NVIDIA BlueField DPU Scalable Function

User Guide

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Chapter 1. Introduction

Scalable functions (SFs), or sub-functions, are very similar to virtual functions (VFs) which are part of a Single Root I/O Virtualization (SR-IOV) solution. I/O virtualization is one of the key features used in data centers today. It improves the performance of enterprise servers by giving virtual machines direct access to hardware I/O devices. The SR-IOV specification allows one PCI Express (PCIe) device to present itself to the host as multiple distinct "virtual" devices. This is done with a new PCIe capability structure added to a traditional PCIe function (i.e., a physical function or PF).

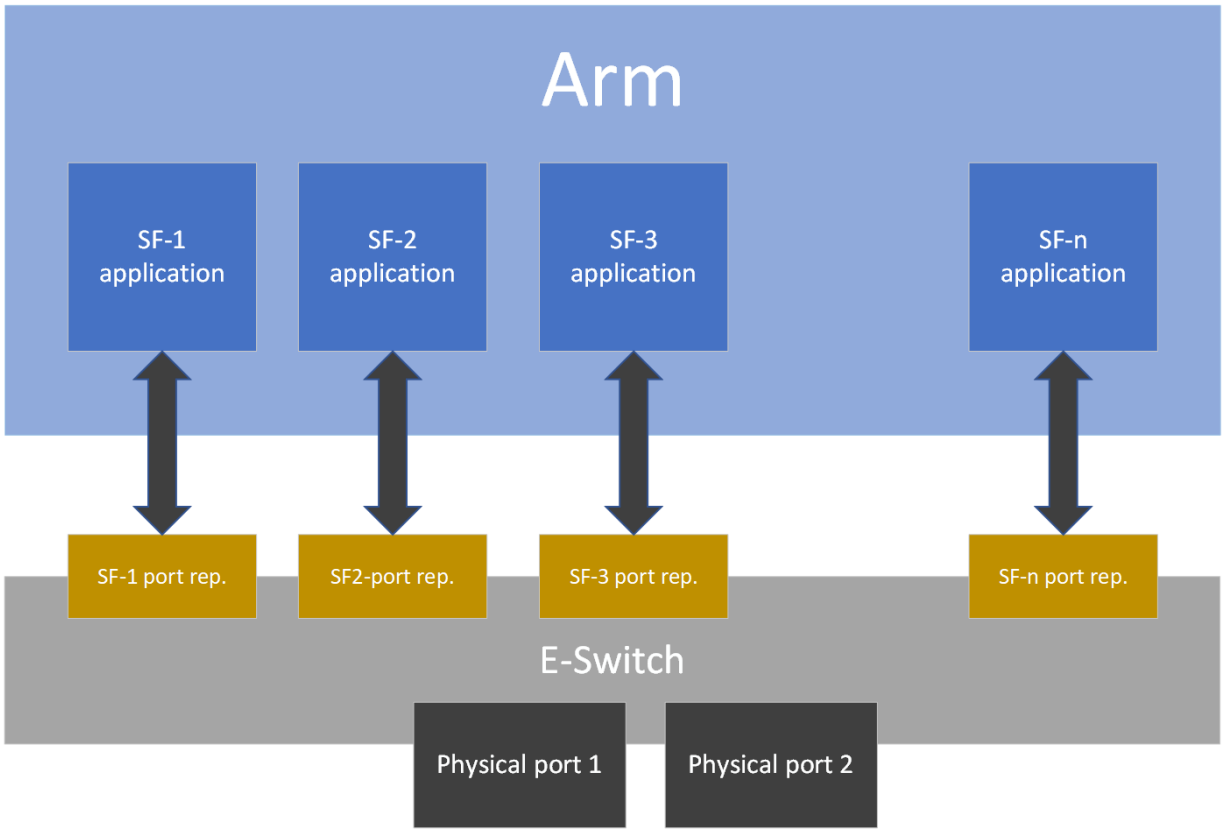
The PF provides control over the creation and allocation of new VFs. VFs share the device's underlying hardware and PCIe. A key feature of the SR-IOV specification is that VFs are very lightweight so that many of them can be implemented in a single device.

To utilize the capabilities of VF in the BlueField, SFs are used. SFs allow support for a larger number of functions than VFs, and more importantly, they allow running multiple services concurrently on the DPU.

An SF is a lightweight function which has a parent PCIe function on which it is deployed. The SF, therefore, has access to the capabilities and resources of its parent PCIe function and has its own function capabilities and its own resources. This means that an SF would also have its own dedicated queues (i.e., txq, rxq).

SFs co-exist with PCIe SR-IOV virtual functions (on the host) but also do not require enabling PCIe SR-IOV.

SFs support E-Switch representation offload like existing PF and VF representors. An SF shares PCIe-level resources with other SFs and/or with its parent PCIe function.


Arm
SF-1 application
SF-2 application
SF-3 application
SF-n application
SF-1 port rep.
SF2-port rep.
SF-3 port rep.
SF-n port rep.
E-Switch
Physical port 1
Physical port 2

Chapter 2. Prerequisites

Please refer to the DOCA Installation Guide for details on how to install BlueField related software.

- The minimum firmware version required for cloud configuration is 16.29.1040 or higher.
- The minimum firmware version required for non-cloud, physical, or server BlueField configuration is 16.31.0238 or higher.
- Set SFs to "trusted" on the device using the following command on the Arm side:

```
mlxreg -d /dev/mst/mt41686_pciconf0 --reg_id 0xc007 --reg_len 0x40 --indexes
 "0x0.0:32=0x80000000" --yes --set "0x4.0:32=0x1"
```

Note: This command sets all SFs to "trusted".

Chapter 3. SF Configuration

To use a subfunction, a 3-step setup sequence must be followed first:

1. Create.
2. Configure.
3. Deploy.

These steps may be performed in the following two methods:

- Using mlnx-sf script
- Using mlxdevm tool (legacy)

3.1. Configuration Using mlnx-sf Script

The mlnx-sf script creates, configures, and deploys an SF using one command:

```
mlnx-sf --action create --device <pci_address> --sfnum <sfnum> --hwaddr
 <mac_address>
```

For example:

```
mlnx-sf --action create --device 0000:03:00.0 --sfnum 9 --hwaddr 02:25:f2:8d:a2:4c
```

- `--action create` – creates the SF (there is a "show" action as well)
- `--device <pci_address>` – links the created SF to a parent PCIe device
- `--sfnum <sfnum>` – gives the SF a unique SF number
- `--hwaddr <mac_address>` – configures the MAC address of the SF

Useful commands:

- During configuration or after it is complete, you may use the command `mlnx-sf --action show` to display the attached auxiliary device to each SF, as that is needed during application runtime. For example (only a single device is shown):

```
SF Index: pci/0000:03:00.0/229409
  Parent PCI dev: 0000:03:00.0
  Representor netdev: en3f0pf0sf70
  Function HWADDR: 00:01:01:01:01:70
  Auxiliary device: mlx5_core.sf.4
    netdev: enp3s0f0s70
    RDMA dev: mlx5_4
```

- To delete the SF port representor, run:

```
mlnx-sf --action delete --sfindex pci/<pci_address>/<pasre_dev>
```

  For example:

```
mlnx-sf --action delete --sfindex pci/0000:03:00.0/229409
```

- Please use the command "`mlnx-sf --help`" for more details

3.2. Configuration Using mlxdevm Tool

1. Create the SF.

   SFs are managed using the `mlxdevm` tool supplied with iproute2 package. The tool is found at `/opt/mellanox/iproute2/sbin/mlxdevm`.

   An SF is created using the mlxdevm interface. The SF is added by adding a port of "`pcisf`" flavor.

   To create an SF port representor, run:

```
/opt/mellanox/iproute2/sbin/mlxdevm port add pci/<pci_address> flavour pcisf
 pfnum <corresponding pfnum> sfnum <sfnum>
```

   Note: Each SF must have a unique number (<sfnum>).

   For example:

```
/opt/mellanox/iproute2/sbin/mlxdevm port add pci/0000:03:00.0 flavour pcisf pfnum
 0 sfnum 8
```

   Output:

```
Pci/0000:30:00.0/229409: type eth netdev eth0 flavour pcisf controller 0 pfnum 0
 sfnum 8
   function:
hw_addr 00:00:00:00:00:00 state inactive opstate detached roce true max_uc_macs
 1024
```

   The highlighted number (229409) will be required to complete the next two steps (i.e., configuration and deployment).

   "`pci/0000:03:00.0/229409`" represents SF port representor that is created. That is, "`pci/0000:03:00.0`" is the parent port of the SF port representor 229409.

2. Configure the SF.

   A subfunction representor (SF port representor) is created but it is not active yet. Users may use the e-switch port representor to configure settings such as adding the SF port representor to an OVS bridge, adding TC rules, etc. Users may also configure the hardware address (e.g., MAC address) of the SF while it is inactive.

To set the MAC address, run:

```
/opt/mellanox/iproute2/sbin/mlxdevm port function set pci/<pci_address>/
<pasre_dev>  hw_addr <MAC address>
```

For example:

```
/opt/mellanox/iproute2/sbin/mlxdevm port function set pci/0000:03:00.0/229409
 hw_addr 00:00:00:00:08:0
```

Note: Other SF capabilities (e.g., disabling RoCE for the SF) must be set before activating the SF (optional).

To verify that the MAC address has been configured as expected, run the following command:

```
/opt/mellanox/iproute2/sbin/mlxdevm port show pci/<pci_address>/<pasre_dev>
```

For example:

```
/opt/mellanox/iproute2/sbin/mlxdevm port show pci/0000:30:00.0/229409
```

Output:

```
pci/0000:30:00.0/229409: type eth netdev en3f0pf0sf8 eth0 flavour pcisf
 controller 0 pfnum 0 sfnum 8
   function:
 hw_addr 00:00:00:00:08:08 state inactive opstate detached roce true max_uc_macs
 1024
```

3. Deploy the SF.

   Once an SF is configured, it must be activated for it to be used.

   To activate the SF, run:

   ```
   /opt/mellanox/iproute2/sbin/mlxdevm port function set pci/< pci_address > /
   <pasre_dev> state active
   ```

   For example:

   ```
   /opt/mellanox/iproute2/sbin/mlxdevm port function set pci/0000:03:00.0/229409
    state active
   ```

   Note: To verify that the SF state is active, you may run either the command `mlnx-sf --action show`, or:

   ```
   /opt/mellanox/iproute2/sbin/mlxdevm port show pci/<pci_address> /
   <pasre_dev>
   ```

   To unbind the SF from the default config driver and bind the actual SF driver, run:

   ```
   echo mlx5_core.sf.<next_serial> >  /sys/bus/auxiliary/drivers/mlx5_core.sf_cfg/
   unbind
   echo mlx5_core.sf.<next_serial>  > /sys/bus/auxiliary/drivers/mlx5_core.sf/bind
   ```

   Note: See the useful commands listed below to know where to obtain the `<next_serial>` value.

   For example:

   ```
   echo mlx5_core.sf.8  > /sys/bus/auxiliary/drivers/mlx5_core.sf_cfg/unbind
   echo mlx5_core.sf.8  > /sys/bus/auxiliary/drivers/mlx5_core.sf/bind
   ```

   Useful commands:

   - To see the available sub-functions, run:

     ```
     ls /sys/bus/auxiliary/devices/mlx5_core.sf.*
     ```

For example, if you run the command before creating the SF (`port add` command), then the output would be as follows:

```
/sys/bus/auxiliary/devices/mlx5_core.sf.2:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.3:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.4:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.5:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.6:
driver  power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.7:
driver  power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.8:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent
```

After creating the SF, the output would be:

```
/sys/bus/auxiliary/devices/mlx5_core.sf.2:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.3:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.4:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.5:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.6:
driver  power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.7:
driver  power sfnum subsystem uevent

/sys/bus/auxiliary/devices/mlx5_core.sf.8:
driver infiniband infiniband_mad infiniband_vrebs mlx5_core.eth2
 mlx5_core.rdma.2 net power sfnum subsystem uevent
```

Note that the `<next_serial>` number is 8 for the created SF.

- To see the sfnum of each sub-function, run:

```
cat /sys/bus/auxiliary/devices/mlx5_core.sf.<next_serial>/sfnum
```

For example:

```
cat /sys/bus/auxiliary/devices/mlx5_core.sf.8/sfnum
```

Output:

```
cat /sys/bus/auxiliary/devices/mlx5_core.sf.8
```

```
8
```

- To remove an SF, you must first make its state inactive and only then remove the SF representor.

  To make the SF's state inactive, run:

  ```
  opt/mellanox/iproute2/sbin/mlxdevm port function set pci/<pci_address>/
  <pasre_dev> state inactive
  ```

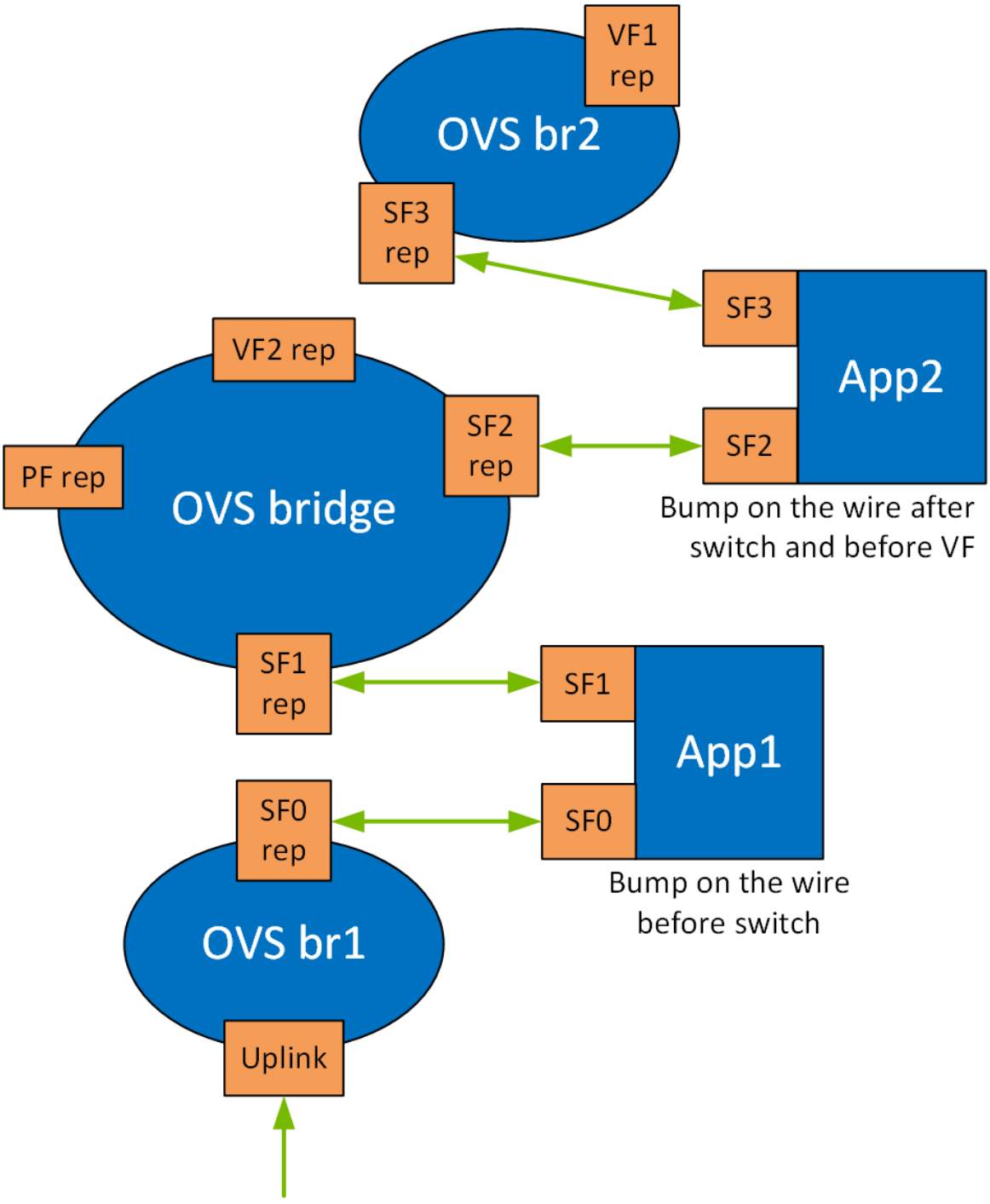
  To delete the SF port representor, run:

  ```
  /opt/mellanox/iproute2/sbin/mlxdevm port del pci/<pci_address>/<pasre_dev>
  ```

  For example:

  ```
  /opt/mellanox/iproute2/sbin/mlxdevm port function set pci/0000:03:00.0/229409
   state inactive
  /opt/mellanox/iproute2/sbin/mlxdevm/devlink port del pci/0000:03:00.0/229409
  ```

4. Use the SF.



Running the application on the DPU requires OVS configuration. By creating SFs, an SF representor for the OVS is also created and named `en3f0pf*sf*`. Therefore, each representor needs to be connected to the correct OVS bridge.

Note: Two SFs related to the same PCIe are necessary for the configuration in the illustration.

The following example configures 2 SFs and adds their representors to the OVS.

a). Create, configure, and deploy the SFs. Run:

```
mlnx-sf --action create --device 0000:03:00.0 --sfnum 4 --hwaddr
 02:25:f2:8d:a2:4c
mlnx-sf --action create --device 0000:03:00.0 --sfnum 5 --hwaddr
 02:25:f2:8d:a2:5c
```

Using `ifconfig`, you may see that there are 2 added network interfaces: `en3f0pf0sf4` and `en3f0pf0sf5` for the two respective SF port representors.

b). Add the port representors to the OVS bridges:

```
ovs-vsctl add-port sf_bridge1 en3f0pf0sf4
ovs-vsctl add-port sf_bridge2 en3f0pf0sf5
```

The OVS bridges after adding the SF representors:

```
Bridge sf_bridge1
     Port p0
         Interface p0
     Port sf_bridge1
         Interface sf_bridge1
             type: internal
     Port en3f0pf0sf4
         Interface en3f0pf0sf4
Bridge sf_bridge2
     Port sf_bridge2
         Interface sf_bridge2
             type: internal
     Port en3f0pf0sf5
         Interface en3f0pf0sf5
     Port pf0hpf
         Interface pf0hpf
ovs_version: "2.14.1"
```

Note: The interface might be down by default. Remember to `ifconfing` the interface to "up" status.

Note: When deleting the SF port representor, you must also de-attach it from the bridge it is connected to using the command `ovs-vsctl port-del en3f0pf0sf*`. Otherwise, the port representor will still be connected to the bridge but would not be recognizable.

To run the application, use the following command to initialize the subfunctions during runtime:

```
*Executable_binary* -a auxiliary:mlx5_core.sf.* -a auxiliary:mlx5_core.sf.*
```

For example:

```
doca_app_rec -a 0000:03:00.0,class=regex -a auxiliary:mlx5_core.sf.4,sft_en=1 -a
 auxiliary:mlx5_core.sf.5,sft_en=1 -v - [application_flags]
```

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