排除Catalyst 9000上的MACsec故障

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- 捆绑/端口通道接口上具有MKA的MACsec交换机到交换机链路安全
- 第2层中间交换机之间的MACsec交换机到交换机链路安全，PSK模式

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简介

本文档介绍MACsec功能、其使用案例以及如何对Catalyst 9000交换机上的功能进行故障排除。

先决条件

要求

本文档没有任何特定的要求。

使用的组件

- C9300
- C9400
- C9500
- C9600

注意：请参阅相应的配置指南，了解用于在其他Cisco平台上启用这些功能的命令。

本文档中的信息都是基于特定实验室环境中的设备编写的。本文档中使用的所有设备最初均采用原始（默认）配置。如果您的网络处于活动状态，请确保您了解所有命令的潜在影响。

背景信息

本文档的范围是两台交换机/路由器之间的LAN上的介质访问安全控制(MACsec)。

明文数据通信容易受到安全威胁。 安全漏洞可能发生在OSI模型的任何层。第2层的一些常见漏洞是嗅探、数据包窃听、篡改、注入、MAC地址欺骗、ARP欺骗、针对DHCP服务器的拒绝服务(DoS)攻击以及VLAN跳跃。

MACsec是IEEE 802.1AE标准中描述的一种L2加密技术。 MACsec可保护物理介质上的数据，使数据不可能在更高层受到危害。因此，MACsec加密比任何其他更高层加密方法（例如IPsec和SSL）的优先级更高。

MACsec的优点

面向客户端的模式：MACsec用于两个相互对等交换机在交换密钥之前可以交替作为密钥服务器或密钥客户端的设置。密钥服务器生成并维护两个对等体之间的CAK。

数据完整性检查:MACsec使用MKA为到达端口的帧生成完整性检查值(ICV)。如果生成的ICV与帧中的ICV相同，则接受该帧；否则丢弃该帧。

数据加密：MACsec在交换机的接口上提供端口级加密。这意味着从配置的端口发出的帧会被加密，端口上收到的帧会被解密。MACsec还提供一种机制，在该机制中您可以配置是仅加密帧还是所有加密帧

接口上接受帧（加密和明文）。

重播保护：当帧通过网络传输时，帧可能会脱离有序的序列。MACsec提供了一个可配置的窗口，该窗口接受指定数量的无序帧。

MACsec和MTU

MACsec报头最多可增加32个字节的报头开销。考虑路径中交换机上更大的系统/接口最大传输单元(MTU)，以解决MACsec报头增加的额外开销。 如果MTU太低，您可以看到需要使用更高MTU的应用程序出现意外的丢包/延迟。

注意：如果存在与MACsec相关的问题，请确保根据兼容性表支持两端的千兆字节接口转换器

(GBIC)。

使用MACsec的位置

园区使用案例

- 主机到交换机
- 在站点或建筑之间
- 多租户中的楼层之间

数据中心使用案例

- 数据中心互联
- 服务器到交换机

WAN使用案例

- 数据中心互联
- 园区互联
- 中心辐射型

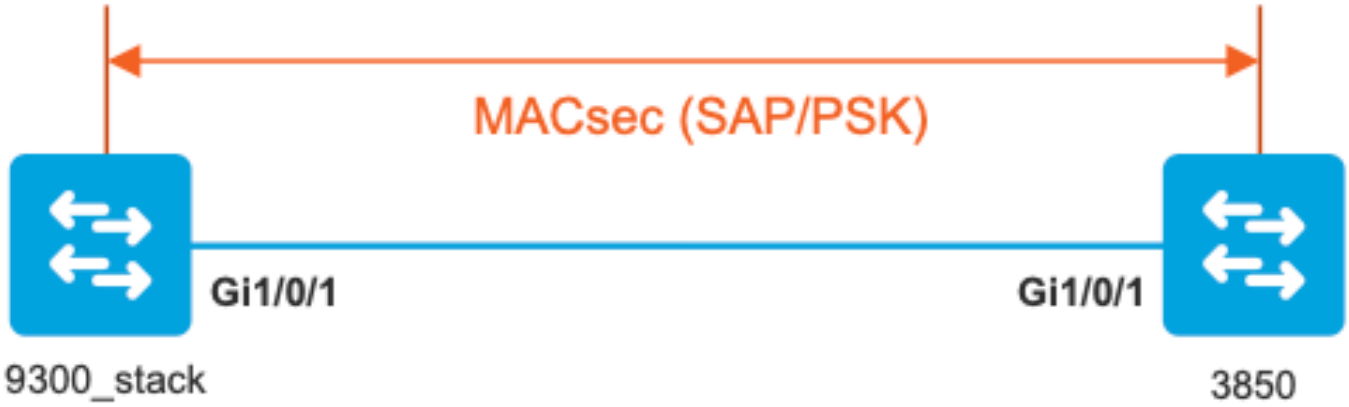
术语

MKA	MACsec密钥协议	在IEEE 802.1X REV-2010中定义为用于发现MACsec对等体和协商密钥的关键协议协议
CAK	连接关联密钥	用于生成所有其他用于MACsec的密钥的长寿命主密钥。 LAN实施从MSK派生此信息（在EAP交换期间生成）
PMK	成对主键	用于派生用于加密流量的会话密钥的组件之一。手动配置或从802.1X派生
CKN	CAK密钥名称	用于配置密钥值或CAK。仅允许偶数个十六进制字符（最多64个字符）。
SAK	安全关联密钥	由从CAK选出的密钥服务器派生，是路由器/终端设备用于加密给定会话流量的密钥。
ICV	完整性检查值键	从CAK派生，并在每个数据/控制帧中标记，以证明该帧来自授权对等体。8-16个字节，具体取决于密码套件
KEK	密钥加密密钥	派生自CAK（预共享密钥），用于保护MACsec密钥
SCI	安全通道标识符	每个虚拟端口接收一个唯一的安全通道标识符(SCI)，该标识符基于与16位端口ID连接的物理接口的MAC地址

场景1：在预共享密钥(PSK)模式下使用SAP实现MACsec交换机到

交换机的链路安全

拓扑



步骤1:验证链路两端的配置。

<#root>

9300_stack#

show run interface gig 1/0/1

```
interface GigabitEthernet1/0/1
description MACsec_manual_3850-2-gi1/0/1
switchport access vlan 10
switchport mode trunk
```

cts manual

no propagate sgt

sap pmk

AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

mode-list gcm-encrypt <-- use full packet encrypt mode

3850#

show run interface gig1/0/1

```
interface GigabitEthernet1/0/1
description 9300-1gi1/0/1 MACsec manual
switchport access vlan 10
switchport mode trunk
```

cts manual

no propagate sgt

sap pmk

AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

mode-list gcm-encrypt

NOTE:

cts manual

<-- Supplies local configuration for Cisco TrustSec parameters

no propagate sgt

<-- disable SGT tagging on a manually-configured TrustSec-capable interface,

if you do not need to propage the SGT tags.

sap pmk AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA mode-list gcm-encrypt

<--

Use the sap command to manually specify the Pairwise Primary Key (PMK) and the Security Association Prot

authentication and encryption modes to negotiate MACsec link encryption between two interfaces.

The default encryption is sap modelist gcm-encrypt null

9300_stack#(config-if-cts-manual)#

sap pmk fa mode-list

?
gcm-encrypt GCM authentication, GCM encryption
gmac GCM authentication, no encryption
no-encap No encapsulation
null Encapsulation present, no authentication, no encryption

Use "gcm-encrypt" for full GCM-AES-128 encryption.

These protection levels are supported when you configure SAP pairwise primary key (sap pmk):

SAP is not configured– no protection.
sap mode-list gcm-encrypt gmac no-encap–protection desirable but not mandatory.
sap mode-list gcm-encrypt gmac–confidentiality preferred and integrity required.
The protection is selected by the supplicant according to supplicant preference.
sap mode-list gmac –integrity only.
sap mode-list gcm-encrypt-confidentiality required.
sap mode-list gmac gcm-encrypt-integrity required and preferred, confidentiality optional.

第二步： 检验MACsec状态，以及参数/计数器是否正确。

<#root>

Ping issued between endpoints to demonstrate counters

Host-1#

ping 10.10.10.12 <-- sourced from Host-1 IP 10.10.10.11

!!!!!!!!!!!!!!!!!!!!

9300_stack#

sh MACsec summary

Interface

Transmit SC Receive SC <-- Secure Channel (SC) flag is set for transmit and receive

GigabitEthernet1/0/1

1 1

9300_stack#

sh MACsec interface gigabitEthernet 1/0/1

MACsec is enabled

Replay protect : enabled
Replay window : 0
Include SCI : yes
Use ES Enable : no
Use SCB Enable : no
Admin Pt2Pt MAC : forceTrue(1)

```
 Pt2Pt MAC Operational : no
 Cipher : GCM-AES-128

 Confidentiality Offset : 0
!
Capabilities

 ICV length : 16
 Data length change supported: yes
 Max. Rx SA : 16
 Max. Tx SA : 16
 Max. Rx SC : 8
 Max. Tx SC : 8
 Validate Frames : strict
 PN threshold notification support : Yes
 Ciphers supported :

    GCM-AES-128

    GCM-AES-256

    GCM-AES-XPN-128

    GCM-AES-XPN-256

!
Transmit Secure Channels

   SCI : 682C7B9A4D010000
   SC state : notInUse(2)

 Elapsed time : 03:17:50

   Start time : 7w0d
   Current AN: 0
   Previous AN: 1
   Next PN: 185
   SA State: notInUse(2)
   Confidentiality : yes
   SAK Unchanged : no

  SA Create time : 03:58:39

   SA Start time : 7w0d

   SC Statistics
```

```
   Auth-only Pkts : 0
   Auth-only Bytes : 0
   Encrypt Pkts : 2077
   Encrypt Bytes : 0
!
SA Statistics
   Auth-only Pkts : 0
Encrypt Pkts : 184
<-- packets are being encrypted and transmitted on this link
!
Port Statistics
   Egress untag pkts 0
   Egress long pkts 0
!
Receive Secure Channels
   SCI : D0C78970C3810000
   SC state : notInUse(2)
   Elapsed time : 03:17:50
   Start time : 7w0d
   Current AN: 0
   Previous AN: 1
   Next PN: 2503
   RX SA Count: 0
   SA State: notInUse(2)
   SAK Unchanged : no
SA Create time : 03:58:39
   SA Start time : 7w0d
   SC Statistics
   Notvalid pkts 0
   Invalid pkts 0
   Valid pkts 28312
   Valid bytes 0
   Late pkts 0
   Uncheck pkts 0
   Delay pkts 0
   UnusedSA pkts 0
   NousingSA pkts 0
   Decrypt bytes 0
!
   SA Statistics
```

```
      Notvalid pkts 0
      Invalid pkts 0
```

Valid pkts 2502

<-- number of valid packets received on this link

```
      UnusedSA pkts 0
      NousingSA pkts 0
!
Port Statistics
Ingress untag pkts 0
Ingress notag pkts 36
Ingress badtag pkts 0
Ingress unknownSCI pkts 0
Ingress noSCI pkts 0
Ingress overrun pkts 0
!

9300_stack#
```

sh cts interface summary

```
Global Dot1x feature is Disabled
CTS Layer2 Interfaces
---------------------
Interface  Mode   IFC-state  dot1x-role   peer-id  IFC-cache  Critical-Authentication
-------------------------------------------------------------------------------
Gi1/0/1
```

MANUAL   OPEN

```
      unknown    unknown    invalid     Invalid

CTS Layer3 Interfaces
---------------------
Interface IPv4 encap IPv6 encap IPv4 policy IPv6 policy
-------------------------------------------------------------------------
!

9300_stack#
```

sh cts interface gigabitEthernet 1/0/1

```
Global Dot1x feature is Disabled
Interface GigabitEthernet1/0/1:
```

CTS is enabled, mode: MANUAL

```
IFC state: OPEN
```

Interface Active for 04:10:15.723 <--- Uptime of MACsec port

```
Authentication Status: NOT APPLICABLE
Peer identity: "unknown"
Peer's advertised capabilities: "sap"
Authorization Status: NOT APPLICABLE
!
```

SAP Status: SUCCEEDED <-- SAP is successful

```
   Version: 2
   Configured pairwise ciphers:
   gcm-encrypt
!
```

Replay protection: enabled

Replay protection mode: STRICT

```
!
Selected cipher: gcm-encrypt
!
Propagate SGT: Disabled
Cache Info:
Expiration : N/A
Cache applied to link : NONE
!
Statistics:
   authc success: 0
   authc reject: 0
   authc failure: 0
   authc no response: 0
   authc logoff: 0
```

sap success: 1 <-- Negotiated once

sap fail: 0   <-- No failures

authz success: 0

authz fail: 0

port auth fail: 0

L3 IPM: disabled

第三步： 当链路接通时，检查软件调试。

<#root>

Verify CTS and SAP events

```
debug cts sap events
debug cts sap packets
```

Troubleshoot MKA session bring up issues

debug mka event
debug mka errors
debug mka packets

Troubleshoot MKA keep-alive issues

debug mka linksec-interface
debug mka MACsec
debug MACsec

*May 8 00:48:04.843: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/1, changed state to down
*May 8 00:48:05.324: interface GigabitEthernet1/0/1 is UP

***May 8 00:48:05.324: CTS SAP ev (Gi1/0/1): Session started (new).**

***May 8 00:48:05.324: cts_sap_session_start CTS SAP ev (Gi1/0/1) peer:0000.0000.0000**
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

CTS SAP ev (Gi1/0/1): Old state: [waiting to restart],
event: [restart timer expired], action:

[send message #0] succeeded.

New state: [waiting to receive message #1].

***May 8 00:48:05.449: CTS SAP ev (Gi1/0/1): EAPOL-Key message from D0C7.8970.C381   <-- MAC of peer switc**

***May 8 00:48:05.449: CTS SAP ev (Gi1/0/1): EAPOL-Key message #0 parsed and validated.**

***May 8 00:48:05.449: CTS SAP ev (Gi1/0/1): Our MAC = 682C.7B9A.4D01   <-- MAC of local inte**

peer's MAC = D0C7.8970.C381.
CTS SAP ev (Gi1/0/1): Old state: [waiting to receive message #1],

event: [received message #0], action: [break tie] succeeded.

New state: [determining role].

***May 8 00:48:05.449: cts_sap_generate_pmkid_and_sci CTS SAP ev (Gi1/0/1) auth:682c.7b9a.4d01 supp:d0c7.8**
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

CTS SAP ev (Gi1/0/1): Old state: [determining role],

event: [change to authenticator], action: [send message #1] succeeded.

New state: [waiting to receive message #2].

***May 8 00:48:05.457: CTS SAP ev (Gi1/0/1): EAPOL-Key message from D0C7.8970.C381.**

CTS SAP ev (Gi1/0/1): New keys derived:
KCK = 700BEF1D 7A8E10F7 1243A168 883C74FB,
KEK = C207177C B6091790 F3C5B4B1 D51B75B8,
TK = 1B0E17CD 420D12AE 7DE06941 B679ED22,

***May 8 00:48:05.457: CTS SAP ev (Gi1/0/1): EAPOL-Key message #2 parsed and validated.**

***May 8 00:48:05.457: CTS-SAP ev: cts_sap_action_program_msg_2: (Gi1/0/1) GCM is allowed.**

*May 8 00:48:05.457: MACsec-IPC: sending clear_frames_option
*May 8 00:48:05.457: MACsec-IPC: geting switch number
*May 8 00:48:05.457: MACsec-IPC: switch number is 1
*May 8 00:48:05.457: MACsec-IPC: clear_frame send msg success
*May 8 00:48:05.457: MACsec-IPC: getting MACsec clear frames response
*May 8 00:48:05.457: MACsec-IPC: watched boolean waken up
*May 8 00:48:05.457: MACsec-CTS: create_sa invoked for SA creation
*May 8 00:48:05.457: MACsec-CTS: Set up TxSC and RxSC before we installTxSA and RxSA
*May 8 00:48:05.457: MACsec-CTS: create_tx_sc, avail=yes sci=682C7B9A
*May 8 00:48:05.457: NGWC-MACsec: create_tx_sc vlan invalid
*May 8 00:48:05.457: NGWC-MACsec: create_tx_sc client vlan=1, sci=0x682C7B9A4D010000
*May 8 00:48:05.457: MACsec-IPC: sending create_tx_sc
*May 8 00:48:05.457: MACsec-IPC: geting switch number
*May 8 00:48:05.457: MACsec-IPC: switch number is 1
*May 8 00:48:05.457: MACsec-IPC: create_tx_sc send msg success
*May 8 00:48:05.458: MACsec API blocking the invoking context
*May 8 00:48:05.458: MACsec-IPC: getting MACsec sa_sc response
*May 8 00:48:05.458: MACsec_blocking_callback
*May 8 00:48:05.458: Wake up the blocking process
*May 8 00:48:05.458: MACsec-CTS: create_rx_sc, avail=yes sci=D0C78970
*May 8 00:48:05.458: NGWC-MACsec: create_rx_sc client vlan=1, sci=0xD0C78970C3810000
*May 8 00:48:05.458: MACsec-IPC: sending create_rx_sc
*May 8 00:48:05.458: MACsec-IPC: geting switch number
*May 8 00:48:05.458: MACsec-IPC: switch number is 1
*May 8 00:48:05.458: MACsec-IPC: create_rx_sc send msg success
*May 8 00:48:05.458: MACsec API blocking the invoking context
*May 8 00:48:05.458: MACsec-IPC: getting MACsec sa_sc response
*May 8 00:48:05.458: MACsec_blocking_callback
*May 8 00:48:05.458: Wake up the blocking process
*May 8 00:48:05.458: MACsec-CTS: create_tx_rx_sa, txsci=682C7B9A, an=0
*May 8 00:48:05.458: MACsec-IPC: sending install_tx_sa
*May 8 00:48:05.458: MACsec-IPC: geting switch number
*May 8 00:48:05.458: MACsec-IPC: switch number is 1
*May 8 00:48:05.459: MACsec-IPC: install_tx_sa send msg success
*May 8 00:48:05.459: NGWC-MACsec:Sending authorized event to port SM
*May 8 00:48:05.459: MACsec API blocking the invoking context
*May 8 00:48:05.459: MACsec-IPC: getting MACsec sa_sc response
*May 8 00:48:05.459: MACsec_blocking_callback
*May 8 00:48:05.459: Wake up the blocking process
*May 8 00:48:05.459: MACsec-CTS: create_tx_rx_sa, rxsci=D0C78970, an=0
*May 8 00:48:05.459: MACsec-IPC: sending install_rx_sa
*May 8 00:48:05.459: MACsec-IPC: getting switch number

```
*May 8 00:48:05.459: MACsec-IPC: switch number is 1
*May 8 00:48:05.460: MACsec-IPC: install_rx_sa send msg success
*May 8 00:48:05.460: MACsec API blocking the invoking context
*May 8 00:48:05.460: MACsec-IPC: getting MACsec sa_sc response
*May 8 00:48:05.460: MACcsec_blocking_callback
*May 8 00:48:05.460: Wake up the blocking process
CTS SAP ev (Gi1/0/1): Old state: [waiting to receive message #2],
event: [received message #2], action: [program message #2] succeeded.
New state: [waiting to program message #2].
CTS SAP ev (Gi1/0/1): Old state: [waiting to program message #2],
event: [data path programmed], action: [send message #3] succeeded.
```

New state: [waiting to receive message #4].

***May 8 00:48:05.467: CTS SAP ev (Gi1/0/1): EAPOL-Key message from D0C7.8970.C381.**

***May 8 00:48:05.467: CTS SAP ev (Gi1/0/1): EAPOL-Key message #4 parsed and validated.**

***May 8 00:48:05.473: CTS-SAP ev: cts_sap_sync_sap_info: incr sync msg sent for Gi1/0/1**

***May 8 00:48:07.324: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/1, changed state to up**

第四步：查看链路接通时的平台级跟踪。

<#root>

9300_stack#

sh platform software fed switch 1 ifm mappings

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
GigabitEthernet1/0/1	0x8	1	0	1	0	0	26	6	1	1	NIF	Y

Note the IF_ID for respective intf

- This respective IF_ID shows in MACsec FED traces seen here.

9300_stack#

set platform software trace fed switch 1 cts_aci verbose

9300_stack#

set platform software trace fed switch 1 MACsec verbose

<-- switch number with MACsec port

9300_stack#

request platform software trace rotate all

/// shut/no shut the MACsec interface ///

9300_stack#

show platform software trace message fed switch 1

2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sent MACsec_

2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sending MACs

2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Running Instal
2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing job
2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Install RxSA c
2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing SPI
2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): MACSec install
2019/05/08 01:08:50.688 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): Entering ins_rx_

2019/05/08 01:08:50.688 {fed_F0-0}{1}: [l2tunnel_bcast] [16837]: UUID: 0, ra: 0, TID: 0 (ERR): port_idMA

2019/05/08 01:08:50.687 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sent macsec_

2019/05/08 01:08:50.687 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sending macs

2019/05/08 01:08:50.687 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): if_id = 8, cts_

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Calling Install

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [sec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): sci=0x682c7b9a4d01

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing job

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Create time of

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): sci=0x682c7b9a4

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Install TxSA ca

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing SPI

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): MACSec install T

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): Entering ins_tx_

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sent macsec_

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sending macs

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Conf_Offset in

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Successfully in

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Secy policy han

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Install policy

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Attach policy

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Creating drop e

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): if_id = 8, cts_

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): sci=0x682c7b9a4

2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Create RxSC ca
2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing SPI
2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): MACSec create R
2019/05/08 01:08:50.686 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): Entering cre_rx_
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sent macsec_
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sending mac
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): txSC setting x

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Conf_Offset in

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): if_id = 8, cts_

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): secy created su

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): if_id = 8, cts_

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): if_id = 8, cts_

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): is_remote is 0

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Create TxSC cal

2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing SPI
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): MACSec create TX
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): Entering cre_tx_
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sent clear_t
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): FED sending mac
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing job
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (debug): Processing SPI
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): MACSec clear_fra
2019/05/08 01:08:50.685 {fed_F0-0}{1}: [MACsec] [16837]: UUID: 0, ra: 0, TID: 0 (info): Entering clear_t
2019/05/08 01:08:50.527 {fed_F0-0}{1}: [pm_xcvr] [17885]: UUID: 0, ra: 0, TID: 0 (note): XCVR POST:XCVR
speed_auto Oper Speed:speed_gbps1 Autoneg Mode:Unknown autonegmode type
2019/05/08 01:08:50.525 {fed_F0-0}{1}: [xcvr] [17885]: UUID: 0, ra: 0, TID: 0 (note): ntfy_lnk_status:

2019/05/08 01:08:48.142 {fed_F0-0}{1}: [pm_xcvr] [16837]: UUID: 0, ra: 0, TID: 0 (note): Enable XCVR for

2019/05/08 01:08:48.142 {fed_F0-0}{1}: [pm_tdl] [16837]: UUID: 0, ra: 0, TID: 0 (note): Received PM port

第五步：验证硬件中MACsec接口的状态。

<#root>

9300_stack#

sh platform pm interface-numbers

interface iif-id gid slot unit slun HWIDB-Ptr status status2 state snmp-if-index

---

Gi1/0/1 8 1 1 1 1 0x7F2C90D7C600 0x10040 0x20001B 0x4 8

9300_stack#

sh pl software fed switch 1 ifm if-id 8 <-- iif-id 8 maps to gig1/0/1

Interface IF_ID : 0x0000000000000008

Interface Name : GigabitEthernet1/0/1

Interface Block Pointer : 0x7f4a6c66b1b8
Interface Block State : READY

Interface State : Enabled

Interface Status : ADD, UPD
Interface Ref-Cnt : 8
Interface Type : ETHER
Port Type : SWITCH PORT

Port Location : LOCAL

Slot : 1
Unit : 0
Slot Unit : 1
SNMP IF Index : 8
GPN : 1
EC Channel : 0
EC Index : 0

Port Handle : 0x4e00004c

LISP v4 Mobility : false
LISP v6 Mobility : false
QoS Trust Type : 3
!
Port Information
Handle ..... [0x4e00004c]
Type ..... [Layer2]
Identifier ..... [0x8]
Slot ..... [1]
Unit ..... [1]

Port Physical Subblock
Affinity ..... [local]
Asic Instance ..... [1 (A:0,C:1)]
AsicPort ..... [0]
AsicSubPort ..... [0]
MacNum ..... [26]
ContextId ..... [6]
LPN ..... [1]
GPN ..... [1]
Speed ..... [1GB]
type ..... [NIF]

PORT_LE ..... [0x7f4a6c676bc8]

<--- port_LE

L3IF_LE ..... [0x0]
DI ..... [0x7f4a6c67d718]
SubIf count ..... [0]

```
Port L2 Subblock
Enabled ..... [Yes]
Allow dot1q ..... [Yes]
Allow native ..... [Yes]
Default VLAN ..... [1]
Allow priority tag ... [Yes]
Allow unknown unicast [Yes]
Allow unknown multicast[Yes]
Allow unknown broadcast[Yes]
Allow unknown multicast[Enabled]
Allow unknown unicast [Enabled]
Protected ..... [No]
IPv4 ARP snoop ..... [No]
IPv6 ARP snoop ..... [No]
Jumbo MTU ..... [1500]
Learning Mode ..... [1]
Vepa ..... [Disabled]

Port QoS Subblock
Trust Type ..... [0x2]
Default Value ..... [0]
Ingress Table Map ..... [0x0]
Egress Table Map ..... [0x0]
Queue Map ..... [0x0]
Port Netflow Subblock
Port Policy Subblock
List of Ingress Policies attached to an interface
List of Egress Policies attached to an interface
```

Port CTS Subblock

```
Disable SGACL ..... [0x0]
Trust ..... [0x0]
Propagate ..... [0x0]
%Port SGT ..... [-1717360783]
```

Physical Port Macsec Subblock <-- This block is not present when MACsec is not enabled

MACsec Enable .... [Yes]

MACsec port handle.... [0x4e00004c] <-- Same as PORT_LE

MACsec Virtual port handles....

.....**[0x11000005]**

```
MACsec Rx start index.... [0]
MACsec Rx end index.... [6]
MACsec Tx start index.... [0]
MACsec Tx end index.... [6]

Ref Count : 8 (feature Ref Counts + 1)
```

```
IFM Feature Ref Counts
FID : 102 (AAL_FEATURE_SRTP), Ref Count : 1
FID : 59 (AAL_FEATURE_NETFLOW_ACL), Ref Count : 1
FID : 95 (AAL_FEATURE_L2_MULTICAST_IGMP), Ref Count : 1
FID : 119 (AAL_FEATURE_PV_HASH), Ref Count : 1
FID : 17 (AAL_FEATURE_PBB), Ref Count : 1
FID : 83 (AAL_FEATURE_L2_MATM), Ref Count : 1
FID : 30 (AAL_FEATURE_URPF_ACL), Ref Count : 1
IFM Feature Sub block information
FID : 102 (AAL_FEATURE_SRTP), Private Data : 0x7f4a6c9a0838
FID : 59 (AAL_FEATURE_NETFLOW_ACL), Private Data : 0x7f4a6c9a00f8
FID : 17 (AAL_FEATURE_PBB), Private Data : 0x7f4a6c9986b8
FID : 30 (AAL_FEATURE_URPF_ACL), Private Data : 0x7f4a6c9981c8


9300_stack#
```

sh pl hard fed switch 1 fwd-asic abstraction print-resource-handle 0x7f4a6c676bc8 1 <-- port_LE handle

```
Handle:0x7f4a6c676bc8 Res-Type:ASIC_RSC_PORT_LE Res-Switch-Num:0 Asic-Num:1 Feature-ID:AL_FID_IFM Lkp-f
priv_ri/priv_si Handle: (nil)Hardware Indices/Handles: index1:0x0 mtu_index/l3u_ri_index1:0x2 sm handle
Detailed Resource Information (ASIC# 1)

**snip**
LEAD_PORT_ALLOW_CTS value 0 Pass
LEAD_PORT_ALLOW_NON_CTS value 0 Pass
```

LEAD_PORT_CTS_ENABLED value 1 Pass <-- Flag = 1 (CTS enabled)

LEAD_PORT_MACsec_ENCRYPTED value 1 Pass <-- Flag = 1 (MACsec encrypt enabled)

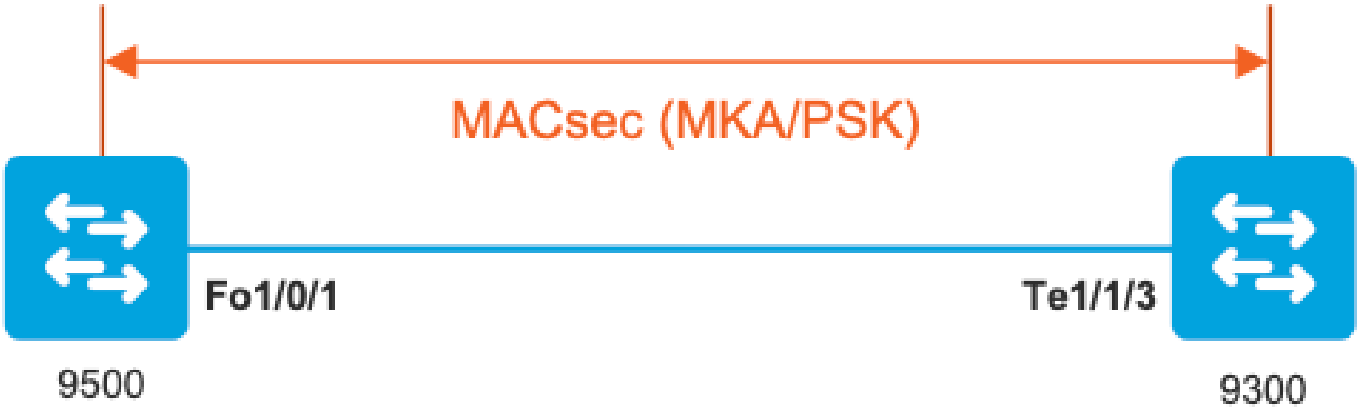
```
LEAD_PORT_PHY_MAC_SEC_SUB_PORT_ENABLED value 0 Pass
LEAD_PORT_SGT_ALLOWED value 0 Pass
```

LEAD_PORT_EGRESS_MAC_sec_ENABLE_WITH_SCI value 1 Pass <-- Flag = 1 (MACsec with SCI enabled)

```
LEAD_PORT_EGRESS_MAC_sec_ENABLE_WITHOUT_SCI value 0 Pass
LEAD_PORT_EGRESS_MAC_sec_SUB_PORT value 0 Pass
LEAD_PORT_EGRESS_MACsec_ENCRYPTED value 0 Pass
**snip**
```

场景2：在预共享密钥(PSK)模式下使用MKA的MACsec交换机到交换机链路安全

拓扑



步骤1:验证链路两端的配置。

<#root>

C9500#

sh run | sec key chain

```
key chain KEY MACsec
 key 01
   cryptographic-algorithm aes-256-cmac
  key-string 7 101C0B1A0343475954532E2E767B3233214105150555030A0004500B514B175F5B05515153005E0E5E505C52
```

lifetime local 00:00:00 Aug 21 2019 infinite <-- use NTP to sync the time for key chains

mka policy MKA

```
key-server priority 200
MACsec-cipher-suite gcm-aes-256
confidentiality-offset 0
```

C9500#

sh run interface fo1/0/1

```
interface fo1/0/1
```

MACsec network-link

mka policy MKA

mka pre-shared-key key-chain KEY

C9300#

sh run interface te1/1/3

interface te1/1/3

MACsec network-link

mka policy MKA

mka pre-shared-key key-chain KEY

步骤2.验证MACsec已启用且所有参数/计数器均正确。

<#root>

This example shows the output from one side, verify on both ends of MACsec tunnel

C9500#

sh MACsec summary

Interface Transmit SC Receive SC

FortyGigabitEthernet1/0/1 1 1

C9500#

sh MACsec interface fortyGigabitEthernet 1/0/1

MACsec is enabled

Replay protect : enabled
Replay window : 0
Include SCI : yes
Use ES Enable : no
Use SCB Enable : no
Admin Pt2Pt MAC : forceTrue(1)
Pt2Pt MAC Operational : no

Cipher : GCM-AES-256

Confidentiality Offset : 0

Capabilities

ICV length : 16

Data length change supported: yes
Max. Rx SA : 16
Max. Tx SA : 16
Max. Rx SC : 8
Max. Tx SC : 8
Validate Frames : strict
PN threshold notification support : Yes

Ciphers supported : GCM-AES-128

GCM-AES-256

GCM-AES-XPN-128

GCM-AES-XPN-256

Transmit Secure Channels

SCI : 0CD0F8DCDC010008
SC state : notInUse(2)

Elapsed time : 00:24:38

Start time : 7w0d
Current AN: 0
Previous AN: -
Next PN: 2514
SA State: notInUse(2)
Confidentiality : yes
SAK Unchanged : yes

SA Create time : 1d01h

SA Start time : 7w0d

SC Statistics

Auth-only Pkts : 0
Auth-only Bytes : 0

Encrypt Pkts : 3156 <-- can increment with Tx traffic

Encrypt Bytes : 0

SA Statistics

Auth-only Pkts : 0

Encrypt Pkts : 402 <-- can increment with Tx traffic

Port Statistics

Egress untag pkts 0
Egress long pkts 0

Receive Secure Channels

SCI : A0F8490EA91F0026
SC state : notInUse(2)

Elapsed time : 00:24:38

Start time : 7w0d
Current AN: 0
Previous AN: -
Next PN: 94
RX SA Count: 0
SA State: notInUse(2)
SAK Unchanged : yes
SA Create time : 1d01h
SA Start time : 7w0d

SC Statistics

Notvalid pkts 0
Invalid pkts 0
Valid pkts 0
Valid bytes 0
Late pkts 0
Uncheck pkts 0
Delay pkts 0
UnusedSA pkts 0
NousingSA pkts 0
Decrypt bytes 0

SA Statistics

Notvalid pkts 0
Invalid pkts 0

Valid pkts 93

UnusedSA pkts 0
NousingSA pkts 0
!

Port Statistics

Ingress untag pkts 0

Ingress notag pkts 748

Ingress badtag pkts 0
Ingress unknownSCI pkts 0
Ingress noSCI pkts 0
Ingress overrun pkts 0

C9500#

sh mka sessions interface fortyGigabitEthernet 1/0/1

Summary of All Currently Active MKA Sessions on Interface FortyGigabitEthernet1/0/1...

Interface	Local-TxSCI	Policy-Name	Inherited	Key-Server Port-ID	Peer-RxSCI	MACsec-Peers	Status	CKN
Fo1/0/1	**0cd0.f8dc.dc01/0008**	**MKA**	NO	YES	**8**	**a0f8.490e.a91f/0026**	**1**	**Secured01**	**<-- CKN number must match on both sides**

0cd0.f8dc.dc01

<--

MAC of local interface

a0f8.490e.a91f

<--

MAC of remote neighbor

8

<-- indicates IIF_ID of respective local port (here IF_ID is 8 for local port fo1/0/1)

C9500#

sh platform pm interface-numbers | in iif|1/0/1

interface

iif-id

  gid slot unit slun   HWIDB-Ptr   status   status2 state snmp-if-index

Fo1/0/1

8

     1   1   1   1   0x7EFF3F442778 0x10040 0x20001B 0x4   8

C9500#

sh mka sessions interface fortyGigabitEthernet 1/0/1 detail

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

Local Tx-SCI..... 0cd0.f8dc.dc01/0008

Interface MAC Address.... 0cd0.f8dc.dc01

MKA Port Identifier..... 8

Interface Name..... FortyGigabitEthernet1/0/1

Audit Session ID.....
CAK Name (CKN)..... 01
Member Identifier (MI)... DFDC62E026E0712F0F096392

Message Number (MN)..... 536   <-- can increment as message numbers increment

EAP Role..... NA
Key Server..... YES

MKA Cipher Suite..... AES-256-CMAC

Latest SAK Status..... Rx & Tx
Latest SAK AN..... 0
Latest SAK KI (KN)..... DFDC62E026E0712F0F09639200000001 (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)
SAK Rekey Time..... 0s (SAK Rekey interval not applicable)

MKA Policy Name..... MKA

```
Key Server Priority...... 200
Delay Protection......... NO
Delay Protection Timer.......... 0s (Not enabled)

Confidentiality Offset... 0
Algorithm Agility........ 80C201
SAK Rekey On Live Peer Loss........ NO
Send Secure Announcement.. DISABLED
SAK Cipher Suite......... 0080C20001000002 (GCM-AES-256)
MACsec Capability........ 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired........... YES
```

# of MACsec Capable Live Peers..... 1 <-- Peers capable of MACsec

# of MACsec Capable Live Peers Responded.. 1 <-- Peers that responded to MACsec negotiation

Live Peers List:

```
MI                        MN    Rx-SCI (Peer)        KS           RxSA
                                                    Priority     Installed
--------------------------------------------------------------------------------
```

ACF0BD8ECCA391A197F4DF6B 537 a0f8.490e.a91f/0026   200   YES <-- One live peer

!

Potential Peers List:

```
MI                        MN    Rx-SCI (Peer)        KS           RxSA
                                                   Priority     Installed
--------------------------------------------------------------------------------
```

Check the MKA policy and ensure that it is applied to expected interface

C9500#

sh mka policy MKA

```
MKA Policy defaults :
Send-Secure-Announcements: DISABLED
!
MKA Policy Summary...
!
Codes : CO - Confidentiality Offset, ICVIND - Include ICV-Indicator,
SAKR OLPL - SAK-Rekey On-Live-Peer-Loss,
DP - Delay Protect, KS Prio - Key Server Priority
```

Policy

```
      KS    DP       CO SAKR    ICVIND  Cipher   Interfaces
```

Name

Prio OLPL Suite(s) Applied

==========

MKA

200 FALSE 0 FALSE TRUE

GCM-AES-256

Fo1/0/1 <-- Applied to Fo1/0/1

Ensure that PDU counters are incrementing at Tx/Rx at both sides.

This is useful to determine the direction of issues at transport. ###

C9500#

sh mka statistics | sec PDU

MKPDU Statistics

MKPDUs Validated & Rx..... 2342 <-- can increment

"Distributed SAK"..... 0
"Distributed CAK"..... 0

MKPDUs Transmitted..... 4552 <-- can increment

MKA Error Counters

C9500#

show mka statistics

** snip***

MKA Error Counter Totals

==========

Session Failures

Bring-up Failures..... 0
Reauthentication Failures..... 0
Duplicate Auth-Mgr Handle..... 0

```
!
```

SAK Failures

```
SAK Generation..................... 0
Hash Key Generation................ 0
SAK Encryption/Wrap................ 0
SAK Decryption/Unwrap.............. 0
SAK Cipher Mismatch................ 0
!
```

CA Failures

```
Group CAK Generation.............. 0
Group CAK Encryption/Wrap........ 0
Group CAK Decryption/Unwrap...... 0
Pairwise CAK Derivation.......... 0
CKN Derivation..................... 0
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
!
```

MKPDU Failures

```
MKPDU Tx........................... 0
MKPDU Rx Validation................ 0
MKPDU Rx Bad Peer MN.............. 0
MKPDU Rx Non-recent Peerlist MN.. 0
```

第3步到第5步

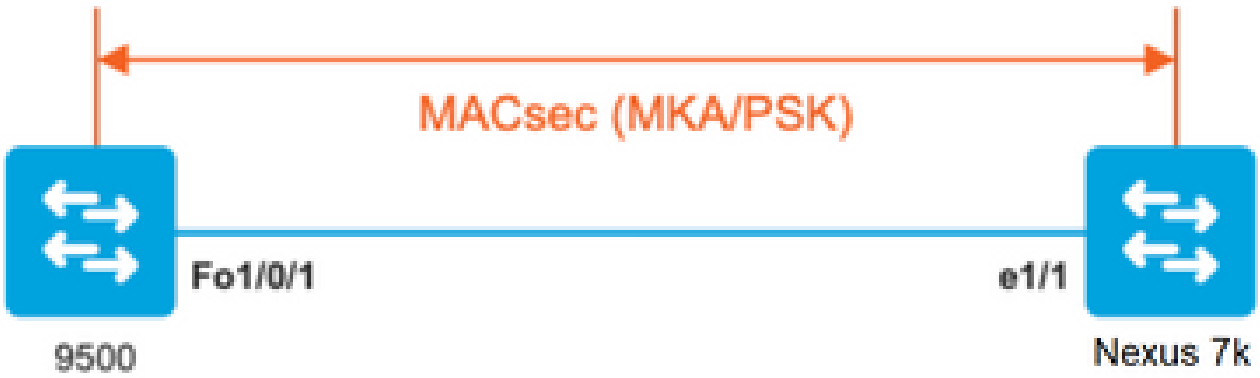
使用场景1中提到的相同说明。

警告：出于互操作性的目的，请注意某些平台有填充功能，而某些平台没有。这会导致mka会话保持初始状态的关键问题。您可以使用命令show mka sessions进行验证。

填充问题示例

此使用案例显示了NX-OS 8.2(2)中的Catalyst 9500和Nexus 7k，但也可能与C3560CX等Catalyst设备配合使用。

(思科漏洞ID CSCvs92023记录了问题)。



- 如果使用场景2中显示的配置，由于密钥不匹配，MKA无法建立隧道。
- 由于此设备不进行填充，因此必须在9500端手动完成密钥和0。

Catalyst 9500

<#root>

```
conf t
  key chain MACsec1 MACsec
     key
```

01000000000000000000000000000000000000000000000000000000000000000000 --> device does not do padding automati

```
       key-string 12345678901234567890123456789012
       end
```

Nexus 7k

<#root>

```
conf t
  key chain MACsec1 MACsec
```

key 01 --> Device does automatic padding.

```
      key-octet-string 12345678901234567890123456789012
      end
```

其他配置选项

捆绑/端口通道接口上具有MKA的MACsec交换机到交换机链路安全

- L3和L2端口通道（LACP、PAgP和模式开启）
- 加密类型（AES-128和AES-256,AES-256适用于Advantage许可证）
- 仅密钥交换MKA PSK

支持的平台:

- Catalyst 9200（仅AES-128）
- Catalyst 9300
- Catalyst 9400
- Catalyst 9500和Catalyst 9500H
- Catalyst 9600

交换机到交换机Etherchannel配置示例

密钥链和MKA策略配置保持不变，如前面的MKA配置部分所示。

<#root>

interface <> <-- This is the physical member link. MACsec encrypts on the individual links

MACsec network-link

```
mka policy <policy-name>
mka pre-shared-key key-chain <key-chain name>
macsec replay-protection window-size frame number
```

channel-group

mode active <-- Adding physical member to the port-channel

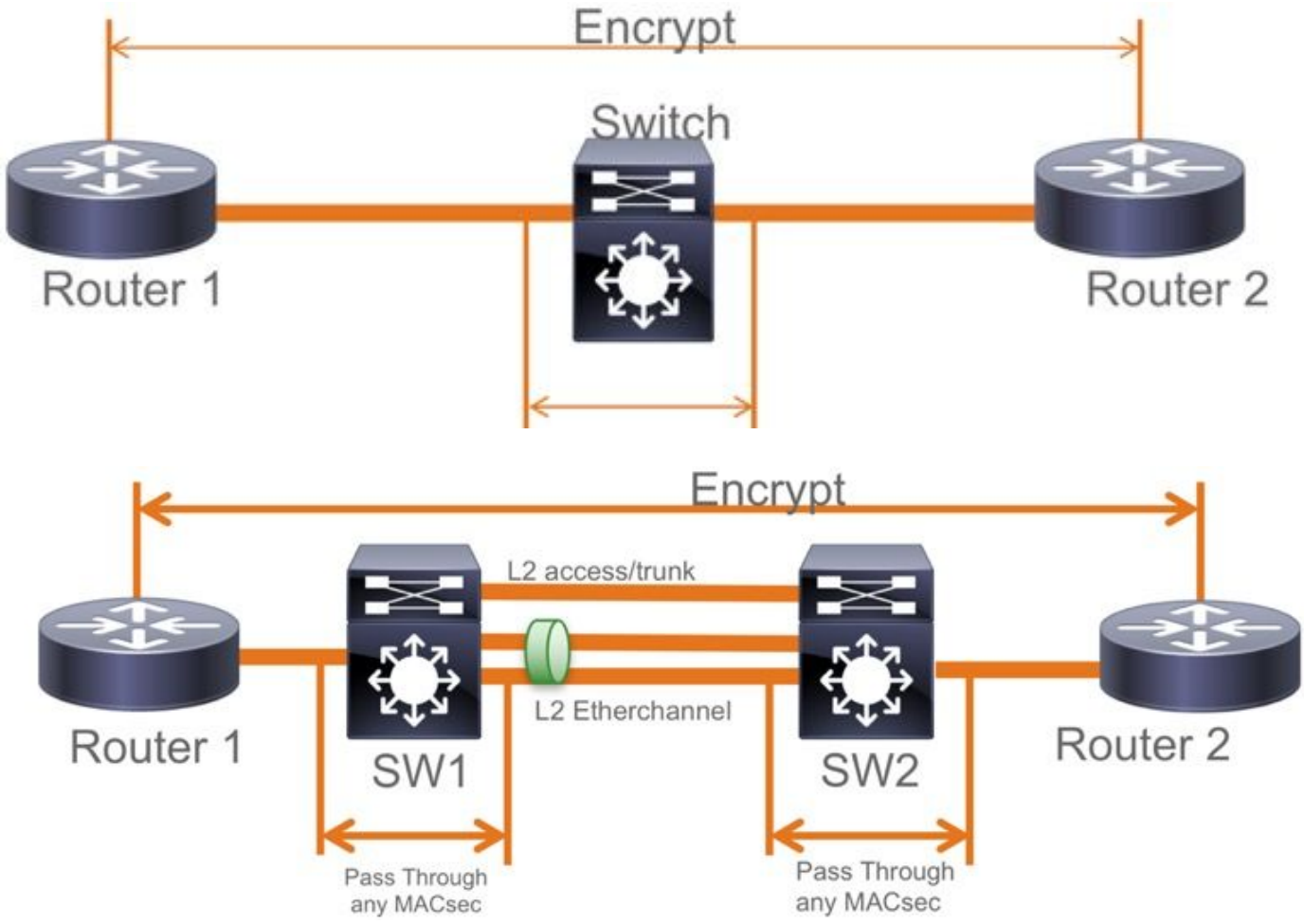
第2层中间交换机之间的MACsec交换机到交换机链路安全，PSK模式

本节介绍一些受支持的WAN MACsec场景，其中Cat9K需要透明地传递加密数据包。

有时，路由器没有直接连接，但是它们有L2中间交换机，L2交换机可以绕过加密数据包，而无需任何加密处理。

从16.10(1)开始，Catalyst 9000交换机使用Clear Tag透明转发数据包

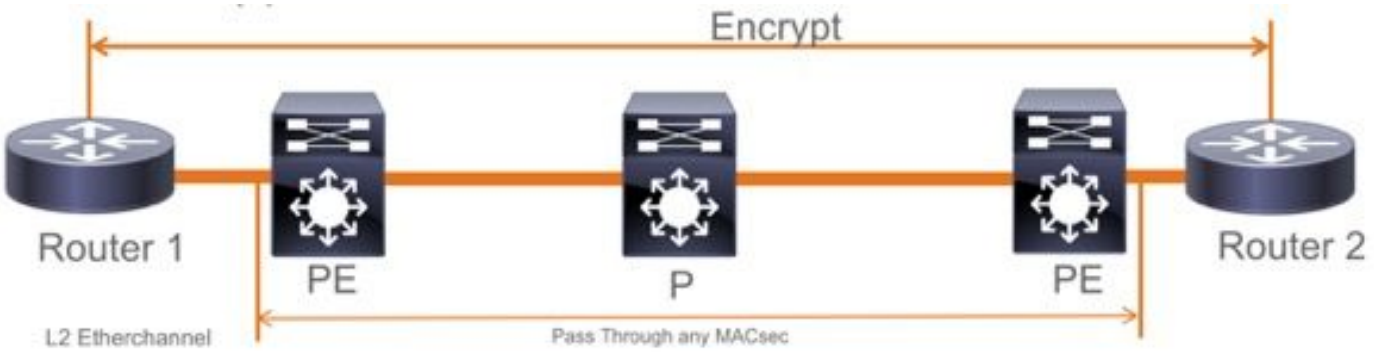
- MKA/SAP支持直通
- 支持L2接入、中继或Etherchannel
- 默认支持（没有要启用/禁用的配置CLI）
- 确保路由器使用非默认(0x888E)以太网类型发送EAPOL帧



EoMPLS/VPLS拓扑

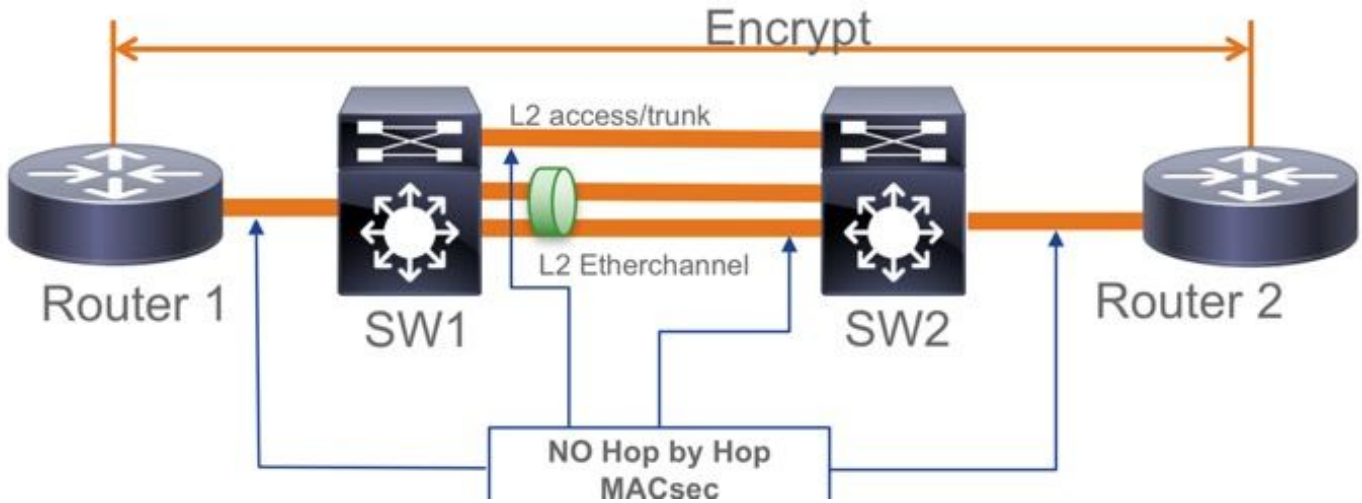
支持PE或P设备Cat 9300/9400、9500/9500H平台

- VPLS
- EoMPLS
- 默认支持（没有要启用/禁用的配置CLI）
- 开始16.10(1)

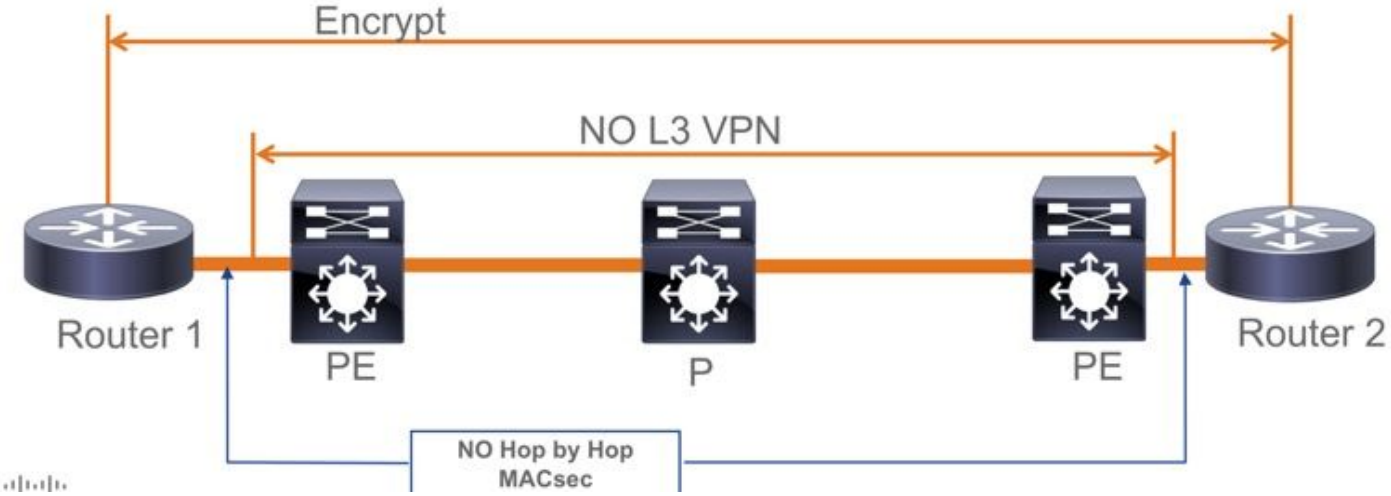


限制

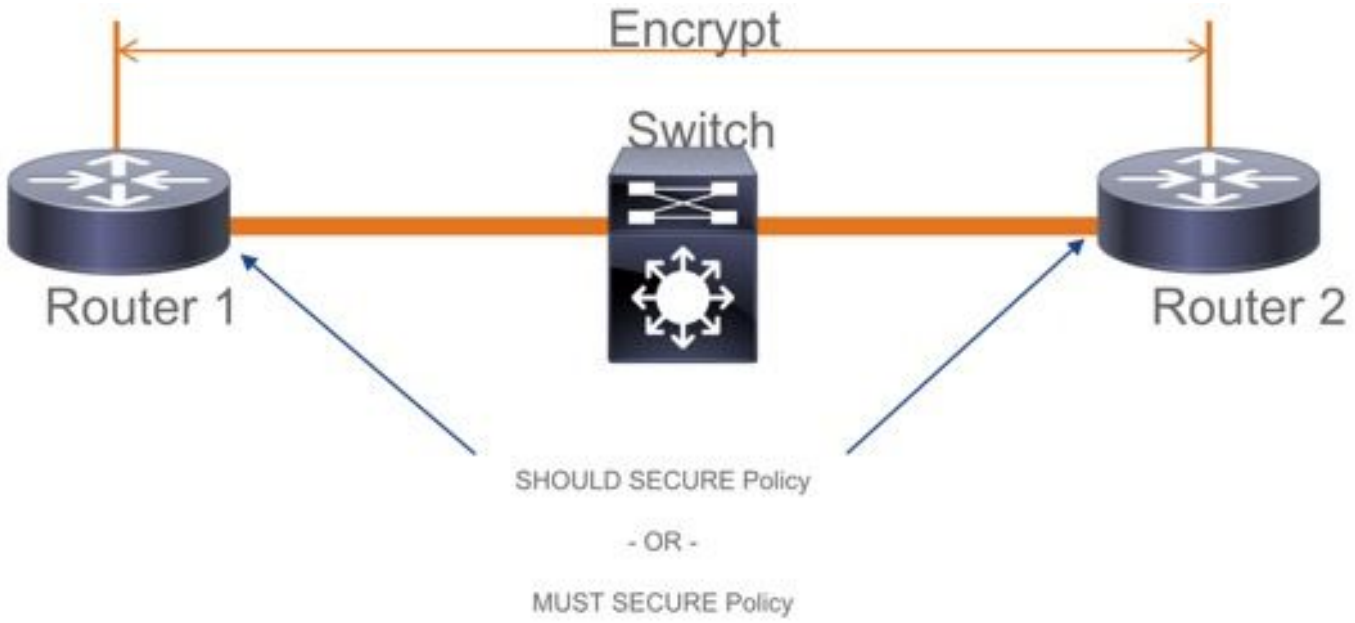
不支持双重加密。带Clear标签的端到端MACsec要求逐跳交换机不能在L2直连链路上启用。



- ClearTag + EoMPLS（仅使用中间第2层交换机），MACsec无法在CE-PE链路上启用
- 不支持带有中间交换机的ClearTag + L3VPN



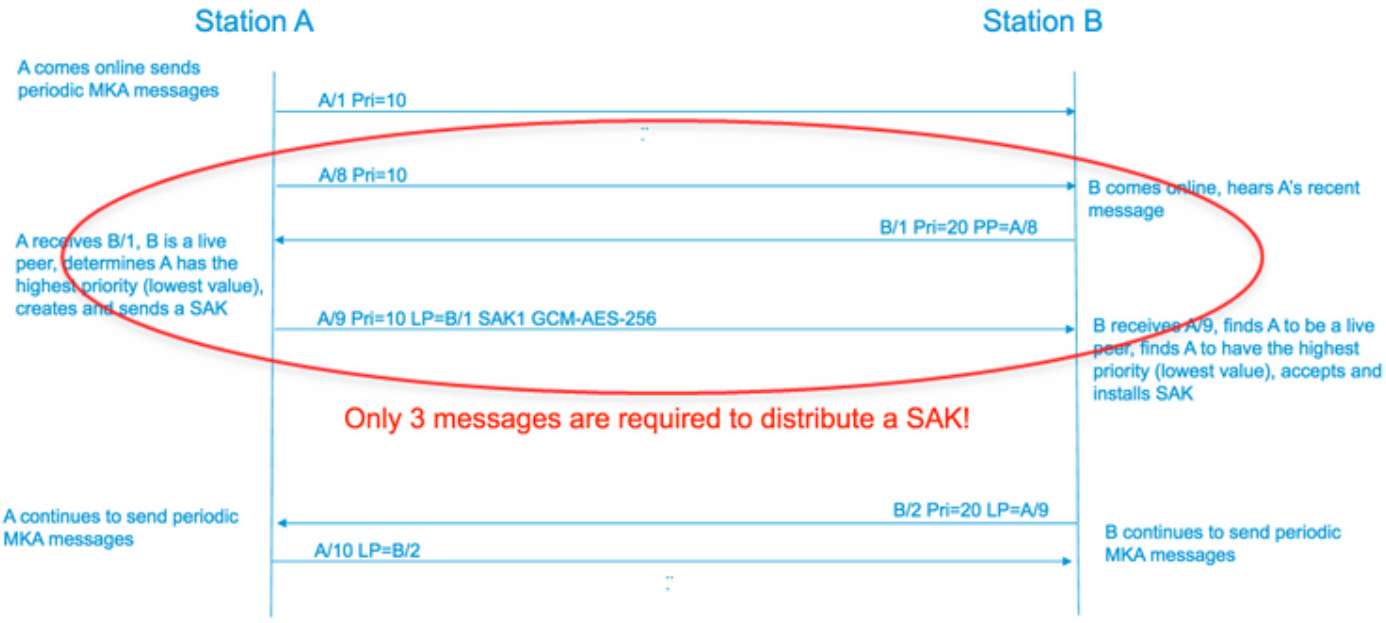
- 在PSK模式下不支持Should Secure。Must Secure是默认模式。
- Must Secure policy does not encrypt only EAPoL to negotiate the MACsec settings.（必须安全策略不仅加密EAPoL才能协商MACsec设置。）



MACsec操作信息

操作顺序

1. 当链路和两台终端设备恢复时，它们会交换MKA帧（ethertype = 0x888E，与数据包类型为MKA的EAPOL相同）。它是多点到多点协商协议。CAK密钥值（通常为静态预共享）、密钥名称(CKN)必须匹配，并且ICV必须有效才能发现和接受对等体。
2. 具有最低密钥服务器优先级（默认值为0）的设备被选为密钥服务器。密钥服务器生成SAK并通过MKA消息分发。如果安全信道标识符(SCI)的最高值为胜。
3. 随后，所有MACsec安全帧都使用对称加密(SAC)进行加密。创建了单独的TX和RX安全通道。但加密和解密使用相同的密钥SAK。
4. 当在多路访问LAN中检测到新设备时（通过EAPOL-MKA消息），密钥服务器生成供所有设备使用的新密钥。新密钥在所有设备确认后开始使用（请参阅IEEE标准802.1X-2010第9.17.2节）。



MACsec数据包

控制帧(EAPOL-MKA)

- EAPOL目标MAC = 01:80:C2:00:00:03将数据包组播到多个目标
- EAPOL以太网类型= 0x888E

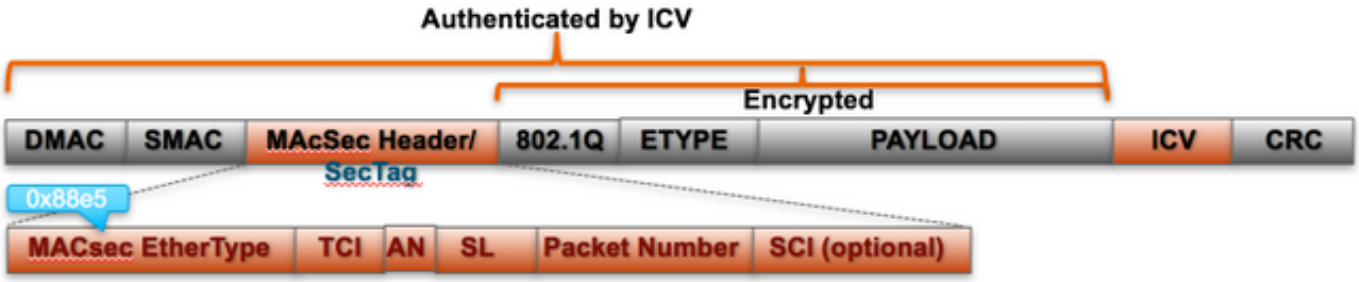
控制帧格式的L2负载。

Protocol Version		
Packet Type = EAPOL-MKA		
Packet Body Length		Size
Packet Body (MKPDU)	Basic Parameter Set	Multiple of 4 octets
	Parameter Set	Multiple of 4 octets
	Parameter Set	Multiple of 4 octets
	ICV	16 octets

数据帧

MACsec会在数据帧上插入两个额外的标记，最大开销为32字节（最少16字节）。

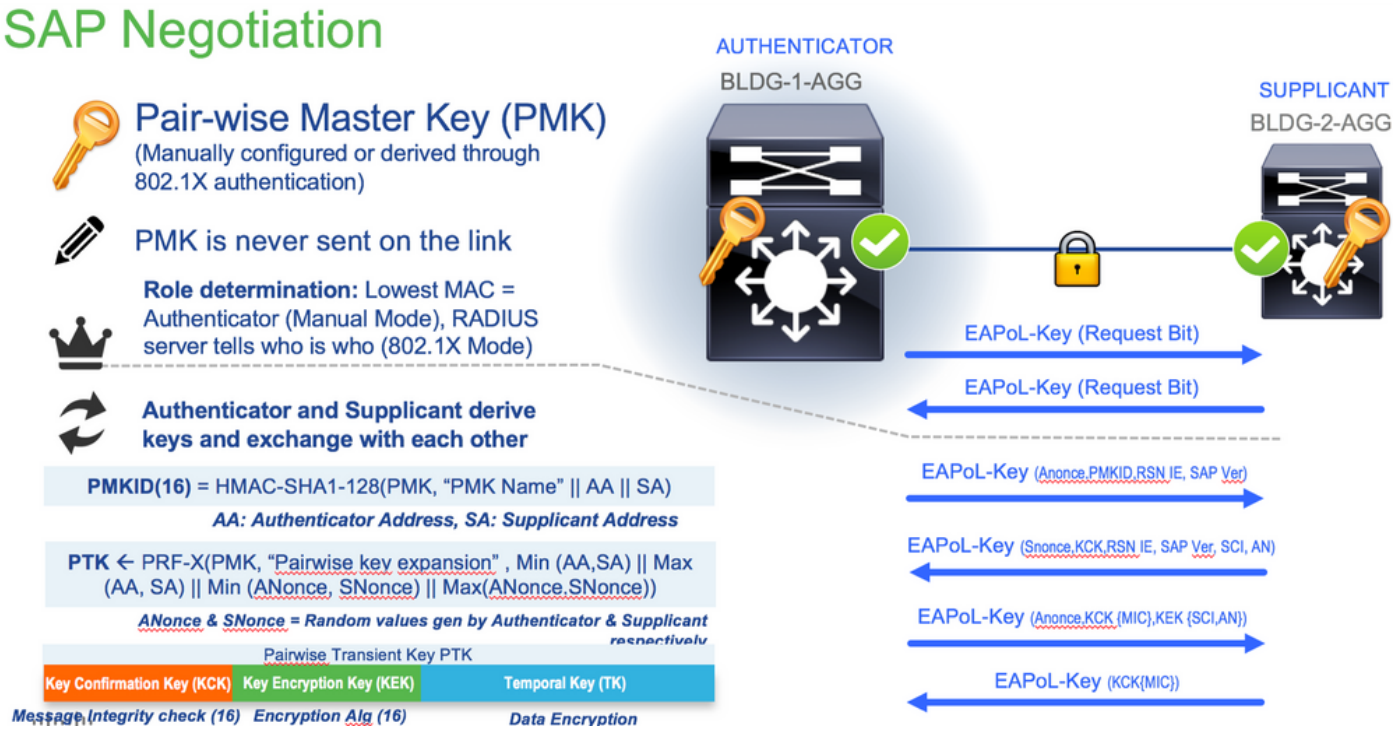
- SecTag = 8到16个字节（8个字节SCI可选）
- ICV = 8到16个字节，基于密码套件(AES128/256)



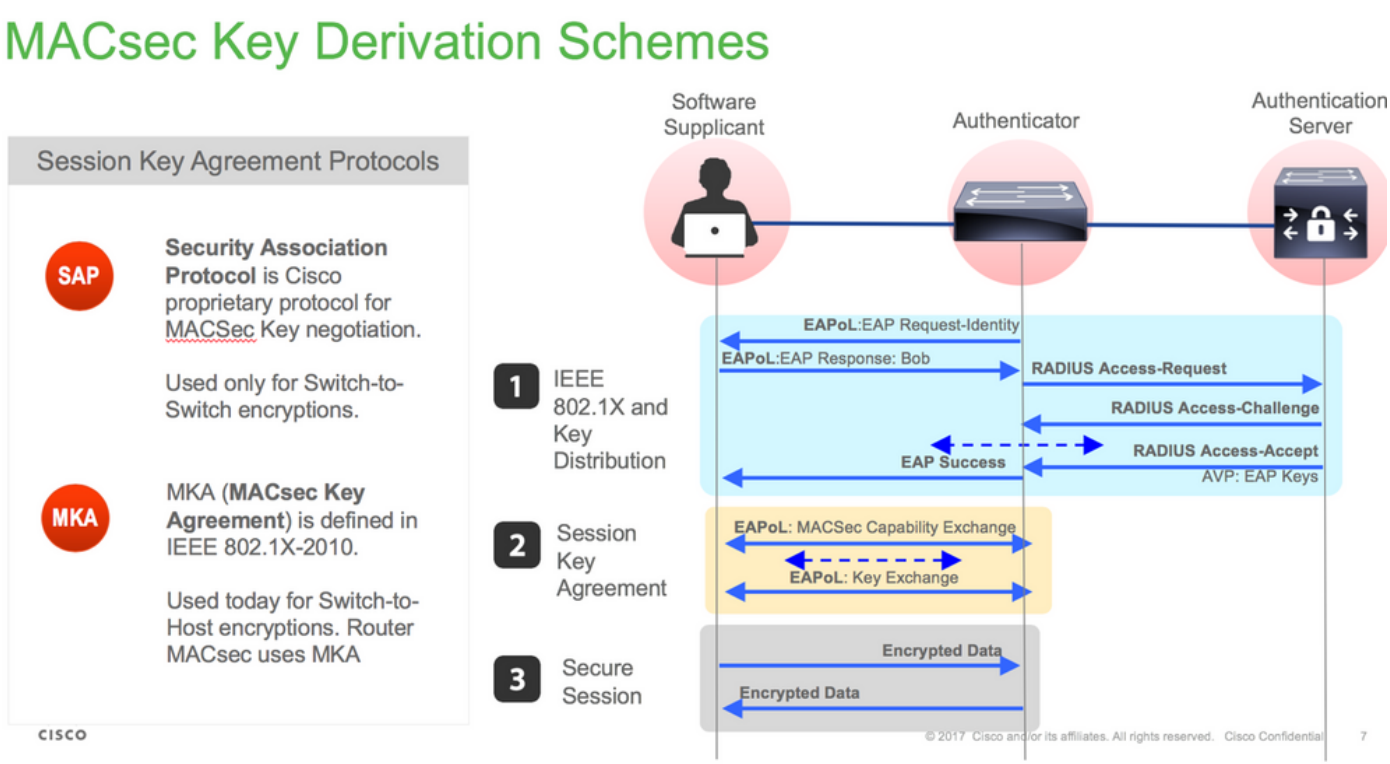
MACsec Tag Format

Field	Size	Description
Ethertype	16 bit	MAC length/type value for MACsec packet Ethertype = 88-E5
TCI	6 bit	Tag control info contains: Version, ES, SC, SCB, E, C (indicates how frame is protected)
AN	2 bit	Association number
SL	8 bit	Short Length Indicates MSDU length of 1-48 octets 0 indicates MSDU length > 48 octets
PN	32 bit	Packet sequence number
SCI	64 bit	Secure channel identified (optional)

SAP协商


SAP Negotiation
Pair-wise Master Key (PMK)
(Manually configured or derived through 802.1X authentication)
PMK is never sent on the link
Role determination: Lowest MAC = Authenticator (Manual Mode), RADIUS server tells who is who (802.1X Mode)
Authenticator and Supplicant derive keys and exchange with each other
PMKID(16) = HMAC-SHA1-128(PMK, "PMK Name" || AA || SA)
AA: Authenticator Address, SA: Supplicant Address
PTK ← PRF-X(PMK, "Pairwise key expansion" , Min (AA,SA) || Max (AA, SA) || Min (ANonce, SNonce) || Max(ANonce,SNonce))
ANonce & SNonce = Random values gen by Authenticator & Supplicant
Pairwise Transient Key PTK
Key Confirmation Key (KCK)
Key Encryption Key (KEK)
Temporal Key (TK)
Message Integrity check (16)
Encryption Alg (16)
Data Encryption
AUTHENTICATOR
BLDG-1-AGG
SUPPLICANT
BLDG-2-AGG
EAPoL-Key (Request Bit)
EAPoL-Key (Request Bit)
EAPoL-Key (Anonce,PMKID,RSN IE, SAP Ver)
EAPoL-Key (Snonce,KCK,RSN IE, SAP Ver, SCI, AN)
EAPoL-Key (Anonce,KCK {MIC},KEK {SCI,AN})
EAPoL-Key (KCK{MIC})

密钥交换


MACsec Key Derivation Schemes
Session Key Agreement Protocols
SAP
Security Association Protocol is Cisco proprietary protocol for MACSec Key negotiation.
Used only for Switch-to-Switch encryptions.
MKA
MKA (MACsec Key Agreement) is defined in IEEE 802.1X-2010.
Used today for Switch-to-Host encryptions. Router MACsec uses MKA
1 IEEE 802.1X and Key Distribution
2 Session Key Agreement
3 Secure Session
Software Supplicant
Authenticator
Authentication Server
EAPoL:EAP Request-Identity
EAPoL:EAP Response: Bob
RADIUS Access-Request
RADIUS Access-Challenge
RADIUS Access-Accept
EAP Success
AVP: EAP Keys
EAPoL: MACSec Capability Exchange
EAPoL: Key Exchange
Encrypted Data
Encrypted Data
CISCO
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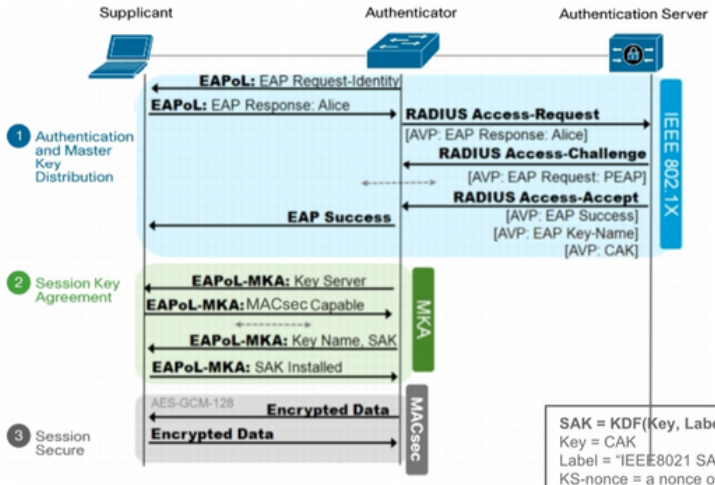
MKA Exchange



A pairwise CAK (Connectivity Association Key) is derived directly from the EAP MSK:
CAK = KDF(Key, Label, mac1 | mac2, CAKlength)

Key = MSK[0-15] for a 128 bit CAK, MSK[0-31] for a 256 bit CAK
Label = "IEEE8021 EAP CAK"
mac1 = the lesser of the two source MAC addr used in the EAPOL-EAP exchange
mac2 = the greater of the two source MAC addr used in the EAPOL-EAP exchange
CAKlength = two octets representing an integer value (128 for a 128 bit CAK, 256 for a 256 bit CAK) with the most significant octet first

The KEK(Key Encryption Key) is derived from the CAK using the following transform:
KEK = KDF(Key, Label, Keyid, KEKLength)

Key = CAK
Label = "IEEE8021 KEK"
Keyid = the first 16 octets of the CKN, with null octets appended to pad to 16 octets
KEKLength = two octets representing an integer value (128 for a 128 bit KEK, 256 for a 256 bit KEK) with the most significant octet first

The ICK (ICV Key) is derived from the CAK using the following transform:

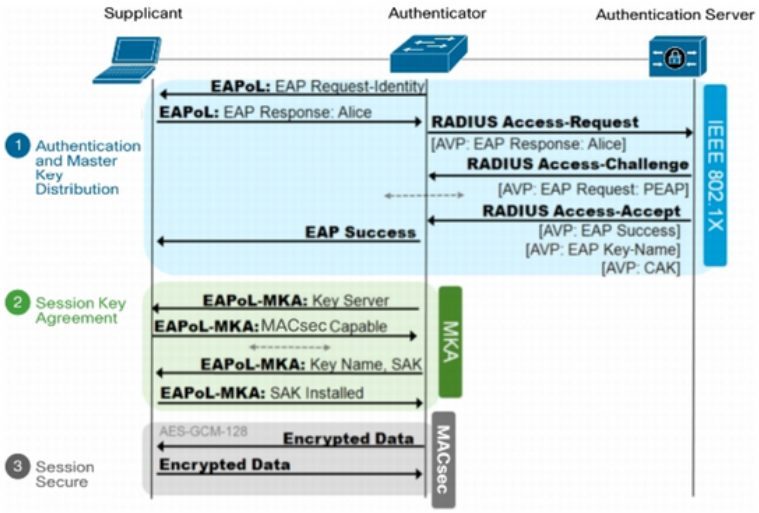
ICK = KDF(Key, Label, Keyid, ICKLength)

Key = CAK
Label = "IEEE8021 ICK"
Keyid = the first 16 octets of the CKN, with null octets appended to pad to 16
ICKLength = two octets representing an integer value (128 for a 128 bit ICK, 256 for a 256 bit ICK) with the most significant octet first

SAK = KDF(Key, Label, KS-nonce | MI-value list | KN, SAKlength)
Key = CAK
Label = "IEEE8021 SAK"
KS-nonce = a nonce of the same size as the required SAK, obtained from an RNG each time an SAK is generated.
MI-value list = a concatenation of MI values (in no particular order) from all live participants
KN = four octets, the Key Number assigned by the Key Server as part of the KI
SAKlength = two octets representing an integer value (128 for a 128 bit SAK, 256 for a 256 bit SAK) with the most significant octet first.

ICV = AES-CMAC(ICK, M, 128)
M = DA + SA + (MSDU – ICV)

MKA Exchange



MKA key Exchange uses:

* 802.1x EAP-TLS
* Pre Shared key (PSK) framework

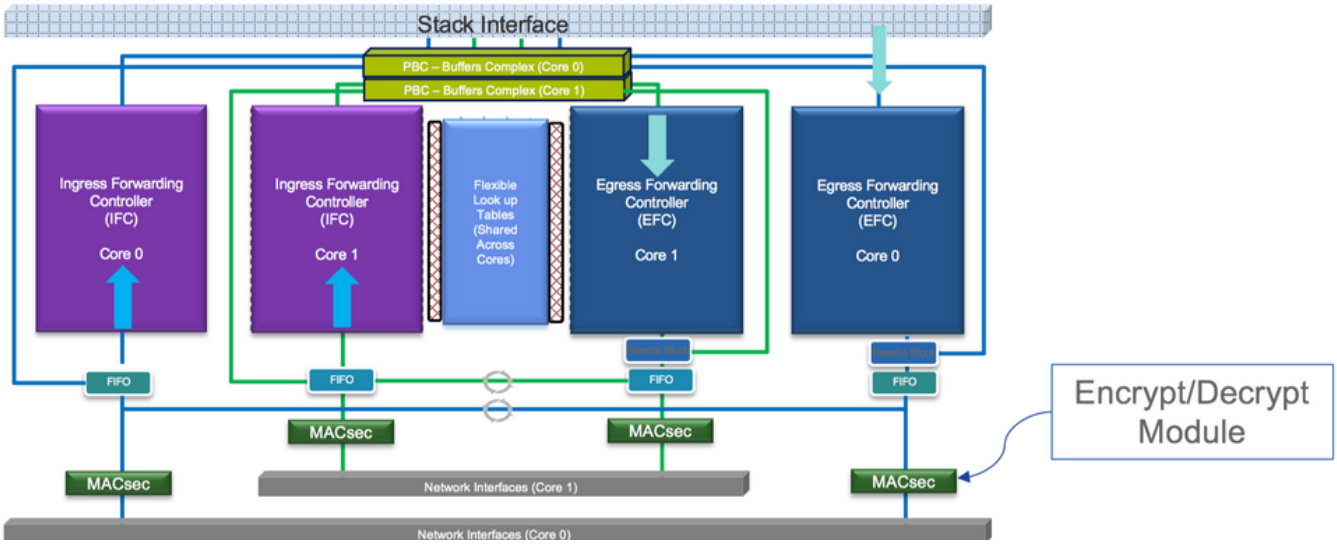
MKA 802.1x EAP-TLS

* Require Certificate Authority
* ISE 2.0 +
* 802.1x AAA config

平台上的MACsec

Where is MACsec performed in Hardware?

Applicable for UADP 2.0/3.0/Mini ASIC



产品兼容性矩阵

LAN MACsec Support per Platform

	MACsec	Cat 9200		Cat 9300		Cat 9400		Cat 9500		Cat 9500H / 9600	
		SW	License	SW	License	SW	License	SW	License	SW	License
Switch to Switch	128 Bits SAP	16.10.1 +	NE	16.6.1 +	NE	16.10.1 +	NE	16.6.1 +	NE	16.9.1 + / 16.11.1 +	NE
	128 Bits MKA	16.10.1 +	NE	16.6.1 +	NE	16.10.1 +	NE	16.6.1 +	NE	16.9.1 + / 16.11.1 +	NE
	256 Bits MKA	Not Supported		16.6.1 +	NA	16.10.1 +	NA	16.6.1 +	NA	16.9.1 + / 16.11.1 +	NA
	ClearTag Pass Through	16.10.1 +	NE	16.10.1 +	NE	16.10.1 +	NE	16.10.1 +	NE	16.10.1 + / 16.11.1 +	NE
Host to Switch	128 Bits MKA	16.10.1 +	NE	16.8.1 +	NE	16.9.1 +	NE	16.8.1 +	NE	16.9.1 + / 16.11.1 +	NE
	256 Bits MKA	Not Supported		16.9.1 +	NA	16.10.1 +	NA	16.9.1 +	NA	16.9.1 + / 16.11.1 +	NA

NE – Network Essentials. NA – Network Advantage.

C9300 Stackwise 480 / C9500 SWV High Availability is not supported for MACsec

C9400 Sup 1XL-Y does not Support MACsec on any Supervisor ports

C9400 Sup 1 and 1XL support MACsec for only for interfaces with speed 10/40 Gbps

LAN MACsec Performance Data

	MACsec	Cat 9200	Cat 9300	Cat 9400	Cat 9500	Cat 9500H / 9600
Switch to Switch	128 Bits SAP	Line Rate	Line Rate	Line Rate	Line Rate	Line Rate
	128 Bits MKA	Line Rate	Line Rate	Line Rate	Line Rate	Line Rate
	256 Bits MKA	Not Supported	Line Rate	Line Rate	Line Rate	Line Rate
Host to Switch	128 Bits MKA	Line Rate	Line Rate	Line Rate	Line Rate	Line Rate
	256 Bits MKA	Not Supported	Line Rate	Line Rate	Line Rate	Line Rate

C9400 Sup 1XL-Y does not Support MACsec on any Supervisor ports
C9400 Sup 1 and 1XL support MACsec for only for interfaces with speed 10/40 Gbps

NE – Network Essentials. NA – Network Advantage.
Line rate is calculated with the additional MACsec header overhead

相关信息

[安全配置指南，Cisco IOS® XE Gibraltar 16.12.x（Catalyst 9300交换机）]

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