NVIDIA DOCA YARA Inspection Application Guide

Application Guide

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Chapter 1. Introduction

YARA inspection monitors all processes in the host system for specific YARA rules using the DOCA App Shield library.

This security capability helps identify malware detection patterns in host processes from an independent and trusted DPU. This is an innovative intrusion detection system (IDS) as it is designed to run independently on the DPU's Arm cores without hindering the host.

This DOCA App Shield based application provides the capability to read, analyze, and authenticate the host (bare metal/VM) memory directly from the DPU.

Using the library, this application scans host processes and looks for pre-defined YARA rules. After every scan iteration, the application indicates if any of the rules matched. Once there is a match, the application reports which rules were detected in which process. The reports are both printed to the console and exported to the DOCA Telemetry Service (DTS) using inter-process communication (IPC).

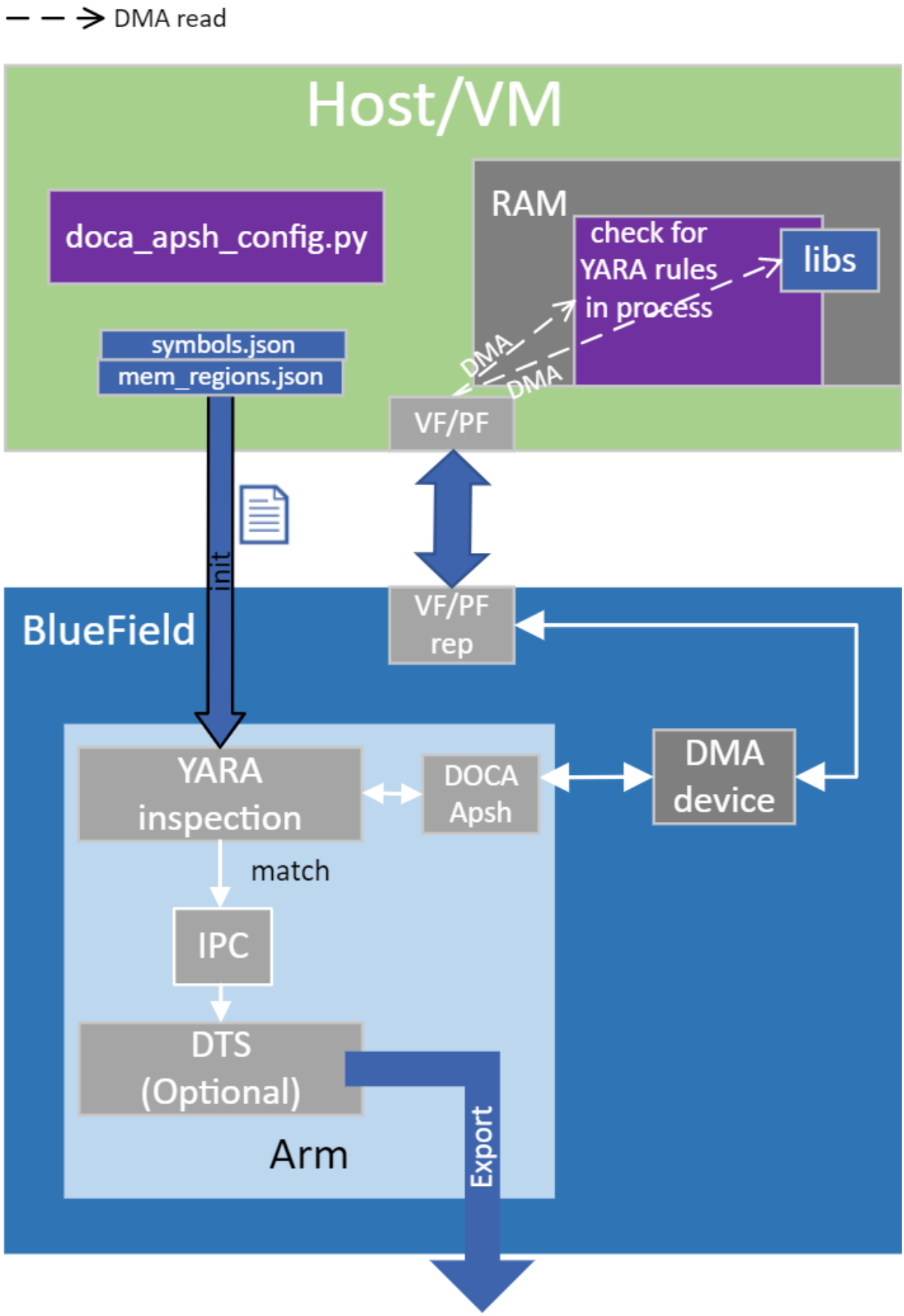
This guide describes how to build YARA inspection using the DOCA App Shield library which leverages DPU abilities such as hardware-based DMA, integrity, and more.

Note: As the DOCA App Shield library only supports the YARA API for Windows hosts, this application can only be used to inspect Windows hosts.

Chapter 2. System Design

The host's involvement is limited to generating the required ZIP and JSON files to pass to the DPU. This is done before the app is triggered, when the host is still in a "safe" state.

Generating the needed files can be done by running DOCA App Shield's `doca_apsh_config.py` tool on the host. See NVIDIA DOCA App Shield Programming Guide for more info.

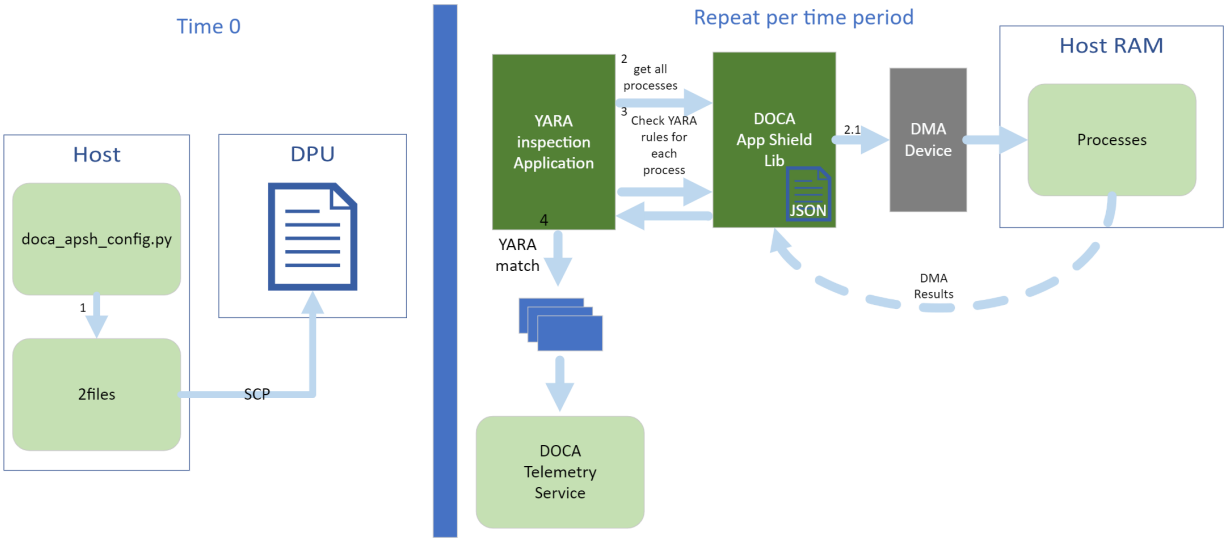

DMA read
Host/VM
doca_apsh_config.py
RAM
check for YARA rules in process
libs
symbols.json
mem_regions.json
DMA
DMA
VF/PF
init
BlueField
VF/PF rep
YARA inspection
DOCA Apsh
DMA device
match
IPC
DTS (Optional)
Arm
Export

Chapter 3. Application Architecture

The user creates the ZIP and JSON files using the DOCA tool `doca_apsh_config.py` and copies them to the DPU.

The application can report YARA rules detection to the:

- File
- Terminal
- DTS



1. The files are generated by running `doca_apsh_config.py` on the host against the process at time zero.
2. The following steps recur at regular time intervals:
   a). The YARA inspection app requests a list of all apps from the DOCA App Shield library.
   b). The app loops over all processes and checks for YARA rules match using the DOCA App Shield library.
   c). If YARA rules are found (1 or more), the YARA attestation app reports results with a timestamp and details about the process and rules to:

- Local telemetry files – a folder and files representing the data a real DTS would have received

  Note: These files are used for the purpose of this example only as normally this data is not exported into user-readable files.

- DOCA log
- DTS IPC interface (even if no DTS is active)

3. The App Shield agent exits on first YARA rule detection.

Chapter 4. DOCA Libraries

This application leverages following DOCA libraries:

- DOCA App Shield 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_apsh_params();
   ```
   c). Parse app flags.
   ```
   doca_argp_start();
   ```
2. Initialize DOCA App Shield lib context.
   a). Create lib context.
   ```
   doca_apsh_create();
   ```
   b). Set DMA device for lib.
   ```
   open_doca_device_with_ibdev_name();
   doca_apsh_dma_dev_set();
   ```
   c). Start the context.
   ```
   doca_apsh_start();
   apsh_system_init();
   ```
3. Initialize DOCA App Shield lib system context handler.
   a). Get the representor of the remote PCIe function exposed to the system.
   ```
   open_doca_device_rep_with_vuid();
   ```
   b). Create and start the system context handler.
   ```
   doca_apsh_system_create();
   doca_apsh_sys_os_symbol_map_set();
   doca_apsh_sys_mem_region_set();
   doca_apsh_sys_dev_set();
   doca_apsh_sys_os_type_set();
   doca_apsh_system_start();
   ```
4. Telemetry initialization.
   ```
   telemetry_start();
   ```
   a). Initialize a new telemetry schema.
   b). Register YARA type event.
   c). Set up output to file (in addition to default IPC).
   d). Start the telemetry schema.
   e). Initialize and start a new DTS source with the `gethostname()` name as source ID.
5. Loop until YARA rule is matched.

a). Get all processes from the host.

```
doca_apsh_processes_get();
```

b). Check for YARA rule identification and send a DTS event if there is a match.

```
doca_apsh_yara_get();
if (yara_matches_size != 0) {
    /* event fill logic
    doca_telemetry_source_report();
DOCA_LOG_INFO();
sleep();
```

6. Telemetry destroy.

```
telemetry_destroy();
```

7. YARA inspection clean-up.

```
doca_apsh_system_destroy();
doca_apsh_destroy();
doca_dev_close();
doca_dev_rep_close();
```

8. Arg parser destroy.

```
doca_argp_destroy();
```

Chapter 6. Dependencies

- Firmware version 24.32.1010 or greater
- BFB Ubuntu 22.04 only
- Supported only for Windows hosts

Chapter 7. 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 of DOCA applications.
2. The App Shield Agent binary is located under `/opt/mellanox/doca/applications/yara_inspection/bin/doca_yara_inspection`. To build the applications together, run:

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

3. To build only the App Shield Agent application:

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

   - Set `enable_all_applications` to `false`
   - Set `enable_yara_inspection` to `true`

   b). Run the commands in step 2.

> Note: `doca_yara_inspection` is created under `./build/yara_inspection/src/`.

Application usage:

```
Usage: doca_yara_inspection [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:
  -m, --memr <path>                 System memory regions map
  -f, --vuid                        VUID of the System device
  -d, --dma                         DMA device name
  -o, --osym <path>                 System OS symbol map path
```

```
-t, --time <seconds>                Scan time interval in seconds
```

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

```
/opt/mellanox/doca/applications/yara_inspection/bin/doca_yara_inspection -h
```

4. The following steps must be done only once.

   a). Configure the BlueField's firmware.

   i. On the BlueField system, configure the PF base address register and NVME emulation. Run:

   ```
   dpu> mlxconfig -d /dev/mst/mt41686_pciconf0 s PF_BAR2_SIZE=2
    PF_BAR2_ENABLE=1 NVME_EMULATION_ENABLE=1
   ```

   ii. Perform a cold boot from the host. Run:

   ```
   host> ipmitool power cycle
   ```

   Note: These configurations can be checked using the following command:

   ```
   dpu> mlxconfig -d /dev/mst/mt41686_pciconf0 q | grep -E "NVME|BAR"
   ```

   b). Perform IOMMU passthrough. This stage is only necessary in cases where IOMMU is not enabled by default (e.g., when the host is using an AMD CPU).

   Note: Skip this step if you are not sure whether you need it. Return to it only if DMA fails with a message in `dmesg` similar to the following:

   ```
   host> dmesg
   [ 3839.822897] mlx5_core 0000:81:00.0: AMD-Vi: Event logged
    [IO_PAGE_FAULT domain=0x0047 address=0x2a0aff8 flags=0x0000]
   ```

   i. Locate your OS's `grub` file (most likely `/boot/grub/grub.conf`, `/boot/grub2/grub.cfg`, or `/etc/default/grub`) and open it for editing. Run:

   ```
   host> vim /etc/default/grub
   ```

   ii. Search for the line defining `GRUB_CMDLINE_LINUX_DEFAULT` and add the argument `iommu=pt`. For example:

   ```
   GRUB_CMDLINE_LINUX_DEFAULT="iommu=pt <intel/amd>_iommu=on"
   ```

   iii. Run:

   - For Ubuntu:

   ```
   host> sudo update-grub
   host> ipmitool power cycle
   ```

   - For CentOS:

   ```
   host> grub2-mkconfig -o /boot/grub2/grub.cfg
   host> ipmitool power cycle
   ```

   c). For Windows targets only, turn off Hyper-V capability

5. Running the application on BlueField:

   - Pre-run setup:

   a). The DOCA App Shield library uses huge pages for DMA buffers. Therefore, the user must allocate 42 huge pages. Run:

   ```
   dpu> nr_huge=$(cat /sys/devices/system/node/node0/hugepages/
   hugepages-2048kB/nr_hugepages)
        nr_huge=$((42+$nr_huge))
   ```

```
     sudo echo $nr_huge > /sys/devices/system/node/node0/hugepages/
hugepages-2048kB/nr_hugepages
```

b). Create the ZIP and JSON files. Run:

Note: If the kernel and process `.exe` have not changed, there no need to redo this step.

```
target-system> cd /opt/mellanox/doca/tools/
target-system> python3 doca_apsh_config.py <pid-of-process-to-monitor> --
os <windows/linux> --path <path to dwarf2json executable  or pdbparse-to-
json.py>
target-system> cp /opt/mellanox/doca/tools/*.* <shared-folder-with-
baremetal>
dpu> scp <shared-folder-with-baremetal>/* <path-to-app-shield-binary>
```

If the target system does not have DOCA installed, the script can be copied from the BlueField.

The required `dwaf2json` and `pdbparse-to-json.py` are not provided with DOCA. Follow the NVIDIA DOCA App Shield Programming Guide for more information.

- CLI example for running the app:

```
dpu> /opt/mellanox/doca/applications/yara_inspection/bin/doca_yara_inspection
 -m mem_regions.json -o symbols.json -f MT2125X03335MLNXS0D0F0VF1 -d mlx5_0 -
t 3
```

Chapter 8. Arg Parser DOCA Flags

Refer to NVIDIA DOCA Arg Parser Programming Guide for more information.

Flag Type	Short Flag	Long Flag/JSON Key	Description
General flags	`l`	`log-level`	Set the log level for the application: ▶ CRITICAL=20 ▶ ERROR=30 ▶ WARNING=40 ▶ INFO=50 ▶ DEBUG=60
	`v`	`version`	Print program version information
	`h`	`help`	Print a help synopsis
Program flags	`m`	`memr`	Path to the pre-generated `mem_regions.json` file transfered from the host

	`f`	`pcif`	System PCIe function vendor unique identifier (VUID) of the VF/PF exposed to the target system. Used for DMA operations.
			To obtain this argument, run:
			`target-system> lspci -vv | grep "\[VU\] Vendor specific:"`
			Example output:
			`[VU] Vendor specific: MT2125X03335MLNXS0D0F0`

Flag Type	Short Flag	Long Flag/JSON Key	Description
			`[VU] Vendor specific: MT2125X03335MLNXS0D0F1` Two VUIDs are printed for each DPU connected to the target system. The first is of the DPU on `pf0` and the second is of the DPU on port `pf1`. Note: Running this command on the DPU outputs VUIDs with an additional "EC" string in the middle. You must remove the "EC" to arrive at the correct VUID. The VUID of a VF allocated on PF0/1 is the VUID of the PF with an additional suffix, `VF<vf-number>`, where `vf-number` is the VF index +1. For example, for the output in the example above: ▶ PF0 VUID = MT2125X03335MLNXS0D0F0 ▶ PF1 VUID = MT2125X03335MLNXS0D0F1 ▶ VUID of VF0 on PF0 = MT2125X03335MLNXS0D0F0VF1 VUIDs are persistent even on reset.
	`d`	`dma`	DMA device name to use
	`o`	`osym`	Path to the pre-generated

Flag Type	Short Flag	Long Flag/JSON Key	Description
			`symbols.json` file transferred from the host
	`t`	`time`	Number of seconds to sleep between scans

Chapter 9. References

- `/opt/mellanox/doca/applications/yara_inspection/src`

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