NVIDIA DOCA Simple Forward VNF

Application

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Chapter 1. Introdution

Simple forward is a forwarding application that takes either VXLAN, GRE, or GTP traffic from a single RX port and transmits it on a single TX port.

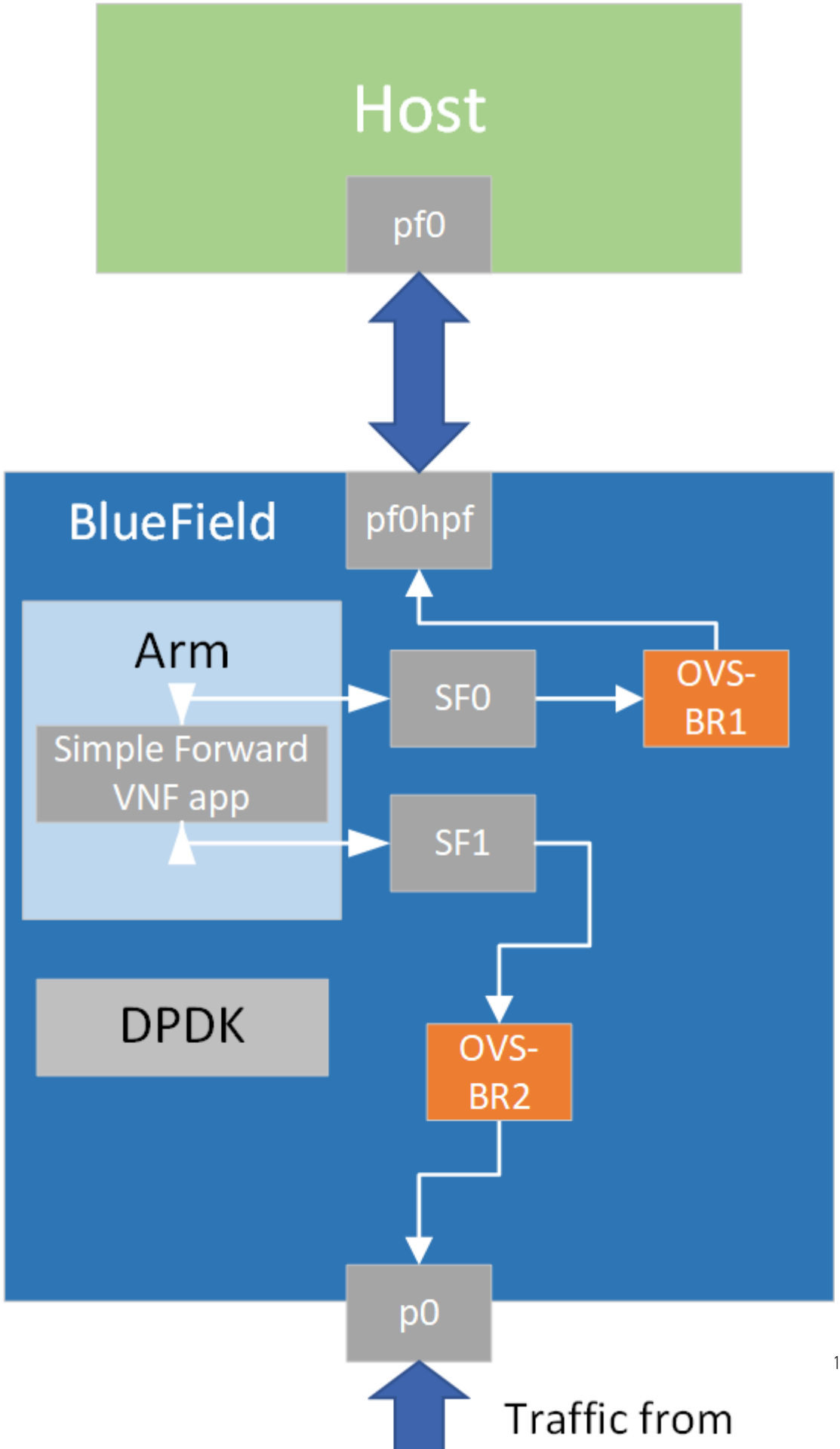
For every packet received on an RX queue on a given port, DOCA Simple Forward checks the packet's key, which consists of a 5-tuple. If it finds that the packet matches an existing flow, then it does not create a new one. Otherwise, a new flow is created with a FORWARDING component. Finally, the packet is forwarded to the TX queue of the egress port if "rx-only" mode is not set. Refer to Arg Parser DOCA Flags for more.

The FORWARDING component type depends on the flags delivered when running the application. For example, if the hairpinq flag is provided, then the FORWARDING component would be hairpin. Otherwise, it would be RSS'd to software, and hence every VXLAN, GTP, or GRE packet would be received on RX queues.

Simple forward should be run with dual ports. By using a traffic generator, the RX port receives the VXLAN, GRE, or GTP packets and forwarding forwards them back to the traffic generator.

Chapter 2. System Design

The following diagram illustrates simple forward's packet flows. It receives traffic coming from the wire and passes it to the other port.


Host
pf0
BlueField
pf0hpf
Arm
Simple Forward
VNF app
SF0
SF1
OVS-
BR1
OVS-
BR2
DPDK
p0
Traffic from

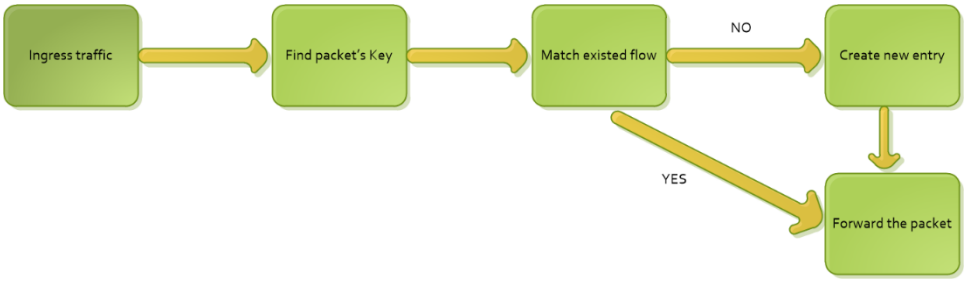
Chapter 3. Application Architecture

Simple forward first initializes DPDK, after which the application handles the incoming packets.

The following diagram illustrates the initialization process.

1. `Init_DPDK` – EAL init, parse argument from command line and register signal.
2. Start port – `mbuf_create`, `dev_configure`, rx/tx/hairpin queue setup and start the port.
3. `Simple_fwd INIT` – create flow tables, build default forward pipes.

The following diagram illustrates how to process the packet.



1. Based on the packet's info, find the key values (e.g. src/dst IP, src/dst port, etc).
2. Traverse the inner flow tables, check if the keys exist or not.
   - If yes, update inner counter
   - If no, a new flow table is added to the DPU
3. Forward the packet to the other port.

Chapter 4. DOCA Libraries

This application leverages the 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 DOCA general flags.
   ```
   register_simple_fwd_params();
   ```
   c). Register application flags.
   ```
   doca_argp_start();
   ```
      i. Parse DPDK flags and invoke handler for calling the `rte_eal_init()` function.
      ii. 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 DPDK ports.
   b). Create mbuf pool using `rte_pktmbuf_pool_create`
   c). Driver initialization – use `rte_eth_dev_configure` to configure the number of queues
   d). Rx/Tx queue initialization – use `rte_eth_rx_queue_setup` and `rte_eth_tx_queue_setup` to initialize the queues
   e). Rx hairpin queue initialization – use `rte_eth_rx_hairpin_queue_setup` to initialize the queues
   f). Start the port using `rte_eth_dev_start`
4. Simple forward initialization.
   ```
   simple_fwd_init();
   ```
   a). `simple_fwd_create_ins` - create flow tables using `simple_fwd_ft_create`
   b). `simple_fwd_init_ports_and_pipes` – initialize DOCA port using `simple_fwd_init_doca_port` and build default pipes for each port.
5. Main loop.
   ```
   simple_fwd_process_pkts();
   ```
   a). Receive packets using `rte_eth_rx_burst` in a loop
   b). Process packets using `simple_fwd_process_offload`

c). Transmit the packets on the other port by calling `rte_eth_tx_burst`. Or free the packet mbuf if `rx_only` is set to `true`.

6. Process packets.
```
simple_fwd_process_offload();
```
   a). Parse the packet's `rte_mbuf` using `simple_fwd_pkt_info`.

   b). Handle the packet using `simple_fwd_handle_packet`. If the packet's key does not match the existed the flow entry, create a new flow entry and PIPE using `simple_fwd_handle_new_flow`. Otherwise, increase the total packet's counter.

7. Simple forward destroy.
```
simple_fwd_destroy();
```
   Simple forward closes port and cleans the flow 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 by call `rte_eal_cleanup()` function.

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 of DOCA applications.
2. FLEX profile number should be manually set to 3 on the system for the application to build the GRE, Standard VXLAN and GRE pipes.
   a). Set FLEX profile number to 3 from the DPU.
   ```
   sudo mlxconfig -d <pcie_address> s FLEX_PARSER_PROFILE_ENABLE=3
   ```
   b). Reset the firmware from the host side by power cycling.
   ```
   ipmitool power cycle
   ```

   Note: Resetting the firmware can be done from the DPU as well. For more information, please refer to step 3.b of section "Upgrading Firmware" of the NVIDIA DOCA Installation Guide for Linux.
3. The simple forward binary is located under `/opt/mellanox/doca/applications/simple_fwd_vnf/bin/doca_simple_fwd_vnf`. To build all the applications together, run:
   ```
   cd /opt/mellanox/doca/applications/
   meson build
   ninja -C build
   ```
4. To build only the simple forward application:
   a). Edit the following flags in `/opt/mellanox/doca/applications/meson_options.txt`:
      - Set `enable_all_applications` to `false`
      - Set `enable_simple_fwd_vnf` to `true`
   b). Run the commands in step 2.

   Note: `doca_simple_fwd_vnf` will be created under `./build/simple_fwd_vnf/src/`.

   Application usage:
   ```
   Usage: doca_simple_forward_vnf [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:
  -t, --stats-timer <time>      Set interval to dump stats information
  -q, --nr-queues <num>         Set queues number
  -r, --rx-only                 Set rx only
  -o, --hw-offload              Set hw offload
  -hq, --hairpinq               Set forwarding to hairpin queue
  -a, --age-thread              Start thread do aging
```

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

```
/opt/mellanox/doca/applications/simple_fwd_vnf/bin/doca_simple_fwd_vnf -h
```

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

```
/opt/mellanox/doca/applications/simple_fwd_vnf/bin/doca_simple_fwd_vnf --
 -h
```

5. Running the application on BlueField:

   - Pre-run setup:

     The simple forward 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
     ```

   - CLI example for running the app:

     ```
     /opt/mellanox/doca/applications/simple_fwd_vnf/bin/doca_simple_fwd_vnf -a
      auxiliary:mlx5_core.sf.4 -a auxiliary:mlx5_core.sf.5 -- -l 4
     ```

     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 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.

     Before creating SFs on a specific physical port, it is important to verify the encap mode on the respective PF FDB. The default mode is basic. To check the encap mode, run:

     ```
     cat /sys/class/net/p0/compat/devlink/encap
     ```

     In this case, disable encap on the PF FDB before creating the SFs by running:

     ```
     /opt/mellanox/iproute2/sbin/devlink dev eswitch set pci/0000:03:00.0
      mode legacy
     /opt/mellanox/iproute2/sbin/devlink dev eswitch set pci/0000:03:00.1
      mode legacy
     echo none > /sys/class/net/p0/compat/devlink/encap
     echo none > /sys/class/net/p1/compat/devlink/encap
     /opt/mellanox/iproute2/sbin/devlink dev eswitch set pci/0000:03:00.0
      mode switchdev
     /opt/mellanox/iproute2/sbin/devlink dev eswitch set pci/0000:03:00.1
      mode switchdev
     ```

     Note that if the encap mode is set to `basic` then the application fails upon initialization.

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

```
/opt/mellanox/doca/applications/simple_fwd_vnf/bin/doca_simple_fwd_vnf -a 04:00.3
 -a 04:00.4 -- -l 60
```

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

7. To run `doca_simple_fwd_vnf` using a JSON file:

```
doca_simple_fwd_vnf --json [json_file]
```

For example:

```
cd /opt/mellanox/doca/applications/simple_fwd_vnf/bin
./doca_simple_fwd_vnf --json simple_fwd_params.json
```

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 PCIe device into the list of devices to probe.	"devices": [{"device": "sf", "id": "4","s true}, {"device": "sf", "id": "5","s 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	t	stats-timer	Set interval to dump stats information.	"stats-timer": 2
	q	nr-queues	Set queues number.	"nr-queues": 4
	r	rx-only	Set RX only. When set, the packets	"rx-only": false

Flag Type	Short Flag	Long Flag/JSON Key	Description	JSON Content
			will not be sent to the TX queues.	
	o	hw-offload	Set HW offload of the RXP engine to use.	"hw-offload": false
	hq	hairpinq	Set forwarding to hairpin queue.	"hairpinq": false
	a	age-thread	Start a dedicated thread that handles the aged flows.	"age-thread": false

Chapter 8. References

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

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