Certificate-based MACsec Encryption

The Certificate-based MACsec Encryption feature uses 802.1X port-based authentication with Extensible Authentication Protocol – Transport Layer Security (EAP-TLS) to carry Certificates for router ports where MACsec encryption is required. EAP-TLS mechanism is used to do the mutual authentication and to get the Master Session Key (MSK) from which the Connectivity Association Key (CAK) is derived for the MACsec Key Agreement (MKA) protocol.

Feature Information for Certificate-based MACsec Encryption

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

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 1: Feature Information for Certificate-based MACsec Encryption

Feature Name	Releases	Feature Information
Certificate-based MACsec Encryption	Cisco IOS XE Everest Release 16.6.1	The Certificate-based MACsec Encryption feature uses 802.1X port-based authentication with Extensible Authentication Protocol – Transport Layer Security (EAP-TLS) to carry Certificates for router ports where MACsec encryption is required. EAP-TLS mechanism is used to do the mutual authentication and to get the Master Session Key (MSK) from which the Connectivity Association Key (CAK) is derived for the MACsec Key Agreement (MKA) protocol.

Prerequisites for Certificate-based MACsec Encryption

- Ensure that you have a Certificate Authority (CA) server configured for your network.
- Generate a CA certificate.
- Ensure that you have configured Cisco Identity Services Engine (ISE) Release 2.0. Refer to the *Cisco Identity Services Engine Administrator Guide, Release 2.3*.
- Ensure that both the participating devices, the CA server, and Cisco Identity Services Engine (ISE) are synchronized using Network Time Protocol (NTP). If time is not synchronized on all your devices, certificates will not be validated.
- Ensure that 802.1x authentication and AAA are configured on your device.

Restrictions for Certificate-based MACsec Encryption

- MKA is not supported on port-channels.
- High Availability for MKA is not supported.

Information About Certificate-based MACsec Encryption

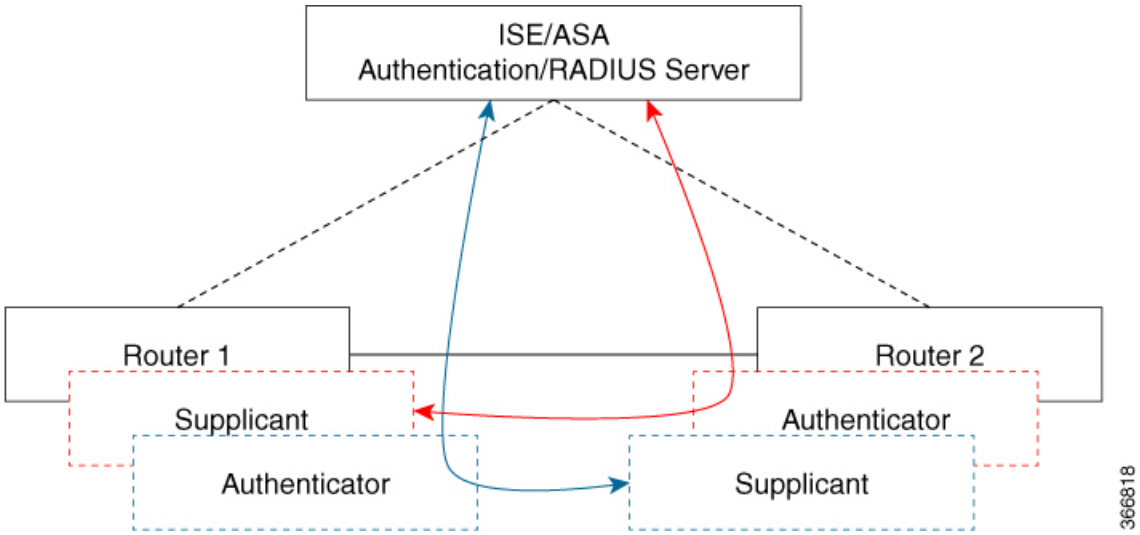
MKA MACsec is supported on router-to-router links. Using IEEE 802.1X Port-based Authentication with Extensible Authentication Protocol (EAP-TLS), you can configure MKA MACsec between device ports. EAP-TLS allows mutual authentication and obtains an MSK (master session key) from which the connectivity association key (CAK) is derived for MKA protocol. Device certificates are carried, using EAP-TLS, for authentication to the AAA server.

Call Flow for Certificate-based MACsec Encryption

Suppllicants are unauthorized devices that try to gain access to the network. Authenticators are devices that control the physical access to the network based on the authentication status of the supplicant.

As shown in the following diagram, the devices are connected directly. The router acts as both EAP Supplicant and Authenticator on the port.

The figure below depicts two EAP call flows (with separate EAP-Session ID) on the router. The red flow depicts Router 1 as supplicant and Router 2 as authenticator and the blue flow is vice-versa.



When the interface is configured for 802.1x role as both, The authentication manager creates a session with supplicant/authenticator role and both trigger EAP with both a supplicant as well as an authenticator role (separate EAP flow with separate EAP session ID).

Based on the MAC address of the peer, if the local MAC of the interface is less than the peer MAC, the authenticator role's MSK used for MKA session; if the MAC is higher then the supplicant role's MSK is used for MKA session (to derive the CAK).

In the example above, if Router 1 MAC address is less than Router 2, then the MSK obtained from the Blue EAP session is used as EAP-MSK for the MKA (Router 1 acts as authenticator and Router 2 as supplicant). This ensures that Router 1 acts as MKA Key Server and Router 2 will be the Non-Key Server.

If the Router 2 MAC Address is less than Router 1 then MSK obtained from the Red EAP flow is used (by both routers) as EAP-MSK for the MKA session.

Configuring Certificate-based MACsec Encryption using Remote Authentication

To configure MACsec with MKA on point-to-point links, perform these tasks:

Configuring Certificate Enrollment

Generating Key Pairs

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters global configuration mode.
Step 3	**crypto key generate rsa label** *label name* **general-keys modulus** *size*	Generates a RSA key pair for signing and encryption. You can also assign a label to each key pair using the label keyword. The label is referenced by the trustpoint that uses the key pair. If you do not assign a label, the key pair is automatically labeled <Default-RSA-Key>. If you do not use additional keywords this command generates one general purpose RSA key pair. If the modulus is not specified, the default key modulus of 1024 is used. You can specify other modulus sizes with the modulus keyword.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**show authentication session interface** *interface-id*	Verifies the authorized session security status.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Configuring Enrollment using SCEP

Simple Certificate Enrollment Protocol (SCEP) is a Cisco-developed enrollment protocol that uses HTTP to communicate with the certificate authority (CA) or registration authority (RA). SCEP is the most commonly used method for sending and receiving requests and certificates.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal**	Enters global configuration mode.
Step 3	**crypto pki trustpoint** *server name*	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.
Step 4	**enrollment url** *url name pem*	Specifies the URL of the CA on which your device should send certificate requests. An IPv6 address can be added in the URL enclosed in brackets. For example: http://[2001:DB8:1:1::1]:80. The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.
Step 5	**rsakeypair** *label*	Specifies which key pair to associate with the certificate. **Note** The **rsakeypair** name must match the trust-point name.
Step 6	**serial-number none**	The **none** keyword specifies that a serial number will not be included in the certificate request.
Step 7	**ip-address none**	The **none** keyword specifies that no IP address should be included in the certificate request.
Step 8	**revocation-check crl**	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
Step 9	**auto-enroll** *percent* **regenerate**	Enables auto-enrollment, allowing the client to automatically request a rollover certificate from the CA. If auto-enrollment is not enabled, the client must be manually re-enrolled in your PKI upon certificate expiration. By default, only the Domain Name System (DNS) name of the device is included in the certificate. Use the percent argument to specify that a new certificate will be requested after the percentage of the lifetime of the current certificate is reached. Use the regenerate keyword to generate a new key for the certificate even if a named key already exists. If the key pair being rolled over is exportable, the new key pair will also be exportable. The following comment will appear in the trustpoint configuration to indicate whether the key pair is exportable: “! RSA key pair associated with trustpoint is exportable.” It is recommended that a new key pair be generated for security reasons.
Step 10	**crypto pki authenticate** *name*	Retrieves the CA certificate and authenticates it.
Step 11	**exit**	Exits global configuration mode.
Step 12	**show crypto pki certificate** *trustpoint name*	Displays information about the certificate for the trust point.

Configuring Enrollment Manually

If your CA does not support SCEP or if a network connection between the router and CA is not possible. Perform the following task to set up manual certificate enrollment:

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters global configuration mode.
Step 3	**crypto pki trustpoint** *server name*	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.
Step 4	**enrollment url** *url name pem*	Specifies the URL of the CA on which your device should send certificate requests. An IPv6 address can be added in the URL enclosed in brackets. For example: http:// [2001:DB8:1:1::1]:80. The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.
Step 5	**rsakeypair** *label*	Specifies which key pair to associate with the certificate.
Step 6	**serial-number none**	The **none** keyword specifies that a serial number will not be included in the certificate request.
Step 7	**ip-address none**	The **none** keyword specifies that no IP address should be included in the certificate request.
Step 8	**revocation-check crl**	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
Step 9	**exit**	Exits Global Configuration mode.
Step 10	**crypto pki authenticate** *name*	Retrieves the CA certificate and authenticates it.
Step 11	**crypto pki enroll** *name*	Generates certificate request and displays the request for copying and pasting into the certificate server. Enter enrollment information when you are prompted. For example, specify whether to include the device FQDN and IP address in the certificate request. You are also given the choice about displaying the certificate request to the console terminal. The base-64 encoded certificate with or without PEM headers as requested is displayed.
Step 12	**crypto pki import** *name* **certificate**	Imports a certificate via TFTP at the console terminal, which retrieves the granted certificate.

	Command or Action	Purpose
		The device attempts to retrieve the granted certificate via TFTP using the same filename used to send the request, except the extension is changed from ".req" to ".crt". For usage key certificates, the extensions "-sign.crt" and "-encr.crt" are used. The device parses the received files, verifies the certificates, and inserts the certificates into the internal certificate database on the switch. **Note** Some CAs ignore the usage key information in the certificate request and issue general purpose usage certificates. If your CA ignores the usage key information in the certificate request, only import the general purpose certificate. The router will not use one of the two key pairs generated.
Step 13	**exit**	Exits Global Configuration mode.
Step 14	**show crypto pki certificate** *trustpoint name*	Displays information about the certificate for the trust point.
Step 15	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Enabling 802.1x Authentication and Configuring AAA

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters global configuration mode.
Step 3	**aaa new-model**	Enables AAA.
Step 4	**dot1x system-auth-control**	Enables 802.1X on your device.
Step 5	**radius server** *name*	Specifies the name of the RADIUS server configuration for Protected Access Credential (PAC) provisioning and enters RADIUS server configuration mode.
Step 6	**address** *ip-address* **auth-port** *port-number* **acct-port** *port-number*	Configures the IPv4 address for the RADIUS server accounting and authentication parameters.
Step 7	**automate-tester username** *username*	Enables the automated testing feature for the RADIUS server. With this practice, the device sends periodic test authentication messages to the RADIUS server. It looks for a RADIUS response from the server. A success message is not necessary - a failed authentication suffices, because it shows that the server is alive.

	Command or Action	Purpose
Step 8	**key** *string*	Configures the authentication and encryption key for all RADIUS communications between the device and the RADIUS server.
Step 9	**radius-server deadtime** *minutes*	Improves RADIUS response time when some servers might be unavailable and skips unavailable servers immediately.
Step 10	**exit**	Returns to global configuration mode.
Step 11	**aaa group server radius** *group-name*	Groups different RADIUS server hosts into distinct lists and distinct methods, and enters server group configuration mode.
Step 12	**server** *name*	Assigns the RADIUS server name.
Step 13	**exit**	Returns to global configuration mode.
Step 14	**aaa authentication dot1x default group** *group-name*	Sets the default authentication server group for IEEE 802.1x.
Step 15	**aaa authorization network default group** *group-name*	Sets the network authorization default group.

Configuring EAP-TLS Profile and 802.1x Credentials

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters global configuration mode.
Step 3	**eap profile** *profile-name*	Configures EAP profile and enters EAP profile configuration mode.
Step 4	**method tls**	Enables EAP-TLS method on the device.
Step 5	**pki-trustpoint** *name*	Sets the default PKI trustpoint.
Step 6	**exit**	Returns to global configuration mode.
Step 7	**dot1x credentials** *profile-name*	Configures 802.1x credentials profile and enters dot1x credentials configuration mode.
Step 8	**username** *username*	Sets the authentication user ID.
Step 9	**pki-trustpoint** *name*	Sets the default PKI trustpoint.

	Command or Action	Purpose
Step 10	**end**	Returns to privileged EXEC mode.

Applying the 802.1x MKA MACsec Configuration on Interfaces

To apply MKA MACsec using EAP-TLS to interfaces, perform the following task:

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters global configuration mode.
Step 3	**interface** *interface-id*	Identifies the MACsec interface, and enter interface configuration mode. The interface must be a physical interface.
Step 4	**macsec**	Enables MACsec on the interface.
Step 5	**authentication periodic**	Enables reauthentication for this port.
Step 6	**authentication timer reauthenticate interval**	Sets the reauthentication interval.
Step 7	**access-session host-mode multi-domain**	Allows hosts to gain access to the interface.
Step 8	**access-session closed**	Prevents preauthentication access on the interface.
Step 9	**access-session port-control auto**	Sets the authorization state of a port.
Step 10	**dot1x pae both**	Configures the port as an 802.1X port access entity (PAE) supplicant and authenticator.
Step 11	**dot1x credentials profile**	Assigns a 802.1x credentials profile to the interface.
Step 12	**dot1x supplicant eap profile** *name*	Assigns the EAP-TLS profile to the interface.
Step 13	**service-policy type control subscriber** *control-policy name*	Applies a subscriber control policy to the interface.
Step 14	**exit**	Returns to privileged EXEC mode.
Step 15	**show macsec interface**	Displays MACsec details for the interface.
Step 16	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Verifying Certificate-based MACsec Encryption

Use the following **show** commands to verify the configuration of certificate-based MACsec encryption. Given below are the sample outputs of the **show** comamnds.

The **show mka sessions** command displays a summary of active MACsec Key Agreement (MKA) Protocol sessions.

```
Device# show mka sessions

  Total MKA Sessions....... 1
      Secured Sessions... 1
      Pending Sessions... 0

=============================================================================================
Interface      Local-TxSCI         Policy-Name      Inherited         Key-Server

Port-ID        Peer-RxSCI          MACsec-Peers     Status            CKN

=============================================================================================
Te0/1/3        74a2.e625.4413/0013 *DEFAULT POLICY* NO                YES

19             74a2.e625.4c22/0012 1                Secured
1000000000000000000000000000000000000000000000000000000000000000
```

The **show macsec status interface** *interface-id* displays MACsec status information for the given interface.

```
Device# show macsec status interface te0/1/2

  Capabilities:
  Ciphers Supported:        GCM-AES-128 GCM-AES-256
  Cipher:                   GCM-AES-128
  Confidentiality Offset:   0
  Replay Window:            64
  Delay Protect Enable:     FALSE
  Access Control:           must-secure

Transmit SC:
  SCI:                      74A2E6254C220012
  Transmitting:             TRUE
Transmit SA:
  Next PN:                  412
  Delay Protect AN/nextPN:  99/0

Receive SC:
  SCI:                      74A2E62544130013
  Receiving:                TRUE
Receive SA:
  Next PN:                  64
  AN:                       0
  Delay Protect AN/LPN:     0/0
```

The **show access-session interface** *interface-id* **details** displays detailed information about the access session for the given interface.

```
Device# show access-session interface te1/0/1 details

   Interface:  TenGigabitEthernet1/0/1
              IIF-ID:  0x17298FCD
         MAC Address:  f8a5.c592.13e4
        IPv6 Address:  Unknown
        IPv4 Address:  Unknown
           User-Name:  DOT1XCRED
              Status:  Authorized
              Domain:  DATA
       Oper host mode:  multi-host
     Oper control dir:  both
```

```
      Session timeout:  N/A
    Common Session ID:  000000000000000BB72E8AFA
      Acct Session ID:  Unknown
               Handle:  0xc3000001
       Current Policy:  MUSTS_1


Local Policies:
 Security Policy:  Must Secure
      Security Status:  Link Secured

Server Policies:


Method status list:
       Method           State
     dot1xSup           Authc Success
        dot1x           Authc Success
```

Configuration Examples for Certificate-based MACsec Encryption

Example: Enrolling the Certificate

```
Configure Crypto PKI Trustpoint:
  crypto pki trustpoint POLESTAR-IOS-CA
   enrollment terminal
   subject-name CN=ASR1000x1@polestar.com, C=IN, ST=KA, OU=ENG,O=Polestar
   revocation-check none
   rsakeypair mkaioscarsa
   storage nvram:
  !
Manual Installation of Root CA certificate:
 crypto pki authenticate POLESTAR-IOS-CA
```

Example: Enabling 802.1x Authentication and AAA Configuration

```
aaa new-model
dot1x system-auth-control
radius server ISE
 address ipv4 <ISE ipv4 address> auth-port 1645 acct-port 1646
 automate-tester username dummy
 key dummy123
 radius-server deadtime 2
!
aaa group server radius ISEGRP
 server name ISE
!
aaa authentication dot1x default group ISEGRP
aaa authorization network default group ISEGRP
```

Example: Configuring EAP-TLS Profile and 802.1X Credentials

```
eap profile EAPTLS-PROF-IOSCA
 method tls
 pki-trustpoint POLESTAR-IOS-CA
```

```
!

dot1x credentials EAPTLSCRED-IOSCA
 username asr1000@polestar.company.com
 pki-trustpoint POLESTAR-IOS-CA
!
```

Example: Applying 802.1X, PKI, and MACsec Configuration on the Interface

```
interface TenGigabitEthernet0/1
 macsec network-link
 authentication periodic
 authentication timer reauthenticate <reauthentication interval>
 access-session host-mode multi-host
 access-session closed
 access-session port-control auto
 dot1x pae both
 dot1x credentials EAPTLSCRED-IOSCA
 dot1x supplicant eap profile EAPTLS-PROF-IOSCA
 service-policy type control subscriber DOT1X_POLICY_RADIUS
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
Security commands	• Security Command Reference: Commands A to C • Security Command Reference: Commands D to L • Security Command Reference: Commands M to R • Security Command Reference: Commands S to Z

Standards and RFCs

Standard/RFC	Title
IEEE 802.1AE	*Media Access Control (MAC) Security*

Standard/RFC	Title
IEEE 802.1X-2010	*Port-Based Network Access Control*
RFC 4493	*The AES-CMAC Algorithm*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html