DOCA IPsec Security Gateway Application Guide

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This document provides an IPsec security gateway implementation on top of NVIDIA® BlueField® DPU.

> **Note**
>
> If your target application utilizes 100Gb/s or higher bandwidth, where a substantial part of the bandwidth is allocated for IPsec traffic, please refer to the *NVIDIA BlueField-2 DPUs Product Release Notes* to learn about a potential bandwidth limitation. To access the relevant product release notes, please contact your NVIDIA sales representative.

Introduction

> **Note**
>
> DOCA IPsec Security Gateway is supported at alpha level.

DOCA IPsec Security Gateway leverages the DPU's hardware capability for secure network communication. The application demonstrates how to insert rules related to IPsec encryption and decryption based on the DOCA Flow library.

The application demonstrates how to insert rules to create an IPsec tunnel.

> **Note**
>
> An example for configuring the Internet Key Exchange (IKE) can be found under section "Keying Daemon Integration (StrongSwan)" but is not considered part of the application.

The application can be configured to receive IPsec rules in one of the following ways:

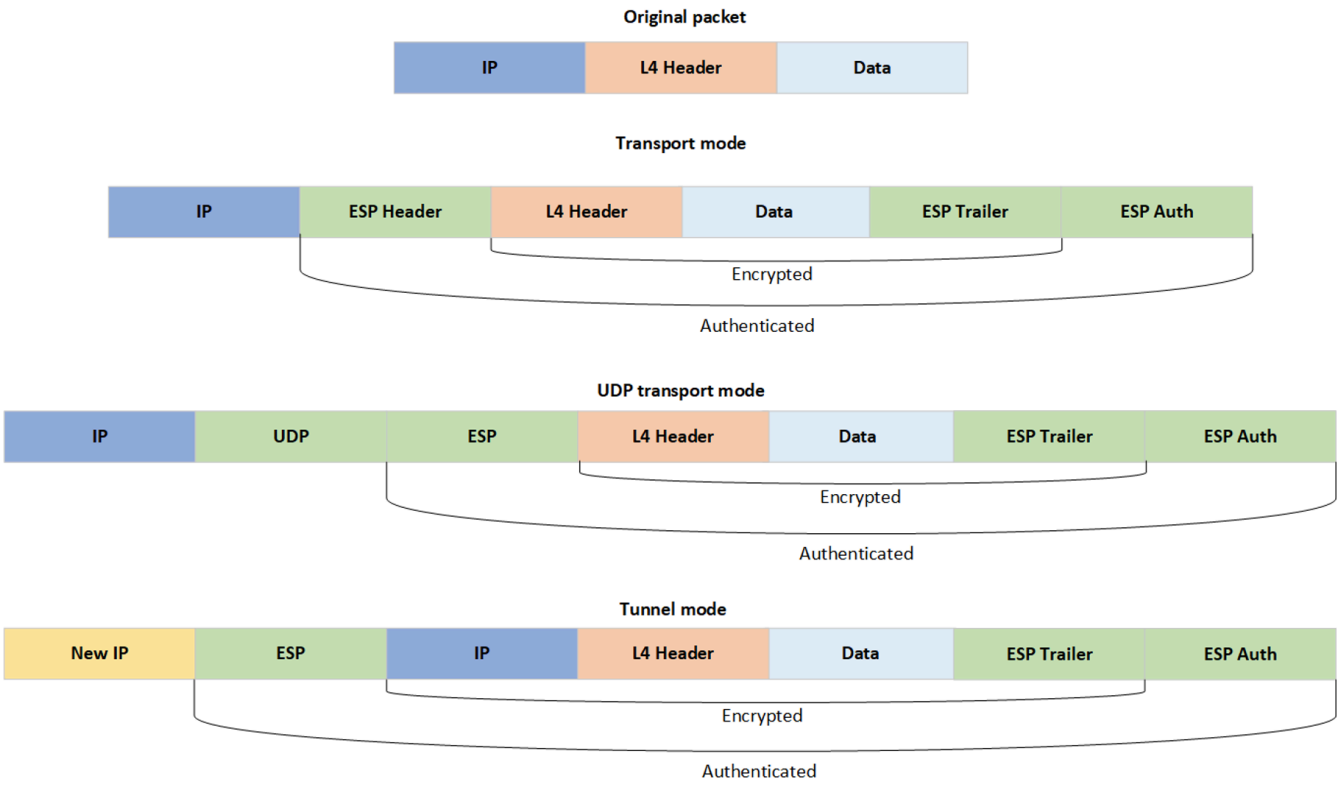
- Static configuration – (default) receives a fixed list of rules for IPsec encryption and decryption

> **Note**
>
> When creating the security association (SA) object, the application gets the key, salt, and other SA attributes from the JSON input file.

- Dynamic configuration – receives IPsec encryption and decryption rules during runtime through a Unix domain socket (UDS) which is enabled when providing a socket path to the application

> **Note**
>
> You may find an example of integrating a rules generator with the application under strongSwan project (DOCA plugin).

The application supports the following IPsec modes: Tunnel, transport, UDP transport.

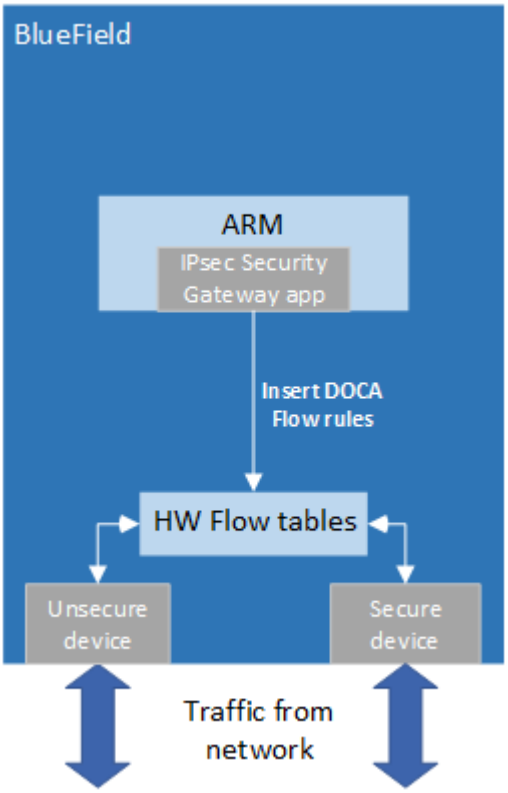


System Design

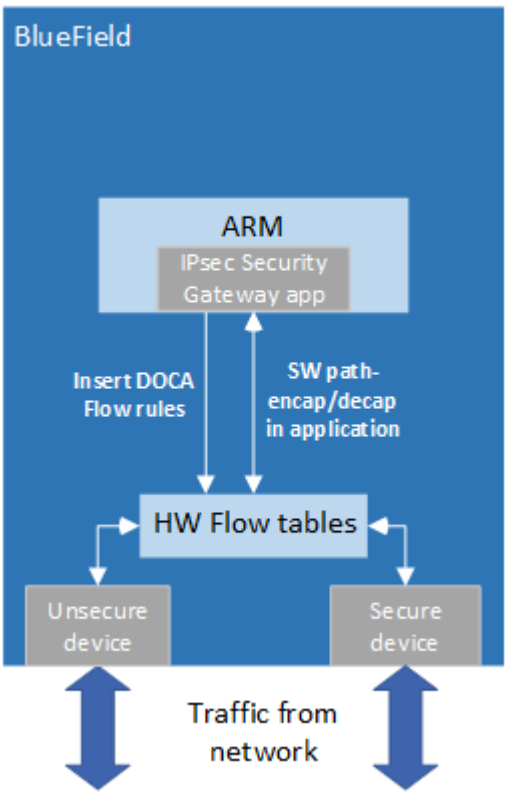
DOCA IPsec Security Gateway is designed to run with 2 ports, secured and unsecured:

- Secured port – BlueField receives IPsec encrypted packets and, after decryption, they are sent through the unsecured port
- Unsecured port – BlueField receives regular (plain text) packets and, after encryption, they are sent through the secured port

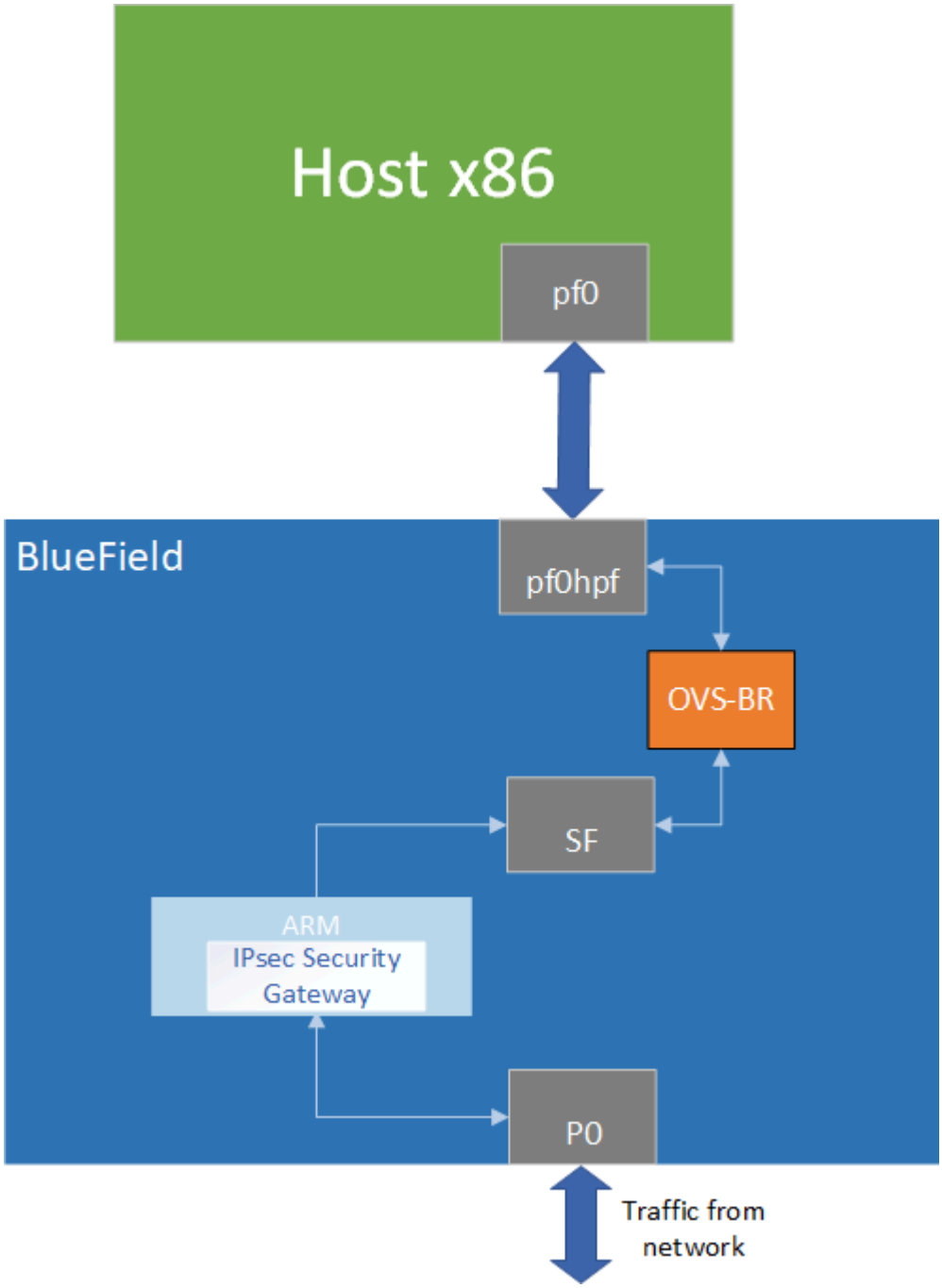
Example packet path for hardware (HW) offloading:



Example packet path for partial software processing (handling encap/decap in software):



Using the application with SF:



Application Architecture

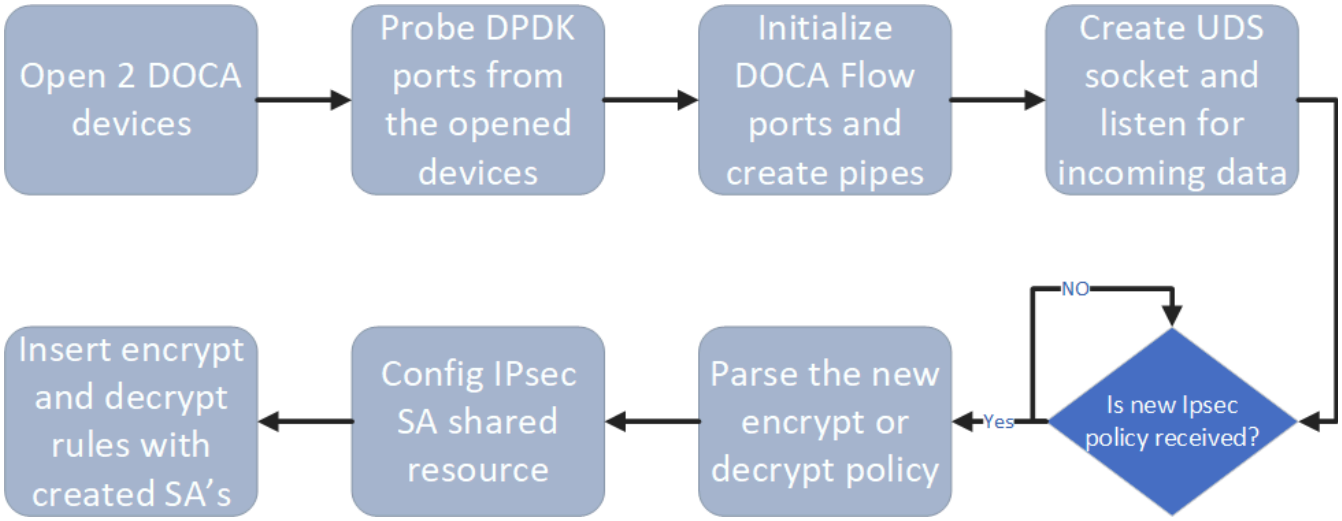
Static Configuration

1. Open two DOCA devices, one for the secured port and another for the unsecured port.

2. With the open DOCA devices, the application probes DPDK ports and initializes DOCA Flow and DOCA Flow ports accordingly.

3. On the created ports, build DOCA Flow pipes.
4. In a loop according to the JSON rules:
    1. Create IPSec SA shared resource for the new rule.
    2. Insert encrypt or decrypt rule to DOCA Flow pipes.

Dynamic Configuration



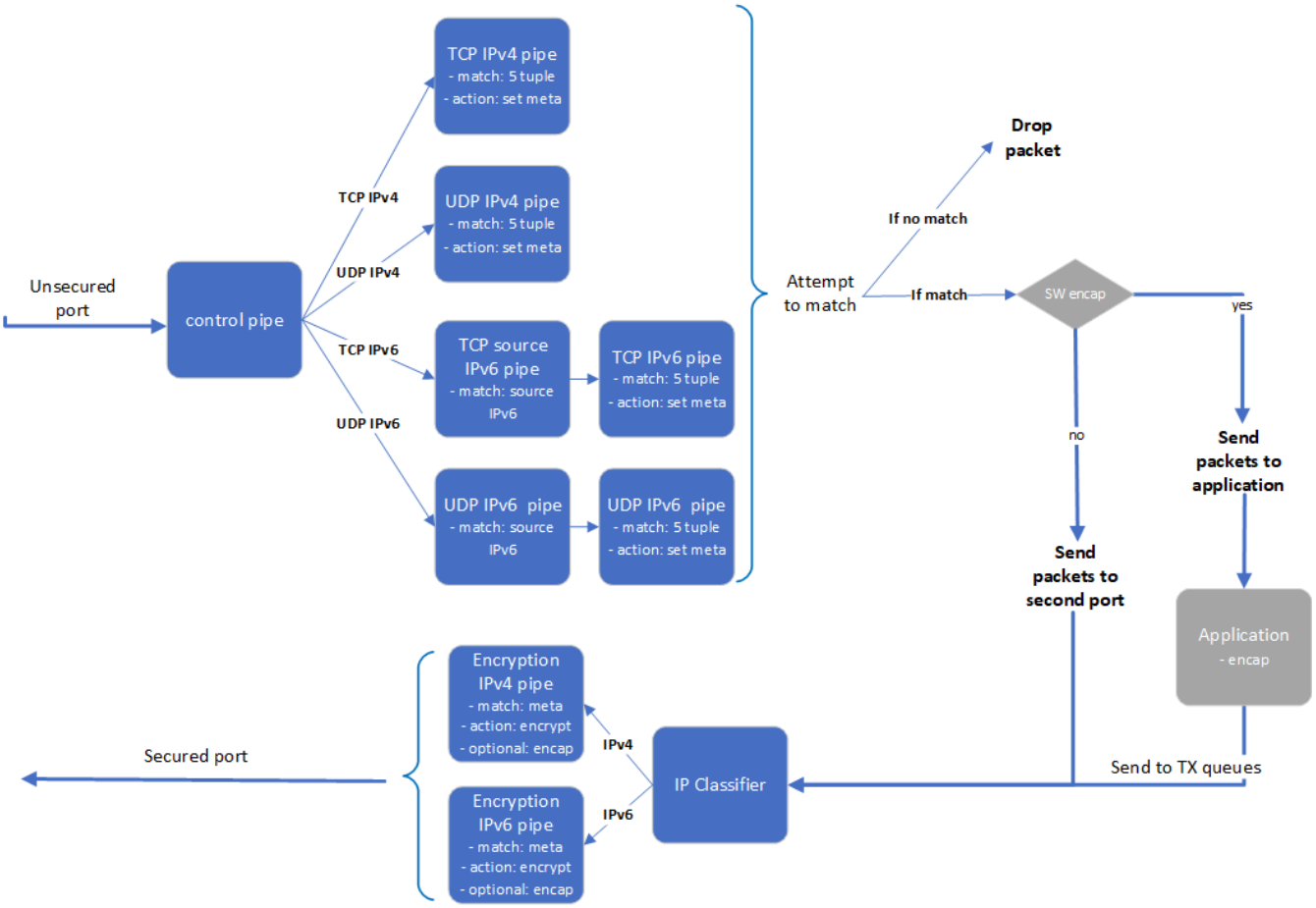
1. Open two DOCA devices, one for the secured port and another for the unsecured port.
2. With the open DOCA devices, the application probes DPDK ports and initializes DOCA Flow and DOCA Flow ports accordingly.
3. On the created ports, build DOCA Flow pipes.
4. Create UDS socket and listen for incoming data.
5. While waiting for new IPsec policies to be received in a loop, if a new IPsec policy is received:
    1. Parse the policy whether it is an encryption or decryption rule.
    2. Create IPSec SA shared resource for the new rule.
    3. Insert encrypt or decrypt rule to DOCA Flow pipes.

DOCA Flow Modes

The application can run in two modes, `vnf` and `switch`. For more information about the modes, please refer to "Pipe Mode" in the DOCA Flow.

VNF Mode

Encryption



1. The application builds pipes for encryption. Control pipe as root with four entries that match L3 and L4 types and forward the traffic to the relevant pipes.

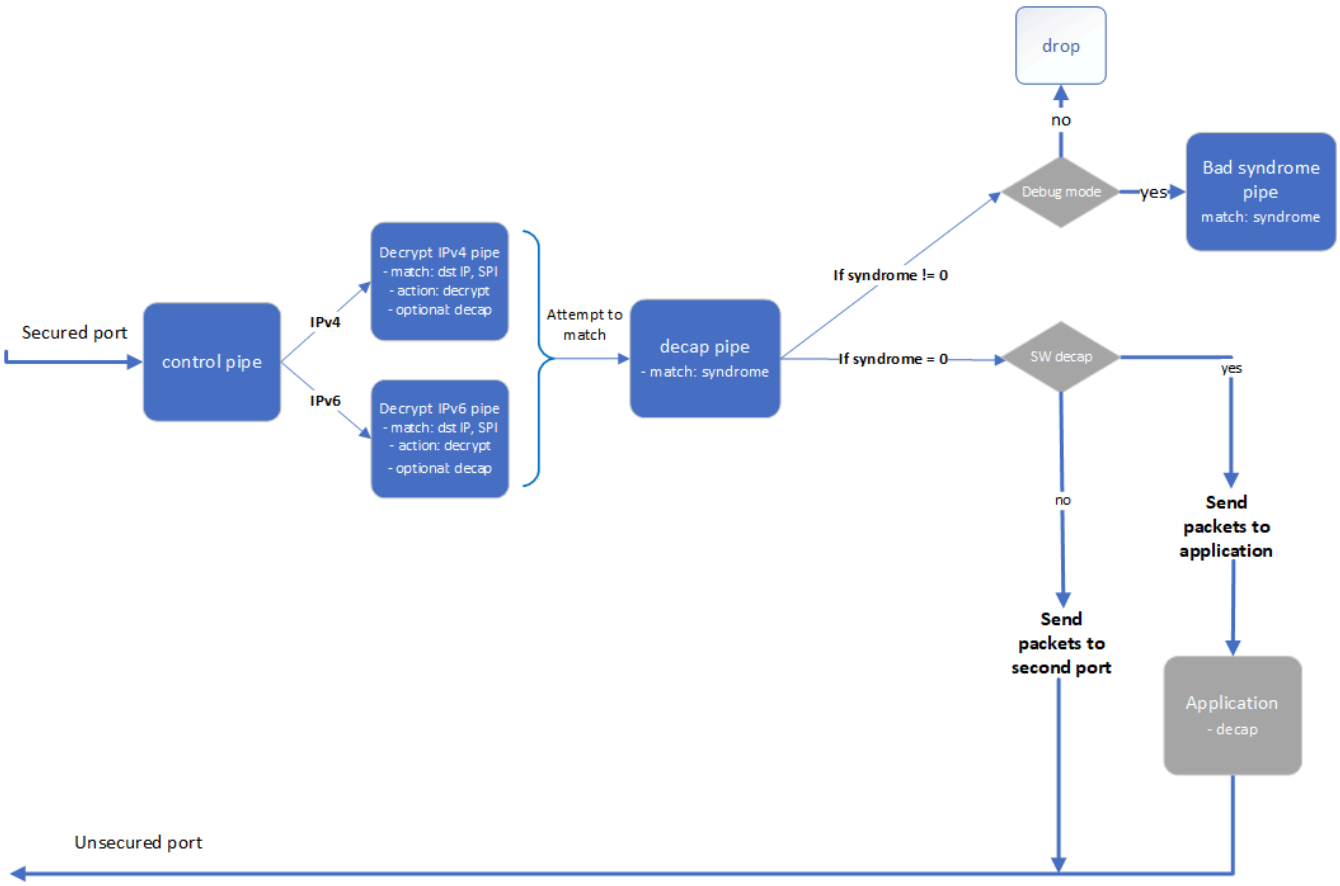
    1. IPv6 pipes – match the source IP address and forward the traffic to a pipe that matches 5-tuple excluding the source IP.

    2. In the 5-tuple match pipes set action of "set meta data", the metadata would be the rule's index in the JSON file.

3. The matched packet is forwarded to the second port.

2. In the secured egress domain, the IP classifier pipe sends the packets to the correct encryption pipe (IPv4 or IPv6) which has a shared IPsec encrypt action. According to the metadata match, the packet is encrypted with the encap destination IP and SPI as defined in the user's rules.

Decryption



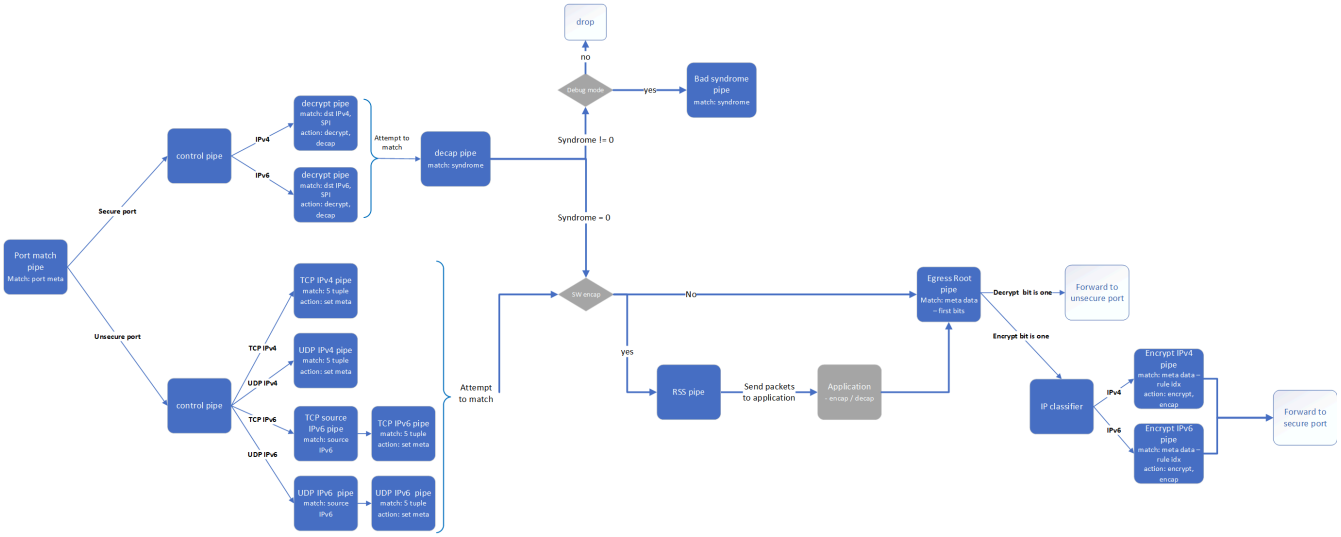
1. The application builds pipes for decryption. Control pipe as root with two entries that match L3 type and forward the traffic to the relevant decrypt pipe.

2. The decrypt pipe matches the destination IP and SPI according to the rule files and has a shared IPsec action for decryption.

3. After decryption, the matched packets are forwarded to the decap pipe and, if the syndrome is non-zero, the packets are dropped. Otherwise, the packets decap the ESP header and forward to the second port.

1. In debug mode, if syndrome is non-zero, then it sends to bad syndrome pipe to match on the syndrome, count and drop/send to application.

Switch Mode



In switch mode, an ingress root pipe matches the source port to decide what the next pipe is:

- Based on the port, the packet passes through almost the same path as VNF mode and the metadata is set. Afterwards, the packet moves to egress root pipe.

In egress root pipe, the match is on encrypt and decrypt bits that were set in the packet meta:

- Decrypt bit is 1 – packet finishes the decrypt path and must be sent to the unsecure port

- Encrypt bit is 1 – packet almost finishes the encrypt path and must be sent to the encrypt pipe on the secure egress domain and to the secure port from there

DOCA Libraries

This application leverages the following DOCA libraries:

- DOCA Flow

Refer to their respective programming guide for more information.

Compiling the Application

> **Info**
>
> Please refer to the DOCA Installation Guide for Linux for details on how to install BlueField-related software.

The installation of DOCA's reference applications contains the sources of the applications, alongside the matching compilation instructions. This allows for compiling the applications "as-is" and provides the ability to modify the sources, then compile a new version of the application.

> **Tip**
>
> For more information about the applications as well as development and compilation tips, refer to the DOCA Reference Applications page.

The sources of the application can be found under the application's directory: `/opt/mellanox/doca/applications/ipsec_security_gw/`.

Prerequisites

The application relies on the `json-c` open source, hence, requires the following installation:

- Ubuntu/Debian:

```
$ sudo apt install libjson-c-dev
```

- CentOS/RHEL:

```
$ sudo yum install json-c-devel
```

Compiling All Applications

All DOCA applications are defined under a single meson project. So, by default, the compilation includes all of them.

To build all the applications together, run:

```
cd /opt/mellanox/doca/applications/
meson /tmp/build
ninja -C /tmp/build
```

Info

`doca_ipsec_security_gw` is created under `/tmp/build/ipsec_security_gw/`.

Compiling Only the Current Application

To directly build only the IPsec Security Gateway application:

```
cd /opt/mellanox/doca/applications/
meson /tmp/build -Denable_all_applications=false -
Denable_ipsec_security_gw=true
ninja -C /tmp/build
```

Info

`doca_ipsec_security_gw` is created under `/tmp/build/ipsec_security_gw/`.

Alternatively, users can set the desired flags in the `meson_options.txt` file instead of providing them in the compilation command line:

1. Edit the following flags in `/opt/mellanox/doca/applications/meson_options.txt`:
   - Set `enable_all_applications` to `false`
   - Set `enable_ipsec_security_gw` to `true`
2. Run the following compilation commands :

   ```
   cd /opt/mellanox/doca/applications/
   meson /tmp/build
   ninja -C /tmp/build
   ```

   Info

`doca_ipsec_security_gw` is created under `/tmp/build/ipsec_security_gw/`.

Troubleshooting

Refer to the DOCA Troubleshooting for any issue encountered with the compilation of the application .

Running the Application

Prerequisites

1. The IPsec security gateway application is based on DOCA Flow. Therefore, the user is required to allocate huge pages.

```
$ echo '2048' | sudo tee -a /sys/kernel/mm/hugepages/hugepages-
2048kB/nr_hugepages
$ sudo mkdir /mnt/huge
$ sudo mount -t hugetlbfs -o pagesize=2M nodev /mnt/huge
```

2. VNF mode – the IPsec security gateway application requires disabling some of the hardware tables:

```
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.0 mode legacy
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.1 mode legacy

echo none > /sys/class/net/p0/compat/devlink/encap
echo none > /sys/class/net/p1/compat/devlink/encap
```

```
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.0 mode switchdev
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.1 mode switchdev
```

To restore the old configuration:

```
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.0 mode legacy
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.1 mode legacy

echo basic > /sys/class/net/p0/compat/devlink/encap
echo basic > /sys/class/net/p1/compat/devlink/encap

/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.0 mode switchdev
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.1 mode switchdev
```

3. Switch mode – the IPsec security gateway application requires configuring the ports to run in switch mode:

```
sudo mlxconfig -d /dev/mst/mt41686(mt41692)_pciconf0 s
LAG_RESOURCE_ALLOCATION=1
# power cycle the host to apply this setting

/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.0 mode legacy
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.1 mode legacy
```

```
sudo devlink dev param set pci/0000:03:00.0 name esw_pet_insert
value false cmode runtime
sudo devlink dev param set pci/0000:03:00.1 name esw_pet_insert
value false cmode runtime

/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.0 mode switchdev
/opt/mellanox/iproute2/sbin/devlink dev eswitch set
pci/0000:03:00.1 mode switchdev

sudo devlink dev param set pci/0000:03:00.0 name esw_multiport
value true cmode runtime
sudo devlink dev param set pci/0000:03:00.1 name esw_multiport
value true cmode runtime
```

Note

Make sure to perform BlueField system reboot prior to power cycling the host.

To restore the old configuration:

```
sudo devlink dev param set pci/0000:03:00.0 name esw_multiport
value false cmode runtime
sudo devlink dev param set pci/0000:03:00.1 name esw_multiport
value false cmode runtime
```

Application Execution

The IPsec Security Gateway application is provided in source form. Therefore, a compilation is required before the application can be executed.

1. Application usage instructions:

```
Usage: doca_ipsec_security_gw [DOCA Flags] [Program Flags]

DOCA Flags:
  -h, --help                          Print a help synopsis
  -v, --version                       Print program version
information
  -l, --log-level                     Set the (numeric) log
level for the program <10=DISABLE, 20=CRITICAL, 30=ERROR,
40=WARNING, 50=INFO, 60=DEBUG, 70=TRACE>
  --sdk-log-level                     Set the SDK (numeric) log
level for the program <10=DISABLE, 20=CRITICAL, 30=ERROR,
40=WARNING, 50=INFO, 60=DEBUG, 70=TRACE>
  -j, --json <path>                   Parse all command flags
from an input json file

Program Flags:
  -s, --secured                       secured port pci-address
  -u, --unsecured                     unsecured port pci-
address
  -c, --config                        Path to the JSON file
with application configuration
  -m, --mode                          ipsec mode -
{tunnel/transport/udp_transport}
  -i, --ipc                           IPC socket file path
  -sn, --secured-name                 secured port interface name
  -un, --unsecured-name               unsecured port interface
name
  -n, --nb-cores                      number of cores
  --debug                             Enable debug counters
```

Info

This usage printout can be printed to the command line using the `-h` (or `--help`) options:

```
./doca_ipsec_security_gw -h
```

Info

For additional information, refer to section "Command Line Flags".

2. CLI example for running the application on the BlueField or host:

   - Static Configuration:

```
./doca_ipsec_security_gw -s 03:00.0 -u 03:00.1 -c
./ipsec_security_gw_config.json -m transport
```

Note

Both the PCIe address identifiers (`-s` and `-u` flags) should match the addresses of the desired PCIe devices.

   - Dynamic Configuration:

```
./doca_ipsec_security_gw -s 03:00.0 -u 03:00.1 -c
./ipsec_security_gw_config.json -m transport -i
/tmp/rules_socket
```

> **Note**
>
> Both the PCIe address identifiers (`-s` and `-u` flags) should match the addresses of the desired PCIe devices.

3. The application also supports a JSON-based deployment mode, in which all command-line arguments are provided through a JSON file:

```
./doca_ipsec_security_gw --json [json_file]
```

For example

```
./doca_ipsec_security_gw --json ipsec_security_gw_params.json
```

> **Note**
>
> Before execution, ensure that the used JSON file contains the correct configuration parameters, and especially the PCIe addresses necessary for the deployment.

Command Line Flags

Flag Type	Short Flag	Long Flag/JSON Key	Description	JSON Content
General flags	`h`	`help`	Prints a help synopsis	N/A
	`v`	`version`	Prints program version information	N/A
	`l`	`log-level`	Set the log level for the application: • DISABLE=10 • CRITICAL=20 • ERROR=30 • WARNING=40 • INFO=50 • DEBUG=60 • TRACE=70 (requires compilation with `TRACE` log level support)	`"log-level" : 60`
	N/A	`sdk-log-level`	Sets the log level for the program: • DISABLE=10 • CRITICAL=20 • ERROR=30 • WARNING=40 • INFO=50 • DEBUG=60 • TRACE=70	`"sdk-log-level" : 40`
	`j`	`json`	Parse all command flags from an input json file	N/A
Program flags	`c`	`config`	Path to JSON file with configurations	`"config" : "security_gateway_config.json"`
	`u`	`unsecured`	PCIe address for the unsecured port	`"unsecured" : "03:00.1"`

Flag Type	Short Flag	Long Flag/JSON Key	Description	JSON Content
	`s`	`secured`	PCIe address for the secured port	`"secured" : "03:00.0"`
	`m`	`mode`	IPsec mode. Possible values: `tunnel`, `transport`, `udp_transport`	`"mode" : "tunnel"`
	`un`	`unsecured-name`	Interface name of the unsecured port	`"unsecured-name" : "p1"`
	`sn`	`secured-name`	Interface name of the secured port	`"secured-name" : "p0"`
	`i`	`ipc`	IPC socket file path for receiving IPsec rules during runtime	`"ipc" : "/tmp/rules_socket"`
	`n`	`nb-cores`	Number of cores	`"nb-cores" : 8`
	N/A	`debug`	Add counters to all the entries	`"debug" : true`

Info

Refer to DOCA Arg Parser for more information regarding the supported flags and execution modes.

Static Configuration IPsec Rules

IPsec rules and other configuration can be added with a JSON config file which is passed using the `--config` parameter.

Section	Field	Type	Description	Example
`config`	`switch`	bool	Configures whether DOCA Flow runs in VNF (`false`) or switch (`true`) mode	`"switch" : true`
	`esp-header-offload`	string	Decap and encap offloading: `both` , `encap` , `decap` , or `none` . Default is `both` (offloading both encap and decap).	`"esp-header-offload" : "none"`
	`sw-sn-inc-enable`	bool	Increments sequence number of ESP in software if set to `true` . Default is false. **Note** Available only if `esp_header_offload` is `decap` or `none` .	`"sw-sn-inc-enable" : true`

Section	Field	Type	Description	Example
	`sw-antireplay-enable`	bool	Enables anti-replay mechanism in software if set to `true`. Default is false. **Note** Available only if `esp_header_offload` is `encap` or `none`. **Note** Window size is 64. Not ESN. Supports non-zero `sn_initial`.	`"sw-antireplay-enable" : true`
	`sn-initial`	uint	Initial sequence number for ESP header. Used also when `sw_antireplay_enable` is true. Default is 0.	`"sn-initial" : 0`
	`debug`	bool	Set debug counter for all entries when `true`. Default is `false`. This parameter is also used from CLI, will be taken as true if was sent in one of them.	`"debug" : false`

Section	Field	Type	Description	Example
	`fwd-bad-syndrome`	string	Forward packets that has bad syndrome: `drop`, `RSS`. Default is `drop`. **Note** Only available in debug mode.	"fwd-bad-syndrome" : "drop"
	`perf-measurements`	string	Possible values: `none`, `insertion-rate`, `bandwidth`, `both`. Default is `none`. • `insertion-rate` – print the total time it took to add the entries • `bandwidth` – optimize the pipe to improve pps for IPv6	"perf-measurements" : "both"
	`vxlan-encap`	bool	When `true`, preform `vxlan-encap` after encryption and decap before decryption. Default is `false`.	"vxlan-encap" : false
	`vni`	uint	When `vxlan-encap` is true, use this `vni` value in the VXLAN tunnel.	"vni" : 5
	`marker-encap`	bool	When `true`, add an extra non-ESP marker of 8 bytes. Default is `false`.	"marker-encap" : false
	`icv-length`	int	ICV length value: `8`, `12`, or `16`. Default is `16`.	"icv-length" : 12

Section	Field	Type	Description	Example
`encrypt_rules`	`ip-version`	int	Source and destination IP version. Possible values: `4`, `6`. Optional; default is `4`.	`"ip-version" : 6`
	`src-ip`	string	Source IP to match	`"src-ip" : "1.2.3.4"`
	`dst-ip`	string	Destination IP to match	`"dst-ip" : "101:101:101:101:101:101:101:101"`
	`protocol`	string	L4 protocol: TCP or UDP	`"protocol"`
	`src-port`	int	Source port to match	
	`dst-port`	int	Destination port to match	`"dst-port" : 55`
	`encap-ip-version`	int	Encap IP version: `4` or `6`. Optional; default is `4`.	`"ip-version" : 4`
	`encap-dst-ip`	string	Encap destination IP **Note**	`"encap-dst-ip" : "1.1.1.1"`

Section	Field	Type	Description	Example
			Mandatory for tunnel mode only.	
	`spi`	int	SPI integer to set in the ESP header	`"spi" : 5`
	`key`	string	Key for creating the SA (in hex format)	`"key" : "112233445566778899aabbccdd"`
	`key-type`	int	Key size: `128` or `256`. Optional; default is `256`.	`"key-type" : 128`
	`salt`	int	Salt value for creating the SA. Default is `6`.	`"salt" : 1212`
	`lifetime-threshold`	int	Set IPsec lifetime threshold. Ignored if `sw-sn-inc-enable` is true. Default is 0.	`"lifetime-threshold" : 1000000`
	`esn_en`	bool	Enables extended sequence number. Default is `false`.	`"esn_en" : true`

Section	Field	Type	Description	Example
`decrypt_rules`	`ip-version`	int	Destination IP version: `4` or `6`. Optional; default is `4`.	`"ip-version" : 6`
	`dst-ip`	string	Destination IP to match	`"dst-ip" : "1122:3344:5566:7788:99aa:bbcc:ddee:ff00"`
	`inner-ip-version`	int	Inner IP version: `4` or `6`. Optional; default is `4`. **Note** Mandatory for tunnel mode only.	`"inner-ip-version" : 4`
	`spi`	int	SPI to match in the ESP header	`"spi" : 5`
	`key`	string	Key for creating the SA (in hex format)	`"key" : "112233445566778899aabbccdd"`
	`key-type`	int	Key size: `128` or `256`. Optional; default is `256`.	`"key-type" :`

Section	Field	Type	Description	Example
				128
	`salt`	int	Salt value for creating the SA. Default is `6`.	"salt" : 1212
	`lifetime-threshold`	int	Set IPsec lifetime threshold. Ignored if `sw-antireplay-enable` is true. Default is 0.	"lifetime-threshold" : 1000000
	`esn_en`	bool	Enables extended sequence number. Default is `false`.	"esn_en" : true

Dynamic Configuration IPsec Rules

The application listens on the UDS socket for receiving a predefined structure for the IPsec policy defined in the `policy.h` file.

The client program or keying daemon should connect to the socket with the same socket file path provided to the application by the `--ipc`/`-i` flags, and send the policy structure as packed to the application through the same socket.

> **Note**
>
> In the dynamic configuration, the application uses the `config` section from the JSON config file and ignores the `encrypt_rules` and `decrypt_rules` sections.

The IPsec policy structure:

```
struct ipsec_security_gw_ipsec_policy {
	/* Protocols attributes */
	uint16_t src_port;			/* Policy inner source port */
	uint16_t dst_port;			/* Policy inner destination port */
	uint8_t l3_protocol;			/* Policy L3 proto
{POLICY_L3_TYPE_IPV4, POLICY_L3_TYPE_IPV6} */
	uint8_t l4_protocol;			/* Policy L4 proto
{POLICY_L4_TYPE_UDP, POLICY_L4_TYPE_TCP} */
	uint8_t outer_l3_protocol;		/* Policy outer L3 type
{POLICY_L3_TYPE_IPV4, POLICY_L3_TYPE_IPV6} */

	/* Policy attributes */
	uint8_t policy_direction;		/* Policy direction {POLICY_DIR_IN,
POLICY_DIR_OUT} */
	uint8_t policy_mode;			/* Policy IPSEC mode
{POLICY_MODE_TRANSPORT, POLICY_MODE_TUNNEL} */

	/* Security Association attributes */
	uint8_t esn;				/* Is ESN enabled? */
	uint8_t icv_length;			/* ICV length in bytes {8, 12, 16}
*/
	uint8_t key_type;			/* AES key type
{POLICY_KEY_TYPE_128, POLICY_KEY_TYPE_256} */
	uint32_t spi;				/* Security Parameter Index */
	uint32_t salt;				/* Cryptographic salt */
	uint8_t enc_key_data[MAX_KEY_LEN];	/* Encryption key (binary) */

	/* Policy inner and outer addresses */
	char src_ip_addr[MAX_IP_ADDR_LEN + 1];		/* Policy inner IP source
address in string format */
	char dst_ip_addr[MAX_IP_ADDR_LEN + 1];		/* Policy inner IP destination
address in string format */
	char outer_src_ip[MAX_IP_ADDR_LEN + 1];		/* Policy outer IP source
address in string format */
```

```
    char outer_dst_ip[MAX_IP_ADDR_LEN + 1];        /* Policy outer IP destination address in string format */
};
```

Note

The policy type, whether it is encrypted or decrypted, is classified according to the `policy_direction` attribute:

- `POLICY_DIR_IN` – decryption policy
- `POLICY_DIR_OUT` – encryption policy

Troubleshooting

Refer to the DOCA Troubleshooting for any issue encountered with the installation or execution of the DOCA applications .

Application Code Flow

1. Parse application argument.
    1. Initialize arg parser resources and register DOCA general parameters.

    ```
    doca_argp_init();
    ```

    2. Register the application's parameters.

```
register_ipsec_security_gw_params();
```

3. Parse the arguments.

```
doca_argp_start();
```

1. Parse app parameters.

2. DPDK initialization.

```
rte_eal_init();
```

Call `rte_eal_init()` to initialize EAL resources with the provided EAL flags for not probing the ports.

3. Parse config file.

```
ipsec_security_gw_parse_config();
```

4. Initialize devices and ports.

```
ipsec_security_gw_init_devices();
```

1. Open DOCA devices with input PCIe addresses / interface names.

2. Probe DPDK port from each opened device.

5. Initialize and start DPDK ports.

```
dpdk_queues_and_ports_init();
```

1. Initialize DPDK ports, including mempool allocation.
2. Initialize hairpin queues if needed.
3. Binds hairpin queues of each port to its peer port.

6. Initialize DOCA Flow.

```
ipsec_security_gw_init_doca_flow();
```

1. Initialize DOCA Flow library.
2. Find the indices of the DPDK-probed ports and start DOCA Flow ports with them.

7. Insert rules.

1. Insert encryption rules.

```
ipsec_security_gw_insert_encrypt_rules();
```

2. Insert decryption rules.

```
ipsec_security_gw_insert_decrypt_rules();
```

8. Wait for traffic.

```
ipsec_security_gw_wait_for_traffic();
```

1. wait in a loop until the user terminates the program.

9. IPsec security gateway cleanup:

    1. DOCA Flow cleanup; destroy initialized ports.

        ```
        doca_flow_cleanup();
        ```

    2. SA destruction.

        ```
        ipsec_security_gw_destroy_sas();
        ```

    3. IPsec objects destruction.

        ```
        ipsec_security_gw_ipsec_ctx_destroy();
        ```

    4. Destroy DPDK ports and queues.

        ```
        dpdk_queues_and_ports_fini();
        ```

    5. DPDK finish.

        ```
        dpdk_fini();
        ```

        Calls `rte_eal_destroy()` to destroy initialized EAL resources.

    6. Arg parser destroy.

```
doca_argp_destroy()
```

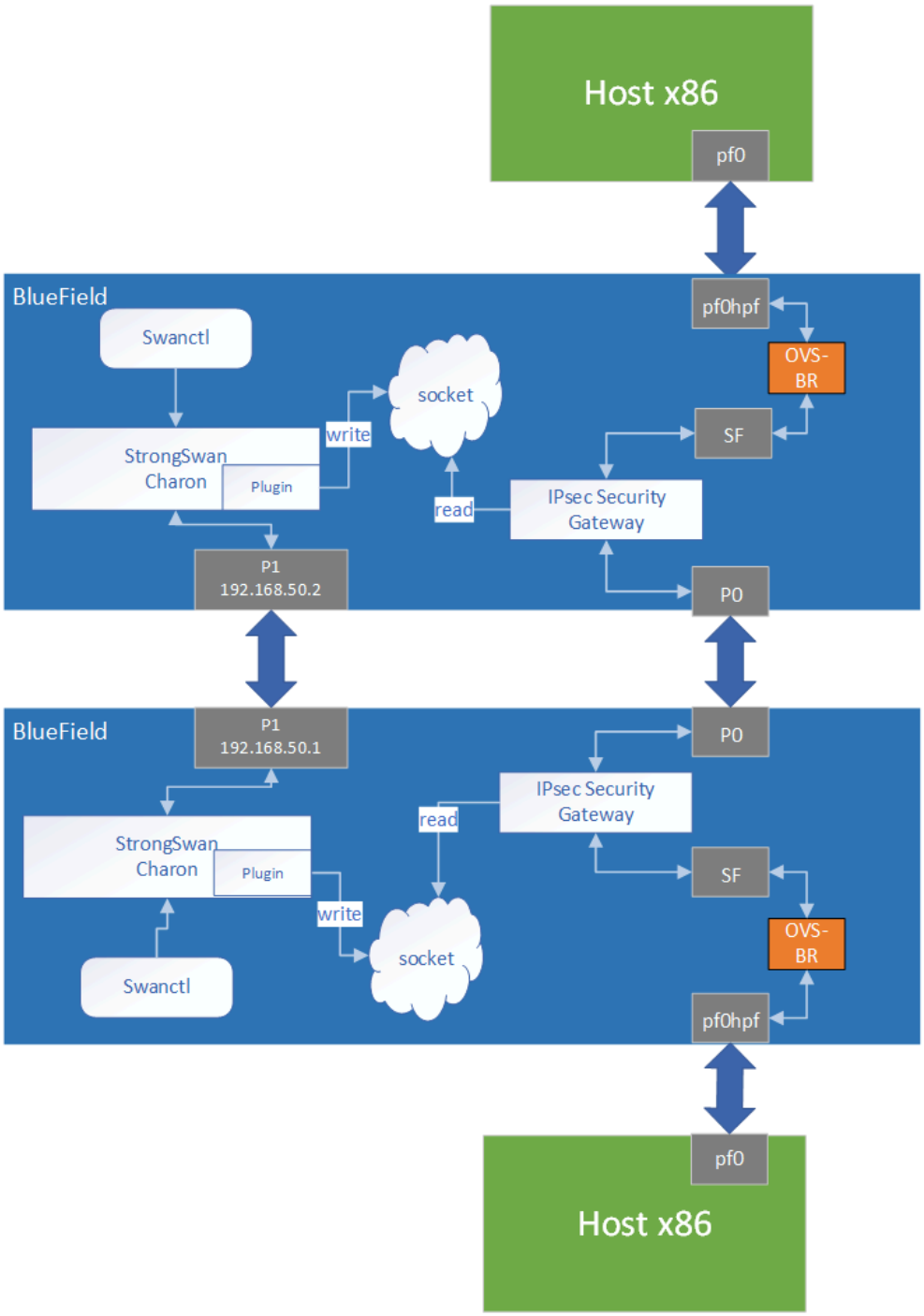
Keying Daemon Integration (StrongSwan)

strongSwan is a keying daemon that uses the Internet Key Exchange Version 2 (IKEv2) protocol to establish SAs between two peers. s trongSwan includes a DOCA plugin that is part of the strongSwan package in BFB. The plugin is loaded only if the DOCA IPsec Security Gateway is triggered. The plugin connects to UDS socket and sends IPsec policies to the application after the key exchange completes.

For more information about the key daemon, refer to strongSwan documentation .

End-to-end Architecture

The following diagram presents an architecture where two BlueField DPUs are connected to each other with DOCA IPsec Security Gateway running on each.



`swanctl` is a command line tool used for strongSwan IPsec configuration:

1. Run DOCA IPsec Security Gateway on both sides in a dynamic configuration.
2. Start strongSwan service.
3. Configure strongSwan IPsec using the `swanctl.conf` configuration file on both sides.

4. Start key exchange between the two peers. At the end of the flow, the result arrives to the DOCA plugin, populates the policy-defined structure, and sends it to the socket.

5. DOCA IPsec Security Gateway on both sides reads new policies from the socket, performs the parsing, creates a DOCA SA object, and adds flow decrypt/encrypt entry.

This architecture uses P1 uplink on both BlueField DPUs to run the strongSwan key daemon. To configure the uplink:

1. Configure an IP addresses for the PFs of both DPUs:

    1. On BF1:

    ```
    ip addr add 192.168.50.1/24 dev p1
    ```

    2. On BF2:

    ```
    ip addr add 192.168.50.2/24 dev p1
    ```

    > **Note**
    >
    > It is possible to configure multiple IP addresses to uplinks to run key exchanges with different policy attributes.

2. Verify the connection between two BlueField DPUs.

    ```
    BF1> ping 192.168.50.2
    ```

> **Note**
>
> Make sure that the uplink is not in OVS bridges.

3. Configure the `swanctl.conf` files for each machine. The file should be located under `/etc/swanctl/conf.d/`.

   Adding `swanctl.conf` file examples:

   - Transport mode
     - `swanctl.conf` example for BF1:

```
connections {
   BF1-BF2 {
      local_addrs  = 192.168.50.1
      remote_addrs = 192.168.50.2
          rekey_time = 0

      local {
        auth = psk
        id = host1
      }
      remote {
        auth = psk
        id = host2
      }

      children {
         bf {
            local_ts = 192.168.50.1/32 [udp/60]
            remote_ts = 192.168.50.2/32 [udp/90]
            esp_proposals = aes128gcm128-x25519-esn
            mode = transport
```

```
            policies_fwd_out = yes
                        life_time = 0
         }
      }
      version = 2
      mobike = no
      reauth_time = 0
      proposals = aes128-sha256-x25519
   }
}

secrets {
   ike-BF {
      id-host1 = host1
      id-host2 = host2
      secret = 0sv+NkxY9LLZvwj4qCC2o/gGrWDF2d21jL
   }
}
```

- `swanctl.conf` example for BF2:

```
connections {
   BF2-BF1 {
      local_addrs  = 192.168.50.2
      remote_addrs = 192.168.50.1
          rekey_time = 0

      local {
        auth = psk
        id = host2
      }
      remote {
        auth = psk
        id = host1
```

```
        }

        children {
           bf {
              local_ts = 192.168.50.2/32 [udp/90]
              remote_ts = 192.168.50.1/32 [udp/60]
              esp_proposals = aes128gcm128-x25519-esn
              mode = transport
                           life_time = 0
           }
        }
        version = 2
        mobike = no
        reauth_time = 0
        proposals = aes128-sha256-x25519
     }
  }

  secrets {
     ike-BF {
        id-host1 = host1
        id-host2 = host2
        secret = 0sv+NkxY9LLZvwj4qCC2o/gGrWDF2d21jL
     }
  }
```

- Tunnel mode

```
connections {
   BF1-BF2 {
      local_addrs  = 192.168.50.2
      remote_addrs = 192.168.50.1
          rekey_time = 0
```

```
      local {
        auth = psk
        id = host2
      }
      remote {
        auth = psk
        id = host1
      }

      children {
         bf {
            local_ts = 2001:db8:85a3::8a2e:370:7334/128
[udp/3030]
            remote_ts = 2001:db8:85a3::8a2e:370:7335/128
[udp/55]
            esp_proposals = aes128gcm128-x25519-esn
                        life_time = 0
         }
      }
      version = 2
      mobike = no
      proposals = aes128-sha256-x25519
   }
}

secrets {
   ike-BF {
      id-host1 = host1
      id-host2 = host2
      secret = 0sv+NkxY9LLZvwj4qCC2o/gGrWDF2d21jL
   }
}
```

Note

`local_ts` and `remote_ts` must have a netmask of /32 for IPv4 addresses and /128 for IPv6 addresses.

Note

SA rekey is not supported in DOCA plugin.
`connection.rekey_time` must be set to 0 and
`connection.child.life_time` must be set to 0.

DOCA IPsec only supports ESP headers, AES-GCM encryption algorithm, and key sizes 128 or 256. Therefore, when setting ESP proposals in the `swanctl.conf`, please adhere to the values provided in the following table:

ESP Proposal	Algorithm Type Including ICV Length	Key Size
aes128gcm8	ENCR_AES_GCM_ICV8	128
aes128gcm64	ENCR_AES_GCM_ICV8	128
aes128gcm12	ENCR_AES_GCM_ICV12	128
aes128gcm96	ENCR_AES_GCM_ICV12	128
aes128gcm16	ENCR_AES_GCM_ICV16	128
aes128gcm128	ENCR_AES_GCM_ICV16	128
aes128gcm	ENCR_AES_GCM_ICV16	128
aes256gcm8	ENCR_AES_GCM_ICV8	256
aes256gcm64	ENCR_AES_GCM_ICV8	256
aes256gcm12	ENCR_AES_GCM_ICV12	256
aes256gcm96	ENCR_AES_GCM_ICV12	256
aes256gcm16	ENCR_AES_GCM_ICV16	256
aes256gcm128	ENCR_AES_GCM_ICV16	256
aes256gcm	ENCR_AES_GCM_ICV16	256

Building strongSwan

To enable the DOCA plugin in strongSwan:

1. Verify that the dependencies listed here are installed in your environment. `libgmp-dev` is missing from that list so make sure to install that as well.
2. Git clone https://github.com/Mellanox/strongswan.git.
3. Git checkout BF-5.9.10 branch.
4. Add your changes in the plugin located under `src/libcharon/plugins/doca`.
5. Run `autogen.sh` within the strongSwan repo.
6. Run the following:

```
./configure --enable-openssl --disable-random --
prefix=/usr/local --sysconfdir=/etc --enable-systemd --
enable-doca
make
make install
systemctl daemon-reload
systemctl restart strongswan.service
```

Running the Solution

Run the following commands on both BlueField peers.

1. Run DOCA IPsec Security Gateway in dynamic configuration, assuming the socket location is `/tmp/rules_socket`.

```
doca_ipsec_security_gw -s 03:00.0 -un <sf_net_dev> -c
./ipsec_security_gw_config.json -m transport -i
/tmp/rules_socket
```

> **Note**
>
> DOCA IPsec Security Gateway application should be run first.

2. Edit the `/etc/strongswan.d/charon/doca.conf` file and add the UDS socket path. If the `socket_path` is not set, the plugin uses the default path `/tmp/strongswan_doca_socket`.

```
doca {

# Whether to load the plugin
load = yes

# Path to DOCA socket
socket_path = /tmp/rules_socket
}
```

> **Note**
>
> You must provide the application with this path as well.

3. Restart the strongSwan server:

```
systemctl restart strongswan.service
```

> **Note**
>
> If the application has been run with log level debug, you can see that the connection has been done successfully and the application is waiting for new IPsec policies.

4. Verify that the `swanctl.conf` file exists in `/etc/swanctl/conf.d/`. directory.

> **Note**
>
> It is recommended to remove any unused conf files under `/etc/swanctl/conf.d/`.

5. Load IPsec configuration:

```
swanctl --load-all
```

6. Start IKE protocol on either the initiator or the target side:

```
swanctl -i --child <child_name>
```

> **Info**

In the example above, the child's name is `bf`.

References

- `/opt/mellanox/doca/applications/ipsec_security_gw/`
- `/opt/mellanox/doca/applications/ipsec_security_gw/ipsec_security_`

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