Configuring MACsec

This module describes how to configure Media Access Control Security (MACsec) encryption on Cisco 8000 Series Routers. MACsec is a Layer 2 IEEE 802.1AE standard for encrypting packets between two MACsec-capable routers.

- Understanding MACsec Encryption, on page 1
- MKA Authentication Process, on page 2
- MACsec Frame Format, on page 3
- Advantages of Using MACsec Encryption, on page 3
- Hardware Support for MACsec, on page 4
- MACsec PSK, on page 5
- Fallback PSK, on page 5
- Configuring and Verifying MACsec Encryption , on page 6
- Create a MACsec keychain, on page 8
- Create a user-defined MACsec policy, on page 12
- EAPoL Ether-type and destination address, on page 14
- Applying MACsec Configuration on an Interface, on page 17
- MACsec mode on PHY, on page 26
- MACsec Encryption on Layer 3 Subinterface, on page 27
- MACsec Policy Exceptions, on page 35
- Verifying MACsec Encryption on IOS XR, on page 39
- Verifying MACsec Encryption on Cisco 8000 Series Routers , on page 49
- MACsec SecY Statistics, on page 53
- Power-on Self-Test KAT for Common Criteria and FIPS, on page 61
- Dynamic Power Management for MACSec-Enabled Ports, on page 64
- Quantum safe key distribution options for MACsec, on page 67
- Secure Key Integration Protocol, on page 75
- Related Commands for MACsec, on page 82

Understanding MACsec Encryption

Security breaches can occur at any layer of the OSI model. At Layer 2, some of the common breaches are MAC address spoofing, ARP spoofing, Denial of Service (DoS) attacks against a DHCP server, and VLAN hopping.

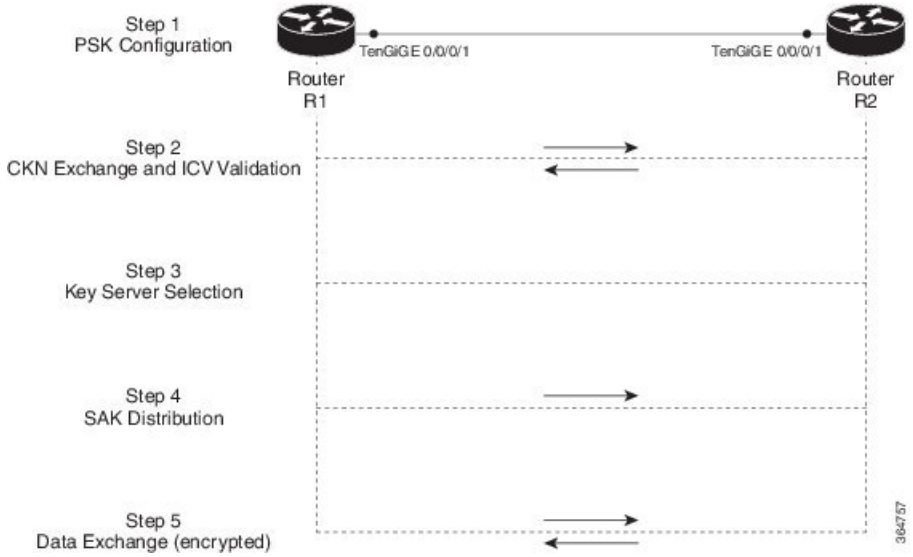
MACsec secures data on physical media, making it impossible for data to be compromised at higher layers. As a result, MACsec encryption takes priority over any other encryption method such as IPsec and SSL at higher layers. MACsec is configured on the Customer Edge (CE) router interfaces that connect to Provider Edge (PE) routers and on all the provider router interfaces.

MKA Authentication Process

MACsec provides the secure MAC Service on a frame-by-frame basis, using GCM-AES algorithm. MACsec uses the MACsec Key Agreement protocol (MKA) to exchange session keys, and manage encryption keys.

The MACsec encryption process is illustrated in the following figure and description.

Figure 1: MKA Encryption Process



Step 1: When a link is first established between two routers, they become peers. Mutual peer authentication takes place by configuring a Pre-shared Key (PSK).

Step 2: On successful peer authentication, a connectivity association is formed between the peers, and a secure Connectivity Association Key Name (CKN) is exchanged. After the exchange, the MKA ICV is validated with a Connectivity Association Key (CAK), which is effectively a secret key.

Step 3: A key server is selected between the routers, based on the configured key server priority. Lower the priority value, higher the preference for the router to become the key server. If no value is configured, the default value of 16 is taken to be the key server priority value for the router. Lowest priority value configures that router as the key server, while the other router functions as a key client. The following rules apply to key server selection:

- Numerically lower values of key server priority and SCI are accorded the highest preference.
- Each router selects a peer advertising the highest preference as its key server provided that peer has not selected another router as its key server or is not willing to function as the key server.
- In the event of a tie for highest preferred key server, the router with the highest priority SCI is chosen as key server (KS).

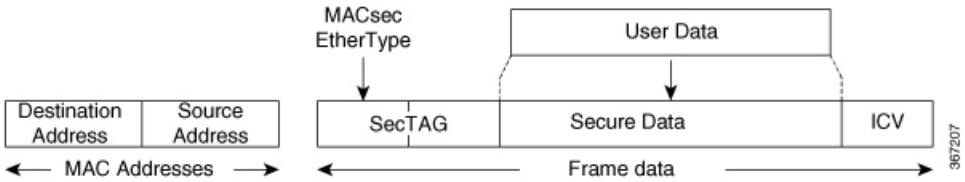
Step 4: A security association is formed between the peers. The key server generates and distributes the Secure Association Key (SAK) to the key client (peer). Each secure channel is supported by an overlapped sequence of Security Associations (SA). Each SA uses a new Secure Association Key (SAK).

Step 5: Encrypted data is exchanged between the peers.

MACsec Frame Format

The MACsec header in a frame consists of three components as illustrated in the following figure.

Figure 2: MACsec Frame Format



- **SecTAG**: The security tag is 8-16 bytes in length and identifies the SAK to be used for the frame. With Secure Channel Identifier (SCI) encoding, the security tag is 16 bytes in length, and without the encoding, 8 bytes in length (SCI encoding is optional).The security tag also provides replay protection when frames are received out of sequence.
- **Secure Data**: This is the data in the frame that is encrypted using MACsec and can be 2 or more octets in length.
- **ICV**: The ICV provides the integrity check for the frame and is usually 8-16 bytes in length, depending on the cipher suite. Frames that do not match the expected ICV are dropped at the port.

Advantages of Using MACsec Encryption

- **Data Integrity Check**: Integrity check value (ICV) is used to perform integrity check. The ICV is sent with the protected data unit and is recalculated and compared by the receiver to detect data modification.
- **Data Encryption**: Enables a port to encrypt outbound frames and decrypt MACsec-encrypted inbound frames.
- **Replay Protection**: When frames are transmitted through the network, there is a strong possibility of frames getting out of the ordered sequence. MACsec provides a configurable window that accepts a specified number of out-of-sequence frames.
- **Support for Clear Traffic**: If configured accordingly, data that is not encrypted is allowed to transit through the port.

Hardware Support for MACsec

Table 1: Feature History Table

Feature Name	Release Information	Feature Description
MACsec capability for 88-LC0-36FH-M	Release 7.3.15	The Cisco 8800 36x400GE QSFP56-DD Line Card with MACsec based on Q200 Silicon (88-LC0-36FH-M) supports point-to-point (P2P) MACsec capability with 400GE line rate encryption on its physical interfaces. This release also introduces point-to-multipoint (P2MP) MACsec capability on both 8800-LC-36FH-M and 8800-LC-48H (Cisco 8800 48x100 GbE QSFP28 Line Card based on Q100 Silicon). The P2MP topology connects multiple nodes to one central node, thereby avoiding unnecessary packet replication at the ingress router.

The MACsec technology is supported on 48-port 100GE line cards and 36-port 400GE line cards.

Table 2: MACsec Hardware Support Matrix

Cisco IOS XR Software Release	Product ID (PID)
Release 24.4.1	8711-32FH-M
Release 24.3.1	• 8212-48FH-M • 88-LC1-52Y8H-EM
Release 7.10.1	Cisco 8608: • 86-MPA-14H2FH-M • 86-MPA-4FH-M • 86-MPA-24Z-M
Release 7.5.2	8202-32FH-M
Release 7.3.3	88-LC0-34H14FH
Release 7.3.15	88-LC0-36FH-M

Cisco IOS XR Software Release	Product ID (PID)
Release 7.0.12	8800-LC-48H

Also, see MACsec on Layer 3 Subinterface Hardware Support Matrix.

MACsec PSK

A pre-shared key includes a connectivity association key name (CKN) and a connectivity association key (CAK). A pre-shared key is exchanged between two devices at each end of a point-to-point (P2P) link to enable MACsec using static CAK security mode. The MACsec Key Agreement (MKA) protocol is enabled after the pre-shared keys are successfully verified and exchanged. The pre-shared keys, the CKN and CAK, must match on both ends of a link.

For more information on MACsec PSK configuration, see Applying MACsec Configuration on an Interface, on page 17.

Fallback PSK

Fallback is a session recovery mechanism when primary PSK fails to bring up secured MKA session. It ensures that a PSK is always available to perform MACsec encryption and decryption.

- In CAK rollover of primary keys, if latest active keys are mismatched, system performs a hitless rollover from current active key to fallback key, provided the fallback keys match.
- If a session is up with fallback, and primary latest active key configuration mismatches are rectified between peers, system performs a hitless rollover from fallback to primary latest active key.

Note

- A valid Fallback PSK (CKN and CAK) must be configured with infinite lifetime. If the fallback PSK is configured with CAK mismatch, the only recovery mechanism is to push a new set of PSK configurations (both on fallback PSK keychain and primary PSK chain, in that order) on all the association members.
- In P2P topologies, a rollover to the fallback PSK happens when either of the nodes in the Secure Association (SA) cannot peer up with the primary PSK. Whereas, in P2MP, the fallback happens only at the expiry or deletion of the primary key on all peers, not just on one of the peers. On deletion or expiry of the primary PSK on one of the nodes, say R1, a new key server is chosen among the peer nodes that does a SAK rekey for the remaining nodes. This ensures that R1 is no longer part of the SA, and the network drops all traffic to and from R1.

The following is a sample syslog for session secured with fallback PSK:

```
%L2-MKA-5-SESSION_SECURED_WITH_FALLBACK_PSK : (Hu0/1/0/0) MKA session secured, CKN:ABCD
```

For more information on MACsec fallback PSK configuration, see Applying MACsec Configuration on an Interface, on page 17.

Active Fallback

The Cisco IOS XR Software Release 7.0.14 introduces the support for active fallback feature that initiates a fallback MKA session on having fallback configuration under the interface.

The key benefits of active fallback feature are:

- Faster session convergence on fallback, in the event of primary key deletion, expiry or mismatch.
- Faster traffic recovery under should-secure security policy when both primary and fallback mismatch happens.

With the introduction of active fallback functionality, the output of various MACsec show commands include the fallback PSK entry as well. If the session is secured with primary key, the fallback session will be in ACTIVE state. See, Verifying MACsec Encryption on IOS XR, on page 39 for details and sample outputs.

Note If the peer device is running on an older release that does not support active fallback feature, you must configure the **enable-legacy-fallback** command under the macsec-policy to ensure backward compatibility.

Configuring and Verifying MACsec Encryption

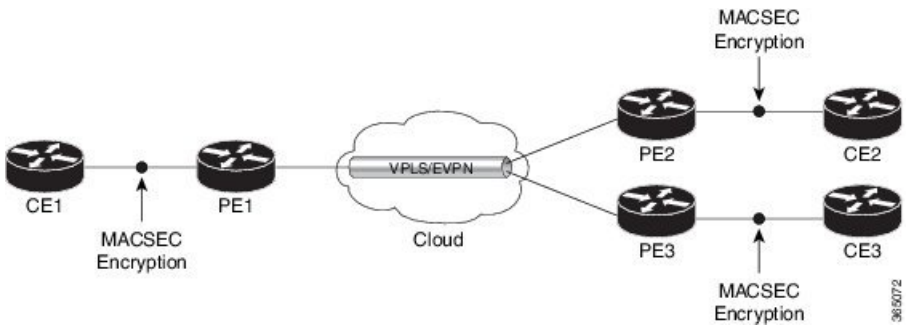
MACsec can be configured on physical Ethernet interfaces or interface bundles (link bundles), as explained in this section.

Note Enabling MACsec encryption on any on physical Ethernet interfaces or interface bundles (link bundles) will add an overhead of 32 bytes on the maximum transmission unit (MTU) size of link-state packets (LSPs). Therefore, you must set the LSP MTU to 32 bytes less than the interface MTU, to account for MACsec overhead. Use the **lsp-mtu** command to configure the maximum transmission unit (MTU) size of link-state packets (LSPs) on each router where MACsec is enabled.

Use Case 1: MACsec in a VPLS/EVPN

A typical VPLS network often suffers the injection of labeled traffic from potential hackers. The following figure illustrates the use of MACsec in a VPLS/EVPN network for encrypting the data being exchanged over the VPLS cloud. In this topology MACsec is configured on the PE-facing interfaces of the CE routers.

Figure 3: MACSec in a VPLS/EVPN Cloud



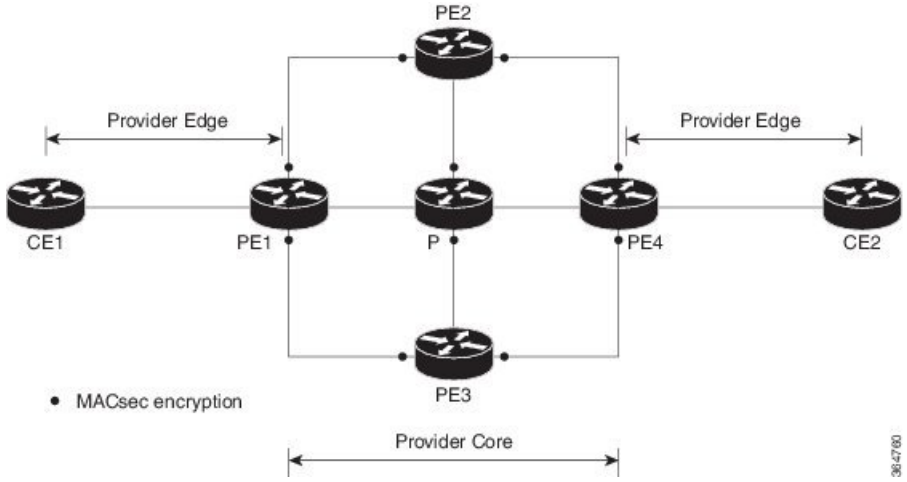
Use Case 2: MACsec in an MPLS Core Network

MACsec in an MPLS core network can be configured on physical interfaces or link bundles (Link Aggregation Group or LAG).

In the following topology, MACsec is configured on all router links in the MPLS core. This deployment is useful when the MPLS network spans data centers that are not co-located in the same geography. Each link is, therefore, a link between two data centers and all data exchanged is encrypted using MACsec.

The following figure illustrates the use of MACsec on physical interfaces in an MPLS core network.

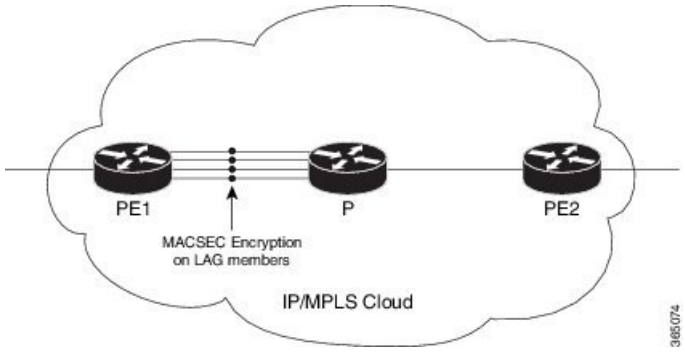
Figure 4: MACsec on Physical Interfaces in an MPLS Core Network



When MACsec is configured on the members of a LAG, an MKA session is set up for each member. SAK is exchanged for each LAG member and encryption or decryption takes place independently of other members in the group.

The following figure illustrates the use of MACsec on a link bundle in an MPLS core network.

Figure 5: MACsec on a Link Bundle in an MPLS Core Network



The following section describes procedures for configuring and verifying MACsec configuration in the described deployment modes.

Prior to configuring MACsec on a router interface, the MACsec keychain must be defined. If you apply the MACsec keychain on the router without specifying a MACsec policy, the default policy is applied. A default MACsec policy is pre-configured with default values. If you need to change any of the pre-configured values, create a different MACsec policy.

Configuring MACsec involves the following steps:

1. Creating a MACsec keychain
2. Creating a user-defined MACsec policy
3. Applying MACsec configuration on physical interfaces

Create a MACsec keychain

A MACsec keychain is a collection of keys used to authenticate peers needing to exchange encrypted information. While creating a keychain, we define the key(s), key string with password, the cryptographic algorithm, and the key lifetime.

MACsec Keychain Keyword	Description
Key	The MACsec key or the CKN can be up to 64 characters in length. The key must be of an even number of characters. Entering an odd number of characters will exit the MACsec configuration mode.
Key-string	The MACsec key-string or the CAK can be either 32 characters or 64 characters in length (32 for AES-128, 64 for AES-256).
Lifetime	This field specifies the validity period of a key. It includes a start time, and an expiry time. We recommend you to set the value for expiry time as *infinite*.

Guidelines for Configuring MACsec Keychain

MACsec keychain management has the following configuration guidelines:

- To establish MKA session, ensure that the MACsec key (CKN) and key-string (CAK) match at both ends.
- MKA protocol uses the latest active key available in the Keychain. This key has the latest Start Time from the existing set of currently active keys. You can verify the values using the **show key chain** *keychain-name* command.
- Deletion or expiry of current active key brings down the MKA session resulting in traffic hit. We recommend you to configure the keys with infinite lifetime. If fallback is configured, traffic is safeguarded using fallback on expiry or deletion of primary-keychain active key.
- To achieve successful key rollover (CAK-rollover), the new key should be configured such that it is the latest active key, and kicks-in before the current key expires.
- We recommend an overlap of at least one minute for hitless CAK rollover from current key to new key.
- Start time and Expiry time can be configured with future time stamps, which allows bulk configuration for daily CAK rotation without any intervention of management agent.
- From Cisco IOS XR Software Release 7.2.1 and later, the MACsec key IDs (configured through CLI using the **macsec key** command under the key chain configuration mode) are considered to be case

insensitive. These key IDs are stored as uppercase letters. For example, a key ID of value 'FF' and of value 'ff' are considered to be the same, and both these key IDs are now stored in uppercase as 'FF'. Whereas, prior to Release 7.2.1, both these values were treated as case sensitive, and hence considered as two separate key IDs. Hence it is recommended to have unique strings as key IDs for a MACsec key chain to avoid flapping of MACsec sessions. However, the support for this case insensitive IDs is applicable only for the configurations done through CLI, and not for configurations done through Netconf protocol.

Also, it is recommended to do a prior check of the MACsec key IDs before upgrading to Release 7.2.1 or later.

Consider a scenario where two MACsec key IDs with the same set of characters (say, ff and FF) are configured under the same key chain.

```
key chain 1
 macsec
  key ff
   lifetime 02:01:01 may 18 2020 infinite
  !
  key FF
   lifetime 01:01:01 may 18 2020 infinite
```

When you upgrade to Release 7.2.1 or later, only one of these key IDs is retained. That is 'FF', the one that was applied second in this example.

Follow these steps to configure a MACsec keychain:

Keychain Name: Provide a name for the MACsec keychain.

```
Router#configure
Router(config)#key chain kc
```

MACsec Mode: Enter the MACsec mode.

```
Router(config-kc)#macsec
Router(config-kc-MacSec)#
```

MACsec key: Provide a name for the MACsec key.

The MACsec key can be up to 64 characters in length. The key must be of an even number of characters. Entering an odd number of characters will exit the MACsec configuration mode.

You can also configure a fall-back pre-shared key(PSK) to ensure that a PSK is always available to perform MACsec encryption and decryption. The fallback PSK along with the primary PSK ensures that the session remains active even if the primary PSK is mismatched or there is no active key for the primary PSK.

The configured key is the CKN that is exchanged between the peers.

See the guidelines section to know more about the need for a unique key ID for a MACsec key chain.

Note If you are configuring MACsec to interoperate with a MACsec server that is running software prior to Cisco IOS XR Release 6.1.3, then ensure that the MACsec key length is of 64 characters. You can add extra zero characters to the MACsec key so that the length of 64-characters is achieved. If the key length is lesser than 64 characters, authentication will fail.

```
Router(config-kc-MacSec)#key 1234
```

AES Encryption: Enter the key string and the cryptographic algorithm to be used for the key.

```
! AES 128-bit encryption

Router(config-kc-MacSec-1234)#key-string 12345678
Router(config-kc-MacSec-1234)#cryptographic-algorithm AES-128-CMAC-96
```

MACsec key (CKN) lifetime or validity period: The lifetime period can be configured as a validity period between two dates (for example, Jan 01 2019 to Dec 31 2019), or with infinite validity. The key is valid from the time you configure (in HH:MM:SS format). Duration is configured in seconds.

Note When a key has expired, the MACsec session is torn down and running the **show macsec mka session** command does not display any information. If you run the **show macsec mka interface detail** command, the output displays ***** No Active Keys Present ***** in the PSK information.

```
Router(config-kc-MacSec-1234)#lifetime 05:00:00 01 January 2019 duration 1800
! Configuring  lifetime for a defined period

Router(config-kc-MacSec-1234)#lifetime 05:00:00 20 february 2019 12:00:00 30 september 2019


! Configuring  lifetime as infinite

Router(config-kc-MacSec-1234)#lifetime 05:00:00 01 January 2019 infinite
Router(config-kc-MacSec-1234)#commit
```

Securing the MACsec Pre-shared Key (PSK) Using Type 6 Password Encryption

Using the Type 6 password encryption feature, you can securely store MACsec plain text key string (CAK) in Type 6 encrypted format.

The primary key is the password or key used to encrypt all plain text MACsec key strings (CAK) in the router configuration with the use of an Advance Encryption Standard (AES) symmetric cipher. The primary key is not stored in the router configuration and cannot be seen or obtained in any way while connected to the router.

The Type 6 password encryption is effective only if a primary key is configured. The Type 6 Password Encryption is currently available on Cisco 8000 Series Routers.

Configuring a Primary Key and Enabling the Type 6 Password Encryption Feature

You can configure a primary key for Type 6 encryption and enable the Advanced Encryption Standard (AES) password encryption feature for securing the MACsec keys (key string/CAK). When prompted, enter the primary key details. The primary key can contain between 6 and 64 alphanumeric characters.

Primary Key Creation

```
Router#key config-key password-encryption
New password Requirements: Min-length 6, Max-length 64
```

```
Characters restricted to [A-Z][a-z][0-9]
Enter new key :
Enter confirm key :
```

Type 6 password encryption

```
Router#configure terminal
Router(config)#password6 encryption aes
Router(config)#commit
```

- **Modifying the Primary Key** - If a primary key is already configured, you are prompted to enter the current primary key before entering a new primary key.

  Modifying a primary key would re-encrypt all the existing Type 6 format key strings with the new primary key. If Type 6 key strings are present, ensure that the **password6 configuration aes** command is present to enable re-encryption with the new primary key. Otherwise, the primary key update operation fails.

- **Deleting the Primary Key** - Follow these steps to delete the primary key at any time.

  ```
  Router# configure terminal
  Router(config)#no password6 encryption aes
  Router(config)#commit
  Router(config)#exit
  Router# key config-key password-encryption delete
  ```

Note Primary key deletion will bring down MACsec traffic if MKA sessions are up with Type 6 keys. To avoid traffic disruptions, configure a new set of PSK key pairs [key (CKN) and key string (CAK)] with latest timestamps with the lifetime of *infinite* validity on both the peers and ensure the successful CAK rekey to the newly configured CKN and CAK.

Configuring MACsec Pre-shared Key (PSK) For Type 6 Password Encryption

Ensure that you have configured a primary key using the **key config-key password-encryption** command and enabled the Type 6 encryption feature using the **password6 encryption aes** command.

```
Router#configure terminal
Router(config)#key chain kc1 macsec
Router(config-kc1-MacSec)# key 1111

! Configuring 32 byte hex CAK

Router(config-kc1-MacSec-1111)# key-string 12345678901234567890123456789022
cryptographic-algorithm aes-128-cmac

! Configuring 64 byte hex CAK

Router(config-kc1-MacSec-1111)# key-string
1234567890123456789012345678902212345678901234567890123456789022 cryptographic-algorithm
aes-256-cmac
Router(config-kc1-MacSec-1111)# lifetime 00:00:00 1 October 2019 infinite
Router(config-kc1-MacSec-1111)# commit
```

Running Configuration

The following is a sample output of the **show running-config key chain** command. The MACsec key chain name, the Type 6 key, and key-string information are displayed.

```
Router#show running-config key chain kc1

key chain kc1
 macsec
  key 1111
    key-string password6 674c434d695b5c5b464f546854474d58504946535455644b5043685969454861685
645464c5047635c464b5a6847566751535f4547526663525664 5a4a49454b4d6467514545434652546849576 5f6149674c5e4d
516843484446575c49685f5648665a604b5450435952634c61455d4b5e414142 cryptographic-algorithm
aes-256-cmac
         lifetime 00:00:00 october 01 2019 infinite
  !
```

Create a user-defined MACsec policy

- **MACsec policy** - Create a MACsec policy and configure the cipher suite to be used for MACsec encryption, including the confidentiality offset.

Note We recommend to change the offset value of the **conf-offset** <*offset_value*> command (MACsec encryption command) in the routers only when the port is in **admin down** state (that is, when the interface is shut down). Changing the offset value otherwise may result in traffic loss.

In this example, the GCM-AES-XPN-256 encryption algorithm is used. A 256-bit encryption algorithm uses a larger key that requires more rounds of hacking to be cracked. 256-bit algorithms provide better security against large mass security attacks, and include the security provided by 128-bit algorithms. Extended Packet Numbering (XPN) is used to reduce the number of key rollovers while data is sent over high speed links. It is therefore highly recommended to use GCM-AES-XPN-256 encryption algorithm for higher data ports.

Note For Cisco 8000 Series Routers to interoperate with Cisco ASR9000 Series Routers that are older than Release 6.2.3, configure a user defined MACsec policy with the `policy-exception lacp-in-clear` command to bring up the MKA sessions over bundle interfaces running in LACP modes.

```
Router# configure terminal
Router(config)# macsec-policy mp-SF
Router(config-macsec-policy)# cipher-suite GCM-AES-XPN-128
Router(config-macsec-policy)# conf-offset CONF-OFFSET-30
```

- **Key server priority** - You can enter a value between 0-255. Lower the value, higher the preference to be selected as the key server. In this example, a value of 0 configures the router as the key server, while the other router functions as a key client. The key server generates and maintains the SAK between the two routers. The default key server priority value is 16.

```
Router(config-macsec-policy)# key-server-priority 10
```

- **Security policy parameters** - Enable the Must-Secure or Should-Secure parameter.

Must-Secure imposes that only MACsec encrypted traffic can flow. Hence, until the MKA session is secured, traffic is dropped.

Should-Secure allows unencrypted traffic to flow until the MKA session is secured. After the MKA session is secured, only encrypted traffic can flow.

Note Unlike in P2P scenarios, the traffic drops in P2MP if a third peer that is added with **should-secure** security policy fails to establish secure connection with two other peers that have already established a secure connection using **should-secure**. This is because, the first two peers update their configurations to drop all untagged (unencrypted) packets, once they establish a secure connection.

```
Router(config-macsec-policy)# security-policy should-secure
```

- **Data delay protection** - Data delay protection allows MKA participants to ensure that the data frames protected by MACsec are not delayed by more than 2 seconds. Each SecY uses MKA to communicate the lowest PN used for transmission with the SAK within two seconds. Traffic delayed longer than 2 seconds are rejected by the interfaces enabled with delay protection.

  By default, the data delay protection feature is disabled. Configuring the delay-protection command under MACsec-policy attached to MACsec interface will enable the data delay protection feature on that interface. When enabled, the **show macsec mka session interface** *interface* **detail** command output displays the **Delay Protection** field as **TRUE**.

  ```
  Router(config-macsec-policy)# delay-protection
  ```

- **Replay protection window size** - The window size dictates the maximum out-of-sequence frames that are accepted. You can configure a value between 0 and 1024.

- **ICV** for the frame arriving on the port - This parameter configures inclusion of the optional ICV Indicator as part of the transmitted MACsec Key Agreement PDU (MKPDU). This configuration is necessary for MACsec to interoperate with routers that run software prior to IOS XR version 6.1.3. This configuration is also important in a service provider WAN setup where MACsec interoperates with other vendor MACsec implementations that expect ICV indicator to be present in the MKPDU.

  ```
  Router(config-macsec-policy)# window-size 64
  Router(config-macsec-policy)# include-icv-indicator
  Router(config-macsec-policy)# commit
  ```

Running Configuration

The following is a sample output of the **show running-config macsec-policy** command.

```
Router# show running-config macsec-policy mp-SF

macsec-policy mp-SF
 conf-offset CONF-OFFSET-30
 security-policy should-secure
 cipher-suite GCM-AES-XPN-128
 window-size 64
 include-icv-indicator
 delay-protection
 key-server-priority 10
!
```

MACsec SAK Rekey Interval

You can set a timer value to rekey the MACsec secure association key (SAK) at a specified interval. This periodic refresh of SAK ensures that data encryption key is frequently updated. The configuration is effective on the node acting as a key server.

To set the rekey interval, use the **sak-rekey-interval** command in macsec-policy configuration mode. The timer ranges from 60 to 2,592,000 seconds, the default being OFF.

Configuration Example

```
Router#configure
Router(config)#macsec-policy test-policy
Router(config-macsec-policy)#sak-rekey-interval 120
Router(config-macsec-policy)#commit
```

Running Configuration

```
macsec-policy test-policy
 sak-rekey-interval 120
 !
```

Associated Command

sak-rekey-interval

EAPoL Ether-type and destination address

In WAN MACsec, when two peers establish an MKA session using the standard EAPoL Ether-type (0x888E) and destination MAC address (01:80:C2:00:00:03) through the service provider network, the Layer 2 intermediate devices may intercept and consume the EAPoL packets, which in turn can affect the MACsec session establishment between the two endpoints.

Table 3: Feature History Table

Feature Name	Release Information	Feature Description
Alternate EAPoL Ether-type and destination address	Release 24.4.1	Introduced in this release on: Fixed Systems (8700 [ASIC: P100])(select variants only*). This feature now allows to configure an alternate EAPoL Ether-type, destination MAC address, or both under the MACsec-enabled interface on the following hardware. *This feature is now supported on the Cisco 8711-32FH-M routers.

Feature Name	Release Information	Feature Description
Alternate EAPoL Ether-type and destination address	Release 24.3.1	Introduced in this release on: Fixed Systems (8200 [ASIC: Q200, P100])(select variants only*); Modular Systems (8800 [LC ASIC: Q100, Q200, P100])(select variants only*). You can now configure an alternate EAPoL Ether-type, destination MAC address, or both under the MACsec-enabled interface on the following hardware. *This feature is now supported on: • 88-LC1-52Y8H-EM • 8212-48FH-M
Alternate EAPoL Ether-type and destination address	Release 7.10.1	Introduced in this release on: Centralized Systems (8600 [ASIC:Q200]) . This feature that allows you to configure an alternate EAPoL Ether-type, destination MAC address, or both under the MACsec-enabled interface is now supported on the following hardware. This feature is now supported on the Cisco 8608 routers.
Alternate EAPoL Ether-type and destination address	Release 7.5.2	Introduced in this release on: Fixed Systems (8200 [ASIC: Q200])(select variants only*). You can now configure an alternate EAPoL Ether-type, destination MAC address, or both under the MACsec-enabled interface on the following hardware. *This feature is now supported on the Cisco 8202-32FH-M routers.

Feature Name	Release Information	Feature Description
Alternate EAPoL Ether-type and destination address	Release 7.3.3	Introduced in this release on: Modular Systems (8800 [LC ASIC: Q100, Q200])(select variants only*). You can now configure an alternate EAPoL Ether-type, destination MAC address, or both under the MACsec-enabled interface. This feature helps to overcome the challenge that occurs when the Layer 2 intermediate devices intercept and consume the EAPoL packets from an MKA session with the standard EAPoL Ether-type (0x888E) and destination MAC address (01:80:C2:00:00:03). *This feature is now supported on the Cisco 88-LC0-34H14FH line cards.
Alternate EAPoL Ether-type and destination address	Release 7.3.15	Introduced in this release on: Modular Systems (8800 [LC ASIC: Q100, Q200])(select variants only*). Starting from this release, you can now configure an alternate EAPoL Ether-type, destination MAC address, or both under the MACsec-enabled interface on the following hardware. *This feature is now supported on the Cisco 88-LC0-36FH-M line cards.
Alternate EAPoL Ether-type and destination address	Release 7.0.12	Introduced in this release on: Modular Systems (8800 [LC ASIC: Q100])(select variants only*). This feature allows to configure an alternate EAPoL Ether-type, destination MAC address, or both under the MACsec-enabled interface on the following hardware. *This feature is now supported on the Cisco 8800-LC-48H line cards.

The supported alternate EAPoL Ether-type is 0x876F. To configure an alternate EAPoL Ether-type, see Configure EAPoL Ether-type 0x876F.

The supported alternate EAPoL destination MAC address is the broadcast address FF:FF:FF:FF:FF or the nearest bridge group address. To configure an alternate EAPoL destination address, see Configure EAPoL destination broadcast address and Configure EAPoL destination bridge group address.

Applying MACsec Configuration on an Interface

The MACsec service configuration is applied to the host-facing interface of a CE router.

Guidelines for MACsec Interface Configuration

- Configure different keychains for primary and fallback PSKs.
- We do not recommend to update both primary and fallback PSKs simultaneously, because fallback PSK is intended to recover MACsec session on primary key mismatch.
- When using MACsec, we recommend you adjust the maximum transmission unit (MTU) of an interface to accommodate the MACsec overhead. Configuring MTU value on an interface allows protocols to do MTU negotiation including MACsec overhead. For instance, if the default MTU is 1514 bytes, configure the MTU to 1546 bytes (1514 + 32).
- The minimum MTU for IS-IS protocol on the MACsec interface is 1546 bytes.
- To enable MACsec on bundles:
  - Enable MACsec on all bundle members.
  - MACsec peers running IOS-XR version 24.1.1 or higher:
    - For routing protocols running on the bundle interface, configure **impose-overhead-on-bundle** in the MACsec policy to adjust the bundle interface MTU with MACsec overhead.
  - MACsec peers running IOS-XR versions prior to 24.1.1:
    - We recommend configuring the maximum possible MTU on the bundle interface.
    - The MTU configurations must account for the maximum packet size of the protocols running on the bundle interface and 32 bytes of MACsec overhead.
    - For IS-IS protocol running on the bundle interface, hello-padding must be disabled.

Tip You can programmatically view the MACsec configuration using the `openconfig-macsec.yang` OpenConfig data model. To get started with using data models, see *Programmability Configuration Guide for Cisco 8000 Series Routers*.

MACsec PSK Configuration on an Interface

```
Router#configure
Router(config)#interface hundredGigE 0/1/0/10
Router(config-if)# macsec psk-keychain kc policy mp-SF
```

To enable MACsec PSK on a physical interface without the MACsec policy, use this command:

```
Router(config-if)#macsec psk-keychain script_kc
```

MACsec Fallback PSK Configuration on an Interface

It is optional to configure a fallback PSK. If a fallback PSK is configured, the fallback PSK along with the primary PSK ensures that the session remains active even if the primary PSK is mismatched, or there is no active key for the primary PSK.

```
Router(config-if)#macsec psk-keychain kc fallback-psk-keychain fallback_kc policy mp-SF
Router(config-if)#commit
```

Verification

Before the introduction of active fallback functionality:

```
Router# show macsec mka session detail

NODE: node0_1_CPU0

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 7872.5d1a.e7d4/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 7872.5d1a.e7d4
MKA Port Identifier             : 1
Interface Name                  : Hu0/1/0/10
CAK Name (CKN)                  : 1234
CA Authentication Mode          : PRIMARY-PSK
Keychain                        : kc
Member Identifier (MI)          : C12A70FEE1212B835BDDDCBA
Message Number (MN)             : 395
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-128-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-128

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 0
Latest SAK KI (KN)              : 018E2F0D63FF2ED6A5BF270E00000001 (1)
Old SAK Status                  : FIRST-SAK
Old SAK AN                      : 0
Old SAK KI (KN)                 : FIRST-SAK (0)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : mp-SF
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 30
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000003 (GCM-AES-XPN-128)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 1
# of MACsec Capable Live Peers Responded : 0

Live Peer List:
```

```
-------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
-------------------------------------------------------------------------------
018E2F0D63FF2ED6A5BF270E       86       008a.962d.7400/0001    2        16

Potential Peer List:
-------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
-------------------------------------------------------------------------------

Peers Status:
 Last Tx MKPDU          : 2019 Oct 08 07:39:56.905
 Peer Count             : 1

 RxSCI                  : 008A962D74000001
  MI                    : 018E2F0D63FF2ED6A5BF270E
  Peer CAK              : Match
  Latest Rx MKPDU       : 2019 Oct 08 07:39:57.363
```

With the introduction of active fallback functionality:

The following is a snippet from the sample output that displays entry for active fallback PSK as well. The secured primary session output part is truncated here, which is exactly same as the output given above.

```
Router# show macsec mka session detail
NODE: node0_1_CPU0

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 0257.3fae.5cda/0001
Local Tx-SSCI                   : 1
- - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - -
MKA Detailed Status for MKA Session
===================================
Status: Active - Marked Peer as Live (Waiting for SAK generation/distribution)

Local Tx-SCI                    : 0257.3fae.5cda/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 0257.3fae.5cda
MKA Port Identifier             : 1
Interface Name                  : Hu0/1/0/0
CAK Name (CKN)                  : 1111
CA Authentication Mode          : FALLBACK-PSK
Keychain                        : fb1
Member Identifier (MI)          : FC53A31E030E385981E0AACE
Message Number (MN)             : 178
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-256-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-256
Key Distribution Mode           : SAK

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 1
Latest SAK KI (KN)              : 725FF8F6605A3D428972538F00000001 (1)
Old SAK Status                  : No Rx, No Tx
Old SAK AN                      : 0
Old SAK KI (KN)                 : RETIRED (0)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
```

```
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : *DEFAULT POLICY*
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 0
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000004 (GCM-AES-XPN-256)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 1
# of MACsec Capable Live Peers Responded : 0

Live Peer List:
-----------------------------------------------------------------------------
           MI                   MN             Rx-SCI          SSCI  KS-Priority
-----------------------------------------------------------------------------
6A894FE1E984AD5314F33D21      188       0201.9ab0.85af/0001    0        16

Potential Peer List:
-----------------------------------------------------------------------------
           MI                   MN             Rx-SCI          SSCI  KS-Priority
-----------------------------------------------------------------------------

Peers Status:
 Last Tx MKPDU          : 2021 Apr 30 14:56:33.797
 Peer Count             : 1

 RxSCI                  : 02019AB085AF0001
  MI                    : 6A894FE1E984AD5314F33D21
  Peer CAK              : Match
  Latest Rx MKPDU       : 2021 Apr 30 14:56:34.638
```

The following is a sample output of the **show macsec mka session interface** command. With this command, you can verify whether the interface of the router is peering with its neighbor after MACsec configuration. The MACsec PSK validation detects inconsistency or mismatch of primary and fallback keys (CAK) being used by MKA, allowing operators to rectify the mismatch.

Verify whether the MKA session is secured with MACsec on the respective interface. The **Status** field in the output verifies if the MKA session is secured with MACsec encryption. The output also displays information about the interface and other MACsec parameters.

```
Router#show macsec mka session interface hundredGigE 0/1/0/10

===============================================================================================

   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN

===============================================================================================

     Hu0/1/0/10      7872.5d1a.e7d4/0001     1      Secured      NO       PRIMARY     1234

     Hu0/1/0/10      7872.5d1a.e7d4/0001     1      Secured      NO       FALLBACK
5678
```

Before the introduction of active fallback functionality:

```
Router# show macsec mka session interface hundredGigE 0/1/0/10 detail

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 7872.5d1a.e7d4/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 7872.5d1a.e7d4
MKA Port Identifier             : 1
Interface Name                  : Hu0/1/0/10
CAK Name (CKN)                  : 1234
CA Authentication Mode          : PRIMARY-PSK
Keychain                        : kc
Member Identifier (MI)          : C12A70FEE1212B835BDDDCBA
Message Number (MN)             : 433
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-128-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-128

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 0
Latest SAK KI (KN)              : 018E2F0D63FF2ED6A5BF270E00000001 (1)
Old SAK Status                  : FIRST-SAK
Old SAK AN                      : 0
Old SAK KI (KN)                 : FIRST-SAK (0)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : mp-SF
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 30
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000003 (GCM-AES-XPN-128)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers          : 1
# of MACsec Capable Live Peers Responded : 0

Live Peer List:
-----------------------------------------------------------------------------
          MI                  MN             Rx-SCI          SSCI  KS-Priority
-----------------------------------------------------------------------------
018E2F0D63FF2ED6A5BF270E      123       008a.962d.7400/0001    2        16

Potential Peer List:
-----------------------------------------------------------------------------
          MI                  MN             Rx-SCI          SSCI  KS-Priority
-----------------------------------------------------------------------------

Peers Status:
 Last Tx MKPDU          : 2019 Oct 08 07:41:12.929
 Peer Count             : 1

 RxSCI                  : 008A962D74000001
  MI                    : 018E2F0D63FF2ED6A5BF270E
```

```
  Peer CAK              : Match
  Latest Rx MKPDU       : 2019 Oct 08 07:41:11.400
```

With the introduction of active fallback functionality:

The following is a snippet from the sample output that displays entry for active fallback PSK as well. The secured primary session output part is truncated here, which is exactly same as the output given above.

```
Router# show macsec mka session interface hundredGigE 0/1/0/10 detail

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 7872.5d1a.e7d4/0001
Local Tx-SSCI                   : 1
- - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - -
MKA Detailed Status for MKA Session
===================================
Status: Active - Marked Peer as Live (Waiting for SAK generation/distribution)

Local Tx-SCI                    : 34ed.1b5b.d0d7/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 34ed.1b5b.d0d7
MKA Port Identifier             : 1
Interface Name                  : Hu0/4/0/27
CAK Name (CKN)                  : 2222
CA Authentication Mode          : FALLBACK-PSK
Keychain                        : fb1
Member Identifier (MI)          : C0978A6B0916C3FC959773FE
Message Number (MN)             : 24039
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-256-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-256

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 2
Latest SAK KI (KN)              : 3D008A7D75DF0A9A35F9E3A900000002 (2)
Old SAK Status                  : No Rx, No Tx
Old SAK AN                      : 1
Old SAK KI (KN)                 : RETIRED (0)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : r1
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 0
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000004 (GCM-AES-XPN-256)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 1
# of MACsec Capable Live Peers Responded : 0
```

```
Live Peer List:
----------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
----------------------------------------------------------------------------------
B5ED6849883F34FEE89F74D1     26068      008a.9681.c02c/0001    2        16

Potential Peer List:
----------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
----------------------------------------------------------------------------------

Peers Status:
Last Tx MKPDU          : 2021 Apr 28 02:08:03.795
Peer Count             : 1

RxSCI                  : 008A9681C02C0001
  MI                    : B5ED6849883F34FEE89F74D1
  Peer CAK              : Match
  Latest Rx MKPDU       : 2021 Apr 28 02:08:02.749
```

Configure EAPoL Ether-type 0x876F

This procedure allows to configure the EAPoL Ether-type 0x876F.

Procedure

Step 1 Create a MACsec key chain. For information, see Create a MACsec key chain.

Step 2 (Optional) Create a MACsec policy. For information, see Create a MACsec policy.

Step 3 Configure the EAPoL ether-type.

Example:

```
Router(config)# interface HundredGigE0/1/0/2
Router(config-if)# eapol eth-type 876F
Router(config-if)# commit
```

Step 4 Apply MACsec on a interface.

Example:

```
Router(config)# interface HundredGigE0/1/0/2
Router(config-if)# macsec psk-keychain kc fallback-psk-keychain fb
Router(config-if)# commit
```

Running Configuration

This example shows the running configuration for the EAPoL Ether-type 0x876F.

```
Router# show running-config interface HundredGigE0/1/0/2
interface HundredGigE0/1/0/2
  eapol eth-type 876F
  macsec psk-keychain kc fallback-psk-keychain fb
!
```

Verification

This example provides the verification for the EAPoL Ether-type 0x876F.

```
Router# show macsec mka interface  HundredGigE0/1/0/2 detail | i Ethertype
Ethertype                : 876F

Router# show macsec mka session interface HundredGigE0/1/0/2.1
==============================================================================================

   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN

==============================================================================================

     Hu0/1/0/2        0201.9ab0.77cd/0001     1      Secured      YES      PRIMARY     1234

     Hu0/1/0/2        0201.9ab0.77cd/0001     1      Active       YES     FALLBACK     9999
```

Configure EAPoL destination broadcast address

This procedure allows to configure the EAPoL destination address with the broadcast address FF:FF:FF:FF:FF, to ensure that the underlying L2 network floods the EAPoL packets to all receivers.

Procedure

Step 1 Create a MACsec key chain. For information, see Create a MACsec key chain.

Step 2 (Optional) Create a MACsec policy. For information, see Create a MACsec policy.

Step 3 Configure the EAPoL destination address.

Example:

```
Router(config)# interface HundredGigE0/1/0/2
Router(config-if)# eapol destination-address broadcast-address
Router(config-if)# commit
```

Step 4 Apply MACsec on a interface.

Example:

```
Router(config)# interface HundredGigE0/1/0/2
Router(config-if)# macsec psk-keychain kc fallback-psk-keychain fb
Router(config-if)# commit
```

Running Configuration

This example shows the running configuration for the EAPoL destination broadcast address.

```
Router# show running-config interface HundredGigE0/1/0/2
 eapol destination-address ffff.ffff.ffff
 macsec psk-keychain kc fallback-psk-keychain fb
!
```

Verification

This example provides the verification for the EAPoL destination broadcast address.

```
Router# show macsec mka interface  HundredGigE0/1/0/2 detail  | i EAPoL
    EAPoL Destination Addr   : ffff.ffff.ffff
```

```
Router# show macsec mka session interface HundredGigE0/1/0/2
==============================================================================================

   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN

==============================================================================================

     Hu0/1/0/2       02df.3638.d568/0001     1      Secured      YES      PRIMARY     1234

     Hu0/1/0/2       02df.3638.d568/0001     1      Active       YES     FALLBACK     9999
```

Configure EAPoL destination bridge group address

This procedure allows to set the EAPoL destination address with the nearest bridge group address, for example 01:80:C2:00:00:00 and provides the EAPoL destination address configuration on a physical interface, which is inherited by the MACsec-enabled subinterface.

Procedure

Step 1 Create a MACsec key chain. For information, see Create a MACsec key chain.

Step 2 (Optional) Create a MACsec policy. For information, see Create a MACsec policy.

Step 3 Configure the EAPoL destination bridge group address on a MACsec-enabled physical interface.

Example:

```
Router(config)# interface HundredGigE0/1/0/1
Router(config-if)# eapol destination-address bridge-group-address
Router(config-if)# commit
```

Step 4 Configure MACsec on a subinterface.

Example:

```
Router(config)# interface HundredGigE0/1/0/1.1
Router(config-subif)# encapsulation dot1q 1
Router(config-subif)# macsec psk-keychain kc fallback-psk-keychain fb
outer(config-subif)# commit
```

Running Configuration

This example shows the running configuration for the EAPoL destination bridge group address on the MACsec-enabled physical interface.

```
Router# show running-config interface Hu0/1/0/1
interface HundredGigE0/1/0/1
eapol destination-address 0180.c200.0000
```

This example shows the running configuration for the EAPoL destination bridge group address on the MACsec-enabled subinterface.

```
Router# show running-config interface HundredGigE0/1/0/1.1
interface HundredGigE0/1/0/0.1
  macsec psk-keychain kc fallback-psk-keychain fb
  encapsulation dot1q 1
!
```

Verification

This example provides the verification for the EAPoL destination bridge group address configured on the MACsec-enabled subinterface.

```
Router# show macsec mka interface  HundredGigE0/1/0/1.1 detail  | i EAPoL
    EAPoL Destination Addr   : 0180.c200.0000

Router# show macsec mka session interface HundredGigE0/1/0/1.1
==============================================================================================

   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN

==============================================================================================

     Hu0/1/0/1.1       0201.9ab0.85af/0001     1      Secured      YES       PRIMARY
1234
     Hu0/1/0/1.1       0201.9ab0.85af/0001     1      Active       YES     FALLBACK
9999
```

MACsec mode on PHY

MACsec mode is a mode that ensures allocation of the required power for all MACsec ports on a line card or a router. Enabling MACsec mode prevents interface flap when MACsec feature is enabled on a port.

Enable MACsec Mode on PHY

You can enable the MACsec mode for the PHY of a line card or of a fixed router by using the **hw-module macsec-mode** command in XR Config mode mode.

Configuration Example

```
Router#configure
Router(config)#hw-module macsec-mode location 0/1/CPU0
Router(config)#commit
```

Note You must reload the line card for the MACsec mode configuration to take effect.

Note If the MACsec mode is already enabled on a node such as a line card, then the system does not allow you to configure the **hw-module macsec-mode location all** command again. This restriction is in place to prevent conflicts in configuration, especially in a configuration restore scenario. In such scenarios, you can make use of the **show hw-module macsec-mode** command to know of the respective running configurations in place.

Running Configuration

```
hw-module macsec-mode location 0/1/CPU0
!
```

Verification

You can use the **show hw-module macsec-mode** command in the XR EXEC mode to display the MACsec mode of line cards, and the user action to be performed.

```
Router#show hw-module macsec-mode location 0/1/CPU0
Sat Dec  7 14:31:52.668 UTC
Location       Configured     Running          Action
--------------------------------------------------------------
0/1/CPU0       YES            NO               RELOAD
```

You can also use the **show hw-module macsec-mode location all** command to display the MACsec mode information of all nodes. This **location all** option is available starting Cisco IOS XR Software Release 7.0.14.

```
Router#show hw-module macsec-mode location all
Sun Feb 16 21:06:07.726 UTC

Location       Configured     Running          Action
--------------------------------------------------------------
0/0/CPU0       YES            NO               RELOAD
0/7/CPU0       NO             NO               NONE
```

MACsec Encryption on Layer 3 Subinterface

Table 4: Feature History Table

Feature Name	Release Information	Feature Description
MACsec Encryption on Layer 3 Subinterfaces	Release 24.4.1	Introduced in this release on: Centralized Systems (8600 [ASIC:Q200]) The MACsec Encryption on Layer 3 Subinterfaces feature support is now extended to Cisco 8608 Routers.

Feature Name	Release Information	Feature Description
MACsec Encryption on Layer 3 Subinterfaces	Release 7.11.1	You can now configure MACsec policy on Layer 3 subinterfaces, which gives you the flexibility to apply MACsec policies to different L3 subinterfaces that belong to the same main physical interface. This capability is possible because we've enabled the router to keep the VLAN tags unencrypted, enabling the L3 subinterfaces to be the MACsec endpoints. When you apply MACsec policies on these subinterfaces, you can enhance the overall security of your network by adding an extra layer of security to the communication between different subnets. This feature is supported on Cisco 8202-32FH-M fixed port routers and 88-LC0-36FH-M line cards. The feature introduces these changes: **CLI:** • **vlan-tags-in-clear** **YANG Data Models:** • `Cisco-IOS-XR-um-macsec-cfg` • Cisco-IOS-XR-crypto-macsec-mka-cfg See GitHub, YANG Data Models Navigator

You can now implement MACsec on L3 subinterfaces to provide secure communication within a specific L3 VLAN. On implementing MACsec on the L3 subinterface, the MACsec encryption and authentication are unique to the traffic on that subinterface. As a result, you can control the traffic encryption for individual subinterfaces of a physical interface by customizing MACsec policies.

MACsec on L3 subinterface configurations are similar to the MACsec configurations on a physical interface. For a successful MACsec Key Agreement protocol (MKA) session to be up on any L3 subinterface, it must have a valid tagging protocol encapsulation and a VLAN identifier assigned. All L3 subinterfaces always default to the 802.1Q VLAN encapsulation. However, the VLAN identifier must be explicitly defined.

Table 5: Hardware Support Matrix for MACsec on Layer 3 Subinterfaces

Cisco IOS XR Software Release	PID
Release 24.4.1	Cisco 8608

Cisco IOS XR Software Release	PID
Release 24.3.1	88-LC1-52Y8H-EM
Release 7.11.1	8202-32FH-M
	88-LC0-36FH-M

Guidelines and Restrictions for MACsec Encryption on Layer 3 Subinterface

- The L3 subinterfaces belonging to a physical interface must have either of the following encapsulation combinations:
  - 802.1Q tag(single tag)
  - 802.1ad outer and 802.1Q inner tags (double tags)
- You must configure the same type of VLAN tag on all the subinterfaces belonging to a physical interface.
- The MACsec encryption on layer 3 subinterface supports VLAN identifier range of 1–4094.
- The encapsulation configured on the L3 subinterface and the number of VLAN tags in-clear configured on the associated MACsec policy must match. That is, if the encapsulation on the interface is 802.1Q with a single tag, then the number of VLAN tags in-clear in the MACsec policy must be 1. Similarly, if the encapsulation on the interface is 802.1ad outer and 802.1Q inner tags, then the number of VLAN tags in-clear in the MACsec policy must be 2.
- To configure VLAN tags in-clear, use the **vlan-tags-in-clear** command.
- To configure encapsulation on the L3 subinterface, use the **encapsulation dot1q**(802.1Q with a single tag) or **encapsulation dot1ad**(802.1ad outer and 802.1Q inner tags) command.
- MACsec support on physical interfaces and subinterfaces is mutually exclusive. The routers don't support simultaneously enabling MACsec on a physical interface and its subinterfaces and reject such configuration attempts. To configure MACsec on subinterfaces, clear the MACsec configurations on the corresponding physical interface and conversely.
- MACsec on subinterfaces does not support data delay protection.
- All subinterfaces in a physical interface must have identical MACsec policy parameters such as allow-lacp-in-clear, allow-pause-frames-in-clear, vlan-tags-in-clear, or security policy.
- The Cisco 8800-LC-48H and 88-LC0-34H14FH line cards do not support MACsec on VLAN subinterfaces.
- We recommend keeping the MACsec session limit on any line card or fixed port router, including all port-level and subinterface-level MACsec sessions, at 192 for optimal functioning of simultaneous hitless SAK rekey performance.

Configuring and Verifying MACsec Encryption on VLAN Subinterfaces

Enabling MACsec encryption on subinterfaces involves the following steps:

Configuration

1. Creating a MACsec Key Chain:

```
Router# configure
Router(config)# key chain kc
Router(config-kc)# macsec
Router(config-kc-macsec)# key 1234
Router(config-kc-macsec-1234)# key-string
12345678123456781234567812345678123456781234567812345678 cryptographic-algorithm
 aes-256-cmac
Router(config-kc-macsec-1234)# lifetime 05:00:00 1 January 2023 infinite
Router(config-kc-macsec-1234)# commit
```

For more information, see Create a MACsec keychain, on page 8.

2. Creating a MACsec Policy:

```
802.1Q with a single tag
Router# configure
Router(config)# macsec-policy mp-SF1
Router(config-macsec-policy)# cipher-suite GCM-AES-XPN-256
Router(config-macsec-policy)# security-policy should-secure
Router(config-macsec-policy)# allow-lldp-in-clear
Router(config-macsec-policy)# key-server-priority 10
Router(config-macsec-policy)# window-size 64
Router(config-macsec-policy)# vlan-tags-in-clear 1
/* The VLAN tagging in the MACsec policy must match the encapsulation on the interface
*/
Router(config-macsec-policy)# commit

802.1ad outer and 802.1q inner with double tags
Router# configure
Router(config)# macsec-policy mp-SF2
Router(config-macsec-policy)# cipher-suite GCM-AES-XPN-256
Router(config-macsec-policy)# security-policy should-secure
Router(config-macsec-policy)# allow-lldp-in-clear
Router(config-macsec-policy)# key-server-priority 20
Router(config-macsec-policy)# window-size 64
Router(config-macsec-policy)# vlan-tags-in-clear 2
/* The VLAN tagging in the MACsec policy must match the encapsulation on the interface
*/
Router(config-macsec-policy)# commit
```

For more information, see Create a user-defined MACsec policy, on page 12.

3. Applying MACsec on a Subinterface:

```
802.1Q with a single tag
Router# configure
Router(config)# interface HundredGigE 0/5/0/16.100
Router(config-subif)# encapsulation dot1q 100
Router(config-subif)# ipv4 address 192.168.16.1 255.255.255.0
Router(config-subif)# macsec psk-keychain kc policy mp-SF1
Router(config-subif)# commit

802.1ad outer and 802.1q inner with double tags
Router# configure
Router(config)# interface HundredGigE 0/5/0/30.200
Router(config-subif)# encapsulation dot1ad 200 dot1q 300
Router(config-subif)# ipv4 address 192.168.30.1 255.255.255.0
Router(config-subif)# macsec psk-keychain kc policy mp-SF2
Router(config-subif)# commit
```

Running Configuration

MACsec Key Chain:

```
Router# show running-config psk-keychain kc
key chain kc
 macsec
  key 1234
   key-string password
11584B5643475D6B5C7B79777C6663754B56445055030F0F0B055C504C430F0F0F020006005E0D515F0905574753520C53575D72181B5F4E5D464058585 17C7C7C
 cryptographic-algorithm aes-256-cmac
   lifetime 05:00:00 january 01 2023 infinite
  !
 !
!
```

MACsec Policy:

802.1Q with a single tag

```
Router# show running-config macsec-policy mp-SF1
macsec-policy mp-SF1
 security-policy should-secure
 allow-lldp-in-clear
 window-size 64
 cipher-suite GCM-AES-XPN-256
 vlan-tags-in-clear 1
 key-server-priority 10
!
```

802.1ad outer and 802.1q inner with double tags

```
Router# show running-config macsec-policy mp-SF2
macsec-policy mp-SF2
 security-policy should-secure
 allow-lldp-in-clear
 window-size 64
 cipher-suite GCM-AES-XPN-256
 vlan-tags-in-clear 2
 key-server-priority 20
!
```

Sub-Interface Configurations:

802.1Q with a single tag

```
Router# show running-config interface HundredGigE 0/5/0/16.100
interface HundredGigE0/5/0/16.100
 ipv4 address 192.168.16.1 255.255.255.0
 macsec psk-keychain kc policy mp-SF1
 encapsulation dot1q 100
!
```

802.1ad outer and 802.1q inner with double tags

```
Router# show running-config interface HundredGigE 0/5/0/30.200
interface HundredGigE0/5/0/30.200
 ipv4 address 192.168.30.1 255.255.255.0
 macsec psk-keychain kc policy mp-SF2
 encapsulation dot1ad 200 dot1q 300
!
```

Verification

```
Router# show macsec mka summary
NODE: node0_5_CPU0
==============================================================================================
   Interface-Name     Status     Cipher-Suite       KeyChain       PSK/EAP      CKN
==============================================================================================
```

```
   Hu0/5/0/16.100     Secured  GCM-AES-XPN-256         kc          PRIMARY     1234
   Hu0/5/0/30.200     Secured  GCM-AES-XPN-256         kc          PRIMARY     1234
```

802.1Q with a single tag

```
Policy Name                 : mp-SF1
      Cipher Suite          : GCM-AES-XPN-256
      Key-Server Priority   : 10
      Window Size           : 64
      Conf Offset           : 0
      Replay Protection     : TRUE
      Delay Protection      : FALSE
      Security Policy       : Should Secure
      Vlan Tags In Clear    : 1
      LACP In Clear         : FALSE
      LLDP In Clear         : TRUE
      Pause Frame In Clear  : FALSE
      Sak Rekey Interval    : OFF
      Include ICV Indicator : FALSE
      Use Eapol PAE in ICV  : FALSE
      Disable Suspend On Request    : FALSE
      Disable Suspend For           : FALSE
      Enable legacy fallback        : FALSE
      SKS Profile                   : N/A
      Max AN                        : 3
      Impose Overhead on Bundle     : FALSE
```

802.1ad outer and 802.1q inner with double tags

```
Router# show macsec policy mp-SF2 detail
Policy Name                 : mp-SF2
      Cipher Suite          : GCM-AES-XPN-256
      Key-Server Priority   : 20
      Window Size           : 64
      Conf Offset           : 0
      Replay Protection     : TRUE
      Delay Protection      : FALSE
      Security Policy       : Should Secure
      Vlan Tags In Clear    : 2
      LACP In Clear         : FALSE
      LLDP In Clear         : TRUE
      Pause Frame In Clear  : FALSE
      Sak Rekey Interval    : OFF
      Include ICV Indicator : FALSE
      Use Eapol PAE in ICV  : FALSE
      Disable Suspend On Request    : FALSE
      Disable Suspend For           : FALSE
      Enable legacy fallback        : FALSE
      SKS Profile                   : N/A
      Max AN                        : 3
      Impose Overhead on Bundle     : FALSE


Router# show macsec mka interface detail
Interface Name : HundredGigE0/5/0/16.100
    Interface Namestring     : HundredGigE0/5/0/16.100
    Interface short name     : Hu0/5/0/16.100
    Interface handle         : 0x2800b00
    Interface number         : 0x2800b00
    MacSecControlledIfh      : 0x2800b08
    MacSecUnControlledIfh    : 0x2800b10
    Interface MAC            : e069.bafd.e3a0
    Ethertype                : 888E
    EAPoL Destination Addr   : 0180.c200.0003
    MACsec Shutdown          : FALSE
    Config Received          : TRUE
    IM notify Complete       : TRUE
```

```
    MACsec Power Status      : Allocated
    Interface CAPS Add       : TRUE
    RxSA CAPS Add            : TRUE
    TxSA CAPS Add            : TRUE
    IM notify with VLAN Info : TRUE
    Supported VLAN encaps    : TRUE
    SecTAG Offset validation : TRUE
    VLAN                     : Outer tag (etype=0x8100, id=100, priority=0, cfi=0)
    Principal Actor          : Primary
    MKA PSK Info
      Key Chain Name         : kc
      MKA Cipher Suite       : AES-256-CMAC
      CKN                    : 12 34
    MKA fallback_PSK Info
      fallback keychain Name : - NA -
    Policy                   : mp-SF1
    SKS Profile              : N/A
    Traffic Status           : Protected
    Rx SC 1
      Rx SCI                 : e069bafde3a80064
      Rx SSCI                : 1
      Peer MAC               : e0:69:ba:fd:e3:a8
      Is XPN                 : YES
      SC State               : Provisioned
      SAK State[0]           : Provisioned
      Rx SA Program Req[0]   : 2023 Oct 27 05:41:51.701
      Rx SA Program Rsp[0]   : 2023 Oct 27 05:41:51.705
      SAK Data
        SAK[0]               : ***
        SAK Len              : 32
        SAK Version          : 1
        HashKey[0]           : ***
        HashKey Len          : 16
        Conf offset          : 0
        Cipher Suite         : GCM-AES-XPN-256
        CtxSalt[0]           : c2 b0 88 9d d6 c0 9d 3f 0a b7 99 37
        CtxSalt Len          : 12
        ssci                 : 1

    Tx SC
      Tx SCI                 : e069bafde3a00064
      Tx SSCI                : 2
      Active AN              : 0
      Old AN                 : 255
      Is XPN                 : YES
      Next PN                : 1, 0, 0, 0
      SC State               : Provisioned
      SAK State[0]           : Provisioned
      Tx SA Program Req[0]   : 2023 Oct 27 05:41:51.713
      Tx SA Program Rsp[0]   : 2023 Oct 27 05:41:51.715
      SAK Data
        SAK[0]               : ***
        SAK Len              : 32
        SAK Version          : 1
        HashKey[0]           : ***
        HashKey Len          : 16
        Conf offset          : 0
        Cipher Suite         : GCM-AES-XPN-256
        CtxSalt[0]           : c2 b0 88 9e d6 c0 9d 3f 0a b7 99 37
        CtxSalt Len          : 12
        ssci                 : 2


Interface Name : HundredGigE0/5/0/30.200
```

```
Interface Namestring     : HundredGigE0/5/0/30.200
Interface short name     : Hu0/5/0/30.200
Interface handle         : 0x2800b30
Interface number         : 0x2800b30
MacSecControlledIfh      : 0x2800b38
MacSecUnControlledIfh    : 0x2800b40
Interface MAC            : e069.bafd.e410
Ethertype                : 888E
EAPoL Destination Addr   : 0180.c200.0003
MACsec Shutdown          : FALSE
Config Received          : TRUE
IM notify Complete       : TRUE
MACsec Power Status      : Allocated
Interface CAPS Add       : TRUE
RxSA CAPS Add            : TRUE
TxSA CAPS Add            : TRUE
IM notify with VLAN Info : TRUE
Supported VLAN encaps    : TRUE
SecTAG Offset validation : TRUE
VLAN                     : Outer tag (etype=0x88a8, id=200, priority=0, cfi=0)
                         : Inner tag (etype=0x8100, id=300, priority=0, cfi=0)
Principal Actor          : Primary
MKA PSK Info
  Key Chain Name         : kc
  MKA Cipher Suite       : AES-256-CMAC
  CKN                    : 12 34
MKA fallback_PSK Info
  fallback keychain Name : - NA -
Policy                   : mp-SF2
SKS Profile              : N/A
Traffic Status           : Protected
Rx SC 1
  Rx SCI                 : e069bafde41800c8
  Rx SSCI                : 1
  Peer MAC               : e0:69:ba:fd:e4:18
  Is XPN                 : YES
  SC State               : Provisioned
  SAK State[0]           : Provisioned
  Rx SA Program Req[0]   : 2023 Oct 27 05:44:01.270
  Rx SA Program Rsp[0]   : 2023 Oct 27 05:44:01.274
  SAK Data
    SAK[0]               : ***
    SAK Len              : 32
    SAK Version          : 1
    HashKey[0]           : ***
    HashKey Len          : 16
    Conf offset          : 0
    Cipher Suite         : GCM-AES-XPN-256
    CtxSalt[0]           : 02 52 27 e4 ba 7f 16 62 52 d8 a6 e8
    CtxSalt Len          : 12
    ssci                 : 1

Tx SC
  Tx SCI                 : e069bafde41000c8
  Tx SSCI                : 2
  Active AN              : 0
  Old AN                 : 255
  Is XPN                 : YES
  Next PN                : 1, 0, 0, 0
  SC State               : Provisioned
  SAK State[0]           : Provisioned
  Tx SA Program Req[0]   : 2023 Oct 27 05:44:01.282
  Tx SA Program Rsp[0]   : 2023 Oct 27 05:44:01.284
  SAK Data
```

```
SAK[0]              : ***
SAK Len             : 32
SAK Version         : 1
HashKey[0]          : ***
HashKey Len         : 16
Conf offset         : 0
Cipher Suite        : GCM-AES-XPN-256
CtxSalt[0]          : 02 52 27 e7 ba 7f 16 62 52 d8 a6 e8
CtxSalt Len         : 12
ssci                : 2
```

MACsec Policy Exceptions

By default, the MACsec security policy uses **must-secure** option, that mandates data encryption. Hence, the packets cannot be sent in clear-text format. To optionally bypass the MACsec encryption or decryption for Link Aggregation Control Protocol (LACP) packets, and to send the packets in clear-text format, use the **policy-exception lacp-in-clear** command in macsec-policy configuration mode. This functionality is beneficial in scenarios such as, in a network topology with three nodes, where bundles are terminated at the middle node, whereas MACsec is terminated at the end nodes.

This MACsec policy exception is also beneficial in interoperability scenarios where the node at the other end expects the data packets to be in clear text.

From Cisco IOS XR Software Release 7.3.1 and later, an alternative option, **allow**, is introduced under the macsec-policy configuration mode, that allows packets to be sent in clear-text format. You can use the **allow lacp-in-clear** command for LACP packets.

Similarly, you can use the **allow pause-frames-in-clear** to allow Ethernet PAUSE frame packets in clear text, from Release 7.3.15 and later.

How to Create MACsec Policy Exception

Note The **policy-exception lacp-in-clear** command under macsec-policy configuration mode is deprecated. Hence, it is recommended to use the **allow lacp-in-clear** command instead, to allow LACP packets in clear-text format.

Configuration Example

Using the **policy-exception** command:

```
Router#configure
Router(config)#macsec-policy test-macsec-policy
Router(config-macsec-policy)#policy-exception lacp-in-clear
Router(config-macsec-policy)#commit
```

Using the **allow** command:

```
Router#configure
Router(config)#macsec-policy test-macsec-policy
Router(config-macsec-policy)#allow lacp-in-clear
Router(config-macsec-policy)#allow pause-frames-in-clear
Router(config-macsec-policy)#commit
```

Running Configuration

With the **policy-exception** command:

```
Router#show run macsec-policy test-macsec-policy
macsec-policy test-macsec-policy
  policy-exception lacp-in-clear
  security-policy should-secure
  include-icv-indicator
  sak-rekey-interval seconds 120
!
```

With the **allow** command:

```
Router#show run macsec-policy test-macsec-policy
macsec-policy test-macsec-policy
  allow lacp-in-clear
  allow pause-frames-in-clear
  security-policy should-secure
  include-icv-indicator
  sak-rekey-interval seconds 120
!
```

Associated Commands

- **policy-exception lacp-in-clear**
- **allow lacp-in-clear**
- **allow pause-frames-in-clear**

MACsec Policy Exception for Link Layer Discovery Protocol Packets

Table 6: Feature History Table

Feature Name	Release Information	Feature Description
MACsec Policy Exception for Link Layer Discovery Protocol Packets	Release 7.11.1	We have introduced an option in MACsec policy exceptions to accommodate Link Layer Discovery Protocol (LLDP) packets in an unencrypted format. LLDP packets in clear text format help you troubleshoot LLDP neighbor discovery network issues on MAcsec-enabled ports. By default, MACsec always operates in must-secure mode, allowing encrypted traffic flow including LLDP packets only after securing the MACsec Key Agreement (MKA) session. The feature introduces these changes: **CLI:** • The **lldp-in-clear** keyword is introduced in the **allow** command. • The **lldp-in-clear** status is displayed in the **show macsec policy detail** command. • The **lldp-in-clear** status is displayed in the **show macsec mka interface detail** command. **YANG Data Models:** • `Cisco-IOS-XR-crypto-macsec-mka-cfg.yang` • `Cisco-IOS-XR-crypto-macsec-mka-oper.yang` • `Cisco-IOS-XR-um-macsec-cfg.yang` (See GitHub, YANG Data Models Navigator)

Link Layer Discovery Protocol (LLDP) is a layer 2 neighbor discovery protocol that allows routers to advertise themselves to peer devices in the network. The router announces its identification, configuration, and capabilities to the peer devices and learns about its peers using LLDP. The router saves the data learned in the Management Information Base (MIB).

MACsec provides secure communication by encrypting the ethernet frames at the data link layer. When MACsec is enabled, it encrypts network traffic between peers for enhanced security. By default, MACsec also encrypts LLDP packets.

Starting from Cisco IOS XR Software Release 7.11.1, the routers now offer an option to transmit the LLDP packets in clear text on a MACsec enabled port. You can enable an exception for LLDP packets in the MACsec policy using the **allow lldp-in-clear** command.

Note For detailed information about the Link Layer Discovery Protocol (LLDP), refer to the *LLDP* section in the *Configuring Ethernet Interfaces* chapter of the *Interface and Hardware Component Configuration Guide for Cisco 8000 Series Routers*.

Note We strongly advise against enabling the MACsec exception to retain LLDP packets unencrypted unless necessary for network maintenance. You must ensure to configure LLDP packets in clear text at both ends of the MACsec link.

Configure MACsec Policy Exception for LLDP Packets

This section details the configuration example for MACsec policy exception for LLDP packets:

Configurations

```
Router# configure
Router(config)# macsec-policy test-macsec
Router(config-macsec-policy)# allow lldp-in-clear
Router(config-macsec-policy)# commit
```

Running Configurations

```
Router# show running-config macsec-policy test-macsec

macsec-policy test-macsec
 …
 allow lldp-in-clear
!
```

Verification

```
Router# show macsec policy detail
Total Number of Policies = 1
-----------------------------------------------------
Policy Name                 : test-macsec
      Cipher Suite          : GCM-AES-XPN-256
      Key-Server Priority   : 10
      Window Size           : 64
      Conf Offset           : 50
      Replay Protection     : TRUE
      Delay Protection      : FALSE
      Security Policy       : Must Secure
      Vlan Tags In Clear    : 1
      LACP In Clear         : FALSE
      LLDP In Clear         : TRUE
```

```
      Pause Frame In Clear  : FALSE
      Sak Rekey Interval    : 60 seconds

Router# show macsec mka interface detail
Number of interfaces on node node0_3_CPU0 : 1
--------------------------------------------------
Interface Name : HundredGigE0/3/0/5
    Interface Namestring     : HundredGigE0/3/0/5
    Interface short name     : Hu0/3/0/5
    Interface handle         : 0x1800238
    Interface number         : 0x1800238
    MacSecControlledIfh      : 0x18005e0
    MacSecUnControlledIfh    : 0x18005e8
    Interface MAC            : 5cb1.2ede.7648
    Ethertype                : 888E
    EAPoL Destination Addr   : 0180.c200.0003
    MACsec Shutdown          : FALSE
    Config Received          : TRUE
    IM notify Complete       : TRUE
    MACsec Power Status      : Allocated
    Interface CAPS Add       : TRUE
    RxSA CAPS Add            : TRUE
    TxSA CAPS Add            : TRUE
    lldp-in-clear            : TRUE
```

Verifying MACsec Encryption on IOS XR

MACsec encryption on IOS XR can be verified by running relevant commands in the Privileged Executive Mode.

Note With the introduction of active fallback functionality in Cisco IOS XR Software Release 7.0.14, the output of various MACsec show commands include the fallback PSK entry as well.

To verify if MACsec encryption has been correctly configured, follow these steps.

SUMMARY STEPS

1. Verify the MACsec policy configuration.
2. Verify the MACsec configuration on the respective interface.
3. Verify whether the interface of the router is peering with its neighbor after MACsec configuration.
4. Verify whether the MKA session is secured with MACsec on the respective interface.
5. Verify the MACsec session counter statistics.

DETAILED STEPS

Procedure

Step 1 Verify the MACsec policy configuration.

Example:

```
Router# show macsec policy mp-SF

================================================================================
Policy            Cipher              Key-Svr   Window    Conf      Delay
name              Suite               Priority  Size      Offset    Protection
================================================================================
mp-SF             GCM-AES-XPN-128     16        64        30        FALSE
```

If the values you see are different from the ones you configured, then check your configuration by running the **show run macsec-policy** command.

Step 2 Verify the MACsec configuration on the respective interface.

You can verify the MACsec encryption on the configured interface bundle (MPLS network) or P2MP interface (VPLS network).

Example:

```
Router# show macsec mka summary

NODE: node0_1_CPU0
================================================================================================
   Interface-Name     Status     Cipher-Suite       KeyChain       PSK/EAP       CKN
================================================================================================
     Hu0/1/0/10       Secured  GCM-AES-XPN-128         kc          PRIMARY     1234

Total MACSec Sessions  : 1
    Secured Sessions   : 1
    Pending Sessions   : 1
    Suspended Sessions : 0
```

With the introduction of active fallback functionality:

The following is a sample output that displays active fallback PSK entry as well:

```
Router# show macsec mka summary
Wed Apr 28 01:50:57.543 UTC

NODE: node0_4_CPU0
================================================================================================
   Interface-Name     Status     Cipher-Suite       KeyChain       PSK/EAP       CKN
================================================================================================
     Hu0/4/0/27       Secured  GCM-AES-XPN-256         kc1          PRIMARY     1111
     Hu0/4/0/27       Active   GCM-AES-XPN-256         fb1         FALLBACK     2222

NODE: node0_6_CPU0
================================================================================================
   Interface-Name     Status     Cipher-Suite       KeyChain       PSK/EAP       CKN
================================================================================================
     Hu0/6/0/29       Secured  GCM-AES-XPN-256         kc1          PRIMARY     1111
     Hu0/6/0/29       Active   GCM-AES-XPN-256         fb1         FALLBACK     2222

Total MACSec Sessions  : 4
    Secured Sessions   : 2
    Pending Sessions   : 0
    Suspended Sessions : 0
      Active  Sessions : 2
```

Run the **show run macsec-policy** command in the privileged executive mode to troubleshoot the configuration entered.

Step 3 Verify whether the interface of the router is peering with its neighbor after MACsec configuration.

The MACsec PSK validation detects inconsistency or mismatch of primary and fallback keys (CAK) being used by MKA, allowing operators to rectify the mismatch. The **#Peers** field in the output confirms the number of peers you have configured on the physical interface. If the number of peers is not reflected accurately in this output, run the **show run** command and verify the peer configuration on the interface.

Example:

```
Router#show macsec mka session

NODE: node0_1_CPU0
==============================================================================================
   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN
==============================================================================================
     Hu0/1/0/10      7872.5d1a.e7d4/0001     1      Secured      NO       PRIMARY     1234
```

The following is a sample output that displays active fallback PSK entry as well:

```
Router# show macsec mka session
Wed Apr 28 01:59:39.478 UTC

NODE: node0_4_CPU0
==============================================================================================
   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN
==============================================================================================
     Hu0/4/0/27      34ed.1b5b.d0d7/0001     1      Secured      NO       PRIMARY     1111
     Hu0/4/0/27      34ed.1b5b.d0d7/0001     1      Active       NO       FALLBACK    2222

NODE: node0_6_CPU0
==============================================================================================
   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN
==============================================================================================
     Hu0/6/0/29      00d6.fee7.fe44/0001     1      Secured      YES      PRIMARY     1111
     Hu0/6/0/29      00d6.fee7.fe44/0001     1      Active       YES      FALLBACK    2222
```

Note
In the VPLS network, because of the configuration on a multipoint interface, the number of live peers displayed is more than 1.

```
Router#show macsec mka session
Mon Nov 23 11:20:39.835 UTC

NODE: node0_4_CPU0
================================================================
Interface-Name Local-TxSCI #Peers Status Key-Server PSK/EAP CKN
================================================================
FH0/4/0/34 34ed.1b5b.d10f/0001 2 Secured YES PRIMARY  1111
FH0/4/0/34 34ed.1b5b.d10f/0001 2 Active  YES FALLBACK 2222
Hu0/4/0/28 34ed.1b5b.d0df/0001 2 Secured NO PRIMARY   1111
Hu0/4/0/28 34ed.1b5b.d0df/0001 2 Active  NO FALLBACK  2222
Hu0/4/0/29 34ed.1b5b.d0e7/0001 2 Secured NO PRIMARY   1111
Hu0/4/0/29 34ed.1b5b.d0e7/0001 2 Active  NO FALLBACK  2222
```

Before the introduction of active fallback functionality:

The following show command output verifies if the primary and fallback keys (CAK) are mismatched on both peer ends.

```
Router# show macsec mka session detail

NODE: node0_1_CPU0

MKA Detailed Status for MKA Session
===================================
```

```
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 7872.5d1a.e7d4/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 7872.5d1a.e7d4
MKA Port Identifier             : 1
Interface Name                  : Hu0/1/0/10
CAK Name (CKN)                  : 1234
CA Authentication Mode          : PRIMARY-PSK
Keychain                        : kc
Member Identifier (MI)          : C12A70FEE1212B835BDDDCBA
Message Number (MN)             : 3009
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-128-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-128

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 0
Latest SAK KI (KN)              : 018E2F0D63FF2ED6A5BF270E00000001 (1)
Old SAK Status                  : FIRST-SAK
Old SAK AN                      : 0
Old SAK KI (KN)                 : FIRST-SAK (0)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : mp-SF
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 30
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000003 (GCM-AES-XPN-128)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 1
# of MACsec Capable Live Peers Responded : 0

Live Peer List:
-----------------------------------------------------------------------------
          MI                  MN             Rx-SCI          SSCI  KS-Priority
-----------------------------------------------------------------------------
018E2F0D63FF2ED6A5BF270E      2699      008a.962d.7400/0001    2        16

Potential Peer List:
-----------------------------------------------------------------------------
          MI                  MN             Rx-SCI          SSCI  KS-Priority
-----------------------------------------------------------------------------

Peers Status:
 Last Tx MKPDU          : 2019 Oct 08 09:07:06.475
 Peer Count             : 1

 RxSCI                  : 008A962D74000001
  MI                    : 018E2F0D63FF2ED6A5BF270E
  Peer CAK              : Match
  Latest Rx MKPDU       : 2019 Oct 08 09:07:06.032
```

With the introduction of active fallback functionality:

The following is a snippet from the sample output that displays entry for active fallback PSK as well. The secured primary session output part is truncated here, which is exactly same as the output given above.

```
Router# show macsec mka session detail
NODE: node0_1_CPU0

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 0257.3fae.5cda/0001
Local Tx-SSCI                   : 1
- - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - -

MKA Detailed Status for MKA Session
===================================
Status: Active - Marked Peer as Live (Waiting for SAK generation/distribution)

Local Tx-SCI                    : 0257.3fae.5cda/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 0257.3fae.5cda
MKA Port Identifier             : 1
Interface Name                  : Hu0/1/0/0
CAK Name (CKN)                  : 1111
CA Authentication Mode          : FALLBACK-PSK
Keychain                        : fb1
Member Identifier (MI)          : FC53A31E030E385981E0AACE
Message Number (MN)             : 178
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-256-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-256
Key Distribution Mode           : SAK

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 1
Latest SAK KI (KN)              : 725FF8F6605A3D428972538F00000001 (1)
Old SAK Status                  : No Rx, No Tx
Old SAK AN                      : 0
Old SAK KI (KN)                 : RETIRED (0)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : *DEFAULT POLICY*
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 0
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000004 (GCM-AES-XPN-256)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 1
# of MACsec Capable Live Peers Responded : 0

Live Peer List:
```

```
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------
6A894FE1E984AD5314F33D21      188       0201.9ab0.85af/0001    0        16

Potential Peer List:
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------

Peers Status:
 Last Tx MKPDU          : 2021 Apr 30 14:56:33.797
 Peer Count             : 1

 RxSCI                  : 02019AB085AF0001
  MI                    : 6A894FE1E984AD5314F33D21
  Peer CAK              : Match
  Latest Rx MKPDU       : 2021 Apr 30 14:56:34.638
```

Note
If the MKA session status is shown as **Secured** with **0 (Zero)** peer count, this means that the link is locally secured (Tx). This is because of MKA peer loss caused by **No Rx Packets (MKA Packet)** from that peer.

Step 4 Verify whether the MKA session is secured with MACsec on the respective interface.

Example:

```
Router# show macsec mka session interface hundredGigE 0/1/0/10

================================================================================================
   Interface-Name        Local-TxSCI       #Peers   Status   Key-Server   PSK/EAP      CKN
================================================================================================
     Hu0/1/0/10      7872.5d1a.e7d4/0001     1      Secured      NO       PRIMARY     1234
     Hu0/1/0/10      7872.5d1a.e7d4/0001     1      Secured      NO       FALLBACK     5678
```

Before the introduction of active fallback functionality:

```
Router# show macsec mka session interface hundredGigE 0/1/0/10 detail

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 7872.5d1a.e7d4/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 7872.5d1a.e7d4
MKA Port Identifier             : 1
Interface Name                  : Hu0/1/0/10
CAK Name (CKN)                  : 1234
CA Authentication Mode          : PRIMARY-PSK
Keychain                        : kc
Member Identifier (MI)          : C12A70FEE1212B835BDDDCBA
Message Number (MN)             : 3058
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-128-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-128

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 0
Latest SAK KI (KN)              : 018E2F0D63FF2ED6A5BF270E00000001 (1)
Old SAK Status                  : FIRST-SAK
Old SAK AN                      : 0
Old SAK KI (KN)                 : FIRST-SAK (0)
```

```
SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : mp-SF
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 30
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000003 (GCM-AES-XPN-128)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 1
# of MACsec Capable Live Peers Responded : 0

Live Peer List:
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------
018E2F0D63FF2ED6A5BF270E      2748      008a.962d.7400/0001    2        16

Potential Peer List:
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------

Peers Status:
 Last Tx MKPDU          : 2019 Oct 08 09:08:44.506
 Peer Count             : 1

 RxSCI                  : 008A962D74000001
  MI                    : 018E2F0D63FF2ED6A5BF270E
  Peer CAK              : Match
  Latest Rx MKPDU       : 2019 Oct 08 09:08:44.081
```

The **Status** field in the output confirms that the respective interface is **Secured**. If MACsec encryption is not successfully configured, you will see a status such as **Pending** or **INITIALIZING**.

With the introduction of active fallback functionality:

The following is a snippet from the sample output that displays entry for active fallback PSK as well. The secured primary session output part is truncated here, which is exactly same as the output given above.

```
Router# show macsec mka session interface hundredGigE 0/1/0/10 detail

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : 7872.5d1a.e7d4/0001
Local Tx-SSCI                   : 1
- - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - -
MKA Detailed Status for MKA Session
===================================
Status: Active - Marked Peer as Live (Waiting for SAK generation/distribution)
```

```
Local Tx-SCI                    : 34ed.1b5b.d0d7/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : 34ed.1b5b.d0d7
MKA Port Identifier             : 1
Interface Name                  : Hu0/4/0/27
CAK Name (CKN)                  : 2222
CA Authentication Mode          : FALLBACK-PSK
Keychain                        : fb1
Member Identifier (MI)          : C0978A6B0916C3FC959773FE
Message Number (MN)             : 24039
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-256-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-256

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 2
Latest SAK KI (KN)              : 3D008A7D75DF0A9A35F9E3A900000002 (2)
Old SAK Status                  : No Rx, No Tx
Old SAK AN                      : 1
Old SAK KI (KN)                 : RETIRED (0)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : r1
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 0
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000004 (GCM-AES-XPN-256)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 1
# of MACsec Capable Live Peers Responded : 0

Live Peer List:
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------
B5ED6849883F34FEE89F74D1     26068      008a.9681.c02c/0001    2        16

Potential Peer List:
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------

Peers Status:
Last Tx MKPDU          : 2021 Apr 28 02:08:03.795
Peer Count             : 1

RxSCI                  : 008A9681C02C0001
  MI                    : B5ED6849883F34FEE89F74D1
  Peer CAK              : Match
  Latest Rx MKPDU       : 2021 Apr 28 02:08:02.749
```

In a VPLS network with multipoint interface, the output would display more than one peer as follows:

```
Router#show macsec mka session interface Hu0/3/0/16 detail
```

```
Thu Oct 29 10:09:25.586 UTC


MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : fc58.9a05.9aa0/0001
Local Tx-SSCI                   : 4
Interface MAC Address           : fc58.9a05.9aa0
MKA Port Identifier             : 1
Interface Name                  : Hu0/3/0/16
CAK Name (CKN)                  : 1234
CA Authentication Mode          : PRIMARY-PSK
Keychain                        : kc
Member Identifier (MI)          : C45D5F2028232022F30C6BD8
Message Number (MN)             : 9427
Authenticator                   : NO
Key Server                      : YES
MKA Cipher Suite                : AES-128-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-256

Latest SAK Status               : Rx & Tx
Latest SAK AN                   : 1
Latest SAK KI (KN)              : C45D5F2028232022F30C6BD800000036 (54)
Old SAK Status                  : No Rx, No Tx
Old SAK AN                      : 0
Old SAK KI (KN)                 : RETIRED (53)

SAK Transmit Wait Time          : 0s (Not waiting for any peers to respond)
SAK Retire Time                 : 0s (No Old SAK to retire)
Time to SAK Rekey               : NA
Time to exit suspension         : NA

MKA Policy Name                 : ms
Key Server Priority             : 16
Delay Protection                : FALSE
Replay Window Size              : 64
Include ICV Indicator           : FALSE
Confidentiality Offset          : 0
Algorithm Agility               : 80C201
SAK Cipher Suite                : 0080C20001000004 (GCM-AES-XPN-256)
MACsec Capability               : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired                  : YES

# of MACsec Capable Live Peers           : 3
# of MACsec Capable Live Peers Responded : 3

# of MACSec Suspended Peers              : 0

Live Peer List:
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------
499BFCA3044D65A9BA4FC219      9427      fc58.9a05.9aa8/0001    3        16
56765F41D6BE434860E62991      9427      fc58.9a05.9ab0/0001    2        16
7236084C87ADD66D59C63FE1      9425      fc58.9a05.9ab1/0001    1        16

Potential Peer List:
------------------------------------------------------------------------------
           MI                  MN             Rx-SCI          SSCI  KS-Priority
------------------------------------------------------------------------------

Suspended Peer List:
```

```
--------------------------------------------------------------------------------
       Rx-SCI          SSCI
--------------------------------------------------------------------------------

Peers Status:
 Last Tx MKPDU          : 2020 Oct 29 10:09:25.071
 Peer Count             : 3

 RxSCI                  : FC589A059AB00001
  MI                    : 56765F41D6BE434860E62991
  Peer CAK              : Match
  Latest Rx MKPDU       : 2020 Oct 29 10:09:24.072

 RxSCI                  : FC589A059AA80001
  MI                    : 499BFCA3044D65A9BA4FC219
  Peer CAK              : Match
  Latest Rx MKPDU       : 2020 Oct 29 10:09:25.574

 RxSCI                  : FC589A059AB10001
  MI                    : 7236084C87ADD66D59C63FE1
  Peer CAK              : Match
  Latest Rx MKPDU       : 2020 Oct 29 10:09:24.572
```

The **Status** field in the output verifies if the MKA session is secured with MACsec encryption. The output also displays information about the interface and other MACsec parameters.

Step 5 Verify the MACsec session counter statistics.

Example:

```
Router# show macsec mka statistics interface hundredGigE 0/1/0/10

MKA Statistics for Session on interface (Hu0/1/0/10)
=====================================================
Reauthentication Attempts.. 0

CA Statistics
   Pairwise CAKs Derived... 0
   Pairwise CAK Rekeys..... 0
   Group CAKs Generated.... 0
   Group CAKs Received..... 0

SA Statistics
   SAKs Generated.......... 0
   SAKs Rekeyed............ 0
   SAKs Received........... 1
   SAK Responses Received.. 0

MKPDU Statistics
   MKPDUs Transmitted...... 3097
      "Distributed SAK".. 0
      "Distributed CAK".. 0
   MKPDUs Validated & Rx... 2788
      "Distributed SAK".. 1
      "Distributed CAK".. 0

MKA IDB Statistics
   MKPDUs Tx Success.......... 3097
   MKPDUs Tx Fail............. 0
   MKPDUS Tx Pkt build fail... 0
   MKPDUS No Tx on intf down.. 3
   MKPDUS No Rx on intf down.. 0
   MKPDUs Rx CA Not found..... 0
   MKPDUs Rx Error............ 0
```

```
   MKPDUs Rx Success.......... 2788
   MKPDUs Rx Invalid Length... 0
   MKPDUs Rx Invalid CKN...... 0
   MKPDUs Rx force suspended.. 0
   MKPDUs Tx force suspended.. 0

MKPDU Failures
   MKPDU Rx Validation (ICV)................. 0
   MKPDU Rx Bad Peer MN...................... 0
   MKPDU Rx Non-recent Peerlist MN........... 0
   MKPDU Rx Drop SAKUSE, KN mismatch......... 0
   MKPDU Rx Drop SAKUSE, Rx Not Set.......... 0
   MKPDU Rx Drop SAKUSE, Key MI mismatch..... 0
   MKPDU Rx Drop SAKUSE, AN Not in Use....... 0
   MKPDU Rx Drop SAKUSE, KS Rx/Tx Not Set.... 0
   MKPDU Rx Drop Packet, Ethertype Mismatch.. 0
   MKPDU Rx Drop Packet, Source MAC NULL..... 0
   MKPDU Rx Drop Packet, Destination MAC NULL 0
   MKPDU Rx Drop Packet, Payload NULL........ 0

SAK Failures
   SAK Generation.................. 0
   Hash Key Generation............. 0
   SAK Encryption/Wrap............. 0
   SAK Decryption/Unwrap........... 0

CA Failures
   ICK Derivation.................. 0
   KEK Derivation.................. 0
   Invalid Peer MACsec Capability... 0

MACsec Failures
   Rx SC Creation.................. 0
   Tx SC Creation.................. 0
   Rx SA Installation.............. 0
   Tx SA Installation.............. 0
```

The counters display the MACsec PDUs transmitted, validated, and received. The output also displays transmission errors, if any.

This completes the verification of MACsec encryption on the IOS-XR.

Verifying MACsec Encryption on Cisco 8000 Series Routers

MACsec encryption on the router hardware can be verified by running relevant commands in the Privileged Executive Mode.

To verify if MACsec encryption has been correctly configured, follow these steps.

SUMMARY STEPS

1. Verify the MACsec encryption and hardware interface descriptor block (IDB) information on the interface.
2. To verify if the hardware programming is done, use the following command:

DETAILED STEPS

Procedure

Step 1 Verify the MACsec encryption and hardware interface descriptor block (IDB) information on the interface.

Example:

```
Router# show macsec ea idb interface hundredGigE 0/1/0/10

IDB Details:
  if_sname                : Hu0/1/0/10
  if_handle               : 0x8001e0
  MacSecControlledIfh     : 0x800330
  MacSecUnControlledIfh   : 0x800338
  Replay window size      : 64
  Local MAC               : 78:72:5d:1a:e7:d4
  Rx SC Option(s)         : Validate-Frames Replay-Protect
  Tx SC Option(s)         : Protect-Frames Always-Include-SCI
  Security Policy         : SHOULD SECURE
  Delay Protection        : FALSE
  Sectag offset           : 0
  Rx SC 1
    Rx SCI                : 008a962d74000001
    Peer MAC              : 00:8a:96:2d:74:00
    Stale                 : NO
    SAK Data
      SAK[0]              : ***
      SAK Len             : 16
      SAK Version         : 1
      HashKey[0]          : ***
      HashKey Len         : 16
      Conf offset         : 30
      Cipher Suite        : GCM-AES-XPN-128
      CtxSalt[0]          : 01 8f 2f 0f 63 ff 2e d6 a5 bf 27 0e
      ssci                : 2
      Rx SA Program Req[0]: 2019 Oct 08 07:37:14.870
      Rx SA Program Rsp[0]: 2019 Oct 08 07:37:14.902

  Tx SC
    Tx SCI                : 78725d1ae7d40001
    Active AN             : 0
    Old AN                : 255
    Next PN               : 1, 0, 0, 0
    SAK Data
      SAK[0]              : ***
      SAK Len             : 16
      SAK Version         : 1
      HashKey[0]          : ***
      HashKey Len         : 16
      Conf offset         : 30
      Cipher Suite        : GCM-AES-XPN-128
      CtxSalt[0]          : 01 8f 2f 0c 63 ff 2e d6 a5 bf 27 0e
      ssci                : 1
      Tx SA Program Req[0]: 2019 Oct 08 07:37:14.908
      Tx SA Program Rsp[0]: 2019 Oct 08 07:37:14.931
```

When more than 1 RX SA is configured in P2MP networks, the output would be as follows:

```
Router#show macsec ea idb interface Hu0/3/0/16
Thu Oct 29 10:10:10.947 UTC
```

```
IDB Details:
  if_sname                : Hu0/3/0/16
  if_handle               : 0x1800240
  MacSecControlledIfh     : 0x1800270
  MacSecUnControlledIfh   : 0x1800278
  Replay window size      : 64
  Local MAC               : fc:58:9a:05:9a:a0
  Rx SC Option(s)         : Validate-Frames Replay-Protect
  Tx SC Option(s)         : Protect-Frames Always-Include-SCI
  Security Policy         : MUST SECURE
  Delay Protection        : FALSE
  Sectag offset           : 0
  Rx SC 1
    Rx SCI                : fc589a059ab10001
    Peer MAC              : fc:58:9a:05:9a:b1
    Stale                 : NO
    SAK Data
      SAK[1]              : ***
      SAK Len             : 32
      SAK Version         : 3
      HashKey[1]          : ***
      HashKey Len         : 16
      Conf offset         : 0
      Cipher Suite        : GCM-AES-XPN-256
      CtxSalt[1]          : c4 6b 5f 21 28 23 20 22 f3 0c 6b d8
      ssci                : 1
      Rx SA Program Req[1]: 2020 Oct 29 05:04:30.803
      Rx SA Program Rsp[1]: 2020 Oct 29 05:04:30.807

  Rx SC 2
    Rx SCI                : fc589a059ab00001
    Peer MAC              : fc:58:9a:05:9a:b0
    Stale                 : NO
    SAK Data
      SAK[1]              : ***
      SAK Len             : 32
      SAK Version         : 3
      HashKey[1]          : ***
      HashKey Len         : 16
      Conf offset         : 0
      Cipher Suite        : GCM-AES-XPN-256
      CtxSalt[1]          : c4 6b 5f 22 28 23 20 22 f3 0c 6b d8
      ssci                : 2
      Rx SA Program Req[1]: 2020 Oct 29 05:04:30.792
      Rx SA Program Rsp[1]: 2020 Oct 29 05:04:30.796

  Rx SC 3
    Rx SCI                : fc589a059aa80001
    Peer MAC              : fc:58:9a:05:9a:a8
    Stale                 : NO
    SAK Data
      SAK[1]              : ***
      SAK Len             : 32
      SAK Version         : 3
      HashKey[1]          : ***
      HashKey Len         : 16
      Conf offset         : 0
      Cipher Suite        : GCM-AES-XPN-256
      CtxSalt[1]          : c4 6b 5f 23 28 23 20 22 f3 0c 6b d8
      ssci                : 3
      Rx SA Program Req[1]: 2020 Oct 29 05:04:30.788
      Rx SA Program Rsp[1]: 2020 Oct 29 05:04:30.792
```

```
  Tx SC
    Tx SCI               : fc589a059aa00001
    Active AN            : 1
    Old AN               : 0
    Next PN              : 1, 1, 1, 1
    SAK Data
      SAK[1]             : ***
      SAK Len            : 32
      SAK Version        : 3
      HashKey[1]         : ***
      HashKey Len        : 16
      Conf offset        : 0
      Cipher Suite       : GCM-AES-XPN-256
      CtxSalt[1]         : c4 6b 5f 24 28 23 20 22 f3 0c 6b d8
      ssci               : 4
      Tx SA Program Req[1]: 2020 Oct 29 05:04:32.773
      Tx SA Program Rsp[1]: 2020 Oct 29 05:04:32.780
```

The **if_handle** field provides the IDB instance location.

The **Replay window size** field displays the configured window size.

The **Security Policy** field displays the configured security policy.

The **Local MAC** field displays the MAC address of the router.

The **Peer MAC** field displays the MAC address of the peer. This confirms that a peer relationship has been formed between the two routers.

Step 2 To verify if the hardware programming is done, use the following command:

Example:

```
Router# show macsec platform hardware sa interface hundredGigE 0/1/0/10
----------------------------------------------------------------
Tx SA Details:
----------------------------------------------------------------
    SCI                   : 7872.5d1a.e7d4/0001
    Crypto Algo           : GCM-AES-XPN-128
    AES Key Len           : 128 bits
    AN                    : 0
    Initial Packet Number : 1
    Current Packet Number : 1
    Maximum Packet Number : 3221225400
    XForm in Use          : YES
    Action Type           : SA Action Egress
    Direction             : Egress
    Conf Offset           : 00000030
    Drop Type             : 0x00000003
    SA In Use             : YES
    ConfProtect           : YES
    IncludeSCI            : YES
    ProtectFrame          : YES
    UseEs                 : NO
    UseSCB                : NO

----------------------------------------------------------------
Rx SA Details:
----------------------------------------------------------------
    SCI                   : 008a.962d.7400/0001
    Replay Window         : 64
    Crypto Algo           : GCM-AES-XPN-128
    AES Key Len           : 128 bits
    AN                    : 0
    Initial Packet Number : 1
```

```
Current Packet Number : 1
Maximum Packet Number : 3221225400
XForm in Use          : YES
Action Type           : SA Action Ingress
Direction             : Ingress
Conf Offset           : 00000030
Drop Type             : 0x00000002
SA In Use             : YES
ReplayProtect         : YES
lowPN                 : 1
nxtPN                 : 2
```

This completes the verification of MACsec encryption on the router hardware, and the configuration and verification of MACsec encryption.

MACsec SecY Statistics

The following methods are used to query MACsec SecY statistics such as, encryption, decryption, and the hardware statistics.

- CLI
- SNMP MIB

Querying SNMP Statistics Using CLI

The following example shows how to query SNMP statistics using a CLI. Use the **show macsec secy statistics interface** *interface name* command to display the MACsec SecY statistics details.

Note When you use the **show macsec secy statistics interface** command in the 8712-MOD-M routers, all TxSC counters will display value of zero. This is due to a hardware limitation, as the collection of TxSC statistics is not supported in K100 ASIC-based systems like the Cisco 8712-MOD-M routers.

```
Router# show macsec secy stats interface hundredGigE 0/1/0/10 sc

Interface Stats
    InPktsUntagged     :  0
    InPktsNoTag        :  0
    InPktsBadTag       :  0
    InPktsUnknownSCI   :  0
    InPktsNoSCI        :  0
    InPktsOverrun      :  0
    InOctetsValidated  :  0
    InOctetsDecrypted  :  0
    OutPktsUntagged    :  0
    OutPktsTooLong     :  0
    OutOctetsProtected :  0
    OutOctetsEncrypted :  0

SC Stats
  TxSC Stats
    OutPktsProtected   : 0
```

```
  OutPktsEncrypted   : 0
  OutOctetsProtected : 0
  OutOctetsEncrypted : 0
  OutPktsTooLong     : 0
  TxSA Stats
    TxSA 0:
      OutPktsProtected : 0
      OutPktsEncrypted : 0
      NextPN           : 1
    TxSA 1:
      OutPktsProtected : 0
      OutPktsEncrypted : 0
      NextPN           : 0
    TxSA 2:
      OutPktsProtected : 0
      OutPktsEncrypted : 0
      NextPN           : 0
    TxSA 3:
      OutPktsProtected : 0
      OutPktsEncrypted : 0
      NextPN           : 0

RxSC Stats
  RxSC 1: 10000742d968a00
    InPktsUnchecked     : 0
    InPktsDelayed       : 0
    InPktsLate          : 0
    InPktsOK            : 0
    InPktsInvalid       : 0
    InPktsNotValid      : 0
    InPktsNotUsingSA    : 0
    InPktsUnusedSA      : 0
    InPktsUntaggedHit   : 0
    InOctetsValidated   : 0
    InOctetsDecrypted   : 0
  RxSA Stats
    RxSA 0:
      InPktsUnusedSA      : 0
      InPktsNotUsingSA    : 0
      InPktsNotValid      : 0
      InPktsInvalid       : 0
      InPktsOK            : 0
      NextPN              : 1
    RxSA 1:
      InPktsUnusedSA      : 0
      InPktsNotUsingSA    : 0
      InPktsNotValid      : 0
      InPktsInvalid       : 0
      InPktsOK            : 0
      NextPN              : 0
    RxSA 2:
      InPktsUnusedSA      : 0
      InPktsNotUsingSA    : 0
      InPktsNotValid      : 0
      InPktsInvalid       : 0
      InPktsOK            : 0
      NextPN              : 0
    RxSA 3:
      InPktsUnusedSA      : 0
      InPktsNotUsingSA    : 0
      InPktsNotValid      : 0
      InPktsInvalid       : 0
      InPktsOK            : 0
      NextPN              : 0
```

MACsec SNMP MIB (IEEE8021-SECY-MIB)

The IEEE8021-SECY-MIB provides Simple Network Management Protocol (SNMP) access to the MAC security entity (SecY) MIB running with IOS XR MACsec-enabled line cards. The IEEE8021-SECY-MIB is used to query on the SecY data, encryption, decryption, and the hardware statistics. The SecY MIB data is queried only on the Controlled Port.

The object ID of the IEEE8021-SECY-MIB is 1.0.8802.1.1.3. The IEEE8021-SECY-MIB contains the following tables that specifies the detailed attributes of the MACsec Controlled Port interface index.

Table 7: IEEE8021-SECY-MIB Table

Tables	OID
secyIfTable	1.0.8802.1.1.3.1.1.1
secyTxSCTable	1.0.8802.1.1.3.1.1.2
secyTxSATable	1.0.8802.1.1.3.1.1.3
secyRxSCTable	1.0.8802.1.1.3.1.1.4
secyRxSATable	1.0.8802.1.1.3.1.1.5
secyCipherSuiteTable	1.0.8802.1.1.3.1.1.6
secyTxSAStatsTable	1.0.8802.1.1.3.1.2.1
secyTxSCStatsTable	1.0.8802.1.1.3.1.2.2
secyRxSAStatsTable	1.0.8802.1.1.3.1.2.3
secyRxSCStatsTable	1.0.8802.1.1.3.1.2.4
secyStatsTable	1.0.8802.1.1.3.1.2.5

For more information, see the SecY IEEE MIB at the following URL:

http://www.ieee802.org/1/files/public/MIBs/IEEE8021-SECY-MIB-200601100000Z.mib

secyIfTable

The following table represents the system level information for each interface supported by the MAC security entity. The index tuple for this table is secyIfInterfaceIndex.

Table 8: secyIfTable

Object	Object identifier
secyIfInterfaceIndex	1.0.8802.1.1.3.1.1.1.1.1
secyIfMaxPeerSCs	1.0.8802.1.1.3.1.1.1.1.2
secyIfRxMaxKeys	1.0.8802.1.1.3.1.1.1.1.3
secyIfTxMaxKeys	1.0.8802.1.1.3.1.1.1.1.4

Object	Object identifier
secyIfProtectFramesEnable	1.0.8802.1.1.3.1.1.1.1.5
secyIfValidateFrames	1.0.8802.1.1.3.1.1.1.1.6
secyIfReplayProtectEnable	1.0.8802.1.1.3.1.1.1.1.7
secyIfReplayProtectWindow	1.0.8802.1.1.3.1.1.1.1.8
secyIfCurrentCipherSuite	1.0.8802.1.1.3.1.1.1.1.9
secyIfAdminPt2PtMAC	1.0.8802.1.1.3.1.1.1.1.10
secyIfOperPt2PtMAC	1.0.8802.1.1.3.1.1.1.1.11
secyIfIncludeSCIEnable	1.0.8802.1.1.3.1.1.1.1.12
secyIfUseESEnable	1.0.8802.1.1.3.1.1.1.1.13
secyIfUseSCBEnable	1.0.8802.1.1.3.1.1.1.1.14

secyTxSCTable

The following table provides information about the status of each transmitting SC supported by the MAC security entity. The index tuple for this table is secyIfInterfaceIndex.

Table 9: secyTxSCTable

Object	Object identifier
secyTxSCI	1.0.8802.1.1.3.1.1.2.1.1
secyTxSCState	1.0.8802.1.1.3.1.1.2.1.2
secyTxSCEncodingSA	1.0.8802.1.1.3.1.1.2.1.3
secyTxSCEncipheringSA	1.0.8802.1.1.3.1.1.2.1.4
secyTxSCCreatedTime	1.0.8802.1.1.3.1.1.2.1.5
secyTxSCStartedTime	1.0.8802.1.1.3.1.1.2.1.6
secyTxSCStoppedTime	1.0.8802.1.1.3.1.1.2.1.7

secyTxSATable

The following table provides information about the status of each transmitting SA supported by the MAC security entity. The index tuple for this table is: {secyIfInterfaceIndex, secyTxSA}.

Table 10: secyTxSATable

Object	Object identifier
secyTxSA	1.0.8802.1.1.3.1.1.3.1.1
secyTxSAState	1.0.8802.1.1.3.1.1.3.1.2
secyTxSANextPN	1.0.8802.1.1.3.1.1.3.1.3
secyTxSAConfidentiality	1.0.8802.1.1.3.1.1.3.1.4
secyTxSASAKUnchanged	1.0.8802.1.1.3.1.1.3.1.5
secyTxSACreatedTime	1.0.8802.1.1.3.1.1.3.1.6
secyTxSAStartedTime	1.0.8802.1.1.3.1.1.3.1.7
secyTxSAStoppedTime	1.0.8802.1.1.3.1.1.3.1.8

secyRxSCTable

The following table provides information about the status of each receiving SC supported by the MAC security entity. The index tuple for this table is: {secyIfInterfaceIndex, secyRxSCI}.

Table 11: secyRxSCTable

Object	Object identifier
secyRxSCI	1.0.8802.1.1.3.1.1.4.1.1
secyRxSCState	1.0.8802.1.1.3.1.1.4.1.2
secyRxSCCurrentSA	1.0.8802.1.1.3.1.1.4.1.3
secyRxSCCreatedTime	1.0.8802.1.1.3.1.1.4.1.4
secyRxSCStartedTime	1.0.8802.1.1.3.1.1.4.1.5
secyRxSCStoppedTime	1.0.8802.1.1.3.1.1.4.1.6

secyRxSATable

The following table provides information about the status of each receiving SA supported by the MAC security entity. The index tuple for this table is: {secyIfInterfaceIndex, secyRxSCI, secyRxSA}.

Table 12: secyRxSATable

Object	Object identifier
secyRxSA	1.0.8802.1.1.3.1.1.5.1.1
secyRxSAState	1.0.8802.1.1.3.1.1.5.1.2
secyRxSANextPN	1.0.8802.1.1.3.1.1.5.1.3

Object	Object identifier
secyRxSASAKUnchanged	1.0.8802.1.1.3.1.1.5.1.4
secyRxSACreatedTime	1.0.8802.1.1.3.1.1.5.1.5
secyRxSAStartedTime	1.0.8802.1.1.3.1.1.5.1.6
secyRxSAStoppedTime	1.0.8802.1.1.3.1.1.5.1.7

secyCipherSuiteTable

The following table is a list of selectable cipher suites for the MAC security entity. The index tuple for this table is: {secyCipherSuiteIndex}.

Table 13: secyCipherSuiteTable

Object	Object identifier
secyCipherSuiteIndex	1.0.8802.1.1.3.1.1.6.1.1
secyCipherSuiteId	1.0.8802.1.1.3.1.1.6.1.2
secyCipherSuiteName	1.0.8802.1.1.3.1.1.6.1.3
secyCipherSuiteCapability	1.0.8802.1.1.3.1.1.6.1.4
secyCipherSuiteProtection	1.0.8802.1.1.3.1.1.6.1.5
secyCipherSuiteProtectionOffset	1.0.8802.1.1.3.1.1.6.1.6
secyCipherSuiteDataLengthChange	1.0.8802.1.1.3.1.1.6.1.7
secyCipherSuiteICVLength	1.0.8802.1.1.3.1.1.6.1.8
secyCipherSuiteRowStatus	1.0.8802.1.1.3.1.1.6.1.9

secyTxSAStatsTable

The following table that contains the statistics objects for each transmitting SA in the MAC security entity.

Table 14: secyTxSAStatsTable

Object	Object identifier
secyTxSAStatsProtectedPkts	1.0.8802.1.1.3.1.2.1.1.1
secyTxSAStatsEncryptedPkts	1.0.8802.1.1.3.1.2.1.1.2
secyTxSCStatsProtectedPkts	1.0.8802.1.1.3.1.2.2.1.1
secyTxSCStatsEncryptedPkts	1.0.8802.1.1.3.1.2.2.1.4
secyTxSCStatsOctetsProtected	1.0.8802.1.1.3.1.2.2.1.10

Object	Object identifier
secyTxSCStatsOctetsEncrypted	1.0.8802.1.1.3.1.2.2.1.11

secyTxSCStatsTable

The following table that contains the statistics objects for each transmitting SC in the MAC security entity.

Table 15: secyTxSCStatsTable

Object	Object identifier
secyTxSCStatsProtectedPkts	1.0.8802.1.1.3.1.2.2.1.1
secyTxSCStatsEncryptedPkts	1.0.8802.1.1.3.1.2.2.1.4
secyTxSCStatsOctetsProtected	1.0.8802.1.1.3.1.2.2.1.10
secyTxSCStatsOctetsEncrypted	1.0.8802.1.1.3.1.2.2.1.11

secyRxSAStatsTable

The following table that contains the statistics objects for each receiving SA in the MAC security entity.

Table 16: secyRxSAStatsTable

Object	Object identifier
secyRxSAStatsUnusedSAPkts	1.0.8802.1.1.3.1.2.3.1.1
secyRxSAStatsNoUsingSAPkts	1.0.8802.1.1.3.1.2.3.1.4
secyRxSAStatsNotValidPkts	1.0.8802.1.1.3.1.2.3.1.13
secyRxSAStatsInvalidPkts	1.0.8802.1.1.3.1.2.3.1.16
secyRxSAStatsOKPkts	1.0.8802.1.1.3.1.2.3.1.25

secyRxSCStatsTable

The following table that contains the statistics objects for each receiving SC in the MAC security entity.

Table 17: secyRxSCStatsTable

Object	Object identifier
secyRxSCStatsUnusedSAPkts	1.0.8802.1.1.3.1.2.4.1.1
secyRxSCStatsNoUsingSAPkts	1.0.8802.1.1.3.1.2.4.1.2
secyRxSCStatsLatePkts	1.0.8802.1.1.3.1.2.4.1.3
secyRxSCStatsNotValidPkts	1.0.8802.1.1.3.1.2.4.1.4

Object	Object identifier
secyRxSCStatsInvalidPkts	1.0.8802.1.1.3.1.2.4.1.5
secyRxSCStatsDelayedPkts	1.0.8802.1.1.3.1.2.4.1.6
secyRxSCStatsUncheckedPkts	1.0.8802.1.1.3.1.2.4.1.7
secyRxSCStatsOKPkts	1.0.8802.1.1.3.1.2.4.1.8
secyRxSCStatsOctetsValidated	1.0.8802.1.1.3.1.2.4.1.9
secyRxSCStatsOctetsDecrypted	1.0.8802.1.1.3.1.2.4.1.10

secyStatsTable

The following table lists the objects for the statistics information of each Secy supported by the MAC security entity.

Table 18: secyStatsTable

Object	Object identifier
secyStatsTxUntaggedPkts	1.0.8802.1.1.3.1.2.5.1.1
secyStatsTxTooLongPkts	1.0.8802.1.1.3.1.2.5.1.2
secyStatsRxUntaggedPkts	1.0.8802.1.1.3.1.2.5.1.3
secyStatsRxNoTagPkts	1.0.8802.1.1.3.1.2.5.1.4
secyStatsRxBadTagPkts	1.0.8802.1.1.3.1.2.5.1.5
secyStatsRxUnknownSCIPkts	1.0.8802.1.1.3.1.2.5.1.6
secyStatsRxNoSCIPkts	1.0.8802.1.1.3.1.2.5.1.7
secyStatsRxOverrunPkts	1.0.8802.1.1.3.1.2.5.1.8

Obtaining the MACsec Controlled Port Interface Index

The ifindex of the controlled port can be obtained using the following commands:

- **snmpwalk** command on IfMib[OID: 1.3.6.1.2.1.31.1.1.1]

```
rtr1.0/1/CPU0/ $ snmpwalk -v2c -c public 10.0.0.1  1.3.6.1.2.1.31.1.1.1.1
SNMPv2-SMI::mib-2.31.1.1.1.1.3 = STRING: "GigabitEthernet0/1/0/0"
SNMPv2-SMI::mib-2.31.1.1.1.1.18 = STRING: "MACSecControlled0/1/0/0"
SNMPv2-SMI::mib-2.31.1.1.1.1.19 = STRING: "MACSecUncontrolled0/1/0/0"
```

- **show snmp interface** command

```
Router# show snmp interface
.
.
ifName : MACSecControlled0/0/0/0  ifIndex : 77
```

```
ifName : MACSecControlled0/0/0/4  ifIndex : 79
ifName : MACSecControlled0/0/0/21  ifIndex : 94
ifName : MACSecControlled0/0/0/30  ifIndex : 118
ifName : MACSecControlled0/0/0/34  ifIndex : 116
ifName : MACSecUncontrolled0/0/0/0  ifIndex : 78
ifName : MACSecUncontrolled0/0/0/4  ifIndex : 80
ifName : MACSecUncontrolled0/0/0/21  ifIndex : 95
ifName : MACSecUncontrolled0/0/0/30  ifIndex : 119
ifName : MACSecUncontrolled0/0/0/34  ifIndex : 117
```

SNMP Query Examples

In the following examples, it is assumed that the configured SNMP community is public, and the management IP of the box is 10.0.0.1.

To perform SNMP walk on the entire SECY MIB for the router, use the following command:

snmpwalk -v2c -c public 10.0.0.1 1.0.8802.1.1.3

To query on the secyTxSCTable to get the TxSCI for interface Gi0/1/0/0, using the ifindex of MACsecControlled0/1/0/0 that is 18, use the following command:

snmpget -v2c -c public 10.0.0.1 iso.0.8802.1.1.3.1.1.2.1.1.18

Power-on Self-Test KAT for Common Criteria and FIPS

The Cisco IOS XR Software Release 7.0.14 introduces the support for power-on self-test (POST) known answer test (KAT) for common criteria and FIPS compliance for the MACsec-enabled hardware on Cisco 8000 Series Routers. In POST KAT, the KAT is executed immediately after the cipher module is powered on. With this feature enabled, the system allows the traffic to pass through the MACsec-enabled hardware only if it passes the KAT. If the KAT fails, the modules shut down and the ports do not come up.

The POST KAT functionality is now available on Cisco 8800 48x100 GbE QSFP28 Line Card (8800-LC-48H) and Cisco 8800 36x400GE QSFP56-DD Line Card with MACsec (8800-LC-36FH-M).

How to Configure Power-on Self-Test KAT

KAT is not enabled by default. You can configure the **hw-module macsec-fips-post** command to enable POST KAT for the MACsec-enabled hardware. With this configuration in place, the KAT always runs as a self-test during power on. The cryptographic algorithm tests are performed on every physical layer chip (PHY) with hardware crypto once it powered up.

Note

- With KAT enabled, you can expect a delay of approximately 2 to 3 minutes for the boot up of a line card, in comparison to the boot up time without enabling KAT.
- If power-on self-test (POST) known answer test (KAT) is already enabled on the PHY, then the system does not allow you to configure the **hw-module macsec-fips-post location all** command again. This restriction is in place to prevent conflicts in configuration, especially in a configuration restore scenario. In such scenarios, you can make use of the **show hw-module macsec-mode fips-post** command to know of the respective running configurations in place.

Pass criteria for KAT: Any change in the FIPS mode configuration requires a line card reload. On reload, the FIPS POST is run as part of the LC boot sequence. The subsequent boot (based on the FIPS mode) state re-triggers the KAT. If there are multiple PHYs hardware in a module, then the system performs the KAT on each of the PHYs and returns the KAT results. If all PHYs pass the KAT, then the system brings up the line card for regular usage.

Fail criteria for KAT: Traffic does not pass through a MACsec-enabled PID that failed KAT. If any of the PHYs registers a KAT failure, then the module enters into an ERROR state and the system displays a critical ERROR SYSLOG output which reads as: *KAT Test Failed*. The system does not allow any traffic or data flow through the interfaces on that line card. Although the interfaces are present, they do not come up or allow any traffic to flow through them on a line card that failed KAT. In a modular chassis, all other line cards, except the one that failed the KAT, will be up and running.

Prerequisites for Power-on Self-Test KAT

- The k9sec package must be installed on the router.
- FIPS must be supported and enabled on the line card.

Configuration Example

```
Router#config
Router(config)#hw-module macsec-fips-post location 0/4/CPU0
Router(config)#commit
```

Running Configuration

```
hw-module macsec-fips-post location 0/4/CPU0
!
```

Verification

Before configuring POST KAT:

```
Router#show hw-module macsec-fips-post
Wed Jun 17 09:29:18.780 UTC

Location       Configured     Applied          Action
--------------------------------------------------------------
0/0/CPU0       NO             NO               NONE          >>> LC36
0/11/CPU0      NO             NO               NONE          >>> LC48
```

After configuring the command for POST KAT, and before the line card reload:

```
Router#show hw-module macsec-fips-post
Wed Jun 17 09:36:31.932 UTC

Location       Configured     Applied          Action
--------------------------------------------------------------
0/0/CPU0       NO             NO               NONE
0/11/CPU0      YES            NO               RELOAD
```

After the line card reload:

```
Router#show hw-module macsec-fips-post
Wed Jun 17 10:03:57.263 UTC

Location       Configured     Applied          Action
--------------------------------------------------------------
0/0/CPU0       NO             NO               NONE
0/11/CPU0      YES            YES              NONE
```

These are sample logs displayed after a successful KAT. The system performs KAT on each port, but the ports may not be in order in the display output.

```
Router#show logging | inc KAT
Wed Jun 10 12:07:29.849 UTC
LC/0/4/CPU0:Jun 9 10:37:37.521 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 0
LC/0/4/CPU0:Jun 9 10:37:37.522 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 28
LC/0/4/CPU0:Jun 9 10:37:37.522 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 27
LC/0/4/CPU0:Jun 9 10:37:37.522 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 1
LC/0/4/CPU0:Jun 9 10:39:10.393 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 2
LC/0/4/CPU0:Jun 9 10:39:10.393 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 6
LC/0/4/CPU0:Jun 9 10:39:10.393 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 7
LC/0/4/CPU0:Jun 9 10:39:10.393 UTC: optics_driver[159]: %L2-SECY_DRIVER-6-KAT_PASS : KAT
Test PASSED for Port No: 8
```

These are sample logs displayed in KAT failure scenarios:

```
Router#show logging | inc SECY
Thu Jul 16 09:13:29.217 UTC
LC/0/7/CPU0:Jul 16 08:41:30.709 UTC: optics_driver[152]: %L2-SECY_DRIVER-0-KAT_FAIL_DETECTED
 : KAT Test FAILED for Port No: 0
LC/0/7/CPU0:Jul 16 08:41:30.709 UTC: optics_driver[152]: %L2-SECY_DRIVER-0-KAT_FAIL_DETECTED
 : KAT Test FAILED for Port No: 47
LC/0/7/CPU0:Jul 16 08:41:30.709 UTC: optics_driver[152]: %L2-SECY_DRIVER-0-KAT_FAIL_DETECTED
 : KAT Test FAILED for Port No: 7
LC/0/7/CPU0:Jul 16 08:41:30.709 UTC: optics_driver[152]: %L2-SECY_DRIVER-0-KAT_FAIL_DETECTED
 : KAT Test FAILED for Port No: 6
```

Related Topics

- Power-on Self-Test KAT for Common Criteria and FIPS, on page 61

Associated Commands

- **hw-module macsec-fips-post**
- **show hw-module macsec-fips-post**

Dynamic Power Management for MACSec-Enabled Ports

Table 19: Feature History Table

Feature Name	Release Information	Feature Description
Dynamic Power Management for MACSec-Enabled Ports	Release 7.3.3	From this release, the Dynamic Power Management feature—which allocates power to the fabric and line cards based on certain dynamic factors—also factors in the power requirement for bringing up MACSec sessions on the line card interfaces. This feature thus ensures optimal use of the power supply units (PSUs) by providing more accurate dynamic power calculation for the hardware. This feature is supported on 88-LC0-36FH-M, 88-LC0-34H14FH, and 8800-LC-48H line cards.

The dynamic power management feature allocates total power to a router and its fabric cards or line cards based on certain factors like number and type of fabric cards and line cards installed on the router, operating modes of fabric cards, combination of line card and fabric card types installed, NPU power mode configured on a fabric card, optics, and so on.

For details on dynamic power management feature, see the *Managing Router Hardware* chapter in the *System Management Configuration Guide for Cisco 8000 Series Routers*.

Prior to Cisco IOS XR Software Release 7.3.3, enabling or disabling MACSec on line card interfaces was not accounted in dynamic power management functionality. Starting Release 7.3.3, when you configure MACSec on interfaces, the software internally checks if there is enough power to bring up MACSec sessions for all those configured interfaces. Accordingly, if there is shortage of power to cater to all MACSec sessions, some MACSec sessions might not come up, irrespective of the fact that MACSec feature configuration was successful on those interfaces. The router console displays the following log message in such cases indicating the reason for session failure.

```
LC/0/4/CPU0:Dec 21 07:35:27.977 UTC: macsec_mka[131]: %L2-MKA-5-MACSEC_POWER_STATUS_ERR :
(Hu0/4/0/9), Insufficient power
```

You may choose to remove the MACSec configuration from the corresponding interfaces or re-provision the PSUs based on the additional power requirement for the new sessions.

Note If you choose not to remove MACSec configurations for sessions which are down, there is no guarantee that the same MACSec sessions that were brought up earlier will come up after a router or line card reload.

By default, the dynamic power management is enabled on a router. You can disable the feature using the **no power-mgmt action** command in XR Config mode.

Verify Dynamic Power Management for MACSec-Enabled Ports

Syslog

The router console displays this syslog when power is allocated for a MACSec interface:

```
LC/0/6/CPU0:Sep 9 13:25:12.838 UTC: macsec_mka[277]: %L2-MKA-5-MACSEC_POWER_STATUS :
(Hu0/6/0/0), Power allocated
```

The router console displays this syslog when power is released for a MACSec interface (say, when you remove MACSec policy from the interface):

```
LC/0/6/CPU0:Sep 11 12:53:24.955 UTC: macsec_mka[277]: %L2-MKA-5-MACSEC_POWER_STATUS :
(Hu0/6/0/0), Power released
```

Show Commands

- Use the **show environment power** command to know of the chassis-level power information.

```
Router#show environment power
Thu Dec  9 11:12:54.239 UTC
===============================================================================
CHASSIS LEVEL POWER INFO: 0
===============================================================================
   Total output power capacity (N + 1)             :   31500W +     6300W
   Total output power required                     :   11208W
   Total power input                               :    3778W
   Total power output                              :    3395W

===============================================================================
   Power       Supply         -------Input--------   -----Output---     Status
   Module      Type            Volts A/B   Amps A/B   Volts     Amps
===============================================================================
   0/PT0-PM0   PSU6.3KW-HV     246.0/244.3 1.2/1.2    55.3      9.9      OK
   0/PT0-PM1   PSU6.3KW-HV     245.7/244.3 1.3/1.3    55.4      10.1     OK
   0/PT0-PM2   PSU6.3KW-HV     245.7/246.3 1.5/1.2    55.4      10.3     OK
   0/PT1-PM0   PSU6.3KW-HV     246.0/246.0 1.3/1.3    55.4      10.3     OK
   0/PT1-PM1   PSU6.3KW-HV     244.3/244.6 1.3/1.3    55.1      10.7     OK
   0/PT1-PM2   PSU6.3KW-HV     245.7/245.5 1.3/1.2    55.2      10.1     OK
   0/PT2-PM0   PSU6.3KW-HV     0.0/0.0     0.0/0.0    0.0       0.0      FAILED or NO
PWR
   0/PT2-PM1   PSU6.3KW-HV     0.0/0.0     0.0/0.0    0.0       0.0      FAILED or NO
PWR
   0/PT2-PM2   PWR-6.3KW-HV    0.0/0.0     0.0/0.0    0.0       0.0      FAILED or NO
PWR

Total of Power Modules:       3778W/15.4A              3395W/61.4A

===============================================================================
   Location     Card Type               Power       Power        Status
                                                    Allocated    Used
                                                    Watts        Watts
===============================================================================
   0/RP0/CPU0   8800-RP-O              95          78           ON
   0/RP1/CPU0   8800-RP-O              95          -            ON
```

```
   0/0/CPU0     88-LC0-36FH-O           934         543         ON
   0/1/CPU0      -                      102         -           RESERVED
   0/2/CPU0     8800-LC-48H-O           778         474         ON
   0/3/CPU0     -                       102         -           RESERVED
   0/4/CPU0     -                       102         -           RESERVED
   0/5/CPU0     -                       102         -           RESERVED
   0/6/CPU0     8800-LC-48H             102         -           OFF
   0/7/CPU0     -                       102         -           RESERVED
   0/8/CPU0     -                       102         -           RESERVED
   0/9/CPU0     -                       102         -           RESERVED
   0/10/CPU0    -                       102         -           RESERVED
   0/11/CPU0    -                       102         -           RESERVED
   0/FC0        -                       26          -           RESERVED
   0/FC1        8812-FC                 784         338         ON
   0/FC2        8812-FC                 784         337         ON
   0/FC3        8812-FC                 784         343         ON
   0/FC4        8812-FC                 784         338         ON
   0/FC5        8812-FC                 784         344         ON
   0/FC6        -                       26          -           RESERVED
   0/FC7        -                       26          -           RESERVED
   0/FT0        SF-D-12-FAN             1072        135         ON
   0/FT1        SF-D-12-FAN             1072        105         ON
   0/FT2        SF-D-12-FAN             1072        123         ON
   0/FT3        SF-D-12-FAN             1072        123         ON
Router#
```

- Use the **show environment power allocated location** command to know the power allocated for each component (such as MACSec, optics and so on) on a line card.

  This example shows that a total power of 778W is allocated for the line card, out of which 3W is for MACSec component and another 3W for optics.

  A power of 3W is allocated for MACSec component on 88-LC0-34H14FH, and 8800-LC-48H line cards. Similarly, a power of 6W is allocated for MACSec component on 88-LC0-36FH-M line card.

```
Router#show environment power allocated location 0/2/CPU0
Thu Dec  9 09:53:49.921 UTC
================================================================================
   Location    Components              Power
                                       Allocated
                                       Watts
================================================================================
  0/2/CPU0     Data-path               772
               MACSEC                    3
               OPTICS                    3
================================================================================
               Total                   778
Router#
```

- Use the **show environment power allocated details** to know the interface-level details of power allocated for each component on a line card.

  This example shows that a power of 3W is allocated for MACSec component as part of enabling MACSec on interface 0/2/0/9.

```
Router#show environment power allocated details location 0/2/CPU0
Thu Dec  9 09:53:49.921 UTC
================================================================================
   Location    Components              Power
                                       Allocated
                                       Watts
================================================================================
```

```
  0/2/CPU0      Data-path                772
                0/2/0/9                  3
                0/2/0/0                    3
================================================================================
                Total                    778
Router#
```

- Use the **show macsec mka interface detail** command to know the MACSec power status of each interface. The *MACsec Power Status* field indicates if sufficient power is allocated to the interface or not.

```
Router#show macsec mka interface hundredGigE 0/2/0/9 detail
Tue Dec 21 08:10:41.571 UTC
Interface Name : HundredGigE0/2/0/9
 Interface Namestring : HundredGigE0/2/0/9
 Interface short name : Hu0/2/0/9
 Interface handle : 0x2000480
 Interface number : 0x2000480
 MacSecControlledIfh : 0x20005b8
 MacSecUnControlledIfh : 0x20005c0
 Interface MAC : 34ed.1b5b.d047
 Ethertype : 888E
 EAPoL Destination Addr : 0180.c200.0003
 MACsec Shutdown : FALSE
 Config Received : TRUE
 IM notify Complete : TRUE
 MACsec Power Status : Allocated
 Interface CAPS Add : TRUE
 RxSA CAPS Add : TRUE
 TxSA CAPS Add : TRUE
 MKA PSK Info
  Key Chain Name : psk
  MKA Cipher Suite : AES-128-CMAC
  CKN : 22 22
 MKA fallback_PSK Info
  fallback keychain Name : - NA -
 Policy : p3
```

Quantum safe key distribution options for MACsec

Quantum computers are a threat to existing cryptographic algorithms. To address this problem, you can use session keys to establish a secure connection between two routers.

Cisco offers two solutions to derive session keys:

- Session Key Service (SKS): Used to derive the session keys on both the routers establishing the MACsec connection without using an external key source.
- Secure Key Integration Protocol: Used to derive the session keys on both the routers establishing the MACsec connection using an external server. Enables a router to securely import a post-quantum pre-shared key (PPK) from an external key source such as a quantum key distribution (QKD) device.

Table 20: Feature History Table

Feature Name	Release Information	Feature Description
Session key service	Release 7.9.1	The router integrates the Session Key Service (SKS) as a software component, allowing it to generate and manage the cryptographic keys needed for quantum-safe MACsec. By using SKS, you can implement MACsec without requiring additional hardware, simplifying deployment and reducing costs. The SKS software should be present on the peer routers. For more information on Quantum Key Distribution, see Post Quantum Security Brief.

Session key service

The Session Key Service (SKS) is a cryptographic service that manages symmetric keys for encryption and decryption. These are the salient features of SKS on a router.

Key generation

The SKS engine is a software component within the router responsible for generating cryptographic keys. It creates keys that will be used to encrypt and decrypt data between peer routers.

No additional hardware required

This implies that the key generation and exchange process does not need extra hardware components. The SKS engine functions with the existing router hardware, making it cost-effective and easy to deploy.

Seed protected by McEliece cryptosystem

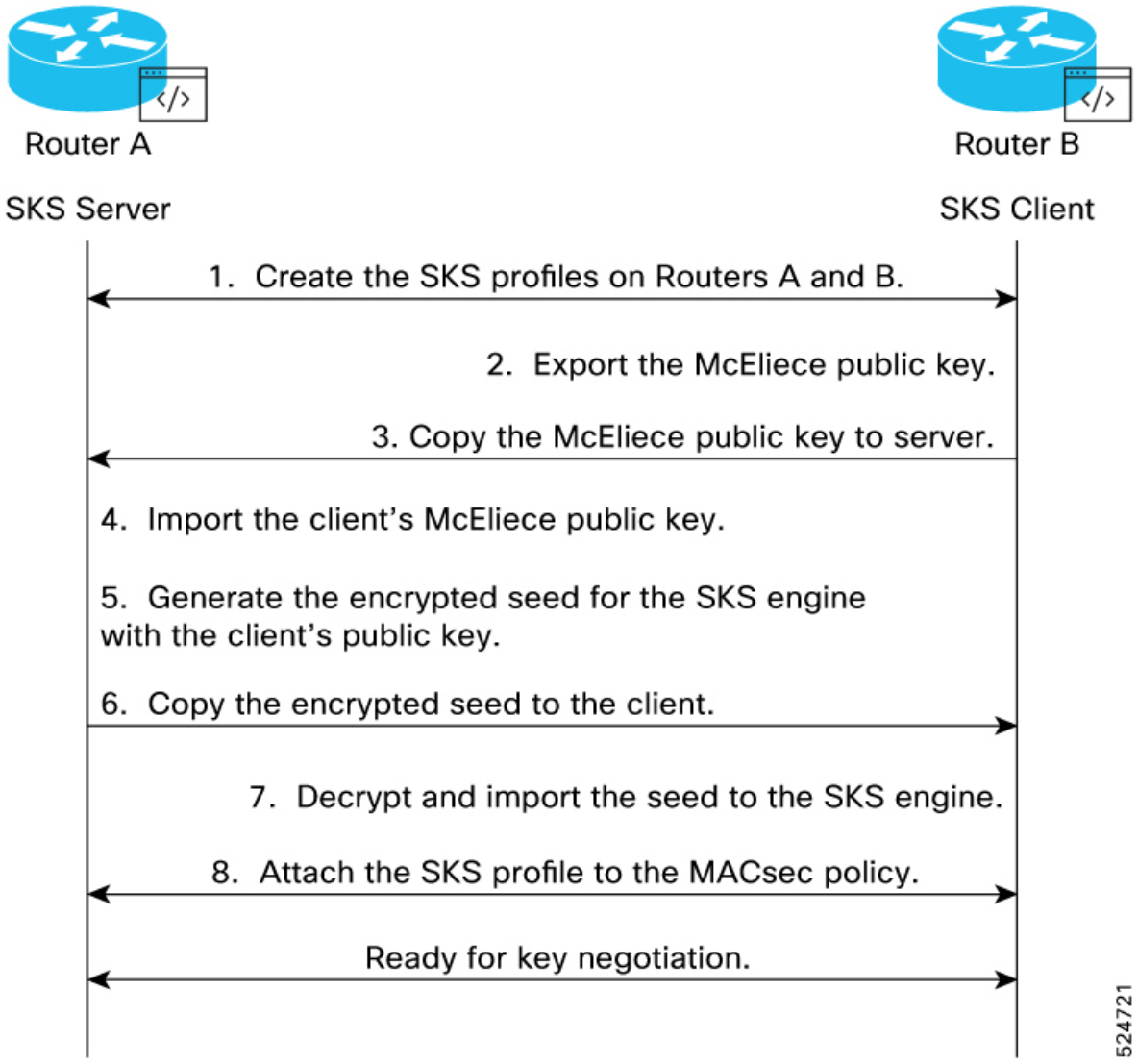
Seeding refers to initializing the SKS with a specific value, called a seed, which ensures that both communicating peers generate the same cryptographic keys. This is crucial for successful encryption and decryption. The McEliece cryptosystem is a public-key cryptosystem known for its resistance to quantum computer attacks. Protecting the seed with McEliece ensures it remains secure against future quantum computing threats.

Only Key ID sent on the network

Instead of sending the entire cryptographic key over the network, the router sends only a Key Identifier (Key ID). The receiving peer uses the Key ID to derive the corresponding key locally using its SKS. Using the Key ID enhances security by minimizing exposure of the actual key during transmission.

Configure SKS

The SKS software component on a router is used to configure the server and client to generate preshared keys for quantum-safe MACsec. This image depicts the steps you should perform to generate preshared keys. You can click a step to learn more.



1 Create the SKS profiles on Routers A and B.
2 Export the McEliece public key.
3 Copy the McEliece public key to the server.
4 Import the client's McEliece public key.
5 Generate the encrypted seed for the SKS engine with the clients public key.
6 Copy the encrypted seed to the client.
7 Decrypt and import the seed to the sks engine.
8 Attach the SKS profile to the MACsec policy.

Create the SKS profile on the server and client

Follow these steps to create the SKS profile on the server and client.

Before you begin

First, let us gather the required details to facilitate the devices to agree on encryption parameters to establish a secure connection:

- Routers A and B are equipped with the SKS engine.
- Router A acts as the server and Router B acts as the client.
- Routers A and B are ready for key negotiation after all the steps are performed and the SKS profile is attached to the MACsec policy.

Procedure

Step 1 Enter the **sks profile** <*profile-name*> **device-identifier** <*name of peer*> command to apply a profile to manage secure communications.

Server configuration

```
Router A# sks profile prof-A device-identifier peer-1
```

Client configuration

```
Router B# sks profile prof-B device-identifier peer-2
```

Step 2 Enter the **live-key** <*number of MACsec sessions*> command to manage the active keys used in MACsec sessions.

Server configuration

```
Router A# live-keys 5
```

Client configuration

```
Router B# live-keys 5
```

Step 3 Enter the **peer identifier** <*peer-name*> command to associate the server with the client and the client with the server.

Server configuration

```
Router A# peer-identifier peer-2
```

Client configuration

```
Router B# peer-identifier peer-1 master
```

Export the McEliece public key

Follow these steps to export the McEliece public key.

Procedure

Step 1 Enter the **crypto sks key export mceliece** command to export the public key to the client.

Client configuration

```
Router B# crypto sks key export mceliece
```

Step 2 Verify the path where the public key is exported.

Client configuration

```
Router B# dir disk0:/MeCe_the_MC_default_pub
Mon Feb 24 04:25:25.013 UTC

Directory of disk0:/MeCe_the_MC_default_pub
73 -rw-r--r--. 1 1357824 Feb 24 04:20 MeCe_the_MC_default_pub

989244 kbytes total (919872 kbytes free)
```

Copy the McEliece public key to the server

Follow these steps to copy the McEliece public key to the server.

Before you begin

In the example, **disk0:/MeCe_the_MC_default_pub** is the source path of the client and **cisco@1.2.42.3** is the IP address of the server.

Procedure

Step 1 Using the Secure Copy Protocol (SCP), enter the **scp / disk0\:/***<source path on the client <destination path of the server***:/disk0:/** to copy the files from the client to the server.

Client configuration

```
Router B# scp /disk0\:/MeCe_the_MC_default_pub cisco@1.2.42.3:/disk0:/
```

This command has securely copied the file named **MeCe_the_MC_default_pub** from the local directory **/disk0:/** to the remote directory **/disk0:/** on the host **1.2.42.3** using the Cisco user account.

Step 2 Verify that the files are copied from the client to the server.

Client configuration

```
Router B #dir disk0:/MeCe_the_MC_default_pub
Mon Feb 24 04:27:00.398 UTC

Directory of disk0:/MeCe_the_MC_default_pub
73 -rw-r--r--. 1 1357824 Feb 24 04:26 MeCe_the_MC_default_pub

989244 kbytes total (919868 kbytes free)
```

Import the client McEliece public key

Follow these steps to import the client McEliece public key.

Before you begin

In the example, peer 2 is Router B's name to which the key corresponds. The local directory **disk0:/MeCe_the_MC_default_pub** is the source path of the key on the server that was copied in the previous step.

Procedure

Step 1 Enter the **crypto sks key import mceliece** *<client's name> <source path of the key on the server>* command to import the McEliece public key to the server.

Server configuration

```
Router A# crypto sks key import mceliece peer-2 disk0:/MeCe_the_MC_default_pub
```

Step 2 Verify that the **Pubkey Import Done** is set to **True** for the required peer.

Server configuration

```
Router A# show crypto sks peer all
Mon Feb 24 04:29:06.492 UTC
Peer Name          : peer-2
Profile Name       : prof-A
Seed Done          : TRUE
Pubkey Import Done : TRUE
Master             : FALSE
```

Generate the encrypted seed for the SKS engine with the client public key

Follow these steps to generate the encrypted seed for the SKS engine with the client public key.

Procedure

Step 1 Enter the **crypto sks seed export mceliece** *<client name>* command to generate and export the seed to the server.

Server configuration

```
Router A# crypto sks seed export mceliece peer-2
```

The command exports a McEliece cryptographic seed that is associated with Router B.

Step 2 Verify if an encrypted seed is exported to the */disk0\:/enc_self_peer-2* location.

Server configuration

```
Router A# dir disk0:/enc_self_peer-2
Mon Feb 24 04:35:57.596 UTC

Directory of disk0:/enc_self_peer-2
74 -rw-r--r--. 1 480 Feb 24 04:35 enc_self_peer-2

989244 kbytes total (919860 kbytes free)
```

Copy the encrypted seed to the client

Follow these steps to copy the encrypted seed to the client.

Procedure

Step 1 Using the Secure Copy Protocol (SCP), enter the **scp /disk0\:/***<source path of the client> <destination path of the server>* command to copy the files from the server to the client.

Server Configuration

```
Router A# scp /disk0\:/enc_self_peer-2 cisco@1.2.43.3:/disk0:/
```

Step 2 Verify that the files are copied from the server to the client.

Client configuration

```
Router B# dir disk0:/enc_self_peer-2
Mon Feb 24 04:35:57.596 UTC

Directory of disk0:/enc_self_peer-2
74 -rw-r--r--. 1 480 Feb 24 04:35 enc_self_peer-2

989244 kbytes total (919860 kbytes free)
```

Decrypt and import the seed to the sks engine

Follow these steps to decrypt and import the seed to the sks engine.

Procedure

Step 1 Enter the **crypto sks seed import mceliece** *<server name> <server path>* command to import the seed on the client.

Client configuration

```
Router B# crypto sks seed import mceliece peer-1 disk0:/enc_self_peer-2
```

The seed is associated with Router A and **disk0:/enc_self_peer-2** is the file path from which the seed is being imported. It indicates that the seed is stored in a file located at **disk0:/enc_self_peer-2** on the router.

Step 2 Verify that the seed is imported to the client.

Client configuration

```
Router B# show crypto sks peer all
Mon Feb 24 04:37:35.578 UTC
Peer Name          : peer-1
Profile Name       : prof-B
Seed Done       : TRUE
Pubkey Import Done : FALSE
Master             : TRUE
------------------------------
```

Attach the SKS profile to the MACsec policy

Follow these steps to create the SKS profile on the server and client.

Procedure

Step 1 Configure the SKS profile on both MACsec peers.

Router A

```
Router A# macsec-policy p1
Router A# ppk
Router A# sks-profile prof-A
```

Router B

```
Router B# macsec-policy p2
Router B# ppk
Router B# sks-profile prof-B
```

Step 2 Verify the MACsec configuration.

Router A

```
Router A# show macsec mka session

MKA Detailed Status for MKA Session
===================================
Status: Secured - Secured MKA Session with MACsec

Local Tx-SCI                    : c847.091c.d060/0001
Local Tx-SSCI                   : 1
Interface MAC Address           : c847.091c.d060
MKA Port Identifier             : 1
Interface Name                  : Te0/0/0/24
CAK Name (CKN)                  : 4000
CA Authentication Mode          : PRIMARY-PSK
Keychain                        : tet
Member Identifier (MI)          : 2E222A17F6E9535E1ACD4747
Message Number (MN)             : 333807
Authenticator                   : NO
Key Server                      : NO
MKA Cipher Suite                : AES-256-CMAC
Configured MACSec Cipher Suite  : GCM-AES-XPN-256
Key Distribution Mode           : PPK
------------<truncated>--------------
```

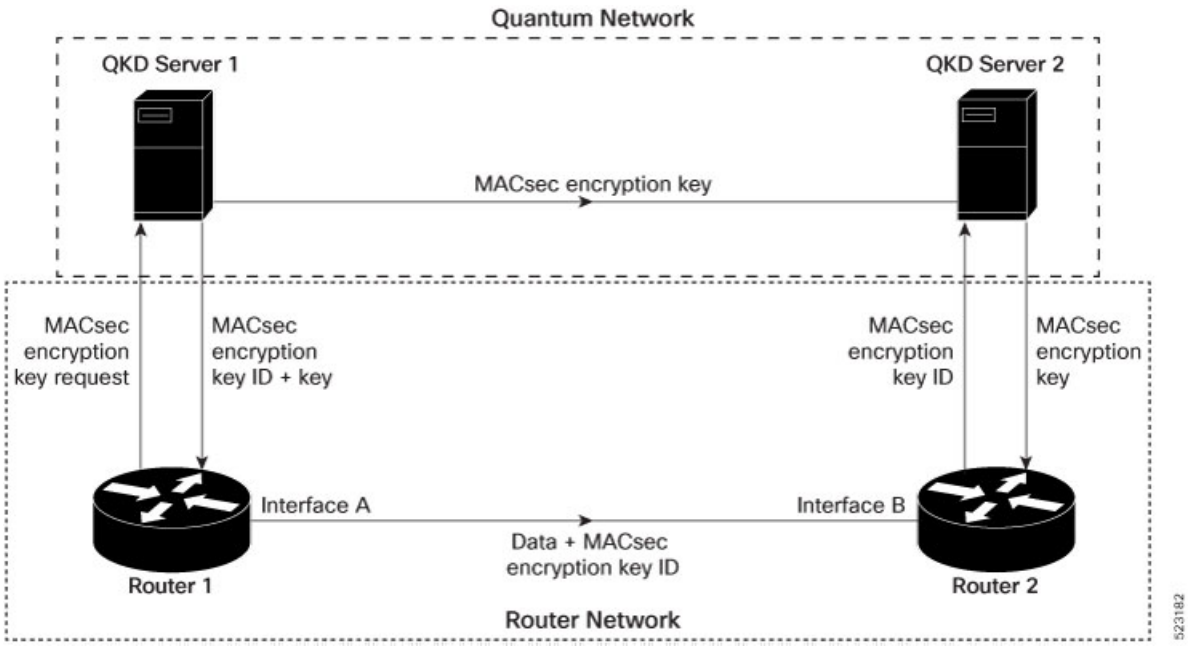
Once the routers attach the SKS profile to the MACsec policy, they have met all technical and security prerequisites. Routers A and B can now establish a secure communication link using symmetric key cryptography.

Secure Key Integration Protocol

Table 21: Feature History Table

Feature Name	Release Information	Feature Description
Secure Key Integration Protocol for Routers	Release 7.9.1	Your routers are now capable of handling the Secure Key Integration Protocol (SKIP) protocol. The SKIP protocol enables your routers to communicate with external quantum devices. With this ability, you can use the Quantum Key Distribution (QKD) devices for exchanging MACsec encryption keys between routers. Using QKD eliminates the key distribution problem in a post quantum world where the current cryptographic systems are no longer secure due to the advent of quantum computers. This feature introduces the following: • **CLI:** • **crypto-sks-kme** • **show crypto sks profile** • **Yang Data Model**: Cisco-IOS-XR-um-sks-server-cfg.yang (see GitHub, YANG Data Models Navigator) For more information on Quantum Key Distribution, see Post Quantum Security Brief.

Cisco Secure Key Integration Protocol (SKIP) enables your router that supports encryption to use keys by a quantum distribution system. SKIP implementation in Cisco IOS-XR software supports integrating external Quantum Key Distribution (QKD) devices with your routers. With integration support between the routers and QKD devices, you can use the QKD devices to exchange encryption keys for communication between the routers. And this mechanism eliminates the key distribution problem in a post quantum world.



Quantum Key Distribution (QKD) is a method for securely transmitting a secret key between two parties. QKD uses the laws of quantum mechanics to guarantee security even when eavesdroppers monitor the communication channel. In QKD, the key is encoded in the states of single photons. The QKD transmits the keys over optical fiber or free space (vacuum). The security of the key relies on the fact that measuring a quantum state introduces a change in the quantum state. The change in quantum states helps the two end parties of the communication channel to identify any interception of their key.

QKD is a secure key exchange mechanism against quantum attacks and will remain so, even with future advancements in cryptanalysis or quantum computing. Unlike other cryptographic algorithms, QKD doesn't need continual updates based on discovered vulnerabilities.

Feature Highlights

- You can use the QKD devices in the following combinations:
  - Same QKD device on the end ports of the peer routers
  - Different QKD devices on the end ports of the peer routers
  - Multiple links between the same peer routers using different QKD devices
- You can use a specific source interface for the router communication with the QKD devices. To use a specific source interface, configure the source interface in the QKD profile. Use the **source interface** command in SKS configuration mode as follows.

```
Router# config
Router(config)# sks profile ProfileR1toR2 type remote
Router(config-sks-profile)# kme server ipv4 192.0.2.34 port 10001
Router(config-sks-profile)# source interface hundredGigE 0/1/0/17
Router(config-sks-profile)# commit
```

- You can use an HTTP Proxy for the router communication with the QKD devices. Use the following configuration for the router to use an HTTP proxy server to communicate to the QKD devices.

```
Router# config
Router(config)# sks profile ProfileR1toR2 type remote
Router(config-sks-profile)# kme server ipv4 192.0.2.34 port 10001
Router(config-sks-profile)# http proxy ipv4 192.0.2.68 port 804
Router(config-sks-profile)# commit
```

Note The **http proxy server** command supports configuration using IPv4 address, IPv6 address, and hostname of the HTTP proxy.

Restrictions

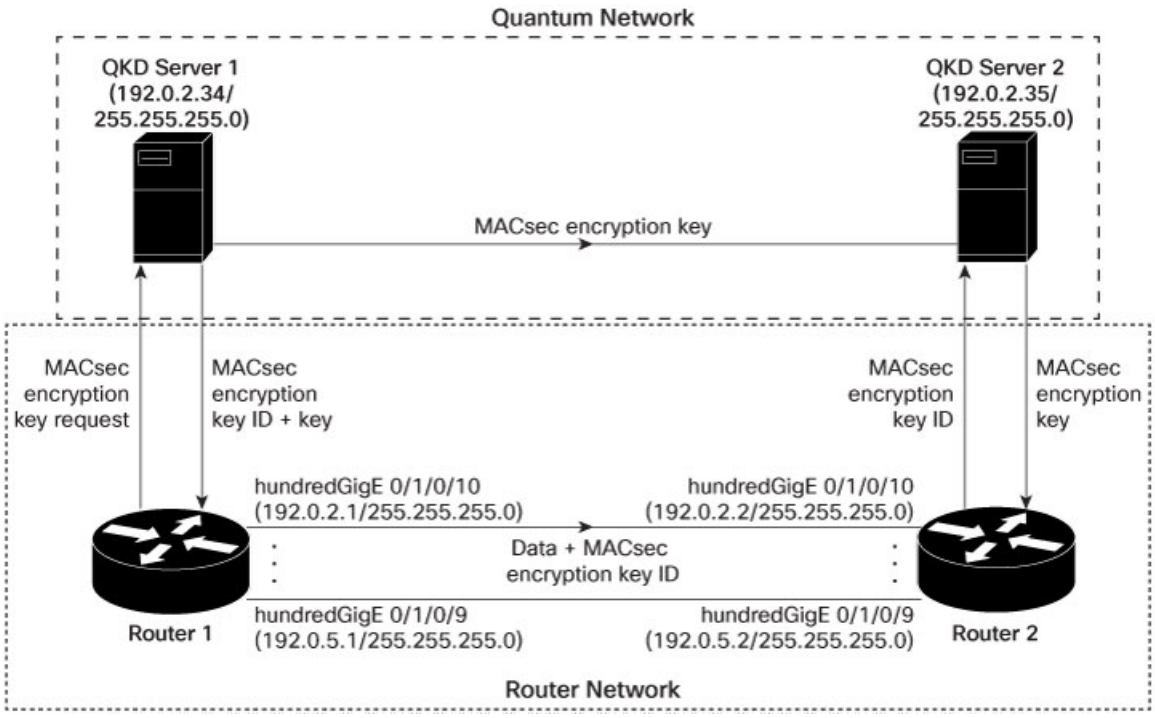
Consider the following restrictions before implementing SKIP:

- The SKIP protocol is supported only on the 8202-32FH-M chassis.
- You can use the SKIP protocol only in a Point to Point MACSec link encryption scenario.
- The SKIP protocol is available only on the interfaces that support MACSec encryption.

Configuring Point to Point MACsec Link Encryption using SKIP

In Point-to-Point MACsec Link Encryption, the router uses SKIP to establish secure encryption. This encryption is set up between two interfaces in peer routers and requires the assistance of an external QKD device network. The QKD network shares the MACsec encryption key instead of the router network. Thus, when the router needs to create a MACsec link between peer router interfaces, it contacts the external QKD device and requests the key. The external QKD device generates a Key pair comprising the Key ID and the Key. The Key ID serves as the unique identification string for the Key (Shared Secret). The QKD then shares both the Key ID and Key with the router and the router shares only the Key ID with its peer. The Peer router uses this Key ID to retrieve encryption keys from its QKD device. Therefore, Quantum networks securely communicate encryption keys always.

Figure 6: Point to Point MACsec Link Encryption using SKIP



Prerequisites

- Configure MACsec Pre-Sared Key (PSK). For more information, see MACsec PSK, on page 5.
- Configure MACsec in the PPK mode.
- An external QKD devices network.
- Add the QKD server CA to the trustpoint in the router. For more information, see Configure Trustpoint.
- Import the QKD server root CA certificate in the router. For more information, see Configure Certificate Enrollment Using Cut-and-Paste.

Configuration

The following example details how to establish Point to Point MACsec Link Encryption using SKIP:

Router 1:

1. Configure the QKD profile.

```
Router# config
Router(config)# sks profile ProfileR1toR2 type remote
Router(config-sks-profile)# kme server ipv4 192.0.2.34 port 10001
Router(config-sks-profile)# commit
```

2. Map the QKD profile to the MACsec policy.

```
Router# config
Router(config)# macsec-policy R1toR2
Router(config-macsec-policy)# ppk sks-profile ProfileR1toR2
Router(config-macsec-policy)# commit
```

Note For more information on MACsec Policy, see Create a user-defined MACsec policy, on page 12.

3. Apply MACsec policy to the interfaces.

```
Router# config
Router(config)#interface hundredGigE 0/1/0/10
Router(config-if)# ipv4 address 192.0.2.1 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R1toR2
Router(config)# commit
Router(config)#interface hundredGigE 0/1/0/11
Router(config-if)# ipv4 address 192.0.3.1 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R1toR2
Router(config)# commit
Router(config)#interface hundredGigE 0/1/0/12
Router(config-if)# ipv4 address 192.0.4.1 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R1toR2
Router(config)# commit
Router(config)#interface hundredGigE 0/1/0/9
Router(config-if)# ipv4 address 192.0.5.1 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R1toR2
Router(config)# commit
```

Router 2:

1. Configure the QKD profile.

```
Router# config
Router(config)# sks profile ProfileR2toR1 type remote
Router(config-sks-profile)# kme server ipv4 192.0.2.35 port 10001
Router(config-sks-profile)# commit
```

2. Map the QKD profile to the MACsec policy.

```
Router# config
Router(config)# macsec-policy R2toR1
Router(config-macsec-policy)# ppk sks-profile ProfileR2toR1
Router(config-macsec-policy)# commit
```

Note For more information on MACsec Policy, see Create a user-defined MACsec policy, on page 12.

3. Apply MACsec policy to the interfaces.

```
Router# config
Router(config)#interface hundredGigE 0/1/0/10
Router(config-if)# ipv4 address 192.0.2.2 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R2toR1
Router(config-if)# commit
Router(config)#interface hundredGigE 0/1/0/11
Router(config-if)# ipv4 address 192.0.3.2 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R2toR1
Router(config-if)# commit
Router(config)#interface hundredGigE 0/1/0/12
Router(config-if)# ipv4 address 192.0.4.2 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R2toR1
Router(config-if)# commit
Router(config)#interface hundredGigE 0/1/0/9
Router(config-if)# ipv4 address 192.0.5.2 255.255.255.0
Router(config-if)# macsec psk-keychain mac_chain policy R2toR1
```

```
Router(config-if)# commit
```

Running Configuration

Router 1:

```
sks profile ProfileR1toR2 type remote
 kme server ipv4 192.0.2.34 port 10001
!
macsec-policy R1toR2
 ppk
  sks-profile ProfileR1toR2
 !
!
interface hundredGigE 0/1/0/10
 ipv4 address 192.0.2.1 255.255.255.0
 macsec psk-keychain mac_chain policy R1toR2
!
interface hundredGigE 0/1/0/11
 ipv4 address 192.0.3.1 255.255.255.0
 macsec psk-keychain mac_chain policy R1toR2
!
interface hundredGigE 0/1/0/12
 ipv4 address 192.0.4.1 255.255.255.0
 macsec psk-keychain mac_chain policy R1toR2
!
interface hundredGigE 0/1/0/9
 ipv4 address 192.0.5.1 255.255.255.0
 macsec psk-keychain mac_chain policy R1toR2
!
```

Router 2:

```
sks profile ProfileR2toR1 type remote
 kme server ipv4 192.0.2.35 port 10001
!
macsec-policy R2toR1
 ppk
  sks-profile ProfileR2toR1
 !
!
interface hundredGigE 0/1/0/10
 ipv4 address 192.0.2.2 255.255.255.0
 macsec psk-keychain mac_chain policy R2toR1
!t
interface hundredGigE 0/1/0/11
 ipv4 address 192.0.3.2 255.255.255.0
 macsec psk-keychain mac_chain policy R2toR1
!
interface hundredGigE 0/1/0/12
 ipv4 address 192.0.4.2 255.255.255.0
 macsec psk-keychain mac_chain policy R2toR1
!
interface hundredGigE 0/1/0/9
 ipv4 address 192.0.5.2 255.255.255.0
 macsec psk-keychain mac_chain policy R2toR1
!
```

Verification

```
Router(ios)# show crypto sks profile all
Profile Name        :ProfileR1toR2
Myidentifier       :Router1
Type               :Remote
Reg Client Count     :1

Server
IP                  :192.0.2.34
Port                :10001
Vrf                 :Notconfigured
Source Interface    :Notconfigured
Status              :Connected
Entropy             :true
Key                 :true
Algorithm           :QKD
Local identifier    :Alice
Remote identifier   :Alice

Peerlist
QKD ID               :Bob
State                :Connected

Peerlist
QKD ID               :Alice
State                :Connected


Router(ios)# show crypto sks profile all stats
Profile Name            : ProfileR1toR2
My identifier           : Router1
Server
 IP                     : 192.0.2.34
 Port                   : 10001
 Status                 : connected
Counters
 Capability request         : 1
 Key request                : 3
 Key-id request             : 0
 Entropy request            : 0
 Capability response        : 1
 Key response               : 3
 Key-id response            : 0
 Entropy response           : 0
 Total request              : 4
 Request failed             : 0
 Request success            : 4
 Total response             : 4
 Response failed            : 0
 Response success           : 4
 Retry count                : 0
 Response Ignored           : 0
 Cancelled count            : 0
Response time
 Max Time                   : 100 ms
 Avg Time                   : 10  ms
 Min Time                   : 50  ms
Last transaction
 Transaction Id             : 9
 Transaction type           : Get key
 Transaction status         : Response data received, successfully
 Http code                  : 200 OK (200)
```

Related Commands for MACsec

The following commands are available to verify the SNMP results.

Command	Description
show macsec mka session detail	Displays the details of all MACsec Key Agreement (MKA) sessions on the device.
show macsec mka interface detail	Verifies the MACsec MKA status on the interface.
show macsec ea idb interface	Verifies the MACsec encryption and hardware interface descriptor block (IDB) information on the interface.