NVIDIA DOCA NAT

Application Guide

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Chapter 1. Introduction

A network address translation (NAT) application leverages the DPU's hardware capability to switch packets with local IP addresses to global ones and vise versa.

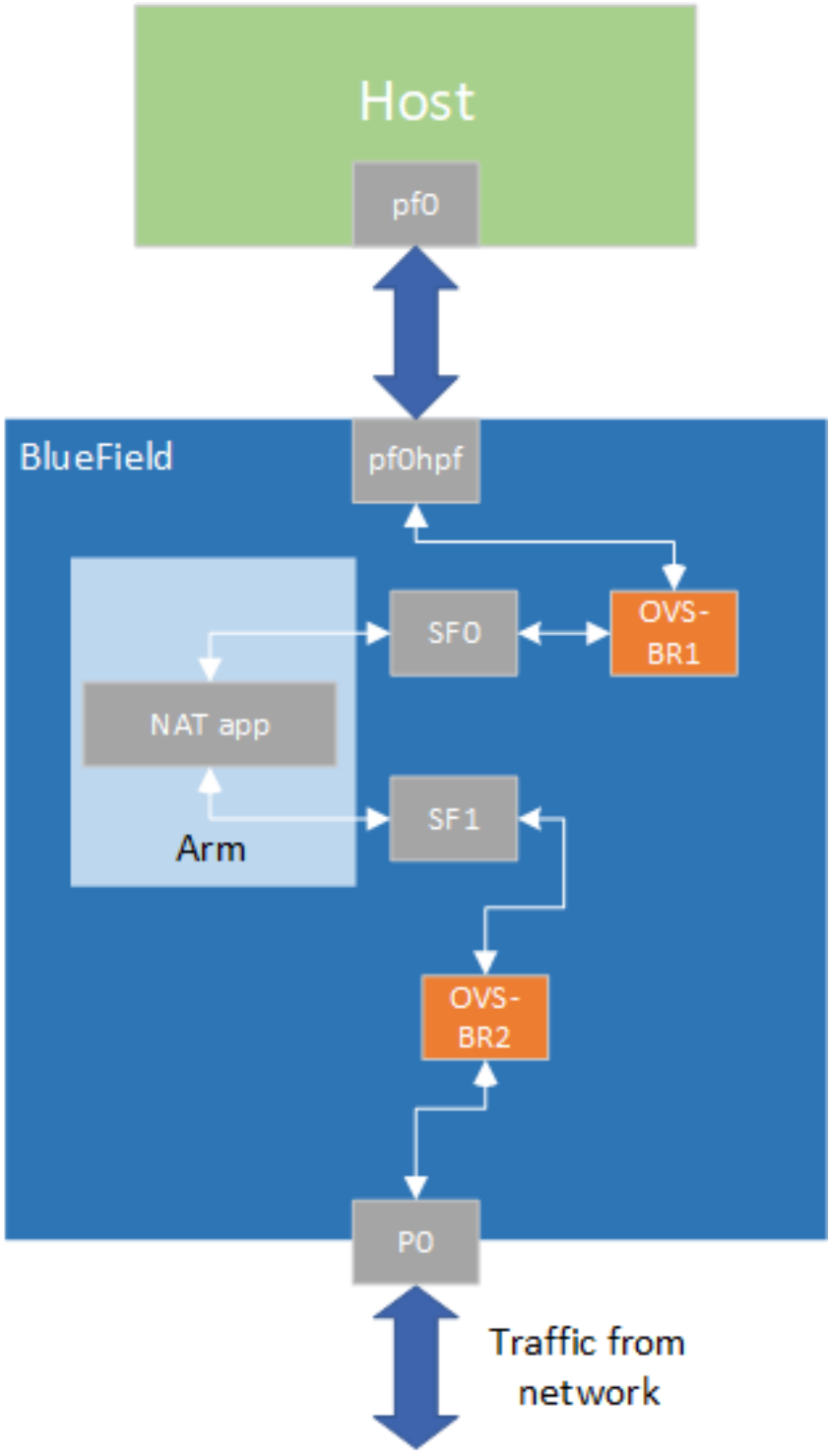
The NAT application is based on DOCA Flow, used for the programming of the DPU's hardware.

NAT can operate in three modes:

- Static mode – application gets pairs of local IP address and global IP address from the user using a JSON file
- Dynamic mode – user provides pool of global IP addresses that can be used. The application should pick 1 address from the pool for new local area network (LAN) IP address and use it. Upon session close, address are returned to the pool.
- PAT mode (DNS offload) – the user provides 1 global address to use. In addition, the user provides mapping between the local port address to the global port. For each packet, the local address is replaced with the global one and ports are replaced according to mapping table.

Chapter 2. System Design

The NAT application is design to run on the DPU. The DPU intercepts ingress traffic from both wire and host, switches the relevant IP address and port according to data configured by the user, and forwards it to the egress port.


Host
pf0
BlueField
pf0hpf
SF0
OVS-
BR1
NAT app
SF1
Arm
OVS-
BR2
P0
Traffic from
network

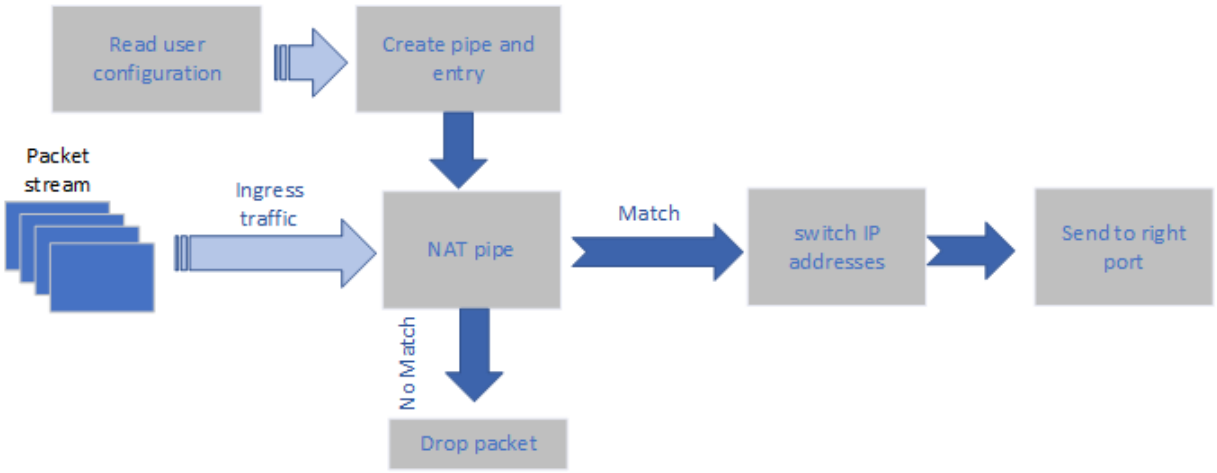
Chapter 3. Application Architecture

NAT runs on the DPU to classify packets.

The app should be configured using a JSON file which includes the operation mode.

3.1. Static Mode

For static mode, the JSON file should include pairs of local and global IP addresses. No change for ports in this mode.

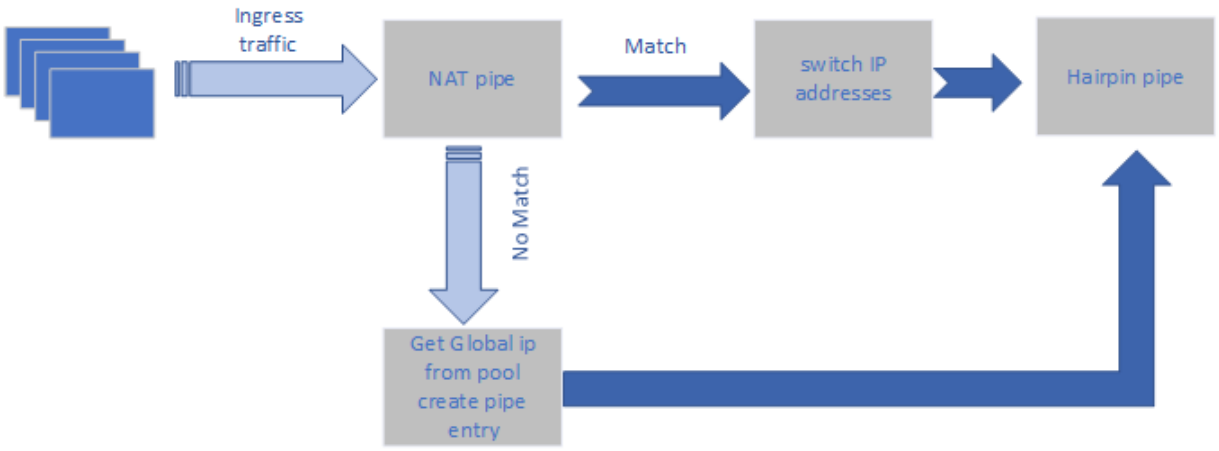


3.2. Dynamic Mode

The user must provide a pool of global IP addresses to use. The application allocates a global address to every miss in the pipe (new local address).

If no more global addresses are available in the pool, the user gets an error message and the packet is sent as is.

The application performs a callback to remove the matching of global and local IPs and returns the address to the pool.

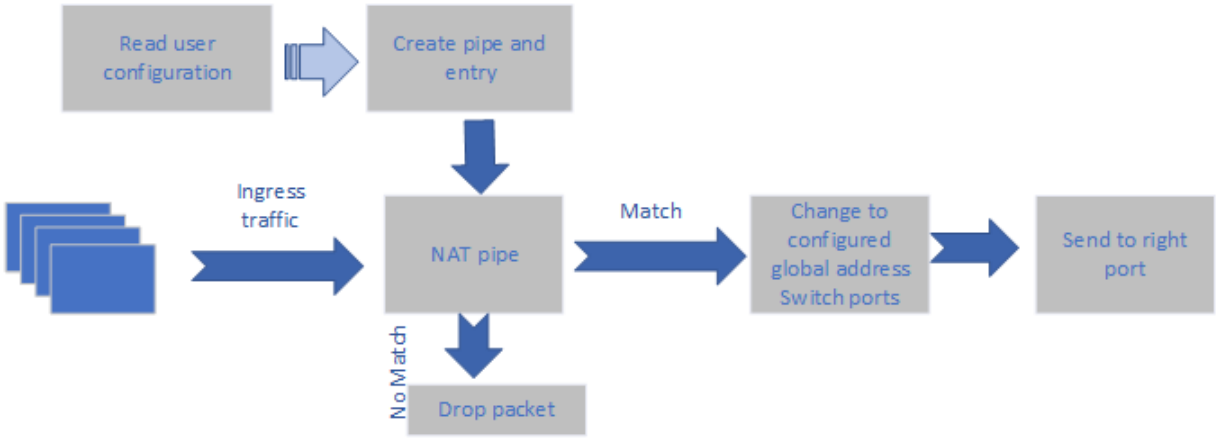


3.3. PAT (NAT Offload) Mode

The user provides a global address to replace all local addresses in the user LAN.

The user provides a matching of local IP and port to global port.

The application changes the local IP of every match to the global IP provided by the user and updates the port number according to user configuration.



Chapter 4. DOCA Libraries

This application leverages the following DOCA libraries:

- DOCA Flow 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_nat_params()
   ```
   c). Parse the arguments.
   ```
   doca_argp_start();
   ```
      i. Parse DPDK flags and invoke handler for calling the `rte_eal_init()` function.
      ii. Parse 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 DPDK ports, including mempool allocation.
   b). Initialize hairpin queues if needed.
   c). Bind hairpin queues of each port to its peer port.
4. NAT initialization.
   ```
   nat_init();
   ```
   a). DOCA Flow and DOCA Flow port initialization.
5. Init user configuration rules into app structure.
   ```
   parsing_nat_rules();
   ```
6. Init pipes and entry according to rules.
   ```
   nat_pipes_init
   ```
7. Wait for signal to end application.
8. NAT Destroy.
   ```
   nat_destroy();
   ```
9. DPDK ports and queues destruction.
   ```
   dpdk_queues_and_ports_fini();
   ```
10. DPDK finish.
    ```
    dpdk_fini();
    ```
    a). Calls `rte_eal_destroy()` to destroy initialized EAL resources.

11. Arg parser destroy.

```
doca_argp_destroy();
```

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.
   - NVIDIA DOCA Applications Overview for additional compilation instructions and development tips regarding the DOCA applications.
2. The NAT binary is located under `/opt/mellanox/doca/applications/nat/bin/doca_nat`. To build all the applications together, run:

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

3. To build only the NAT application:

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

   b). Run the commands in step 2.

> **Note:** `doca_file_integrity` is created under `./build/file_integrity/src/`.

Application usage:

```
Usage: doca_nat [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:
  -m, --mode <mode>             Set nat mode
  -r, --nat-rules <path>        Path to the JSON file with nat rules
  -lan --lan-intf   <sfX>       Interface of traffic from lan to wan
```

```
  -wan --wan-intf   <sfX>       Interface of traffic from wan to lan
```

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

```
/opt/mellanox/doca/applications/nat/bin/doca_nat -h
```

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

```
/opt/mellanox/doca/applications/nat/bin/doca_nat -- -h
```

4. Running the application on BlueField:

   a). The NAT 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). CLI example for running the application:

   ```
   /opt/mellanox/doca/applications/nat/bin/doca_nat
    -a auxiliary:mlx5_core.sf.4,dv_flow_en=2 -a
    auxiliary:mlx5_core.sf.5,dv_flow_en=2 -- -m static -r /opt/mellanox/doca/
   applications/nat/bin/nat_static_rules.json -lan sf3 -wan sf4
   ```

   Note: The flag `-a auxiliary:mlx5_core.sf.4 -a auxiliary:mlx5_core.sf.5` is mandatory for proper usage of the application. Modifying this flag results in unexpected behavior as only 2 ports are supported. The SF number is arbitrary and configurable.

   Note: SFs must be enabled according to Scalable Function Setup Guide.

5. To run `doca_nat` using a JSON file:

   ```
   doca_nat --json [json_file]
   ```

   For example:

   ```
   cd /opt/mellanox/doca/applications/nat/bin
   ./doca_nat --json nat_params.json
   ```

Chapter 7. Arg Parser DOCA Flags

For more information, refer to NVIDIA DOCA Arg Parser User Guide.

Flag Type	Short Flag	Long Flag/JSON Key	Description	JSON Content
DPDK Flags	a	devices	Add a PCIe device into the list of devices to probe	"devices": [{"device": "sf", "id": "4","h true}, {"device": "sf", "id": "5","h true},]
General Flags	l	log-level	Set 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
	h	help	Print a help synopsis	N/A
Program Flags	m	mode	Set NAT mode	"mode": "static"
	r	nat-rules	Path to the JSON file with NAT rules	"nat-rules": "nat_static_rules.jso
	lan	Lan-intf	Name of LAN interface	"lan-intf": "sf3"
	wan	Wan-intf	Name of WAN interface	"wan-intf": "sf4"

Chapter 8. References

- `/opt/mellanox/doca/applications/nat/src/nat.c`

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