



NVIDIA DOCA IPS

Application Guide

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Chapter 1. Introduction

Intrusion prevention system (IPS) is an application that monitors a network for malicious activity or policy violations.

IPS uses the deep packet inspection (DPI) engine to scan network flow for malicious content based on predefined Suricata signatures. Packets that are deemed malicious are dropped and a corresponding message is printed.

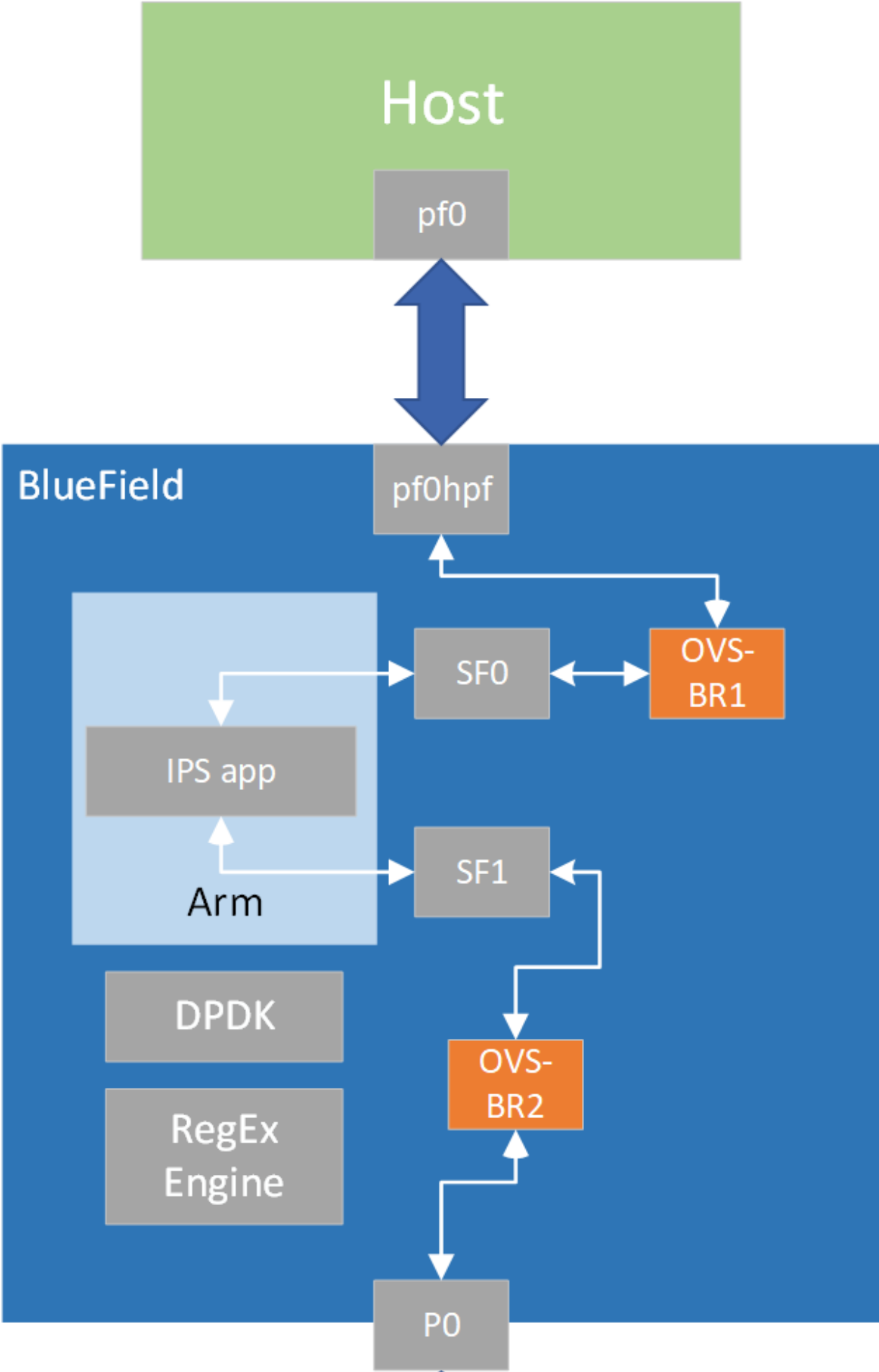
IPS supports NetFlow protocol for sending data from the DPU to remote NetFlow collector for further analysis.

Connection tracking is also supported for tracking all network connections or flows which helps the identification of all the packets that make up a flow for better handling of the network traffic.

This document describes how to build and run the IPS application both on the host and on the DPU.

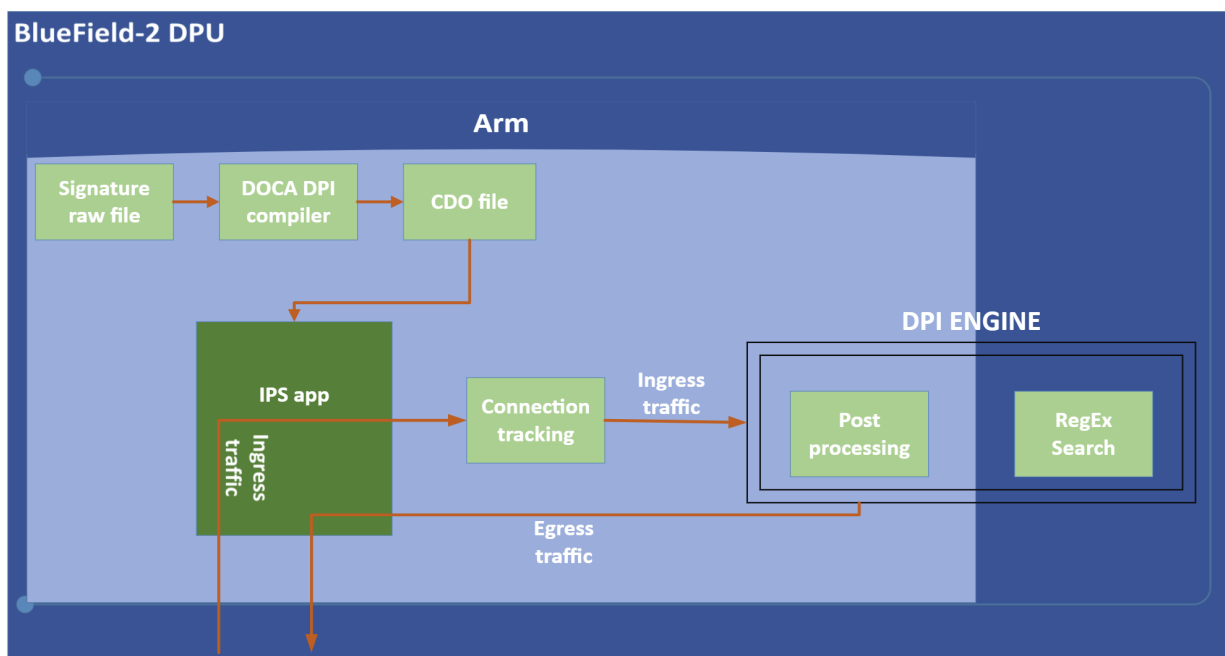
Chapter 2. System Design

The IPS application is designed to run as "bump-on-the-wire" on the BlueField instance, it intercepts the traffic coming from the wire, and passes it to peer port.



Chapter 3. Application Architecture

IPS runs on top of DPDK-based stateful flow tracking (SFT) to identify the flow that each packet belongs to, then uses DPI to process L7 classification.



1. Signatures are compiled by DPI compiler and then loaded to DPI engine. See [DOCA DPI Compiler](#) for more information.
2. Ingress traffic is identified using the stateful table module which utilizes the connection tracking hardware offloads.
3. Traffic is scanned against DPI-engine-compiled signature DB.
4. Post-processing is performed for match decision.
5. Matched flows are identified and drop actions can be offloaded to the hardware to increase performance as no further inspection is needed.
6. Flow termination is done by a configurable aging timer set in the SFT to 60 seconds. When a flow is offloaded, it cannot be tracked and destroyed.

Chapter 4. DOCA Libraries

This application leverages the following DOCA libraries:

- ▶ [DOCA DPI Library](#)
- ▶ [DOCA Telemetry Library](#)

Chapter 5. Configuration Flow

1. Parse application argument.
 - a). Initialize Arg Parser resources and register DOCA general parameters.

```
doca_argp_init();
```
 - b). Register application parameters.

```
register_ips_params();
```
 - c). Parse the arguments.

```
doca_argp_start();
```

 - i. Parse DPDK flags and invoke handler for calling the `rte_eal_init()` function
 - ii. Parsing app parameters.
2. DPDK initialization.

```
dpdk_init();
```

Calls `rte_eal_init()` to initialize EAL resources with the provided EAL flags.
3. DPDK port initialization and start.

```
dpdk_queues_and_ports_init();
```

 - a). Initialize SFT.
 - b). Initialize DPDK ports, including mempool allocation.
4. Initialize IPS application resources including DPI engine and NetFlow.

```
ips_init();
```
5. Configure DPI packet processing.

```
ips_worker_lcores_run();
```

 - a). Configure DPI enqueue packets.
 - b). Send jobs to RegEx engine.
 - c). Configure DPI dequeue packets.
6. If Netflow is enabled.

```
send_netflow_record();
```
7. IPS destroy.

```
ips_destroy();
```

 - a). Stop and free DPI resources.
 - b). Destroy netflow resources.
 - c). Stop SFT.
 - d). Free IPS resources.

8. DPDK ports and queues destruction.

```
dpdk_queues_and_ports_fini();
```

9. DPDK finish.

```
dpdk_fini();
```

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

10. 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 for the DOCA applications.

2. The IPS application binary is located under `/opt/mellanox/doca/applications/ips/bin/doca_ips`. To build all the applications, run:

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

3. To build the IPS application only:

a). Edit the following flags in `/opt/mellanox/doca/applications/meson_options.txt`:

- ▶ Set `enable_all_applications` to `false`
- ▶ Set `enable_ips` to `true`

b). Run the commands in step 2.



Note: `doca_ips` is created under `./build/ips/src/`.

Application usage:

```
Usage: doca_ips [DPDK Flags] -- [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>  
Program Flags:  
-p, --print-match        Prints FID when matched in DPI engine  
-n <source_id>, --netflow exports data from BlueField to remote DOCA Telemetry  
service, also sets source_id to be written to the Netflow packet.  
-o, --output-csv <path> Path to the output of the CSV file  
-c, --cdo <path>       Path to CDO file compiled from a valid PDD
```

`-f, --fragmented` Enables processing fragmented packets

Note: For additional information on available flags for DPDK, use `-h` before the `--` separator:

```
/opt/mellanox/doca/applications/ips/bin/doca_ips -h
```

Note: For additional information on the application, use `-h` after the `--` separator:

```
/opt/mellanox/doca/applications/ips/bin/doca_ips -- -h
```

4. Running the application on BlueField:

► Pre-run setup.

a). The IPS example is based on DPDK libraries. Therefore, the user is required to provide DPDK flags and allocate huge pages. Run:

```
sudo echo 2048 > /sys/kernel/mm/hugepages/hugepages-2048kB/nr_hugepages
```

b). Make sure the RegEx engine is active:

```
systemctl status mlx-regex
```

If the status is inactive (Active: failed), run:

```
systemctl start mlx-regex
```

► CLI example for running the app:

Note: Make sure to compile signature before running the application. For more information, please refer to [NVIDIA DOCA DPI Compiler](#).

```
/opt/mellanox/doca/applications/ips/bin/doca_ips -a 0000:03:00.0,class=regex -a auxiliary:mlx5_core.sf.4,sft_en=1 -a auxiliary:mlx5_core.sf.5,sft_en=1 -- --cdo /root/ips.cdo -p -n
```

Note: The SFT supports a maximum of 64 queues. Therefore, the application cannot be run with more than 64 cores. To limit the number of cores, run:

```
/opt/mellanox/doca/examples/ips/bin/doca_ips -a 0000:03:00.0,class=regex -a auxiliary:mlx5_core.sf.4,sft_en=1 -a auxiliary:mlx5_core.sf.5,sft_en=1 -l 0-64 -- --cdo /root/ips.cdo -p -n
```

This limits the application to use 65 cores (core-0 to core-64). That is 1 core for the main thread and 64 cores to serve as workers.

Note: The flags `-a 0000:03:00.0,class=regex -a auxiliary:mlx5_core.sf.4,sft_en=1 -a auxiliary:mlx5_core.sf.5,sft_en=1` are necessary for proper usage of the application. Modifying these flags results in unexpected behavior as only 2 ports are supported. The SF numbers are arbitrary and configurable. The RegEx device, however, is not and must be initiated on port 0.

Note: Sub-functions must be enabled according to [Scalable Function Setup Guide](#).

5. Running the application on the host, CLI example:

```
cd /opt/mellanox/doca/applications/ips/
```

```
./doca_ips#-a 0000:21:00.0,class=regex -a 0000:21:00.3 -a 0000:21:00.4 -- --cdo
~/ips.cdo
```



Note: Refer to section "Running DOCA Application on Host" in [NVIDIA DOCA Virtual Functions User Guide](#).

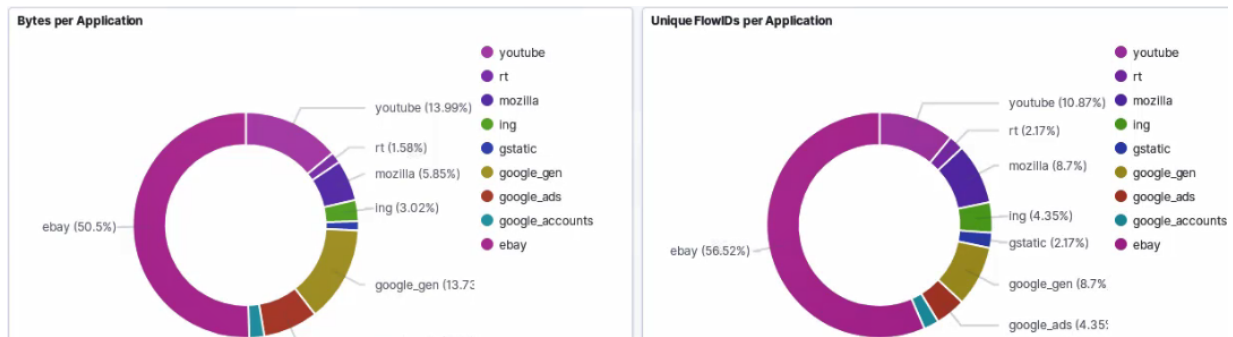
6. To run `doca_ips` using a JSON file:

```
doca_ips --json [json_file]
```

For example:

```
cd /opt/mellanox/doca/applications/ips/bin
./doca_ips --json ips_params.json
```

NetFlow collector UI example:



The NetFlow module uses the DOCA's Telemetry NetFlow library to export NetFlow packets in the NetFlow v9 format. The usage of telemetry is hardcoded to send packets to a collector set on the host connected to the Bluefield device through the RShim interface, 192.168.100.2:2055.


It is recommended to use the DOCA telemetry service as an aggregator service to export records instead of exporting directly from the client side which requires enabling IPC.

Refer to the [NVIDIA DOCA Telemetry Service Guide](#) for more information.

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
DPDK flags	a	devices	Adds a PCIe device into the list of devices to probe	<pre>"devices": [{ "device": "regex", "id": "00"}, { "device": "sf", "id": "4", "s true}, { "device": "sf", "id": "5", "s true},]</pre>
	l	core-list	Lists cores to run on	<pre>"core- list": "0-4"</pre>
General flags	l	log-level	Sets the log level for the application: <ul style="list-style-type: none"> ▶ CRITICAL=20 ▶ ERROR=30 ▶ WARNING=40 ▶ INFO=50 ▶ DEBUG=60 	<pre>"log-level": 60</pre>
	v	version	Print program version information	N/A
	h	help	Prints a help synopsis	N/A
Program flags	p	print-match	Prints FID when matched in DPI engine	<pre>"print-match": true</pre>
	n	netflow	Exports data from BlueField to remote DTS, IP is set to 192.168.100.2 which is the	<pre>"netflow": 0</pre>

Flag Type	Short Flag	Long Flag/JSON Key	Description	JSON Content
			host's IP using the RShim interface. Also sets <code>source_id</code> to be written to the NetFlow packet.	
	o	output-csv	Path to the output of the CSV file	<code>"output-csv": "/tmp/ips_stats.csv"</code>
	c	cdo	Path to CDO file compiled from a valid PDD  Note: This flag is mandatory.	<code>"cdo": "/tmp/ips.cdo"</code>
	f	fragmented	Enables processing fragmented packets	<code>"fragmented": false</code>

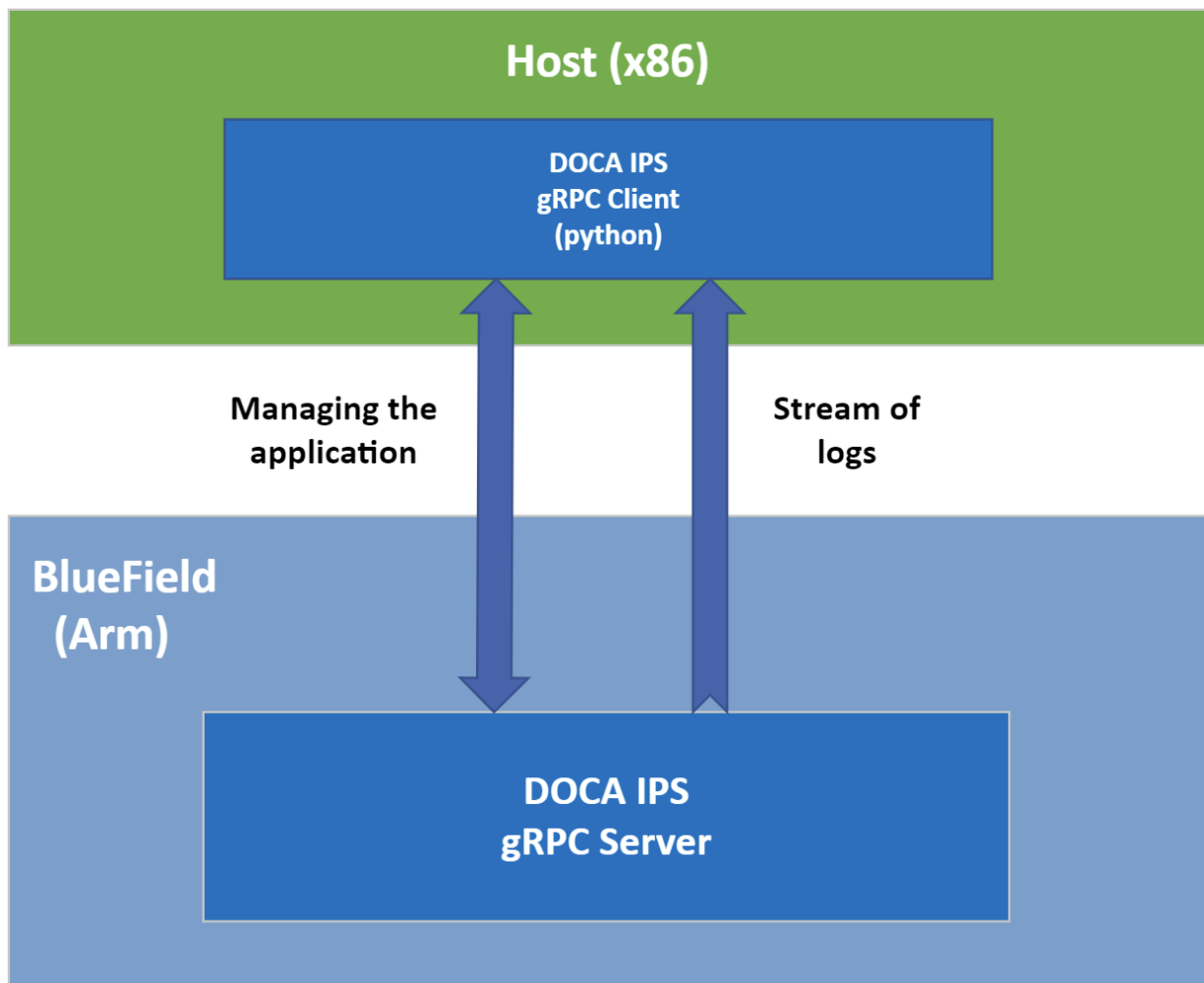
Chapter 8. Deploying Containerized Application

The IPS example supports a container-based deployment. Refer to the [NVIDIA DOCA Container Deployment Guide](#) for more information.

Application-specific configuration steps may be found on NGC under the application's [container page](#).

Chapter 9. Managing gRPC-Enabled Application from Host

For instructions on running the gRPC application server on BlueField, refer to [NVIDIA DOCA gRPC Infrastructure User Guide](#).



To run the Python client of the gRPC-enabled application:

```
./doca_ips_gRPC_client.py -d/--debug <server address[:server port]>
```

For example:

```
/opt/mellanox/doca/examples/ips/bin/grpc/client/doca_ips_gRPC_client.py  
192.168.104.2
```

Chapter 10. References

- ▶ `/opt/mellanox/doca/applications/ips/src/ips.c`
- ▶ `/opt/mellanox/doca/applications/ips/src/grpc/ips.proto`
- ▶ `/opt/mellanox/doca/applications/ips/bin/ips_suricata_rules_example`

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