rte_security: enabling hardware acceleration of security protocols

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Agenda

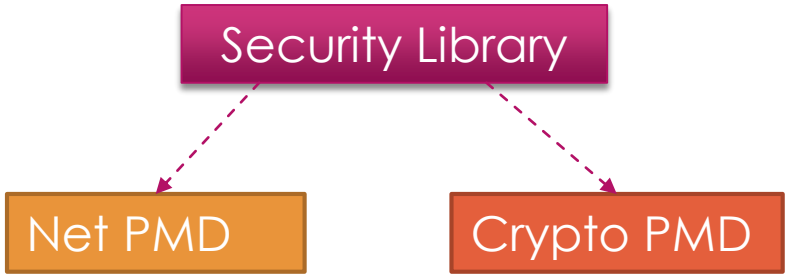
- Introduction
- Acceleration enablement modes
  - Inline Crypto
  - Lookaside Security Protocol
  - Inline Security Protocol
- Security Library Details
- Summary & Future Work
- Discussion and Q&A

Introduction

Introduction and IPsec basics

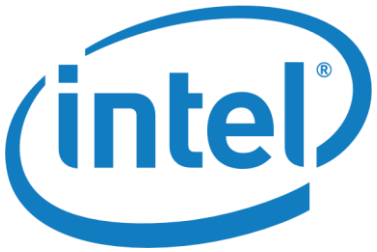
Introduction

- Framework for management and provisioning of hardware acceleration of security protocols.
- Generic APIs to manage security sessions.
- Security acceleration functions are accessed through security instances which can instantiated on any device type, current supports security instances on Crypto and Ethernet devices.
- Rich capabilities discovery APIs
- Current only targets the support of IP Security (IPsec) protocol.
- Could support a wide variety of protocols/applications
  - Enterprise/SMB VPNs — IPsec
  - Wireless backhaul — IPsec, PDCP
  - Data-center — SSL
  - WLAN backhaul — CAPWAP/DTLS
  - Control-plane options for above — PKCS, RNG



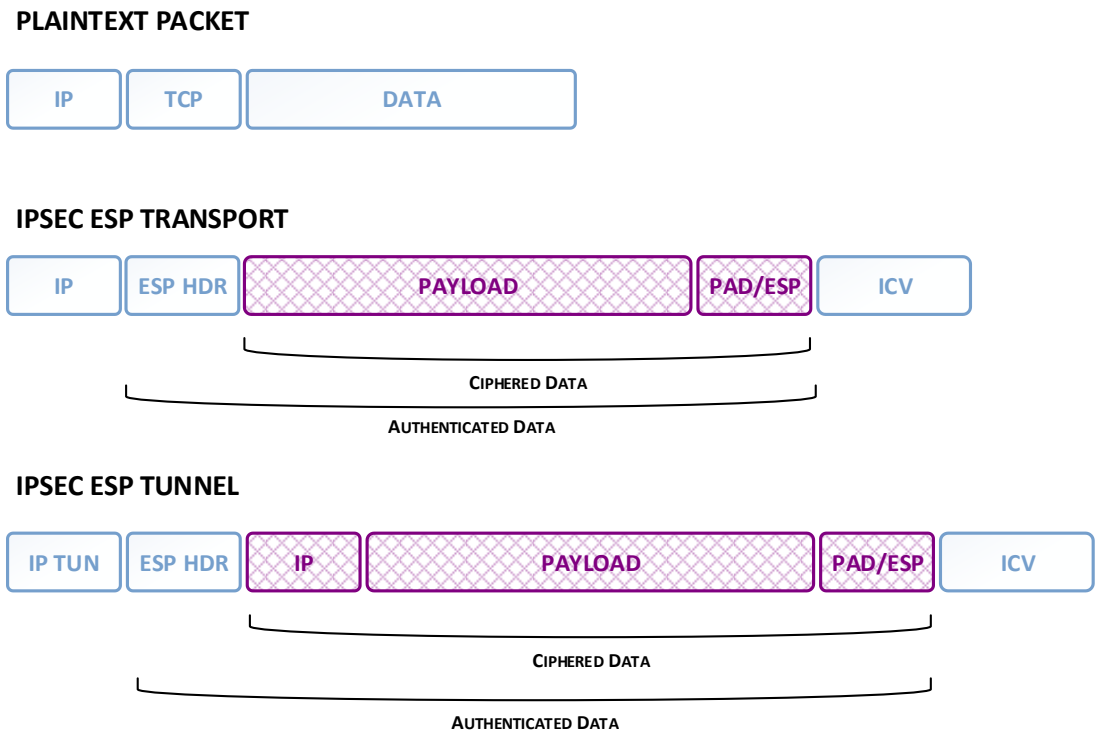
Community Collaboration

- Collaborative work between Intel, Mellanox and NXP with contributions from:
  - Hemant Agrawal, Declan Doherty, Akhil Goyal, Radu Nicolau, Boris Pismenny, and Aviad Yehezkel.
- Security library approach evolved out of the following RFC's
  - [1] http://dpdk.org/ml/archives/dev/2017-July/070793.html
  - [2] http://dpdk.org/ml/archives/dev/2017-July/071893.html
  - [3] http://dpdk.org/ml/archives/dev/2017-August/072900.html
- The joint proposal has been developed on dpdk.org dpdk-draft-ipsec repo.



IPsec Protocol Basics

- IPsec is a layer 3 IP security service.
- Security services offered by IPsec includes:
  - Connectionless integrity
  - Data confidentiality (encryption)
  - Sequence Integrity (partial, anti-replay windowing)
  - limited traffic flow confidentiality (tunnel mode).
- These security services are provided by the use of two traffic security protocols.
  - Authentication Header (AH)
  - Encapsulating Security Payload (ESP)
- IPsec is designed to be crypto algorithm independent



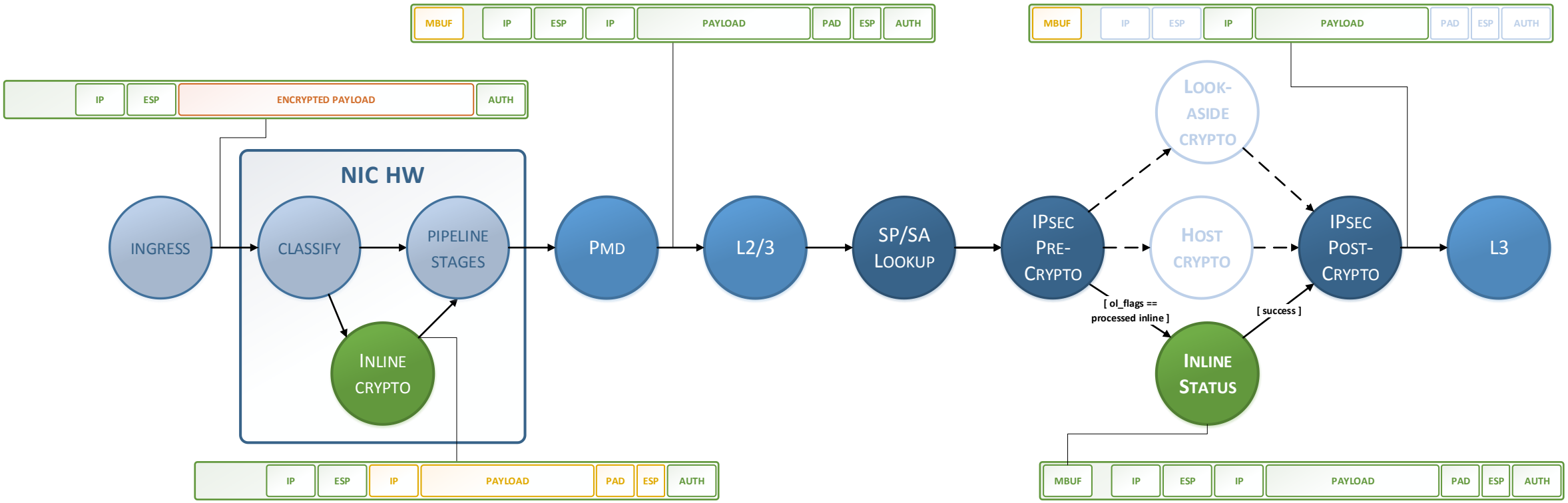
IPsec Hardware Acceleration Modes

Inline Crypto, Lookaside Protocol and Inline Protocol

Inline Crypto Acceleration

- IO based acceleration performed on the physical interface as packet ingress/egress the system.
- No packet headers modifications* on the hardware, only encryption/decryption and authentication operations are preformed.
  - Hardware may support extra features like payload padding of etc.
- Requires that Ethernet CRC is also offloaded to the physical interface also.

Inline Crypto Ingress Data Path

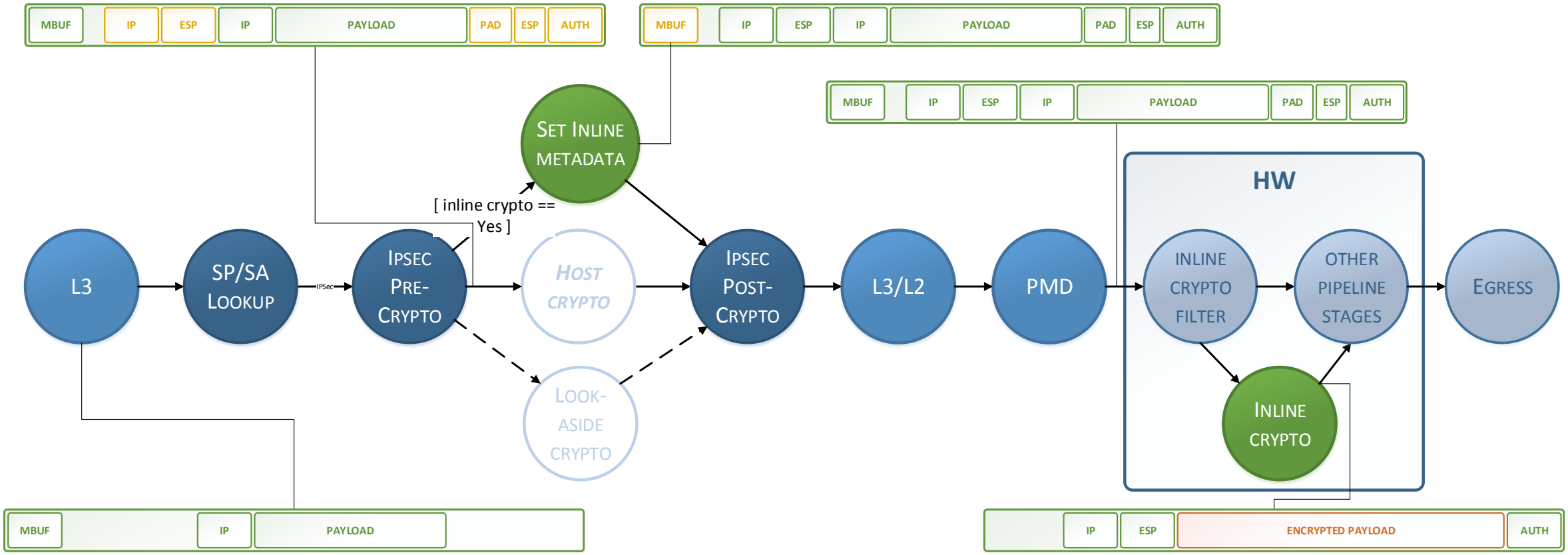


Inline Crypto Ingress Data Path

- HW performs the following for matching (SIP, DIP, ESP)* packets:
  - Decryption and authentication processing – mark the result in metadata
  - Remove the ESP trailer*
- PMD provides the following info per packet:
  - Crypto result – success/failure.
  - Inner ESP next protocol*
  - Packet without a trailer*
- Application:
  - Check mbuf->ol_flags for PKT_RX_SEC_OFFLOAD / PKT_RX_SEC_OFFLOAD_FAILED
  - Read the inner ESP next protocol to remove the ESP header

* Support is hardware dependent, there may be some variation in the ex

Inline Crypto Egress Data Path



Inline Crypto Egress Data Path

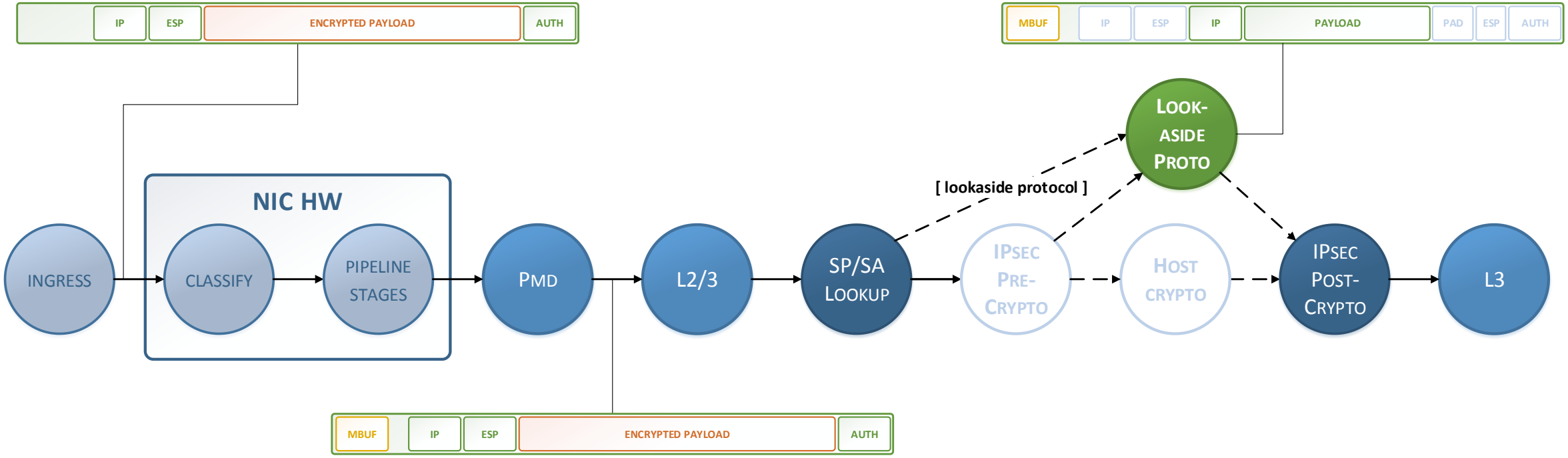
- Application:
  - Mark mbuf->ol_flags using PKT_TX_SEC_OFFLOAD
  - Marks packet with IPsec as ESP tunnel
  - Set all security metadata in mbuf as needed, including inner_esp_next_proto according to inner packet*
- PMD can preform special processing on packets with the PKT_TX_SEC_OFFLOAD flag set, including:
  - Inner ESP next protocol*
  - Security Association Index for hardware*
  - More information for LSO support*
- HW performs the following for marked packets:
  - Add the ESP trailer if supported
  - Encryption and authentication

*Exact requirements, if any, are hardware dependent

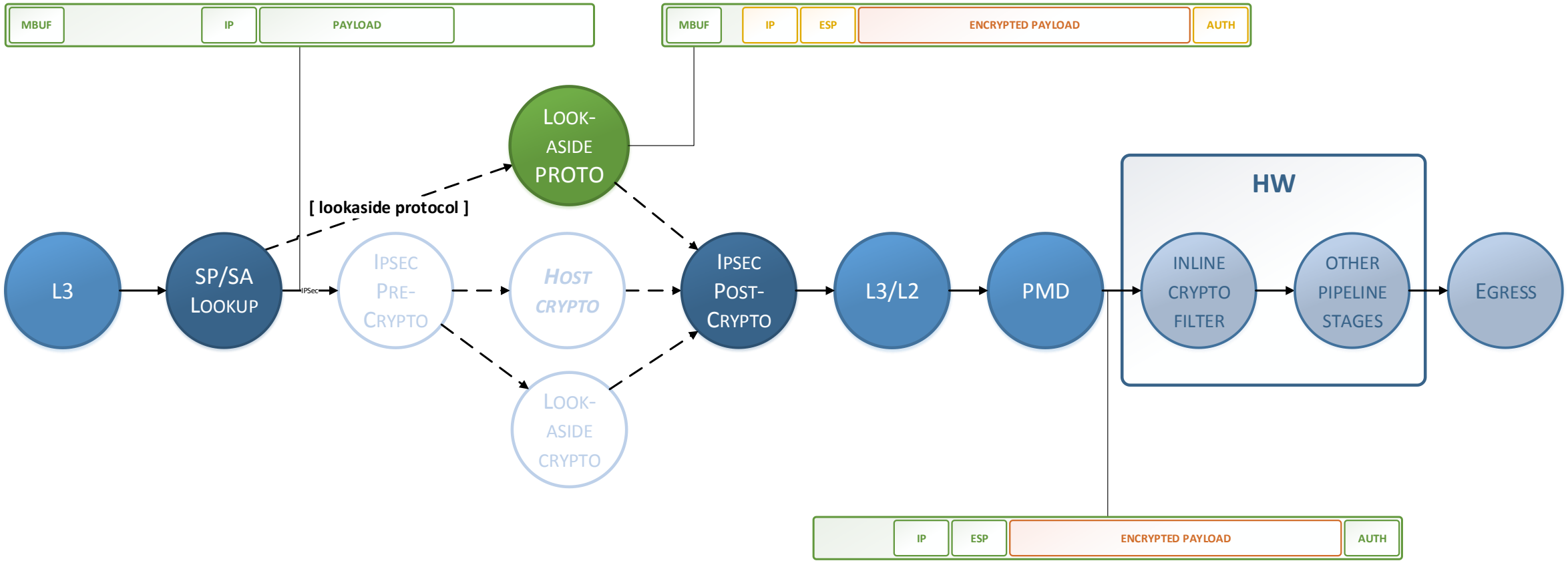
Lookaside Protocol Acceleration

- Lookaside acceleration model where packet is given to an accelerator for processing and then returned to the host after processing is complete.
- Security function is provided as an extension of a librte_cryptodev crypto PMD.
  - Session is used to configure the IPsec SA material on the accelerator.
  - Security session is used in place of crypto session in crypto op when enqueuing and dequeuing packets to the crypto PMD.
- Supports full protocol (IPsec) processing on the accelerator. Including:
  - Add/remove protocol headers, including IP tunnel headers as well as IPsec (AH/ESP) headers.
  - Handling SA state information:
    - Sequence numbers
    - Anti-replay window

Lookaside Protocol Acceleration (Ingress)



Lookaside Protocol Acceleration (Egress)



Inline Protocol Acceleration**

- IO based acceleration performed on the physical interface as the packet ingresses/egresses the platform.
- Interface performs all crypto processing for the security protocol (e.g. IPsec) during transmission and reception.
- Packet headers modification is performed on hardware including all state management and encryption/decryption and authentication operations.
  - Hardware may support extra features like padding of payload etc.
- Requires that ARP entries for MAC headers are programmed along with the security action, as host may not know destination IP in case of a tunnel mode SA

** Currently no supported implementation, so implementation will be subject to change.

Library Implementation

Core features of the librte_security

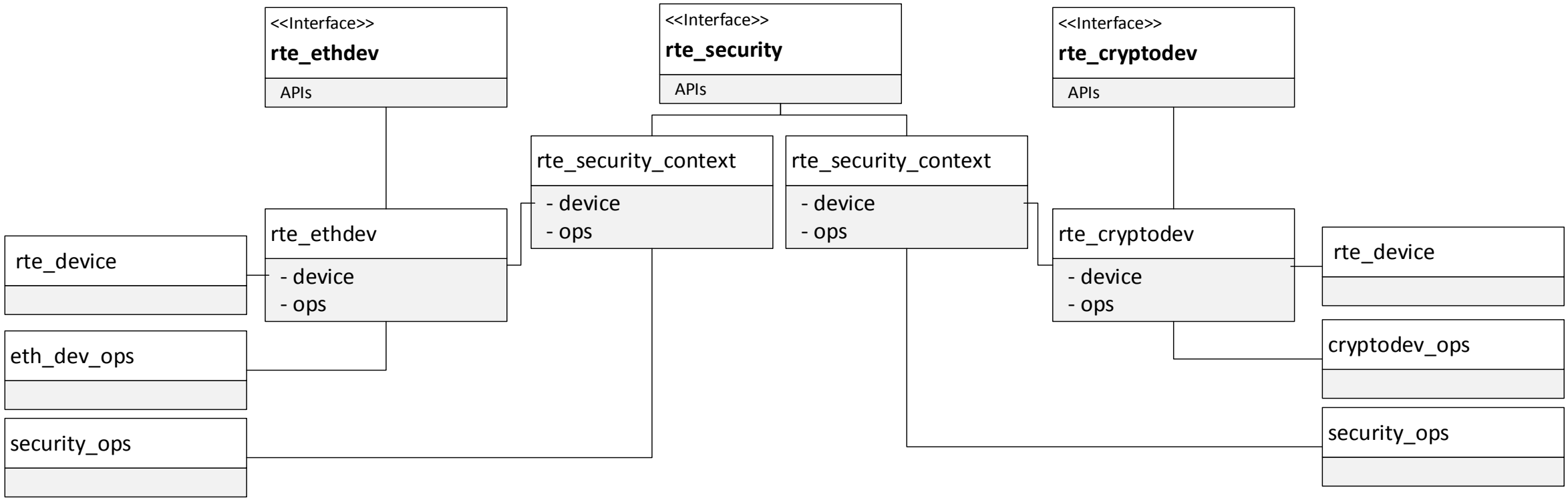
Library Features

- Security instance management and abstraction from base device type.
- Protocol agnostic session API for the management of protocol state on underlying hardware.
- Definitions of supported protocols, currently only IPsec, and the parameters for configuring the options. For IPsec this includes:
  - Acceleration type – inline crypto/lookaside protocol/inline protocol
  - Defining security association (SA) parameters such as Tunnel/Transport, ESP/AH, Ingress/Egress as well as associated crypto processing and key material
- Crypto operations are defined using primitives defined in librte_cryptodev limit any redefinition of parameters within DPDK.
- Capabilities APIs to allow dynamic discovery of a instances features.

Security Instance Management

- The library is not specifically associated with a specific device instance in DPDK
- Any driver can register itself as security capably using the rte_security_register() API.
- The library maintains an array of active instances, which define the supported rte_security_ops and a void pointer to the supporting device.
- API can be supported by multiple device types or possibly even as a stand-alone device.

A multi-device API (Object Model)



Protocols and actions

- Select the session Protocol: “rte_security_session_protocol”
  - IPSEC, MACSEC, SSL, PDCP etc.
- Select the Security Action Type: “rte_security_session_action_type”
  - `RTE_SECURITY_ACTION_TYPE_INLINE_CRYPTO: Inline crypto processing as NIC offload during recv/transmit.`
  - `RTE_SECURITY_ACTION_TYPE_INLINE_PROTOCOL: Inline security protocol processing as NIC offload during recv/transmit.`
  - `RTE_SECURITY_ACTION_TYPE_LOOKASIDE_PROTOCOL: Security protocol processing including crypto on a crypto accelerator.`
- Action type can be a input for the given application during SA creation
- Based on the action type and other SA related information, application configures session parameters for security offload.

Security Session Management

- Session APIs support
  - Create Session

struct rte_security_session *
rte_security_session_create(uint16_t id,

struct **rte_security_session_conf** *conf,

struct **rte_mempool** *mp);

  - Update
  - Destroy
  - Query (Get Stats)

```
struct rte_security_session_conf {
        enum rte_security_session_action_type action_type;
        /**< Type of action to be performed on the session */

        enum rte_security_session_protocol protocol;
        /**< Security protocol to be configured */
        union {
                struct rte_security_ipsec_xform ipsec;
         };
        /**< Configuration parameters for security session */

        struct rte_crypto_sym_xform *crypto_xform;
        /**< Security Session Crypto Transformations */
}
```

rte_security_ipsec_xform

- The current set support some of the basic feature set of IPSEC – More to be added incrementally.
- Many parameters are applicable for Full Protocol Offload only

```
struct rte_security_ipsec_xform {
        uint32_t spi;           /**< SA security parameter index  */
        uint32_t salt;          /**< Salt */
        struct rte_security_ipsec_sa_options options;
        enum rte_security_ipsec_sa_direction dir;
        /**< SA Direction Egress/Ingress */
        enum rte_security_ipsec_sa_protocol proto;
        /**< SA Protocol AH/ESP  */
        enum rte_security_ipsec_sa_mode mode;
        /**< SA Mode Transport/Tunnel */
        struct rte_security_ipsec_tunnel_param tunnel;
        /**<
         * SA Tunnel Parameter. Only applicable when SA is tunnel mode
         * and offload type is either inline/lookaside protocol
         */
};
```

IPsec SA options include

- Extended Sequence Number Support
- NAT/UDP encapsulation,
- NAT-T L4 Checksum verify/update
- Qos/TOS copy support (inner to outer - tunnel)
- DF copy support (inner to outer - tunnel)
- TTL decrement support
- Address copy support (inner to outer for tunnel)
- Trailer addition support

Capabilities Example

- Capabilities API allow user to get all the capabilities of the devices or to query a single capability

- List of Capabilities

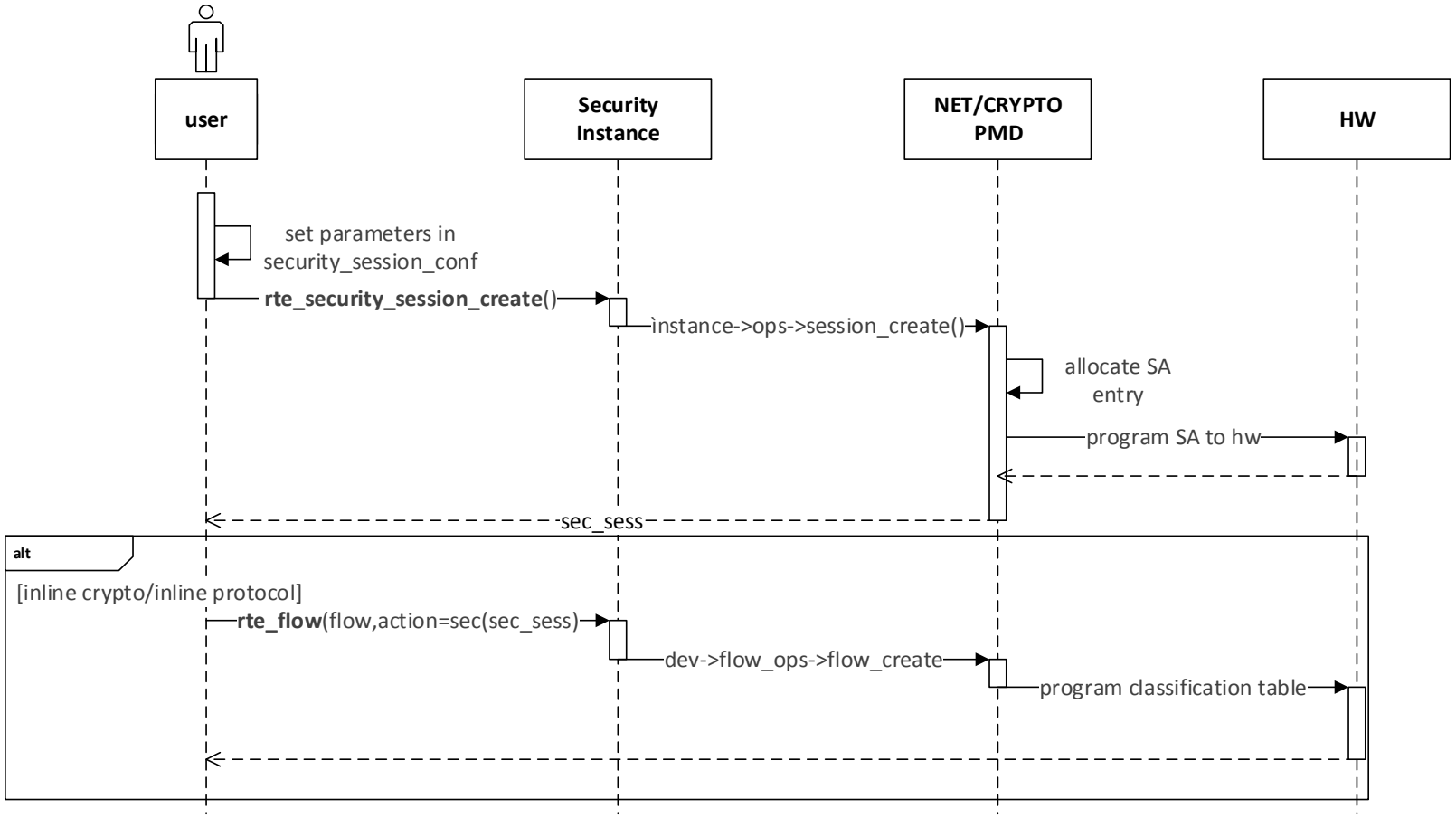
```
const struct rte_security_capability *
        rte_security_capabilities_get(uint16_t id);
```

- Check on Specific Capability

```
const struct rte_security_capability *
rte_security_capability_get(uint16_t id,
        struct rte_security_capability_idx *idx);
```

```
{  /* IPsec Inline Crypto Ingress ESP Transport  */
        .action = RTE_SECURITY_ACTION_TYPE_INLINE_CRYPTO,
        .protocol = RTE_SECURITY_PROTOCOL_IPSEC,
        .ipsec = {
                .proto = RTE_SECURITY_IPSEC_SA_PROTO_ESP,
                .mode = RTE_SECURITY_IPSEC_SA_MODE_TRANSPORT,
                .direction = RTE_SECURITY_IPSEC_SA_DIR_INGRESS
        },
        .crypto_capabilities = { /* AES-GCM (128-bit) */
                .op = RTE_CRYPTO_OP_TYPE_SYMMETRIC,
                .sym = {
                        .xform_type = RTE_CRYPTO_SYM_XFORM_AEAD,
                        .aead = {
                                .algo = RTE_CRYPTO_AEAD_AES_GCM,
                                .block_size = 16,
                                .key_size =    { .min = 16, .max = 16, .increment = 0 },
                                .digest_size =         { .min = 8, .max = 16, .increment = 4 },
                                .aad_size =   { .min = 4, .max = 8, .increment = 4 },
                                .iv_size =      { .min = 12, .max = 12, .increment = 0 }
                        },
                },
        },
},
```

Control Path




```
/** security session configuration parameters */
struct rte_security_session_conf sess_conf = {
        .action_type = RTE_SECURITY_ACTION_TYPE_INLINE_CRYPTO,
        .protocol = RTE_SECURITY_PROTOCOL_IPSEC,
        .ipsec = {
                .spi = /** Security Protocol Index */,
                .salt = /** Salt value */,
                .direction = RTE_SECURITY_IPSEC_SA_DIR_INGRESS,
                .proto = RTE_SECURITY_IPSEC_SA_PROTO_ESP,
                .mode = RTE_SECURITY_IPSEC_SA_MODE_TUNNEL
        },
        .crypto_xform = /** crypto transforms*/
};
```

```
/** flow parameters */
attr->ingress = 1;

pattern[0].type = RTE_FLOW_ITEM_TYPE_ETH;
pattern[1].type = RTE_FLOW_ITEM_TYPE_IPV4;
pattern[2].type = RTE_FLOW_ITEM_TYPE_ESP;
pattern[3].type = RTE_FLOW_ITEM_TYPE_END;

action[0].type = RTE_FLOW_ACTION_TYPE_SECURITY;
action[0].conf = /** security session */;
action[1].type = RTE_FLOW_ACTION_TYPE_END;
```

rte_flow Implementation

ethdev control path for rte_security

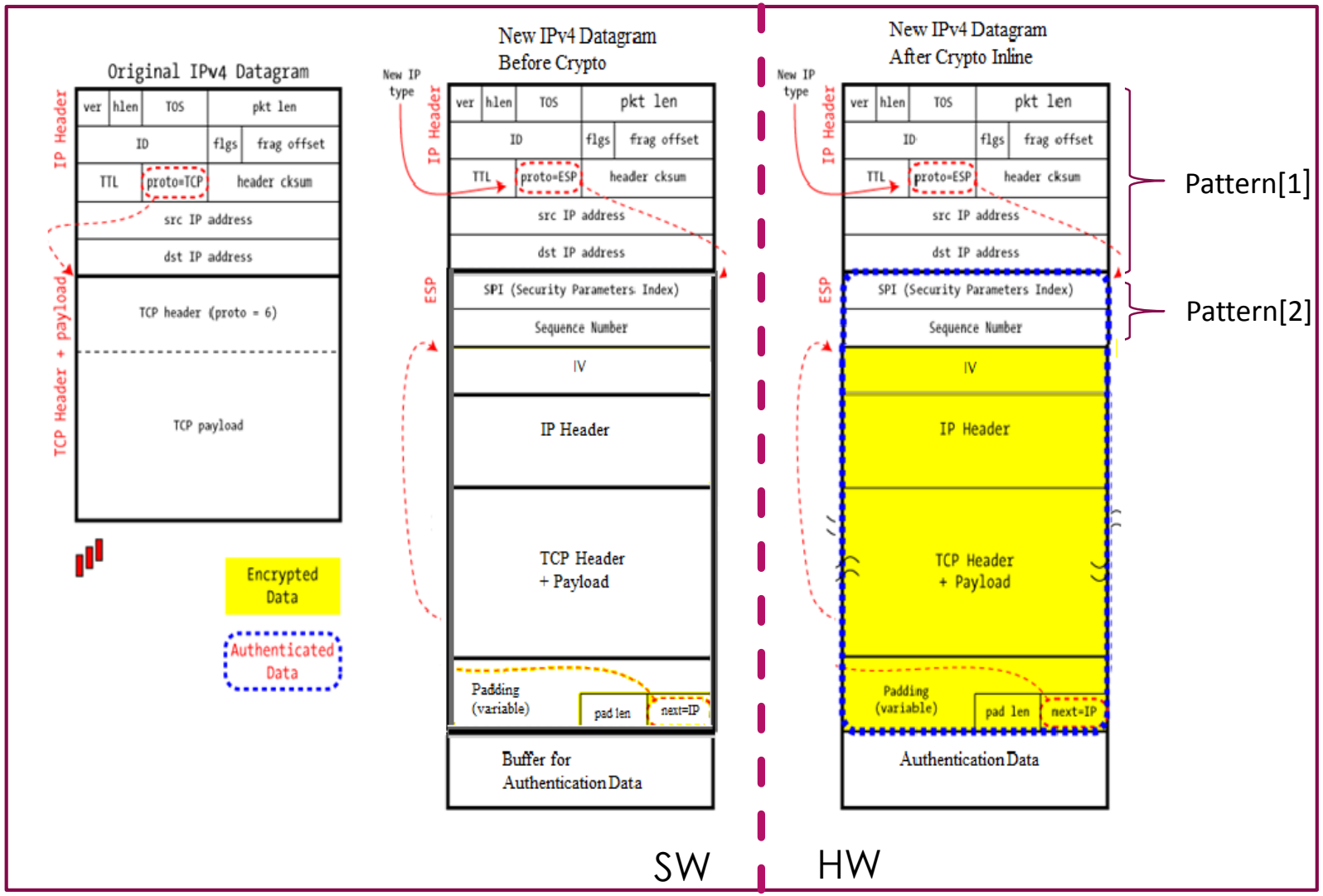
Inline Crypto Offload

```
/** security session configuration parameters */
struct rte_security_session_conf sess_conf = {
        .action_type =
RTE_SECURITY_ACTION_TYPE_INLINE_CRYPTO,
        .protocol = RTE_SECURITY_PROTOCOL_IPSEC,
        .ipsec = {
                .spi = /**< Security Protocol Index */,
                .salt = /** Salt value */,
                .direction = RTE_SECURITY_IPSEC_SA_DIR_INGRESS,
                .proto = RTE_SECURITY_IPSEC_SA_PROTO_ESP,
                .mode = RTE_SECURITY_IPSEC_SA_MODE_TUNNEL
        },
        .crypto_xform = /** crypto transforms*/
};
```

```
/** flow parameters */
attr->ingress = 1; /** attr->egress = 1 */

pattern[0].type = RTE_FLOW_ITEM_TYPE_ETH;
pattern[1].type = RTE_FLOW_ITEM_TYPE_IPV4;
pattern[2].type = RTE_FLOW_ITEM_TYPE_ESP;
pattern[3].type = RTE_FLOW_ITEM_TYPE_END;

action[0].type = RTE_FLOW_ACTION_TYPE_SECURITY;
action[0].conf = sa->sec_session;
action[1].type = RTE_FLOW_ACTION_TYPE_END;
```



Inline Crypto Offload - Example 1

rte_flow allows for extensible inline crypto support, without redefining network headers in crypto library:

For example:

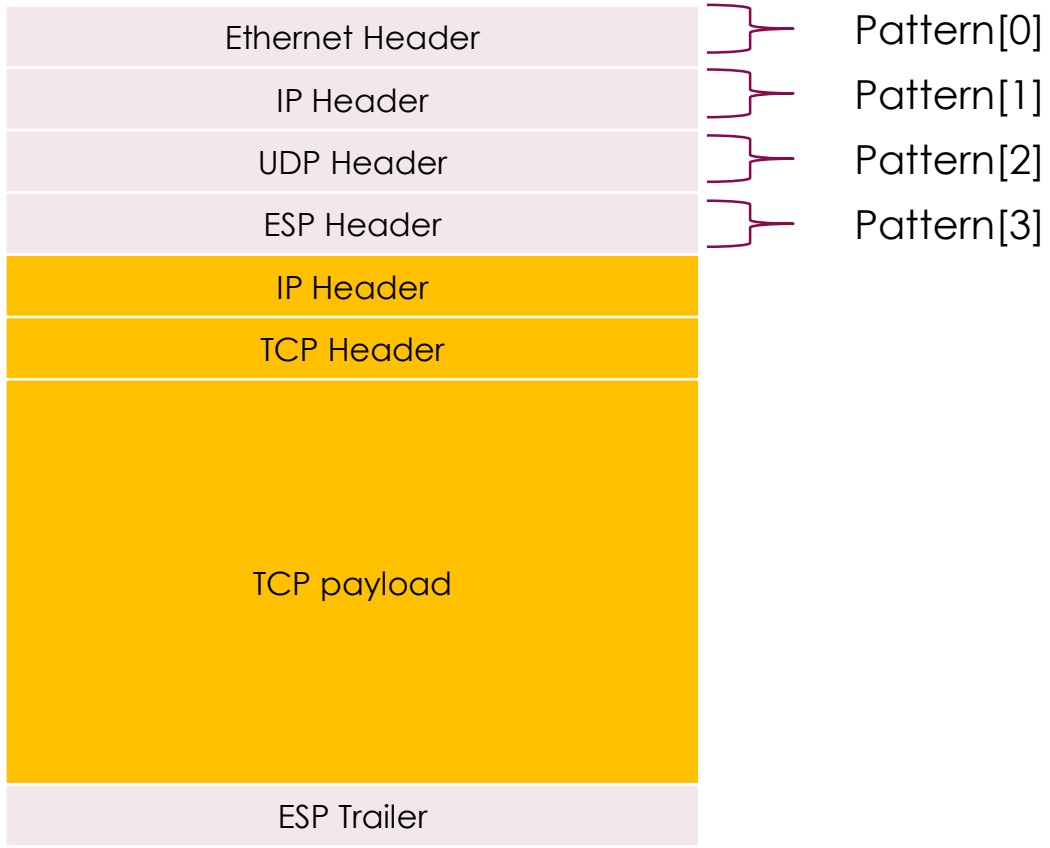
- UDP Encap using rte_flow

```
/** flow parameters */
attr->ingress = 1; /** attr->egress = 1 */

pattern[0].type = RTE_FLOW_ITEM_TYPE_ETH;
pattern[1].type = RTE_FLOW_ITEM_TYPE_IPV4;
pattern[2].type = RTE_FLOW_ITEM_TYPE_UDP;
pattern[3].type = RTE_FLOW_ITEM_TYPE_ESP;
pattern[4].type = RTE_FLOW_ITEM_TYPE_END;

action[0].type = RTE_FLOW_ACTION_TYPE_SECURITY;
action[0].conf = sa->sec_session;
action[1].type = RTE_FLOW_ACTION_TYPE_END;
```

UDP ESP example:



Inline Crypto Offload - Example 2

rte_flow allows for extensible inline crypto support, without redefining network headers in crypto library:

For example:

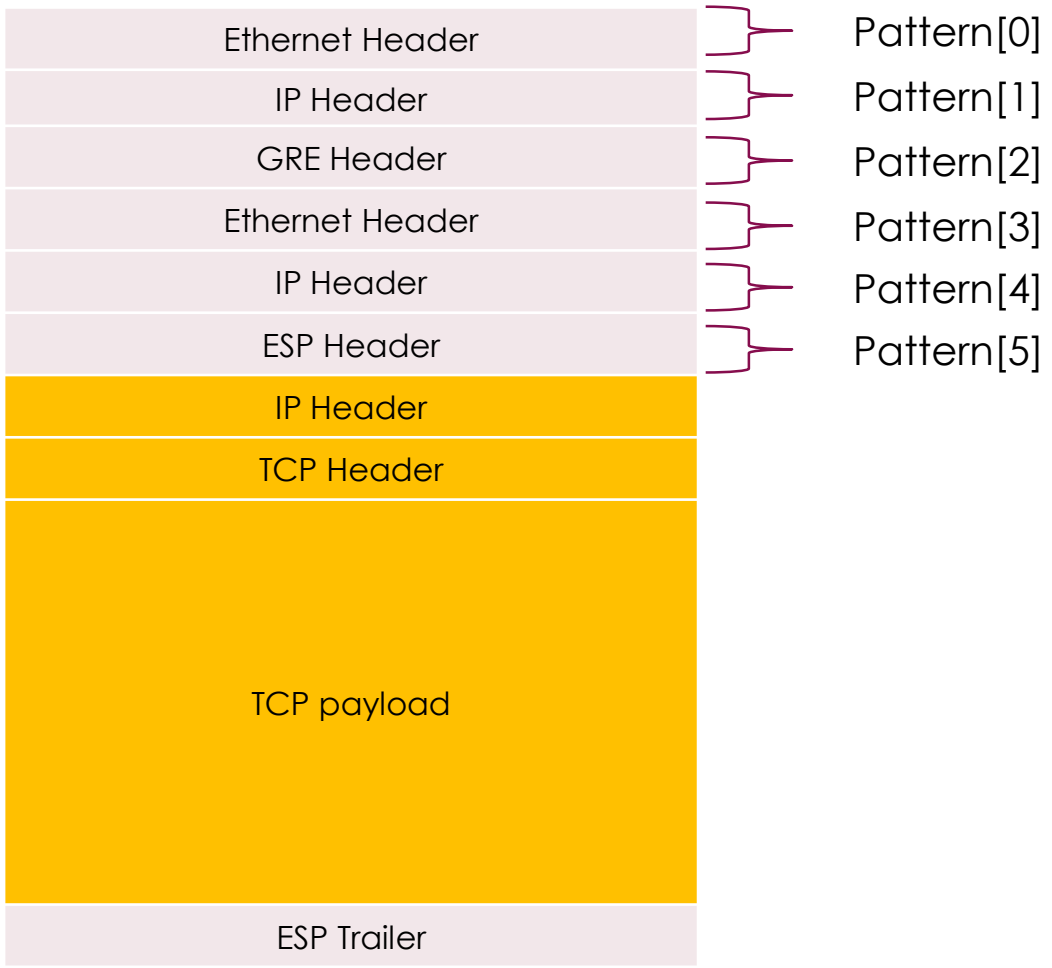
- NVGRE | ESP | TCP using rte_flow

```
/** flow parameters */
attr->ingress = 1; /** attr->egress = 1 */

pattern[0].type = RTE_FLOW_ITEM_TYPE_ETH;
pattern[1].type = RTE_FLOW_ITEM_TYPE_IPV4;
pattern[2].type = RTE_FLOW_ITEM_TYPE_NVGRE;
pattern[3].type = RTE_FLOW_ITEM_TYPE_ETH;
pattern[4].type = RTE_FLOW_ITEM_TYPE_IPV4;
pattern[5].type = RTE_FLOW_ITEM_TYPE_ESP;
pattern[6].type = RTE_FLOW_ITEM_TYPE_END;

action[0].type = RTE_FLOW_ACTION_TYPE_SECURITY;
action[0].conf = sa->sec_session;
action[1].type = RTE_FLOW_ACTION_TYPE_END;
```

NVGRE | ESP | TCP example:



Discussion

Inline Protocol Offload – Control Path

- INLINE_PROTOCOL might be the first encap/decap action in rte_flow.
- How do we describe these with rte_flow?
- Do we need to define an order between actions and patterns?
  - Linking actions to patterns
- How to express the ARP entries for destination IPs in case of encap/decap.

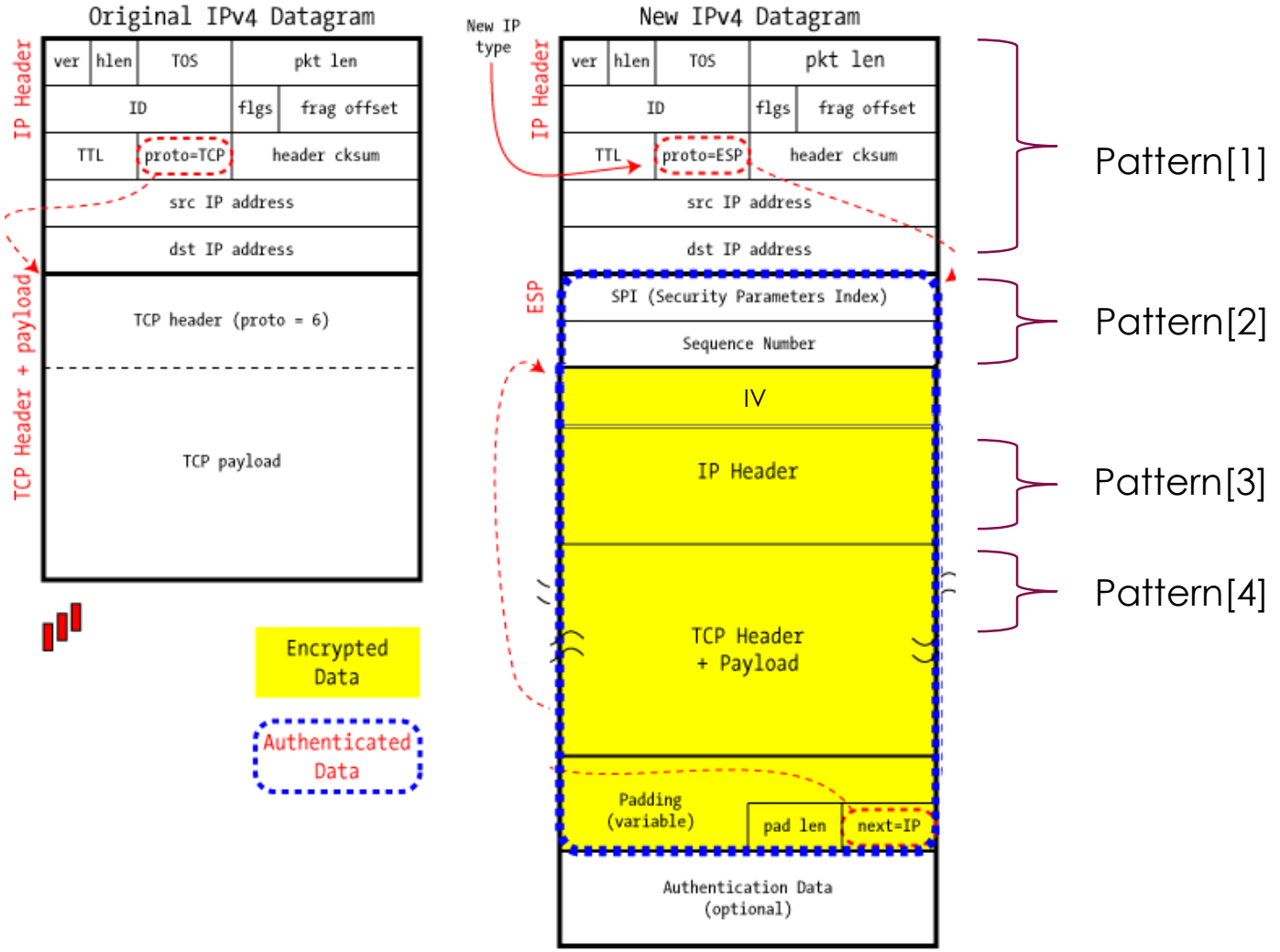
Inline Protocol Offload – Control Path

- Actions referring to patterns

```
/** security session configuration parameters */
struct rte_security_session_conf sess_conf = {
        .action_type = RTE_SECURITY_ACTION_TYPE_INLINE_PROTOCOL,
        .protocol = RTE_SECURITY_PROTOCOL_IPSEC,
        .ipsec = {
                .spi = /**< Security Protocol Index */,
                .salt = /** Salt value */,
                .direction = RTE_SECURITY_IPSEC_SA_DIR_INGRESS,
                .proto = RTE_SECURITY_IPSEC_SA_PROTO_ESP,
                .mode = RTE_SECURITY_IPSEC_SA_MODE_TUNNEL
                .tunnel = /** Tunnel parameters */,
        },
        .crypto_xform = /** crypto transforms*/
};
```

```
/** flow parameters */
pattern[0].type = RTE_FLOW_ITEM_TYPE_ETH; /** encap/decap */
pattern[1].type = RTE_FLOW_ITEM_TYPE_IPV4; /** encap/decap */
pattern[2].type = RTE_FLOW_ITEM_TYPE_ESP; /** encap/decap */
pattern[3].type = RTE_FLOW_ITEM_TYPE_IPV4; /** inner IP */
pattern[4].type = RTE_FLOW_ITEM_TYPE_TCP; /** inner TCP */
pattern[5].type = RTE_FLOW_ITEM_TYPE_END;

action[0].type = RTE_FLOW_ACTION_TYPE_SECURITY;
action[0].conf = sa->sec_session;
action[1].type = RTE_FLOW_ACTION_TYPE_END;
```



Inline Protocol Offload – Data Path

- **Idea:** Offload could be transparent to the data-path after configuration is complete
- Do we need to use any mbuf flags?
- Do we need to provide any metadata with mbufs? SA identifier? Crypto result?
- How are we to handle IP fragments?
- Error handling – failed to decap – Bad IP header, ESP trailer, etc.

Summary

Summary

- rte_security is a representation of a security session
- rte_security can be used with ethdev and cryptodev
- rte_security + rte_flow = powerful control plane
- Redundancy to ease the application migration between security offloads.

Future Work

- Further IPsec enablement
  - Further encapsulations
  - LSO + checksum
  - IPsec inline protocol offload
- Further protocol enablement
  - MACsec, PDCP, DTLS, etc would fit under this model.
- Software equivalent enablement
  - It could be possible to offer software equivalent processing under this API, may or may not be desirable depending on protocol and it’s processing overhead.

Questions?

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