Configuring FIPS Mode

The Federal Information Processing Standard (FIPS) 140-2 is an U.S. and Canadian government certification standard that defines requirements that the cryptographic modules must follow. The FIPS specifies best practices for implementing cryptographic algorithms, handling key material and data buffers, and working with the operating system.

In Cisco IOS XR software, these applications are verified for FIPS compliance:

- Secure Shell (SSH)
- Secure Socket Layer (SSL)
- Transport Layer Security (TLS)
- Internet Protocol Security (IPSec) for Open Shortest Path First version 3 (OSPFv3)
- Simple Network Management Protocol version 3 (SNMPv3)
- AAA Password Security

Note Any process that uses any of the following cryptographic algorithms is considered non-FIPS compliant:

- Rivest Cipher 4 (RC4)
- Message Digest (MD5)
- Keyed-Hash Message Authentication Code (HMAC) MD5
- Data Encryption Standard (DES)

The Cisco Common Cryptographic Module (C3M) provides cryptographic services to a wide range of the networking and collaboration products of Cisco. This module provides FIPS-validated cryptographic algorithms for services such as RTP, SSH, TLS, 802.1x, and so on. The C3M provides cryptographic primitives and functions for the users to develop any protocol.

By integrating with C3M, the Cisco IOS-XR software is compliant with the FIPS 140-2 standards and can operate in FIPS mode, level 1 compliance.

AAA Password Security for FIPS compliance is available from Cisco IOS XR Software Release Release 6.2.1 and later. See AAA Password Security for FIPS Compliance.

- Prerequisites for Configuring FIPS, on page 2

• How to Configure FIPS, on page 3
• Configuration Examples for Configuring FIPS, on page 11

Prerequisites for Configuring FIPS

Install and activate the **asr9k-k9sec-px.pie** file.

Note From Cisco IOS XR Software Release 7.0.1 and later, you need not install the **asr9k-k9sec-px.pie**, because the functionality is available in the base image itself.

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command.

If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Guidelines for Enabling FIPS Mode

From Cisco IOS XR Software Release 7.1.2 and later, you must follow these guidelines while enabling FIPS mode:

- You must configure the session with a FIPS-approved cryptographic algorithm. A session configured with non-approved cryptographic algorithm for FIPS (such as, **MD5** and **HMAC-MD5**) does not work. This is applicable for OSPF, BGP, RSVP, ISIS, or any application using key chain with non-approved cryptographic algorithm, and only for FIPS mode (that is, when **crypto fips-mode** is configured).
- If you are using any **HMAC-SHA** algorithm for a session, then you must ensure that the configured *key-string* has a minimum length of 14 characters. Otherwise, the session goes down. This is applicable only for FIPS mode.
- If you try to execute the telnet configuration on a system where the FIPS mode is already enabled, then the system rejects the telnet configuration.
- If telnet configuration already exists on the system, and if FIPS mode is enabled later, then the system rejects the telnet connection. But, it does not affect the telnet configuration as such.
- It is recommended to configure the **crypto fips-mode** command first, followed by the commands related to FIPS in a separate commit. The list of commands related to FIPS with non-approved cryptographic algorithms are:
  - **key chain** *key-chain-name* **key** *key-id* **cryptographic-algorithm MD5**
  - **key chain** *key-chain-name* **key** *key-id* **cryptographic-algorithm HMAC-MD5**
  - **router ospfv3 1 authentication ipsec spi 256 md5** *md5-value*
  - **router ospfv3 1 encryption ipsec spi 256 esp des** *des-value*
  - **router ospfv3 1 encryption ipsec spi 256 esp des** *des-value* **authentication md5** *md5-value*
  - **snmp-server user** *username usergroup-name* **v3 auth md5 priv des56**
  - **ssh server algorithms key-exchange diffie-hellman-group1-sha1**

- **telnet vrf default ipv4 server max-servers** *server-limit*

How to Configure FIPS

Perform these tasks to configure FIPS.

Enabling FIPS mode

SUMMARY STEPS

1. **configure**
2. **crypto fips-mode**
3. Use the **commit** or **end** command.
4. **show logging**
5. **admin**
6. **reload location all**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**crypto fips-mode** **Example:** `RP/0/RSP0/CPU0:router(config)#crypto fips-mode`	Enters FIPS configuration mode. **Note** Stop new incoming SSH sessions while configuring or unconfiguring **crypto fips-mode**. Restart the router upon configuration.
Step 3	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

	Command or Action	Purpose
Step 4	**show logging** **Example:** `RP/0/RSP0/CPU0:router#show logging`	Displays the contents of logging buffers. **Note** Use the **show logging | i fips** command to filter FIPS specific logging messages.
Step 5	**admin** **Example:** `RP/0/RSP0/CPU0:router#admin`	Enters into the admin EXEC mode.
Step 6	**reload location all** **Example:** `RP/0/RSP0/CPU0:router(admin)#reload location all`	Reloads a node or all nodes on a single chassis or multishelf system.

Configuring FIPS-compliant Keys

Perform these steps to configure the FIPS-compliant keys:

Note From Cisco IOS XR Software Release 7.0.1 and later, the crypto keys are auto-generated at the time of router boot up. Hence, you need to perform these steps to generate the keys only if the keys are missing under some scenarios.

Before you begin

Refer the configuration steps in the Enabling FIPS mode, on page 3 section for enabling the FIPS mode.

SUMMARY STEPS

1. **crypto key generate rsa [usage-keys | general-keys]** *key label*
2. **crypto key generate dsa**
3. **show crypto key mypubkey rsa**
4. **show crypto key mypubkey dsa**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**crypto key generate rsa [usage-keys | general-keys]** *key label* **Example:** `RP/0/RSP0/CPU0:router#crypto key generate rsa general-keys rsakeypair`	Generate a RSA key pair. Ensure that all the key pairs meet the FIPS requirements. The length of the key can vary from 1024 to 2048 bits. The option **usage-keys** generates separate RSA key pairs for signing and encryption. The option **general-keys**

	Command or Action	Purpose
		generates a general-purpose RSA key pair for signing and encryption. To delete the RSA key pair, use the **crypto key zeroize rsa** *keypair-label* command.
Step 2	**crypto key generate dsa** **Example:** `RP/0/RSP0/CPU0:router#crypto key generate dsa`	Generate a DSA key pair if required. Ensure that all the key pairs meet the FIPS requirements. The length of the key is restricted to1024 bits. To delete the DSA key pair, use the **crypto key zeroize dsa** *keypair-label* command.
Step 3	**show crypto key mypubkey rsa** **Example:** `RP/0/RSP0/CPU0:router#show crypto key mypubkey rsa`	Displays the existing RSA key pairs
Step 4	**show crypto key mypubkey dsa** **Example:** `RP/0/RSP0/CPU0:router#show crypto key mypubkey dsa`	Displays the existing DSA key pairs

Configuring FIPS-compliant Key Chain

Perform these steps to configure the FIPS-compliant key chain:

Before you begin

Refer the configuration steps in the Enabling FIPS mode, on page 3 section for enabling the FIPS mode.

SUMMARY STEPS

1. **configure**
2. **key chain** *key-chain-name*
3. **key** *key-id*
4. **cryptographic-algorithm** {**HMAC-SHA1-20** | **SHA-1**}
5. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router#configure`	Enters the global configuration mode.

	Command or Action	Purpose
Step 2	**key chain** *key-chain-name* **Example:** `RP/0/RSP0/CPU0:router(config)#key chain mykeychain`	Creates a key chain.
Step 3	**key** *key-id* **Example:** `RP/0/RSP0/CPU0:router(config-mykeychain)#key 1`	Creates a key in the key chain.
Step 4	**cryptographic-algorithm** {**HMAC-SHA1-20** | **SHA-1**} **Example:** `RP/0/RSP0/CPU0:router(config-mykeychain-1)#cryptographic-algorithm HMAC-SHA1-20`	Configures the cryptographic algorithm for the key chain. Ensure that the key chain configuration always uses SHA-1 as the hash or keyed hash message authentication code (hmac) algorithm.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring FIPS-compliant Certificates

Perform these steps to configure the FIPS-compliant certificates:

Before you begin

Refer the configuration steps in the Enabling FIPS mode, on page 3 section for enabling the FIPS mode.

SUMMARY STEPS

1. **configure**
2. **crypto ca trustpoint** *ca-name key label*
3. Use the **commit** or **end** command.
4. **show crypto ca certificates**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**crypto ca trustpoint** *ca-name key label* **Example:** `RP/0/RSP0/CPU0:router(config)#crypto ca trustpoint msiox rsakeypair`	Configures the trustpoint by utilizing the desired RSA keys. Ensure that the certificates meet the FIPS requirements for key length and signature hash or encryption type. **Note** The minimum key length for RSA or DSA key is 1024 bits. The required hash algorithm is SHA-1-20.
Step 3	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 4	**show crypto ca certificates** **Example:** `RP/0/RSP0/CPU0:router#show crypto ca certificates`	Displays the information about the certificate

Configuring FIPS-compliant OSPFv3

Perform these steps to configure the FIPS-compliant OSPFv3:

Before you begin

Refer the configuration steps in the Enabling FIPS mode, on page 3 section for enabling the FIPS mode.

SUMMARY STEPS

1. **configure**
2. **router ospfv3** *process name*
3. **area** *id*

4. **authentication** {**disable** | **ipsec spi** *spi-value* **sha1** [**clear** | **password**] *password*}
5. **exit**
6. **encryption** {**disable** | {**ipsec spi** *spi-value* **esp** {**3des** | **aes** [**192** | **256**] [**clear** | **password**] *encrypt-password*} [**authentication sha1** [**clear** | **password**] *auth-password*]}}
7. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospfv3** *process name* **Example:** `RP/0/RSP0/CPU0:router(config)#router ospfv3 ospfname`	Configures the OSPFv3 process.
Step 3	**area** *id* **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3)#area 1`	Configures the OSPFv3 area ID. The ID can either be a decimal value or an IP address.
Step 4	**authentication** {**disable** | **ipsec spi** *spi-value* **sha1** [**clear** | **password**] *password*} **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3-ar)#authentication ipsec spi 256 sha1 password pa1`	Enables authentication for OSPFv3. Note that the OSPFv3 configuration supports only SHA-1 for authentication. **Note** IPSec is supported only for Open Shortest Path First version 3 (OSPFv3).
Step 5	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3-ar)#exit`	Exits OSPFv3 area configuration and enters the OSPFv3 configuration mode.
Step 6	**encryption** {**disable** | {**ipsec spi** *spi-value* **esp** {**3des** | **aes** [**192** | **256**] [**clear** | **password**] *encrypt-password*} [**authentication sha1** [**clear** | **password**] *auth-password*]}} **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3)#encryption ipsec spi 256 esp 3des password pwd`	Encrypts and authenticates the OSPFv3 packets. Ensure that the OSPFv3 configuration uses the following for encryption in the configuration. • 3DES: Specifies the triple DES algorithm. • AES: Specifies the Advanced Encryption Standard (AES) algorithm. Ensure that SHA1 is chosen if the authentication option is specified.

	Command or Action	Purpose
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring FIPS-compliant SNMPv3 Server

Perform these steps to configure the FIPS-compliant SNMPv3 server:

Before you begin

Refer the configuration steps in the Enabling FIPS mode, on page 3 section for enabling the FIPS mode.

SUMMARY STEPS

1. **configure**
2. **snmp-server user** *username groupname* {**v3** [**auth sha** {**clear** | **encrypted**} *auth-password* [**priv** {**3des** |**aes** { **128** | **192** | **256**} } {**clear** | **encrypted** } *priv-password*]] } [**SDROwner** | **SystemOwner**] *access-list-name*
3. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router#configure`	Enters the global configuration mode.
Step 2	**snmp-server user** *username groupname* {**v3** [**auth sha** {**clear**	**encrypted**} *auth-password* [**priv** {**3des** |**aes** { **128**	**192**	**256**} } {**clear**	**encrypted** } *priv-password*]] } [**SDROwner**	**SystemOwner**] *access-list-name* **Example:**	Configures the SNMPv3 server.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config)#snmp-server user user1 g v3 auth sha clear pass priv aes 128 clear privp`	
Step 3	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring FIPS-compliant SSH Client and Server

Perform these steps to configure the FIPS-compliant SSH Client and the Server:

Before you begin

Refer the configuration steps in the Enabling FIPS mode, on page 3 section for enabling the FIPS mode.

SUMMARY STEPS

1. **ssh** {*ipv4-address* | *ipv6-address*} **cipher aes** {**128-CTR** | **192-CTR** | **256-CTR**} **username** *username*
2. **configure**
3. **ssh server v2**
4. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**ssh** {*ipv4-address*	*ipv6-address*} **cipher aes** {**128-CTR**	**192-CTR**	**256-CTR**} **username** *username* **Example:** `RP/0/RSP0/CPU0:router#ssh 10.1.2.3 cipher aes 128-CTR username user1`	Configures the SSH client. Ensure that SSH client is configured only with the FIPS-approved ciphers. AES(Advanced Encryption Standard)-CTR (Counter mode) is the FIPS-compliant cipher algorithm with key lengths of 128, 192 and 256 bits.
Step 2	**configure** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router# configure`	
Step 3	**ssh server v2** **Example:** `RP/0/RSP0/CPU0:router(config)#ssh server v2`	Configures the SSH server.
Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuration Examples for Configuring FIPS

This section provides examples for configuring FIPS.

Configuring FIPS: Example

This example shows how to configure FIPS:

```
RP/0/3/CPU0:SSH#configure
RP/0/3/CPU0:SSH(config)#crypto fips-mode
RP/0/3/CPU0:SSH(config)#commit
RP/0/3/CPU0:SSH(config)#end
```

This example shows the output of **show logging** command:

```
RP/0/3/CPU0:SSH(config)#crypto fips-mode
RP/0/3/CPU0:SSH(config)#commit
RP/0/3/CPU0:SSH(config)#end
RP/0/3/CPU0:SSH#show logging

Syslog logging: enabled (0 messages dropped, 0 flushes, 0 overruns)
    Console logging: level debugging, 60 messages logged
    Monitor logging: level debugging, 0 messages logged
    Trap logging: level informational, 0 messages logged
    Buffer logging: level debugging, 3 messages logged

Log Buffer (9000000 bytes):
<output omitted>

Log Buffer (307200 bytes):
```

```
RP/0/RSP0/CPU0:Apr 16 12:48:17.736 : cepki[433]: The configuration setting for FIPS mode
has been modified. The system must be reloaded to finalize this configuration change. Please
 refer to the IOS XR System Security Configuration Guide, Federal Information Process
Standard(FIPS) Overview section when modifying the FIPS mode setting.
RP/0/RSP0/CPU0:Apr 16 12:48:17.951 : config[65757]: %MGBL-CONFIG-6-DB_COMMIT :
Configuration committed by user 'lab'. Use 'show configuration commit changes 1000000002'
to view the changes.
RP/0/RSP0/CPU0:Apr 16 12:48:23.988 : config[65757]: %MGBL-SYS-5-CONFIG_I : Configured from
 console by lab


....
....
....
```