NVIDIA DOCA Firewall

Application Guide

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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.

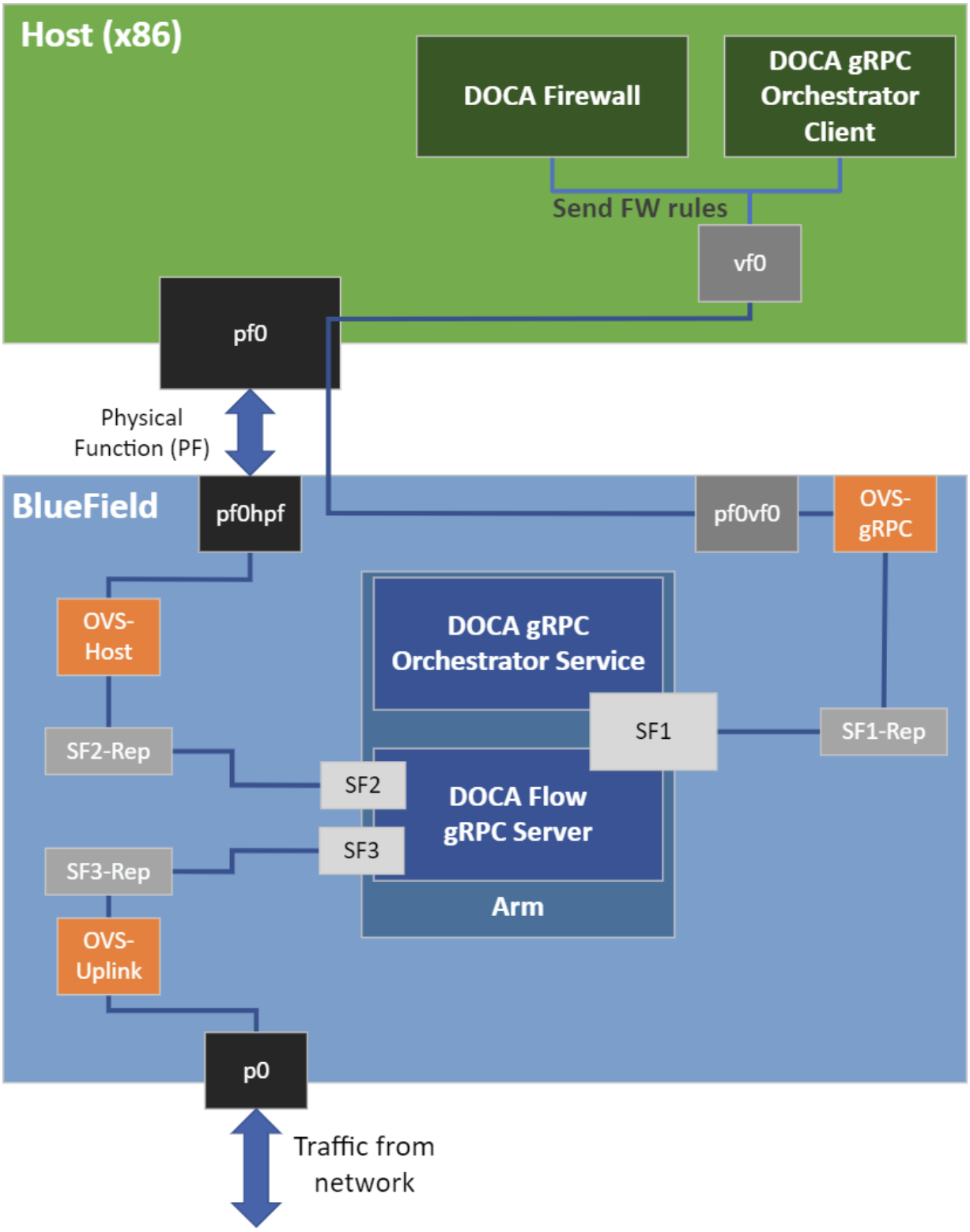
The firewall application is based on DOCA Flow gRPC, used for remote programming of the DPU's hardware.

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

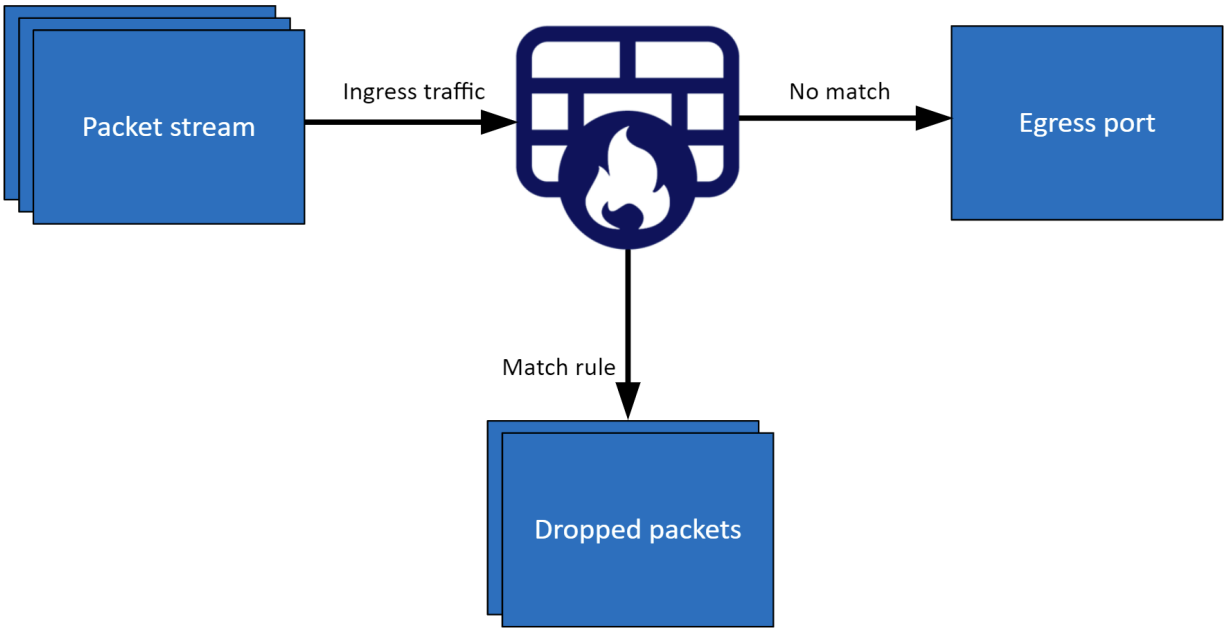
Chapter 2. System Design

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.

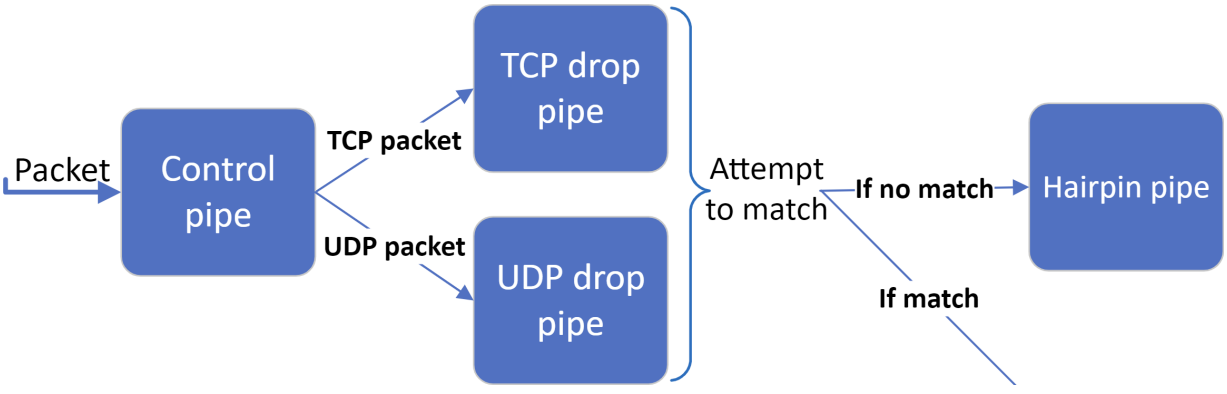

Host (x86)
DOCA Firewall
DOCA gRPC Orchestrator Client
Send FW rules
vf0
pf0
Physical Function (PF)
BlueField
pf0hpf
pf0vf0
OVS-gRPC
OVS-Host
DOCA gRPC Orchestrator Service
SF1
SF1-Rep
SF2-Rep
SF2
DOCA Flow gRPC Server
SF3
SF3-Rep
Arm
OVS-Uplink
p0
Traffic from network

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, creates the same pipes as in "Static Mode", and the user then adds or removes entries.

- When adding an entry, the user must run commands to create a 5-tuple match beforehand
- After an entry is created successfully, the relevant ID is printed for future use

Available commands:

- `add entry port_id=<port_id>`
- `rm entry port_id=<port_id>,entry_id=[entry_id]`
- `port pipes flush port_id=[port_id]`
- `port pipes dump port_id=[port_id],file=[file_name]`
- `create entry_match [field=value,…]`

5-tuple match struct fields:

Fields	Field Options
`outer.src_ip_addr`	
`outer.dst_ip_addr`	
`outer.l4_type_ext`	`tcp`, `udp`
`outer.tcp_src_port`	
`outer.tcp_dst_port`	
`outer.udp_src_port`	
`outer.udp_dst_port`	

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

```
create entry_match
 outer.src_ip_addr=192.168.105.2,outer.dst_ip_addr=192.168.105.3,outer.l4_type_ext=tcp,outer.tcp_s
add entry port_id=0,pipe_queue=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. Create control, TCP, UDP, and hairpin pipes for both ports.
   ```
   firewall_pipes_init();
   ```
4. Configure firewall rules.

Mode	Procedure

Static	a). Initialize drop packets array from the input JSON file:
	`init_drop_packets();`
	b). Add firewall drop rules parsed from JSON file:
	`firewall_add_drop_rules();`

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

5. Firewall cleanup.
   ```
   firewall_ports_destroy();
   ```
   a). Destroy all DOCA Flow resources.
6. 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 Programming 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
	`g`	`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`

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