TCP Authentication Option

With TCP Authentication Option (TCP-AO), defined in RFC 5925, you can protect long-lived TCP connections against replays using stronger Message Authentication Codes (MACs).

- Overview of TCP Authentication Option, on page 1
- TCP-AO Key Chain, on page 1
- TCP-AO Format, on page 4
- TCP-AO Key Rollover, on page 4
- Restrictions for TCP Authentication Option, on page 5
- How to Configure TCP Authentication Option, on page 5
- Feature Information for TCP Authentication Option, on page 18

Overview of TCP Authentication Option

TCP-AO is the proposed replacement for TCP MD5, defined in RFC 2385. Unlike TCP MD5, TCP-AO is resistant to collision attacks and provides algorithmic agility and support for key management.

TCP-AO has the following distinct features:

- TCP-AO supports the use of stronger Message Authentication Codes (MACs) to enhance the security of long-lived TCP connections.
- TCP-AO protects against replays for long-lived TCP connections, and coordinates key changes between endpoints by providing a more explicit key management.

TCP-AO is supported along with TCP MD5, and you can choose one of the authentication methods. However, a configuration in which one of the devices is configured with the TCP MD5 option and the other with the TCP-AO option is not supported.

TCP-AO Key Chain

TCP-AO is based on traffic keys and Message Authentication Codes (MACs) generated using the keys and a MAC algorithm. The traffic keys are derived from master keys that you can configure in a TCP-AO key chain. Use the key chain key-chain-name tcp command in the global configuration mode to create a TCP-AO key chain and configure keys in the chain. The TCP-AO key chain must be configured on both the peers communicating via a TCP connection.
Keys in a TCP-AO key chain have the following configurable properties:

<table>
<thead>
<tr>
<th>Configurable Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>send-id</strong></td>
<td>Key identifier of the TCP-AO option of the outgoing segment. The send identifier configured on a router must match the receive identifier configured on the peer.</td>
</tr>
<tr>
<td><strong>recv-id</strong></td>
<td>Key identifier compared with the TCP-AO key identifier of the incoming segment during authentication. The receive identifier configured on a router must match the send identifier configured on the peer.</td>
</tr>
</tbody>
</table>
| **cryptographic-algorithm** | The MAC algorithm to be used to create MACs for outgoing segments. The algorithm can be one of the following:  
• AES-128-CMAC authentication algorithm  
• HMAC-SHA-1 authentication algorithm  
• HMAC-SHA-256 authentication algorithm. |
| **include-tcp-options** | This flag indicates whether TCP options other than TCP-AO will be used to calculate MACs. With this flag enabled, the contents of all options along with a zero-filled authentication option, is used to calculate the MAC. When the flag is disabled, all options other than TCP-AO are excluded from MAC calculations. This flag is disabled by default. **Note** The configuration of this flag is overridden by the application configuration when the application configuration is available. |
| **send-lifetime**     | This configuration determines the time for which a key is valid and can be used for TCP-AO-based authentication of TCP segments to be sent. When the lifetime of key elapses and the key expires, the next key with the longest lifetime is selected. |
| **accept-lifetime**   | This configuration determines the time for which a key is valid and can be used for TCP-AO-based authentication of received TCP segments. |
| **key-string**        | The key string is a pre-shared master key configured on both peers and is used to derive the traffic keys. |
Configurable Property | Description
--- | ---
accept-ao-mismatch | This flag determines whether the receiver accepts segments for which the MAC in the incoming TCP-AO does not match the MAC generated on the receiver. With this configuration, incoming segments without TCP Authentication Option are also accepted.

**Note**
- Use this configuration with caution. This configuration disables TCP-AO functionality and key rollover on associated connections.
- The configuration of this flag is overridden by the application configuration when the application configuration is available.

---

**Master Key Tuples**

The key chain and keys are used to create Master Key Tuples (MKTs) that are optimized for look-ups during TCP send and receive operations. An MKT consists of a master key, identifiers for the key, algorithms to be used for the Key Derivation Function (KDF) and MAC, and other properties.

On both the peers, two pointers called current-key and next-key are used to track MKTs.
- current-key: Identifies the MKT that is being used to compute traffic keys for outgoing TCP segments.
- next-key: Identifies the MKT that is ready to be used to authenticate received segments.

**Traffic Keys**

Traffic keys are used to compute MACs of segment data using an MAC algorithm. Traffic keys are derived using a Key Derivation Function (KDF) from an MKT and the KDF context. The KDF context consists of the local and remote IP address pairs and TCP port numbers. For established connections, the KDF context also includes the TCP Initial Sequence Numbers (ISNs) in each direction.

A single MKT can be used to derive the four traffic keys in the following list. An endpoint uses at least three of the keys for authentication.
- Send SYN Traffic Key – the traffic key used to authenticate outgoing SYN.
- Receive SYN Traffic Key – the traffic key used to authenticate incoming SYN.
- Send Other Key – the traffic key used to authenticate all other outgoing TCP segments.
- Receive Other Key – the traffic key used to authenticate all other incoming TCP segments.

**Message Authentication Codes**

An MAC is computed for a TCP segment using the configured MAC algorithm, relevant traffic keys, and the TCP segment data prefixed with a pseudo-header.

**Protection from Replays in Long-lived TCP Connections**

The 32-bit sequence number of TCP segments may roll over and repeat in the case of long-lived TCP connections. As a result of a repetition of sequence numbers, TCP Segments may get replayed within a
connection. To avoid this, TCP-AO uses a 32-bit Sequence Number Extension (SNE) in the pseudo-header along with the TCP sequence number for transmitted and received segments. Thus, TCP-AO emulates a 64-bit sequence number space by combining SNE and the TCP sequence number.

### TCP-AO Format

TCP-AO has the following TLV format in the options sequence of a TCP segment:

<table>
<thead>
<tr>
<th>Kind (1B) = 29</th>
<th>Length (1B)</th>
<th>KeyID (1B)</th>
<th>RNextKeyID (1B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC (12-16B)</td>
<td>MAC</td>
<td>MAC</td>
<td>MAC</td>
</tr>
</tbody>
</table>

The fields of the TLV format are as follows:

- **Kind**: Indicates TCP-AO with a value of 29.
- **Length**: Indicates the length of the TCP-AO sequence.
- **KeyID**: The send identifier of the MKT that was used to generate the traffic keys.
- **RNextKeyID**: The receive identifier of the MKT that is ready to be used to authenticate received segments.
- **MAC**: The MAC computed for the TCP segment data and the prefixed pseudo header.

### TCP-AO Key Rollover

TCP-AO keys are valid for a defined duration configured using the send-lifetime and accept-lifetime properties. If send-lifetime and accept-lifetime are not configured for a key, the key has infinite send and accept lifetimes. Key rollover is initiated based on the send lifetimes of keys. As part of key rollover, a key that is valid and has the longest send lifetime into the future is selected as the active key.

When key rollover is initiated, one of the peer routers, say Router A, indicates that the rollover is necessary. To indicate that the rollover is necessary, Router A sets the RNextKeyID to the receive identifier of the new MKT to be used. On receiving the TCP segment, the peer router, say Router B, finds the MKT indicated by the RNextKeyID in the TCP-AO payload. If the key is available and valid, Router B sets the current key to the new MKT. After Router B has rolled over, Router A also sets the current key to the new MKT.

Key rollover can be initiated by one of the following methods:

- Rollover on send-lifetime expiry
- Rollover with overlapping send-lifetimes

If you do not configure a new key that can be activated before the expiry of the current key, the key may time out and expire. Such an expiry can cause retransmissions with the peer router rejecting segments authenticated with the expired key. The connection may fail due to Retransmission Time Out (RTO). When new valid keys are configured, a new connection is established.
Restrictions for TCP Authentication Option

- The send-id and recv-id of each key in the key chain must be unique. Because send-id and recv-id must be chosen from the range 0 to 255, the TCP-AO key chain can have a maximum of 256 keys.
- Only one keychain can be associated with an application connection. Rollover is always performed within the keys in this keychain.
- TCP-AO does not allow the modification of a key in use. Modify a key after disassociating the key from the connection.
- If the key in use expires, expect segment loss until a new key that has a valid lifetime is configured on each side and keys rollover.

How to Configure TCP Authentication Option

Configure TCP Key Chain and Keys

Configure TCP-AO key chain and keys on both the peers communicating through a TCP connection.

- Ensure that the key-string, send-lifetimes, cryptographic-algorithm, and ids of keys match on both peers.
- Ensure that the send-id on a router matches the recv-id on the peer router. We recommend using the same id for both the parameters unless there is a need to use separate key spaces.
- The send-id and recv-id of a key cannot be reused for another key in the same key chain.
- Do not modify properties of a key in use, except when you need to modify the send-lifetime of the key to trigger rollover. Before modifying properties other than send-lifetime, disassociate the key from the TCP connection.

Step 1
enable
Example:
Device> enable
Enables privileged EXEC mode. Enter your password if prompted.

**Step 2**
**configure terminal**

**Example:**
Device# configure terminal
Enters global configuration mode.

**Step 3**
**key chain key-chain-name tcp**

**Example:**
Device(config)# key chain kc1 tcp
Creates a TCP-AO key chain of with a specified name and enters the TCP-AO key chain configuration mode.
The key chain name can have a maximum of 256 characters.

**Step 4**
**key key-id**

**Example:**
Device(config-keychain-tcp)# key 10
Creates a key with the specified key-id and enters the TCP-AO key chain key configuration mode.
The key-id must be in the range from 0 to 2147483647.

**Note** The key-id has only local significance. It is not part of the TCP Authentication Option.

**Step 5**
**send-id send-identifier**

**Example:**
Device(config-keychain-tcp)# send-id 218
Specifies the send identifier for the key.
The send-identifier must be in the range from 0 to 255.

**Step 6**
**recv-id receiver-identifier**

**Example:**
Device(config-keychain-tcp)# recv-id 218
Specifies the receive identifier for the key.
The receive-identifier must be in the range from 0 to 255.

**Step 7**
**cryptographic-algorithm {aes-128-cmac | hmac-sha-1 | hmac-sha-256}**

**Example:**
Device(config-keychain-tcp)# cryptographic-algorithm hmac-sha-1
Specifies the algorithm to be used to compute MACs for TCP segments.

<table>
<thead>
<tr>
<th>cryptographic-algorithm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>aes-128-cmac</td>
<td>AES-128-CMAC-96: Configures AES-128-CMAC as a cryptographic algorithm with a digest size of 12 bytes.</td>
</tr>
<tr>
<td>hmac-sha-1</td>
<td>HMAC-SHA1-96: Configures HMAC-SHA1-96 as a cryptographic algorithm with a digest size of 12 bytes.</td>
</tr>
</tbody>
</table>
**Step 8**
(Optional) **include-tcp-options**

**Example:**
```
Device(config-keychain-tcp-key)# include-tcp-options
```

This flag indicates whether TCP options other than TCP-AO must be used to calculate MACs.

With the flag enabled, the content of all options, in the order present, is included in the MAC and TCP-AO’s MAC field is zero-filled.

When the flag is disabled, all options other than TCP-AO are excluded from MAC calculations.

By default, this flag is disabled.

**Step 9**
**send-lifetime** [local] **start-time** {infinite | end-time | duration seconds}

**Example:**
```
Device(config-keychain-tcp-key)# send-lifetime local 12:00:00 28 Feb 2018 duration 20
```

Specifies the time for which the key is valid to be used for TCP-AO authentication in the send direction.

Use the `local` keyword to specify the start-time in the local time zone. By default, the start-time corresponds to UTC time.

**Step 10**
**key-string** **master-key**

**Example:**
```
Device(config-keychain-tcp-key)# key-string abcde
```

Specifies the master-key for deriving traffic keys.

The master-keys must be identical on both the peers. If the master-keys do not match, authentication fails and segments may be rejected by the receiver.

**Step 11**
(Optional) **accept-ao-mismatch**

**Example:**
```
Device(config-keychain-tcp-key)# accept-ao-mismatch
```

This flag indicates whether the receiver should accept segments for which the MAC in the incoming TCP AO does not match the MAC generated on the receiver.

**Note** Use this configuration with caution. This configuration disables TCP-AO functionality and key rollover on associated connections.

**Step 12**
**end**

**Example:**
```
Device(config-keychain-tcp-key)# end
```

Exits TCP-AO key chain key configuration mode and returns to privileged EXEC mode.
Verifying TCP-AO Key Chain and Key Configuration

Use the `show key chain key-chain-name` command in the privileged EXEC mode to display information about a TCP-AO key chain and keys, and association with TCBs.

Router1# show key chain key-chain-name

```
Key-chain kc1:
  TCP key chain
  key 7893 -- text "abcde"
  cryptographic-algorithm: hmac-sha-1
  accept lifetime (12:32:00 IST Nov 9 2018) - (10:30:00 IST Dec 30 2019) [valid now]
  send lifetime (13:05:00 IST Jan 12 2019) - (10:31:00 IST Dec 30 2019) [valid now]
  send-id = 218
  recv-id = 218
  include-tcp-options
  MKT ready = true
  MKT preferred = true
  MKT in-use = true
  MKT id = 7893
  MKT send-id = 218
  MKT recv-id = 218
  MKT alive (send) = true
  MKT alive (recv) = true
  MKT include TCP options = true
  MKT accept AO mismatch = false
  TCB = 0x7FBD68361838
curr key = 7893
next key = 7893
```

Verifying TCP-AO Key Chain Information in the TCB

Use the `show tcp tcb address-of-tcb` command in the privileged EXEC mode to display information about TCP-AO in the Transmission Control Block. Obtain `address-of-tcb`(the hexadecimal address of the TCB) from the output of the `show key chain key-chain-name` command.

Router1# show tcp tcb address-of-tcb

```
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Minimum incoming TTL 0, Outgoing TTL 255
Local host: 1.0.2.1, Local port: 40125
Foreign host: 1.0.2.2, Foreign port: 5555
Connection tableid (VRF): 0
Maximum output segment queue size: 50

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x2818B07):
<table>
<thead>
<tr>
<th>Timer</th>
<th>Starts</th>
<th>Wakeups</th>
<th>Next</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrans</td>
<td>1</td>
<td>0</td>
<td>0x0</td>
</tr>
<tr>
<td>TimeWait</td>
<td>0</td>
<td>0</td>
<td>0x0</td>
</tr>
<tr>
<td>AckHold</td>
<td>1</td>
<td>0</td>
<td>0x0</td>
</tr>
<tr>
<td>SendWnd</td>
<td>0</td>
<td>0</td>
<td>0x0</td>
</tr>
<tr>
<td>KeepAlive</td>
<td>6651</td>
<td>0</td>
<td>0x281AC36</td>
</tr>
<tr>
<td>GiveUp</td>
<td>0</td>
<td>0</td>
<td>0x0</td>
</tr>
<tr>
<td>PmtuAger</td>
<td>0</td>
<td>0</td>
<td>0x0</td>
</tr>
</tbody>
</table>
```
Configuring Key Rollover on Send Lifetime Expiry

Configure a new key in the key chain such that the key becomes active on the expiry of the send-lifetime of the currently active key. The examples in the following steps show sample configurations on two peer routers, Router 1 and Router 2. In these examples, the active key has an id of 7890 and the new key has an id of 7891.

**Step 1** Identify the active key on both peer routers.

**Example:**

Identify active key on Router 1:

```
Router1#show run | sec key
key chain kcl tcp
key 7890
send-id 215
recv-id 215
cryptographic-algorithm hmac-sha-1
key-string abcde
```
Identify active key on Router 2:

Router2# show run | sec key
key chain kc1 tcp
  key 7890
  send-id 215
  recv-id 215
  cryptographic-algorithm hmac-sha-1
  key-string abcde

Step 2 Configure the new key on both peer routers.

Example:
Configure new key on Router 1:
key chain kc1 tcp
  key 7890
  send-id 215
  recv-id 215
  cryptographic-algorithm hmac-sha-1
  key-string abcde
  key 7891
    send-id 216
    recv-id 216
    cryptographic-algorithm hmac-sha-1
    key-string fghij

Configure new key on Router 2:
key chain kc1 tcp
  key 7890
  send-id 215
  recv-id 215
  cryptographic-algorithm hmac-sha-1
  key-string abcde
  key 7891
    send-id 216
    recv-id 216
    cryptographic-algorithm hmac-sha-1
    key-string fghij

When the send-lifetime of the active key expires, the new key is activated. Syslog messages are displayed indicating rollover to the new key.

Step 3 Reduce the send-lifetimes of active keys on the peer routers.

Example:
Reduce send-lifetime of the active key on Router 1:
key chain kc1 tcp
  key 7890
  send-id 215
  recv-id 215
  cryptographic-algorithm hmac-sha-1
  key-string abcde
  send-lifetime local 10:00:00 Jun 24 2019 13:45:00 Jun 24 2019
key 7891
  send-id 216
  recv-id 216
  cryptographic-algorithm hmac-sha-1
  key-string fghij

Reduce send-lifetime of active key on Router 2:
key chain kc1 tcp
key 7890
send-id 215
recv-id 215
cryptographic-algorithm hmac-sha-1
key-string abcde
send-lifetime local 10:00:00 Jun 24 2019 13:45:00 Jun 24 2019
key 7891
send-id 216
recv-id 216
cryptographic-algorithm hmac-sha-1
key-string fghij

Step 4 Verify the send-lifetimes of the currently active and new keys on the peer routers.

Example:
Verify send-lifetimes of the keys on Router 1:
Router1# sh key chain
Key-chain kc1:
TCP key chain
Preferred MKT id - 7891
key 7890 -- text "abcde"
cryptographic-algorithm: hmac-sha-1
accept lifetime (always valid) - (always valid) [valid now]
send-lifetime (10:00:00 IST Jun 24 2019) - (13:45:00 IST Jun 24 2019) --- [valid now]
send-id - 215
recv-id - 215
MKT ready - true
MKT preferred - false
MKT in-use - true
MKT id - 7890
MKT send-id - 215
MKT recv-id - 215
MKT alive (send) - true
MKT alive (recv) - true
MKT include TCP options - false
MKT accept AO mismatch - false
TCB - 0x7FC0EC097AC0
curr key - 7890
next key - 7890
TCB - 0x7FC0EBBE7600
curr key - 7890
next key - 7890
key 7891 -- text "fghij"
cryptographic-algorithm: hmac-sha-1
accept lifetime (always valid) - (always valid) [valid now]
send-lifetime (always valid) - (always valid) --- [valid now]
send-id - 216
recv-id - 216
MKT ready - true
MKT preferred - true
MKT in-use - false
MKT id - 7891
MKT send-id - 216
MKT recv-id - 216
MKT alive (send) - true
MKT alive (recv) - true
MKT include TCP options - false
MKT accept AO mismatch - false

Verify send-lifetimes of the keys on Router 2:
Router2# sh key chain
Key-chain kc1:
  TCP key chain
  Preferred MKT id - 7891
  key 7890 -- text "abcde"
    cryptographic-algorithm: hmac-sha-1
    accept lifetime (always valid) - (always valid) [valid now]
    send lifetime (10:00:00 IST Jun 24 2019) - (13:45:00 IST Jun 24 2019) [valid now]
    send-id - 215
    recv-id - 215
    MKT ready - true
    MKT preferred - false
    MKT in-use - true
    MKT id - 7890
    MKT send-id - 215
    MKT recv-id - 215
    MKT alive (send) - true
    MKT alive (recv) - true
    MKT include TCP options - false
    MKT accept AO mismatch - false
    TCB - 0x7FB6BEF4CC10
    curr key - 7890
    next key - 7890
  key 7891 -- text "fghij"
    cryptographic-algorithm: hmac-sha-1
    accept lifetime (always valid) - (always valid) [valid now]
    send lifetime (always valid) - (always valid) [valid now]
    send-id - 216
    recv-id - 216
    MKT ready - true
    MKT preferred - true
    MKT in-use - false
    MKT id - 7891
    MKT send-id - 216
    MKT recv-id - 216
    MKT alive (send) - true
    MKT alive (recv) - true
    MKT include TCP options - false
    MKT accept AO mismatch - false

Step 5  Verify key rollover on the routers using the show key chain command.

Example:
Verify key rollover on Router 1:

Router1# sh key chain
Key-chain kc1:
  TCP key chain
  Preferred MKT id - 7891
  key 7890 -- text "abcde"
    cryptographic-algorithm: hmac-sha-1
    accept lifetime (always valid) - (always valid) [valid now]
    send lifetime (10:00:00 IST Jun 24 2019) - (13:45:00 IST Jun 24 2019)
    send-id - 215
    recv-id - 215
    MKT ready - true
    MKT preferred - false
TCP Authentication Option

Configuring Key Rollover on Send Lifetime Expiry

Verify key rollover on Router 2:

Router2# *Jun 24 08:15:00.000: %TCP-6-AOKEYSENDEXPIRED: TCP AO Keychain kcl key 7890 send lifetime expired
*Jun 24 08:15:00.000: %TCP-6-AOROLLOVER: TCP AO Keychain kcl rollover from key 7890 to key 7891

Router2# sh key chain
Key-chain kcl:
  TCF key chain
  Preferred MKT id - 7891
  key 7890 -- text "abcde"
  cryptographic-algorithm: hmac-sha-1
  accept lifetime (always valid) - (always valid) [valid now]
  send lifetime (10:00:00 IST Jun 24 2019) - (13:45:00 IST Jun 24 2019)
  send-id - 215
  recv-id - 215
  MKT ready - true
  MKT preferred - false
  MKT in-use - false
  MKT id - 7890
  MKT send-id - 215
  MKT recv-id - 215
  MKT alive (send) - false
  MKT alive (recv) - true
  MKT include TCP options - false
  MKT accept AO mismatch - false

key 7891 -- text "fghij"
  cryptographic-algorithm: hmac-sha-1
  accept lifetime (always valid) - (always valid) [valid now]
  send lifetime (always valid) - (always valid) [valid now]
  send-id - 216
  recv-id - 216
  MKT ready - true
  MKT preferred - true
  MKT in-use - true
  MKT id - 7891
  MKT send-id - 216
  MKT recv-id - 216
  MKT alive (send) - true
  MKT alive (recv) - true
  MKT include TCP options - false
  MKT accept AO mismatch - false

TCB - 0x7FC0EBBE7600
  curr key - 7891
  next key - 7891

TCB - 0x7FC0EC097AC0
  curr key - 7891
  next key - 7891

TCP Authentication Option
Configuring Key Rollover with Overlapping Send Lifetimes

Configure a new key in the key chain such that the currently active key and new key have overlapping send-lifetime values. Also, configure the send-lifetime of the new key such that it extends longer into the future than the send-lifetime of the currently active key. During key rollover, the key with the longest send-lifetime into the future is selected as the active key. Thus, when the send-lifetime of the new key begins, the key becomes active.

The examples in the following steps show sample configurations on two peer routers, Router 1 and Router 2. In these examples, the active key has an id of 7890 and the new key has an id of 7891.

**Step 1** Identify the active key on both peer routers.

**Example:**
Identify active key on Router 1:
```
Router1# show run | sec key
key chain kc1 tcp
key 7890
send-id 215
recv-id 215
cryptographic-algorithm hmac-sha-1
key-string abcde
send-lifetime local 10:00:00 Jun 24 2019
10:00:00 Aug 24 2019
```

Identify active key on Router 2:
```
Router2# show run | sec key
key chain kc1 tcp
key 7890
send-id 215
recv-id 215
cryptographic-algorithm hmac-sha-1
key-string abcde
send-lifetime local 10:00:00 Jun 24 2019
10:00:00 Aug 24 2019
```

**Step 2** Configure a new key with an overlapping send-lifetime on both peer routers.

**Example:**
Configure new key on Router 1:
key chain kc1 tcp
key 7890
  send-id 215
  recv-id 215
  cryptographic-algorithm hmac-sha-1
  key-string abcd
  send-lifetime local 10:00:00 Jun 24 2019 10:00:00 Aug 24 2019
key 7891
  send-id 216
  recv-id 216
  cryptographic-algorithm hmac-sha-1
  key-string fghij
  send-lifetime local 21:50:00 Jun 24 2019 11:00:00 Aug 24 2019

Configure new key on Router 2:
key chain kc1 tcp
key 7890
  send-id 215
  recv-id 215
  cryptographic-algorithm hmac-sha-1
  key-string abcd
  send-lifetime local 10:00:00 Jun 24 2019 10:00:00 Aug 24 2019
key 7891
  send-id 216
  recv-id 216
  cryptographic-algorithm hmac-sha-1
  key-string fghij
  send-lifetime local 21:50:00 Jun 24 2019 11:00:00 Aug 24 2019

When the send-lifetime of the new key starts, the new key is activated. Syslog messages are displayed indicating rollover to the new key.

**Step 3** Verify that the send-lifetimes of the currently active and new keys are overlapping.

**Example:**
Verify send-lifetimes of the keys on Router 1:
Router1# sh key chain
Key-chain kc1:
  TCP key chain
  Preferred MKT id - 7890
  key 7890 -- text "abcd"
    cryptographic-algorithm: hmac-sha-1
    accept lifetime (always valid) - (always valid) [valid now]
    send lifetime (10:00:00 IST Jun 24 2019) - (10:00:00 IST Aug 24 2019) [valid now]
  send-id - 215
  recv-id - 215
  MKT ready - true
  MKT preferred - true
  MKT in-use - true
  MKT id - 7890
  MKT send-id - 215
  MKT recv-id - 215
  MKT alive (send) - true
  MKT alive (recv) - true
  MKT include TCP options - false
  MKT accept AO mismatch - false
  TCB - 0x7F8352155318
  curr key - 7890
  next key - 7890
  TCB - 0x7F8352155318
  curr key - 7890
  next key - 7890
key 7891 -- text "fghij"
cryptographic-algorithm: hmac-sha-1
accept lifetime (always valid) - (always valid) [valid now]
send lifetime (21:50:00 IST Jun 24 2019) - (11:00:00 IST Aug 24 2019)
send-id = 216
recv-id = 216
MKT ready = true
MKT preferred = false
MKT in-use = false
MKT id = 7891
MKT send-id = 216
MKT recv-id = 216
MKT alive (send) = false
MKT alive (recv) = true
MKT include TCP options = false
MKT accept AO mismatch = false

Verify send-lifetimes of the keys on Router 2:

Router2#sh key chain
Key-chain kc1:
TCP key chain
Preferred MKT id = 7890
key 7890 -- text "abcde"
cryptographic-algorithm: hmac-sha-1
accept lifetime (always valid) - (always valid) [valid now]
send lifetime (10:00:00 IST Jun 24 2019) - (10:00:00 IST Aug 24 2019)--- [valid now]
send-id = 215
recv-id = 215
MKT ready = true
MKT preferred = true
MKT in-use = true
MKT id = 7890
MKT send-id = 215
MKT recv-id = 215
MKT alive (send) = true
MKT alive (recv) = true
MKT include TCP options = false
MKT accept AO mismatch = false

Step 4 Verify key rollover on the routers using the show key chain command.

Example:
Verify key rollover on Router 1:

Router1# 
*Jun 24 16:20:00.000: %TCP-6-AOROLLOVER: TCP AO Keychain kc1 rollover from key 7890 to key 7891 

Router1#sh key chain 
Key-chain kc1: 
TCP key chain 
Preferred MKT id - 7891 
key 7890 -- text "abcde" 
cryptographic-algorithm: hmac-sha-1 
accept lifetime (always valid) - (always valid) [valid now] 
send lifetime (10:00:00 IST Jun 24 2019) - (10:00:00 IST Aug 24 2019) [valid now] 
send-id - 215 
recv-id - 215 
MKT ready - true 
MKT preferred - false 
MKT in-use - false 
MKT id - 7890 
MKT send-id - 215 
MKT recv-id - 215 
MKT alive (send) - true 
MKT alive (recv) - true 
MKT include TCP options - false 
MKT accept AO mismatch - false 
key 7891 -- text "fghij" 
cryptographic-algorithm: hmac-sha-1 
accept lifetime (always valid) - (always valid) [valid now] 
send lifetime (21:50:00 IST Jun 24 2019) - (11:00:00 IST Aug 24 2019) [valid now] 
send-id - 216 
recv-id - 216 
MKT ready - true 
MKT preferred - true 
MKT in-use - true 
MKT id - 7891 
MKT send-id - 216 
MKT recv-id - 216 
MKT alive (send) - true 
MKT alive (recv) - true 
MKT include TCP options - false 
MKT accept AO mismatch - false 
TCB - 0x7F8352FF37F0 
curr key - 7891 
next key - 7891 

TCB - 0x7F8352155318 
curr key - 7891 
next key - 7891 

Verify key rollover on Router 2:

Router2# 
*Jun 24 16:20:00.000: %TCP-6-AOROLLOVER: TCP AO Keychain kc1 rollover from key 7890 to key 7891 

Router2#sh key chain 
Key-chain kc1: 
TCP key chain 
Preferred MKT id - 7891 
key 7890 -- text "abcde" 
cryptographic-algorithm: hmac-sha-1 
accept lifetime (always valid) - (always valid) [valid now] 
send lifetime (10:00:00 IST Jun 24 2019) - (10:00:00 IST Aug 24 2019) [valid now] 
send-id - 215 
recv-id - 215 
MKT ready - true 
MKT preferred - false 
MKT in-use - false 
MKT id - 7890 
MKT send-id - 215 
MKT recv-id - 215 
MKT alive (send) - true 
MKT alive (recv) - true 
MKT include TCP options - false 
MKT accept AO mismatch - false
Feature Information for TCP Authentication Option

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

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

Table 1: Feature Information for TCP Authentication Option

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP Authentication Option</td>
<td>Cisco IOS XE</td>
<td>With TCP Authentication Option (TCP-AO), defined in RFC 5925, you can protect long-lived TCP connections against replays using stronger Message Authentication Codes (MACs). The following commands were introduced or modified: key chain key-chain-name tcp, show key chain, and show tcp tcb.</td>
</tr>
<tr>
<td></td>
<td>Gibraltar 16.12.1</td>
<td></td>
</tr>
</tbody>
</table>