears secure areas by SPI
vrf clears VRF (Routing/Forwarding) instance

This command can also clear the packet counters, and it can be used for debugging.

IPSec Commands

encryption Command

Use the **encryption** command, a isakmp policy command, to establish IKE policy.

```
encryption {aes | aes 192 | aes 256}
```

```
Where:
aes specifies 128-bit AES
aes 192 specifies 192-bit AES
aes 256 specifies 256-bit AES
```

View information about the configuration by using the **show crypto isakmp policy** EXEC command.

crypto ipsec transform-set Command

Use the **crypto ipsec transform-set** command to define IPSec security protocols and algorithms.

crypto ipsec transform-set *transform-set-name transform1 [transform2 transform3]*

The accepted transform values are expanded. Under the category of Encapsulating Security Payload (ESP) Encryption Transform, one of the following can be chosen:

esp-aes ESP with the 128-bit AES encryption algorithm
esp-aes192 ESP with the 192-bit AES encryption algorithm
esp-aes256 ESP with the 256-bit AES encryption algorithm
esp-des ESP with the 56-bit Data Encryption Standard (DES) encryption algorithm
esp-3des ESP with the 168-bit 3DES encryption algorithm
esp-null null encryption algorithm

View information about the configuration by using the **show crypto ipsec transform-set** and **show crypto isakmp policy** EXEC commands.

Manual Certificate Enrollment

The TFTP and cut-and-paste (Manual Certificate Enrollment) generates a certificate request and accept certification authority (CA) certificates as well as the router certificates. These tasks are accomplished by using a TFTP server or manual cut-and-paste operations. Use TFTP or manual cut-and-paste enrollment in the following situations:

- The CA does not support Simple Certificate Enrollment Protocol (SCEP), the most commonly used method for sending and receiving requests and certificates.
- A network connection between the router and the CA is not possible.

Brief descriptions of some of the commands are provided in this section. A detailed explanation of the commands needed to configure Manual Certificate Enrollment can be found in the "Command Reference" section of Manual Certificate Enrollment (TFTP and Cut-and-Paste), and can be found at http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122newft/122t/122t13/ftmancrt.htm.

Manual Certificate Enrollment (TFTP and Cut-and-Paste) Prerequisites

TFTP and cut-and-paste enrollment has been added to the public key infrastructure (PKI) subsystem. The PKI subsystem requires the crypto subsystem.

Manual Certificate Enrollment (TFTP and Cut-and-Paste) Restrictions

You can switch between TFTP and cut-and-paste; for example, you can paste the CA certificate by using the **enrollment terminal** command, and then enter the **no enrollment terminal** and **enrollment url** *tftp://certserver/file_specification* commands to TFTP the requests and router certificates. However, Cisco does not recommend switching URLs if SCEP is used; that is, if the enrollment URL is "http://," *do not* change the enrollment URL between fetching the CA certificate and enrolling the certificate.

Manual Certificate Enrollment Concepts

This section describes the TFTP Certificate Enrollment and Cut-and-Paste Certificate Enrollment concepts.

TFTP Certificate Enrollment

A user might enable TFTP certificate enrollment if his or her CA does not support SCEP, which is the most commonly used method for sending and receiving requests and certificates. This feature takes the existing **enrollment ca-trustpoint** configuration subcommand and enhances the **url** *url* option to support TFTP certificate enrollment—**enrollment url** *tftp://certserver/file_specification*.

This subcommand specifies that TFTP should be used to send the enrollment requests and to retrieve the certificate of the CA and the certificate of the router. The *file_specification* is optional. However, if the *file_specification* is included in the URL, the router appends an extension to the file specification.

When the **crypto ca authenticate** command is entered, the router retrieves the certificate of the CA from the specified TFTP server. As appropriate, the router appends the extension ".ca" to the filename or the fully qualified domain name (FQDN). (If the **url** *url* option does not include a file specification, the router FQDN is used.) For example, if a user enters **enrollment url**

tftp://CA-server/TFTPfiles/router1, the TFTPfiles/router1.ca file is read from the TFTP server CA-server. If the router FQDN is router1.cisco.com, and you enter **enrollment url tftp://CA.cisco.com**, the router1.cisco.com.ca file is read from the TFTP server CA.cisco.com.

The file must contain the certificate of the CA in binary format or base 64 encoded.

When a user enrolls the router by using the **crypto ca enroll** command, he or she is prompted for information regarding the enrollment. The filename that is to be written is already determined at this point, and an extension of .req is appended to indicate that this is a certificate request.

For usage keys, two requests are generated and two certificates are expected to be granted. Thus, the extension for the certificate requests are -sign.req and -encr.req.

After the user enters the **crypto ca import** command, the router attempts to fetch the granted certificate by using TFTP and using the same filename that was used to send the request, except that .req extension is replaced by a .crt extension. (The certificates are expected to be base 64 encoded PCKS#10 format certificates.) The router parses the files it receives, verifies the certificates, and inserts the certificates into the internal certificate database.

Cut-and-Paste Certificate Enrollment

A user might want to manually cut-and-paste certificate enrollment requests and certificates when he or she does not have a network connection between the router and CA. Cut-and-paste enrollment introduces a new ca-trustpoint configuration subcommand—**enrollment**. This command should be used when configuring the trustpoint CA. After entering the **crypto ca enroll** command, you are asked the same questions about the IP address and serial number as a TFTP enrollment. The base 64 encoded certificate request is displayed on the terminal.

Similar to the TFTP process, the user enters the **crypto ca import** command to enter the granted certificate. With cut-and-paste, the base 64 encoded certificate is accepted from the console terminal. Certificate input ends after the user enters “quit” on a line by itself.

How to Configure Manual Certificate Enrollment

To enable manual certificate enrollment via TFTP or cut-and-paste, you must configure a trustpoint CA and the relevant enrollment tasks. This section contains the following procedures:

- Configuring Certificate Enrollment by Using TFTP
- Configuring Certificate Enrollment by Using Cut-and-Paste
- Verifying Manual Certificate Enrollment

Configuring Certificate Enrollment by Using TFTP

To declare the trustpoint CA that your router should use and to configure that trustpoint CA for manual enrollment by using TFTP, use the commands described in this section.

- You must know the correct URL to use if you are configuring certificate enrollment by using TFTP.
- The router must be able to write a file to the TFTP server for the **crypto ca enroll** command. Some TFTP servers require that the file exist on the server before it can be written. Most TFTP servers require that the file be writeable by the world. This requirement might pose a risk because any router or other device can write or overwrite the certificate request; in such a case, the router would not be able to use the certificate after it is granted by the CA because the request has been modified.

	Command or Action	Purpose
Step 1	**enable**	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**}	Enters global configuration mode.
Step 3	**crypto ca trustpoint** *name*	Declares the CA that your router should use and enters ca-trustpoint configuration mode.
Step 4	**enrollment** [**mode**] [**retry** *minutes*] [**retry** *number*] [**url** *url*]	Specifies the enrollment parameters of your CA. • **mode**—Specifies registration authority (RA) mode if your CA system provides a RA. • **retry** *minutes*—Specifies the wait period between certificate request retries. The default is 1 minute between retries. • **retry** *number*—Specifies the number of times that a router will resend a certificate request when it does not receive a response from the previous request. (Specify from 1 to 100 retries.) • **url** *url*—Specifies the URL of the CA to which your router should send certificate requests. If you are using SCEP for enrollment, *url* must be in the form http://CA_name, where CA_name is the CA's host Domain Name System (DNS) name or IP address. If you are using TFTP for enrollment, *url* must be in the form tftp://certserver/file_specification.
Step 5	**crypto ca authenticate** *name*	Takes the name of the CA as the argument.
Step 6	**exit**	Exits ca-trustpoint configuration mode and returns to global configuration.
Step 7	**crypto ca enroll** *name*	Obtains your router's certificate(s) from the CA.
Step 8	**crypto ca import** *name* **certificate**	Imports a certificate by using TFTP or manual cut-and-paste at the terminal.

Configuring Certificate Enrollment by Using Cut-and-Paste

To declare the trustpoint CA that your router should use and to configure that trustpoint CA for manual enrollment via cut-and-paste, use the commands described in this section.

	Command or Action	Purpose
Step 1	**enable**	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**}	Enters global configuration mode.
Step 3	**crypto ca trustpoint** *name*	Declares the CA that your router should use and enters ca-trustpoint configuration mode.
Step 4	**enrollment terminal**	Specifies manual cut-and-paste certificate enrollment.
Step 5	**crypto ca authenticate** *name*	Takes the name of the CA as the argument.

	Command or Action	Purpose
Step 6	`exit`	Exits ca-trustpoint configuration mode and returns to global configuration mode.
Step 7	`crypto ca enroll` *name*	Obtains your router's certificate(s) from the CA.
Step 8	`crypto ca import` *name* `certificate`	Imports a certificate via TFTP or manually at the terminal. You must enter the **crypto ca import** command twice if usage keys (signature and encryption keys) are used. The first time the command is entered, one of the certificates is pasted into the router; the second time the command is entered, the other certificate is pasted into the router. (It does not matter which certificate is pasted first.)

Certificate Enrollment Command Descriptions

crypto ca import Command

To import a certificate manually by using TFTP or cut-and-paste at the terminal, use the **crypto ca import** command in global configuration mode:

`crypto ca import` *name* **`certificate`**

where *name* **certificate** specifies the name of the CA. This name is the same name used when the certification authority (CA) was declared with the **crypto ca trustpoint** command (declares the CA that your router should use).

You must enter the **crypto ca import** command twice if usage keys (signature and encryption keys) are used. The first time the command is entered, one of the certificates is pasted into the router; the second time the command is entered, the other certificate is pasted into the router. (It does not matter which certificate is pasted first.)

enrollment terminal Command

To specify manual cut-and-paste certificate enrollment, use the enrollment terminal command in ca-trustpoint configuration mode.

`enrollment terminal`

To delete a current enrollment request, use the **no** form of this command.

enrollment Command

To specify the enrollment parameters of your certification authority (CA), use the **enrollment** command in ca-trustpoint configuration mode:

`enrollment [mode] [retry minutes] [retry number] URL` *url*

Where *url* specifies the URL of the CA where your router should send certificate requests. If you are using TFTP for enrollment, the URL must be in the form **tftp:**//*certserver*/*file_specification*. The *file_specification* is optional. If the *file_specification* is included in the URL, the router appends an extension to the file specification.

To remove any of the configured parameters, use the **no** form of this command.

Example of Manual Certificate Enrollment Configuration

The following example shows how to specify a manual cut-and-paste certificate enrollment by using the **enrollment terminal** subcommand of the **crypto ca trustpoint** command. In this example, the name of the trustpoint CA is "MS," and the **crypto ca import** command is entered twice because usage keys (signature and encryption keys) are used.

```
Router(config)# crypto ca trustpoint MS
Router(ca-trustpoint)# enrollment terminal
Router(ca-trustpoint)# crypto ca authenticate MS

Enter the base 64 encoded CA certificate.
End with a blank line or the word "quit" on a line by itself

-----BEGIN CERTIFICATE-----
MIICNDCCAd6gAwIBAgIQOsCmXpVHwodKryRoqULV7jANBgkqhkiG9w0BAQUFADA5
MQswCQYDVQQGEwJVUzEWMBQGA1UEChMNQ2lzY28gU3lzdGVtczESMBAGA1UEAxMJ
bXNjYS1yb290MB4XDTAyMDIxNDAwNDYwMVoXDTA3MDIxNDAwNTQ0OFowOTELMAkG
A1UEBhMCVVMxFjAUBgNVBAoTDUNpc2NvIFN5c3RlbXMxEjAQBgNVBAMTCW1zY2Et
cm9vdDBcMA0GCSqGSIb3DQEBAQUAA0sAMEgCQQCix8nIGFg+wvy3BjFbVi25wYoG
K2N0HWWHpqxFuFhqyBnIC0OshIn9CtrdN3JvUNHr0NIKocEwNKUGYmPwWGTfAgMB
AAGjgcEwgb4wCwYDVR0PBAQDAgHGMA8GA1UdEwEB/wQFMAMBAf8wHQYDVR0OBBYE
FKIacsl6dKAfuNDVQymlSp7esf8jMG0GA1UdHwRmMGQwL6AtoCuGKWh0dHA6Ly9t
c2NhLXJvb3QvQ2VydEVucm9sbC9tc2NhLXJvb3QuY3JsMDGgL6AthitmaWxlOi8v
XFxtc2NhLXJvb3RcQ2VydEVucm9sbFxtc2NhLXJvb3QuY3JsMBAGCSsGAQQBgjcV
AQQDAgEAMA0GCSqGSIb3DQEBBQUAA0EAeuZkZMX9qkoLHfETYTpVWjZPQbBmwNRA
oJDSdYdtL3BcI/uLL5q7EmODyGfLyMGxuhQYx5r/40aSQgLCqBq+yg==
-----END CERTIFICATE-----

Certificate has the following attributes:
Fingerprint:D6C12961 CD78808A 4E02193C 0790082A
% Do you accept this certificate? [yes/no]:y
Trustpoint CA certificate accepted.
% Certificate successfully imported

Router(config)#
Router(config)#crypto ca enroll MS
% Start certificate enrollment..

% The subject name in the certificate will be:Router.cisco.com
% Include the router serial number in the subject name? [yes/no]:n
% Include an IP address in the subject name? [no]:n
Display Certificate Request to terminal? [yes/no]:y
Signature key certificate request -
Certificate Request follows:

MIIBhTCB7wIBADAlMSMwIQYJKoZIhvcNAQkCFhRTYW5kQmFnZ2VyLmNpc2NvLmNv
bTCBnzANBgkqhkiG9w0BAQEFAAOBjQAwgYkCgYEAxdhXFDiWAn/hIZs9zfOtssKA
daoWYu0ms9Fe/Pew01dh14vXdxgacstOs2Pr5wk6jLOPxpvxOJPWyQM6ipLmyVxv
ojhyLTrVohrh6Dnqcvk+G/5ohss9o9RxvONwx042pQchFnx9EkMuZC7evwRxJEqR
mBHXBZ8GmP3jYQsjS8MCAwEAAaAhMB8GCSqGSIb3DQEJDjESMBAwDgYDVR0PAQH/
BAQDAgeAMA0GCSqGSIb3DQEBBAUAA4GBAMT6WtyFw95POY7UtF+YIYHiVRUf4SCq
hRIAGrljUePLo9iTqyPU1Pnt8JnIZ5P5BHU3MfgP8sqodaWub6mubkzaohJ1qD06
O87fnLCNid5Tov5jKogFHIki2EGGZxBosUw9lJlenQdNdDPbJc5LIWdfDvciA6jO
Nl8rOtKnt8Q+

---End - This line not part of the certificate request---

Redisplay enrollment request? [yes/no]:
Encryption key certificate request -
```

```
Certificate Request follows:

MIIBhTCB7wIBADAlMSMwIQYJKoZIhvcNAQkCFhRTYW5kQmFnZ2VyLmNpc2NvLmNv
bTCBnzANBgkqhkiG9w0BAQEFAAOBjQAwgYkCgYEAwG60QojpDbzbKnyj8FyTiOcv
THkDP7XD4vLT1XaJ409z0gSIoGnIcdFtXhVlBWtpq3/O9zYFXr1tH+BMCRQi3Lts
0IpxYa3D9iFPqev7SPXpsAIsY8a6FMq7TiwLObqiQjLKL4cbuV0Frjl0Yuv5A/Z+
kqMOm7c+pWNWFdLe9lsCAwEAAaAhMB8GCSqGSIb3DQEJDjESMBAwDgYDVR0PAQH/
BAQDAgUgMA0GCSqGSIb3DQEBBAUAA4GBACF7feURj/fJMojPBlR6fa9BrlMJx+2F
H91YM/CIiz2n4mHTeWTWKhLoT8wUfa9NGOk7yi+nF/F7035twLfq6n2bSCTW4aem
8jLMMaeFxwkrV/ceQKrucmNC1uVx+fBy9rhnKx8j60XE25tnp1U08r6om/pBQABU
eNPFhozcaQ/2

---End - This line not part of the certificate request---

Redisplay enrollment request? [yes/no]:
n
Router(config)#crypto ca import MS certificate

Enter the base 64 encoded certificate.
End with a blank line or the word "quit" on a line by itself

MIIDajCCAxSgAwIBAgIKFN7C6QAAAAAMRzANBgkqhkiG9w0BAQUFADA5MQswCQYD
VQQGEwJVUzEWMBQGA1UEChMNQ2lzY28gU3lzdGVtczESMBAGA1UEAxMJbXNjYS1y
b290MB4XDTAyMDYwODAxMTY0MloXDTAzMDYwODAxMjY0MlowJTEjMCEGCSqGSIb3
DQEJAhMUU2FuZEJhZ2dlci5jaXNjby5jb20wgZ8wDQYJKoZIhvcNAQEBBQADgY0A
MIGJAoGBAMXYVxQ4lgJ/4SGbPc3zrbLCgHWqFmLtJrPRXvz3sNNXYdeL13cYGnLL
TrNj6+cJOoyzj8ab8TiT1skDOoqS5slcb6I4ci061aIa4eg56nL5Phv+aIbLPaPU
cbzjcMdONqUHIRZ8fRJDLmQu3r8EcSRKkZgR1wWfBpj942ELI0vDAgMBAAGjggHM
MIIByDALBgNVHQ8EBAMCB4AwHQYDVR0OBBYEFL8Quz8dyz4EGIeKx9A8UMNHLE4s
MHAGA1UdIwRpMGeAFKIacsl6dKAfuNDVQymlSp7esf8joT2kOzA5MQswCQYDVQQG
EwJVUzEWMBQGA1UEChMNQ2lzY28gU3lzdGVtczESMBAGA1UEAxMJbXNjYS1yb290
ghA6wKZelUfCh0qvJGipQtXuMCIGA1UdEQEB/wQYMBaCFFNhbmRCYWdnZXIuY2lz
Y28uY29tMG0GA1UdHwRmMGQwL6AtoCuGKWh0dHA6Ly9tc2NhLXJvb3QvQ2VydEVu
cm9sbC9tc2NhLXJvb3QuY3JsMDGgL6AthitmaWxlOi8vXFxtc2NhLXJvb3RcQ2Vy
dEVucm9sbFxtc2NhLXJvb3QuY3JsMIGUBggrBgEFBQcBAQSBhzCBhDA/BggrBgEF
BQcwAoYzaHR0cDovL21zY2Etcm9vdC9DZXJ0RW5yb2xsL21zY2Etcm9vdF9tc2Nh
LXJvb3QuY3J0MEEGCCsGAQUFBzAChjVmaWxlOi8vXFxtc2NhLXJvb3RcQ2VydEVu
cm9sbFxtc2NhLXJvb3RfbXNjYS1yb290LmNydDANBgkqhkiG9w0BAQUFAANBAJo2
r6sHPGBdTQX2EDoJpR/A2UHXxRYqVSHkFKZw0z31r5JzUM0oPNUETV7mnZlYNVRZ
CSEX/G8boi3WOjz9wZo=

% Router Certificate successfully imported

Router(config)#
Router(config)#crypto ca import MS certificate

Enter the base 64 encoded certificate.
End with a blank line or the word "quit" on a line by itself

MIIDajCCAxSgAwIBAgIKFN7OBQAAAAAMSDANBgkqhkiG9w0BAQUFADA5MQswCQYD
VQQGEwJVUzEWMBQGA1UEChMNQ2lzY28gU3lzdGVtczESMBAGA1UEAxMJbXNjYS1y
b290MB4XDTAyMDYwODAxMTY0NVoXDTAzMDYwODAxMjY0NVowJTEjMCEGCSqGSIb3
DQEJAhMUU2FuZEJhZ2dlci5jaXNjby5jb20wgZ8wDQYJKoZIhvcNAQEBBQADgY0A
MIGJAoGBAMButEKI6Q282yp8o/Bck4jnL0x5Az+1w+Ly09V2ieNPc9IEiKBpyHHR
bV4VZQVraat/zvc2BV69bR/gTAkUIty7bNCKcWGtw/YhT6nr+0j16bACLGPGuhTK
u04sCzm6okIyyi+HG7ldBa45dGLr+QP2fpKjDpu3PqVjVhXS3vZbAgMBAAGjggHM
MIIByDALBgNVHQ8EBAMCBSAwHQYDVR0OBBYEFPDO29oRdlEUSgBMg6jZR+YFRWlj
MHAGA1UdIwRpMGeAFKIacsl6dKAfuNDVQymlSp7esf8joT2kOzA5MQswCQYDVQQG
EwJVUzEWMBQGA1UEChMNQ2lzY28gU3lzdGVtczESMBAGA1UEAxMJbXNjYS1yb290
ghA6wKZelUfCh0qvJGipQtXuMCIGA1UdEQEB/wQYMBaCFFNhbmRCYWdnZXIuY2lz
Y28uY29tMG0GA1UdHwRmMGQwL6AtoCuGKWh0dHA6Ly9tc2NhLXJvb3QvQ2VydEVu
cm9sbC9tc2NhLXJvb3QuY3JsMDGgL6AthitmaWxlOi8vXFxtc2NhLXJvb3RcQ2Vy
dEVucm9sbFxtc2NhLXJvb3QuY3JsMIGUBggrBgEFBQcBAQSBhzCBhDA/BggrBgEF
BQcwAoYzaHR0cDovL21zY2Etcm9vdC9DZXJ0RW5yb2xsL21zY2Etcm9vdF9tc2Nh
```

```
LXJvb3QuY3J0MEEGCCsGAQUFBzAChjVmaWxlOi8vXFxtc2NhLXJvb3RcQ2VydEVu
cm9sbFxtc2NhLXJvb3RfbXNjYS1yb290LmNydDANBgkqhkiG9w0BAQUFAANBAHaU
hyCwLirUghNxCmLzXRG7C3W1j0kSX7a4fX9OxKR/Z2SoMjdMNPPyApuh8SoT2zBP
ZKjZU2WjcZG/nZF4W5k=

% Router Certificate successfully imported
```

Verifying Manual Certificate Enrollment

To verify that the Manual Certificate Enrollment feature is working, perform the following optional steps:

	Command or Action	Purpose
Step 1	**enable**	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**show crypto ca certificates**	(Optional) Verifies information about your certificate, the certificate of the CA, and RA certificates.
Step 3	**show crypto ca trustpoints**	(Optional) Displays the trustpoints that are configured in the router.

The following sample output is displayed after manual certificate enrollment has been successfully configured by using the **enrollment terminal** command (cut-and-paste):

```
Router# show crypto ca certificates

Certificate
  Status:Available
  Certificate Serial Number:14DECE05000000000C48
  Certificate Usage:Encryption
  Issuer:
    CN = msca-root
     O = Cisco Systems
     C = US
  Subject:
    Name:Router.cisco.com
    OID.1.2.840.113549.1.9.2 = Router.cisco.com
  CRL Distribution Point:
    http://msca-root/CertEnroll/msca-root.crl
  Validity Date:
    start date:18:16:45 PDT Jun 7 2002
    end   date:18:26:45 PDT Jun 7 2003
    renew date:16:00:00 PST Dec 31 1969
  Associated Trustpoints:MS

Certificate
  Status:Available
  Certificate Serial Number:14DEC2E9000000000C47
  Certificate Usage:Signature
  Issuer:
    CN = msca-root
     O = Cisco Systems
     C = US
  Subject:
    Name:Router.cisco.com
    OID.1.2.840.113549.1.9.2 = Router.cisco.com
  CRL Distribution Point:
    http://msca-root/CertEnroll/msca-root.crl
```

```
  Validity Date:
    start date:18:16:42 PDT Jun 7 2002
    end   date:18:26:42 PDT Jun 7 2003
    renew date:16:00:00 PST Dec 31 1969
  Associated Trustpoints:MS

CA Certificate
  Status:Available
  Certificate Serial Number:3AC0A65E9547C2874AAF2468A942D5EE
  Certificate Usage:Signature
  Issuer:
    CN = msca-root
     O = Cisco Systems
     C = US
  Subject:
    CN = msca-root
     O = Cisco Systems
     C = US
  CRL Distribution Point:
    http://msca-root/CertEnroll/msca-root.crl
  Validity Date:
    start date:16:46:01 PST Feb 13 2002
    end   date:16:54:48 PST Feb 13 2007
  Associated Trustpoints:MS
```

Related Documents

Table 9-1 shows documents that contain additional information on Mobile IP Security.

Table 9-1 Documents Related to Mobile IP Security

Related Topic	Document Title
CA configuration tasks	The chapter "Configuring Certification Authority Interoperability" in the *Cisco IOS Security Configuration Guide*, Release 12.2
Additional certificate and CA commands	The chapter "Certification Authority Interoperability Commands" in the *Cisco IOS Security Command Reference*, Release 12.2
Additional ca-trustpoint configuration commands	*Trustpoint CLI*, Cisco IOS Release 12.2(8)T feature module