NVIDIA DOCA URL Filter

Application

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Chapter 1. Introduction

URL filtering limits access by comparing web traffic against a database to prevent users from different threats, malware and accessing harmful sites such as phishing pages.

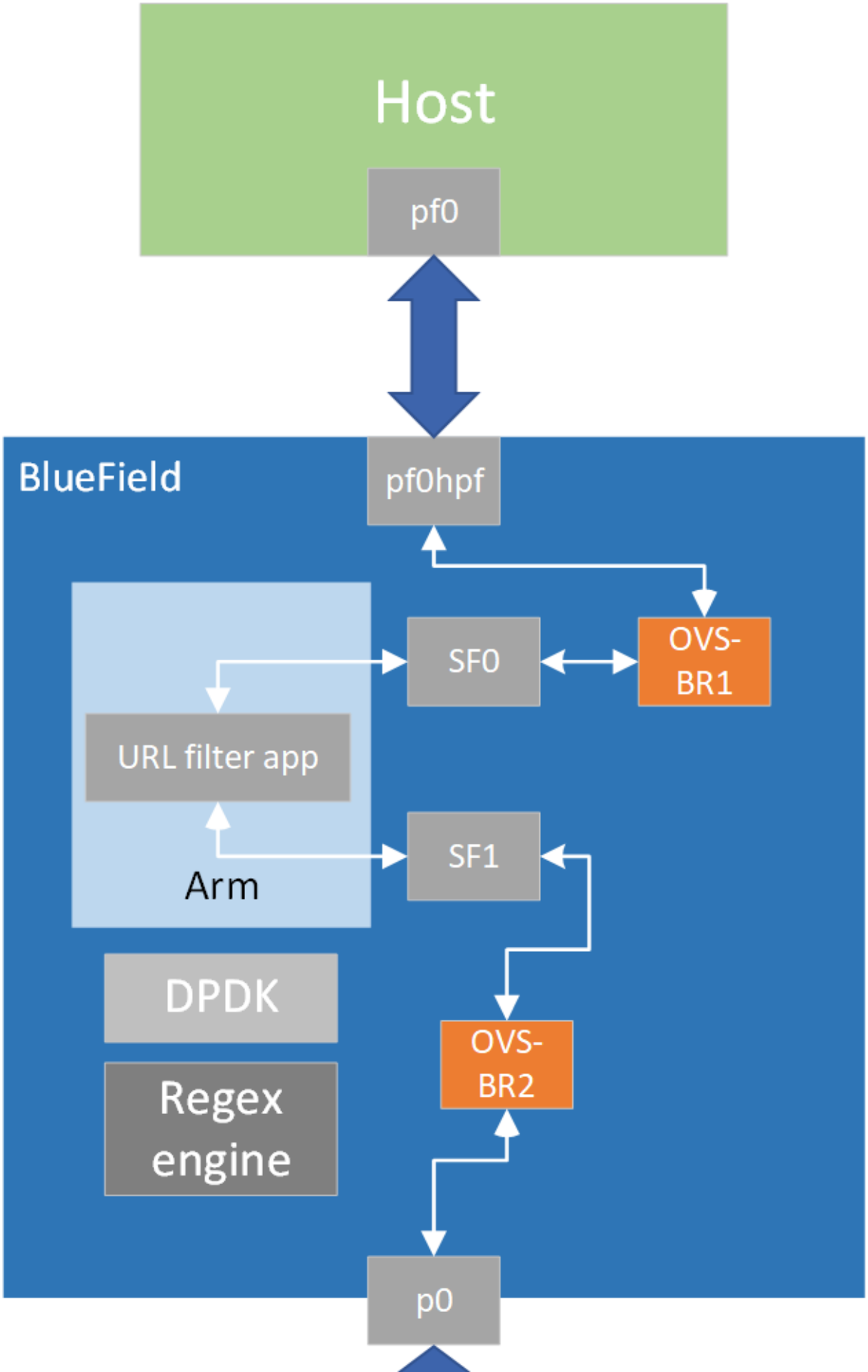
This kind of content filtering can increase network security and enforce policies on different network resources.

URL filter uses Suricata format to create a signature file that can be compiled and loaded to the DPI RegEx engine. The signatures created attempt to find a match in a TCP header's payload, either inside an HTTP header or an SNI match inside a TLS header. Two different signatures. In terms of packet direction, the match can be both on the sender and receiver. The exact format can be seen in the attached signature file.

Chapter 2. System Design

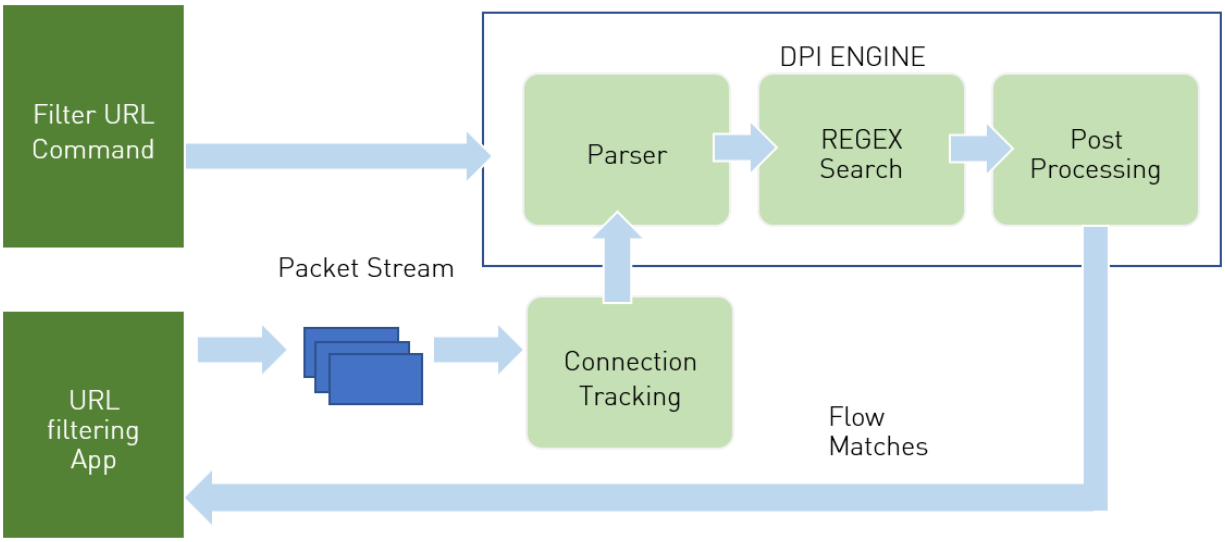
URL filtering is designed to run as "bump-on-the-wire" on the BlueField-2 instance. It intercepts traffic coming from the wire and passes it to the physical function (PF) representor connected to the host.

URL filter utilizes the SFT and RegEx engines which are HW accelerators on BlueField.


Host
pf0
BlueField
pf0hpf
SF0
OVS-
BR1
URL filter app
SF1
Arm
DPDK
OVS-
BR2
Regex
engine
p0

Chapter 3. Application Architecture

- User adds a URL using the URL command from the CLI. Available commands:
  - Create database – create DB of URLs to be filtered (also removes old signatures)
  - Filter – add specific URL/URL RegEx pattern to be filtered
  - Commit database [PATH] – compile and load signature database
- Ingress traffic is identified using the connection tracking module
- Traffic is scanned against compiled signature DB
- Post-processing is performed for match decision
- Matched flows are filtered and traffic is blocked



1. Signatures are compiled by the DPI compiler and are then loaded to the DPI engine.
2. Ingress traffic is identified and classified using the stateful table module in the DPDK libs which utilizes the connection tracking hardware offloads. This allows flow classifications to be done at the hardware level and forwarded to a hairpin queue without being processed by the software, which increases performance dramatically.
3. Traffic is scanned against the DPI engine compiled signature DB.
4. Post-processing is performed for match decision.

5. Matched flows are identified and can be offloaded to the hardware to increase performance as not further inspection is needed.
6. Flow termination is done by the aging timer (set in the SFT to 60 seconds). When a flow is offloaded it cannot be tracked and destroyed.

Note: It is important to note that only sites that support non-encrypted HTTP traffic can be matched against signatures created by the URL filtering as it specifically targets the URI field in the HTTP request.

Chapter 4. DOCA Libraries

This application leverages the DOCA DPI library.

Chapter 5. Configuration Flow

1. Parse application argument.
   ```
   doca_argp_init();
   ```
   a). Initialize the arg parser resources.
   b). Register DOCA general flags.
   ```
   register_url_params();
   ```
   c). Register URL filter application flags.
   ```
   doca_argp_start();
   ```
   d). Parse DPDK flags and invoke handler for calling the `rte_eal_init()` function.
   e). Parse app flags.
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. URL filter initialization.
   ```
   url_filter_init();
   ```
   a). Init URL filter resources.
   b). Configure RegEx engine.
   c). Configure DPI queues.
5. Configure DPI packet processing.
   ```
   dpi_worker_lcores_run();
   ```
   a). Configure DPI enqueue packets.
   b). Send jobs to RegEx engine.
   c). Configure DPI dequeue packets.
6. Add URL shell command
   ```
   initiate_cmdline("URL FILTER>>");
   ```
   a). Create database.
   b). Filter http.
   c). Commit database.

7. DPI destroy
   ```
   url_filter_destroy();
   ```
   - Stop DPI worker and free DPI 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();
    ```
    - Free DPDK resources

Chapter 6. Running 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.
2. The URL filtering example binary is located under `/opt/mellanox/doca/applications/url_filter/bin/doca_url_filter`. To build all the applications together, run:

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

3. To build the URL Filter application only:

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

   b). Run the commands in step 2.

> **Note:** `doca_url_filter` is created under `./build/url_filter/src/`.

Application usage:

```
Usage: doca_url_filter [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
  -f, --fragmented              Enables processing fragmented packets
```

> **Note:** For additional information on available flags for DPDK, use `-h` before the `--` separator:
>
> `/opt/mellanox/doca/applications/url_filter/bin/doca_url_filter -h`

> **Note:** For additional information on the application, use `-h` after the `--` separator:
>
> `/opt/mellanox/doca/applications/url_filter/bin/doca_url_filter -- -h`

4. Running the application on BlueField:

   - Pre-run setup:

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

     ```
     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:

     ```
     /opt/mellanox/doca/applications/url_filter/bin/doca_url_filter -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 -c3 -- -p
     ```

   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/applications/url_filter/bin/doca_url_filter -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 -- -p
   ```

   This limits the application to 65 cores (core-0 to core-64) with 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 them results in unexpected behavior as only 2 ports are supported. The subfunction number is arbitrary and configurable. The RegEx device, however, is not and must be initiated on port 0.

   Note: Sub-functions must be enabled according to the Scalable Function Setup Guide.

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

   ```
   /opt/mellanox/doca/applications/url_filter/bin/doca_url_filter -a
    0000:05:00.0,class=regex  -a 05:00.3 -a 05:00.4 -v -- -p
   ```

   Note: Refer to section "Running DOCA Application on Host" in NVIDIA DOCA Virtual Functions User Guide.

6. a). To run `doca_url_filter` using a JSON file:

   ```
   doca_url_filter --json [json_file]
   ```

   For example:

   ```
   cd /opt/mellanox/doca/applications/url_filter/bin
   ./doca_url_filter --json url_params.json
   ```

URL Filter is based on user interaction with shell commands. Using the TAB key allows autocompletion while the `quit` command terminates the application. The following are other available commands:

- `create database` – removes and creates a new signature database at `/tmp/signature.txt` so it can be used in the filter command
- `filter http [msg] [regex]` – a signature containing the regular expression written is created in the database. When a match is found, a message is printed.
- `commit database [path]` – compiles and loads the signatures created by the filter command from the file path provided. The default database is `/tmp/signature.txt`.

Note: To load a signatures file that was created beforehand, simply run `commit database` with the desired path to load the file.

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	Add a PCI device into the list of devices to probe	`"devices": [ {"device": "regex",” id": "0000:03:00.0"}, {"device": "sf", "id": “4”,"sft": true}, {"device": "sf", "id": “5”,"sft": true}, ]`
	c	core-mask	Hexadecimal bitmask of cores to run on	`"core-mask": 3`
	l	core-list	List of cores to run on	`"core-list": "0-4"`
General Flags	l	log-level	Sets 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

Flag Type	Short Flag	Long Flag/JSON Key	Description	JSON Content
	h	help	Print a help synopsis	N/A
Program Flags	p	print-match	Prints FID when matched in DPI engine	`"print-match": true`
	f	fragmented	Enables processing of fragmented packets	`"fragmented": false`

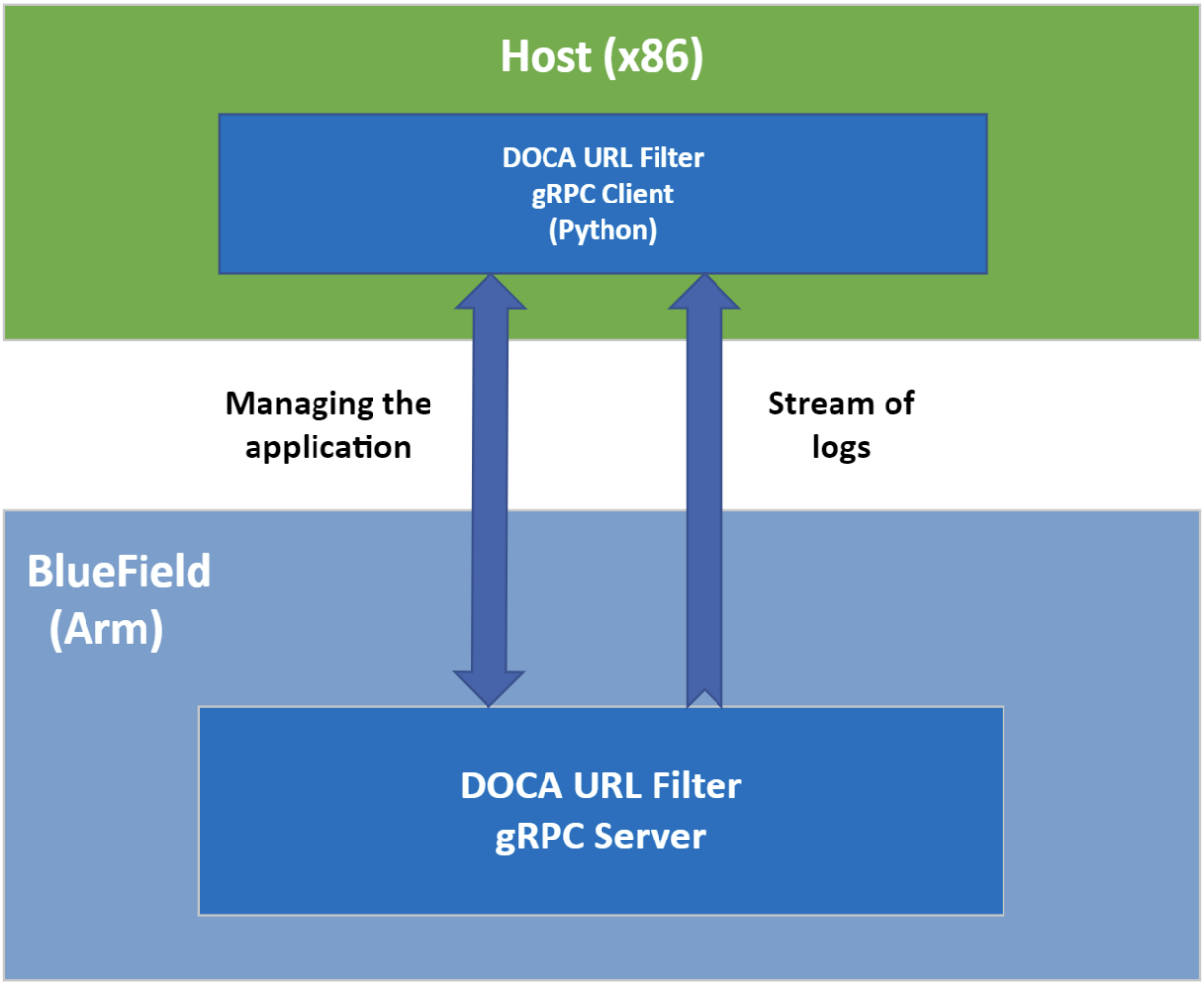
Chapter 8. Deploying Containerized Application

The URL filter example supports a container-based deployment.

1. Refer to the NVIDIA DOCA Container Deployment Guide for details on how to deploy a DOCA container to the BlueField.
2. Notice that the container starts in sleeping mode. That is because of the interactive nature of the URL Filter example app. To run the example, attach to the running container. Run the following:
   ```
   sudo crictl exec -it <container-id> /bin/bash
   ```
   Then refer to the `entrypoint.sh` script at the root directory for an example of how to run the URL filter.
3. Application-specific configuration steps can 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 the BlueField, refer to NVIDIA DOCA gRPC Infrastructure User Guide.



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

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

For example:

```
/opt/mellanox/doca/applications/url_filter/bin/grpc/client/
doca_url_filter_gRPC_client.py -d 192.168.104.2
```

Chapter 10. References

- /opt/mellanox/doca/applications/url_filter/src/url_filter.c
- /opt/mellanox/doca/applications/url_filter/src/grpc/url_filter.proto

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