Open vSwitch Test Plan

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Contents

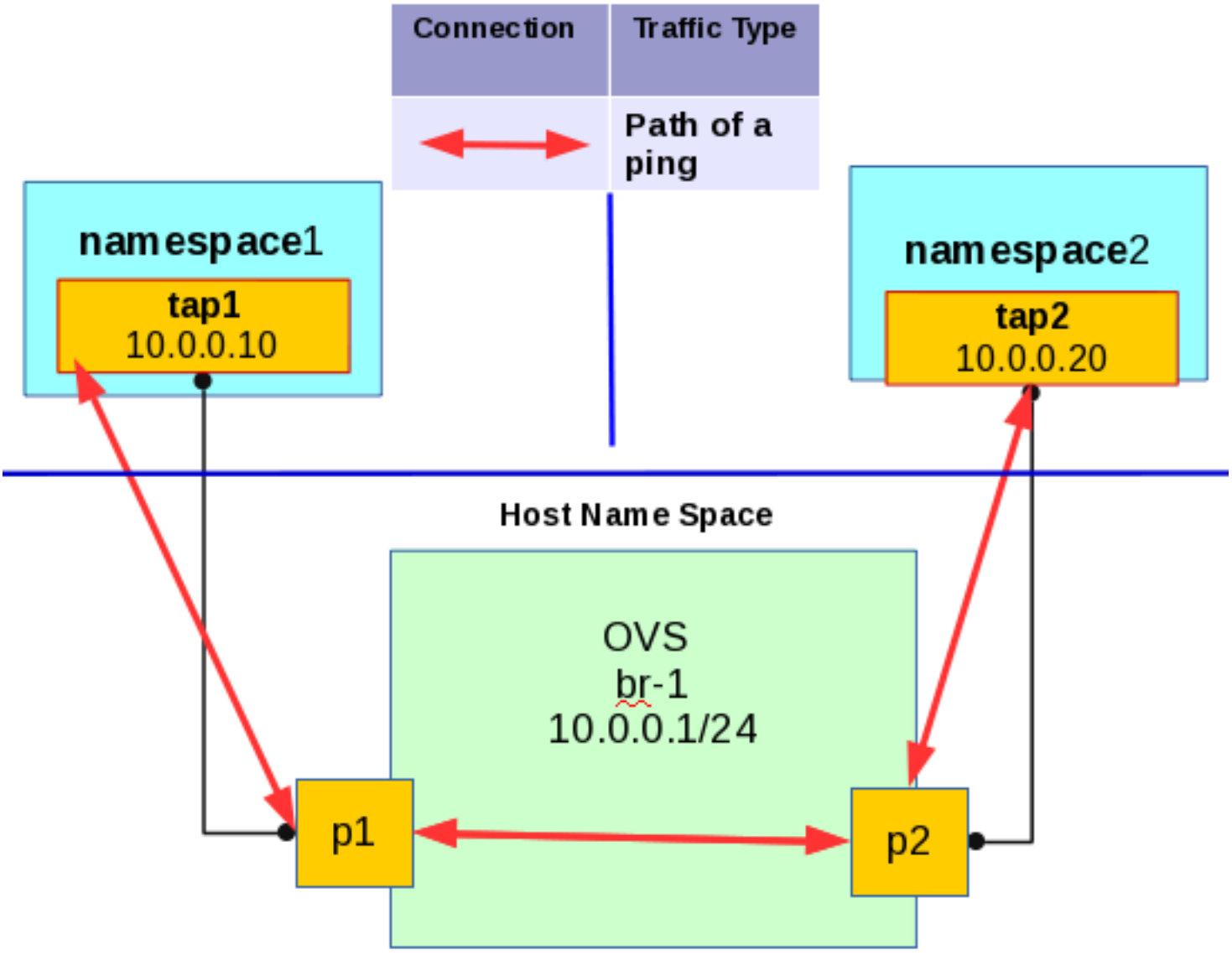
1 Introduction and Methodology

The purpose of this test plan is to test Open vSwitch (OvS). The document provides commands and the expected output. This test plan aims to provide a pass/failure reference point based on the output of the command. Output may change over time due to the nature of this project, however certain information should still be retained from output to signify a pass or failure. Important information from output will be highlited. Verify that your output has something similar to the highlited parts of the output.

Each section is self-containing such that you may skip around the document. After setup and execution of tests, the test concludes with a verification section. Highlited output missing from verification section would indicate a failure. If there is a possibility of a failure refer to the Appendix first. Make sure you remove previous bridges or interfaces before moving to the next test in case there is a naming conflict.

This test plan utilizes network name spaces (ns) to create virtual network endpoints in order to test the features of OvS. Each network name space will be an endpoint on our virtual switch. The picture below represents the basic network topology this test plan will use.

Figure 1: Path of ICMP packet from `namespace1` through `br-1` to `namespace2`



Looking at the diagram above we see 3 name spaces. One root name space, and 2 network name spaces. The veth peers for `namespace1` are `tap1` and `p1`. `tap1` device exists only inside namespace1. Much similar to a VM having a different

Ethernet interface than the host machine. *Please note that root namespace and host are used interchanbly throughout the document.* `p1` exists on the host and in this picture it has been added as a port to the OvS bridge named `br-1`. Additional information about name spaces may be found in appendix B.

Commands below are going to be used most often in this test plan

- `ovs-vsctl` : Used for configuring the ovs-vswitchd configuration database (known as ovs-db)
- `ovs-ofctl` : A command line tool for monitoring and administering OpenFlow switches
- `ovs-appctl` : A utility that sends commands to and controls Open vSwitch daemons
- `ovsdb-tool` : Open vSwitch database management utility
- `netperf` : a network performance benchmark
- `tcpdump` : dump traffic on a network
- `netcat` : create, concatenate, and redirect sockets.

Any refernce to another section will be a clickable link to that section.

2 Installation

2.1 RHEL: Installing .rpm

```
# yum install openvswitch
```

Verify the `openvswitch.service` is running with systemctl

```
# systemctl status openvswitch
 openvswitch.service - LSB: Open vSwitch switch
   Loaded: loaded (/etc/rc.d/init.d/openvswitch; bad; vendor preset: disabled)
   Active: active (running) since Thu 2017-03-16 14:30:46 PDT; 28min ago
```

Here we can see that its `Active: active (running)`

2.2 Ubuntu: Installing .deb

```
# apt-get install openvswitch-common
# apt-get install openvswitch-switch
```

Verify the `openvswitch-switch.service` is `active`

```
# systemctl status openvswitch-switch.service
 openvswitch-switch.service - Open vSwitch
   Loaded: loaded (/lib/systemd/system/openvswitch-switch.service; enabled;)
   Active: active (exited) since Wed 2017-03-22 18:08:12 EDT; 6 days ago
  Process: 5754 ExecStart=/bin/true (code=exited, status=0/SUCCESS)
 Main PID: 5754 (code=exited, status=0/SUCCESS)
    Tasks: 0 (limit: 4915)
   CGroup: /system.slice/openvswitch-switch.service

Mar 22 18:08:12 ubu-1610 systemd[1]: Starting Open vSwitch...
Mar 22 18:08:12 ubu-1610 systemd[1]: Started Open vSwitch.
```

3 Verifying Installation

```
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    ovs_version: "2.7.0"
```

Check that `ovs-vswitchd` and `ovsdb-server` are running. Use `ps -aef` command like so:

```
# ps -aef | grep ovs
root      6528  6482  grep --color=auto ovs
root     25748     1 ovsdb-server: monitoring pid 25749 (healthy)
root     25749 25748 ovsdb-server /etc/openvswitch/conf.db -vconsole:emer
                -vsyslog:err -vfile:info
                --remote=punix:/var/run/openvswitch/db.sock
                --private-key=db:Open_vSwitch,SSL,private_key
                --certificate=db:Open_vSwitch,SSL,certificate
                --bootstrap-ca-cert=db:Open_vSwitch,SSL,ca_cert --no-chdir
                --log-file=/var/log/openvswitch/ovsdb-server.log
                --pidfile=/var/run/openvswitch/ovsdb-server.pid --detach
root     25759     1  ovs-vswitchd: monitoring pid 25760 (healthy)
root     25760 25759  ovs-vswitchd unix:/var/run/openvswitch/db.sock
                -vconsole:emer -vsyslog:err -vfile:info --mlockall --no-chdir
                --log-file=/var/log/openvswitch/ovs-vswitchd.log
                --pidfile=/var/run/openvswitch/ovs-vswitchd.pid --detach
```

Ensure the Open vSwitch kernel module is loaded.

```
# lsmod | grep openv
openvswitch           159225  2
nf_defrag_ipv6         31537  2 openvswitch,nf_conntrack_ipv6
nf_nat_ipv6            11592  2 openvswitch,ip6table_nat
nf_nat_ipv4            10744  2 openvswitch,iptable_nat
nf_nat                 22593  3 openvswitch,nf_nat_ipv4,nf_nat_ipv6
nf_conntrack          135188  7 openvswitch,nf_nat,nf_nat_ipv4,nf_nat_ipv6,
libcrc32c               1614  2 xfs,openvswitch

#  modinfo openvswitch
filename:       /lib/modules/3.10.0-514.el7.ppc64le/kernel/net/
                            openvswitch/openvswitch.ko
license:        GPL
description:    Open vSwitch switching datapath
rhelversion:    7.3
srcversion:     B31AE95554C9D9A0067F935
depends:        nf_conntrack,nf_nat,libcrc32c,nf_nat_ipv6,nf_nat_ipv4
intree:         Y
vermagic:       3.10.0-514.el7.ppc64le SMP mod_unload modversions
signer:         Red Hat Enterprise Linux kernel signing key
sig_key:        12:17:2E:5E:C7:C7:70:4C:68:03:23:AD:F1:D5:8C:88:66:C0:A6:AB
sig_hashalgo:   sha256
```

For further instructions and troubleshooting refer to appendix A

4 Testing Basic OvS Configurations

4.1 OvS Database

First determine where your db is located. Print out the running OvS processes and search for the `.db` file location:

```
# ps -aef | grep openv | grep db
root  8521  8520  0 14:04 ? 00:00:00 ovsdb-server /etc/openvswitch/conf.db
        -vconsole:emer -vsyslog:err -vfile:info
        --remote=punix:/var/run/openvswitch/db.sock
        --private-key=db:Open_vSwitch,SSL,private_key
        --certificate=db:Open_vSwitch,SSL,certificate
        --bootstrap-ca-cert=db:Open_vSwitch,SSL,ca_cert
        --no-chdir --log-file=/var/log/openvswitch/ovsdb-server.log
        --pidfile=/var/run/openvswitch/ovsdb-server.pid --detach --monitor
```

```
root 8532  8531 0 14:04 ? 00:00:00 ovs-vswitchd unix:/var/run/openvswitch/db.sock
        -vconsole:emer -vsyslog:err -vfile:info --mlockall --no-chdir
        --log-file=/var/log/openvswitch/ovs-vswitchd.log
        --pidfile=/var/run/openvswitch/ovs-vswitchd.pid --detach --monitor
```

Here we can see `PID: 8521` is running the ovdb-server from the database located in `/etc/openvswitch/conf.db`
To see the version number of the schema embedded within the database db

```
# ovsdb-tool db-version /etc/openvswitch/conf.db
7.14.0
```

View the newest logs from the database like so:

```
# ovsdb-tool show-log /etc/openvswitch/conf.db | tail
record 962: 2017-03-27 18:17:13.646
record 963: 2017-03-27 18:17:13.646
record 964: 2017-03-27 18:17:44.863 "ovs-vsctl (invoked by -bash):
                ovs-vsctl add-port br-1 p1"
record 965: 2017-03-27 18:17:44.867
record 966: 2017-03-27 19:07:17.562 "ovs-vsctl (invoked by -bash):
                ovs-vsctl del-br br-1"
record 967: 2017-03-27 19:07:17.672
record 969: 2017-03-27 21:07:51.038 "ovs-vsctl (invoked by -bash):
                ovs-vsctl add-br br-1"
record 970: 2017-03-27 21:07:51.088
record 971: 2017-03-27 21:07:51.089
```

If we add a new bridge called `br-3` we will see the logs updated:

```
# ovs-vsctl add-br br-3
# ovsdb-tool show-log /etc/openvswitch/conf.db | tail
record 965: 2017-03-27 18:17:44.867
record 966: 2017-03-27 19:07:17.562 "ovs-vsctl (invoked by -bash):
                ovs-vsctl del-br br-1"
record 967: 2017-03-27 19:07:17.672
record 969: 2017-03-27 21:07:51.038 "ovs-vsctl (invoked by -bash):
                ovs-vsctl add-br br-1"
record 970: 2017-03-27 21:07:51.088
record 971: 2017-03-27 21:07:51.089
record 972: 2017-03-27 21:20:02.145 "ovs-vsctl (invoked by -bash):
                ovs-vsctl add-br br-3"
record 973: 2017-03-27 21:20:02.169
record 974: 2017-03-27 21:20:02.169
```

4.2 Create a Bridge

```
# ovs-vsctl add-br br-1
#
```

A new Open vSwitch bridge has been created.

```
# brctl show
bridge name     bridge id               STP enabled     interfaces
#
```

4.2.1 Verify the Bridge Has Been Created

```
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
```

```
        Port "br-1"
            Interface "br-1"
                type: internal
    ovs_version: "2.7.0"
```

A new bridge interface has been created, in this example named `br-1`

```
# ip add  | grep br-1
br-1: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN qlen 1000
    link/ether ba:db:f2:e7:8f:4a brd ff:ff:ff:ff:ff:ff
```

New records have been written to the database at nearly the same time our bridge was created:

```
# ovsdb-tool show-log /etc/openvswitch/conf.db | tail
record 984: 2017-03-29 01:29:12.859 "ovs-vsctl (invoked by -bash):
                                    ovs-vsctl add-br br-1"
record 985: 2017-03-29 01:29:12.887
record 986: 2017-03-29 01:29:12.887
```

A new flow table for the new interface `br-1` has been added.

```
# ovs-ofctl show br-1
OFPT_FEATURES_REPLY (xid=0x2): dpid:0000badbf2e78f4a
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
actions: output enqueue set_vlan_vid set_vlan_pcp strip_vlan mod_dl_src
                                    mod_nw_tos mod_tp_src mod_tp_dst
 LOCAL(br-1): addr:ba:db:f2:e7:8f:4a
     config:     PORT_DOWN
     state:      LINK_DOWN
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

4.3 Adding Flow to Bridge

```
# ovs-ofctl dump-flows br-1
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=11262.392s, table=0, n_packets=16, n_bytes=1296,
        idle_age=11249, priority=0 actions=NORMAL
```

Add a new flow (using OpenFlow) to Table 0 that drops invalid multicast packets.

```
# ovs-ofctl add-flow br0 \
"table=0, dl_src=01:00:00:00:00:00/01:00:00:00:00:00, actions=drop"
```

We added a new flow using the OpenFlow match field `dl_src`. This flow will drop any broadcast or multicast packets with an invlaid source MAC address (the source must be a unicast address).

4.3.1 Verify a New Flow is Added

```
# ovs-ofctl dump-flows br-1
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=4.678s, table=0, n_packets=0, n_bytes=0,
        idle_age=4, dl_src=01:00:00:00:00:00/01:00:00:00:00:00 actions=drop
 cookie=0x0, duration=11350.365s, table=0, n_packets=16, n_bytes=1296,
        idle_age=11337, priority=0 actions=NORMAL
```

4.4 Removing a Bridge

```
# ovs-vsctl del-br br-1
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    ovs_version: "2.7.0"
```

```
# ip add | grep br-1
#
```

5 Connecting NS to OvS Bridge

5.1 Setup

- 1 Bridge
- 1 Name space

5.1.1 Create Bridge

```
#!/bin/bash

# Create OVS switch
ovs-vsctl add-br br-1

#assign IP address
ip addr add 10.0.0.1/24 dev br-1

#bring the bridge interface up
ip link set br-1 up
```

Verify that you see the bridge:

```
# ip addr | grep br-1
4: br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state
        UNKNOWN qlen 1000
    inet 10.0.0.1/24 scope global br-1
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
    ovs_version: "2.7.0"
```

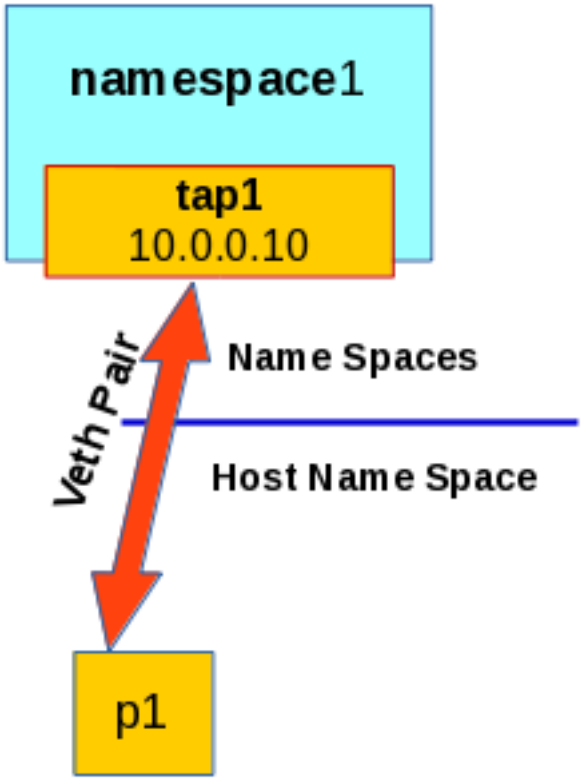
5.1.2 Create a NS with IP Address

```
#!/bin/bash

#create name spaces
ip netns add ns1

# create a port pair. the tap1 exists in the ns, p1 on host
ip link add tap1 type veth peer name p1

#attach namespace dev tap1 to ns1 such that tap1 exists only in ns1
ip link set tap1 netns ns1

#turn on port on OVS. exists on host network
ip link set dev p1 up

#assign ip addresses.
ip netns exec ns1 ip add add 10.0.0.10/24 dev tap1

#turn ports on in ns. execute command inside ns
ip netns exec ns1 ip link set dev tap1 up
```

5.1.3 Attach NS Port to OvS Bridge

We have created a name space with a network interface. The network interface inside the name space is named `tap1`. This interface will be connected to the `p1` interface on the host machine.

Figure 2: Veth Pair `tap1` inside `namespace1` and `p1` on host network



Attach the interface on the host to the OvS bridge `br-1`

```
# ovs-vsctl add-port br-1 p1
#
```

Verify it exists on the bridge

```
# ovs-vsctl show
 d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "p1"
            Interface "p1"
        Port "br-1"
            Interface "br-1"
                type: internal
    ovs_version: "2.7.0"
```

5.2 Verifying NS Connection to Bridge

Look at stats of p1 interface on the bridge

```
# ovs-ofctl dump-ports br-1 p1
OFPST_PORT reply (xid=0x4): 1 ports
  port  1: rx pkts=8, bytes=648, drop=0, errs=0, frame=0, over=0, crc=0
           tx pkts=10, bytes=788, drop=0, errs=0, coll=0
```

There is a new flow table for `p1`

```
# ovs-ofctl show br-1
OFPT_FEATURES_REPLY (xid=0x2): dpid:000006cc0333ba4b
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
actions: output enqueue set_vlan_vid set_vlan_pcp strip_vlan mod_dl_src
                mod_dl_dst mod_nw_src mod_nw_dst mod_nw_tos mod_tp_src mod_tp_dst
 1(p1): addr:76:20:7f:2a:62:1a
     config:     0
     state:      0
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 LOCAL(br-1): addr:06:cc:03:33:ba:4b
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

5.3 Ping Verification

ping bridge br-1 from ns1

```
# ip netns exec ns1 ping -c2 10.0.0.1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp seq=1 ttl=64 time=0.166 ms
64 bytes from 10.0.0.1: icmp seq=2 ttl=64 time=0.019 ms

--- 10.0.0.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.019/0.092/0.166/0.074 ms
```

Ping ns1 from root namespace

```
# ping -c2 10.0.0.10
PING 10.0.0.10 (10.0.0.10) 56(84) bytes of data.
64 bytes from 10.0.0.10: icmp seq=1 ttl=64 time=0.480 ms
64 bytes from 10.0.0.10: icmp seq=2 ttl=64 time=0.024 ms

--- 10.0.0.10 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.024/0.252/0.480/0.228 ms
```

Additionally, the usage stats from `ovs-ofctl dump-ports br-1 p1` should have increased.

5.4 Clean Up

```
# ovs-vsctl del-port p1
#
```

Even though we removed the interface from the bridge, `p1` still exists in the root namespace

```
# ip add | grep p1
392: p1@if393: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
        qlen 1000
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
    ovs_version: "2.7.0"
```

Remove bridge.

```
# ovs-vsctl del-br br-1
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    ovs_version: "2.7.0"
# ip add | grep br-1
#
```

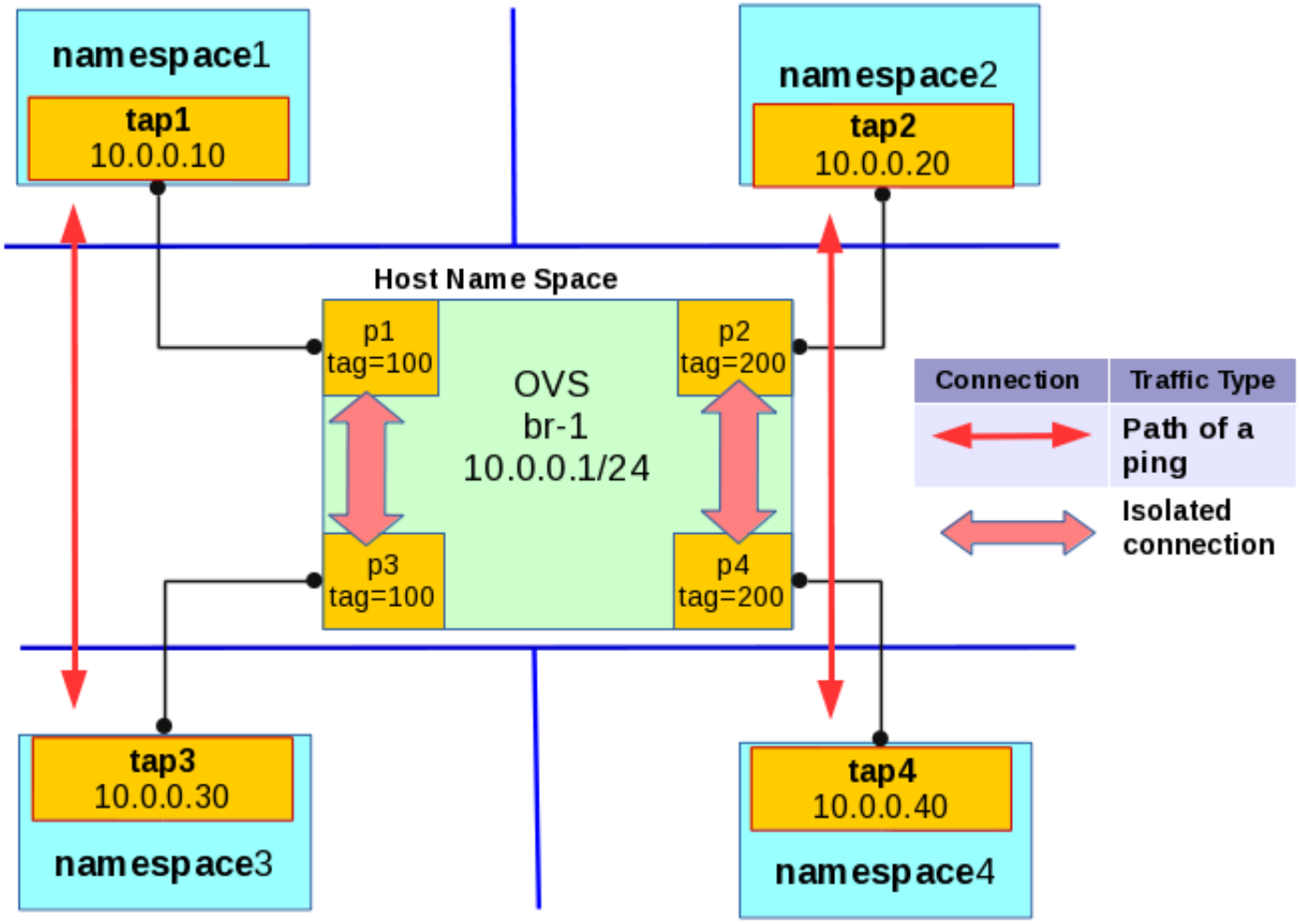
Remove ns

```
# ip netns delete ns1
#
```

6 VLAN Testing

By default, all OvS ports are VLAN trunk ports. Packets sent and received on a trunk port are able to carry a VLAN header that says what VLAN the packet belongs to.
Using VLAN tags, we can connect 2 name spaces to each other with a specific tag. ns1 will have the same VLAN tag as ns3 such that ns1 cannot ping ns2 because it is not in the same VLAN.
These settings are ephemeral. That is, when you power off the guest, the portand its associated configurationgoes away.

Figure 3: VLAN tags are used to isolate `namespace1` and `namespace4` from `namespace2` and `namespace3`



6.1 Setup

- 1 Bridge

- 4 Name spaces

Create a bridge like so.

```
#!/bin/bash

# Create OVS switch
ovs-vsctl add-br br-1

#assign IP address
ip addr add 10.0.0.1/24 dev br-1

#bring the bridge interface up
ip link set br-1 up
```

Create 4 name spaces attached to our bridge

```
#!/bin/bash

#Creates name spaces with ports attached to OVS.
#Assigns an IP address to name space devices

BR=1
NUMNS=4
IP=10.0.0.0

for i in `seq 1 $NUMNS`;
do
        #create name spaces
        ip netns add ns$i

        # create a port pair. the tap$i exists in the ns, br-p$i on host
        ip link add tap$i type veth peer name p$i

        #attach namespace port to OVS
        ovs-vsctl add-port br-$BR p$i

        #attach namespace dev tap$i to ns1 such that tap$i exists only in ns1
        ip link set tap$i netns ns$i

        #turn on port on OVS. exists on host network
        ip link set dev p$i up

        #add ten to last octet of network ip addr
        IP=$(echo $IP | awk -F. '{printf "%d.%d.%d.%d", $1,$2,$3,$4+10}')

        #assign ip addresses.
        ip netns exec ns$i ip add add $IP/24 dev tap$i

        #bring the interface in ns1 up
        ip netns exec ns$i ip link set dev tap$i up

done

#ovs-vsctl show
```

Each name space has a different IP address but belongs to same subnet.

```
# ip netns exec ns1 ip add | grep 10
```

```
 tap1@if415: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
    inet 10.0.0.10/24 brd 10.0.0.255 scope global tap1
#
# ip netns exec ns3 ip add | grep 10
tap3@if419: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
    inet 10.0.0.30/24 brd 10.0.0.255 scope global tap3
```

6.1.1 Assigning Tags to Ports

```
# ovs-vsctl set port p1 tag=100
# ovs-vsctl set port p3 tag=100
```

```
# ovs-vsctl set port p2 tag=200
# ovs-vsctl set port p4 tag=200
```

```
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "p2"
            tag: 200
            Interface "p2"
        Port "p3"
            tag: 100
            Interface "p3"
        Port "p4"
            tag: 200
            Interface "p4"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p1"
            tag: 100
            Interface "p1"
    ovs_version: "2.7.0"
```

`br-1` is not a fake bridge. This bridge does not have 1 single VLAN ID assigned to it, thus:

```
# ovs-vsctl br-to-vlan br-1
0
```

6.2 Ping Verification

Verify name spaces are isolated with pings

```
# ip netns exec ns1 ping -c2 10.0.0.30
 ip netns exec ns1 ping -c2 10.0.0.30
PING 10.0.0.30 (10.0.0.30) 56(84) bytes of data.
64 bytes from 10.0.0.30: icmp_seq=1 ttl=64 time=0.807 ms
64 bytes from 10.0.0.30: icmp_seq=2 ttl=64 time=0.032 ms

--- 10.0.0.30 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.032/0.419/0.807/0.388 ms

# ip netns exec ns2 ping -c2 10.0.0.40
PING 10.0.0.40 (10.0.0.40) 56(84) bytes of data.
64 bytes from 10.0.0.40: icmp_seq=1 ttl=64 time=0.585 ms
64 bytes from 10.0.0.40: icmp_seq=2 ttl=64 time=0.054 ms
```

```
--- 10.0.0.40 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.054/0.319/0.585/0.266 ms
```

The pings below will not work because ns2 is connected to ns4 which is at 10.0.0.40

```
# ip netns exec ns2 ping -c1 10.0.0.30
PING 10.0.0.30 (10.0.0.30) 56(84) bytes of data.

--- 10.0.0.30 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms
```

```
# ip netns exec ns1 ping -c1 10.0.0.40
PING 10.0.0.40 (10.0.0.40) 56(84) bytes of data.

--- 10.0.0.40 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms
```

6.3 Creating a Fake Bridge

OVS fake bridges look and act like a bridge, but are tied to a particular VLAN ID.

```
# ovs-vsctl add-br vlan100 br-1 100
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "p2"
            tag: 200
            Interface "p2"
        Port "vlan100"
            tag: 100
            Interface "vlan100"
                type: internal
        Port "p3"
            tag: 100
            Interface "p3"
        Port "p4"
            tag: 200
            Interface "p4"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p1"
            tag: 100
            Interface "p1"
    ovs_version: "2.7.0"
```

Create a namespace and attach it to the fake bridge

```
# ip netns add ns5
# ip link add tap100 type veth peer name p100
# ip link set tap100 netns ns5
# ip netns exec ns5 ip link set dev tap100 up
# ip link set dev p100 up
# ip netns exec ns5 ip addr add 10.0.0.100/24 dev tap100
```

Add the new `ns5` to fake bridge `vlan100`

```
# ovs-vsctl add-port vlan100 p100
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
         Port "p100"
              tag: 100
              Interface "p100"
        Port "p2"
            tag: 200
            Interface "p2"
        Port "vlan100"
            tag: 100
            Interface "vlan100"
                type: internal
        Port "p3"
            tag: 100
            Interface "p3"
        Port "p4"
            tag: 200
            Interface "p4"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p1"
            tag: 100
            Interface "p1"
    ovs_version: "2.7.0"
```

The name space's port `p100` was automatically assigned tag 100 because it is a port on the fake bridge `vlan100`.

6.3.1 Verifying Fake Bridge

```
# ovs-vsctl br-to-vlan vlan100
100
# ovs-vsctl br-to-parent vlan100
br-1
```

```
# ip netns exec ns5 ping -c2 10.0.0.10
PING 10.0.0.10 (10.0.0.10) 56(84) bytes of data.
64 bytes from 10.0.0.10: icmp_seq=1 ttl=64 time=0.278 ms
64 bytes from 10.0.0.10: icmp_seq=2 ttl=64 time=0.021 ms

--- 10.0.0.10 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.021/0.149/0.278/0.129 ms

# ip netns exec ns5 ping -c2 10.0.0.30
PING 10.0.0.30 (10.0.0.30) 56(84) bytes of data.
64 bytes from 10.0.0.30: icmp_seq=1 ttl=64 time=0.566 ms
64 bytes from 10.0.0.30: icmp_seq=2 ttl=64 time=0.039 ms

--- 10.0.0.30 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 0.039/0.302/0.566/0.264 ms
```

Likewise, `ns5` does not have a valid VLAN ID to ping `ns2` and `ns4`.

```
# ip netns exec ns5 ping -c1 10.0.0.20
```

```
PING 10.0.0.20 (10.0.0.20) 56(84) bytes of data.

--- 10.0.0.20 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms


# ip netns exec ns5 ping -c1 10.0.0.40
PING 10.0.0.40 (10.0.0.40) 56(84) bytes of data.

--- 10.0.0.40 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms
```

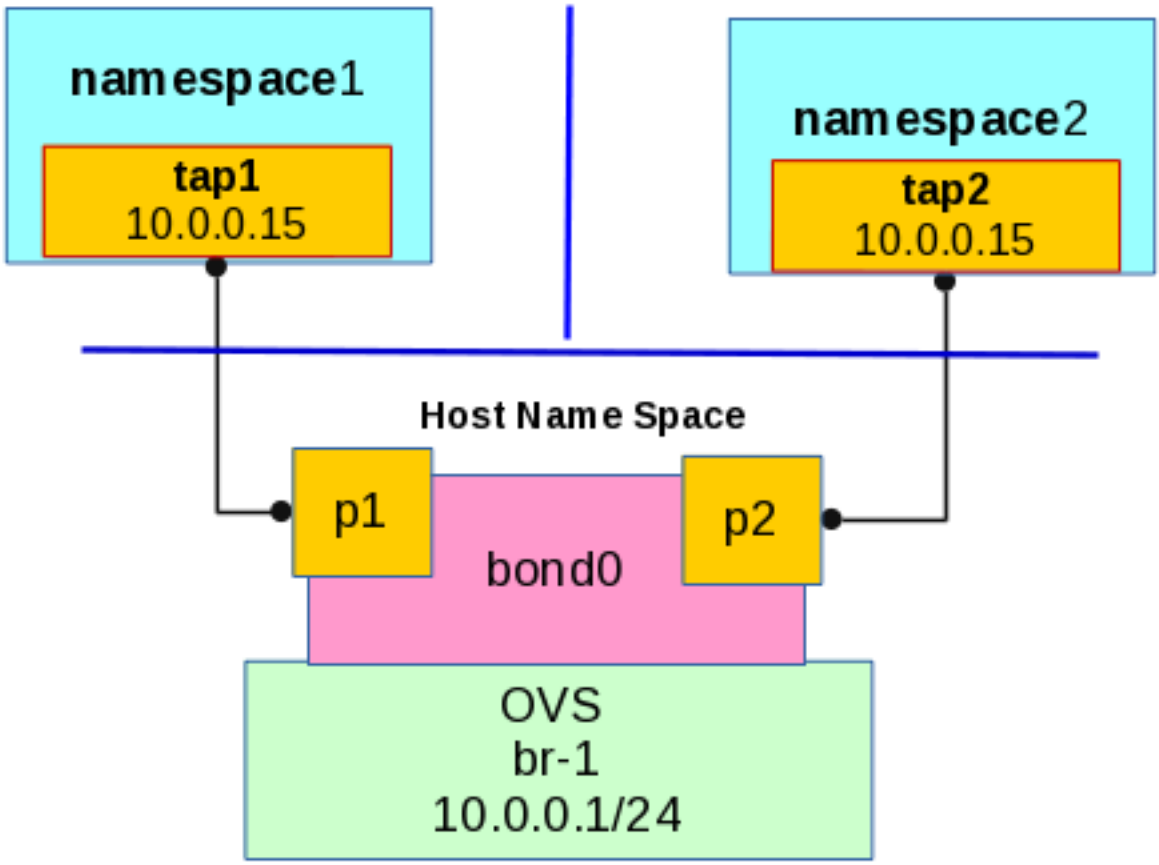
6.4 Clean Up

```
#!/bin/bash
#remove bridge, namespace, and bridge interfaces
BRIDGE=1
NS=$(ip netns list | wc -l)

#delete all net name spaces
ip -all netns del

#delete all bridges
for i in `seq 1 $BRIDGE`;
do
        ip link set br-$i down
        ovs-vsctl del-br br-$i
done
```

7 Bonding - Active Backup

Bonding allows you to aggregate multiple ports into a single group, effectively combining the bandwidth into a single connection. Bonding is the same as port trunking. `active-backup` mode in OvS allows us to configure 2 interfaces such that if one device fails, the other device will then be used in its place. For this test we will configure 2 name spaces with the same IP address. We will bring one name space down but the IP address will still be routable.

Figure 4: Bond device `bond0` with ports `p1` and `p2` connected



7.1 Setup

- 1 Bridge
- 2 Name spaces
- netperf

For netcat install instructions refer to Appendix E
Create a bridge

```
#!/bin/bash

# Create OVS switch
ovs-vsctl add-br br-1

#assign IP address
ip addr add 10.0.0.1/24 dev br-1

#bring the bridge interface up
ip link set br-1 up
```

Create 2 name spaces with the **same IP address**.

```
# ip netns add ns1
# ip link add tap1 type veth peer name p1
# ip link set tap1 netns ns1
# ip netns exec ns1 ip link set dev tap1 up
# ip link set dev p1 up
# ip netns exec ns1 ip addr add 10.0.0.15/24 dev tap1
```

```
# ip netns add ns2
# ip link add tap2 type veth peer name p2
# ip link set tap2 netns ns2
# ip netns exec ns2 ip link set dev tap2 up
# ip link set dev p2 up
# ip netns exec ns2 ip addr add 10.0.0.15/24 dev tap2
```

Create the bond interface named `bond0` with interfaces `p1` and `p2`.

```
# ovs-vsctl add-bond br-1 bond0  p1 p2 bond_mode=active-backup
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "bond0"
            Interface "p1"
            Interface "p2"
        Port "br-1"
            Interface "br-1"
                type: internal
    ovs_version: "2.7.0"
```

7.1.1 Verifying Bond Interface

View the bond information. Determine which interface is active. Both interfaces are considered slaves.

```
# ovs-appctl bond/show bond0
---- bond0 ----
bond_mode: active-backup
bond may use recirculation: no, Recirc-ID : -1
bond-hash-basis: 0
updelay: 0 ms
downdelay: 0 ms
lacp_status: off
active slave mac: 02:6c:ee:36:41:8f(p1)

slave p1: enabled
        active slave
        may_enable: true

slave p2: enabled
        may_enable: true
```

```
# ovs-ofctl show br-1
OFPT_FEATURES_REPLY (xid=0x2): dpid:000036cd4e136441
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
actions: output enqueue set_vlan_vid set_vlan_pcp strip_vlan mod_dl_src mod_dl_dst
 1(p1): addr:02:6c:ee:36:41:8f
     config:     0
     state:      0
```

```
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 2(p2): addr:aa:f0:3d:f2:a5:15
     config:     0
     state:      0
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 LOCAL(br-1): addr:36:cd:4e:13:64:41
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

This output confirms that interface `p1` is the active slave - meaning we can send traffic to `p1`.
Lets send traffic to `p1` then bring the interface down such that traffic will then be routed to `p2`.

7.2 Ping Verification

From the root namespace, make sure the bridge and bond is configured correctly by pinging `10.0.0.15` from the host.

```
# ping  -c2 10.0.0.15
PING 10.0.0.15 (10.0.0.15) 56(84) bytes of data.
64 bytes from 10.0.0.15: icmp_seq=1 ttl=64 time=0.277 ms
64 bytes from 10.0.0.15: icmp_seq=2 ttl=64 time=0.014 ms

--- 10.0.0.15 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.014/0.145/0.277/0.132 ms
```

7.3 Netcat Tests

From the output above we know that `p1` is active. Start the listening nc server on port 8080 in ns1 and echo a message to the connection.

```
# ip netns exec ns1 nc -l 8080 -c "echo hello from ns1"
```

The server is now listening. From the root namespace , run the following command:

```
# nc 10.0.0.15 8080
hello from ns1
```

We were able to connect to `ns1`. Hit `CTRL+C` to kill the client.
Bring `ns1` `tap1` interface down and kill netserver.

```
# ip netns exec ns1 ip link set tap1 down
# ip netns exec ns1 ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
40: tap1@if39: <BROADCAST,MULTICAST> mtu 1500 qdisc noqueue state DOWN qlen 1000
    link/ether 1a:7a:bc:2f:c2:5c brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.15/24 brd 10.0.0.255 scope global tap1
       valid_lft forever preferred_lft forever

# ovs-ofctl show br-1
OFPT_FEATURES_REPLY (xid=0x2): dpid:000036cd4e136441
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
actions: output enqueue set_vlan_vid set_vlan_pcp strip_vlan mod_dl_src mod_dl_dst
 1(p1): addr:02:6c:ee:36:41:8f
     config:     0
```

```
     state:      LINK_DOWN
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 2(p2): addr:aa:f0:3d:f2:a5:15
     config:     0
     state:      0
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 LOCAL(br-1): addr:36:cd:4e:13:64:41
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

Start `nc` in ns2 and run same echo something different

```
# ip netns exec ns2 nc -l 8080 -c "echo hello from ns2"
```

Connect to ns2 from root namespace with *the same* nc command:

```
# nc 10.0.0.15 8080
hello from ns2
^C
#
```

Hit `CTRL+C` to kill the client.

7.4 Clean Up

```
#!/bin/bash
#remove bridge, namespace, and bridge interfaces
BRIDGE=1
NS=$(ip netns list | wc -l)

#delete all net name spaces
ip -all netns del

#delete all bridges
for i in `seq 1 $BRIDGE`;
do
        ip link set br-$i down
        ovs-vsctl del-br br-$i
done
```

8 SPAN Port

SPAN (Switched Port Analyzer) or also known as Port Mirroring, is a method of monitoring network traffic. OvS will send a copy of all network packets seen on one port (or an entire VLAN) to another port, where the packet can be analyzed.

8.1 Setup

- 1 Bridge
- 2 Name spaces
- tcpdump
- 2 terminal windows

For tcpdump install instructions refer to Appendix F
Create a bridge

```
#!/bin/bash

# Create OVS switch
ovs-vsctl add-br br-1

#assign IP address
ip addr add 10.0.0.1/24 dev br-1

#bring the bridge interface up
ip link set br-1 up
```

Create 2 name spaces with IP addresses

```
#!/bin/bash

#Creates name spaces with ports attached to OVS.
#Assigns an IP address to name space devices

BR=1
NUMNS=2
IP=10.0.0.0

for i in `seq 1 $NUMNS`;
do
        #create name spaces
        ip netns add ns$i

        # create a port pair. the tap$i exists in the ns, br-p$i on host
        ip link add tap$i type veth peer name p$i

        #attach namespace port to OVS
        ovs-vsctl add-port br-$BR p$i

        #attach namespace dev tap$i to ns1 such that tap$i exists only in ns1
        ip link set tap$i netns ns$i

        #turn on port on OVS. exists on host network
        ip link set dev p$i up

        #add ten to last octet of network ip addr
        IP=$(echo $IP | awk -F. '{printf "%d.%d.%d.%d", $1,$2,$3,$4+10}')

        #assign ip addresses.
        ip netns exec ns$i ip add add $IP/24 dev tap$i

        #bring the interface in ns1 up
        ip netns exec ns$i ip link set dev tap$i up

done
```

```
# ovs-vsctl add-port br-1 p1
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p2"
```

```
            Interface "p2"
        Port "p1"
            Interface "p1"
    ovs_version: "2.7.0"
```

Mirror p2 traffic to p1

```
# ovs-vsctl add-port br-1 p2 -- --id=@p get port p2 \
-- --id=@m create mirror name=m0 select-all=true output-port=@p \
-- set bridge br-1 mirrors=@m
0dde3367-0192-4068-ab47-ce6b77b442a9

# ovs-vsctl list Bridge br-1 | grep mirror
mirrors             : [0dde3367-0192-4068-ab47-ce6b77b442a9]
```

This mirror is called m0 and routes all traffic for p1 to the output-port which is p2.

8.2 Verifying Traffic Mirror

Because we created a SPAN port on p2, any traffic arriving on p2 is dropped. However, we can still use tcpdump to see the mirrored traffic.
You will need 2 terminal windows for this test.
Terminal 1:

```
tcpdump -i p2
# tcpdump: WARNING: p2: no IPv4 address assigned
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on p2, link-type EN10MB (Ethernet), capture size 65535 bytes1
```

Terminal 2:

```
# ip netns exec ns1 ping -c3 10.0.0.1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.627 ms

--- 10.0.0.1 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.627/0.627/0.627/0.000 ms
```

Terminal 1 output should now be:

```
# tcpdump -i p2
tcpdump: WARNING: p2: no IPv4 address assigned
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on p2, link-type EN10MB (Ethernet), capture size 65535 bytes
14:50:14.244389 IP 10.0.0.10 > myhostname.pok.stglabs.ibm.com: ICMP echo request,
        id 4084, seq 1, length 64
14:50:14.244470 IP myhostname.pok.stglabs.ibm.com > 10.0.0.10: ICMP echo reply,
        id 4084, seq 1, length 64
```

Even though traffic is only traveling from ns1 to br-1 we can use tcpdump and still see the traffic mirrored to p2.

8.3 Clean Up

Remove the mirror port

```
# ovs-vsctl clear bridge br-1 mirrors
```

```
#!/bin/bash
#remove bridge, namespace, and bridge interfaces
BRIDGE=1
NS=$(ip netns list | wc -l)
```

```
#delete all net name spaces
ip -all netns del

#delete all bridges
for i in `seq 1 $BRIDGE`;
do
        ip link set br-$i down
        ovs-vsctl del-br br-$i
done
```

9 QoS

OvS supports policing trafficking that ingresses (enters) into a switch. Policing is a simple form of quality-of-service (QoS) that simply drops packets received in excess of the configured rate. For this specific test, we change the policy algorithm to only allow a throughput less than 1Mbps for one specific interface.

9.1 Setup

- 1 Bridge
- 2 Name spaces
- netperf

For netperf install instructions refer to Appendix D
Create a bridge

```
# ovs-vsctl add-br br-1
#
```

Create 2 name spaces with IP addresses

```
#!/bin/bash

#Creates name spaces with ports attached to OVS.
#Assigns an IP address to name space devices

BR=1
NUMNS=2
IP=10.0.0.0

for i in `seq 1 $NUMNS`;
do
        #create name spaces
        ip netns add ns$i

        # create a port pair. the tap$i exists in the ns, br-p$i on host
        ip link add tap$i type veth peer name p$i

        #attach namespace port to OVS
        ovs-vsctl add-port br-$BR p$i

        #attach namespace dev tap$i to ns1 such that tap$i exists only in ns1
        ip link set tap$i netns ns$i

        #turn on port on OVS. exists on host network
        ip link set dev p$i up
```

```
        #add ten to last octet of network ip addr
        IP=$(echo $IP | awk -F. '{printf "%d.%d.%d.%d", $1,$2,$3,$4+10}')

        #assign ip addresses.
        ip netns exec ns$i ip add add $IP/24 dev tap$i

        #bring the interface in ns1 up
        ip netns exec ns$i ip link set dev tap$i up

done
```

```
# ovs-vsctl add-port br-1 p1
# ovs-vsctl add-port br-1 p2
```

```
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "p1"
            Interface "p1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p2"
            Interface "p2"
    ovs_version: "2.7.0"

# ip netns list
ns2 (id: 3)
ns1 (id: 0)
```

```
# ovs-vsctl list interface p1 | grep ingress
ingress_policing_burst: 0
ingress_policing_rate: 0
```

Start a listening netserver in `ns2`

```
# ip netns exec ns2 netserver
#
```

Send some traffic to listening netserver in `ns2`

```
# ip netns exec ns1 netperf -H 10.0.0.20 -P0 -v0 -l5
13484.52
#
```

9.2 Verifying QoS

Change ingress policy for interface `p1` to accept only 1Mb of traffic limited by OvS.

```
# ovs-vsctl set interface p1 ingress_policing_rate=1000
# ovs-vsctl set interface p1 ingress_policing_burst=100

# ovs-vsctl list interface p1 | grep ingress
ingress_policing_burst: 100
ingress_policing_rate: 1000
```

Run the same netperf test. The netserver is still listening.

```
# ip netns exec ns1 netperf -H 10.0.0.20 -P0 -v0 -l5
   0.51
#
```

Your results may be different and thats ok. The through put number should be less than your first results and should be less than 1.

9.3 Clean Up

```
#!/bin/bash
#remove bridge, namespace, and bridge interfaces
BRIDGE=1
NS=$(ip netns list | wc -l)

#delete all net name spaces
ip -all netns del

#delete all bridges
for i in `seq 1 $BRIDGE`;
do
        ip link set br-$i down
        ovs-vsctl del-br br-$i
done
```

Make sure the netserver has been killed.

```
# ps -aef | grep netserver
root        8234     1  0 12:38 ?        00:00:00 netserver
root        8307  6360  0 12:45 pts/0    00:00:00 grep --color=auto netserver
# kill 8234
```

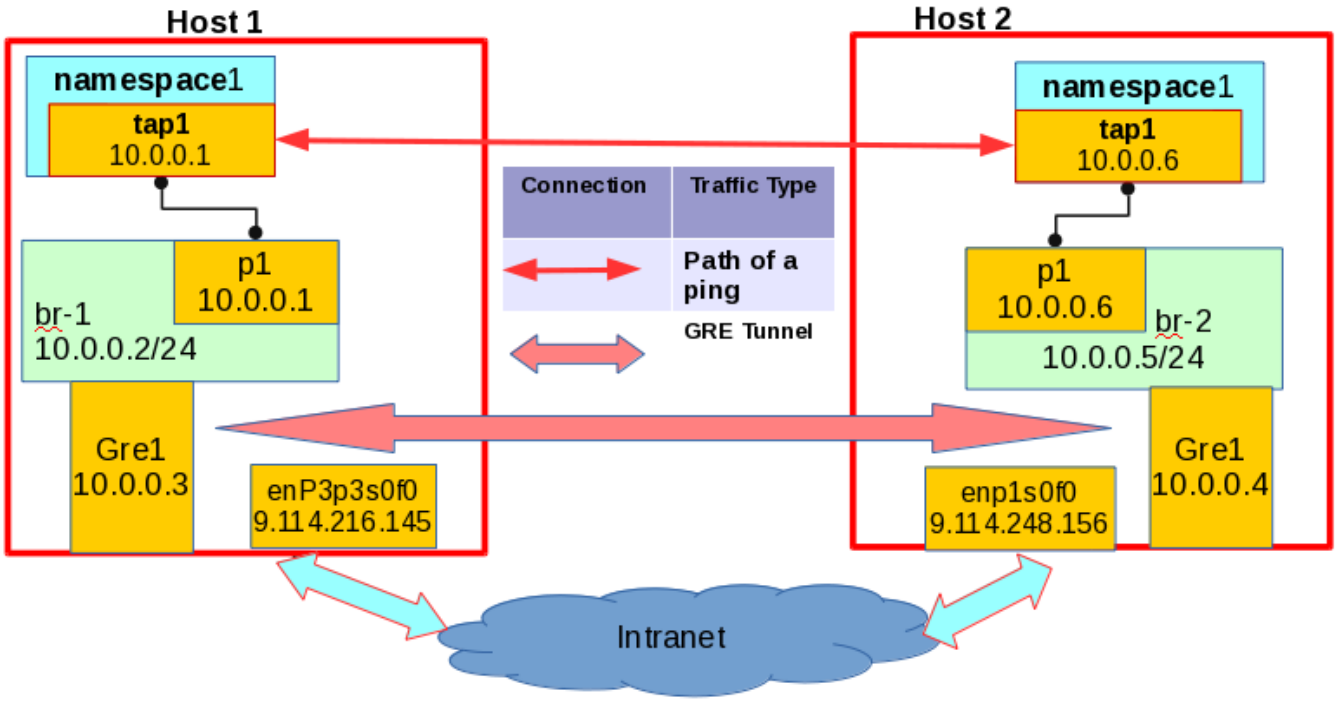
10 Multi-Host Tests

Tests outlined below will utilize 2 differnt kernel instances. I will be using 2 differnt VMs but you may also use 2 physical machines as well.

This test plan is for Open vSwitch and not a network setup tutorial. You will be reponsible for making sure your 2 machines (virtual or not) are already configured properly and can ping each other **before** we add Open vSwitch to the setup.

I recommend using VMs to consume less resources. This test plan was written using VMs and there is more information about OvS and libvirt in appendix.

Figure 5: GRE tunnel between 2 seperate hosts, `Host 1` and `Host 2`



11 GRE Tunnel

A Generic Routing Encapsulation tunnel is a method to connect 2 seperate networks on different physical hosts. This is accomplished by encapsulating packets into a GRE header. I will be setting up a GRE tunnel between 2 VMs running on top of libvirt and QEMU.

11.1 Setup

- 2 Different hosts (2 VMs or physical hosts)
- 2 OvS Bridges
- 1 network namespace in each host

More information about GRE tunnels in Appendix G.1

11.1.1 Host 1 Setup

Create a gre interface pointing to `Host 2`'s network interface. We additionally assign an IP address for the intra-net. First, create a gre interface

```
# ip tunnel add gre1 mode gre local 9.114.216.145 remote 9.114.248.156 ttl 255
# ip add add 10.0.0.3/24 dev gre1
# ip link set gre1 up
```

Create an OvS bridge and verify IP addresses.

```
# ovs-vsctl add-br br-1
# ip add add 10.0.0.2/24 dev br-1
# ip link set br-1 up
# ovs-vsctl show
2cfb3863-56ed-4ea5-89ee-607a64a72b13
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal

# ip add
gre1@NONE: <POINTOPOINT,NOARP,UP,LOWER_UP> mtu 1476 state UNKNOWN qlen 1
    link/gre 9.114.216.145 peer 9.114.248.156
    inet 10.0.0.3/24 scope global gre1
       valid_lft forever preferred_lft forever
    inet6 fe80::200:5efe:972:d891/64 scope link
       valid_lft forever preferred_lft forever
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UNKNOWN qlen 1000
    link/ether e6:df:5d:03:af:4e brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.2/24 scope global br-1
       valid_lft forever preferred_lft forever
    inet6 fe80::e4df:5dff:fe03:af4e/64 scope link
       valid_lft forever preferred_lft forever
```

Create `ns1` with a veth pair `p1` in root ns and `tap1` in ns. Additionally assign an IP address to `p1`

```
# ip netns add ns1
# ip link add tap1 type veth peer name p1
# ip link set tap1 netns ns1
# ip link set dev p1 up
# ip netns exec ns1 ip add add 10.0.0.1/24 dev tap1
# ip netns exec ns1 ip link set dev tap1 up
# ip add add 10.0.0.1/24 dev p1
# ip netns exec ns1 ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: gre0@NONE: <NOARP> mtu 1476 qdisc noop state DOWN qlen 1
    link/gre 0.0.0.0 brd 0.0.0.0
3: gretap0@NONE: <BROADCAST,MULTICAST> mtu 1462 qdisc noop state DOWN qlen 1000
    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff
37: tap1@if36: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether a6:48:98:46:52:ce brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.1/24 scope global tap1
       valid_lft forever preferred_lft forever
    inet6 fe80::a448:98ff:fe46:52ce/64 scope link
       valid_lft forever preferred_lft forever

# ip add
p1@if37:<BROADCAST,MULTICAST,UP,LOWER_UP>mtu 1500 master state UP qlen 1000
    link/ether de:ad:cc:fb:a6:20 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.1/24 scope global p1
       valid_lft forever preferred_lft forever
    inet6 fe80::dcad:ccff:fefb:a620/64 scope link
       valid_lft forever preferred_lft forever
```

Attach `p1` and `gre1` to bridge.

```
# ovs-vsctl add-port br-1 p1
# ovs-vsctl add-port br-1 gre1 \
-- set Interface gre1 type=gre options:remote_ip=9.114.248.156
# ovs-vsctl show
2cfb3863-56ed-4ea5-89ee-607a64a72b13
        Bridge "br-1"
                Port "p1"
                        Interface "p1"
                Port "gre1"
                        Interface "gre1"
                        type: gre
                        options: {remote_ip="9.114.216.156"}
                Port "br-1"
                        Interface "br-1"
                        type: internal
```

Make sure all interfaces have been set to UP with `ip link set` command.

11.1.2 Host 2 Setup

Create a gre interface pointing to `Host 1`'s network interface. We additionally assign an IP address for the intra-net. First, create a gre interface

```
# ip tunnel add gre1 mode gre remote 9.114.216.145 local 9.114.248.156 ttl 255
# ip add add 10.0.0.4/24 dev gre1
# ip link set gre1 up
```

Create an OvS bridge and verify IP addresses.

```
# ovs-vsctl add-br br-1
# ip add add 10.0.0.5/24 dev br-1
# ip link set br-1 up
# ovs-vsctl show
2cfb3863-56ed-4ea5-89ee-607a64a72b13
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal

# ip add
gre1@NONE: <POINTOPOINT,NOARP,UP,LOWER_UP> mtu 1476 state UNKNOWN qlen 1
    link/gre 9.114.248.156 peer 9.114.216.145
    inet 10.0.0.4/24 scope global gre1
       valid_lft forever preferred_lft forever
    inet6 fe80::200:5efe:972:d891/64 scope link
       valid_lft forever preferred_lft forever
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UNKNOWN qlen 1000
    link/ether e6:df:5d:03:af:4e brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.5/24 scope global br-1
       valid_lft forever preferred_lft forever
    inet6 fe80::e4df:5dff:fe03:af4e/64 scope link
       valid_lft forever preferred_lft forever
```

Create `ns1` with a veth pair `p1` in root ns and `tap1` in ns. Additionally assign an IP address to `p1`

```
# ip netns add ns1
# ip link add tap1 type veth peer name p1
# ip link set tap1 netns ns1
# ip link set dev p1 up
```

```
# ip netns exec ns1 ip add add 10.0.0.6/24 dev tap1
# ip netns exec ns1 ip link set dev tap1 up
# ip add add 10.0.0.6/24 dev p1
# ip netns exec ns1 ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: gre0@NONE: <NOARP> mtu 1476 qdisc noop state DOWN qlen 1
    link/gre 0.0.0.0 brd 0.0.0.0
3: gretap0@NONE: <BROADCAST,MULTICAST> mtu 1462 qdisc noop state DOWN qlen 1000
    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff
37: tap1@if36: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether a6:48:98:46:52:ce brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.6/24 scope global tap1
       valid_lft forever preferred_lft forever
    inet6 fe80::a448:98ff:fe46:52ce/64 scope link
       valid_lft forever preferred_lft forever

# ip add
p1@if37:<BROADCAST,MULTICAST,UP,LOWER_UP>mtu 1500 master state UP qlen 1000
    link/ether de:ad:cc:fb:a6:20 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.6/24 scope global p1
       valid_lft forever preferred_lft forever
    inet6 fe80::dcad:ccff:fefb:a620/64 scope link
       valid_lft forever preferred_lft forever
```

Attach `p1` and `gre1` to bridge.

```
# ovs-vsctl add-port br-1 p1
# ovs-vsctl add-port br-1 gre1 \
-- set Interface gre1 type=gre options:remote_ip=9.114.216.145

# ovs-vsctl show
2cfb3863-56ed-4ea5-89ee-607a64a72b13
        Bridge "br-1"
                Port "p1"
                        Interface "p1"
                Port "gre1"
                        Interface "gre1"
                        type: gre
                        options: {remote_ip="9.114.216.145"}
                Port "br-1"
                        Interface "br-1"
                        type: internal
```

Make sure all interfaces have been set to UP with `ip link set` command.

11.2 Ping Verification

On `Host 2` ping ns1 on `Host 1`

```
# ip netns exec ns1 ping -c2 10.0.0.1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.800 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.295 ms

--- 10.0.0.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.295/0.547/0.800/0.253 ms
```

If your pings are not working, first try flushing iptables on *both* hosts. Ensure all interfaces are up on *both* hosts. Some GRE interfaces have a lower MTU than 1500 (the usual default) because there needs to be room to encapsulate the packet. Make sure your MTU's are configured properly.

```
# iptables -F
# ip link set gre1 up
# ip link set br-1 up
# ip netns exec ns1 ip link set tap1 up
```

Likewise, on `Host 1` ping ns1 on `Host 2`

```
# ip netns exec ns1 ping -c2 10.0.0.6
PING 10.0.0.6 (10.0.0.6) 56(84) bytes of data.
64 bytes from 10.0.0.6: icmp_seq=1 ttl=64 time=0.851 ms
64 bytes from 10.0.0.6: icmp_seq=2 ttl=64 time=0.293 ms

--- 10.0.0.6 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.295/0.547/0.800/0.253 ms
```

11.3 Clean Up

On `Host 1`

```
# rmmod ip_gre
# ovs-vsctl del-br br-1
# ip -all netns del
```

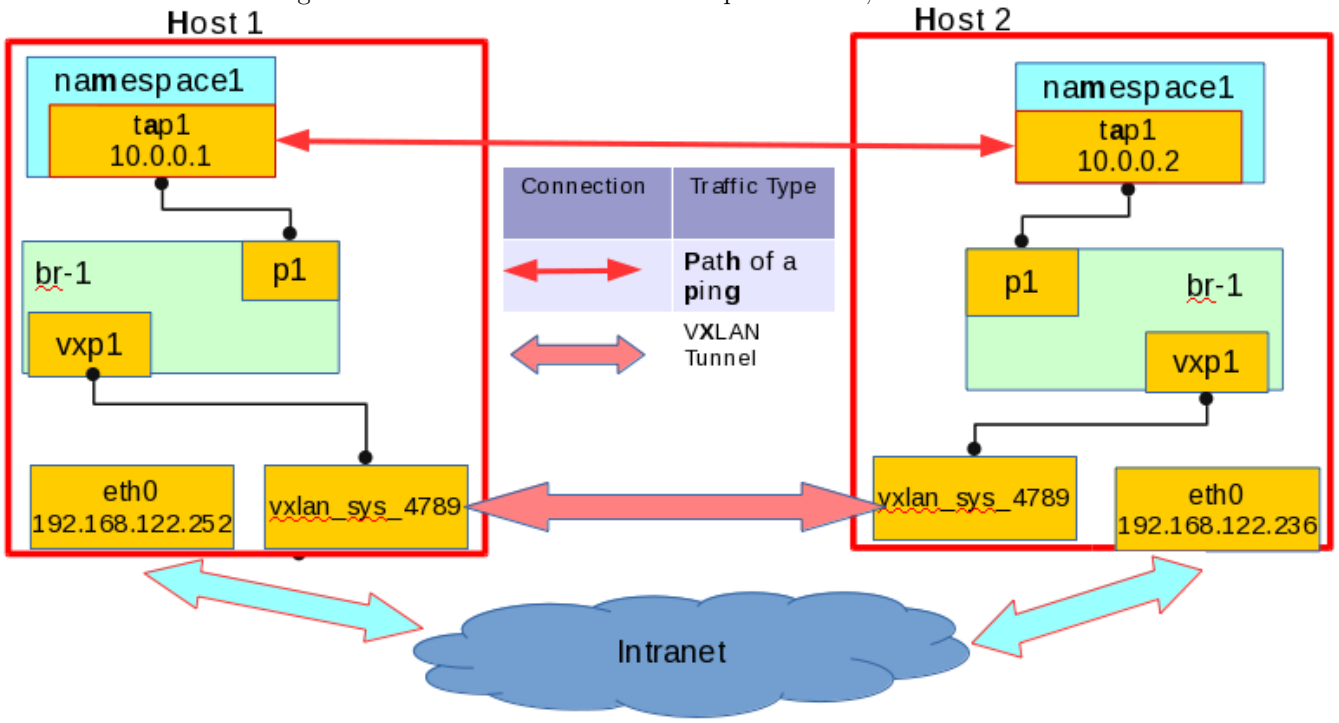
On `Host 2`

```
# rmmod ip_gre
# ovs-vsctl del-br br-2
# ip -all netns del
```

12 VXLAN

VXLAN stands for Virtual eXtensible Local Area Network. VXLAN is an overlay network which transports a L2 network over an existing L3 network Open vSwitch currently supports the framing format for packets on the wire. There is currently no support for the multicast aspects of VXLAN in OvS. Read RFC 7348 for more info about VXLANs.

Figure 6: VXLAN tunnel between 2 seperate hosts, `Host 1` and `Host 2`



12.1 Setup

- 2 Different hosts (2 VMs or physical hosts)
- 2 OvS Bridges
- 1 network namespace in each host

More information about VXLAN's in Appendix G.2

12.1.1 Host 1

First, create an OvS bridge and verify IP addresses.

```
# ovs-vsctl add-br br-1
# ip link set br-1 up
# ovs-vsctl show
2cfb3863-56ed-4ea5-89ee-607a64a72b13
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
```

Create `ns1` with a veth pair `p1` in root ns and `tap1` in ns.

```
# ip netns add ns1
# ip link add tap1 type veth peer name p1
# ip link set tap1 netns ns1
# ip link set dev p1 up
```

```
# ip netns exec ns1 ip add add 10.0.0.1/24 dev tap1
# ip netns exec ns1 ip link set dev tap1 up

# ip netns exec ns1 ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
37: tap1@if36: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether a6:48:98:46:52:ce brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.1/24 scope global tap1
       valid_lft forever preferred_lft forever
    inet6 fe80::a448:98ff:fe46:52ce/64 scope link
       valid_lft forever preferred_lft forever

# ip add

p1@if8718: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 6e:5b:1f:d7:10:70 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::6c5b:1fff:fed7:1070/64 scope link
       valid_lft forever preferred_lft forever
```

Attach `p1` to bridge.

```
# ovs-vsctl add-port br-1 p1
#
```

Create a vxlan port on bridge `br-1`

```
# ovs-vsctl add-port br-1 vxp1 \
-- set Interface vxp1 type=vxlan options:remote_ip=192.168.122.236 options:key=100

# ovs-vsctl show
fc0c4f84-aae6-40ed-a033-af80a44e6096
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "vxp1"
            Interface "vxp1"
                type: vxlan
                options: {key="100", remote_ip="192.168.122.236"}
        Port "p1"
            Interface "p1"
```

OvS creates a `vxlan_sys_xxx` network interface in the root ns. The `_xxxx` prefix at the end of the device name is the port which VXLAN will travel out of. The defaul is 4789. Make sure all interfaces have been set to UP with `ip link set` command.

```
# ip add
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UNKNOWN qlen 1000
    link/ether 46:12:ee:da:e8:4d brd ff:ff:ff:ff:ff:ff
    inet6 fe80::4412:eeff:feda:e84d/64 scope link
       valid_lft forever preferred_lft forever
p1@if8718: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 6e:5b:1f:d7:10:70 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::6c5b:1fff:fed7:1070/64 scope link
       valid_lft forever preferred_lft forever
vxlan_sys_4789: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 65485 state UNKNOWN qlen 1000
    link/ether 1e:21:bd:68:ad:9a brd ff:ff:ff:ff:ff:ff
    inet6 fe80::1c21:bdff:fe68:ad9a/64 scope link
       valid_lft forever preferred_lft forever
```

```
# ip link set dev vxlan_sys_4789 up
#
```

12.1.2 Host 2

First, create an OvS bridge and verify IP addresses.

```
# ovs-vsctl add-br br-1
# ip link set br-1 up
# ovs-vsctl show
2cfb3863-56ed-4ea5-89ee-607a64a72b13
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
```

Create `ns1` with a veth pair `p1` in root ns and `tap1` in ns.

```
# ip netns add ns1
# ip link add tap1 type veth peer name p1
# ip link set tap1 netns ns1
# ip link set dev p1 up
# ip netns exec ns1 ip add add 10.0.0.2/24 dev tap1
# ip netns exec ns1 ip link set dev tap1 up

# ip netns exec ns1 ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
37: tap1@if36: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether a6:48:98:46:52:ce brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.2/24 scope global tap1
       valid_lft forever preferred_lft forever
    inet6 fe80::a448:98ff:fe46:52ce/64 scope link
       valid_lft forever preferred_lft forever

# ip add

p1@if8718: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 6e:5b:1f:d7:10:70 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::6c5b:1fff:fed7:1070/64 scope link
       valid_lft forever preferred_lft forever
```

Attach `p1` to bridge.

```
# ovs-vsctl add-port br-1 p1
#
```

Create a vxlan port on bridge `br-1`

```
# ovs-vsctl add-port br-1 vxp1 \
-- set Interface vxp1 type=vxlan options:remote_ip=192.168.122.252 options:key=100

# ovs-vsctl show
fc0c4f84-aae6-40ed-a033-af80a44e6096
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "vxp1"
```

```
            Interface "vxp1"
                type: vxlan
                options: {key="100", remote_ip="192.168.122.252"}
        Port "p1"
            Interface "p1"
```

OvS creates a `vxlan_sys_xxx` network interface in the root ns. The `_xxxx` prefix at the end of the device name is the port which VXLAN will travel out of. The defaul is 4789. Make sure all interfaces have been set to UP with `ip link set` command.

```
# ip add
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UNKNOWN qlen 1000
    link/ether 46:12:ee:da:e8:4d brd ff:ff:ff:ff:ff:ff
    inet6 fe80::4412:eeff:feda:e84d/64 scope link
       valid_lft forever preferred_lft forever
p1@if8718: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 6e:5b:1f:d7:10:70 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::6c5b:1fff:fed7:1070/64 scope link
       valid_lft forever preferred_lft forever
vxlan_sys_4789: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 65485 state UNKNOWN qlen 1000
    link/ether 1e:21:bd:68:ad:9a brd ff:ff:ff:ff:ff:ff
    inet6 fe80::1c21:bdff:fe68:ad9a/64 scope link
       valid_lft forever preferred_lft forever

# ip link set dev vxlan_sys_4789 up
#
```

12.2 Ping Verifications

Host 1's ns1 should be able to ping Host's 2 ns1.
On `Host 1` ping ns1 on `Host 2`

```
# ip netns exec ns1 ping -c2 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.800 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.295 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.295/0.547/0.800/0.253 ms
```

If your pings are not working, first try flushing iptables on *both* hosts. Ensure all interfaces are up on *both* hosts.

```
# iptables -F
# ip link set gre1 up
# ip link set br-1 up
# ip netns exec ns1 ip link set tap1 up
```

Likewise, on `Host 2` ping ns1 on `Host 1`

```
# ip netns exec ns1 ping -c2 10.0.0.1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.851 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.293 ms

--- 10.0.0.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.295/0.547/0.800/0.253 ms
```

12.3 Clean Up

On `Host 1`

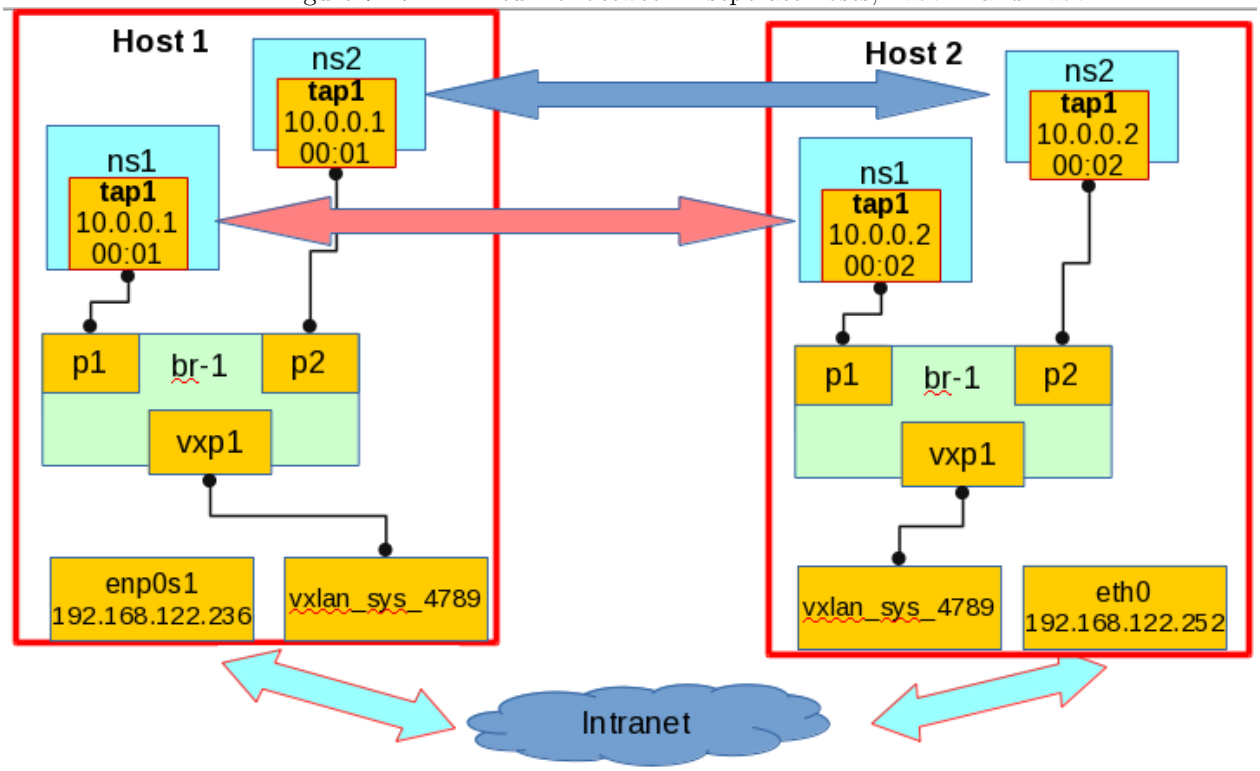
```
# ovs-vsctl del-br br-1
# ip -all netns del
# ip link del dev vxlan_sys_4789
```

On `Host 2`

```
# ovs-vsctl del-br br-1
# ip -all netns del
# ip link del dev vxlan_sys_4789
```

13 Creating a VXLAN with OpenFlow Rules

Figure 7: VXLAN tunnel between 2 seperate hosts, `Host 1` and `Host 2`



13.1 Setup

- 2 Different hosts (2 VMs or physical hosts)
- 2 OvS Bridges
- 2 network namespace in each host

More information about VXLAN's in Appendix G.2

13.1.1 Host 1

First, create an OvS bridge

```
# ovs-vsctl add-br br-1
# ip link set br-1 up
# ovs-vsctl show
```

```
2cfb3863-56ed-4ea5-89ee-607a64a72b13
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
```

Create 2 name spaces with the same IP and MAC address.

```
#!/bin/bash

#Creates 2 name spaces with same MAC and IP address

BR=1
NUMNS=2
IP=10.0.0.0

for i in `seq 1 $NUMNS`;
do
        #create name spaces
        ip netns add ns$i

        # create a port pair. the tap$i exists in the ns, br-p$i on host
        ip link add tap$i type veth peer name p$i

        #attach namespace dev tap$i to ns1 such that tap$i exists only in ns1
        ip link set tap$i netns ns$i

        #turn on port on OVS. exists on host network
        ip link set dev p$i up

        #assign ip addresses.
        ip netns exec ns$i ip add add 10.0.0.1/24 dev tap$i

        #assign MAC address
        ip netns exec ns$i ip link set dev tap$i address 00:00:00:00:00:01

        #bring the interface in ns1 up
        ip netns exec ns$i ip link set dev tap$i up

done
```

```
# ip netns exec ns1 ip add
tap1@if51: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 00:00:00:00:00:01 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.1/24 scope global tap1
       valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:fe00:1/64 scope link tentative dadfailed
       valid_lft forever preferred_lft forever
#
# ip netns exec ns2 ip add
tap2@if53: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 00:00:00:00:00:01 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.1/24 scope global tap2
       valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:fe00:1/64 scope link
       valid_lft forever preferred_lft forever
#
# ip add
```

```
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UNKNOWN qlen 1000
    link/ether 46:b6:12:44:16:4c brd ff:ff:ff:ff:ff:ff
    inet6 fe80::44b6:12ff:fe44:164c/64 scope link
       valid_lft forever preferred_lft forever
p1@if52: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 76:41:dd:fc:4d:fd brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::7441:ddff:fefc:4dfd/64 scope link
       valid_lft forever preferred_lft forever
p2@if54: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 9a:70:f8:da:46:3e brd ff:ff:ff:ff:ff:ff link-netnsid 1
    inet6 fe80::9870:f8ff:feda:463e/64 scope link
       valid_lft forever preferred_lft forever
```

Attach `p1` and `p2` to bridge.

```
# ovs-vsctl add-port br-1 p1
# ovs-vsctl add-port br-1 p2
#
#  ovs-vsctl show
636e52df-62e8-4432-83d0-b69f6f7e87d7
    Bridge "br-1"
        Port "p1"
            Interface "p1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p2"
            Interface "p2"
    ovs_version: "2.7.90"
```

Create a vxlan port on bridge `br-1` named `vxp1`. We do not assign a VNI. We will define our key later using with OpenFlow.

```
# ovs-vsctl add-port br-1 vxp1 \
-- set Interface vxp1 type=vxlan options:remote_ip=192.168.122.252 options:key=flow

# ovs-vsctl show
fc0c4f84-aae6-40ed-a033-af80a44e6096
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "vxp1"
            Interface "vxp1"
                type: vxlan
                options: {key="flow", remote_ip="192.168.122.252"}
        Port "p1"
            Interface "p1"
```

OvS creates a `vxlan_sys_xxx` network interface in the root ns. The `_xxxx` prefix at the end of the device name is the port which VXLAN will travel out of. The defaul is 4789. Make sure all interfaces have been set to UP with `ip link set` command.

```
# ip add
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UNKNOWN group default
    link/ether 46:b6:12:44:16:4c brd ff:ff:ff:ff:ff:ff
    inet6 fe80::44b6:12ff:fe44:164c/64 scope link
       valid_lft forever preferred_lft forever
p1@if52: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master ovs-system state U
    link/ether 76:41:dd:fc:4d:fd brd ff:ff:ff:ff:ff:ff link-netnsid 0
```

```
    inet6 fe80::7441:ddff:fefc:4dfd/64 scope link
       valid_lft forever preferred_lft forever
p2@if54: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master ovs-system state U
    link/ether 9a:70:f8:da:46:3e brd ff:ff:ff:ff:ff:ff link-netnsid 1
    inet6 fe80::9870:f8ff:feda:463e/64 scope link
       valid_lft forever preferred_lft forever
vxlan_sys_4789: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 65485 state UNKNOWN qlen 1000
    link/ether 1e:21:bd:68:ad:9a brd ff:ff:ff:ff:ff:ff
    inet6 fe80::1c21:bdff:fe68:ad9a/64 scope link
       valid_lft forever preferred_lft forever

# ip link set dev vxlan_sys_4789 up
#
```

13.1.2 Host 2

First, create an OvS bridge

```
# ovs-vsctl add-br br-1
# ip link set br-1 up
# ovs-vsctl show
2cfb3863-56ed-4ea5-89ee-607a64a72b13
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
```

Create 2 name spaces with the same IP and MAC address.

```
#!/bin/bash

#Creates 2 name spaces with same MAC and IP address

BR=1
NUMNS=2
IP=10.0.0.0

for i in `seq 1 $NUMNS`;
do
        #create name spaces
        ip netns add ns$i

        # create a port pair. the tap$i exists in the ns, br-p$i on host
        ip link add tap$i type veth peer name p$i

        #attach namespace dev tap$i to ns1 such that tap$i exists only in ns1
        ip link set tap$i netns ns$i

        #turn on port on OVS. exists on host network
        ip link set dev p$i up

        #assign ip addresses.
        ip netns exec ns$i ip add add 10.0.0.2/24 dev tap$i

        #assign MAC address
        ip netns exec ns$i ip link set dev tap$i address 00:00:00:00:00:02

        #bring the interface in ns1 up
```

```
        ip netns exec ns$i ip link set dev tap$i up

done
```

```
# ip netns exec ns1 ip add
tap1@if51: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 00:00:00:00:00:02 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.2/24 scope global tap1
       valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:fe00:1/64 scope link tentative dadfailed
       valid_lft forever preferred_lft forever
#
# ip netns exec ns2 ip add
tap2@if53: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
    link/ether 00:00:00:00:00:02 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.0.2/24 scope global tap2
       valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:fe00:1/64 scope link
       valid_lft forever preferred_lft forever
#
# ip add
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UNKNOWN qlen 1000
link/ether 46:12:ee:da:e8:4d brd ff:ff:ff:ff:ff:ff
    inet6 fe80::4412:eeff:feda:e84d/64 scope link
       valid_lft forever preferred_lft forever
p1@if52: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
   link/ether 42:70:3c:01:bc:5c brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::4070:3cff:fe01:bc5c/64 scope link
       valid_lft forever preferred_lft forever
p2@if54: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 state UP qlen 1000
link/ether 46:b6:9a:96:25:0f brd ff:ff:ff:ff:ff:ff link-netnsid 1
    inet6 fe80::44b6:9aff:fe96:250f/64 scope link
       valid_lft forever preferred_lft forever
```

Attach p1 and p2 to bridge.

```
# ovs-vsctl add-port br-1 p1
# ovs-vsctl add-port br-1 p2
#
#  ovs-vsctl show
636e52df-62e8-4432-83d0-b69f6f7e87d7
    Bridge "br-1"
        Port "p1"
            Interface "p1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p2"
            Interface "p2"
    ovs_version: "2.7.90"
```

Create a vxlan port on bridge br-1 named vxp1. We do not assign a VNI. We will define our key later using OpenFlow.

```
# ovs-vsctl add-port br-1 vxp1 \
-- set Interface vxp1 type=vxlan options:remote_ip=192.168.122.236 options:key=flow

# ovs-vsctl show
fc0c4f84-aae6-40ed-a033-af80a44e6096
    Bridge "br-1"
```

```
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "vxp1"
            Interface "vxp1"
                type: vxlan
                options: {key="flow", remote_ip="192.168.122.236"}
        Port "p1"
            Interface "p1"
```

Same as Host 1, OvS creates a `vxlan_sys_xxx` network interface in the root ns. The `_xxxx` prefix at the end of the device name is the port which VXLAN will travel out of. The defaul is 4789. Make sure all interfaces have been set to UP with `ip link set` command.

```
# ip add
br-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UNKNOWN group default
link/ether 46:12:ee:da:e8:4d brd ff:ff:ff:ff:ff:ff
    inet6 fe80::4412:eeff:feda:e84d/64 scope link
       valid_lft forever preferred_lft forever
p1@if52: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master ovs-system state U
   link/ether 42:70:3c:01:bc:5c brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::4070:3cff:fe01:bc5c/64 scope link
       valid_lft forever preferred_lft forever
p2@if54: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master ovs-system state U
link/ether 46:b6:9a:96:25:0f brd ff:ff:ff:ff:ff:ff link-netnsid 1
    inet6 fe80::44b6:9aff:fe96:250f/64 scope link
       valid_lft forever preferred_lft forever
vxlan_sys_4789: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 65485 state UNKNOWN qlen 1000
    link/ether 8a:27:9a:c5:8f:c8 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::8827:9aff:fec5:8fc8/64 scope link
       valid_lft forever preferred_lft forever

# ip link set dev vxlan_sys_4789 up
#
```

13.1.3 Adding Flows Host 1

This test plan is not focused on explaining the OpenFlow protocol but more details are in Appendix G.2.1
We need to create flows in order to send the packet to the right name space on each host.
We will use OpenFlow to send packets to the correct ports in our OvS bridge.
First, figure out what your OpenFlow ports are. This is a unique integer for each port on your bridge.

```
# ovs-ofctl show br-1
OFPT_FEATURES_REPLY (xid=0x2): dpid:000046b61244164c
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
 mod_nw_tos mod_tp_src mod_tp_dst
 10(vxp1): addr:52:52:4d:59:f1:11
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
 11(p1): addr:76:41:dd:fc:4d:fd
     config:     0
     state:      0
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 12(p2): addr:9a:70:f8:da:46:3e
     config:     0
```

```
     state:      0
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 LOCAL(br-1): addr:46:b6:12:44:16:4c
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

In this setup, `vxp1` is located at OpenFlow port 10. `p1` is port 11.
Now we will tell the packets on our VXLAN how to travel through OvS using flow rules and our port numbers.
The basic idea is to tell OvS that a packet entering or exiting a specific port should be tagged with the approriate VNI. OpenFlow calls the VNI a `tun_id`.
For this setup, we have 2 VXLAN tunnels going through the same port on our bridge. So we need to assign different VNI given the source and destination of the packet. Additionally we tell OvS how to handle ARP packets.
Create the flows in a file called `flows.txt` with *the correct port numbers*.

```
# cat flows.txt
table=0,in_port=11, actions=set_field:100->tun_id,resubmit(,1)
table=0,in_port=12, actions=set_field:200->tun_id,resubmit(,1)
table=0,actions=resubmit(,1)

table=1,tun_id=100,dl_dst=00:00:00:00:00:01,actions=output:11
table=1,tun_id=200,dl_dst=00:00:00:00:00:01,actions=output:12

table=1,tun_id=100,dl_dst=00:00:00:00:00:02,actions=output:10
table=1,tun_id=200,dl_dst=00:00:00:00:00:02,actions=output:10

table=1,tun_id=100,arp,nw_dst=10.0.0.1,actions=output:1
table=1,tun_id=200,arp,nw_dst=10.0.0.1,actions=output:2

table=1,tun_id=100,arp,nw_dst=10.0.0.2,actions=output:10
table=1,tun_id=200,arp,nw_dst=10.0.0.2,actions=output:10

#
```

We will add the flow rules to our `br-1` bridge. Dump flows to verify flows were added.

```
# ovs-ofctl dump-flows br-1 | wc -l
2
# ovs-ofctl add-flows br-1 flows.txt
#
# ovs-ofctl dump-flows br-1 | wc -l
14
```

13.1.4 Adding Flows Host 2

This test plan is not focused on explaining the OpenFlow protocol but more details are in Appendix G.2.1
Create flows in order to send the packet to the right name space on each host.
First, figure out what your OpenFlow ports are. This is a unique integer for each port on your bridge.

```
# ovs-ofctl show br-1
 OFPT_FEATURES_REPLY (xid=0x2): dpid:000046b61244164c
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
 mod_nw_tos mod_tp_src mod_tp_dst
 3(p1): addr:42:70:3c:01:bc:5c
     config:     0
     state:      0
```

```
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 4(p2): addr:46:b6:9a:96:25:0f
     config:     0
     state:      0
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 5(vxp1): addr:7a:13:a8:c9:fb:a5
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
 LOCAL(br-1): addr:46:12:ee:da:e8:4d
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

Now we will tell the packets on our VXLAN how to travel through OvS using flow rules and our port numbers. Create the flows in a file called `flows.txt` with *the correct port numbers*.

```
# cat flows.txt
table=0,in_port=3, actions=set_field:100->tun_id,resubmit(,1)
table=0,in_port=4, actions=set_field:200->tun_id,resubmit(,1)
table=0,actions=resubmit(,1)

table=1,tun_id=100,dl_dst=00:00:00:00:00:02,actions=output:3
table=1,tun_id=200,dl_dst=00:00:00:00:00:02,actions=output:4

table=1,tun_id=100,dl_dst=00:00:00:00:00:01,actions=output:5
table=1,tun_id=200,dl_dst=00:00:00:00:00:01,actions=output:5

table=1,tun_id=100,arp,nw_dst=10.0.0.2,actions=output:3
table=1,tun_id=200,arp,nw_dst=10.0.0.2,actions=output:4

table=1,tun_id=100,arp,nw_dst=10.0.0.1,actions=output:5
table=1,tun_id=200,arp,nw_dst=10.0.0.1,actions=output:5
```

We will add the flow rules to our `br-1` bridge. Dump flows to verify flows were added.

```
# ovs-ofctl dump-flows br-1 | wc -l
2
# ovs-ofctl add-flows br-1 flows.txt
#
# ovs-ofctl dump-flows br-1 | wc -l
14
```

13.2 Ping Verification

13.2.1 Host 1

First ping ns1 on Host 2 from Host 1's ns1.

```
# ip netns exec ns1 ping 10.0.0.2 -c2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.488 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.358 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1011ms
rtt min/avg/max/mdev = 0.358/0.423/0.488/0.065 ms
```

Verify that our 2 ns' on the same host cannot communicate with each other. They have different VNIs.

```
# ip netns exec ns1 ping 10.0.0.1 -c2
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.

--- 10.0.0.1 ping statistics ---
2 packets transmitted, 0 received, 100% packet loss, time 1027ms
```

And repeat the same tests on Host 1 for ns2.

```
# ip netns exec ns2 ping 10.0.0.2 -c2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.680 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.540 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1023ms
rtt min/avg/max/mdev = 0.540/0.610/0.680/0.070 ms
```

13.2.2 Host 2

First ping ns1 on Host 1 from Host 2's ns1.

```
# ip netns exec ns1 ping 10.0.0.1 -c2
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.548 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.550 ms

--- 10.0.0.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1007ms
rtt min/avg/max/mdev = 0.548/0.549/0.550/0.001 ms
```

Confirm the 2 ns' cannot communicate with each other on the same host.

```
# ip netns exec ns1 ping 10.0.0.2 -c2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 0 received, 100% packet loss, time 1047ms
```

Repeat tests for ns2 on Host 2.

```
# ip netns exec ns2 ping 10.0.0.1 -c2
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=1.13 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=1.20 ms

--- 10.0.0.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 1.136/1.172/1.209/0.050 ms
```

13.3 Netcat Verification

Verify that each ns on different hosts is communicating with the correct ns.
For netcat install instructions refer to Appendix E
On Host 1, start netcat in ns1. There will be no output.

```
# ip netns exec ns1 nc -l -p 8080
```

In this specific setup, Host 1 and 2's ns1 communicate with each other.
On Host 2, connect to the listening nc server. Type a message. The message should appear in Host 1's ns1.

```
# ip netns exec ns1 nc 10.0.0.1 8080

hello
```

Output on host 1 should look like this:

```
# ip netns exec ns1 nc -l -p 8080
hello
```

Hit `CTRL + C` to stop the test.

Appendices

A Troubleshooting Installation

A.1 OvS Kernel Module

If kernel module is not loaded, use modprobe command:

```
# modprobe openvswitch
```

Verify that the kernel object exists on your system for your currently booted kernel

```
# ls /lib/modules/$(uname -r)/kernel/net/openvswitch
```

A.2 Starting OvS Service

If you use `yum install` for RHEL or `apt` for Ubuntu, OvS should be started automatically. If not follow these commands:

A.2.1 RHEL

Check the status of the OvS service and confirm it is not running:

```
# systemctl status openvswitch
openvswitch.service - LSB: Open vSwitch switch
   Loaded: loaded (/etc/rc.d/init.d/openvswitch; bad; vendor preset: disabled)
   Active: inactive (dead) since Wed 2017-03-22 14:42:55 PDT; 29s ago
     Docs: man:systemd-sysv-generator(8)
```

Output verifies that it is `inactive (dead)`
Then start the service and verify there are new processes started:

```
# systemctl start openvswitch
# systemctl status openvswitch
openvswitch.service - LSB: Open vSwitch switch
   Loaded: loaded (/etc/rc.d/init.d/openvswitch; bad; vendor preset: disabled)
   Active: active (running) since Wed 2017-03-22 14:45:00 PDT; 4 days ago
     Docs: man:systemd-sysv-generator(8)
  Process: 25684 ExecStop=/etc/rc.d/init.d/openvswitch stop
                              (code=exited, status=0/SUCCESS)
  Process: 25725 ExecStart=/etc/rc.d/init.d/openvswitch start
                              (code=exited, status=0/SUCCESS)
  CGroup: /system.slice/openvswitch.service
             25748 ovsdb-server: monitoring pid 25749 (healthy)
             25749 ovsdb-server /etc/openvswitch/conf.db -vconsole:emer
                   -vsyslog:err -vfile:info --remote=punix:/...
             25759 ovs-vswitchd: monitoring pid 25760 (healthy)
             25760 ovs-vswitchd unix:/var/run/openvswitch/db.sock -vconsole:
                             -vsyslog:err -vfile:info --mlock...
```

A.2.2 Ubuntu

Check the status of the OvS service:

```
# systemctl status openvswitch-switch
openvswitch-switch.service - Open vSwitch
   Loaded: loaded (/lib/systemd/system/openvswitch-switch.service;
                               enabled; vendor preset: enabled)
   Active: inactive (dead) since Wed 2017-03-22 18:07:10 EDT; 22s ago
 Main PID: 5079 (code=exited, status=0/SUCCESS)
```

Then start the service and verify there are new processes started:

```
# systemctl start openvswitch-switch
#
```

```
# ps -aef | grep ovs
root       6528  6482  grep --color=auto ovs
root      25748     1 ovsdb-server: monitoring pid 25749 (healthy)
root      25749 25748 ovsdb-server /etc/openvswitch/conf.db
                -vsyslog:err -vfile:info
                --remote=punix:/var/run/openvswitch/db.sock
                --private-key=db:Open_vSwitch,SSL,private_key
                --certificate=db:Open_vSwitch,SSL,certificate
                --bootstrap-ca-cert=db:Open_vSwitch,SSL,ca_cert --no-chdir
                --log-file=/var/log/openvswitch/ovsdb-server.log
                --pidfile=/var/run/openvswitch/ovsdb-server.pid --detach
root      25759     1  ovs-vswitchd: monitoring pid 25760 (healthy)
root      25760 25759  ovs-vswitchd unix:/var/run/openvswitch/db.sock
                -vconsole:emer -vsyslog:err -vfile:info --mlockall --no-chdir
                --log-file=/var/log/openvswitch/ovs-vswitchd.log
                --pidfile=/var/run/openvswitch/ovs-vswitchd.pid --detach
```

A.2.3 Starting from Source Build

First of all, follow instructions from OvS git repo. Load the kernel module, make sure you have a conf.db file, and start the services:

```
# ps -aef | grep ovs
#
# modprobe openvswitch

# ls /usr/local/etc/openvswitch/
conf.db

# ovsdb-server --remote=punix:/usr/local/var/run/openvswitch/db.sock \
    --remote=db:Open_vSwitch,Open_vSwitch,manager_options \
    --private-key=db:Open_vSwitch,SSL,private_key \
    --certificate=db:Open_vSwitch,SSL,certificate \
    --bootstrap-ca-cert=db:Open_vSwitch,SSL,ca_cert \
    --pidfile --detach --log-file

# ovs-vsctl --no-wait init

# ovs-vswitchd --pidfile --detach --log-file

# ps -aef | grep ovs
root      2131     1  0 16:20 ?        00:00:00 ovsdb-server
--remote=punix:/usr/local/var/run/openvswitch/db.sock
...
root      2134     1  0 16:20 ?        00:00:00 ovs-vswitchd --pidfile
--detach --log-file
```

My output was shortened but it is clear that ovs has been started. Create a bridge to verify.

B Name Spaces

A network name space can be thought of like a container (LXC or Docker) or very tiny virtual machine (VM). Network name spaces have the same idea as a container or VM such that resources are isolated, but a network name space only

isolates the network interface. Each network namespace has its own interfaces, routing tables, and forwarding tables. Think of a network name space as a virtual machine with only network functionality. For our specific usage, our name spaces will have an IP address and will be connected to our bridge to run tests.
It is also important to note that processes can be dedicated to a network name space.
Name spaces use virtual Ethernet devices, called veth. The veth device works like a tunnel. This tunnel can be thought of like a Ethernet cable which we will use to connect our name spaces to our bridge. Veth works with peers, one peer is in the name space and the other peer is a port on OvS.

B.1 Creating Name Spaces

To create a name space named `ns1` type:

```
# ip netns add ns1
```

To view your name spaces type:

```
# ip netns list
ns1 (id: 0)
```

B.2 Deleting Name Space

```
# ip netns delete ns1
#
```

B.3 Creating Veth Interfaces

To create a veth device type the following:

```
# ip link add tap1 type veth peer name p1
```

You will now have 2 new network interfaces on your machine:

```
ip addr | grep tap
 p1@tap1: <BROADCAST,MULTICAST,M-DOWN> mtu 1500 qdisc noop state DOWN qlen 1000
 tap1@p1: <BROADCAST,MULTICAST,M-DOWN> mtu 1500 qdisc noop state DOWN qlen 1000
```

B.4 Attaching Veth Device to Name Space

Attach namespace dev `tap1` to `ns1` such that `tap1` exists only in `ns1`

```
# ip link set tap1 netns ns1
```

Interface `tap1` now exists only in the name space called `ns1`

```
# ip add | grep tap
#
```

Remember that a name space is isolated similar to how a VM would be. So the `tap1` interface no longer exists in the root's name space, it is in `ns1` now.

B.5 Executing Commands in a Name Space

To view network interfaces inside ns1, execute the ip address command inside the name space like so:

```
# ip netns exec ns1 ip addr
# ip netns exec ns1 ip link set dev tap1 up
# ip netns exec ns1 ip addr
```

Now we have a name space with a network interface. The interface in the name space (`tap1`) is connected to the interface named `p1` on the host network.

C Setting Up Name Spaces for Test Environment

To create a name space named `ns1`:

```
# ip netns add ns1
# ip netns list
ns1
```

Create the veth interfaces

```
# ip link add tap1 type veth peer name p1

# ip addr | grep tap
p1@tap1: <BROADCAST,MULTICAST,M-DOWN> mtu 1500 qdisc noop state DOWN qlen 1000
tap1@p1: <BROADCAST,MULTICAST,M-DOWN> mtu 1500 qdisc noop state DOWN qlen 1000
```

Move the `tap1` interface into `ns1`.

```
# ip netns exec ns1  ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
# ip link set tap1 netns ns1
# ip netns exec ns1 ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
381: tap1@if380: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN qlen 1000
    link/ether ba:15:20:dc:63:ec brd ff:ff:ff:ff:ff:ff link-netnsid 0
# ip addr | grep tap
#
```

Set the `tap1` interface to UP state inside `ns1` by executing the `ip addr`. This command is executed inside the name space.

```
# ip netns exec ns1 ip link set dev tap1 up
```

Likewise, we can run the same command on the root namepace and turn on the `p1` interface

```
# ip link set dev p1 up
```

Now we have an interface that is up and a virual environment to execute commands in.

```
# ip add | grep p1
 p1@if381: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
        qlen 1000
    link/ether 72:9b:17:a0:cb:13 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::709b:17ff:fea0:cb13/64 scope link
       valid_lft forever preferred_lft forever
# ip netns exec ns1 ip add
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
tap1@if380: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
        qlen 1000
    link/ether ba:15:20:dc:63:ec brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::b815:20ff:fedc:63ec/64 scope link
       valid_lft forever preferred_lft forever
```

C.1 Troubleshooting: Adding Port to Bridge

First make sure you have a bridge:

```
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "br-1"
```

```
            Interface "br-1"
                type: internal
    ovs_version: "2.7.0"
```

Verify the flows for `br-1`

```
# ovs-ofctl show br-1
OFPT_FEATURES_REPLY (xid=0x2): dpid:0000c24e5f3e2f4b
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
actions: output enqueue set_vlan_vid set_vlan_pcp strip_vlan mod_dl_src
mod_dl_dst mod_nw_src mod_nw_dst mod_nw_tos mod_tp_src mod_tp_dst
 LOCAL(br-1): addr:c2:4e:5f:3e:2f:4b
     config:     PORT_DOWN
     state:      LINK_DOWN
     speed: 0 Mbps now, 0 Mbps max
```

```
#  ovs-ofctl dump-flows br-1
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=233.241s, table=0, n_packets=0, n_bytes=0, idle_age=233,
 priority=0 actions=NORMAL
```

Now lets add some ports to our bridge

```
# ovs-vsctl add-port br-1 p1
ovs-vsctl: Error detected while setting up 'p1':
could not open network device p1 (No such device).
 See ovs-vswitchd log for details.
ovs-vsctl: The default log directory is "/var/log/openvswitch".
```

We added interface `p1` to bridge `br-1` however `p1` interface has not been created on our machine yet.
Unlike a new bridge interface, OvS will not create the network interface for a port. Hoever, OvS will still create the port on the bridge.

```
# ip addr | grep p1
#
```

Take a look at your bridge and flows:

```
# ovs-vsctl show
d35f9ced-06b7-4651-8d1c-f8dd75ff3fc2
    Bridge "br-1"
        Port "br-1"
            Interface "br-1"
                type: internal
        Port "p1"
            Interface "p1"
                error: "could not open network device p1 (No such device)"
    ovs_version: "2.7.0"
```

The output above shows a similar error after we added the port to the bridge, no such device.

```
# ovs-ofctl show br-1
OFPT_FEATURES_REPLY (xid=0x2): dpid:0000c24e5f3e2f4b
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
actions: output enqueue set_vlan_vid set_vlan_pcp strip_vlan mod_dl_src
mod_dl_dst mod_nw_src mod_nw_dst mod_nw_tos mod_tp_src mod_tp_dst
 LOCAL(br-1): addr:c2:4e:5f:3e:2f:4b
     config:     PORT_DOWN
     state:      LINK_DOWN
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

We cannot create a flow for an interface that does not exist. The output above verfies no flows have been added for interface p1. Output from `ovs-ofctl dump-flows br-1` will remain the same as above.

D Installing Netperf

```
# wget ftp://ftp.netperf.org/netperf/netperf-2.7.0.tar.gz
# tar -xzf netperf-2.7.0.tar.gz
# cd netperf-2.7.0
# ./configure
# make
# make install
```

D.1 Troubleshooting Installation

If build is not working, you may need to download 2 patches to determine your system arch.

```
# wget -O config.guess \
'http://git.savannah.gnu.org/gitweb/?p=config.git;a=blob_plain;f=config.guess;hb=HEAD'

# wget -O config.sub \
'http://git.savannah.gnu.org/gitweb/?p=config.git;a=blob_plain;f=config.sub;hb=HEAD'
```

E Installing netcat

```
# yum search all netcat
Loaded plugins: langpacks, product-id, search-disabled-repos, subscription-manager
========================== Matched: netcat ============================
nmap.ppc64le : Network exploration tool and security scanner
nmap-ncat.ppc64le : Nmap's Netcat replacement
socat.ppc64le : Bidirectional data relay between two data channels ('netcat++')

# yum install nc
Resolving Dependencies
--> Running transaction check
---> Package nmap-ncat.ppc64le 2:6.40-7.el7 will be installed
--> Finished Dependency Resolution

Dependencies Resolved

Installing:
 nmap-ncat

Installed:
  nmap-ncat.ppc64le 2:6.40-7.el7

Complete!
```

F Installing tcpdump

```
# yum search tcpdump
Loaded plugins: langpacks, product-id, search-disabled-repos, subscription-manager
====================== N/S matched: tcpdump ======================
tcpdump.ppc64le : A network traffic monitoring tool

# yum install tcpdump
```

G Multiple Host Trouble Shooting

Before you even install Open vSwitch, make sure your 2 machines (physical or virtual) can communicate with each other.

It is recommended to first draw a simple diagram of what your network will look like once configured properly. It can be difficult to think of how your network will look given command outputs and different name spaces.

It is important to approach a network problem in pieces or chunks. If you cannot communicate with your VM start from the VM's point-of-view and start pinging smaller portions of the network. Additionally there may be certain IP Tables or rules on a external switch which may be preventing internet access. First verify the problem is NOT on the host machine, then you could explore the possibility of an additional rule or firewall somewhere else. Don't assume both sides of a connection are working in a network test the problem from all angles.

Use tools like ping and tcpdump to verify connections. If you are pinging Host B from Host A, start tcpdump listening on Host B to see if the ICMP packet even gets to Host B. This will narrow down the issue in the network.

One very helpful way to see the traffic as it passes through OvS is to use the `watch` command.

Here is an example:

```
watch -n.5 "ovs-ofctl dump-flows br-1"
```

G.1 GRE Tunnels

```
# lsmod | grep gre
vport_gre               1889  1
ip_gre                 23515  1 vport_gre
ip_tunnel              31010  1 ip_gre
gre                     4661  1 ip_gre
openvswitch           149665  4 vport_gre
```

To remove all GRE interfaces you will have to unload the ip_gre module.

```
# rmmod vport_gre
# rmmod ip_gre
# ip adr | grep gre
#
```

If vport_gre module is loaded, remove that as well. This module should be loaded from OVS.

```
# rmmod ip_gre
rmmod: ERROR: Module ip_gre is in use by: vport_gre
# rmmod vport_gre
# rmmod ip_gre

# ip add | grep gre
#
```

G.2 VXLAN

OvS will load its own vxlan kernel module, similar to GRE.

```
# lsmod | grep vxl
vport_vxlan             3631  1
vxlan                  50947  1 vport_vxlan
ip6_udp_tunnel          3283  1 vxlan
udp_tunnel              6023  1 vxlan
openvswitch           137923  4 vport_vxlan
```

Make sure the `vxlan` and the `vport_vxlan` kernel module is loaded correctly.

G.2.1 Flows for VXLAN

Flow rules are used to assign VNI to packets travelling into or out of a specific port.

OpenFlow works similar to iptables such that there are rules inside of a table.

Lets take a simple rule as an example.

```
0: table=0,in_port=11, actions=set_field:100->tun_id,resubmit(,1)
1: table=0,in_port=12, actions=set_field:200->tun_id,resubmit(,1)
2: table=0,actions=resubmit(,1)
```

Line 0 defines a new rule in table 0. For any traffic travelling into OpenFlow port 11, set the tun_id a.k.a the VNI, to 100. Then resubmit the packet to table 1 for further processing.

So if ns1 was connected to port number 11 one would say, "any traffic travelling from ns1 should be tagged with VNI 100".

Line 1 does something similar, but packets travelling into OpenFlow port 12 will be tagged with the 200 VNI.

Line 2 is a defualt action to send all packets to Table 1. This means it would be a good idea to set a default action in Table 1 to drop all packets that we will not be manipulating.

Other important OpenFlows rules are mentioned below:

- `dl_dst` : The destination MAC address
- `nw_dst` : Destination IP address
- `arp` : Handle ARP packets

Here is another example of some OpenFlow rules:

```
0: table=1,tun_id=100,arp,nw_dst=10.0.0.1,actions=output:1
1: table=1,tun_id=200,arp,nw_dst=10.0.0.1,actions=output:2

2: table=1,tun_id=100,arp,nw_dst=10.0.0.2,actions=output:10
3: table=1,tun_id=200,arp,nw_dst=10.0.0.2,actions=output:10
4: table=1,priority=100,actions=drop
```

These rules are directing OvS where to send ARP requests. Line 0 states any traffic for 10.0.0.1 with VNI 100 will be sent to OpenFlow port 1. Line 1 is similar but will send packets with VNI 200 to port 2.

Line 2 says that an ARP packet with a VNI of 100 and destination address of 10.0.0.2 will be sent to OpenFlow port 10.

Line 4 is a default drop rules.