NVIDIA DOCA Host-based Networking Service

Guide

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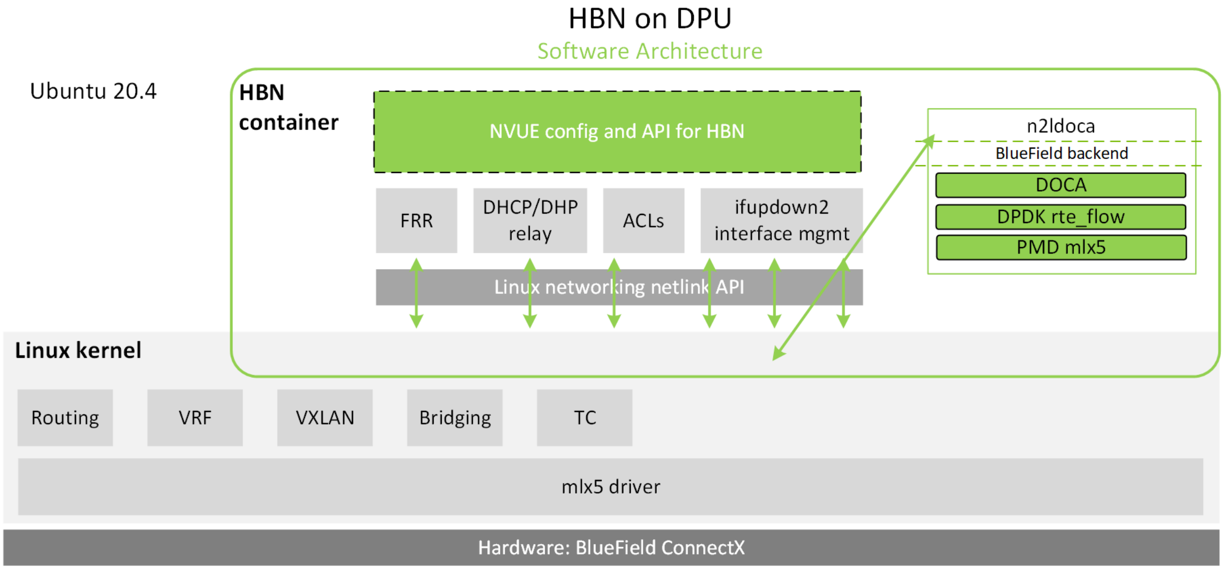
Chapter 1. Introduction

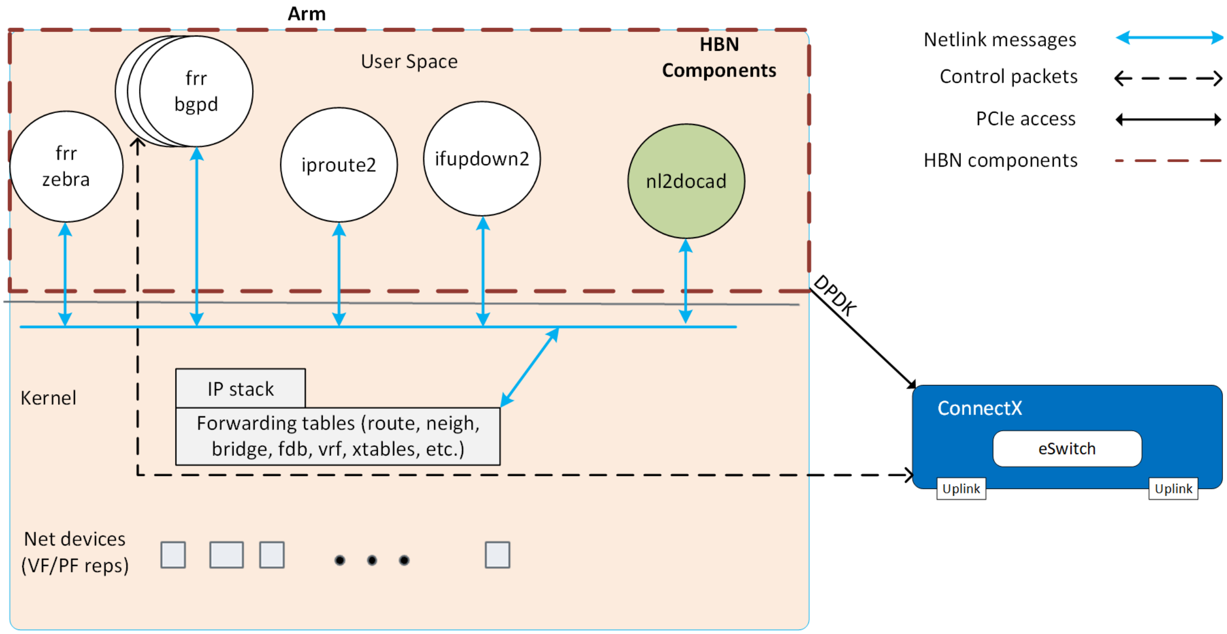
Host-based networking (HBN) is a DOCA service that enables the network architect to design a network purely on L3 protocols, enabling routing to run on the server-side of the network by using the DPU as a BGP router. The EVPN extension of BGP, supported by HBN, extends the L3 underlay network to multi-tenant environments with overlay L2 and L3 isolated networks.

The HBN solution packages a set of network functions inside a container which, itself, is packaged as a service pod to be run on the DPU. At the core of HBN is the Linux networking DPU acceleration driver. Netlink to DOCA daemon, or nl2docad, implements the DPU acceleration driver. nl2docad seamlessly accelerates Linux networking using DPU hardware programming APIs.

The driver mirrors the Linux kernel routing and bridging tables into the DPU hardware by discovering the configured Linux networking objects using the Linux Netlink API. Dynamic network flows, as learned by the Linux kernel networking stack, are also programmed by the driver into DPU hardware by listening to Linux kernel networking events.



The following diagram captures an overview of HBN and the interactions between various components of HBN.



- ifupdown2 is the interface manager which pushes all the interface related states to kernel
- The routing stack is implemented in FRR and pushes all the control states (EVPN MACs and routes) to kernel via netlink
- Kernel maintains the whole network state and relays the information using netlink. The kernel is also involved in the punt path and handling traffic that does not match any rules in the eSwitch.
- nl2docad listens for the network state via netlink and invokes the DOCA interface to accelerate the flows in the DPU HW tables. nl2docad also offloads these flows to eSwitch.

Chapter 2. Service Deployment

For information about the deployment of DOCA containers on top of the BlueField DPU, refer to NVIDIA DOCA Container Deployment Guide.

HBN service is available on NGC, NVIDIA's container catalog. Service-specific configuration steps and deployment instructions can be found under the service's container page.

Make sure to follow the instructions in the NGC page to verify that the container is running.

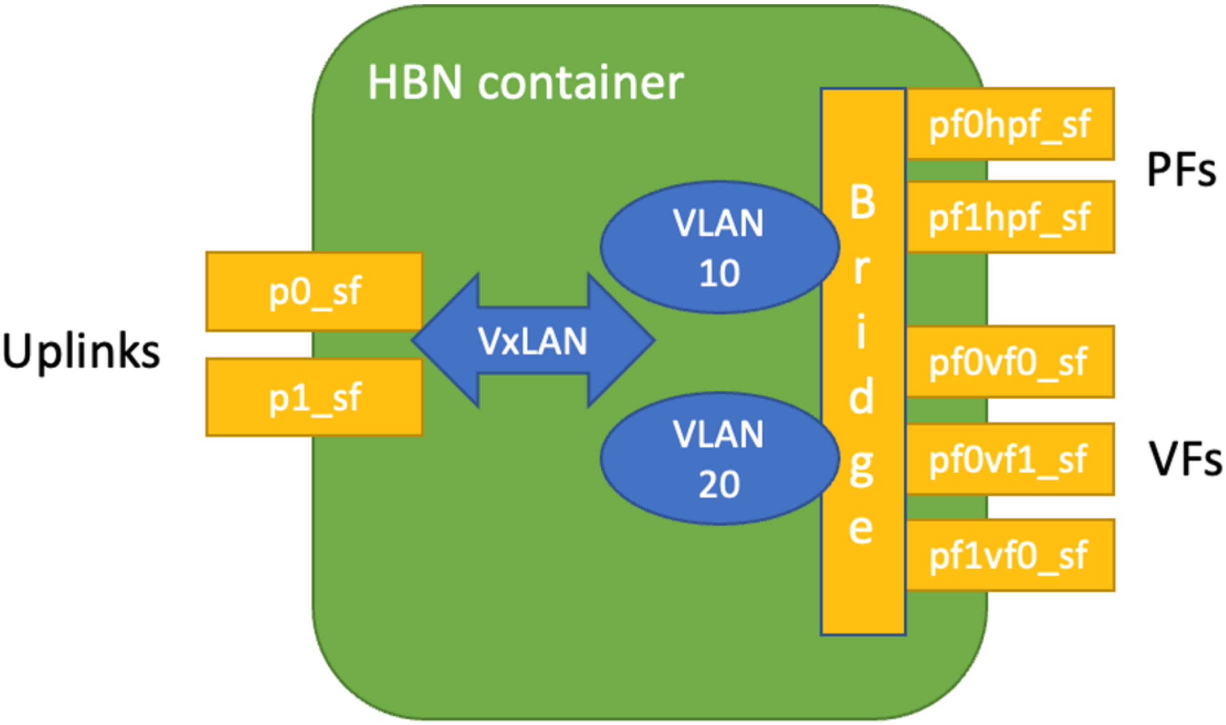
2.1. HBN Default Deployment Configuration

The HBN service comes with three sets of interfaces:

- Two uplinks (`p0_sf`, `p1_sf`)
- Two PF port representors (`pf0hpf_sf`, `pf1hpf_sf`)
- User-defined number of VFs (i.e., `pf0vf0_sf`, `pf0vf1_sf`, ..., `pf1vf0_sf`, `pf1vf1_sf`, ...)

The `*_sf` suffix indicates that these are sub-functions and are different from the physical uplinks (i.e., PFs, VFs). They can be viewed as virtual interfaces from a virtualized DPU.

Each of these interfaces is connected outside the HBN container to the corresponding physical interface, see section Service Function Chaining (SFC) for more details.



As shown in the diagram, the PFs and/or VFs can be bridged together. By adding VLANs and VXLAN on top of the bridge, the user can maintain per-tenant VLAN mappings and per-tenant VLAN-VNI mappings, thus making HBN act as a VTEP in an EVPN network.

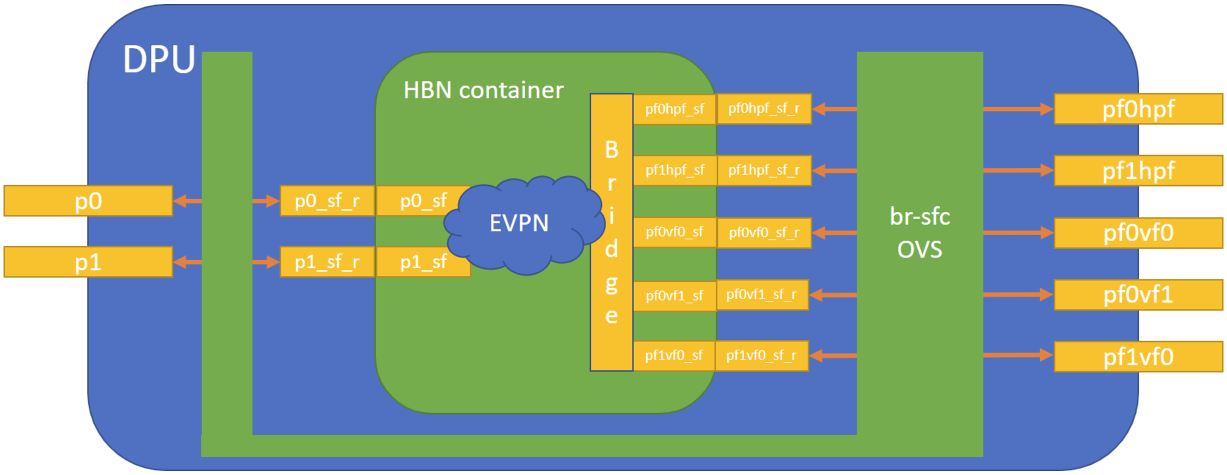
2.2. Service Function Chaining

The following diagram shows the fully detailed default configuration for HBN with service function chaining (SFC). SFC allows for additional services/containers to be chained to HBN and provide additional data manipulation.

In this setup, the HBN container is configured to use sub-function ports (SFs) instead of the actual uplinks, PFs and VFs. To illustrate, for example:

- Uplinks – use `p0_sf` instead of `p0`
- PF – use `pf0hpf_sf` instead of `pf0hpf`
- VF – use `pf0vf0_sf` instead of `pf0vf0`

The indirection layer between the SF and the actual ports is managed via a br-sfc OVS bridge automatically configured when the BFB image is installed on the DPU with HBN enabled. This indirection layer allows other services to be chained to existing SFs and provide additional functionality to transit traffic.



2.2.1. HBN Deployment with SFC

2.2.1.1. Deployment from BFB

To enable HBN SFC during BFB deployment, add the following parameters to the bf.cfg configuration file:

```
ENABLE_SFC_HBN=yes
NUM_SFs_ECPF0=18    # Default value
NUM_SFs_ECPF1=2     # Default value
```

Then run:

```
# bfb-install -c bf.cfg -r rshim0 -b <BFB-image>
```

2.2.1.2. Deployment from PXE

To enable HBN SFC using a PXE installation environment with BFB content, use the following configuration for PXE:

```
bfnet=<IFNAME>:<IPADDR>:<NETMASK> or <IFNAME>:dhcp
bfks=<URL of the kickstart script>
```

The kickstart script (bash) should include the following lines:

```
cat >> /etc/bf.cfg << EOF
ENABLE_SFC_HBN=yes
NUM_SFs_ECPF0=<num-of-SFs-to-prepare-for-VFs-opened-by-x86-on-PF0>
NUM_SFs_ECPF1=<num-of-SFs-to-prepare-for-VFs-opened-by-x86-on-PF1>
EOF
```

`/etc/bf.cfg` will be sourced by the BFB `install.sh` script.

2.2.2. HBN Deployment Considerations

2.2.2.1. SF Interface State Tracking

When HBN is deployed with SFC, the interface state of the following network devices is propagated to their corresponding SFs:

- Uplinks – `p0`, `p1`
- PFs – `pf0hpf`, `pf1hpf`
- VFs – `pf0vfX`, `pf1vfX` where `X` is the VF number

For example, if the p0 uplink cable gets disconnected:

- `p0` transitions to DOWN state with `NO-CARRIER` (default behavior on Linux); and
- `p0` state is propagated to `p0_sf` whose state also becomes DOWN with NO-CARRIER

After `p0` connection is reestablished:

- `p0` transitions to UP state; and
- `p0` state is propagated to `p0_sf` whose state becomes UP

Interface state propagation only happens in the uplink/PF/VF-to-SF direction.

A daemon called `sfc-state-propagation` runs on the DPU, outside of the HBN container, to sync the state. The daemon listens to netlink notifications for interfaces and transfers the state to SFs.

2.2.2.2. Disabling DPU Uplinks

The uplink ports must be always kept administratively up for proper operation of HBN. Otherwise, the NVIDIA® ConnectX® firmware would bring down the corresponding representor port which would cause data forwarding to stop.

Note: Change in operational status of uplink (e.g., carrier down) would result in traffic being switched to the other uplink.

When using ECMP failover on the two uplink SFs, locally disabling one uplink does not result in traffic switching to the second uplink. Disabling local link in this case means to set one uplink admin DOWN directly on the DPU.

To test ECMP failover scenarios correctly, the uplink must be disabled from its remote counterpart (i.e., execute admin DOWN on the remote system's link which is connected to the uplink).

Chapter 3. Configuration

3.1. General Network Configuration

3.1.1. Flat Files Configuration

Add network interfaces and FRR configuration files on the DPU to achieve the desired configuration:

- `/etc/network/interfaces`

  Note: Refer to NVIDIA® Cumulus® Linux documentation for more information.

- `/etc/frr/frr.conf`; `/etc/frr/daemons`

  Note: Refer to NVIDIA® Cumulus® Linux documentation for more information.

3.2. NVUE Configuration

This chapter assumes familiarity with NVIDIA user experience (NVUE) Cumulus Linux documentation. The following subsections, only expand on DPU-specific aspects of NVUE.

3.2.1. NVUE Service

HBN installs NVUE by default and enables NVUE service at boot.

3.2.2. NVUE REST API

HBN enables REST API by default.

Users may run the cURL commands from the command line. Use the default HBN username `nvidia` and password `nvidia`.

To change the default password of the `nvidia` user or add additional users for NVUE access, refer to #unique_18.

REST API example:

```
curl -u 'nvidia:nvidia' --insecure https://10.188.108.58:8765/nvue_v1/interface/p0
{
  "ip": {
    "address": {
      "30.0.0.1/24": {}
    }
  },
  "link": {
    "auto-negotiate": "on",
    "duplex": "full",
    "fec": "auto",
    "mac": "b8:ce:f6:a8:83:9a",
    "mtu": 9216,
    "speed": "100G",
    "state": {
      "up": {}
    },
    "stats": {
      "carrier-transitions": 13,
      "in-bytes": 0,
      "in-drops": 0,
      "in-errors": 0,
      "in-pkts": 0,
      "out-bytes": 14111,
      "out-drops": 0,
      "out-errors": 0,
      "out-pkts": 161
    }
  },
  "pluggable": {
    "identifier": "QSFP28",
    "vendor-name": "Mellanox",
    "vendor-pn": "MCP1600-C00AE30N",
    "vendor-rev": "A4",
    "vendor-sn": "MT2105VB02844"
  },
  "type": "swp"
}
```

Note: For information about using the NVUE REST API, refer to the NVUE API documentation.

3.2.3. NVUE CLI

For information about using the NVUE CLI, refer to the NVUE CLI documentation.

3.2.4. NVUE Startup Configuration File

When the network configuration is saved using NVUE, HBN writes the configuration to the /etc/nvue.d/startup.yaml file.

Startup configuration is applied by following the supervisor daemon at boot time. nvued-startup will appear in EXITED state after applying the startup configuration.

```
# supervisorctl status nvued-startup
```

```
nvued-startup                    EXITED    Apr 17 10:04 AM
```

Note: `nv config apply startup` applies the yaml configuration saved at `/etc/nvue.d/`.

Note: `nv config save` saves the running configuration to `/etc/nvue.d/startup.yaml`.

3.2.5. NVUE User Credentials

NVUE user credentials can be added post installation. This functionality is enabled by the HBN startup script by using the `--username` and `--password` script switches. For example:

```
./hbn-dpu-setup.sh -u newuser -p newpassword
```

After executing this script, respawn the container or start the `decrypt-user-add` script:

```
supervisorctl start decrypt-user-add
decrypt-user-add: started
```

The script creates a user on the HBN container:

```
cat /etc/passwd | grep newuser
newuser:x:1001:1001::/home/newuser:/bin/bash
```

3.3. Configuration Persistence

The following directories are mounted from the host DPU to the HBN container and are persistent across HBN restarts and DPU reboots:

Host DPU Mount Point	HBN Container Mount Point
Configuration Files Mount Pints	
`/var/lib/hbn/etc/network/`	`/etc/network/`
`/var/lib/hbn/etc/frr/`	`/etc/frr/`
`/var/lib/hbn/etc/nvue.d/`	`/etc/nvue.d/`
`/var/lib/hbn/etc/supervisor/conf.d/`	`/etc/supervisor/conf.d/`
`/var/lib/hbn/var/lib/nvue/`	`/var/lib/nvue/`
Support and Log Files Mount Points	
`/var/lib/hbn/var/support/`	`/var/support/`
`/var/log/doca/hbn/`	`/var/log/hbn/`

3.4. SR-IOV Support

3.4.1. Creating VFs on Host Server

The first step to use SR-IOV is to create VFs on the host server. VFs can be created using the following command:

```
echo N > /sys/class/net/<host-rep>/device/sriov_numvfs
```

Where:

- `<host-rep>` is one of the two host representors (e.g., `ens1f0` or `ens1f1`)
- 0≤`N`≤16 is the desired total number of VFs
  - Set `N`=0 to delete all the VFs on 0≤N≤16
  - `N`=16 is the maximum number of VFs supported on HBN across all representors

3.4.2. Automatic Creation of VF Representors on DPU

VFs created on the host must have corresponding SF representors on the DPU side. For example:

- `ens1f0vf0` is the first VF from the first host representor; this interface is created on the host server
- `pf0vf0` is the corresponding VF representor to `ens1f0vf0`; this interface is on the DPU and automatically created at the same time as `en1sf0vf0` is created
- `pf0vf0_sf` is the corresponding SF for `pf0vf0` which is used by HBN

The creation of the SF representor for VFs is done ahead of time when installing the BFB, see section HBN Deployment with SFC to see how to select how many SFs to create ahead of time.

The SF representors for VFs (i.e., `pfXvfY`) are pre-mapped to work with the corresponding VF representors when these are created with the command from section Creating VFs on Host Server.

3.5. Management VRF

The management (MGMT) VRF is enabled by default when the DPU is deployed with SFC (see section HBN Deployment with SFC). The MGMT VRF provides separation between the out-of-band management network and the in-band data plane network.

The uplinks and PFs/SFs/VFs use the default routing table while the `oob_net0` (out-of-band Ethernet port) and the `tmifo_net0` netdevices use the MGMT VRF to route their packets.

When logging in either via SSH or the console, the shell is by default in MGMT VRF context. This is indicated by a `mgmt`added to the shell prompt:

```
root@bf2:mgmt:/home/ubuntu#
```

When logging into the HBN container with `crictl`, the HBN shell will be in the default VRF. Users must switch to MGMT VRF manually if out-of-band access is required. Use `ip vrf exec` to do so.

```
root@bf2:mgmt:/home/ubuntu# ip vrf exec mgmt bash
```

The user must run `ip vrf exec mgmt` to perform other operations (e.g., apt-get update).

Network devices belonging to the MGMT VRF can be listed with the `vrf` utility:

```
root@bf2:mgmt:/home/ubuntu# vrf link list

VRF: mgmt
--------------------
tmfifo_net0      UP             00:1a:ca:ff:ff:03 <BROADCAST,MULTICAST,UP,LOWER_UP>
```

```
oob_net0         UP             08:c0:eb:c0:5a:32 <BROADCAST,MULTICAST,UP,LOWER_UP>

root@bf2:mgmt:/home/ubuntu# vrf help
vrf <OPTS>

VRF domains:
    vrf list

Links associated with VRF domains:
    vrf link list [<vrf-name>]

Tasks and VRF domain asociation:
    vrf task exec <vrf-name> <command>
    vrf task list [<vrf-name>]
    vrf task identify <pid>

    NOTE: This command affects only AF_INET and AF_INET6 sockets opened by the
          command that gets exec'ed. Specifically, it has *no* impact on netlink
          sockets (e.g., ip command).
```

To show the routing table for the default VRF, run:

```
root@bf2:mgmt:/home/ubuntu# ip route show
```

To show the routing table for the MGMT VRF, run:

```
root@bf2:mgmt:/home/ubuntu# ip route show vrf mgmt
```

3.5.1. Running Service in MGMT VRF

If a service needs out-of-band access to run, it can be added to the set of services running in MGMT VRF context. Adding such a service is only possible on the host DPU (i.e., outside the HBN container).

To add a service to the set of MGMT VRF services:

1. Add it to `/etc/vrf/systemd.conf` (if it is not present already). For example, NTP is already listed in this file.
2. Run the following:

   ```
   root@bf2:mgmt:/home/ubuntu# ip vrf exec mgmt bash
   ```

3. Stop and disable to the non-VRF version of the service to be able to start the MGMT VRF one:

   ```
   root@bf2:mgmt:/home/ubuntu# systemctl stop ntp
   root@bf2:mgmt:/home/ubuntu# systemctl disable ntp
   root@bf2:mgmt:/home/ubuntu# systemctl enable ntp@mgmt
   root@bf2:mgmt:/home/ubuntu# systemctl start ntp@mgmt
   ```

3.6. HBN Configuration Examples

3.6.1. HBN Default Configuration

After a fresh HBN installation, the default `/etc/network/interfaces` file would contain only the declaration of the two uplink SFs and a default bridge to which interfaces can be added manually or via NVUE.

```
auto p0_sf
iface p0_sf
```

```
auto p1_sf
iface p1_sf

auto br_default
iface br_default
    bridge-vlan-aware yes
```

FRR configuration files would also be present under `/etc/frr/` but no configuration would be enabled.

3.6.2. Native Routing with BGP and ECMP

HBN supports unicast routing with BGP and ECMP for IPv4 and IPv6 traffic. ECMP is achieved by distributing traffic per destination prefix in a round-robin fashion.

3.6.2.1. ECMP Configuration

ECMP is implemented any time routes have multiple paths over uplinks. For example:

```
20.20.20.0/24 proto bgp metric 20
 nexthop via 169.254.0.1 dev p0_sf weight 1 onlink <<<<< via uplink p0_sf
 nexthop via 169.254.0.1 dev p1_sf weight 1 onlink <<<<< via uplink p1_sf
```

3.6.2.1.1. Sample NVUE Configuration

```
nv set interface lo ip address 10.10.10.1/32
nv set interface lo ip address 2010:10:10::1/128
nv set interface vlan100 type svi
nv set interface vlan100 vlan 100
nv set interface vlan100 base-interface br_default
nv set interface vlan100 ip address 2030:30:30::1/64
nv set interface vlan100 ip address 30.30.30.1/24
nv set bridge domain br_default vlan 100
nv set interface pf0hpf_sf,pf1hpf_sf bridge domain br_default
nv set vrf default router bgp router-id 10.10.10.1
nv set vrf default router bgp autonomous-system 65501
nv set vrf default router bgp path-selection multipath aspath-ignore on
nv set vrf default router bgp address-family ipv4-unicast enable on
nv set vrf default router bgp address-family ipv4-unicast redistribute connected
 enable on
nv set vrf default router bgp address-family ipv6-unicast enable on
nv set vrf default router bgp address-family ipv6-unicast redistribute connected
 enable on
nv set vrf default router bgp neighbor p0_sf remote-as external
nv set vrf default router bgp neighbor p0_sf type unnumbered
nv set vrf default router bgp neighbor p0_sf address-family ipv4-unicast enable on
nv set vrf default router bgp neighbor p0_sf address-family ipv6-unicast enable on
nv set vrf default router bgp neighbor p1_sf remote-as external
nv set vrf default router bgp neighbor p1_sf type unnumbered
nv set vrf default router bgp neighbor p1_sf address-family ipv4-unicast enable on
nv set vrf default router bgp neighbor p1_sf address-family ipv6-unicast enable on
```

3.6.2.1.2. Sample Flat Files Configuration

Example `/etc/network/interfaces` configuration:

```
auto lo
iface lo inet loopback
    address 10.10.10.1/32
    address 2010:10:10::1/128

auto p0_sf
iface p0_sf
```

```
auto p1_sf
iface p1_sf

auto pf0hpf_sf
iface pf0hpf_sf

auto pf1hpf_sf
iface pf1hpf_sf

auto vlan100
iface vlan100
    address 2030:30:30::1/64
    address 30.30.30.1/24
    vlan-raw-device br_default
    vlan-id 100

auto br_default
iface br_default
    bridge-ports pf0hpf_sf pf1hpf_sf
    bridge-vlan-aware yes
    bridge-vids 100
    bridge-pvid 1
```

Example `/etc/frr/daemons` configuration:

```
bgpd=yes
vtysh_enable=yes


FRR Config file @ /etc/frr/frr.conf -
!
frr version 7.5+cl5.3.0u0
frr defaults datacenter
hostname BLUEFIELD2
log syslog informational
no zebra nexthop kernel enable
!
router bgp 65501
 bgp router-id 10.10.10.1
 bgp bestpath as-path multipath-relax
 neighbor p0_sf interface remote-as external
 neighbor p0_sf advertisement-interval 0
 neighbor p0_sf timers 3 9
 neighbor p0_sf timers connect 10
 neighbor p1_sf interface remote-as external
 neighbor p1_sf advertisement-interval 0
 neighbor p1_sf timers 3 9
 neighbor p1_sf timers connect 10
 !
 address-family ipv4 unicast
  redistribute connected
  maximum-paths 64
  maximum-paths ibgp 64
 exit-address-family
 !
 address-family ipv6 unicast
  redistribute connected
  neighbor p0_sf activate
  neighbor p1_sf activate
  maximum-paths 64
  maximum-paths ibgp 64
 exit-address-family
!
line vty
!
end
```

3.6.3. L2 EVPN with BGP and ECMP

HBN supports VXLAN with EVPN control plane for intra-subnet bridging (L2) services for IPv4 and IPv6 traffic in the overlay.

For the underlay, only IPv4 or BGP unnumbered configuration is supported.

The following is a sample config which has L2-VNIs (`vx-2000`, `vx-2001`) for EVPN bridging.

3.6.3.1. Single VXLAN Device

With a single VXLAN device, a set of VNIs represents a single device model. The single VXLAN device has a set of attributes that belong to the VXLAN construct. Individual VNIs include VLAN-to-VNI mapping which allows users to specify which VLANs are associated with which VNIs. A single VXLAN device simplifies the configuration and reduces the overhead by replacing multiple traditional VXLAN devices with a single VXLAN device.

Users may configure a single VXLAN device automatically with NVUE, or manually by editing the `/etc/network/interfaces` file. When users configure a single VXLAN device with NVUE, NVUE creates a unique name for the device in the following format using the bridge name as the hash key: `vxlan<id>`.

This example configuration performs the following steps:

1. Creates a single VXLAN device (vxlan21).
2. Maps VLAN 10 to VNI 10 and VLAN 20 to VNI 20.
3. Adds the VXLAN device to the default bridge.

```
cumulus@leaf01:~$ nv set bridge domain bridge vlan 10 vni 10
cumulus@leaf01:~$ nv set bridge domain bridge vlan 20 vni 20
cumulus@leaf01:~$ nv set nve vxlan source address 10.10.10.1
cumulus@leaf01:~$ nv config apply
```

Alternately, users may edit the file `/etc/network/interfaces` as follows, then run the `ifreload -a` command to apply the SVD configuration.

```
auto lo
iface lo inet loopback
    vxlan-local-tunnelip 10.10.10.1

auto vxlan21
iface vxlan21
    bridge-vlan-vni-map 10=10 20=20
    bridge-learning off

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports vxlan21 pf0hpf_sf pf1hpf_sf
    bridge-vids 10 20
    bridge-pvid 1
```

Note: Users may not use a combination of single and traditional VXLAN devices.

3.6.3.2. Sample NVUE Configuration

```
nv set bridge domain br_default encap 802.1Q
nv set bridge domain br_default type vlan-aware
nv set bridge domain br_default vlan 200 vni 2000 flooding enable auto
nv set bridge domain br_default vlan 200 vni 2000 mac-learning off
nv set bridge domain br_default vlan 201 vni 2001 flooding enable auto
nv set bridge domain br_default vlan 201 vni 2001 mac-learning off

nv set evpn enable on
nv set nve vxlan arp-nd-suppress on
nv set nve vxlan enable on
nv set nve vxlan mac-learning off
nv set nve vxlan source address 27.0.0.4
nv set platform
nv set router bgp enable on
nv set system global anycast-mac 44:38:39:42:42:07
nv set vrf default router bgp address-family ipv4-unicast enable on
nv set vrf default router bgp address-family ipv4-unicast redistribute connected
 enable on

nv set vrf default router bgp address-family l2vpn-evpn enable on
nv set vrf default router bgp autonomous-system 63642
nv set vrf default router bgp enable on
nv set vrf default router bgp neighbor p0_sf peer-group fabric
nv set vrf default router bgp neighbor p0_sf type unnumbered
nv set vrf default router bgp neighbor p1_sf peer-group fabric
nv set vrf default router bgp neighbor p1_sf type unnumbered
nv set vrf default router bgp path-selection multipath aspath-ignore on
nv set vrf default router bgp peer-group fabric address-family ipv4-unicast enable
 on
nv set vrf default router bgp peer-group fabric address-family ipv4-unicast policy
 outbound route-map MY_ORIGIN_ASPATH_ONLY
nv set vrf default router bgp peer-group fabric address-family ipv6-unicast enable
 on
nv set vrf default router bgp peer-group fabric address-family ipv6-unicast policy
 outbound route-map MY_ORIGIN_ASPATH_ONLY
nv set vrf default router bgp peer-group fabric address-family l2vpn-evpn add-path-
tx off
nv set vrf default router bgp peer-group fabric address-family l2vpn-evpn enable on
nv set vrf default router bgp peer-group fabric remote-as external
nv set vrf default router bgp router-id 27.0.0.4

nv set interface lo ip address 2001:c15c:d06:f00d::4/128
nv set interface lo ip address 27.0.0.4/32
nv set interface lo type loopback
nv set interface p0_sf,p1_sf,pf0hpf_sf,pf0vf0__sf,pf1hpf_sf type swp
nv set interface pf0hpf_sf bridge domain br_default access 200
nv set interface pf0vf0_sf bridge domain br_default access 201

nv set interface vlan200-217 base-interface br_default
nv set interface vlan200-217 ip ipv4 forward on
nv set interface vlan200-217 ip ipv6 forward on
nv set interface vlan200-217 ip vrr enable on
nv set interface vlan200-217 ip vrr state up
nv set interface vlan200-217 link mtu 9050
nv set interface vlan200-217 type svi
nv set interface vlan200 ip address 2001:cafe:1ead::3/64
nv set interface vlan200 ip address 45.3.0.2/24
nv set interface vlan200 ip vrr address 2001:cafe:1ead::1/64
nv set interface vlan200 ip vrr address 45.3.0.1/24
nv set interface vlan200 vlan 200
nv set interface vlan201 ip address 2001:cafe:1ead:1::3/64
nv set interface vlan201 ip address 45.3.1.2/24
nv set interface vlan201 ip vrr address 2001:cafe:1ead:1::1/64
nv set interface vlan201 ip vrr address 45.3.1.1/24
nv set interface vlan201 vlan 201
```

3.6.3.3. Sample Flat Files Configuration

This file is located at `/etc/network/interfaces`:

```
auto lo
iface lo inet loopback
    address 2001:c15c:d06:f00d::4/128
    address 27.0.0.4/32
    vxlan-local-tunnelip 27.0.0.4

auto p0_sf
iface p0_sf

auto p1_sf
iface p1_sf

auto pf0hpf_sf
iface pf0hpf_sf
    bridge-access 200

auto pf0vf0_sf
iface pf0vf0_sf
    bridge-access 201

auto pf1hpf_sf
iface pf1hpf_sf
    bridge-access 217

auto vlan200
iface vlan200
    address 2001:cafe:1ead::3/64
    address 45.3.0.2/24
    mtu 9050
    address-virtual 00:00:5e:00:01:01 2001:cafe:1ead::1/64 45.3.0.1/24
    vlan-raw-device br_default
    vlan-id 200

auto vlan201
iface vlan201
    address 2001:cafe:1ead:1::3/64
    address 45.3.1.2/24
    mtu 9050
    address-virtual 00:00:5e:00:01:01 2001:cafe:1ead:1::1/64 45.3.1.1/24
    vlan-raw-device br_default
    vlan-id 201

auto vxlan48
iface vxlan48
    bridge-vlan-vni-map 200=2000 201=2001
217=2017
    bridge-learning off

auto br_default
iface br_default
    bridge-ports pf0hpf_sf pf0vf0_sf
hpf_sf vxlan48
    bridge-vlan-aware yes
    bridge-vids 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216
 217
    bridge-pvid 1
```

This file, which tells the frr package which daemon to start, is located at `/etc/frr/daemons`:

```
bgpd=yes
ospfd=no
ospf6d=no
isisd=no
```

```
pimd=no
ldpd=no
pbrd=no
vrrpd=no
fabricd=no
nhrpd=no
eigrpd=no
babeld=no
sharpd=no
fabricd=no
ripngd=no
ripd=no

vtysh_enable=yes
zebra_options="  -M cumulus_mlag -M snmp -A 127.0.0.1 -s 90000000"
bgpd_options="   -M snmp -A 127.0.0.1"
ospfd_options="  -M snmp -A 127.0.0.1"
ospf6d_options=" -M snmp -A ::1"
ripd_options="   -A 127.0.0.1"
ripngd_options=" -A ::1"
isisd_options="  -A 127.0.0.1"
pimd_options="   -A 127.0.0.1"
ldpd_options="   -A 127.0.0.1"
nhrpd_options="  -A 127.0.0.1"
eigrpd_options=" -A 127.0.0.1"
babeld_options=" -A 127.0.0.1"
sharpd_options=" -A 127.0.0.1"
pbrd_options="   -A 127.0.0.1"
staticd_options="-A 127.0.0.1"
fabricd_options="-A 127.0.0.1"
vrrpd_options="  -A 127.0.0.1"

frr_profile="datacenter"
```

This file is located at `/etc/frr/frr.conf`:

```
!---- Cumulus Defaults ----
frr defaults datacenter
log syslog informational
no zebra nexthop kernel enable
vrf default
outer bgp 63642 vrf default
bgp router-id 27.0.0.4
bgp bestpath as-path multipath-relax
timers bgp 3 9
bgp deterministic-med
! Neighbors
neighbor fabric peer-group
neighbor fabric remote-as external
neighbor fabric timers 3 9
neighbor fabric timers connect 10
neighbor fabric advertisement-interval 0
no neighbor fabric capability extended-nexthop
neighbor p0_sf interface peer-group fabric
neighbor p0_sf timers 3 9
neighbor p0_sf timers connect 10
neighbor p0_sf advertisement-interval 0
neighbor p0_sf capability extended-nexthop
neighbor p0_sf bfd
neighbor p1_sf interface peer-group fabric
neighbor p1_sf timers 3 9
neighbor p1_sf timers connect 10
neighbor p1_sf advertisement-interval 0
neighbor p1_sf capability extended-nexthop
maximum-paths ibgp 64
maximum-paths 64
distance bgp 20 200 200
neighbor fabric activate
neighbor p0_sf activate
neighbor p1_sf activate
exit-address-family
address-family ipv6 unicast
maximum-paths ibgp 64
maximum-paths 64
distance bgp 20 200 200
neighbor fabric activate
neighbor p0_sf activate
neighbor p1_sf activate
exit-address-family
address-family l2vpn evpn
advertise-all-vni
neighbor fabric activate
neighbor p0_sf activate
neighbor p1_sf activate
exit-address-family
```

3.7. Access Control Lists

3.7.1. Stateless ACLs

The following tools administer filtering rules:

- IPTABLES – filtering rules for IPv4 packets
- EBTABLES – filtering rules for Ethernet frames
- IP6TABLES – filtering rules for IPv6 packets

3.7.1.1. NVUE Examples

NVUE IPv4 ACLs Example

The following is an example of an ingress IPv4 ACL that permits DHCP request packets ingressing on the `pf0hpf_sf` port towards the DHCP server:

```
root@hbn01-host01:~# nv set acl acl1_ingress type ipv4
root@hbn01-host01:~# nv set acl acl1_ingress rule 100 match ip protocol udp
root@hbn01-host01:~# nv set acl acl1_ingress rule 100 match ip dest-port 67
root@hbn01-host01:~# nv set acl acl1_ingress rule 100 match ip source-port 68
root@hbn01-host01:~# nv set acl acl1_ingress rule 100 action permit
```

Bind the ingress IPv4 ACL to host representor port `pf0hpf_sf` of the DPU in the inbound direction:

```
root@hbn01-host01:~# nv set interface pf0hpf_sf acl acl1_ingress inbound
root@hbn01-host01:~# nv config apply
```

The following is an example of an egress IPv4 ACL that permits DHCP reply packets egressing out of the `pf0hpf_sf` port towards the DHCP client:

```
root@hbn01-host01:~# nv set acl acl2_egress type ipv4
root@hbn01-host01:~# nv set acl acl2_egress rule 100 match ip protocol udp
root@hbn01-host01:~# nv set acl acl2_egress rule 100 match ip dest-port 68
root@hbn01-host01:~# nv set acl acl2_egress rule 100 match ip source-port 67
root@hbn01-host01:~# nv set acl acl2_egress rule 100 action permit
```

Bind the egress IPv4 ACL to host representor port `pf0hpf_sf` of the DPU in the outbound direction:

```
root@hbn01-host01:~# nv set interface pf0hpf_sf acl acl2_egress outbound
```

```
root@hbn01-host01:~# nv config apply
```

NVUE IPv6 ACLs Example

The following is an example of an ingress IPv6 ACL that permits traffic with matching `dest-ip` and `protocol tcp` ingress on port `pf0hpf_sf`:

```
root@hbn01-host01:~# nv set acl acl5_ingress type ipv6
root@hbn01-host01:~# nv set acl acl5_ingress rule 1 match ip protocol tcp
root@hbn01-host01:~# nv set acl acl5_ingress rule 1 match ip dest-ip 48:2034::80:9
root@hbn01-host01:~# nv set acl acl5_ingress rule 1 action permit
```

Bind the ingress IPv6 ACL to host representor port `pf0hpf_sf` of the DPU in the inbound direction:

```
root@hbn01-host01:~# nv set interface pf0hpf_sf acl acl5_ingress inbound
root@hbn01-host01:~# nv config apply
```

The following is an example of an egress IPv6 ACL that permits traffic with matching `source-ip` and `protocol tcp` egressing out of port `pf0hpf_sf`:

```
root@hbn01-host01:~# nv set acl acl6_egress type ipv6
root@hbn01-host01:~# nv set acl acl6_egress rule 1 match ip protocol tcp
root@hbn01-host01:~# nv set acl acl6_egress rule 1 match ip source-ip 48:2034::80:9
root@hbn01-host01:~# nv set acl acl6_egress rule 1 action permit
```

Bind the egress IPv6 ACL to host representor port `pf0hpf_sf` of the DPU in the outbound direction:

```
root@hbn01-host01:~# nv set interface pf0hpf_sf acl acl6_egress outbound
root@hbn01-host01:~# nv config apply
```

NVUE L2 ACLs Example

The following is an example of an ingress MAC ACL that permits traffic with matching `source-mac` and `dest-mac` ingressing to port `pf0hpf_sf`:

```
root@hbn01-host01:~# nv set acl acl3_ingress type mac
root@hbn01-host01:~# nv set acl acl3_ingress rule 1 match mac source-mac
 00:00:00:00:00:0a
root@hbn01-host01:~# nv set acl acl3_ingress rule 1 match mac dest-mac
 00:00:00:00:00:0b
root@hbn01-host01:~# nv set interface pf0hpf_sf acl acl3_ingress inbound
```

Bind the ingress MAC ACL to host representor port `pf0hpf_sf` of the DPU in the inbound direction:

```
root@hbn01-host01:~# nv set interface pf0hpf_sf acl acl3_ingress inbound
root@hbn01-host01:~# nv config apply
```

The following is an example of an egress MAC ACL that permits traffic with matching `source-mac` and `dest-mac` egressing out of port `pf0hpf_sf`:

```
root@hbn01-host01:~# nv set acl acl4_egress type mac
root@hbn01-host01:~# nv set acl acl4_egress rule 1 match mac source-mac
 00:00:00:00:00:0b
root@hbn01-host01:~# nv set acl acl4_egress rule 1 match mac dest-mac
 00:00:00:00:00:0a
root@hbn01-host01:~# nv set acl acl4_egress rule 1 action permit
```

Bind the egress MAC ACL to host representor port `pf0hpf_sf` of the DPU in the outbound direction:

```
root@hbn01-host01:~# nv set interface pf0hpf_sf acl acl4_egress outbound
root@hbn01-host01:~# nv config apply
```

3.7.1.2. Flat Files (cl-acltool) Examples

For the same example cited above, the following are the corresponding ACL rules which must be configured under `/etc/cumulus/acl/policy.d/<rule_name.rules>` followed by invoking `cl-acltool -i`.

Flat Files IPv4 ACLs Example

The following example configures an ingress IPv4 ACL rule matching with DHCP request under `/etc/cumulus/acl/policy.d/<rule_name.rules>` with the ingress interface as the host representor of the DPU followed by invoking `cl-acltool -i`:

```
[iptables]
## ACL acl1_ingress in dir inbound on interface pf0hpf_sf ##
-t filter -A FORWARD -i pf1vf1_sf -p udp --sport 68 --dport 67 -m mark --mark 888 -m
 comment --comment "priority:1" -j ACCEPT
```

The following example configures an egress IPv4 ACL rule matching with DHCP reply under `/etc/cumulus/acl/policy.d/<rule_name.rules>` with the egress interface as the host representor of the DPU followed by invoking `cl-acltool -i`:

```
[iptables]
## ACL acl2_egress in dir outbound on interface pf0hpf_sf ##
-t filter -A FORWARD -o pf0hpf_sf -p udp --sport 67 --dport 68 -m mark --mark 777 -m
 comment --comment "priority:1" -j ACCEPT
```

Flat File IPv6 ACLs Example

The following example configures an ingress IPv6 ACL rule matching with `dest-ip` and `tcp` protocol under `/etc/cumulus/acl/policy.d/<rule_name.rules>` with the ingress interface as the host representor of the DPU followed by invoking `cl-acltool -i`:

```
[ip6tables]
## ACL acl5_ingress in dir inbound on interface pf0hpf_sf ##
-t filter -A FORWARD -i pf0hpf_sf -d 48:2034::80:9 -p tcp -m comment --
comment "priority:1" -j ACCEPT
```

The following example configures an egress IPv6 ACL rule matching with `source-ip` and `tcp` protocol under `/etc/cumulus/acl/policy.d/<rule_name.rules>` with the egress interface as the host representor of the DPU followed by invoking `cl-acltool -i`:

```
[ip6tables]
## ACL acl6_egress in dir outbound on interface pf0hpf_sf ##
-t filter -A FORWARD -o pf0hpf_sf -s 48:2034::80:9 -p tcp -m comment --
comment "priority:1" -j ACCEPT
```

Flat Files L2 ACLs Example

The following example configures an ingress MAC ACL rule matching with `source-mac` and `dest-mac` under `/etc/cumulus/acl/policy.d/<rule_name.rules>` with the ingress interface as the host representor of the DPU followed by invoking `cl-acltool -i`:

```
[ebtables]
## ACL acl3_ingress in dir inbound on interface pf0hpf_sf ##
-t filter -A FORWARD -i pf0hpf_sf -s 00:00:00:00:00:0a/ff:ff:ff:ff:ff:ff -d
 00:00:00:00:00:0b/ff:ff:ff:ff:ff:ff -j ACCEPT
```

The following example configures an egress MAC ACL rule matching with source-mac and `dest-mac` under `/etc/cumulus/acl/policy.d/<rule_name.rules>` with egress interface as host representor of DPU followed by invoking `cl-acltool -i`:

```
[ebtables]
## ACL acl4_egress in dir outbound on interface pf0hpf_sf ##
```

```
-t filter -A FORWARD -o pf0hpf_sf -s 00:00:00:00:00:0b/ff:ff:ff:ff:ff:ff -d
 00:00:00:00:00:0a/ff:ff:ff:ff:ff:ff -j ACCEPT
```

3.7.2. Stateful ACLs

The following is an example to allow HTTP (TCP) connection originated by host where the DPU is hosted to an external network. Two sets of ACLs matching with conntrack state must be configured for a CONNTRACK entry to be established in the kernel which would be further offloaded to hardware:

- Configure an ACL rule matching TCP/HTTP connection/flow details with CONNTRACK state of NEW, ESTABLISHED and bind it to the host representor of the DPU and the associated VLAN's SVI in the inbound direction.
- Configure an ACL rule matching TCP/HTTP connection/flow details with CONNTRACK state of ESTABLISHED, RELATED and bind it to the host representor of the DPU and the associated VLAN's SVI in the outbound direction.

3.7.2.1. NVUE Examples

In this example, the host representor on the DPU is `pf0hpf_sf` and it is part of VLAN 101.

Configure the ingress ACL rule:

```
root@hbn03-host00:~# nv set acl allow_tcp_conn_from_host rule 11 action permit
root@hbn03-host00:~# nv set acl allow_tcp_conn_from_host rule 11 match conntrack
 established
root@hbn03-host00:~# nv set acl allow_tcp_conn_from_host rule 11 match conntrack new
root@hbn03-host00:~# nv set acl allow_tcp_conn_from_host rule 11 match ip dest-ip
 11.11.11.11/32
root@hbn03-host00:~# nv set acl allow_tcp_conn_from_host rule 11 match ip dest-port
 80
root@hbn03-host00:~# nv set acl allow_tcp_conn_from_host rule 11 match ip protocol
 tcp
root@hbn03-host00:~# nv set acl allow_tcp_conn_from_host type ipv4
```

Bind this ACL to the host representor of the DPU and the associated VLAN's SVI interface in the inbound direction:

```
root@hbn03-host00:~# nv set interface pf0hpf_sf,vlan101 acl allow_tcp_conn_from_host
 inbound
root@hbn03-host00:~# nv config apply
```

Configure the egress ACL rule:

```
root@hbn03-host00:~# nv set acl allow_tcp_resp_from_server rule 21 action permit
root@hbn03-host00:~# nv set acl allow_tcp_resp_from_server rule 21 match conntrack
 established
root@hbn03-host00:~# nv set acl allow_tcp_resp_from_server rule 21 match conntrack
 related
root@hbn03-host00:~# nv set acl allow_tcp_resp_from_server rule 21 match ip protocol
 tcp
root@hbn03-host00:~# nv set acl allow_tcp_resp_from_server type ipv4
root@hbn03-host00:~# nv config apply
```

Bind this ACL to the host representor of the DPU and the associated VLAN's SVI interface in the outbound direction:

```
root@hbn03-host00:~# nv set interface pf0hpf_sf,vlan101 acl
 allow_tcp_resp_from_server outbound
root@hbn03-host00:~# nv config apply
```

3.7.2.2. Flat Files (cl-acltool) Examples

For the same example cited above, the following are the corresponding ACL rules which must be configured under `/etc/cumulus/acl/policy.d/<rule_name.rules>` followed by invoking `cl-acltool -i`.

Configure an ingress ACL rule matching with TCP flow details and conntrack state of NEW, ESTABLISHED under `/etc/cumulus/acl/policy.d/stateful_acl.rules` with the ingress interface as the host representor of the DPU and the associated VLAN's SVI followed by invoking `cl-acltool -i`.

Note: Ingress ACL rules should be configured with mark value of 888 (`-m mark --mark 888`).

```
[iptables]
## ACL allow_tcp_conn_from_host in dir inbound on interface pf1vf7_sf ##
-t mangle -A PREROUTING -p tcp -d 11.11.11.11/32 --dport 80 -m conntrack --ctstate
 EST,NEW -j CONNMARK --set-mark 9999
-t filter -A FORWARD -i pf1vf7_sf -p tcp -d 11.11.11.11/32 --dport 80 -m conntrack
 --ctstate EST,NEW -m mark --mark 888 -m comment --comment "priority:1" -j ACCEPT

## ACL allow_tcp_conn_from_host in dir inbound on interface vlan118 ##
-t filter -A FORWARD -i vlan118 -p tcp -d 11.11.11.11/32--dport 80 -m conntrack --
ctstate EST,NEW -m mark --mark 888 -m comment --comment "priority:1" -j ACCEPT
```

Configure an egress ACL rule matching with TCP and conntrack state of ESTABLISHED, RELATED under `/etc/cumulus/acl/policy.d/stateful_acl.rules` file with the egress interface as the host representor of the DPU and the associated VLAN's SVI followed by invoking `cl-acltool -i`.

Note: Ingress ACL rules should be configured with mark value of 777 (`-m mark --mark 777`).

```
## ACL allow_tcp_resp_from_server in dir outbound on interface pf1vf7_sf ##
-t filter -A FORWARD -o pf1vf7_sf -p tcp -m conntrack --ctstate EST,REL -m mark --
mark 777 -m comment --comment "priority:1" -j ACCEPT

## ACL allow_tcp_resp_from_server in dir outbound on interface vlan118 ##
-t filter -A FORWARD -o vlan118 -p tcp -m conntrack --ctstate EST,REL -m mark --mark
 777 -m comment --comment "priority:1" -j ACCEPT
```

3.7.3. ACL Priorities

To enforce the same order at which ACLs are configured, either through NVUE or natively, in the underlying hardware as well, the user must suffix priority as a comment in the iptable ACL rule configuration. There are 8 priority buckets supported for ACL rules in the hardware, with the lower priority being installed first followed by the higher priority at the end.

With NVUE, rule ID ranges map to the eight ACL hardware priority buckets as shown in the following table:

Rule ID Range	Priority
1-8000	1
8001-16000	2
16001-24000	3

Rule ID Range	Priority
24001-32000	4
32001-40000	5
40001-48000	6
48001-56000	7
56001-64000	8

In this example, the ACLs are configured and bound to the host representor of the DPU and associated VLAN's SVI interface in either the inbound or outbound direction.

1. Configure a stateless allow-list ACL rules permitting DHCP packets with a priority of 1.
2. Configure a stateful allow-list ACL rules permitting http/tcp connection with a priority of 2.
3. Configure a DROP-ALL ACL rule at the end with a higher priority of 8.

3.7.3.1. NVUE Examples

The following is an ACL rule allowing DHCP packets to be configured with rule ID of 1 (mapped to priority 1 bucket):

```
root@hbn03-host00:~# nv set acl ingress_acl_set rule 1 match ip dest-ip
 255.255.255.255
root@hbn03-host00:~# nv set acl ingress_acl_set rule 1 match ip dest-port 67
root@hbn03-host00:~# nv set acl ingress_acl_set rule 1 match ip protocol udp
```

The following is a stateful ACL rule allowing tcp/http connection matching flow details along with conntrack state of NEW, ESTASBLISHED with rule ID of 8001 (mapped to priority 2 bucket):

```
root@hbn03-host00:~# nv set acl ingress_acl_set rule 8001 action permit
root@hbn03-host00:~# nv set acl ingress_acl_set rule 8001 match conntrack
 established
root@hbn03-host00:~# nv set acl ingress_acl_set rule 8001 match conntrack new
root@hbn03-host00:~# nv set acl ingress_acl_set rule 8001 match ip dest-port 80
root@hbn03-host00:~# nv set acl ingress_acl_set rule 8001 match ip protocol tcp
```

The following is the final set of drop all ACL rules with rule ID of 48001 (mapped to priority 7 bucket) and apply the configuration:

```
root@hbn03-host00:~# nv set acl ingress_acl_set rule 48001 action deny
root@hbn03-host00:~# nv set acl ingress_acl_set type ipv4
```

Bind the ACL definition configured to the host representor of the DPU and the associated VLAN's SVI interface and apply the config:

```
root@hbn03-host00:~# nv set interface pf0hpf_sf,vlan101 acl ingress_acl_set inbound
root@hbn03-host00:~# nv config apply
```

3.7.3.2. Flat Files (cl-acltool) Examples

For the same examples cited above, the user must configure ACL rules with ascending priorities in the ACL rules file under the `/etc/cumulus/acl/policy.d/` directory followed by invoking `cl-acltool -i`:

```
[iptables]
-t filter -A FORWARD -i pf0hpf_sf -d 255.255.255.255 -p udp --dport 67 -m mark --
mark 888 -m comment --comment "priority:1" -j ACCEPT

-t filter -A FORWARD -i vlan101 -d 255.255.255.255 -p udp --dport 67 -m mark --mark
 888 -m comment --comment "priority:1" -j ACCEPT
```

```
# priority 2 ACL rule set
-t filter -A FORWARD -i pf0hpf_sf -p tcp -d 11.11.11.11/32 --dport 80 -m conntrack
 --ctstate EST,NEW -m mark --mark 888 -m comment --comment "priority:2" -j ACCEPT
-t filter -A FORWARD -i vlan101 -p tcp -d 11.11.11.11/32 --dport 80 -m conntrack --
ctstate EST,NEW -m mark --mark 888 -m comment --comment "priority:2" -j ACCEPT

#priority 3 ACL rule set
-t filter -A FORWARD -i pf0hpf_sf -m mark --mark 888 -m comment --
comment "priority:7" -j DROP
-t filter -A FORWARD -i vlan101 -m mark --mark 888 -m comment --comment "priority:7"
 -j DROP
```

3.7.4. DHCP Relay on HBN

DHCP is a client server protocol that automatically provides IP hosts with IP addresses and other related configuration information. A DHCP relay (agent) is a host that forwards DHCP packets between clients and servers. DHCP relays forward requests and replies between clients and servers that are not on the same physical subnet.

DHCP relay can be configured using either flat file (supervisord configuration) or through NVUE.

3.7.4.1. Configuration

HBN is a non-systemd based container. Therefore, the DHCP relay must be configured as explained in the following subsections.

3.7.4.1.1. Flat File Configuration (Supervisord)

The HBN initialization script installs default configuration files on the DPU in `/var/lib/hbn/etc/supervisor/conf.d/`. The DPU directory is mounted to `/etc/supervisor/conf.d` which achieves configuration persistence.

By default, DHCP relay is disabled. Default configuration applies to one instance of DHCPv4 relay and DHCPv6 relay.

3.7.4.1.2. NVUE Configuration

The user can use NVUE to configure and maintain DHCPv4 and DHCPv6 relays with CLI and REST API. NVUE generates all the required configurations and maintains the relay service.

3.7.4.1.3. DHCPv4 Relay Configuration

NVUE Example

The following configuration starts a relay service which listens for the DHCP messages on `p0_sf`, `p1_sf`, and `vlan482` and relays the requests to DHCP server 10.89.0.1 with `giaddress-interface` as `lo`.

```
nv set service dhcp-relay default giaddress-interface lo
nv set service dhcp-relay default interface p0_sf
nv set service dhcp-relay default interface p1_sf
nv set service dhcp-relay default interface vlan482
nv set service dhcp-relay default server 10.89.0.1
```

Flat Files Example

```
[program: isc-dhcp-relay-default]
command = /usr/sbin/dhcrelay --nl -d -i p0_sf -i p1_sf -id vlan482 -U lo 10.89.0.1
autostart = true
autorestart = unexpected
startsecs = 3
startretries = 3
exitcodes = 0
stopsignal = TERM
stopwaitsecs = 3
```

Where:

Option	Description
`-i`	Network interface to listen on for requests and replies
`-iu`	Upstream network interface
`-id`	Downstream network interface
`-U [address]%%ifname`	Gateway IP address interface. Use `%%` for `IP%%ifname`. `%` is used as an escape character.
`--loglevel-debug`	Debug logging. Location: `/var/log/syslog`.
`-a`	Append an agent option field to each request before forwarding it to the server with default values for `circuit-id` and `remote-id`
`-r remote-id`	Set a custom remote ID string (max of 255 chars). To use this option, you must also enable the `-a` option.
`--use-pif-circuit-id`	Set the underlying physical interface which receives the packet as the `circuit-id`. To use this option you must also enable the `-a` option.

3.7.4.1.4. DHCPv4 Relay Option 82

NVUE Example

The following NVUE command is used to enable option 82 insertion in DHCP packets with default values:

```
nv set service dhcp-relay default agent
```

To provide a custom `remote-id` (e.g., host10) using NVUE:

```
nv set service dhcp-relay default agent remote-id host10
```

To use the underlying physical interface on which the request is received as `circuit-id` using NVUE:

```
nv set service dhcp-relay default agent use-pif-circuit-id
```

Flat Files Example

```
[program: isc-dhcp-relay-default]
command = /usr/sbin/dhcrelay --nl -d  -i p0_sf -i p1_sf -i vlan482  -U lo -a  --use-
pif-circuit-id  -r host10 10.89.0.1
autostart = true
autorestart = unexpected
startsecs = 3
startretries = 3
```

```
exitcodes = 0
stopsignal = TERM
stopwaitsecs = 3
```

3.7.4.1.5. DHCPv6 Relay Configuration

NVUE Example

The following NVUE command starts the DHCPv6 Relay service which listens for DHCPv6 requests on `vlan482` and sends relayed DHCPv6 requests towards `p0_sf` and `p1_sf`.

```
nv set service dhcp-relay6 default interface downstream vlan482
nv set service dhcp-relay6 default interface upstream p0_sf
nv set service dhcp-relay6 default interface upstream p1_sf
```

Flat Files Example

```
[program: isc-dhcp-relay6-default]
command = /usr/sbin/dhcrelay --nl -6 -d -l vlan482 -u p0_sf -u p1_sf
autostart = true
autorestart = unexpected
startsecs = 3
startretries = 3
exitcodes = 0
stopsignal = TERM
stopwaitsecs = 3
```

Where:

Option	Description
`-l`	Downstream interface. Use `%%` for `IP%%ifname`. `%` is used as escape character.
`-u`	Upstream interface. Use `%%` for `IP%%ifname`. `%` is used as escape character.
`-6`	IPv6
`--loglevel-debug`	Debug logging located at `/var/log/syslog`.

3.7.4.2. DHCP Relay and VRF Considerations

DHCP relay can be spawned inside a VRF context to handle the DHCP requests in that VRF. To achieve that, the user can follow these guidelines:

- DHCPv4 on default VRF:

  ```
  /usr/sbin/dhcrelay --nl -i <interface> -U [address]%%<interface> <server_ip>
  ```

- DHCPv4 on VRF:

  ```
  /usr/sbin/ip vrf exec <vrf> /usr/sbin/dhcrelay --nl -i <interface> -U [address]%
  %<interface> <server_ip>
  ```

- DHCPv6 on default VRF:

  ```
  /usr/sbin/dhcrelay --nl -6 -l <interface> -u <interface>
  ```

- DHCPv6 on VRF:

  ```
  /usr/sbin/ip vrf exec <vrf> /usr/sbin/dhcrelay --nl -6 -l p0 -u p1
  ```

Chapter 4. Troubleshooting

4.1. HBN Container Does Not Start

If the container is not starting and is not appearing in `crictl ps` output, check Kubelet logs with the following:

```
journalctl _SYSTEMD_UNIT=kubelet.service
```

If the following message appears in the logs, try rebooting the DPU to free up the huge pages resources:

```
"Failed to admit pod, unexpected error while attempting to recover from admission
 failure" pod="default/doca-app-hbn-hbn-01-00" err="preemption: error finding a
 set of pods to preempt: no set of running pods found to reclaim resources: [(res:
 hugepages-2Mi, q: 1073741824), ]"
```

4.2. Generating Support Dump

HBN support dump can be generated using the `cl-support` command:

```
root@bf2:/tmp# cl-support
Please send /var/support/cl_support_bf2-s02-1-ipmi_20221025_180508.txz to Cumulus
 support
```

The generated dump would be available in `/var/support` in the HBN container and would contain any process core dump as well as log files.

The `/var/support` directory is also mounted on the host DPU at `/var/lib/hbn/var/support`.

4.3. SFC Troubleshooting

To troubleshoot flows going through SFC interfaces, the first step is to disable the `nl2doca` service in the HBN container:

```
root@bf2:/tmp# supervisorctl stop nl2doca
nl2doca: stopped
```

Stopping `nl2doca` effectively stops hardware offloading and switches to software forwarding. All packets would appear on `tcpdump` capture on the DPU interfaces.

tcpdump can be performed on SF interfaces as well as VLAN, VXLAN, and uplinks to determine where a packet gets dropped or which flow a packet is taking.

4.4. nl2doca Troubleshooting

The nl2doca log file is located at /var/log/hbn/nl2docad.log.

To check the status of the NVUE daemon, run:

```
supervisorctl status nl2doca
```

If a certain traffic flow does not work as expected, disable nl2doca, i.e., disable hardware offloading:

```
supervisorctl stop nl2doca
```

With hardware offloading disabled, you can confirm it is an offloading issue if the traffic starts working.

If it is not an offloading issue, use tcpdump on various interfaces to see where the packet gets dropped.

Offloaded entries can be checked in /cumulus/nl2docad/run/software-tables/15.

Encapsulation format is as follows:

```
flow-entry : 0xb
   flow-pattern :
     ingress port :pf0hpf_sf
     ingress pd port :13
     priority :3
     eth type: 0x800
     ip dst :10.10.10.3/32
   flow-actions :
     SET SRC MAC:08:c0:eb:c0:59:f1
     SET DST MAC:1c:34:da:19:4a:20
     OUTPUT PD PORT ID idx 0:11(p1_sf)*
     STATS: pkts: 0  bytes: 0
```

To check counters for packets going to the kernel, run:

```
echo 1 > /cumulus/nl2docad/ctrl/debug
cat /cumulus/nl2docad/debug/stats/punt
```

4.5. NVUE Troubleshooting

To check the status of the NVUE daemon, run:

```
supervisorctl status nvued
```

To restart the NVUE daemon, run:

```
supervisorctl restart nvued
```

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