APPLICATION RECOGNITION

Reference Guide

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Table of Contents

Chapter 1. Introduction

Application Recognition (AR) allows identifying applications that are in use on a monitored networking node.

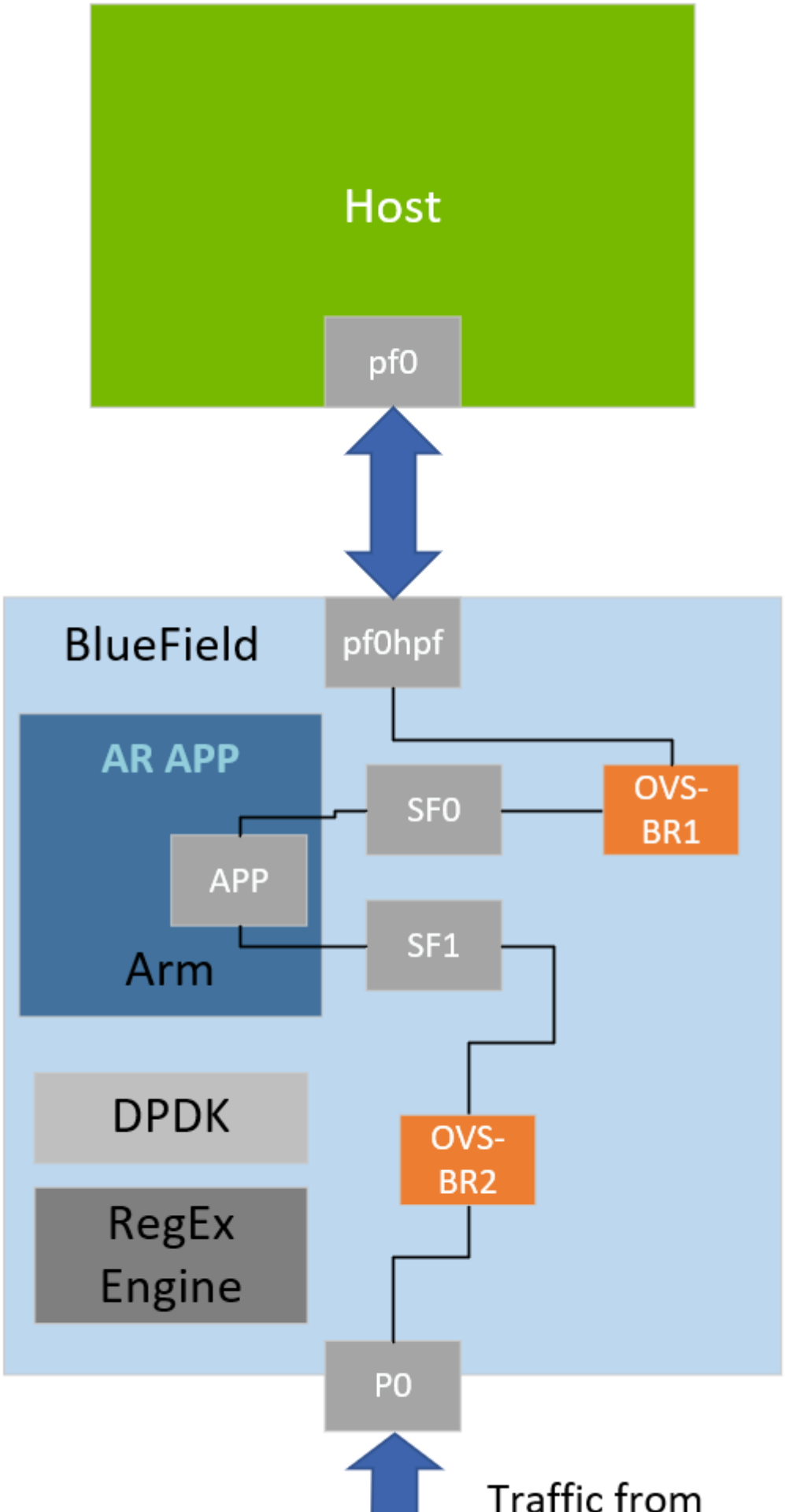
AR enables the security administrator to generate consolidated reports that show usage patterns from the application perspective. AR is also used as a corner stone of many security applications such as L7-based firewalls.

Due to the massive growth in the number of applications that communicate over Layer 7 (HTTP), effective monitoring of network activity requires looking deeper into Layer 7 traffic so individual applications can be identified. Different applications may require different levels of security and service.

This document describes how to build AR using the deep packet inspection (DPI) engine, which leverages NVIDIA® BlueField®-2 DPU capabilities such as regular expression (RXP) acceleration engine, hardware-based connection tracking, and more.

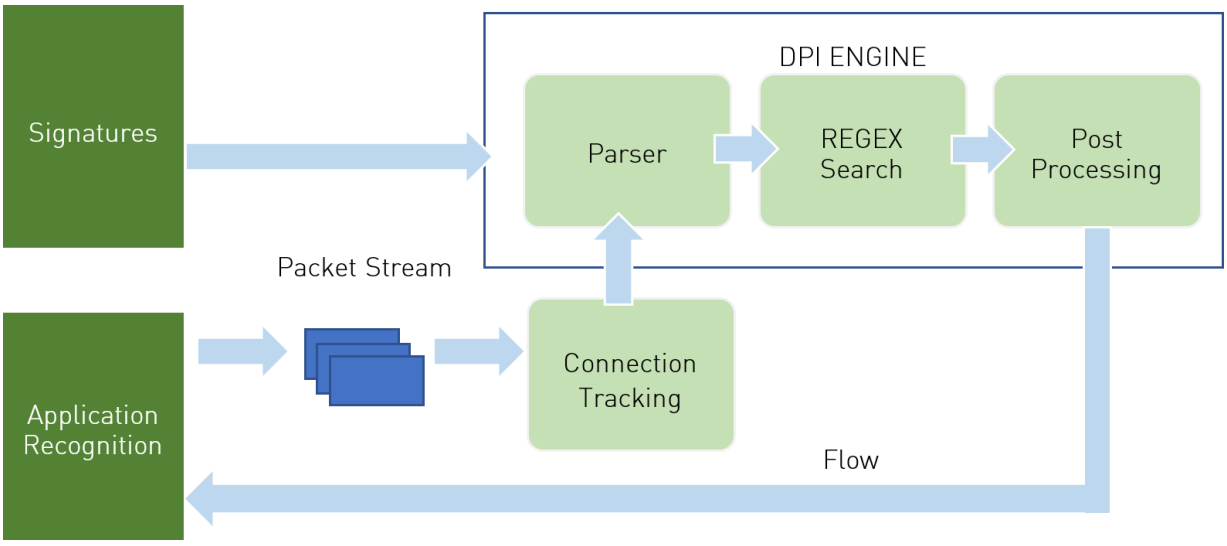
Chapter 2. System Design

The AR application is designed to run as "bump-on-the-wire" on the BlueField-2 instance, it intercepts the traffic coming from the wire, and passes it to the Physical Function (PF) representor connected to the host.


Host
pf0
BlueField
pf0hpf
AR APP
SF0
OVS-
BR1
APP
SF1
Arm
DPDK
OVS-
BR2
RegEx
Engine
P0
Traffic from

Chapter 3. Application Architecture

AR runs on top of Data Plan Development Kit (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.
2. Ingress traffic is identified using the stateful table module in the DPDK libs which utilizes the connection tracking hardware offloads. This allows flow classifications to be done in the hardware level and be forwarded to the hairpin queue without being processed by the software, which increases performance dramatically.
3. Traffic is scanned against DPI engine compiled signature DB.
4. Post processing is performed for match decision.
5. Matched flows are identified and actions can be offloaded to the hardware to increase performance as no 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.

Chapter 4. Configuration Flow

1. DPDK initialization
   ```
   dpdk_init(&argc, &argv, &nb_queues);
   ```
2. AR initialization
   ```
   ar_init(argc, argv, cdo_filename, csv_filename);
   ```
   a). Initialize NetFlow using default configuration `/etc/doca_netflow.conf`.
   b). Initialize signature database.
3. DPDK port initialization.
   ```
   dpdk_ports_init(nb_queues, nb_ports);
   ```
   a). Mempool allocation.
   b). Port initialization.
4. Stateful Flow Table (SFT)
   ```
   dpdk_sft_init (nb_queues) (ar_config.ct, nb_queues, nb_ports);
   ```
   a). SFT initialization with configurable parameters (CT on/off).
   b). Configure RTE flow to forward non-L4 traffic to hairpin queue and L4 traffic to SFT.
5. Configure RTE flow to forward matched traffic to hairpin queue.
   ```
   dpi_ctx = doca_dpi_init(&doca_dpi_config, &err);
   ```
   a). Configure RegEx engine.
   b). Configure DPI queues.
6. Load compiled signatures to RegEx engine.
   ```
   doca_dpi_load_signatures(dpi_ctx, ar_config.cdo_filename);
   ```
7. Configure DPI packet processing.
   ```
   dpi_worker_lcores_run(nb_queues, CLIENT_ID, ar_worker_attr);
   ```
   a). Configure DPI enqueue packets.
   b). Send jobs to RegEx engine.
   c). Configure DPI dequeue packets.
8. Send statistics and write database.
   ```
   sig_database_write_to_csv(ar_config.csv_filename);
   send_netflow();
   ```
   a). Send statistics to the collector.
   b). Write CSV file with signatures statistics.
9. AR destroy
   ```
   ar_destroy(cmdline_thread, ar_config);
   ```

- Clear thread

10. DPI destroy

```
doca_dpi_destroy(dpi_ctx);
```

- Free DPI resources

Chapter 5. Running Application on BlueField

1. Please refer to the DOCA Installation Guide for details on how to install BlueField related software.
2. To build the application:

   a). The application recognition example is installed as part of the doca-dpi-lib package, the binary is located under`/opt/mellanox/doca/examples/ar/bin/doca_app_rec`. To re-build the application recognition sample, run:

   ```
   cd /opt/mellanox/doca/examples/ar/src
   meson /tmp/build
   ninja -C /tmp/build
   ```

   `doca_app_rec` will be created under `tmp/build`.

   b). The build process depends on the PKG_CONFIG_PATH environment variable to locate the DPDK libraries. If the variable was accidently corrupted, and the build fails, please run the following command.

   - For Ubuntu:

     ```
     export PKG_CONFIG_PATH=$PKG_CONFIG_PATH:/opt/mellanox/dpdk/lib/aarch64-linux-gnu/pkgconfig
     ```

   - For CentOS:

     ```
     export PKG_CONFIG_PATH=$PKG_CONFIG_PATH:/opt/mellanox/dpdk/lib64/pkgconfig
     ```

3. The application recognition example is a DPDK application. Therefore, the user is required to provide DPDK flags, and allocate huge pages. Run:

   ```
   echo 2048 > /sys/kernel/mm/hugepages/hugepages-2048kB/nr_hugepages
   systemctl start mlx-regex
   ```

4. To run the application:

   ```
   doca_app_rec [dpdk flags] -- --cdo [cdo_file] --output_csv [output_csv_file] --print_match [additional application flags]
   ```

   Subfunctions must be enabled according to Scalable Function Setup Guide.

   For example:

   ```
   /opt/mellanox/doca/examples/ar/doca_app_rec -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 -v -- -c /root/ar.cdo -p
   ```

   Note: The flag `-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` is necessary for proper usage of the application. Modifying this flag will result 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.

To print the output when the DPI engine finds a match, use `--print_match`.

For additional information about the available flags for DPDK use `-h` before the `--` separator. For the application, use `-h` after the `--`.

The application will periodically dump a `.csv` file with the recognition results containing statistics about the recognized apps in the format `SIG_ID`, `APP_NAME`, `MATCHING_FIDS`, and `DROP`.

As per the example above, a file called `ar_stats.csv` will be created.

Additional features can be triggered by using the shell interaction. This allows blocking and unblocking specific signature IDs using the following commands:

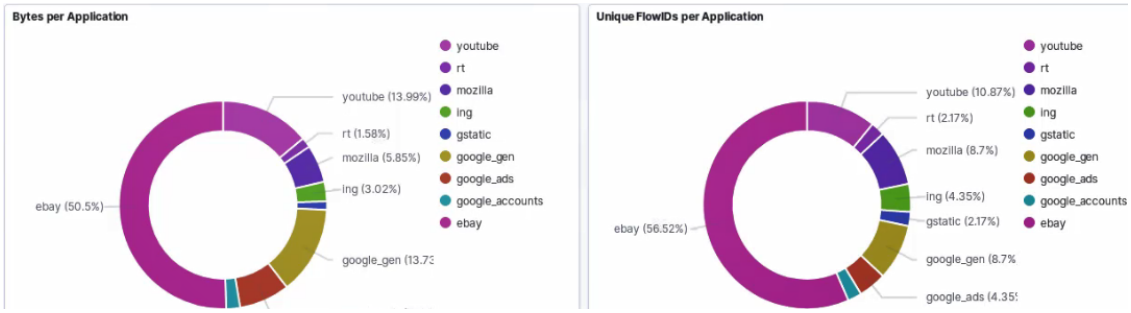
- `block <sig_id>`
- `unblock <sig_id>`

The TAB key allows autocompletion while the `quit` command terminates the application.

Application flags:

- -c or --cdo <path> – path to CDO file compiled from a valid PDD
- -o or --output_csv <path> – path to the output of the CSV file
- -p or --print_match – prints FID when matched in DPI engine
- -i or --interactive – adds interactive mode for blocking signatures
- -n or -netflow – exports data from BlueField to remote NetFlow collector
- -t or -connection_tracking – enables SFT connection tracking (may impact performance)
- -l or -log_level – sets the log level for the app (ERR=0, DEBUG=3)

  NetFlow collector UI example:



5. To use the precompiled signature file (suricata_rules_example), which is installed to the bin directory, the DPI compiler must be used, as the RegEx engine accepts only `.cdo`. The CDO files are constructed by compiling a signature file written in the Suricata open-source format.

   To compile the signature file, run the following:

```
* doca_dpi_compiler -i /opt/mellanox/doca/examples/ar/bin/suricata_rules_example
 -o /tmp/ar.cdo -f suricata
```

A `.cdo` will be created in the output path flagged as the `-o` input path of the compiler. That file can be used when executing the reference application using the `-c` flag as can be seen in previous bullet.

Chapter 6. Running Application on Host

Please refer to Running Reference Applications Over Host Guide.

Chapter 7. References

- /opt/mellanox/doca/examples/ar/src/ar.c
- /opt/mellanox/doca/examples/ar/bin/suricata_rules_example

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