An Introduction to Open vSwitch

Linux.Conf.Au 2012, Ballarat

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20th January 2012

Contents

Open vSwitch

- Multi-Layer Virtual Switch
- Flexible Controller in User-Space
- Fast Datapath in Kernel
- An implementation of Open Flow and more

Open vSwitch Availability

- Available from openvswitch.org
- Development code is available in git
- Datapath scheduled for inclusion in Linux Kernel 3.2
- Announce, discussion and development mailing lists

License

- User-space (controller and tools) is under the Apache license
- Kernel (datapath) is under the GPLv2
- Shared headers are dual-licensed

Open vSwitch Concepts

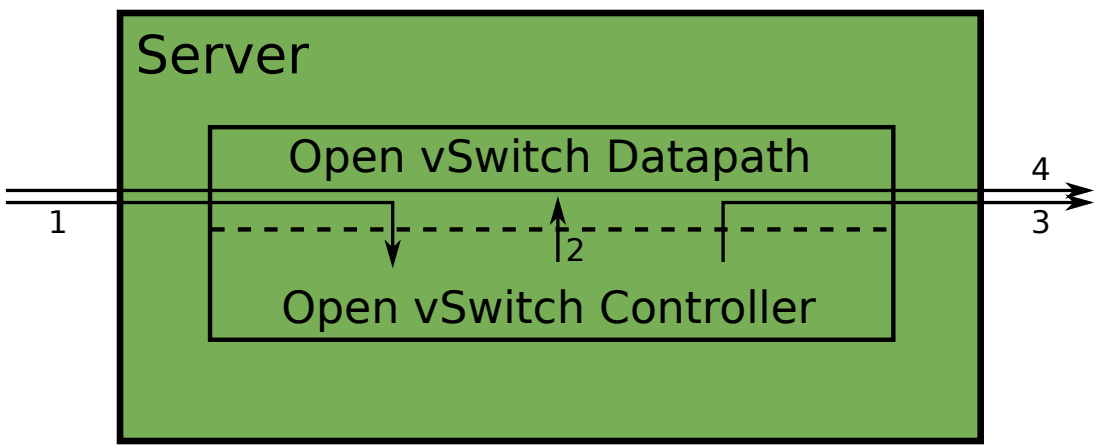
- A switch contains ports
- A port may have one or more interfaces
  - Bonding allows more than once interface per port
- Packets are forward by flow

Identifying Flows

- A flow may be identified by any combination of
  - Tunnel ID
  - IPv6 ND target
  - IPv4 or IPv6 source address
  - IPv4 or IPv6 destination address
  - Input port
  - Ethernet frame type
  - VLAN ID (802.1Q)
  - TCP/UDP source port
  - TCP/UDP destination port
  - Ethernet source address
  - Ethernet destination address
  - IP Protocol or lower 8 bits of ARP ppcode
  - IP ToS (DSCP field)
  - ARP/ND source hardware address
  - ARP/ND destination hardware address

Forwarding Flows

1. The first packet of a flow is sent to the controller
2. The controller programs the datapath's actions for a flow
   - Usually one, but may be a list
   - Actions include:
     - Forward to a port or ports, mirror
     - Encapsulate and forward to controller
     - Drop
3. And returns the packet to the datapath
4. Subsequent packets are handled directly by the datapath



Management

- Open vSwitch controller is configured via a JSON database
- Persistent across restart
- Database actions won't return until the controller is reconfigured
- Database may be controlled locally using a UNIX socket or remotely using TCP

Basic Configuration

1. Ensure that Open vSwitch is running

   ```
   /etc/init.d/openvswitch-switch start
   ```

2. Create a bridge

   ```
   ovs-vsctl -- --may-exist add-br br0
   ```

3. Add port to a bridge

   ```
   ovs-vsctl -- --may-exist add-port br0 eth0
   ```

Basic De-Configuration

1. Ensure that Open vSwitch is running

   ```
   /etc/init.d/openvswitch-switch start
   ```

2. Remove a port from a bridge

   ```
   ovs-vsctl -- --if-exists del-port br0 eth0
   ```

3. Remove a bridge

   ```
   ovs-vsctl -- --if-exists del-br br0
   ```

Examples of Advanced Configuration

- VLAN
- GRE
- Port Mirroring (SPAN)
- QoS

VLAN

- Allows partitioning of logical L2 network
- Access Port
  - Member of a single VLAN
  - Frames are untagged
  - Recipient is VLAN agnostic
- Trunk Port
  - May be a member of multiple VLANs
  - Frames are tagged
  - Must be VLAN aware
  - May be used to give access to multiple VLANs across multiple switches

VLAN Access Port

```
ovs-vsctl add-port br0 tap0 tag=7
```

Port Mirroring (SPAN)

- Allows frames sent to or recieved on one or more ports to be duplicated on a different port
- Useful for debugging

Port Mirroring Configuration (Preparation)

1. Create a dummy interface that will recieve mirrored packets

```
modprobe dummy
ip link set up dummy0
```

2. Add the dummy interface to the bridge in use

```
ovs-vsctl -- --may-exist add-port br0 dummy0
```

Port Mirroring Configuration (Target)

```
0: ovs-vsctl \
1:     -- --id=@p get port dummy0 \
2:     -- --id=@m create mirror name=mirror0 \
3:     -- add bridge br0 mirrors @m \
4:     -- set mirror mirror0 output_port=@p
```

1. Find the UUID of the target interface
2. Create a mirror
3. Add the mirror to a bridge
4. Configure the mirror to output mirrored packets to the target interface

Line numbers added for clarity

Port Mirroring Configuration (Selected Source)

```
0: ovs-vsctl \
1:     -- --id=@p get port tap0 \
2:     -- set mirror mirror0 select_dst_port=@p \
3:     -- set mirror mirror0 select_src_port=@p
```

1. Find the UUID of the source interface
2. All packets sent to tap0 will be mirrored
3. All packets sent from tap0 will be mirrored

Line numbers added for clarity

Port Mirroring Configuration (All Sources)

```
ovs-vsctl set mirror mirror0 select_all=1
```

- All switch packets will go to dummy0

Tunnelling

- Allows logical L2 network to span multiple physical networks
  - Migration
  - Remote Access
- GRE and more recently VXLAN tunnelling supported

GRE Tunnel (Endpoint A)

```
0: ovs-vsctl \
1:  -- --id=@i create interface name=gre0 type=gre \
2:     options="remote_ip=10.0.0.8,local_ip=10.0.0.9,key=1" \
3:  -- --id=@p create port name=gre0 interfaces=[@i] \
4:  -- add bridge br0 ports @p
```

1. Create a gre interface, gre0
2. Set the endpoints and key of gre0
3. Create an interface with gre0 as its only port
4. Add the interface to the bridge

GRE Tunnel (Endpoint B)

```
0: ovs-vsctl \
1:  -- --id=@i create interface name=gre0 type=gre \
2:     options="remote_ip=10.0.0.9,local_ip=10.0.0.8,key=1" \
3:  -- --id=@p create port name=gre0 interfaces=[@i] \
4:  -- add bridge br0 ports @p
```

- remote_ip and local_ip have been exchanged

QoS

Open vSwitch QoS capabilities

1. Interface rate limiting
2. Port QoS policy

Interface rate limiting

- A rate and burst can be assigned to an Interface
- Conceptually similar to Xen's netback credit scheduler
- Utilises the Kernel tc framework's ingress polycing
- Simple
- Configuration example. 100Mbit/s rate with 10Mbit/s burst:

```
# ovs-vsctl set Interface tap0 ingress_policing_rate=100000
# ovs-vsctl set Interface tap0 ingress_policing_burst=10000
```

Control: No interface rate limiting

```
# netperf -4 -t UDP_STREAM -H 172.17.50.253 -- -m 8972
UDP UNIDIRECTIONAL SEND TEST from 0.0.0.0 (0.0.0.0)...
Socket  Message  Elapsed      Messages
Size    Size     Time         Okay Errors   Throughput
bytes   bytes    secs            #      #   10^6bits/sec

120832    8972   10.01       146797      0    1052.60
109568           10.01       146620           1051.33
```

- tap networking used
- jumbo frames required to reach line speed (≈210Mbits/s with 1500 byte frames)
- virtio does much better

Interface rate limiting result

```
# netperf -4 -t UDP_STREAM -H 172.17.50.253
UDP UNIDIRECTIONAL SEND TEST from 0.0.0.0 (0.0.0.0)...
Socket  Message  Elapsed      Messages
Size    Size     Time         Okay Errors   Throughput
bytes   bytes    secs            #      #   10^6bits/sec

120832    8972   10.01       149735      0    1073.66
109568           10.01        14684           105.29
```

- Difference in sent and received packets indicates that excess packets are dropped – no backpressure
- This is an inherent problem when using ingress policying

Port QoS policy

- A port may be assigned one ore more QoS policy
- Each QoS policy consists of a class and a qdisc
- Classes and qdisc use the Linux kernel's tc implementation
- Only HTB and HFSC classes are supported at this time
- The class of a flow is chosen by the controller
- The QoS policy (i.e. class) of a flow is chosen by the controller
- Operates as an egress filter

Port QoS policy example

Hard-coding the controller

```
# ovs-ofctl add-flow br0 "in_port=2 ip nw_dst=172.17.50.253 \
     idle_timeout=0 actions=enqueue:1:0"
# ovs-ofctl add-flow br0 "in_port=3 ip nw_dst=172.17.50.253 \
     idle_timeout=0 actions=enqueue:1:1"
```

Only suitable for testing

Port QoS policy example

```
Guest 0:
# netperf -4 -t TCP_STREAM -H 172.17.50.253 -l 30 -- -m 8972
TCP STREAM TEST from 0.0.0.0 (0.0.0.0)...
Recv   Send    Send
Socket Socket  Message  Elapsed
Size   Size    Size     Time     Throughput
bytes  bytes   bytes    secs.    10^6bits/sec
87380  16384   8972    30.01      99.12

Guest 1:
# netperf -4 -t TCP_STREAM -H 172.17.50.253 -l 30 -- -m 8972
...
87380  16384   8972    30.14      49.56
```

Port QoS policy controller improvements

- Add a default queue to the Port table
- Add enqueue to the FLOOD and NORMAL ports

Questions

Bonus Topic: VLAN Extensions

- Per-Customer VLANs are desirable for security reasons
- But there is a limit of 4094 VLANs

More VLANs

Two, apparently competing, approaches

- IETF / Cisco
  - RFC5517 — Private VLANs
- IEEE
  - 802.1ad — Provider Bridges (Q-in-Q)
  - 802.1ah — Provider Backbone Brides (MAC-in-MAC)

RFC5517 — Private VLANs

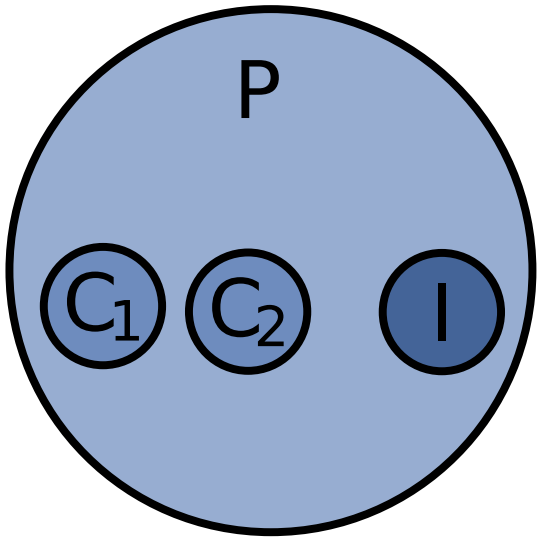
- Uses existing 802.1Q framing
  - Simple to implement (in software/firmware)
- Makes use of pairs of VIDs
  - Requires all switches to support of Private VLANs otherwise switch tables may not merge
- Provides L2 broadcast isolation
  - Forwarding may occur at L3
  - Requires the router to perform proxy ARP
- Currently not supported by Open vSwitch

RFC5517 — Private VLANs

Three VLAN classifications

- Promiscuous
  - May communicate with endpoints on any port
  - e.g.: Gateway, Management Host
- Community
  - May only communicate with endpoints on promiscuous ports or ports belonging to the same comunity
  - e.g.: Different hosts belonging to the same customer
- Isolated
  - May only communicate with endpoints on promiscuous ports
  - e.g.: Hosts that only require access to the gateway

Private VLANs — Domain View



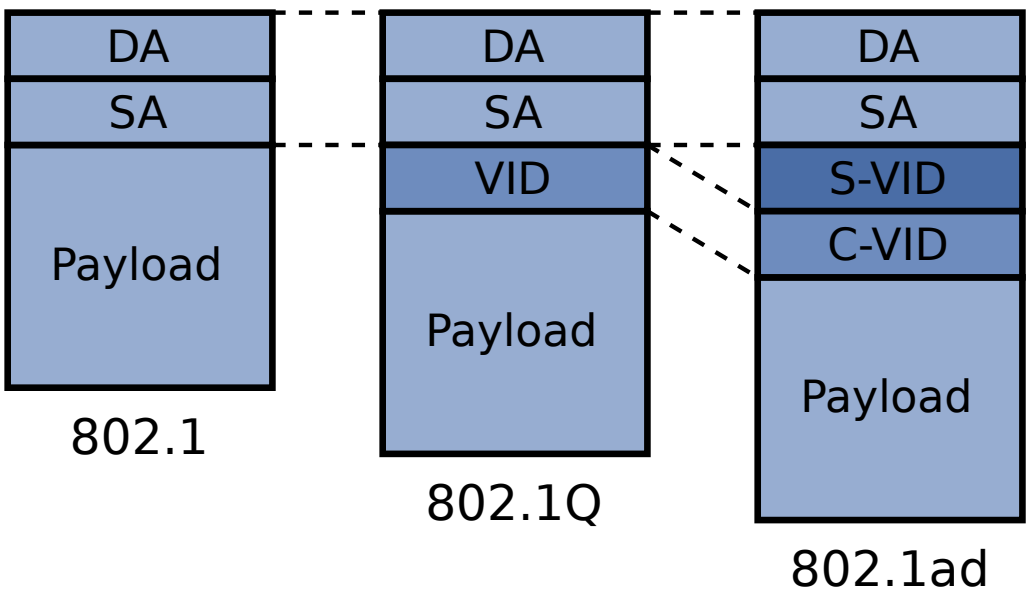
- Promiscous domain (P)
  - May communicate with endpoints in the same domain and sub-domains
- Two community sub-domains (C_1, C_2)
  - May communicate with endpoints in the same domain and parent-domain
- Isolated sub-domain (I)
  - May communicate with endpoints in the parent domain
  - May *not* communicate with endpoints in the same domain

802.1ad — Provider Bridges (Q-in-Q)

- Current standard is 802.1ad-2005, Approved December 2005
- Builds on 802.1Q
- New Framing
  - C-VID (inner)
    - Renamed 802.1Q VID
    - There may be more than one C-VID (inner-inner, ...)
  - S-VID (outer)
    - Different ether-type to C-VID
    - May be translated
- Currently not supported by Linux Kernel / Open vSwitch

802.1ad Framing — Provider Bridges

DA	Destination MAC address
SA	Source MAC addresss
S-VID	Service VLAN ID
C-VID	Customer VLAN ID
VID	VLAN ID

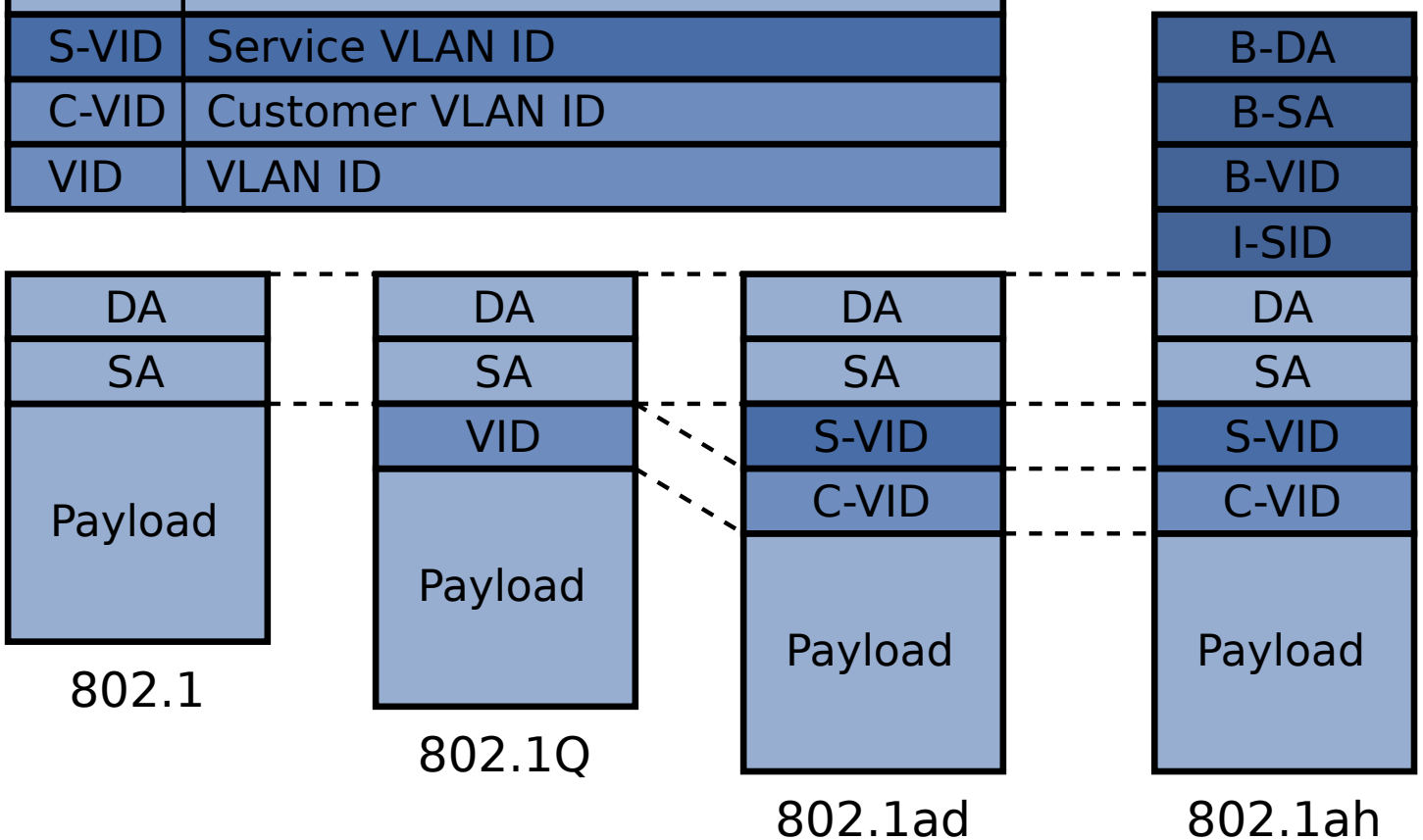


802.1ah — Provider Backbone Bridges (MAC-in-MAC)

- Current standard is 802.1ah-2008, Approved August 2008
- Builds on 802.1ad
- New Framing
  - MAC encapsulation provides full Client VLAN isolation
    - Inner MAC is unknown outside of its scope
  - I-SID: Up to $2^{24} \approx$ 16million backbone services
  - I-VID semantics are the same as the S-VLAN
    - Only edge switches need to be Provider Backbone Bridge aware
    - Core switches need only be Provider Bridge (802.1ad) aware
- Currently not supported by Linux Kernel / Open vSwitch

802.1ah Framing — Provider Backbone Bridges

B-DA	Backbone Destination MAC address
B-SA	Backbone Source MAC address
B-VID	Backbone VLAN ID
I-SID	Service ID
DA	Destination MAC address
SA	Source MAC addresss
S-VID	Service VLAN ID
C-VID	Customer VLAN ID
VID	VLAN ID



Questions