NVIDIA DOCA Firewall

Application Guide

MLNX-15-060537 _v1.5.2 | July 2023

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Chapter 1. Introduction

A firewall application is a network security application that leverages the DPU's hardware capability to monitor incoming and outgoing network traffic and allow or block packets based on a set of preconfigured rules.

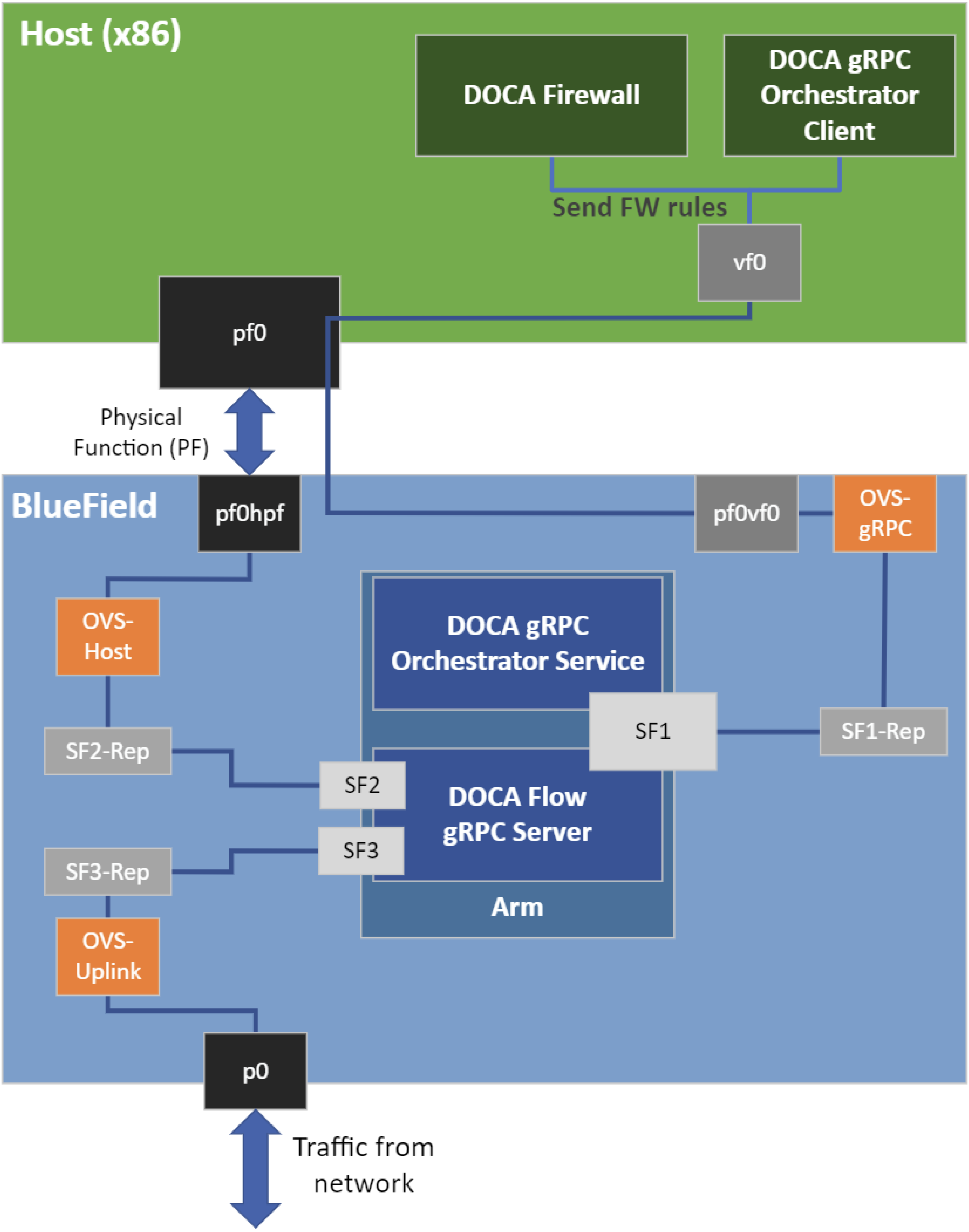
The firewall application is based on DOCA Flow gRPC, used for remote programming of the DPU's hardware.

The firewall can operate in two modes:

- Static mode – the firewall application gets 5-tuple traffic from the user with a JSON file for packets to be dropped. The packets that do not match any of the 5-tuple are forwarded by a hairpin pipe.
- Interactive mode – the user can add rules from the command line in real time to execute different firewall rules

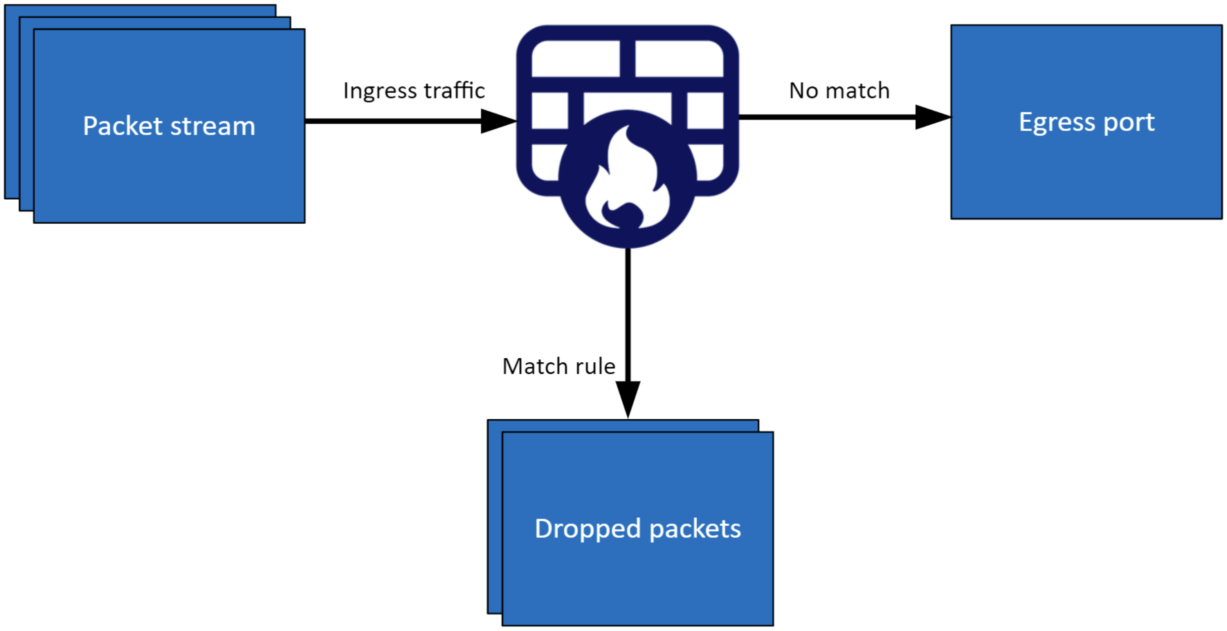
Chapter 2. System Design

The firewall application is designed to run on the host and to use DOCA Flow gRPC client to send instructions to a server that runs on the BlueField DPU instance. The DPU intercepts ingress traffic from the wire and either drops it or forwards it to the egress port using a hairpin. The decision is made using traffic classification.

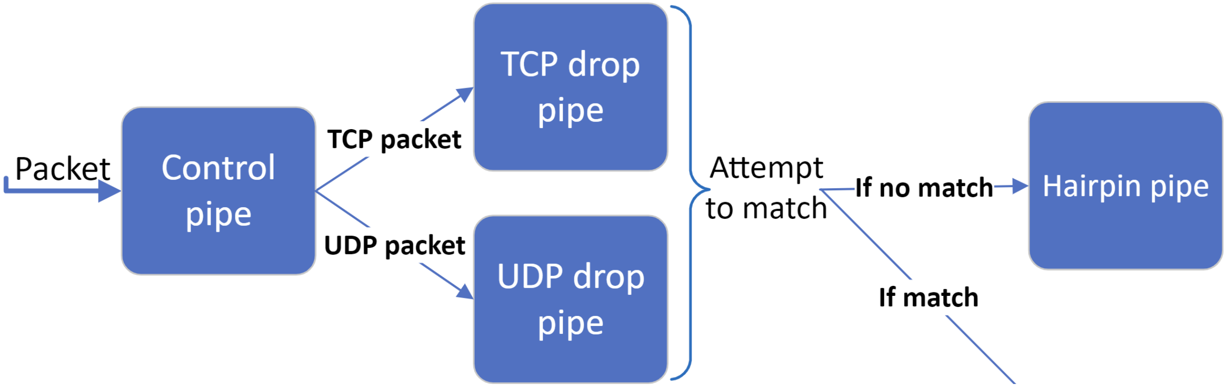

Host (x86)
DOCA Firewall
DOCA gRPC Orchestrator Client
Send FW rules
vf0
pf0
Physical Function (PF)
BlueField
pf0hpf
pf0vf0
OVS-gRPC
OVS-Host
DOCA gRPC Orchestrator Service
SF1
SF1-Rep
SF2-Rep
SF2
DOCA Flow gRPC Server
SF3
SF3-Rep
Arm
OVS-Uplink
p0
Traffic from network

Chapter 3. Application Architecture

The firewall runs on top of DOCA Flow gRPC to classify packets.



3.1. Static Mode



1. The firewall application builds 4 pipes for each port: One control pipe, two drop pipes, and a hairpin pipe.
2. The drop pipes match only 5-tuple traffic with specific source and destination IPs and source and destination ports.
    - One of the drop pipes matches TCP traffic and the other matches UDP
    - The hairpin pipe matches every packet (no misses)
    - The control pipe serves as a root pipe and has two entries: The first entry forwards the TCP traffic to the TCP drop pipe, and the second entry forwards UDP traffic to the UDP drop pipe
    - The hairpin pipe serves as a forwarding miss component to the drop pipes. Therefore, every received packet is checked first against the drop pipes. If there is a match, then it is dropped, otherwise, it is forwarded to the hairpin pipe and is then matched.

3.2. Interactive Mode

Running in interactive mode initializes 2 ports, and the user then configures the pipes and entries.

- When adding a pipe or an entry, one must run commands to create the relevant structs beforehand
- Optional parameters must be specified by the user in the command line. Otherwise, NULL is used.
- After a pipe or an entry is created successfully, the relevant ID is printed for future use

Available commands:

- `create pipe port_id=[port_id][,<optional_parameters>]`

  Available optional parameters:

    - `name=<pipe-name>`
    - `root_enable=[1|0]`
    - `monitor=[1|0]`
    - `match_mask=[1|0]`
    - `fwd=[1|0]`
    - `fwd_miss=[1|0]`
    - `type=[basic|control]`
- `add entry pipe_id=<pipe_id>,pipe_queue=<pipe_queue>[,<optional_parameters>]`

  Available optional parameters:

    - `monitor=[1|0]`

    - `fwd=[1|0]`
- `add control_pipe entry priority=<priority>,pipe_id=<pipe_id>,pipe_queue=<pipe_queue>[,<optional_parameters>]`

  Available optional parameters:

    - `match_mask=[1|0]`
    - `fwd=[1|0]`
- `destroy pipe port_id=[port_id],pipe_id=<pipe_id>`
- `rm entry pipe_queue=<pipe_queue>,entry_id=[entry_id]`
- `port pipes flush port_id=[port_id]`
- `port pipes dump port_id=[port_id],file=[file_name]`
- `query entry_id=[entry_id]`
- `create [struct] [field=value,…]`
    - Struct options: `pipe_match`, `entry_match`, `match_mask`, `actions`, `monitor`, `fwd`, `fwd_miss`
        - Match struct fields:

Fields	Field Options
`flags`	
`out_src_mac`	
`out_dst_mac`	
`out_eth_type`	
`out_vlan_id`	
`out_src_ip_type`	`ipv4`, `ipv6`
`out_src_ip_addr`	
`out_dst_ip_type`	`ipv4`, `ipv6`
`out_dst_ip_addr`	
`out_l4_type`	`tcp`, `udp`, `gre`
`out_tcp_flags`	`FIN`, `SYN`, `RST`, `PSH`, `ACK`, `URG`, `ECE`, `CWR`
`out_src_port`	
`out_dst_port`	
`tun_type`	
`vxlan-tun_id`	
`gre_key`	
`gtp_teid`	
`in_src_mac`	
`in_dst_mac`	
`in_eth_type`	
`in_vlan_id`	

Fields	Field Options
in_src_ip_type	ipv4, ipv6
in_src_ip_addr	
in_dst_ip_type	ipv4, ipv6
in_dst_ip_addr	
in_l4_type	tcp, udp
in_tcp_flags	FIN, SYN, RST, PSH, ACK, URG, ECE, CWR
in_src_port	
in_dst_port	

- Actions struct fields:

Fields	Field Options
decap	true, false
mod_src_mac	
mod_dst_mac	
mod_src_ip_type	ipv4, ipv6
mod_src_ip_addr	
mod_dst_ip_type	ipv4, ipv6
mod_dst_ip_addr	
mod_src_port	
mod_dst_port	
dec_ttl	true, false
has_encap	true, false
encap_src_mac	
encap_dst_mac	
encap_src_ip_type	ipv4, ipv6
encap_src_ip_addr	
encap_dst_ip_type	ipv4, ipv6
encap_dst_ip_addr	
encap_tup_type	vxlan, gtpu, gre
encap_vxlan-tun_id	
encap_gre_key	
encap_gtp_teid	

- FWD struct fields:

Fields	Field Options
type	rss, port, pipe, drop
rss_flags	
rss_queues	
num_of_queues	

Fields	Field Options
rss_mark	
port_id	
next_pipe_id	

- Monitor struct fields:
  - flags
  - id
  - cir
  - cbs
  - aging

The following is an example for creating a pipe and adding an entry:

```
create pipe_match
 out_l4_type=udp,out_src_ip_type=ipv4,out_src_ip_addr=0xffffffff,out_dst_ip_type=ipv4,out_dst_ip_a
create fwd type=drop
create fwd_miss type=pipe,next_pipe_id=1
create pipe port_id=0,name=drop,root_enable=1,fwd=1,fwd_miss=1
create pipe succeed with pipe id: 2
create entry_match
 out_src_ip_type=ipv4,out_src_ip_addr=10.1.20.208,out_dst_ip_type=ipv4,out_dst_ip_addr=10.1.3.216
add entry pipe_id=2,pipe_queue=0
add entry succeed with entry id: 0
```

Chapter 4. DOCA Libraries

This application leverages the DOCA Flow library.

Chapter 5. Configuration Flow

1. Parse application argument.

    a). Initialize the arg parser resources.

    ```
    doca_argp_init();
    ```

    b). Register application parameters.

    ```
    register_firewall_params();
    ```

    c). Parse application parameters.

    ```
    doca_argp_start();
    ```

2. Firewall initialization.

    ```
    firewall_ports_init();
    ```

    a). Create a new gRPC channel and initialize a stub.

    b). Initialize DOCA Flow and DOCA Flow ports.

3. Configure firewall rules.

Mode	Procedure

Static	a). Initialize drop packets array from the input JSON file.
	`init_drop_packets();`
	b). Create hairpin pipe for both ports. This pipe includes one entry that matches every type of packet (no misses) which is then forwarded to the egress port through a hairpin.
	`firewall_pipes_init();`
	c). Creates TCP and UDP drop pipes that serve as root pipes for both ports. The built pipes have a 5-tuple match and entries from the processed JSON file that are dropped. In addition, the hairpin pipe serves as forwarding if the drop entries do not match.

Interactive	a). Initialize the firewall's interactive command line.
	`interactive_cmdline();`
	b). Free allocated resources.
	`interactive_mode_cleanup();`

4. Firewall cleanup.

   ```
   firewall_ports_destroy();
   ```

   a). Destroy all DOCA Flow resources.

5. Arg parser destroy.

   ```
   doca_argp_destroy();
   ```

Chapter 6. Running the Application

1. Refer to the following documents:
   - NVIDIA DOCA Installation Guide for Linux for details on how to install BlueField-related software.
   - NVIDIA DOCA Troubleshooting Guide for any issue you may encounter with the installation, compilation, or execution of DOCA applications.
   - NVIDIA DOCA Applications Overview for additional compilation instructions and development tips regarding the DOCA applications.
2. The firewall example binary is located under `/opt/mellanox/doca/applications/firewall/bin/doca_firewall`.

   > **Note:** Before building the application, make sure that gRPC support is enabled. Set the `enable_grpc_support` flag in `/opt/mellanox/doca/applications/meson_options.txt` to `true`.

   To build all the applications together, run:

   ```
   cd /opt/mellanox/doca/applications/
   meson build
   ninja -C build
   ```
3. To build only the firewall application:

   a). Edit the following flags in `/opt/mellanox/doca/applications/meson_options.txt`:
   - Set `enable_all_applications` to `false`
   - Set `enable_firewall` to `true`

   b). Run the commands in step 2.

   > **Note:** `doca_firewall` will be created under `./build/firewall/src/`.

   Application usage:

   ```
   Usage: doca_firewall [DOCA Flags] [Program Flags]
   DOCA Flags:
    -h, --help                           Print a help synopsis
    -v, --version                        Print program version information
    -l, --log-level                      Set the log level for the program
    <CRITICAL=20, ERROR=30, WARNING=40, INFO=50, DEBUG=60>
    --grpc-address ip_address[:port]    Set the IP address for the grpc server

   Program Flags:
   ```

```
-m, --mode                          Set running mode {static, interactive}
-r, --firewall-rules <path>         Path to the JSON file with 5-tuple rules when
running with static mode
```

Note: For additional information on the app use `-h`:

```
/opt/mellanox/doca/applications/firewall/bin/doca_firewall -h
```

4. Running the application on the host:
   - For instructions on running the DOCA Flow gRPC server on the BlueField, refer to NVIDIA DOCA gRPC Infrastructure User Guide.
   - CLI example for running the app in interactive mode:

     ```
     /opt/mellanox/doca/applications/firewall/bin/doca_firewall --grpc-address
      192.168.101.2 -l 50 -m interactive
     ```
   - CLI example for running the app in static mode:

     ```
     /opt/mellanox/doca/applications/firewall/bin/doca_firewall --grpc-address
      192.168.101.2 -l 50 -m static -d firewall_rules.json
     ```
5. To run `doca_firewall` using a JSON file:

   ```
   doca_firewall --json [json_file]
   ```

   For example:

   ```
   cd /opt/mellanox/doca/applications/firewall/bin
   ./doca_firewall --json firewall_params.json
   ```

Chapter 7. Arg Parser DOCA Flags

Refer to NVIDIA DOCA Arg Parser User Guide for more information.

Flag Type	Short Flag	Long Flag/JSON Key	Description	JSON Content
General Flags	l	log-level	Set the log level for the application: ▶ CRITICAL=20 ▶ ERROR=30 ▶ WARNING=40 ▶ INFO=50 ▶ DEBUG=60	`"log-level": 60`
	v	version	Print program version information	N/A
	h	help	Print a help synopsis	N/A
	-	grpc-address	Set the IP address for the gRPC server	`"grpc-address": "0.0.0.0"`
Program Flags	m	mode	Set running mode {`static` or `interactive`} **Note:** This flag is mandatory.	`"mode": "interactive"`
	r	firewall-rules	Path to JSON rules file	`"firewall-rules": "firewall_rules.json"`

Chapter 8. References

- `/opt/mellanox/doca/applications/firewall/src/firewall.c`

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