

SAI MACsec API Proposal

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# Scope & Overview

Scope:

This document defines the technical specifications for the API used to support 802.1ae MAC Security (MACsec) in Open Compute Project Switch Abstraction Interface (SAI). MAC Security Key Agreement Entity (802.1ae KaY), responsible for obtaining AES key and other parameters, is outside the scope of this document and the MACsec API.

Overview:

The switching hardware consists of network interfaces connected to a forwarding element, such as a switching ASIC. Some switching hardware also include Phy ASIC(s) that interconnect network interfaces and forwarding element interfaces. Each Phy ASIC supports one or more network interfaces. SAI is used for each such Phy ASIC (doc/macsec-gearbox/SAI\_Gearbox\_API\_Proposal-v1.0.docx). A sai\_switch object is used to interface to either a forwarding element or a Phy.

This SAI MACsec API provides a software interface for 802.1ae MACSec Entity (SecY) associated with some or all ports of a sai\_switch object.

MACsec provides data security (confidentiality, integrity, authenticity) to Ethernet port(s). MACsec uses 2 distinct datapath modules:

1. The egress module adds SecTag, encrypts packets and adds a trailer containing ICV (Integrity Check Value).
2. The ingress module decrypts the packet, checks the authentication and integrity (using ICV) and removes the SecTag.

# Block Diagram

The Phy chip contains MACsec functionality that services a set of network ports (a.k.a. Phy line-side ports). Some resources (e.g. encryption keys) are not shared between network ports. Some other resources are shared between multiple network ports e.g. function like parsing, match-criteria for control-packets, etc.



# Object Relationships

The SAI MACsec API provides an interface to programming the MACsec functions:

1. Two sai\_macsec objects (one for ingress and one for egress) are bound to a sai\_switch object.
2. Two sai\_macsec\_port objects (one for ingress and one for egress) are bound to each MACsec enabled sai\_port object. In case of a Phy, the binding should be to a line-side port (SAI\_PORT\_CONNECTOR\_ATTR\_LINE\_SIDE\_PORT\_ID).
3. Two acl\_table objects (one for ingress and one for egress) are bound to the same sai\_port object.



There are 2 specific ACL stages (SAI\_ACL\_STAGE\_INGRESS\_MACSEC and SAI\_ACL\_STAGE\_EGRESS\_MACSEC) used for MACsec.

These ACL tables classify flows based on (dst\_mac, ethertype, outer\_vlan\_id) fields. Depending on implementation, the SCI field from the 802.1ae SecTag header can also be used as an ACL table field for ingress MACsec. Each acl\_entry in such a table, should be assigned a unique ordinal priority value.

Each acl\_entry in these acl\_tables uses one of the following actions:

1. packet\_action using one of 2 enums:
   1. SAI\_PACKET\_ACTION\_DROP to drop packets
   2. SAI\_PACKET\_ACTION\_FORWARD to allow packets without MACsec processing. Packets forwarded without MACsec processing should include MACsec control packets (e.g. EAPOL packets).
2. macsec\_flow for MACsec processing of packet. A macsec\_flow is associated with one or more IEEE 802.1ae SCs (Secure Channels).



For a MACsec-disabled port, all packets should be forwarded. For a MACsec-enabled port, normally the acl\_entry have the following precedence order after SCs are established:

1. permit entries for control packets
2. secure entries for one or more SCs
3. (optionally) deny entry for all other packets



A SC has one or more associated SAs. Each SA has configuration parameters for its cipher suite (encryption key, etc). Each encrypted packet has a packet number (32-bit PN or 64-bit XPN). For each SA, the egress uses a counter to increment the packet number. During the lifetime of a SA, the packet number value used by the egress is periodically sent to the receiver(s) by the key agreement protocol. This ingress logic uses this value as the minimum acceptable value of packet number. The SA is periodically replaced before it exhausts all its packet numbers. The SC can operate uninterrupted for a long time, using rekeying i.e. using a series of overlapping SAs.

1. For egress, only one SA is active at a time. Rekeying involves switching the active SA and changing the SecTAG.AN field in the packet header.
2. For an ingress secure packet flow, multiple SAs can be simultaneously be active, selected for each packet by SecTAG.AN field from the packet header.

For ingress, the SecTAG.SCI field from the packet header has to be matched to a programmed value. This API supports 2 implementation models:

1. If SCI is not matched in ACL, multiple SCs (e.g. SC-21 and SC-22 in Figure 4) can be associated with a flow (e.g. Secure flow-2). Then a specific value of SCI from the SecTAG in the packet is used to identify a specific SC associated with a flow.
2. If SCI is matched in ACL, only one acl\_entry and one SC is associated with each flow.

# Function call sequences

The following sequences assume that a sai\_macsec object has already been created by a create\_macsec function call.

## Enable MACsec on a port

The steps are identical for ingress and egress. The following example is for ingress.

// Create ingress macsec\_port for port\_id1

sai\_object\_id\_t ingr\_macsec\_port\_id1 = 0ULL;

macsec\_attr\_list[0].id = SAI\_MACSEC\_ATTR\_MACSEC\_DIRECTION;

macsec\_attr\_list[0].value.s32 = SAI\_MACSEC\_DIRECTION\_INGRESS;

macsec\_attr\_list[1].id = SAI\_MACSEC\_ATTR\_PORT\_ID;

macsec\_attr\_list[1].value.oid = port\_id1;

saistatus = sai\_macsec\_api->create\_macsec\_port(&ingr\_macsec\_port\_id1, 2,

macsec\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Create ingress MACsec ACL table for port\_id1

sai\_object\_id\_t acl\_table\_id1 = 0ULL;

acl\_attr\_list[0].id = SAI\_ACL\_TABLE\_ATTR\_ACL\_STAGE;

acl\_attr\_list[0].value.s32 = SAI\_ACL\_STAGE\_INGRESS\_MACSEC;

acl\_attr\_list[1].id = SAI\_ACL\_TABLE\_ATTR\_ACL\_BIND\_POINT\_TYPE\_LIST;

acl\_attr\_list[1].value.objlist.count = 1;

acl\_attr\_list[1].value.objlist.list[0] = SAI\_ACL\_BIND\_POINT\_TYPE\_PORT;

acl\_attr\_list[2].id = SAI\_ACL\_TABLE\_ATTR\_FIELD\_DST\_MAC;

acl\_attr\_list[2].value.booldata = True;

acl\_attr\_list[3].id = SAI\_ACL\_TABLE\_ATTR\_FIELD\_ETHER\_TYPE;

acl\_attr\_list[3].value.booldata = True;

acl\_attr\_list[4].id = SAI\_ACL\_TABLE\_ATTR\_FIELD\_NO\_VLAN\_TAG;

acl\_attr\_list[4].value.booldata = True;

acl\_attr\_list[5].id = SAI\_ACL\_TABLE\_ATTR\_FIELD\_HAS\_VLAN\_TAG;

acl\_attr\_list[5].value.booldata = True;

acl\_attr\_list[6].id = SAI\_ACL\_TABLE\_ATTR\_FIELD\_OUTER\_VLAN\_ID;

acl\_attr\_list[6].value.booldata = True;

saistatus = sai\_acl\_api->create\_acl\_table(&acl\_table\_id1, 7, acl\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Create an ACL entry to permit EAPOL packets

sai\_object\_id\_t acl\_entry\_id1 = 0ULL;

acl\_attr\_list[0].id = SAI\_ACL\_ENTRY\_ATTR\_TABLE\_ID;

acl\_attr\_list[0].value.oid = acl\_table\_id1;

acl\_attr\_list[1].id = SAI\_ACL\_ENTRY\_ATTR\_PRIORITY;

acl\_attr\_list[1].value.u32 = 100;

acl\_attr\_list[2].id = SAI\_ACL\_ENTRY\_ATTR\_FIELD\_ETHER\_TYPE;

acl\_attr\_list[2].value.aclfield.data.u16 = EAPOL\_ETHER\_TYPE;

acl\_attr\_list[3].id = SAI\_ACL\_ENTRY\_ATTR\_ACTION\_PACKET\_ACTION;

acl\_attr\_list[3].value.aclfield.data.s32 = SAI\_PACKET\_ACTION\_FORWARD;

saistatus = sai\_acl\_api->create\_acl\_entry(&acl\_entry\_id1, 4, acl\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Create an ACL entry to drop packets (to be later used for macsec\_flow)

sai\_object\_id\_t acl\_entry\_id2 = 0ULL;

acl\_attr\_list[0].id = SAI\_ACL\_ENTRY\_ATTR\_TABLE\_ID;

acl\_attr\_list[0].value.oid = acl\_table\_id2;

acl\_attr\_list[1].id = SAI\_ACL\_ENTRY\_ATTR\_PRIORITY;

acl\_attr\_list[1].value.u32 = 1;

acl\_attr\_list[2].id = SAI\_ACL\_ENTRY\_ATTR\_ACTION\_PACKET\_ACTION;

acl\_attr\_list[2].value.aclfield.data.s32 = SAI\_PACKET\_ACTION\_DROP;

saistatus = sai\_acl\_api->create\_acl\_entry(&acl\_entry\_id2, 3, acl\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Bind this ACL table to port\_id1

port\_attr.id = SAI\_PORT\_ATTR\_INGRESS\_ACL;

port\_attr.value.oid = acl\_table\_id1;

sai\_port\_api->set\_port\_attribute(port\_id1, port\_attr);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

## Create ingress/egress SA

Creating SA for ingress and egress, shown below, are very similar. Only the direction and XPN attributes are different.

// Create ingress macsec\_sa

sai\_object\_id\_t ingr\_macsec\_sa\_id11 = 0ULL;

macsec\_attr\_list[0].id = SAI\_MACSEC\_SC\_ATTR\_MACSEC\_DIRECTION;

macsec\_attr\_list[0].value.s32 = SAI\_MACSEC\_DIRECTION\_INGRESS;

macsec\_attr\_list[1].id = SAI\_MACSEC\_ATTR\_SC\_ID;

macsec\_attr\_list[1].value.macsecsc = ingr\_macsec\_sc\_id1;

macsec\_attr\_list[2].id = SAI\_MACSEC\_ATTR\_AN;

macsec\_attr\_list[2].value.macsecan = ingr\_macsec\_an11;

macsec\_attr\_list[3].id = SAI\_MACSEC\_ATTR\_MACSEC\_SAK;

macsec\_attr\_list[3].value.macsecsak = macsec\_sak1;

macsec\_attr\_list[4].id = SAI\_MACSEC\_ATTR\_MACSEC\_SALT;

macsec\_attr\_list[4].value.macsecsak = macsec\_salt1;

macsec\_attr\_list[5].id = SAI\_MACSEC\_ATTR\_MACSEC\_AUTH\_KEY;

macsec\_attr\_list[5].value.macsecauthkey = macsec\_auth\_key1;

macsec\_attr\_list[6].id = SAI\_MACSEC\_SA\_ATTR\_MINIMUM\_XPN;

macsec\_attr\_list[6].value.u64 = 1;

saistatus = sai\_macsec\_api->create\_macsec\_sa(&ingr\_macsec\_sa\_id11, 7,

macsec\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Create egress macsec\_sa (only DIRECTION and XPN attributes different)

sai\_object\_id\_t egr\_macsec\_sa\_id11 = 0ULL;

macsec\_attr\_list[0].id = SAI\_MACSEC\_SC\_ATTR\_MACSEC\_DIRECTION;

macsec\_attr\_list[0].value.s32 = SAI\_MACSEC\_DIRECTION\_EGRESS;

macsec\_attr\_list[1].id = SAI\_MACSEC\_ATTR\_SC\_ID;

macsec\_attr\_list[1].value.macsecsc = egr\_macsec\_sc\_id1;

macsec\_attr\_list[2].id = SAI\_MACSEC\_ATTR\_AN;

macsec\_attr\_list[2].value.macsecan = egr\_macsec\_an11;

macsec\_attr\_list[3].id = SAI\_MACSEC\_ATTR\_MACSEC\_SAK;

macsec\_attr\_list[3].value.macsecsak = macsec\_sak1;

macsec\_attr\_list[4].id = SAI\_MACSEC\_ATTR\_MACSEC\_SALT;

macsec\_attr\_list[4].value.macsecsak = macsec\_salt1;

macsec\_attr\_list[5].id = SAI\_MACSEC\_ATTR\_MACSEC\_AUTH\_KEY;

macsec\_attr\_list[5].value.macsecauthkey = macsec\_auth\_key1;

macsec\_attr\_list[6].id = SAI\_MACSEC\_SA\_ATTR\_XPN;

macsec\_attr\_list[6].value.u64 = 0;

saistatus = sai\_macsec\_api->create\_macsec\_sa(&egr\_macsec\_sa\_id11, 7,

macsec\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

## Add a SC with 1 SA for a port

For a single SC on a port, the steps are identical for ingress and egress. The following example is for ingress.

// Create ingress macsec\_flow

sai\_object\_id\_t ingr\_macsec\_flow\_id1 = 0ULL;

macsec\_attr\_list[0].id = SAI\_MACSEC\_FLOW\_ATTR\_MACSEC\_DIRECTION;

macsec\_attr\_list[0].value.s32 = SAI\_MACSEC\_DIRECTION\_INGRESS;

saistatus = sai\_macsec\_api->create\_macsec\_flow(&ingr\_macsec\_flow\_id1, 1,

macsec\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Create ingress macsec\_sc for that flow

sai\_object\_id\_t ingr\_macsec\_sc\_id1 = 0ULL;

macsec\_attr\_list[0].id = SAI\_MACSEC\_SC\_ATTR\_MACSEC\_DIRECTION;

macsec\_attr\_list[0].value.s32 = SAI\_MACSEC\_DIRECTION\_INGRESS;

macsec\_attr\_list[1].id = SAI\_MACSEC\_ATTR\_FLOW\_ID;

macsec\_attr\_list[1].value.oid = ingr\_macsec\_flow\_id1;

macsec\_attr\_list[2].id = SAI\_MACSEC\_ATTR\_MACSEC\_SCI;

macsec\_attr\_list[2].value.macsecsci = macsec\_sci1;

macsec\_attr\_list[3].id = SAI\_MACSEC\_ATTR\_MACSEC\_SSCI;

macsec\_attr\_list[3].value.macsecssci = macsec\_ssci1;

saistatus = sai\_macsec\_api->create\_macsec\_sc(&ingr\_macsec\_sc\_id1, 4,

macsec\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

Then, as described in earlier section, create ingress macsec\_sa. And finally:

// Change action from drop to macsec\_flow for an already created ACL entry

acl\_attr.id = SAI\_ACL\_ENTRY\_ATTR\_ACTION\_MACSEC\_FLOW;

acl\_attr.value.oid = ingr\_macsec\_flow\_id1;

sai\_acl\_api->set\_acl\_entry\_attribute(acl\_entry\_id2, acl\_attr);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

## Remove an SA

The steps are identical for ingress and egress. The following example is for egress.

// Collect last statistics for SA

saistatus = sai\_macsec\_api->get\_macsec\_sa\_stats\_ext(&egr\_macsec\_sa\_id11,

SA\_STATS\_COUNT, &macsec\_counter\_list, SAI\_MACSEC\_ATTR\_STATS\_MODE);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

UPDATE\_EGRESS\_SA\_STATISTICS(macsec\_counter\_list);

// Remove old SA

saistatus = sai\_macsec\_api->remove\_macsec\_sa(&egr\_macsec\_sa\_id11);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

## Replace egress SA

## For egr\_macsec\_sc\_id1, replace egr\_macsec\_sa\_id11 with egr\_macsec\_sa\_id12. Assume replacement SA (egr\_macsec\_sa\_id12) has been created earlier.

// Replace active SA for

macsec\_attr\_list.list[0].id = SAI\_MACSEC\_SC\_ATTR\_ACTIVE\_SA;

macsec\_attr\_list.list[0].value.oid = egr\_macsec\_sa\_id12;

sai\_macsec\_api->set\_macsec\_sc\_attribute(egr\_macsec\_sc\_id1, macsec\_attr\_list);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

## Then, as described earlier, collect statistics for old SA and remove old SA.

## Replace ingress SA

The goal is, for ingr\_macsec\_sc\_id1, replace ingr\_macsec\_sa\_id11 with ingr\_macsec\_sa\_id12. The steps are:

1. As described earlier, create a new SA (ingr\_macsec\_sa\_id12). This automatically allows the new ingress SA to receive packet.
2. Then, 0.5 second after actually receiving packets with the new SA, collect statistics for old SA and remove old SA, as described earlier.

## Remove a SC

The steps are identical for ingress and egress. The following example is for ingress.

In this case, ingr\_macsec\_flow\_id1 is associated with acl\_entry\_id2 and ingr\_macsec\_sc\_id1. And ingr\_macsec\_sc\_id1 uses two SAs: ingr\_macsec\_sa\_id11 and ingr\_macsec\_sc\_id12. Removing this SC involves the following steps.

// Change associated ACL entry action from macsec\_flow to drop

acl\_attr.id = SAI\_ACL\_ENTRY\_ATTR\_ACTION\_PACKET\_ACTION;

acl\_attr.value.oid = SAI\_PACKET\_ACTION\_DROP1;

sai\_acl\_api->set\_acl\_entry\_attribute(acl\_entry\_id2, acl\_attr);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

Then, as described earlier, collect last statistics and remove SA, iterating over all SA for this SC (which is ingr\_macsec\_sa\_id11 and ingr\_macsec\_sc\_id12, in this case). And finally:

// Collect last statistics and remove macsec\_sc

saistatus = sai\_macsec\_api->get\_macsec\_sc\_stats\_ext(&ingr\_macsec\_sc\_id1, SC\_STATS\_COUNT,

&macsec\_counter\_list, SAI\_MACSEC\_ATTR\_STATS\_MODE);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

UPDATE\_INGRESS\_SC\_STATISTICS(macsec\_counter\_list);

saistatus = sai\_macsec\_api->remove\_macsec\_sc(&ingr\_macsec\_sc\_id1);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Remove macsec\_flow

saistatus = sai\_macsec\_api->remove\_macsec\_flow(&ingr\_macsec\_flow\_id1);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

## Disable MACsec on a port

// Unbind MACsec ACL table from port\_id1

port\_attr.id = SAI\_PORT\_ATTR\_INGRESS\_ACL;

port\_attr.value.oid = SAI\_NULL\_OBJECT\_ID;;

sai\_port\_api->set\_port\_attribute(port\_id1, port\_attr);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

Then, as described earlier, remove all SC associated with this port.

// Remove ACL table and all its entries

saistatus = sai\_acl\_api->remove\_acl\_entry(&acl\_entry\_id1);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

saistatus = sai\_acl\_api->remove\_acl\_table(&acl\_table\_id1);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

// Remove macsec\_port

saistatus = sai\_macsec\_api->remove\_macsec\_port(&ingr\_macsec\_port\_id1);

if (saistatus != SAI\_STATUS\_SUCCESS) {

return saistatus;

}

## Periodic activities

1. Read statistics
2. Read egress packet number, SAI\_MACSEC\_SECURITY\_ASSOCIATION\_ATTR\_XPN. The Key Agreement Entity sends this value to the MACsec peer.
3. Set minimum acceptable packet number, SAI\_MACSEC\_SECURITY\_ASSOCIATION\_ATTR\_MINIMUM\_XPN, for ingress. The Key Agreement Entity sets this to the value provided by MACsec peer.

# Notes

## Unsupported Features

1. Packet parsing beyond MAC header and VLAN tags.
2. The SAI MACsec API does not support any interrupt or event notification to NOS. Possible uses of notification could include:
   1. Egress packet number crossing threshold. The last used egress packet number can be polled or indirectly inferred from periodically collected egress packet statistics.
   2. A new packet SA value observed at ingress. This can be polled to determine when to remove the old SA.
   3. External Dependencies

The MACsec API makes use of AES key and other parameters obtained by MAC Security Key Agreement Entity (802.1ae KaY). It is the responsibility of the application (NOS or Controller) to implement the MAC Security Key Agreement Entity (802.1ae KaY).

## Hidden Complexities

Some implementation complexities are hidden to simplify the SAI MACsec API:

1. The SAI MACsec API exposes MACsec-specific packet-matching logic as as per-port ACL tables. But since those likely use common resources, the resource availability is tracked per sai\_macsec object.
2. The SAI MACsec API reports the availability of general-purpose acl\_entry resources. But that does not include specialized hardware resources used to support control packets and default action for data packets. The driver may use priority, fields and action of acl\_entry to identify acl\_entries which can be mapped to such specialized hardware. For such acl\_entries, this API may not show any change in resource availability, and the control packet and default action for data packets may appear to "come for free".