NVIDIA DOCA App Shield

Programming Guide

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Table of Contents

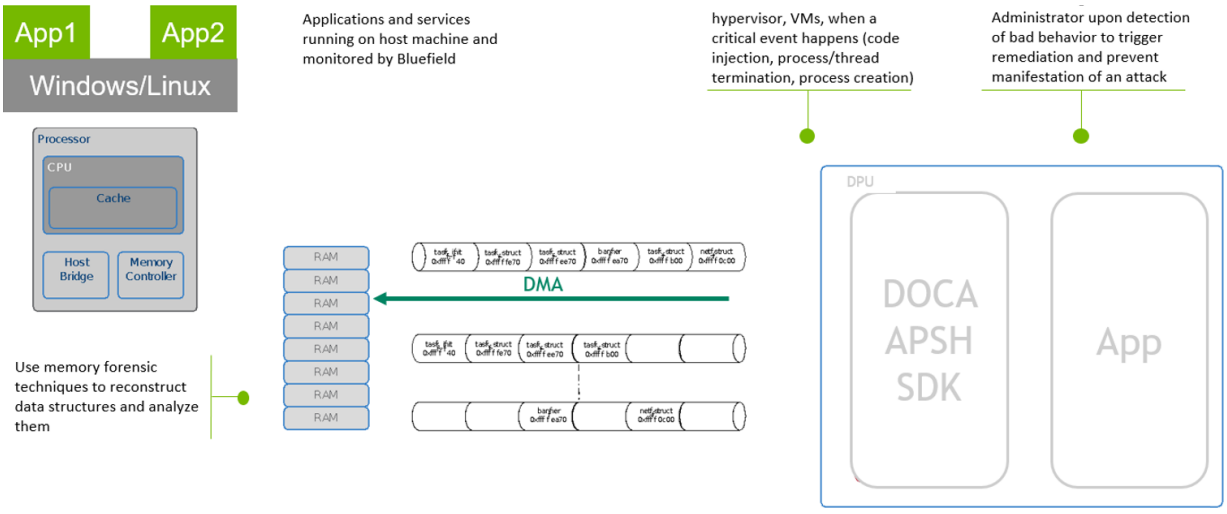
Chapter 1. Introduction

DOCA App Shield API offers a solution for strong intrusion detection capabilities using the DPU services to collect data from the host's memory. This solution provides intrusion detection and forensics investigation that is:

- Robust against attacks on a host machine
-
- Able to detect a wide range of attacks (including zero-day attacks)
- Least disruptive to the execution of host application (where current detection solutions hinder the performance of host applications)

Using App Shield, it is possible to detect attacks on critical services in a system. In many systems, those critical services are responsible for assuring the integrity/privacy of the execution of other applications. For example, a scrubbing service is responsible for erasing private data of users.

The following figure describes the relation between the DPU and the host memory where attacks may occur, and the green squares which are the assets that must resume operation unhindered. DOCA App Shield is responsible for acquiring information about processes to allow attack detection. To that end, DOCA App Shield exposes an API to the user allowing them to detect malicious activities (e.g., malicious processes, DLL files) by monitoring changes in critical memory parts directly from the Arm using DMA without involving the host OS or CPU.

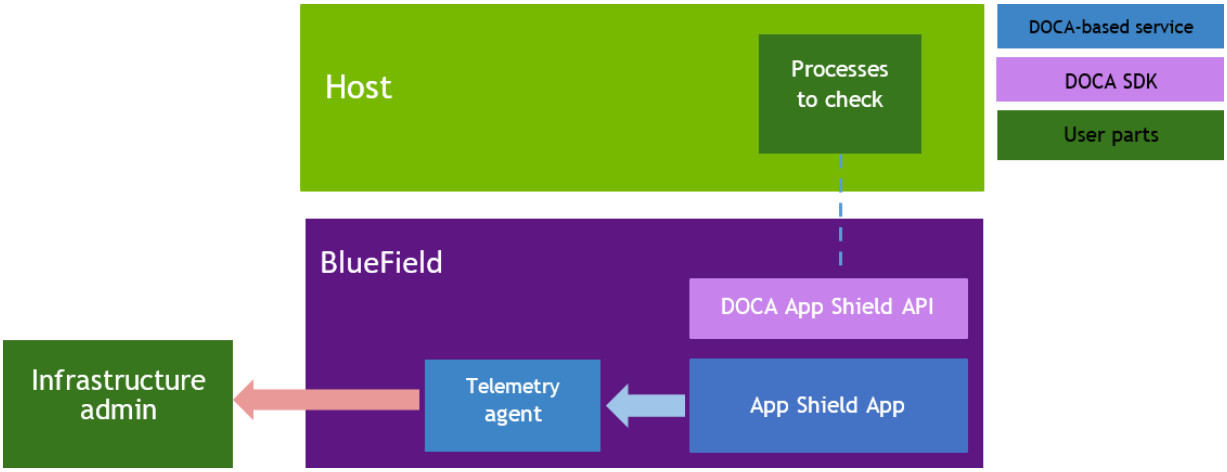


Chapter 2. Setup Configuration

The following code block describes how to configure DOCA App Shield on the DPU.

```
# On the bluefield system, configure PF base address register and NVME emulation

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

#Do Cold boot (from host)
Host> ipmitool power cycle


## repeat after every reboot
# Allocate huge-pages

Arm> rm -rf "/mnt/huge/*"

Arm> echo 42 > /sys/devices/system/node/node0/hugepages/hugepages-32768kB/
nr_hugepages

Arm> \
if [ ! -d "/mnt/huge" ] ; then
  mkdir "/mnt/huge"
fi

Arm> mount -t hugetlbfs -o pagesize=32MB none "/mnt/huge"


# Disable the mlnx-snap service

Arm> systemctl stop mlnx_snap
```

Chapter 3. App Shield Architecture



- App Shield App – user application implementing the specific use case
- Telemetry Agent – collect telemetry metrics
- Processes to check – host process to track

Chapter 4. App Shield Initialization and Teardown

In the App Shield API there are different structures which must be used for a BlueField client to be able to introspect into a system running on the host side, whether it is a bare metal machine or a virtual machine.

4.1. Init App Shield

The App Shield context structure is used to init the devices on the DPU required to start monitoring App Shield systems.

To use `doca_apsh_ctx`, call:

```
struct doca_apsh_ctx* doca_apsh_create(void);
```

For `doca_app_shield_ctx` to work, a RegEx device and an RDMA device must be set, using these two functions:

```
int doca_apsh_dma_dev_set(struct doca_apsh_ctx *ctx, const char *dma_dev_name);
int doca_apsh_regex_dev_set(struct doca_apsh_ctx *ctx, const char *regex_dev_name);
```

For example:

```
int ret = doca_apsh_dma_dev_set(ctx, "mlx5_0");
```

After the above devices were set, the following function should be invoke:

```
int doca_apsh_start(struct doca_apsh_ctx *ctx);
```

This establishes a connection to the devices.

When App Shield lib is no longer needed, a destruction must be called to deallocate any allocated memory:

```
void doca_apsh_destroy(struct doca_apsh_ctx *ctx);
```

4.2. Init System to Monitor

The system structure represents a system on the host that should be monitored. To instantiate an App Shield system, this function must be called:

```
struct doca_apsh_system *doca_apsh_system_create(struct doca_apsh_ctx *ctx);
```

A single `doca_apsh_ctx` instance may be associate with many App Shield systems.

The App Shield system has the following attributes:

- layer – the type of the system. Types: Bare metal, virtual machine, or a container (for future use).
- PCI function – index of PCIe function connected to this system. Using DMA (direct memory access) read over this PCIe function representor on the DPU connected to a PCIe function on the host and is exposed to an OS that needs to be monitored. For example, for bare metal OS on the host, you can use the physical function (PF) that is usually index 0 (PF0). If you have a virtual function (VF) connected to a VM, to inspect that VM specify that VF's index.
- system/symbol map – includes information about the OS App Shield needs to introspect (e.g., Window 10 Build 18363/Linux Ubuntu 20.04) and the size and fields of the OS structures such as process struct, which helps App Shield with the memory forensic techniques it uses to access and analyze these structures in the host's memory.
- memory regions – contains the allowed physical memory regions which App Shield can access. This information is needed since there are memory regions reserved by different PCIe devices. Some of these regions map device registers which change the state of the device each time the regions (certain physical addresses in these regions) are read. These changes may confuse the device firmware and may, therefore, cause the system to crash/ freeze. This must be avoided.

Each one of these attributes must be set by calling its suitable function:

```
int doca_apsh_sys_system_layer_set(struct doca_apsh_system *system, enum
 doca_apsh_system_layer layer_type);
int doca_apsh_sys_pcidev_set(struct doca_apsh_system *system, int pci_index);
int doca_apsh_sys_os_symbol_map_set(struct doca_apsh_system *system, const char
 *system_os_symbol_map_path);
int doca_apsh_sys_mem_region_set(struct doca_apsh_system *system, const char
 *system_mem_region_path);
```

For each system, after all the attributes are set, the following function must be called to start App Shield system monitoring:

```
int doca_apsh_system_start(struct doca_apsh_system *system);
```

Other functions can be called to retrieve information from the system's memory after App Shield system is started. These functions (also called capabilities) are expanded on in Capabilities Per System.

When the App Shield system is no longer needed, a destruction must be called to deallocate internal system memory:

```
void doca_apsh_system_destroy(struct doca_apsh_system *system);
```

Chapter 5. API

5.1. Capabilities Per System

For each initialized system, App Shield can retrieve the following information:

Function Name	Functions Information	Functions Signature	Return Type
Get modules	Returns an array with information about the system modules (drivers) loaded into the kernel of the OS	`int doca_apsh_modules_get(struct doca_apsh_system *system, struct doca_apsh_module ***modules);`	▶ Array of: `struct doca_apsh_module` ▶ int: Size of the returned array or a negative error code on error
Get processes	Returns an array with information about each of the processes running on the system	`int doca_apsh_processes_get(struct doca_apsh_system *system, struct doca_apsh_procces ***processes);`	▶ Array of: `struct doca_apsh_procces` ▶ int: Size of the returned array or a negative error code on error
Process refresh	Refreshes the information of a certain process	`int doca_apsh_proc_refresh(struct doca_apsh_process *process);`	0 on success, or a negative error code on error
Get library	For a specified process, this function returns an array with information about each of the libraries loaded into this process	`int doca_apsh_libs_get(struct doca_apsh_process *process, struct doca_apsh_lib ***libs);`	▶ Array of: `struct doca_apsh_lib` ▶ int: Size of the returned array or a negative error code on error
Get threads	For a specified process, this function returns an array with information about each of the threads running within this process	`int doca_apsh_threads_get(struct doca_apsh_process *process, struct doca_apsh_thread ***threads);`	▶ Array of: `struct doca_apsh_thread` ▶ int: Size of the returned array or a

Function Name	Functions Information	Functions Signature	Return Type
			negative error code on error
Get virtual memory areas	For a specified process, this function returns an array with information about each of the virtual memory areas within this process	`int doca_apsh_vmas_get(struct doca_apsh_process *process, struct doca_apsh_vad ***vmas);`	▶ Array of: `struct doca_apsh_vma` ▶ int: Size of the returned array or a negative error code on error
Process attestation	For a specified process, this function attests the memory pages of this process according to a precomputed golden hash file given as an input	`int doca_apsh_attestation_get(struct doca_apsh_process *process, const char *exec_hash_map_path, struct doca_apsh_attestation ***attestation);`	▶ Array of: `struct doca_apsh_attestation` ▶ int: Size of the returned array or a negative error code on error
Attestation refresh	Refresh a single attestation handler of a process with a new snapshot	`int doca_apsh_attst_refresh(struct doca_apsh_attestation ***attestation);`	▶ Array of: `struct doca_apsh_attestation` ▶ int: Size of the returned array or a negative error code on error

For each of the getter functions, a struct or an array of structs with the requested information is returned. To access this information, another getter function must be called specifying the exact information/attribute required from that struct.

```
const void *doca_apsh_proc_info_get(struct doca_apsh_procces *process, enum
 doca_apsh_process_attr attr);
const void *doca_apsh_module_info_get(struct doca_apsh_module *module, enum
 doca_apsh_module_attr attr);
const void *doca_apsh_lib_info_get(struct doca_apsh_lib *lib, enum
 doca_apsh_lib_attr attr);
const void *doca_apsh_thread_info_get(struct doca_apsh_thread *thread, enum
 doca_apsh_lib_attr attr);
const void *doca_apsh_vma_info_get(struct doca_apsh_vma *vma, enum
 doca_apsh_lib_attr attr);
const void *doca_apsh_attst_info_get(struct doca_apsh_attestation *attestation, enum
 doca_apsh_attestation_attr attr);
```

All the required attributes are defined in `/usr/include/doca_apsh_attr.h`.

5.2. Cleanup

Any of the structures retuned by the getter functions specified in Capabilities Per System must be freed after work is done with it. To destroy these structures, a destruction function must be called:

```
void doca_apsh_processes_free(struct doca_apsh_process **processes);
void doca_apsh_libs_free(struct doca_apsh_lib **libs);
void doca_apsh_threads_free(struct doca_apsh_thread **threads);
```

```
void doca_apsh_vads_free(struct doca_apsh_vad **vads);
void doca_apsh_attestation_free(struct doca_apsh_attestation **attestation);
```

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