



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.

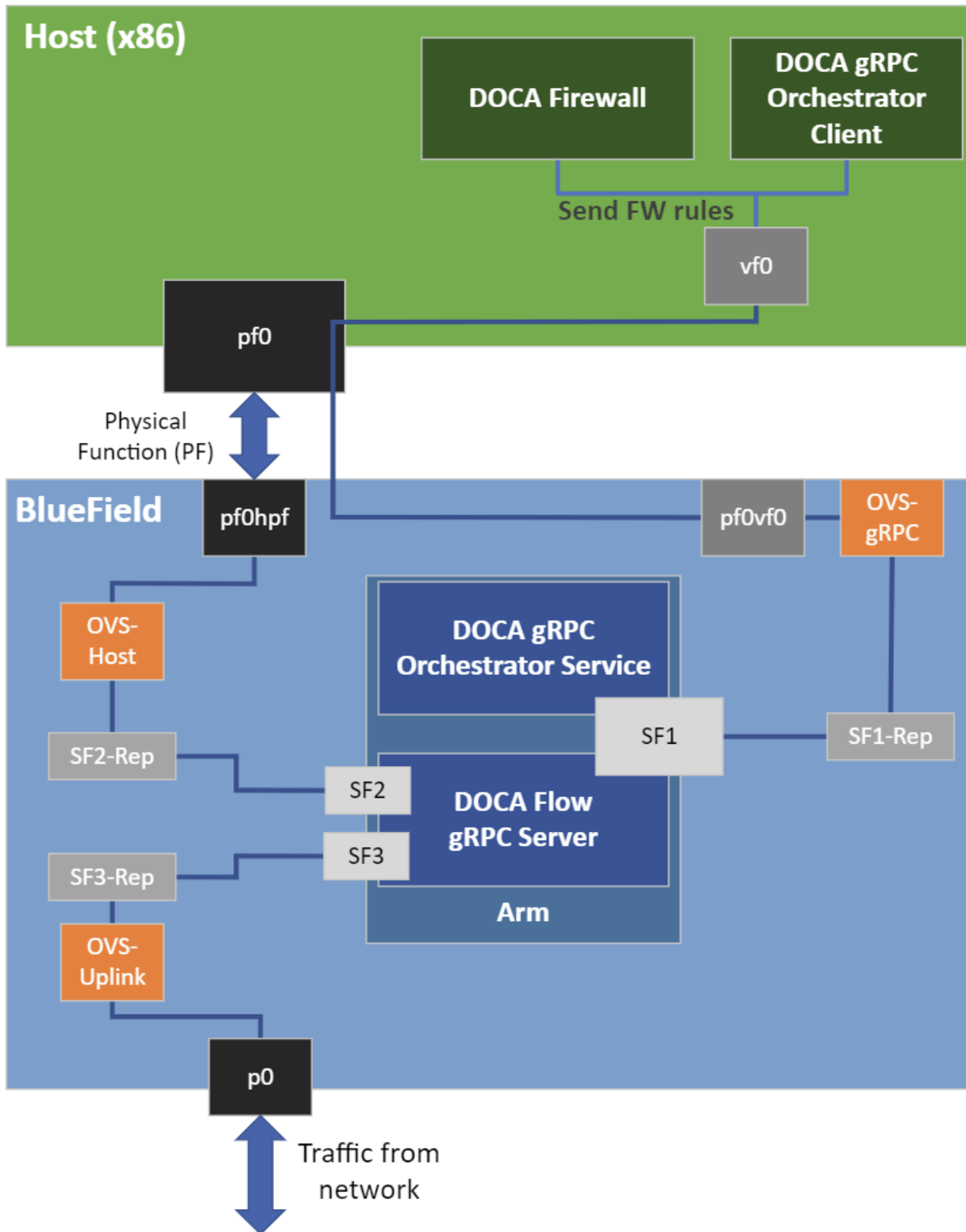
The firewall application is based on DOCA Flow gRPC, used for remote programming of the DPU's hardware.

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

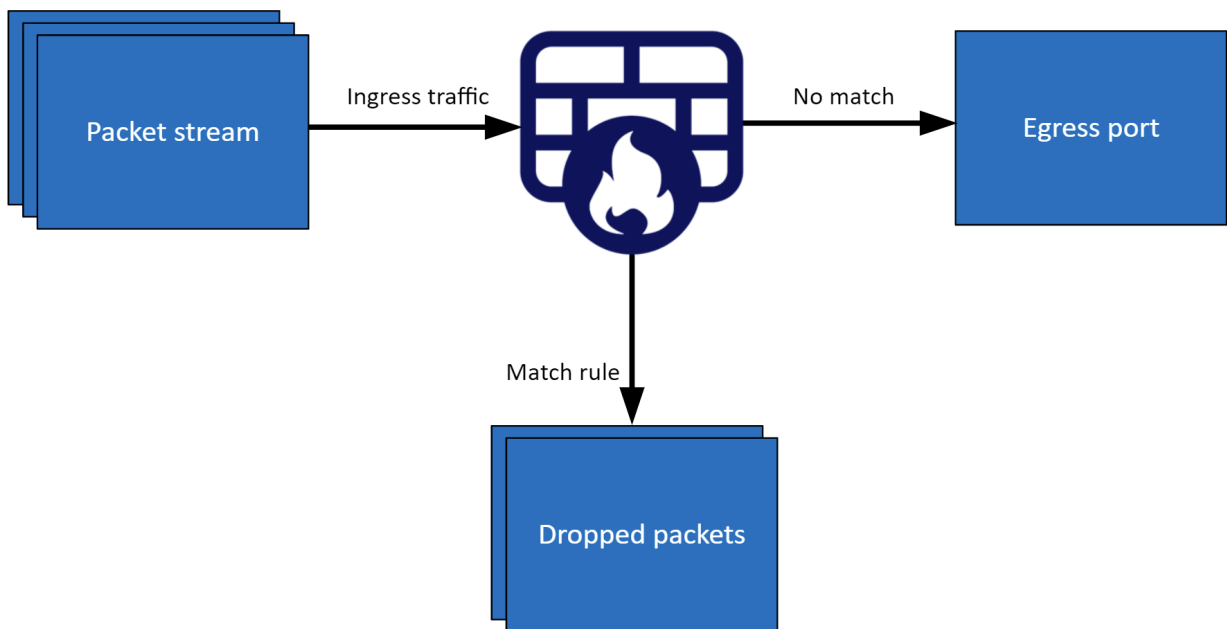
Chapter 2. System Design

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.

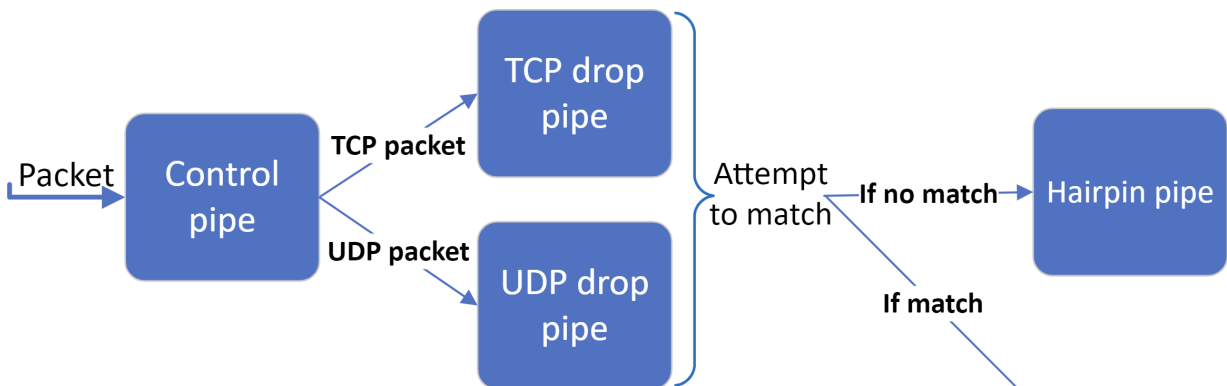


Chapter 3. Application Architecture

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	
port_meta	
outer.eth.src_mac	
outer.eth.dst_mac	
outer.eth.type	
outer.eth_vlan[0].tci	
outer.eth_vlan[1].tci	
outer.l3_type	ipv4, ipv6
outer.src_ip_addr	
outer.dst_ip_addr	
outer.l4_type_ext	tcp, udp, gre
outer.tcp.flags	FIN, SYN, RST, PSH, ACK, URG, ECE, CWR
outer.tcp_src_port	
outer.tcp_dst_port	
outer.udp_src_port	
outer.udp_dst_port	
tun_type	
vxlan_tun_id	
gre_key	

Fields	Field Options
gtp_teid	
inner.eth.src_mac	
inner.eth.dst_mac	
inner.eth.type	
inner.eth_vlan[0].tci	
inner.eth_vlan[1].tci	
inner.l3_type	ipv4, ipv6
inner.src_ip_addr	
inner.dst_ip_addr	
inner.l4_type_ext	tcp, udp
inner.tcp.flags	FIN, SYN, RST, PSH, ACK, URG, ECE, CWR
inner.tcp_src_port	
inner.tcp_dst_port	
inner.udp_src_port	
inner.udp_dst_port	

► Actions struct fields:

Fields	Field Options
decap	true, false
outer.eth.src_mac	
outer.eth.dst_mac	
outer.l3_type	ipv4, ipv6
outer.src_ip_addr	
outer.dst_ip_addr	
outer.l4_type_ext	
outer.tcp_src_port	
outer.tcp_dst_port	
outer.udp_src_port	
outer.udp_dst_port	
outer.ip4.ttl	
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

Fields	Field Options
encap_vxlan-tun_id	
encap_gre_key	
encap_gtp_teid	

► FWD struct fields:

Fields	Field Options
type	rss, port, pipe, drop
rss_outer_flags	
rss_inner_flags	
rss_queues	
num_of_queues	
port_id	
next_pipe_id	

► Monitor struct fields:

- flags
- cir
- cbs
- aging

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

```
create pipe_match
  outer.14_type_ext=udp, outer.13_type=ipv4, outer.src_ip_addr=0xffffffff, outer.dst_ip_addr=0xffffffff
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
  outer.13_type=ipv4, , outer.src_ip_addr=10.1.20.208, outer.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	<p>a). Initialize drop packets array from the input JSON file.</p> <pre>init_drop_packets();</pre> <p>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.</p> <pre>firewall_pipes_init();</pre> <p>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.</p>
Interactive	<p>a). Initialize the firewall's interactive command line.</p> <pre>interactive_cmdline();</pre> <p>b). Free allocated resources.</p> <pre>interactive_mode_cleanup();</pre>

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 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: <ul style="list-style-type: none"> ▶ CRITICAL=20 ▶ ERROR=30 ▶ WARNING=40 ▶ INFO=50 ▶ DEBUG=60 	<code>"log-level": 60</code>
	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	<code>"grpc-address": "0.0.0.0"</code>
Program Flags	m	mode	Set running mode {static or interactive} <div style="border: 1px solid gray; padding: 5px; margin-top: 10px;">  Note: This flag is mandatory. </div>	<code>"mode": "interactive"</code>
	r	firewall-rules	Path to JSON rules file	<code>"firewall-rules": "firewall_rules.json"</code>

Chapter 8. References

- ▶ `/opt/mellanox/doca/applications/firewall/src`

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