
OpenflowSwitch Software for SharpNIC™ PCIE-9205

Installation and Use

P/N: 6806800U20F

January 2020



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Embedded Computing

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Table of Contents

About this Manual	5
1 Introduction	9
1.1 Overview	9
1.2 OpenflowSwitch Software	9
1.2.1 Hardware Requirement	9
1.2.2 Software Requirement	9
1.3 Software Installation	9
1.3.1 Getting Started	9
1.3.2 Prerequisites	10
1.3.3 Installation and Verification	10
1.3.3.1 Verifying the Software Modules	10
1.3.3.2 Configuring the Database	11
1.3.3.3 Configuring the Management Network	11
1.3.3.4 Configuring the Flows	12
1.3.3.5 Configuring the Modes of QSFP Modules	12
2 Usage and Demonstration Through ODL	13
2.1 Introduction	13
2.2 Prerequisites for Demonstration	13
2.3 Topology	14
2.3.1 Demonstration	14
3 Configuring L2 Switching/Forwarding	19
Adding Flows to Configure L2 Switching or Forwarding	19
4 Configuring L3 Unicast Route	25
4.1 Adding Flows to Configure L3 Unicast Route	25
5 Configuring L3 ECMP Route	31
5.1 Adding Flows to Configure L3 ECMP Route	31

Table of Contents

6	Configuring L2 Multicast Forwarding	43
6.1	Adding Flows to Configure L2 Multicast Forwarding to VF Ports	43
6.2	Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports	50
A	Related Documentation	61
A.1	SMART Embedded Computing Documentation	61

About this Manual

Overview of Contents

This manual is divided into the following chapters and appendices.

Introduction on page 9 describes software installation, verification, and configuration of OpenflowSwitch Software on SharpNIC™ PCIE-9205.

Usage and Demonstration Through ODL on page 13 describes how to use ODL controller to control/configure and access OpenflowSwitch.

Appendix 3, Configuring L2 Switching/Forwarding on page 19 describes the configuration of L2 switching or forwarding.

Appendix 4, Configuring L3 Unicast Route on page 25 describes the configuration of L3 Unicast Route.

Appendix 5, Configuring L3 ECMP Route on page 31 describes the configuration of L3 ECMP Route.

Appendix 6, Configuring L2 Multicast Forwarding on page 43 describes the configuration of L2 multicast forwarding to EPL, PF, and VF ports.

Appendix A, Related Documentation on page 61 provides a listing of related product documentation, manufacturer's documents and industry standard specifications.



Abbreviations




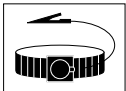

This document uses the following abbreviations:

Abbreviation	Definition
ARP	Address Resolution Protocol
BBS	Basic Blade Services
ECMP	Equal Cost Multi Path
EPL	Ethernet Port Logic
ODL	OpenDaylight (Lithium-SR3)
OvS	Open vSwitch (2.4.0)
OVSDB	Open vSwitch Database Management Protocol i.e. RFC 7047
PCIE	Peripheral Component Interconnect Express

Conventions

The following table describes the conventions used throughout this manual.

Notation	Description
0x00000000	Typical notation for hexadecimal numbers (digits are 0 through F), for example used for addresses and offsets
0b0000	Same for binary numbers (digits are 0 and 1)
bold	Used to emphasize a word
Screen	Used for on-screen output and code related elements or commands. Sample of Programming used in a table (9pt)
Courier + Bold	Used to characterize user input and to separate it from system output
<i>Reference</i>	Used for references and for table and figure descriptions
File > Exit	Notation for selecting a submenu
<text>	Notation for variables and keys
[text]	Notation for software buttons to click on the screen and parameter description
...	Repeated item for example node 1, node 2, ..., node 12
.	Omission of information from example/command that is not necessary at the time
..	Ranges, for example: 0..4 means one of the integers 0,1,2,3, and 4 (used in registers)
	Logical OR
	Indicates a hazardous situation which, if not avoided, could result in death or serious injury
	Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury

Notation	Description
	Indicates a property damage message
	Indicates a hot surface that could result in moderate or serious injury
	Indicates an electrical situation that could result in moderate injury or death
<p>Use ESD</p>  <p>Wrist Strap</p>	Indicates that when working in an ESD environment care should be taken to use proper ESD practices
	No danger encountered, pay attention to important information

Summary of Changes

This manual has been revised and replaces all prior editions.

Part Number	Publication Date	Description
6806800U20F	January 2020	Rebranded to SMART Embedded Computing
6806800U20E	October 2018	Updated to new template.
6806800U20D	February 2017	Removed the <i>Openflow Abstract Switch</i> section.
6806800U20C	September 2016	Updated the product name to OpenflowSwitch, hardware requirement, and OpenflowSwitch RPM name.

Part Number	Publication Date	Description
6806800U20B	August 2016	Added Configuring the Management Network on page 11 and Configuring L2 Multicast Forwarding on page 43 .
6806800U20A	July 2016	Initial version.

Introduction

1.1 Overview

This chapter describes software installation, verification, and configuration of OpenflowSwitch software on the SharpNIC™ PCIE-9205 card. You can refer to the *Openflow Abstract Switch Application Note* for more details about the Openflow switch pipeline.

1.2 OpenflowSwitch Software

The OpenflowSwitch software is designed to provide Open vSwitch Database (OVSDB) and Openflow plug-ins for the SharpNIC™ PCIE-9205 card.

1.2.1 Hardware Requirement

MaxCore™ MC3000 platform with SharpNIC™ PCIE-9205 card in slots1, 3, 9, and 11

1.2.2 Software Requirement

- Open vSwitch
- Compatible Basic Blade Services (BBS)

NOTE: Refer to *OpenflowSwitch Software for SharpNIC™ PCIE-9205 Release Notes* (delivered along with the software) for the applicable software release information.

1.3 Software Installation

1.3.1 Getting Started

The OpenflowSwitch software is installed on the PCIE-9205 card. It enables Openflow and OVSDB plug-ins on the Intel® FM10840 (also known as Red Rock Canyon).

Prerequisites

1.3.2 Prerequisites

To install the OpenflowSwitch software it is required to have a compatible BBS installed on the PCIE-9205 card.

The Open vSwitch 2.4.0 (OvS) should be preinstalled on the PCIE-9205 card. If required, use the following command to install OvS.

```
rpm -ivh openvswitch-2.4.0-1.el7.x86_64.rpm
```

NOTE: The OvS RPM is also packaged as a part of the OpenflowSwitch software.

1.3.3 Installation and Verification

1. Install the OpenflowSwitch software RPMs.

```
rpm -ivh openswitchsw-pcie9205-1.0. <version>.el7.x86_64.rpm
```

2. Provide the OpenflowSwitch configuration details in the following file:

```
/opt/openswitch/config/config.in
```

3. Start OpenflowSwitch modules on the PCIE-9205 card:

```
/opt/openswitch/scripts/openswitch.init start
```

1.3.3.1 Verifying the Software Modules

The following software modules of OpenflowSwitch and Open vSwitch (OvS) are running on the PCIE-9205 card:

1. OvS related software module:

```
ovsdb-server - OvS database server
```

2. OpenflowSwitch related software module:

```
switchagentd - Switch agent daemon
```

```
ofagent - Openflow agent
```

```
ovs-switchd - OpenflowSwitch daemon
```

It is a proprietary extension of the ovs-vswitchd module of OvS. The user space-only mode of ovs-switchd extends netdev-provider interface to the PCIE-9205 card. The Openflow agent functionality of ovs-switchd is replaced by ofagent module of the OpenflowSwitch.

3. Verify the status of the above software modules using:

```
/opt/openswitch/scripts/openswitch.init status command.
```

1.3.3.2 Configuring the Database

The `ovs-vsctl` utility of OvS can be used to query and configure the OvS configuration database. This release supports only the mandatory columns of the following Open_vSwitch database tables:

- Open_vSwitch
- Bridge
- Port
- Interface
- Manager

1.3.3.3 Configuring the Management Network

For the SharpNIC™ PCIE-9205 card in a nonshelf host:

The PCIE-9205 card connects to the management network in the MaxCore platform, using one of the PCIe ports (port 20, 21, 22, or 23) connected to the management CPU (mCPU) in the shelf host. In addition, there is a reserved VLAN that is used for the management traffic. The `/opt/openswitch/config/config.in` file contains `MGMT_NET_PORT` and `MGMT_NET_VLAN` parameters for configuring the port and VLAN respectively.

The PCIE-9205 card acquires an IP address on `<PEP4 port>.MGMT_NET_VLAN` interface, by running the DHCP client program, from the DHCP server that is running on the mCPU. After the management network is up, the OpenflowSwitch software can connect to the Openflow controller.

In case, the DHCP server is not available, you should statically assign IP address to the `<PEP4 port>.MGMT_NET_VLAN` interface (e.g. `enp38s0.21`) and assign the appropriate gateway IP and routes to reach the Openflow controller.

NOTE: Port 24 is assigned as the PEP4 port.

1.3.3.4 Configuring the Flows

Use an Openflow controller like OpenDayLight (ODL) to configure flows on the PCIE-9205 card.

Configure controller/manager IP address and Datapath ID in the following file:
`/opt/openswitch/config/config.in`

1.3.3.5 Configuring the Modes of QSFP Modules

The upper and lower QSFP28 modules present on the SharpNIC™ PCIE-9205 can be configured in one of the following modes:

- 40G_SR4: Group Mode, covering 1x40GBase-SR4
- 10G_SX4: Independent Mode, covering 4x10GBase-SR
- 1G_SX4: Independent Mode, covering 4x1000Base-X

Given below are the default configurations:

- Upper QSFP28 module (QSFP1) = 40G_SR4
- Lower QSFP28 module (QSFP2) = 1G_SX4

Any changes to the QSFP modes would necessitate a `openswitch.init` restart.

Usage and Demonstration Through ODL

2.1 Introduction

This chapter describes how to use the ODL (Open DayLight) controller to control, configure, and access the Openflow switch.

NOTICE

For reactive flow programming, you need to develop an ODL/Controller plug-in based on the Openflow Switch Pipeline as described in the Openflow Abstract Switch Application Note. Get a copy of the Application Note by contacting your local SMART EC sales office.

Openflow agent running on a PCIE-9205 card supports all the required functionalities to enable reactive flow programming.

2.2 Prerequisites for Demonstration

Install the OpenflowSwitch software on SharpNIC™ PCIE-9205.

Install the ODL Lithium-SR3 release or any standard ODL release on the SharpServer PCIE-7410 card or any external PC with the following features:

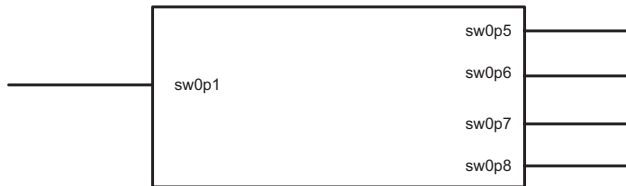
- `feature:install odl-restconf-all`
- `feature:install odl-openflowplugin-all`
- `feature:install odl-ovsdb-all`
- `feature:install odl-ovsdb-openstack`
- `feature:install odl-dlux-all`

You may need to disable the firewall in the controller system so it accepts the Openflow protocol messages.

Install the postman plug-in in Google Chrome for configuring or pushing flows.

2.3 Topology

External QSFP1 is configured in the group mode (port number 1) with bandwidth set to 40G and QSFP2 is configured in the independent mode (port number 5,6,7, and 8) each have bandwidth set to 1G.



Connect sw0p5, sw0p6, sw0p7, and sw0p8 to SmartBits as shown in the figure above.

2.3.1 Demonstration

Test Cases:

Test Case 1: Topology Detection by OpenDayLight Controller

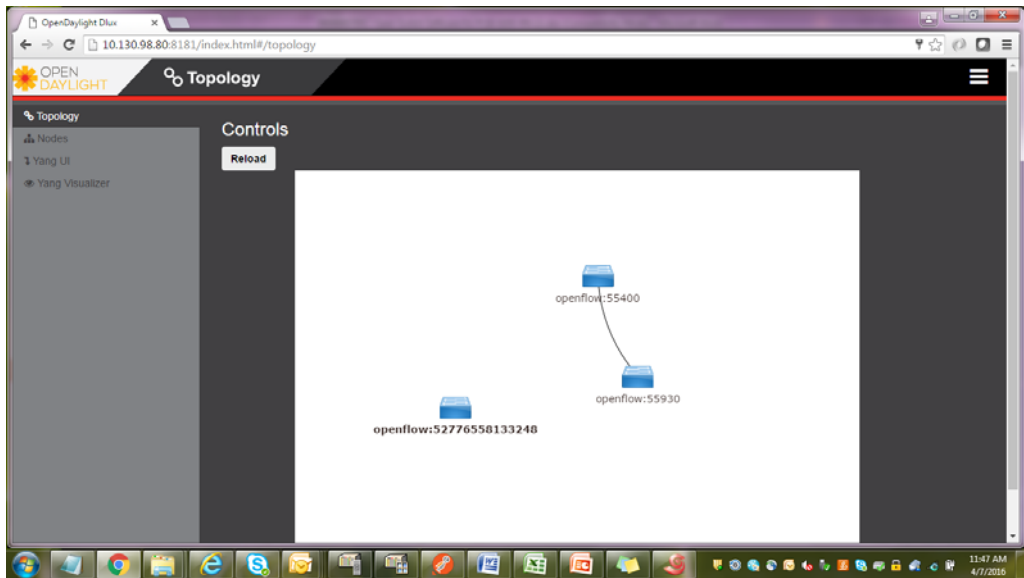
1. Start ODL controller with required features using `./bin/karaf`
2. Configure the controller and manager IP in configuration file.
3. Start OpenflowSwitch service.

Once the ODL controller detects Openflow switch running in the PCIE-9205 card, the topology can be observed through the DLUX web URL.

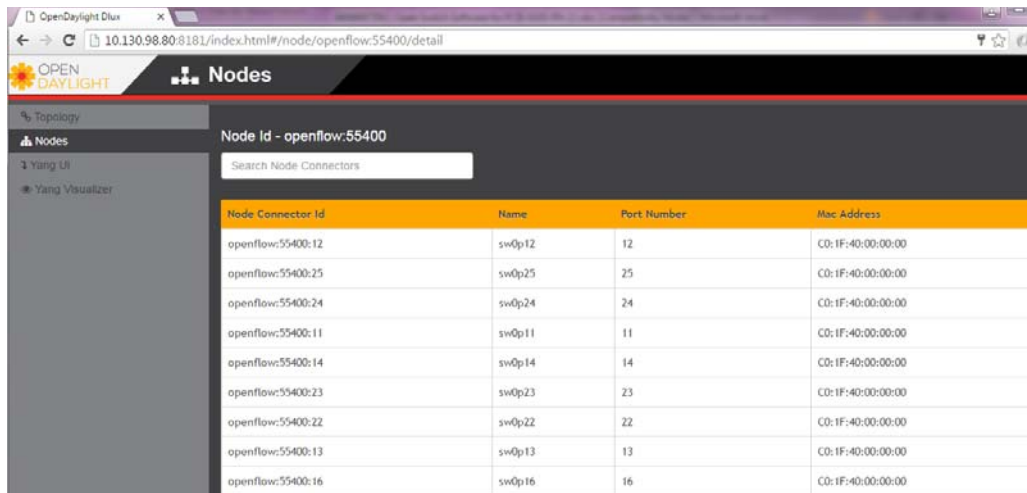
For more details see, <http://<controller-ip>:8181/index.html>.

4. DLUX give multiple tabs - to observe topology/Nodes/Yang.

The Topology tab in DLUX displays the connectivity between switches/hosts. For the switches to be detected by ODL it is required that they should forward LLDP packets. For the hosts to be detected by ODL, they need to send GARP/ARP packets.

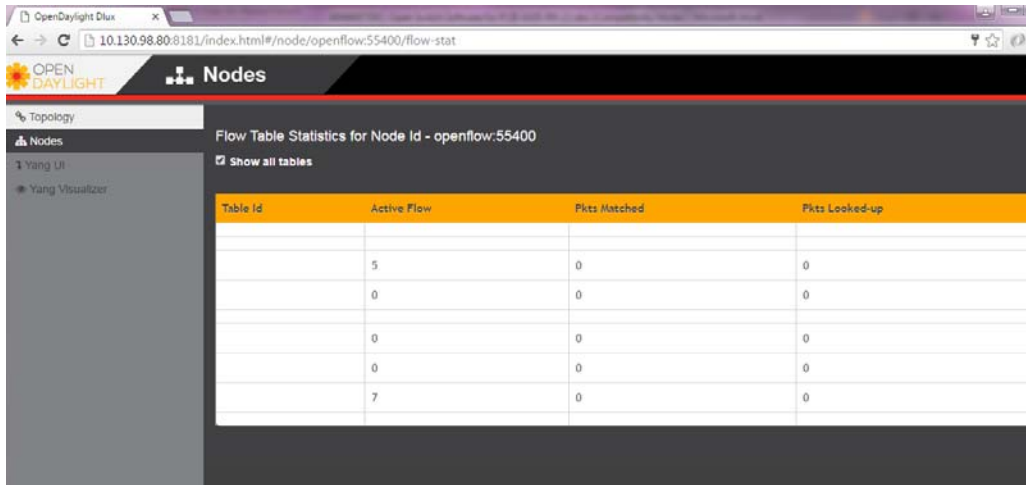


5. Select the Node tab to verify the following parameters.
 - Number of ports



Demonstration

- Number of flows configured on different table

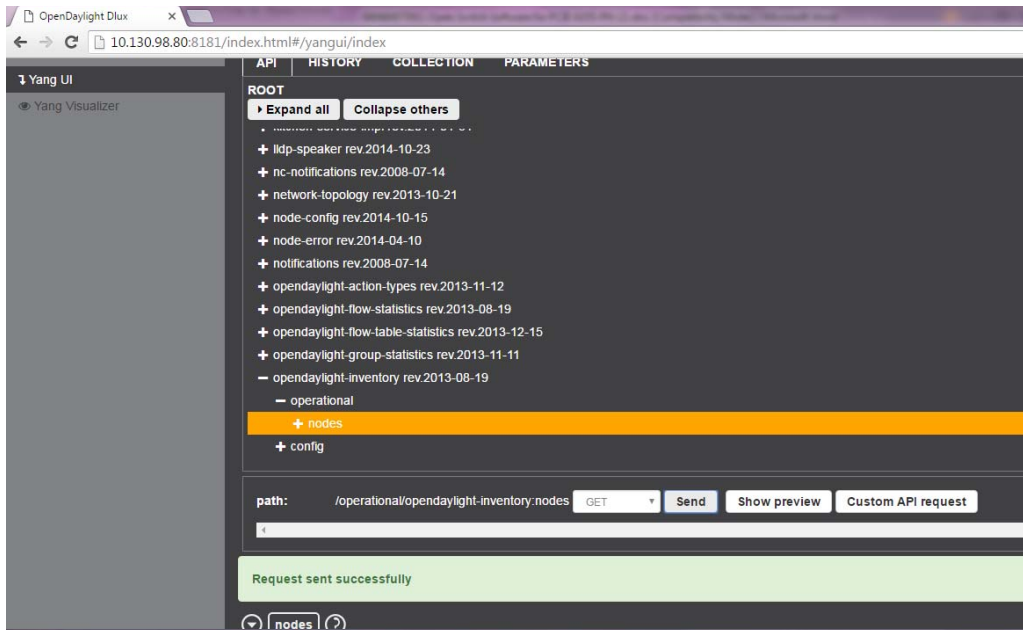


Flow Table Statistics for Node Id - openflow:55400

Show all tables

Table Id	Active Flow	Pkts Matched	Pkts Looked-up
	5	0	0
	0	0	0
	0	0	0
	0	0	0
	7	0	0

- Port statistics



YANG UI

API HISTORY COLLECTION PARAMETERS

ROOT

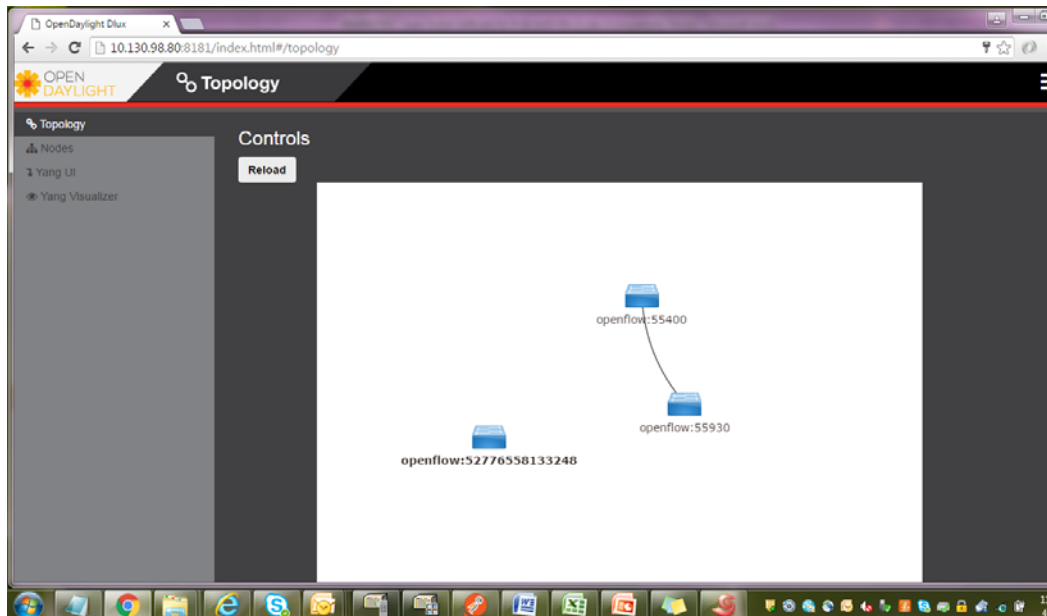
- + ldp-speaker rev.2014-10-23
- + nc-notifications rev.2008-07-14
- + network-topology rev.2013-10-21
- + node-config rev.2014-10-15
- + node-error rev.2014-04-10
- + notifications rev.2008-07-14
- +.opendaylight-action-types rev.2013-11-12
- +.opendaylight-flow-statistics rev.2013-08-19
- +.opendaylight-flow-table-statistics rev.2013-12-15
- +.opendaylight-group-statistics rev.2013-11-11
- .opendaylight-inventory rev.2013-08-19
 - operational
 - + nodes
 - + config

path: /operational/opendaylight-inventory:nodes GET Send Show preview Custom API request

Request sent successfully

nodes

The Yang interface can be used to verify/configure different ODL features. For example, operational states of the ports can be verified and also configure interface and link state.



The ODL controller sends LLDP packets to all running interfaces. The same can be confirmed with statistics in Node Tab and also in Smart.

Test Case 2: Connecting two PCIE-9205 Openflow Switches

Cross-connect either the PCIE-9205 card QSFP1 ports or 1G ports.

1. Start ODL controller.
2. Configure controller IP in config file of OpenflowSwitch software.
3. Install OpenflowSwitch Software on both PCIE-9205 cards.

Once the LLDP packet exchanges are done, topology can be observed in ODL DLUX Web Interface.

Demonstration

Test Case 3: L2 Forwarding

1. Create L2 group entry.
2. For supporting L2 forwarding for specific port, configure the following flows.
 - Table 0, Match - Input Port sw0p5, Action - Send to Termination Mac table (Table 20)
 - Table 20, Match - Input Port 5, Action - Goto Table 50
 - Table 50 bridging table, Match - Dest MAC, Group ID to Send to group table

For more details see, [Configuring L2 Switching/Forwarding on page 19](#).

Test Case 4: L3 Unicast

1. Configure the following flows:
 - Create L2 group entry
 - Create L3 group entry
2. For L3 Unicast, configure the following flows:
 - Table 0, send to Table 20 entry. Table 20, send to Unicast table entry
 - Table 30 Unicast Table, Match - Destination IP and send to L3 group ID

For more details see, [Adding Flows to Configure L3 Unicast Route on page 25](#).

Test Case 5: L3 ECMP

1. Configure the following flows:
 - Create 3 L2 group entries
 - Create 3 L3 group entries
 - Create L3 ECMP group entry
2. For L3 ECMP, configure the following flows:
 - Table 0, send to Table 20 entry, Table 20, send to Unicast table entry
 - Table 30 Unicast Table, Match - Destination IP and send to L3 group ID

For more details see, [Adding Flows to Configure L3 ECMP Route on page 31](#).

Configuring L2 Switching/Forwarding

3.1 Adding Flows to Configure L2 Switching or Forwarding

The following flows are required to switch L2 packet from port 6 to port 5 with VLAN 10 and ethertype 0x8100 (33024).

For example,

Openflow Datapath ID is 55400 and Controller IP is 192.168.2.1

1. Create L2 Group table Entry for VLAN 10, Port 5

PUT:

`http://192.168.2.1:8181/restconf/config/opendaylight-inventory:nodes/node/openflow:55400/group/655365`

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-type>group-indirect</group-type>
  <buckets>
    <bucket>
      <action>
        <output-action>
          <output-node-connector>5</output-node-connector>
        </output-action>
        <order>1</order>
      </action>
      <bucket-id>1</bucket-id>
    </bucket>
  </buckets>
  <barrier>>false</barrier>
  <group-name>l2_0xa0005</group-name>
  <group-id>655365</group-id>
</group>
```

2. Flow (0) on Vlan Table (Table ID - 0, Flow ID - 151)

PUT:

`http://192.168.2.1:8181/restconf/config/.opendaylight-inventory:nodes/node/openflow:55400/table/0/flow/151`

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<flow xmlns="urn:opendaylight:flow:inventory">
<strict>true</strict>
  <priority>2</priority>
  <match>
    <in-port>6</in-port>
    <vlan-match>
      <vlan-id>
        <vlan-id>10</vlan-id>
        <vlan-id-present>true</vlan-id-present>
      </vlan-id>
    </vlan-match>
    <ethernet-match>
      </ethernet-type>
      <type>33024</type>
    </ethernet-type>
    </ethernet-match>
  </match>
  <instructions>
    <instruction>
      <order>0</order>
      <go-to-table>
        <table_id>20</table_id>
      </go-to-table>
    </instruction>
  </instructions>
  <id>151</id>
  <table_id>0</table_id>
</flow>
```

3. Flow (2) on Termination MAC Table (Table ID - 20, Flow ID - 205610)

```
<flow xmlns="urn:opendaylight:flow:inventory">
  <id>205610</id>
  <instructions>
    <instruction>
      <order>0</order>
      <go-to-table>
        <table_id>50</table_id>
      </go-to-table>
    </instruction>
  </instructions>
  <priority>2</priority>
  <table_id>20</table_id>
  <match>
    <in-port>6</in-port>
    <vlan-match>
      <vlan-id>
        <vlan-id-present>true</vlan-id-present>
        <vlan-id>10</vlan-id>
      </vlan-id>
    </vlan-match>
    <ethernet-match>
      <ethernet-type>
        <type>33024</type>
      </ethernet-type>
    </ethernet-match>
  </match>
  <strict>true</strict>
</flow>
```

-
4. Flow 3 on Bridging table (Table ID - 50, Flow ID - 152) to send packet to group ID - 655365 (VLAN 10, Port 6) if the Destination MAC is 00:22:33:44:55:66

PUT:

http://192.168.2.1:8181/restconf/config/opendaylight-inventory:nodes/node/openflow:55400/table/50/flow/152

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<flow xmlns="urn:opendaylight:flow:inventory">
<strict>true</strict>
  <priority>1</priority>
  <match>
    <vlan-match>
      <vlan-id>
        <vlan-id>10</vlan-id>
        <vlan-id-present>true</vlan-id-present>
      </vlan-id>
    </vlan-match>
    <ethernet-match>
      <ethernet-destination>
        <address>00:22:33:44:55:66</address>
      </ethernet-destination>
    </ethernet-match>
  </match>
  <instructions>
    <instruction>
      <order>0</order>
      <apply-actions>
        <action>
          <order>0</order>
          <group-action>
            <group-id>655365</group-id>
          </group-action>
        </action>
      </apply-actions>
    </instruction>
  </instructions>
</id>152</id>
```

```
<table_id>50</table_id>  
</flow>
```


Configuring L3 Unicast Route

4.1 Adding Flows to Configure L3 Unicast Route

The following flows are required to route packets from port 6 to port 5 with Destination IP 1.1.1.1/24 and Destination MAC as switch MAC.

For example,

Openflow Datapath ID is 55400 and Controller IP is 192.168.2.1

The following is the configuration of Headers on Postman (Rest API based application).

Headers:

Authorization: Basic

Accept: application/xml

Content-type: application/xml

1. Create L2 Group table Entry for VLAN 10, Port 5

PUT:

`http://192.168.2.1:8181/restconf/config/opendaylight-inventory:nodes/node/openflow:55400/group/655365`

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-type>group-indirect</group-type>
  <buckets>
    <bucket>
      <action>
        <output-action>
          <output-node-connector>5</output-node-connector>
        </output-action>
        <order>1</order>
      </action>
      <bucket-id>1</bucket-id>
    </bucket>
  </buckets>
  <barrier>>false</barrier>
  <group-name>l2_0xa0005</group-name>
  <group-id>655365</group-id>
</group>
```

Adding Flows to Configure L3 Unicast Route

2. L3 Group Entry Creation (L3 group type & Index) - Set Destination MAC and send to L2 group ID for port 5 VLAN 10

PUT:

http://192.168.2.1:8181/restconf/config/opendaylight-inventory:nodes/node/openflow:55400/group/587654321

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-type>group-indirect</group-type>
  <buckets>
    <bucket>
      <action>
        <order>0</order>
        <group-action>
          <group-id>655365</group-id>
        </group-action>
      </action>
      <action>
        <order>1</order>
        <set-field>
          <ethernet-match>
            <ethernet-destination>
              <address>00:00:00:11:11:11</address>
            </ethernet-destination>
          </ethernet-match>
        </set-field>
      </action>
    </bucket>
  </buckets>
  <barrier>>false</barrier>
  <group-name>l3_0x2306e4b1</group-name>
  <group-id>587654321</group-id>
</group>
```

3. Flow on Vlan Table (Table ID - 0, Flow ID - 300), Send coming to Port 5 to Table 20(Termination MAC Table)

PUT:

http://192.168.2.1:8181/restconf/config/opendaylight-inventory:nodes/node/openflow:55400/table/0/flow/300

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<flow xmlns="urn:opendaylight:flow:inventory">
  <id>0</id>
  <flow>
    <id>300</id>
    <instructions>
      <instruction>
        <order>0</order>
        <go-to-table>
          <table_id>20</table_id>
        </go-to-table>
      </instruction>
    </instructions>
    <priority>1</priority>
  <table_id>0</table_id>
  <match>
    <in-port>6</in-port>
    <vlan-match>
      <vlan-id>
        <vlan-id-present>true</vlan-id-present>
        <vlan-id>10</vlan-id>
      </vlan-id>
    </vlan-match>
  </match>
  <strict>true</strict>
</flow>
```

Adding Flows to Configure L3 Unicast Route

4. Flow on Unicast table (Table ID - 30, Flow ID - 301) to send packet to group ID - 587654321 (L3 Group Entry) if the IP is 1.1.1.1/24

PUT:

http://192.168.2.1:8181/restconf/config/opendaylight-inventory:nodes/node/openflow:55930/table/30/flow/301

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<flow xmlns="urn:opendaylight:flow:inventory">
  <hard-timeout>0</hard-timeout>
  <idle-timeout>0</idle-timeout>
  <priority>2</priority>
  <flow-name>flow1</flow-name>
  <match>
    <ethernet-match>
      <ethernet-type>
        <type>2048</type>
      </ethernet-type>
    </ethernet-match>
    <ipv4-destination>1.1.1.1/24</ipv4-destination>
  </match>
  <instructions>
    <instruction>
      <order>0</order>
      <write-actions>
        <action>
          <order>0</order>
          <group-action>
            <group-id>587654321</group-id>
          </group-action>
        </action>
      </write-actions>
    </instruction>
  </instructions>
  <id>301</id>
  <table_id>30</table_id>
</flow>
```

5. Flow 2 -- Termination MAC Table Flow Entry

```
<flow xmlns="urn:opendaylight:flow:inventory">
<id>2030610</id>
  <instructions>
    <instruction>
      <order>0</order>
      <go-to-table>
        <table_id>30</table_id>
      </go-to-table>
    </instruction>
  </instructions>
  <priority>2</priority>
<table_id>20</table_id>
<match>
  <in-port>6</in-port>
  <vlan-match>
    <vlan-id>
      <vlan-id-present>true</vlan-id-present>
      <vlan-id>10</vlan-id>
    </vlan-id>
  </vlan-match>
  <ethernet-match>
    <ethernet-destination>
      <address>02:4C:D4:1A:00:01</address>
    </ethernet-destination>
    <ethernet-type>
      <type>33024</type>
    </ethernet-type>
  </ethernet-match>
</match>
  <strict>true</strict>
</flow>
```

Adding Flows to Configure L3 Unicast Route

Configuring L3 ECMP Route

5.1 Adding Flows to Configure L3 ECMP Route

The following flows are required to load balance L3 packets from 5 to ports (6,7 and 8) with Destination IP 3.3.3.0/24 and Destination MAC as switch MAC.

For example,

Openflow Data Path ID is 55400 and Controller IP is 192.168.2.1.

The following is the configuration of Headers on Postman (Rest API based application)

Headers:

Authorization: Basic

Accept: application/xml

Content-type: application/xml

1. Create L2 Group table Entry for VLAN 10, Port 6

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/group/655366
```

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>655366</group-id>
  <group-type>group-indirect</group-type>
  <barrier>false</barrier>
  <group-name>0xa0006</group-name>
  <buckets>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <order>1</order>
        <output-action>
          <output-node-connector>6</output-node-connector>
        </output-action>
      </action>
    </bucket>
  </buckets>
</group>
```

Adding Flows to Configure L3 ECMP Route

2. Create L2 Group table Entry for VLAN 10, Port 7

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/group/655367

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>655367</group-id>
  <group-type>group-indirect</group-type>
  <barrier>>false</barrier>
  <group-name>0xa0007</group-name>
  <buckets>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <order>1</order>
        <output-action>
          <output-node-connector>7</output-node-connector>
        </output-action>
      </action>
    </bucket>
  </buckets>
</group>
```


3. Create L2 Group table Entry for VLAN 10, Port 8

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/group/655368

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>655368</group-id>
  <group-type>group-indirect</group-type>
  <barrier>>false</barrier>
  <group-name>0xa0008</group-name>
  <buckets>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <output-action>
          <output-node-connector>8</output-node-
connector>
        </output-action>
      </action>
    </bucket>
  </buckets>
</group>
```

Adding Flows to Configure L3 ECMP Route

4. L3 Group Entry Creation (L3 group type & Index) - Set Destination MAC and send to L2 group ID for port 6 VLAN 10

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/group/537526278

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>537526278</group-id>
  <group-type>group-indirect</group-type>
  <barrier>>false</barrier>
  <group-name>l3_0x200a0006</group-name>
  <buckets>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <order>0</order>
        <group-action>
          <group-id>655366</group-id>
        </group-action>
      </action>
      <action>
        <order>1</order>
        <set-field>
          <ethernet-match>
            <ethernet-destination>
              <address>00:00:00:00:00:64</address>
            </ethernet-destination>
          </ethernet-match>
        </set-field>
      </action>
    </bucket>
  </buckets>
</group>
```

5. L3 Group Entry Creation (L3 group type & Index) - Set Destination MAC and send to L2 group ID for port 7 VLAN 10

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/group/537526279

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>537526279</group-id>
  <group-type>group-indirect</group-type>
  <barrier>>false</barrier>
  <group-name>l3_0x200a0007</group-name>
  <buckets>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <order>0</order>
        <group-action>
          <group-id>655367</group-id>
        </group-action>
      </action>
      <action>
        <order>1</order>
        <set-field>
          <ethernet-match>
            <ethernet-destination>
              <address>00:00:00:00:00:65</address>
            </ethernet-destination>
          </ethernet-match>
        </set-field>
      </action>
    </bucket>
  </buckets>
</group>
```

Adding Flows to Configure L3 ECMP Route

6. L3 Group Entry Creation (L3 group type & Index) - Set Destination MAC and send to L2 group ID for port 8 VLAN 10

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/group/537526280

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>537526280</group-id>
  <group-type>group-indirect</group-type>
  <barrier>>false</barrier>
  <group-name>l3_0x200a0008</group-name>
  <buckets>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <order>0</order>
        <group-action>
          <group-id>655368</group-id>
        </group-action>
      </action>
      <action>
        <order>1</order>
        <set-field>
          <ethernet-match>
            <ethernet-destination>
              <address>00:00:00:00:00:66</address>
            </ethernet-destination>
          </ethernet-match>
        </set-field>
      </action>
    </bucket>
  </buckets>
</group>
```

7. ECMP L3 Group Entry Creation (ECMP group type & Index) - Set Group Action as Multiple L3 group entries with different bucket id

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/group/1879048213

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>1879048213</group-id>
  <group-type>group-select</group-type>
  <barrier>>false</barrier>
  <group-name>ecmp_0x10001</group-name>
  <buckets>
    <bucket>
      <bucket-id>3</bucket-id>
      <action>
        <order>0</order>
        <group-action>
          <group-id>537526280</group-id>
        </group-action>
      </action>
    </bucket>
    <bucket>
      <bucket-id>2</bucket-id>
      <action>
        <order>0</order>
        <group-action>
          <group-id>537526279</group-id>
        </group-action>
      </action>
    </bucket>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <order>0</order>
        <group-action>
```

Adding Flows to Configure L3 ECMP Route

```
        <group-id>537526278</group-id>
      </group-action>
    </action>
  </bucket>
</buckets>
</group>
```

8. Flow on Vlan Table (Table ID - 0, Flow ID - 1020510), Send coming to Port 5 to Table 20(Termination MAC Table)

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/table/0/flow/1020510

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">
  <table_id>0</table_id>
  <id>1020510</id>
  <instructions>
    <instruction>
      <order>0</order>
      <go-to-table>
        <table_id>20</table_id>
      </go-to-table>
    </instruction>
  </instructions>
  <priority>10</priority>
  <match>
    <in-port>5</in-port>
    <vlan-match>
      <vlan-id>
        <vlan-id-present>true</vlan-id-present>
        <vlan-id>10</vlan-id>
      </vlan-id>
    </vlan-match>
  </match>
  <strict>true</strict>
</flow>
```

Adding Flows to Configure L3 ECMP Route

9. Flow on Termination MAC Table (Table ID - 20, Flow ID - 2030510), Send coming to Port 5 vlan 10 packets to Table 30(Unicast Table)

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/table/20/flow/2030510

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">
  <table_id>20</table_id>
  <id>2030510</id>
  <instructions>
    <instruction>
      <order>0</order>
      <go-to-table>
        <table_id>30</table_id>
      </go-to-table>
    </instruction>
  </instructions>
  <priority>10</priority>
  <match>
    <in-port>5</in-port>
    <vlan-match>
      <vlan-id>
        <vlan-id-present>true</vlan-id-present>
        <vlan-id>10</vlan-id>
      </vlan-id>
    </vlan-match>
    <ethernet-match>
      <ethernet-destination>
        <address>02:4C:D4:1A:00:01</address>
      </ethernet-destination>
      <ethernet-type>
        <type>33024</type>
      </ethernet-type>
    </ethernet-match>
  </match>
  <strict>true</strict>
</flow>
```


10. Flow on Unicast table (Table ID - 30, Flow ID - 30021) to send packet to group ID-1879048213 (L3 ECMP Group Entry) if the IP is 3.3.3.0/24

PUT:

http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55930/table/30/flow/30021

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<flow xmlns="urn:opendaylight:flow:inventory">
  <table_id>30</table_id>
  <id>30021</id>
  <instructions>
    <instruction>
      <order>0</order>
      <write-actions>
        <action>
          <order>0</order>
          <group-action>
            <group-id>1879048213</group-id>
          </group-action>
        </action>
      </write-actions>
    </instruction>
  </instructions>
  <flow-name>flow1</flow-name>
  <match>
    <ethernet-match>
      <ethernet-type>
        <type>2048</type>
      </ethernet-type>
    </ethernet-match>
    <ipv4-destination>3.3.3.0/24</ipv4-destination>
  </match>
  <hard-timeout>0</hard-timeout>
  <priority>2</priority>
  <idle-timeout>0</idle-timeout>
</flow>
```

Adding Flows to Configure L3 ECMP Route

Configuring L2 Multicast Forwarding

6.1 Adding Flows to Configure L2 Multicast Forwarding to VF Ports

The following flows are required for the L2 multicast forwarding from port 5 to the VF ports with multicast destination MAC address 01:00:5e:01:02:03 and the corresponding multicast destination IP 233.1.2.3/32. ODL accepts L3 only.

VF ports Multicast configuration from host

In this scenario, we are using the VF ports of PF p3p1 of SharpNIC™ PCIE-9205. We are creating four VFs: p3p1_0, p3p1_1, p3p1_2, and p3p1_3, along with VLAN 10 on these VFs.

1. Add link from the VF interface to the VLAN on that VF interface.

```
ip link add link <VF_IFACE> name <VF_IFACE.10> type vlan id 10
```

For example:

```
ip link add link p3p1_0 name p3p1_0.10 type vlan id 10
```

2. Create multicast group on these VFs.

```
ip maddr add <Multicast DMAC> dev <VF_IFACE>
```

For example, `ip maddr add 01:00:5e:01:02:03 dev p3p1_0`

3. Verify the multicast group entry.

```
ip maddr show p3p1_0
```

Multicast flows configuration from ODL

To create flows for the Openflow data path ID 55400 and controller IP 192.168.2.1, configure the headers on Postman (REST API based application) as:

Authorization: Basic

Accept: application/xml

Content-type: application/xml

Adding Flows to Configure L2 Multicast Forwarding to VF Ports

L2 Group

To send packets to VFs, you should create the corresponding PF to PEP port L2 group entry. In this case, as the PF is p3p1, the corresponding PEP port is 24.

Create L2 Group table entry for VLAN 10, Port 24

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55400/group/655384
```

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>  
  
<group xmlns="urn:opendaylight:flow:inventory">  
  <group-id>655384</group-id>  
  <group-type>group-indirect</group-type>  
  <barrier>>false</barrier>  
  <group-name>0xa0018</group-name>  
  <buckets>  
    <bucket>  
      <bucket-id>1</bucket-id>  
      <action>  
        <order>1</order>  
        <output-action>  
          <output-node-connector>24</output-node-connector>  
        </output-action>  
      </action>  
    </bucket>  
  </buckets>  
</group>
```

Adding Flows to Configure L2 Multicast Forwarding to VF Ports

Multicast Group

For the L2 multicast group entry creation, set the Group Action as Single/Multiple L2 group entries with a different bucket id.

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55400/group/1610612760
```

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>  
  
<group xmlns="urn:opendaylight:flow:inventory">  
  <group-id>1610612760</group-id>  
  <group-type>group-all</group-type>  
  <barrier>>false</barrier>  
  <group-name>0x60000000</group-name>  
  <buckets>  
    <bucket>  
      <bucket-id>1</bucket-id>  
      <action>  
        <order>0</order>  
        <group-action>  
          <group-id>655384</group-id>  
        </group-action>  
      </action>  
    </bucket>  
  </buckets>  
</group>
```

Adding Flows to Configure L2 Multicast Forwarding to VF Ports

Flow entry on the VLAN table (Table ID=0, Flow ID=1020510), Ingress port 5 to Table 20 (termination on MAC table).

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55400/table/0/flow/1020510
```

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">  
  <table_id>0</table_id>  
  <id>1020510</id>  
  <instructions>  
    <instruction>  
      <order>0</order>  
      <go-to-table>  
        <table_id>20</table_id>  
      </go-to-table>  
    </instruction>  
  </instructions>  
  <priority>10</priority>  
  <match>  
    <in-port>5</in-port>  
    <vlan-match>  
      <vlan-id>  
        <vlan-id-present>true</vlan-id-present>  
        <vlan-id>10</vlan-id>  
      </vlan-id>  
    </vlan-match>  
  </match>  
  <strict>true</strict>  
</flow>
```

Adding Flows to Configure L2 Multicast Forwarding to VF Ports

Flow entry on the termination MAC table (Table ID=20, Flow ID=2040510), Ingress port 5 VLAN 10 packets to Table 40 (multicast flow table).

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55400/table/20/flow/2040510
```

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">  
  <table_id>20</table_id>  
  <id>2040510</id>  
  <instructions>  
    <instruction>  
      <order>0</order>  
      <go-to-table>  
        <table_id>40</table_id>  
      </go-to-table>  
    </instruction>  
  </instructions>  
  <priority>10</priority>  
  <match>  
    <in-port>5</in-port>  
    <vlan-match>  
      <vlan-id>  
        <vlan-id-present>true</vlan-id-present>  
        <vlan-id>10</vlan-id>  
      </vlan-id>  
    </vlan-match>  
    <ethernet-match>  
      <ethernet-destination>  
        <address>01:00:5e:01:02:03</address>  
      </ethernet-destination>  
      <ethernet-type>  
        <type>33024</type>  
      </ethernet-type>  
    </ethernet-match>  
  </match>  
</flow>
```

Adding Flows to Configure L2 Multicast Forwarding to VF Ports

```
        </match>  
        <strict>true</strict>  
</flow>
```


Adding Flows to Configure L2 Multicast Forwarding to VF Ports

Flow entry on the multicast flow table (Table ID=40, Flow ID=40024), to send packet to group ID=1610612760 (multicast group) with the DST IP=233.1.2.3/32.

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55930/table/40/flow/40024
```

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">  
  <table_id>40</table_id>  
  <id>40024</id>  
  <instructions>  
    <instruction>  
      <order>0</order>  
      <write-actions>  
        <action>  
          <order>0</order>  
          <group-action>  
            <group-id>1610612760</group-id>  
          </group-action>  
        </action>  
      </write-actions>  
    </instruction>  
  </instructions>  
  <priority>2</priority>  
  <table_id>40</table_id>  
  <match>  
    <vlan-match>  
      <vlan-id>  
        <vlan-id-present>true</vlan-id-present>  
        <vlan-id>10</vlan-id>  
      </vlan-id>  
    </vlan-match>  
    <ethernet-match>  
      <ethernet-type>  
        <type>2048</type>
```

```
        </ethernet-type>
    </ethernet-match>
    <ipv4-destination>233.1.2.3/32</ipv4-destination>
</match>
<strict>>true</strict>
</flow>
```

6.2 Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

The following flows are required for the L2 multicast forwarding from port 5 to the EPL (port 6 and 7), PF (p3p1), and VF ports with the multicast destination MAC address 01:00:5e:01:02:03 and the corresponding multicast destination IP 233.1.2.3/32 (ODL accepts L3 only).

PF/VF ports Multicast configuration from host

In this scenario, we are using the VF ports of PF p3p1 of SharpNIC PCIE-9205. We are creating four VFs: p3p1_0, p3p1_1, p3p1_2, and p3p1_3, along with VLAN 10 on these VFs.

1. Add link from the PF interface to the VLAN on the PF interface.

```
ip link add link <PF/VF_IFACE> name <PF/VF_IFACE.10> type vlan id
10
```

For example, use the following command to add VLAN on the PF interface:

```
ip link add link p3p1 name p3p1.10 type vlan id 10
```

2. Create multicast group on these PF/VFs.

```
ip maddr add <Multicast DMAC> dev <PF/VF_IFACE>
```

For example, use the following command to add PF on multicast group:

```
ip maddr add 01:00:5e:01:02:03 dev p3p1
```

3. Verify the multicast group entry.

```
ip maddr show p3p1
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

Multicast flows configuration from ODL

To create flows for Openflow data path ID 55400 and controller IP 192.168.2.1, configure the headers on Postman (REST API based application) as:

Authorization: Basic

Accept: application/xml

Content-type: application/xml

L2 Group for EPL

To send packets to EPL, you should create the corresponding EPL port L2 group entry. In this case, the EPL ports are 6 and 7.

Create L2 Group table entry for VLAN 10, port 6.

PUT:

```
http://192.168.2.1:8181/restconf/config/.opendaylightinventory:  
nodes/node/openflow:55400/group/655366
```

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>  
  
<group xmlns="urn:opendaylight:flow:inventory">  
  <group-id>655366</group-id>  
  <group-type>group-indirect</group-type>  
  <barrier>false</barrier>  
  <group-name>0xa0006</group-name>  
  <buckets>  
    <bucket>  
      <bucket-id>1</bucket-id>  
      <action>  
        <order>1</order>  
        <output-action>  
          <output-node-connector>6</output-node-connector>  
        </output-action>  
      </action>  
    </bucket>  
  </buckets>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

```
</group>
```

Create L2 Group table entry for VLAN 10, Port 7

PUT:

```
http://192.168.2.1:8181/restconf/config/.opendaylightinventory:  
nodes/node/openflow:55400/group/655367
```

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>  
  
<group xmlns="urn:opendaylight:flow:inventory">  
  <group-id>655367</group-id>  
  <group-type>group-indirect</group-type>  
  <barrier>>false</barrier>  
  <group-name>0xa0007</group-name>  
  <buckets>  
    <bucket>  
      <bucket-id>1</bucket-id>  
      <action>  
        <order>1</order>  
        <output-action>  
          <output-node-connector>7</output-node-connector>  
        </output-action>  
      </action>  
    </bucket>  
  </buckets>  
</group>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

L2 Group for PF/VF

To send packets to VFs, you should create the corresponding PF to PEP port L2 group entry. In this case, as the PF is p3p1, the corresponding PEP port is 24.

Create L2 Group table entry for VLAN 10, Port 24

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:
```

```
nodes/node/openflow:55400/group/655384
```

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>

<group xmlns="urn:opendaylight:flow:inventory">
  <group-id>655384</group-id>
  <group-type>group-indirect</group-type>
  <barrier>false</barrier>
  <group-name>0xa0018</group-name>
  <buckets>
    <bucket>
      <bucket-id>1</bucket-id>
      <action>
        <order>1</order>
        <output-action>
          <output-node-connector>24</output-node-connector>
        </output-action>
      </action>
    </bucket>
  </buckets>
</group>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

Multicast Group

For the L2 multicast group entry creation, set the Group Action as Single/Multiple L2 group entries with different bucket id: EPL (port 6 and 7) and PF (port p3p1) port L2 groups.

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55400/group/1610612773
```

Body:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>  
  
<group xmlns="urn:opendaylight:flow:inventory">  
  <group-id>1610612773</group-id>  
  <group-type>group-all</group-type>  
  <barrier>>false</barrier>  
  <group-name>0x60000000</group-name>  
  <buckets>  
    <bucket>  
      <bucket-id>3</bucket-id>  
      <action>  
        <order>0</order>  
        <group-action>  
          <group-id>655384</group-id>  
        </group-action>  
      </action>  
    </bucket>  
    <bucket>  
      <bucket-id>2</bucket-id>  
      <action>  
        <order>0</order>  
        <group-action>  
          <group-id>655367</group-id>  
        </group-action>  
      </action>  
    </bucket>  
    <bucket>  
      <bucket-id>1</bucket-id>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

```
        <action>
            <order>0</order>
            <group-action>
                <group-id>655366</group-id>
            </group-action>
        </action>
    </bucket>
</buckets>
</group>
```

Flow entry on the VLAN table (Table ID=0, Flow ID=1020510), Ingress port 5 to Table 20 (termination on MAC table).

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:
nodes/node/openflow:55400/table/0/flow/1020510
```

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">
  <table_id>0</table_id>
  <id>1020510</id>
  <instructions>
    <instruction>
      <order>0</order>
      <go-to-table>
        <table_id>20</table_id>
      </go-to-table>
    </instruction>
  </instructions>
  <priority>10</priority>
  <match>
    <in-port>5</in-port>
    <vlan-match>
      <vlan-id>
        <vlan-id-present>true</vlan-id-present>
        <vlan-id>10</vlan-id>
      </vlan-id>
    </vlan-match>
  </match>
</flow>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

```
        </vlan-id>
    </vlan-match>
</match>
    <strict>true</strict>
</flow>
```


Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

Flow entry on the termination MAC table (Table ID=20, Flow ID=2040510), Ingress port 5 VLAN 10 packets to Table 40 (multicast flow table).

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55400/table/20/flow/2040510
```

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">  
  <table_id>20</table_id>  
  <id>2040510</id>  
  <instructions>  
    <instruction>  
      <order>0</order>  
      <go-to-table>  
        <table_id>40</table_id>  
      </go-to-table>  
    </instruction>  
  </instructions>  
  <priority>10</priority>  
  <match>  
    <in-port>5</in-port>  
    <vlan-match>  
      <vlan-id>  
        <vlan-id-present>true</vlan-id-present>  
        <vlan-id>10</vlan-id>  
      </vlan-id>  
    </vlan-match>  
    <ethernet-match>  
      <ethernet-destination>  
        <address>01:00:5e:01:02:03</address>  
      </ethernet-destination>  
      <ethernet-type>  
        <type>33024</type>  
      </ethernet-type>  
    </ethernet-match>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

```
        </match>  
        <strict>true</strict>  
</flow>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

Flow entry on the multicast flow table (Table ID=40, Flow ID=40024), to send packet to group ID=1610612773 (multicast group) with the DST IP=233.1.2.3/32.

PUT:

```
http://192.168.2.1:8181/restconf/config/opendaylightinventory:  
nodes/node/openflow:55930/table/40/flow/40037
```

Body:

```
<flow xmlns="urn:opendaylight:flow:inventory">  
  <table_id>40</table_id>  
  <id>40037</id>  
  <instructions>  
    <instruction>  
      <order>0</order>  
      <write-actions>  
        <action>  
          <order>0</order>  
          <group-action>  
            <group-id>1610612773</group-id>  
          </group-action>  
        </action>  
      </write-actions>  
    </instruction>  
  </instructions>  
  <priority>2</priority>  
  <table_id>40</table_id>  
  <match>  
    <vlan-match>  
      <vlan-id>  
        <vlan-id-present>>true</vlan-id-present>  
        <vlan-id>10</vlan-id>  
      </vlan-id>  
    </vlan-match>  
    <ethernet-match>  
      <ethernet-type>  
        <type>2048</type>
```

Adding Flows to Configure L2 Multicast Forwarding to EPL, PF, and VF Ports

```
        </ethernet-type>
    </ethernet-match>
    <ipv4-destination>233.1.2.3/32</ipv4-destination>
</match>
    <strict>true</strict>
</flow>
```

Related Documentation

A.1 SMART Embedded Computing Documentation

1. The documentation listed is referenced in this manual. Technical documentation can be found by using the Documentation Search at <https://www.smartembedded.com/ec/support/> or you can obtain electronic copies of SMART EC documentation by contacting your local sales representative.

Table A-1 SMART Embedded Computing Publications

Document Title	Publication Number
Switch Software for SharpNIC™ PCIE-9205 CLI Guide	6806800T85
SharpNIC™ PCIE-9205 Quick Start Guide	6806800U04
Openflow Abstract Switch Application Note	Contact your local SMART EC Sales Office

