Faucet Documentation

Faucet Developers

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CHAPTER

ONE

USER DOCUMENTATION

1.1 Introduction to Faucet

1.1.1 What is Faucet?

Faucet is a compact open source OpenFlow controller, which enables network operators to run their networks the same way they do server clusters. Faucet moves network control functions (like routing protocols, neighbor discovery, and switching algorithms) to vendor independent server-based software, versus traditional router or switch embedded firmware, where those functions are easy to manage, test, and extend with modern systems management best practices and tools. Faucet controls OpenFlow 1.3 hardware which delivers high forwarding performance.

You can read more about our approach to networking by reading our ACM Queue article Faucet: Deploying SDN in the Enterprise.

1.1.2 What is Gauge?

Faucet has two main OpenFlow controller components, Faucet itself, and Gauge. Faucet controls all forwarding and switch state, and exposes its internal state, e.g. learned hosts, via Prometheus (so that an open source NMS such as Grafana graph it).

Gauge also has an OpenFlow connection to the switch and monitors port and flow state (exporting it to Prometheus or InfluxDB, or even flat text log files). Gauge, however, does not ever modify the switch's state, so that switch monitoring functions can be upgraded, restarted, without impacting forwarding.

1.1.3 Why Faucet?

Design

Faucet is designed to be very small, simple (1000s of lines of code, versus millions in other systems), and keep relatively little state. Faucet does not have any implementation-specific or vendor driver code, which considerably reduces complexity. Faucet does not need connectivity to external databases for forwarding decisions. Faucet provides "hot/hot" high availability and scales through the provisioning of multiple Faucets with the same configuration - Faucet controllers are not inter-dependent.

Performance and scaling

As well as being compact, Faucet offloads all forwarding to the OpenFlow switch, including flooding if emulating a traditional switch. Faucet programs the switch pre-emptively, though will receive packet headers from the switch if, for example, a host moves ports so that the switch's OpenFlow FIB can be updated (again, if traditional switching is

being emulated). In production, Faucet controllers have been observed to go many seconds without needing to process a packet from a switch. In cold start scenarios, Faucet has been observed to completely program a switch and learn connected hosts within a few seconds.

Faucet uses a multi-table packet processing pipeline as shown in *Faucet Openflow Switch Pipeline*. Using multiple flow tables over a single table allows Faucet to implement more complicated flow-based logic while maintaining a smaller number of total flows. Using dedicated flow tables with a narrow number of match fields, or limiting a table to exact match only, such as the IPv4 or IPv6 FIB tables allows us to achieve greater scalability over the number of flow entries we can install on a datapath.

A large network with many devices would run many Faucets, which can be spread over as many (or as few) machines as required. This approach scales well because each Faucet uses relatively few server resources and Faucet controllers do not have to be centralized - they can deploy as discrete switching or routing functional units, incrementally replacing (for example) non-SDN switches or routers.

An operator might have a controller for an entire rack, or just a few switches, which also reduces control plane complexity and latency by keeping control functions simple and local.

Testing

Faucet follows open source software engineering best practices, including unit and systems testing (python unittest based), as well static analysis (pytype, pylint, and codecov) and fuzzing (python-afl). Faucet's systems tests test all Faucet features, from switching algorithms to routing, on virtual topologies. However, Faucet's systems tests can also be configured to run the same feature tests on real OpenFlow hardware. Faucet developers also host regular PlugFest events specifically to keep switch implementations broadly synchronized in capabilities and compatibility.

1.1.4 Release Notes

1.7.0 Release Notes

We are making a few potentially breaking features in faucet 1.7.0. This document covers how to navigate the changes and safely upgrade from earlier versions to 1.7.0.

1. **Configuration and log directory changed**

   Starting in 1.7.0 and onwards faucet has changed which directories it uses for configuration and log files. The new paths are:

Old path	New path
/etc/ryu/faucet	/etc/faucet
/var/log/ryu/faucet	/var/log/faucet

   Faucet 1.7.0 when being installed by pip will automatically attempt to migrate your old configuration files to `/etc/faucet` assuming it has permissions to do so. Failing this faucet when started will fallback to loading configuration from `/etc/ryu/faucet`. The search paths for configuration files are documented on the *Environment variables* page.

   Note: Consider the `/etc/ryu/faucet` directory deprecated, we will in a future release stop reading config files stored in this directory.

   If you currently set your own configuration or log directory by setting the appropriate environment variables you will be unaffected. In most other cases the migration code or the fallback configuration

search path will allow the upgrade to 1.7.0 to be seamless. We have however identified two cases where manual intervention is required:

Dockers

Dockers will need to be started with new mount directories, the commands to start a 1.7.0 docker version of faucet or gauge are detailed in the *Installation with Docker* section.

Virtualenvs

We are unable to migrate configuration files automatically when faucet is run inside of a virtualenv, please copy the configuration directory over manually.

2. **Changing default flood mode**

   Currently faucet defaults to using `combinatorial_port_flood` when it comes to provisioning flooding flows on a datapath, faucet implicitly configures a datapath like this today:

```
dps:
    mydp:
        combinatorial_port_flood: True
```

   The default is `True`, in 1.7.0 and previously. The default will change to `False` in 1.7.1.

   When `True`, flood rules are explicitly generated for each input port, to accommodate early switch implementations which (differing from the OpenFlow standard - see below) did not discard packets output to the packet input port. `False` generates rules per faucet VLAN which results in fewer rules and better scalability.

   See OpenFlow 1.3.5 specification, section B.6.3:

```
The behavior of sending out the incoming port was not clearly defined
in earlier versions of the specification. It is now forbidden unless
the output port is explicitly set to OFPP_IN_PORT virtual port
(0xfff8) is set.
```

1.9.0 Release Notes

There are some changes in version 1.9.0 of faucet that may affect how you use it. Below are the changes and how they might affect you.

1. **Removing support for older python versions**

   Starting from faucet 1.9.0 and onwards, faucet now requires a version of python 3.5 or newer to function.

   Most currently supported distributions of linux should have a version of python that is compatible, with the notable exception of Debian Jessie which is no longer supported by faucet.

2. **Change BGP configuration syntax**

   Previously, BGP configuration for faucet was attached to a VLAN, for example:

   Listing 1: Older style bgp configuration

```
vlans:
    internet:
        description: 'internet peering'
        vid: 200
        bgp_routerid: '127.0.0.2'
```

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```
        bgp_as: 14031
        bgp_neighbor_as: 14031
        bgp_neighbor_addresses: ['127.0.0.1', '::1']
        bgp_server_addresses: ['127.0.0.2', '::1']
        bgp_port: 9179
        bgp_connect_mode: 'passive'
```

As BGP peering in faucet now has the ability to resolve next hops in all VLANs, we have elected to move where BGP is configured.

We have now implemented a new `bgp` router type that can be configured in faucet, similar to how inter-VLAN routing works today, for example this is an example of the new syntax showing how we would convert the configuration shown above:

Listing 2: Newer style bgp configuration

```
vlans:
    internet:
        description: 'internet peering'
        vid: 200

routers:
    internet-router:
        bgp:
            vlan: internet
            routerid: '127.0.0.2'
            as: 14031
            neighbor_as: 14031
            neighbor_addresses: ['127.0.0.1', '::1']
            server_addresses: ['127.0.0.2', '::1']
            port: 9179
            connect_mode: 'passive'
```

It is also possible to combine inter-VLAN routing and bgp routing in a single routing instance:

Listing 3: Newer style bgp configuration (with IVR)

```
vlans:
    office:
        description: 'internet peering'
        vid: 100
    internet:
        description: 'internet peering'
        vid: 200

routers:
    office-internet-router:
        vlans: [office, internet]
        bgp:
            vlan: internet
            routerid: '127.0.0.2'
            as: 14031
            neighbor_as: 14031
            neighbor_addresses: ['127.0.0.1', '::1']
            server_addresses: ['127.0.0.2', '::1']
            port: 9179
            connect_mode: 'passive'
```

For more information on what each option does, please see the *BGP* documentation section.

1.1.5 Getting Help

We use maintain a number of mailing lists for communicating with users and developers:

- faucet-announce
- faucet-dev
- faucet-users

We also have the #faucetsdn IRC channel on freenode.

A few tutorial videos are available on our YouTube channel.

The FAUCET dev log and faucetsdn twitter are good places to keep up with the latest news about faucet.

If you find bugs, or if have feature requests, please create an issue on our bug tracker.

1.2 Tutorials

1.2.1 Installing faucet for the first time

This tutorial will run you through the steps of installing a complete faucet system for the first time.

We will be installing and configuring the following components:

Component	Purpose
faucet	Network controller
gauge	Monitoring controller
prometheus	Monitoring system & time series database
grafana	Monitoring dashboard

This tutorial was written for Ubuntu 16.04, however the steps should work fine on any newer supported version of Ubuntu or Debian.

Package installation

1. Add the faucet official repo to our system:

```
sudo apt-get install curl gnupg apt-transport-https lsb-release
echo "deb https://packagecloud.io/faucetsdn/faucet/$(lsb_release -si | awk '
↪{print tolower($0)}')/ $(lsb_release -sc) main" | sudo tee /etc/apt/sources.
↪list.d/faucet.list
curl -L https://packagecloud.io/faucetsdn/faucet/gpgkey | sudo apt-key add -
sudo apt-get update
```

2. Install the required packages, we can use the `faucet-all-in-one` metapackage which will install all the correct dependencies.

```
sudo apt-get install faucet-all-in-one
```

Configure prometheus

We need to configure prometheus to tell it how to scrape metrics from both the faucet and gauge controllers. To help make life easier faucet ships a sample configuration file for prometheus which sets it up to scrape a single faucet and gauge controller running on the same machine as prometheus. The configuration file we ship looks like:

Listing 4: prometheus.yml

```
# my global config
global:
  scrape_interval:     15s # Set the scrape interval to every 15 seconds. Default is
↪every 1 minute.
  evaluation_interval: 15s # Evaluate rules every 15 seconds. The default is every 1
↪minute.
  # scrape_timeout is set to the global default (10s).

# Load rules once and periodically evaluate them according to the global 'evaluation_
↪interval'.
rule_files:
  - "faucet.rules.yml"

# A scrape configuration containing exactly one endpoint to scrape:
# Here it's Prometheus itself.
scrape_configs:
  # The job name is added as a label `job=<job_name>` to any timeseries scraped from
↪this config.
  - job_name: 'prometheus'
    static_configs:
      - targets: ['localhost:9090']
  - job_name: 'faucet'
    static_configs:
      - targets: ['localhost:9302']
  - job_name: 'gauge'
    static_configs:
      - targets: ['localhost:9303']
```

To learn more about what this configuration file does you can look at the Prometheus Configuration Documentation. The simple explanation is that it includes an additional `faucet.rules.yml` file that performs some automatic queries in prometheus for generating some additional metrics as well as setting up scrape jobs every 15 seconds for faucet listening on `localhost:9302` and gauge listening on `localhost:9303`.

Steps to make prometheus use the configuration file shipped with faucet:

1. Change the configuration file prometheus loads by editing the file `/etc/default/prometheus` to look like:

Listing 5: /etc/default/prometheus

```
# Set the command-line arguments to pass to the server.
ARGS="--config.file=/etc/faucet/prometheus/prometheus.yml"
```

2. Restart prometheus to apply the changes:

```
sudo systemctl restart prometheus
```

Configure grafana

Grafana running in it's default configuration will work just fine for our needs. We will however need to make it start on boot, configure prometheus as a data source and add our first dashboard:

1. Make grafana start on boot and then start it manually for the first time:

```
sudo systemctl daemon-reload
sudo systemctl enable grafana-server
sudo systemctl start grafana-server
```

2. To finish setup we will configure grafana via the web interface.

   First load `http://localhost:3000` in your web browser (by default both the username and password are `admin`).

3. The web interface will first prompt us to add a data source. Use the following settings then click `Save & Test`:

```
Name:   Prometheus
Type:   Prometheus
URL:    http://localhost:9090
```

4. Next we want to add some dashboards so that we can later view the metrics from faucet.

   Hover over the + button on the left sidebar in the web interface and click `Import`.

   We will import the following dashboards, just download the following links and upload them through the grafana dashboard import screen:

   - Instrumentation
   - Inventory
   - Port Statistics

Configure faucet

For this tutorial we will configure a very simple network topology consisting of a single switch with two ports.

1. Configure faucet

   We need to tell faucet about our topology and VLAN information, we can do this by editing the faucet configuration `/etc/faucet/faucet.yaml` to look like:

Listing 6: /etc/faucet/faucet.yaml

```
vlans:
    office:
        vid: 100
        description: "office network"

dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
                description: "host1 network namespace"
                native_vlan: office
            2:
                name: "host2"
                description: "host2 network namespace"
                native_vlan: office
```

Note: Tabs are forbidden in the YAML language, please use only spaces for indentation.

This will create a single VLAN and a single datapath with two ports.

2. Verify configuration

   The `check_faucet_config` command can be used to verify faucet has correctly interpreted your configuration before loading it. This can avoid shooting yourself in the foot by applying configuration with typos. We recommend either running this command by hand or with automation each time before loading configuration.

```
check_faucet_config /etc/faucet/faucet.yaml
```

   This script will either return an error, or in the case of successfully parsing the configuration it will return a JSON object containing the entire faucet configuration that would be loaded (including any default settings), for example:

```
[{'advertise_interval': 30,
  'arp_neighbor_timeout': 30,
  'cache_update_guard_time': 150,
  'combinatorial_port_flood': False,
  'cookie': 1524372928,
  'description': 'sw1',
  'dot1x': None,
  'dp_acls': None,
  'dp_id': 1,
  'drop_broadcast_source_address': True,
  'drop_spoofed_faucet_mac': True,
  'egress_pipeline': False,
  'fast_advertise_interval': 5,
  'faucet_dp_mac': '0e:00:00:00:00:01',
  'global_vlan': 0,
  'group_table': False,
  'hardware': 'Open vSwitch',
  'high_priority': 9001,
  'highest_priority': 9099,
  'idle_dst': True,
```

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```
 'ignore_learn_ins': 10,
 'interface_ranges': OrderedDict(),
 'interfaces': {'host1': {'acl_in': None,
                          'acls_in': None,
                          'description': 'host1 network namespace',
                          'dot1x': False,
                          'enabled': True,
                          'hairpin': False,
                          'hairpin_unicast': False,
                          'lacp': 0,
                          'lacp_active': False,
                          'lldp_beacon': OrderedDict(),
                          'loop_protect': False,
                          'loop_protect_external': False,
                          'max_hosts': 255,
                          'max_lldp_lost': 3,
                          'mirror': None,
                          'native_vlan': 'office',
                          'number': 1,
                          'opstatus_reconf': True,
                          'output_only': False,
                          'permanent_learn': False,
                          'receive_lldp': False,
                          'stack': OrderedDict(),
                          'tagged_vlans': [],
                          'unicast_flood': True},
                'host2': {'acl_in': None,
                          'acls_in': None,
                          'description': 'host2 network namespace',
                          'dot1x': False,
                          'enabled': True,
                          'hairpin': False,
                          'hairpin_unicast': False,
                          'lacp': 0,
                          'lacp_active': False,
                          'lldp_beacon': OrderedDict(),
                          'loop_protect': False,
                          'loop_protect_external': False,
                          'max_hosts': 255,
                          'max_lldp_lost': 3,
                          'mirror': None,
                          'native_vlan': 'office',
                          'number': 2,
                          'opstatus_reconf': True,
                          'output_only': False,
                          'permanent_learn': False,
                          'receive_lldp': False,
                          'stack': OrderedDict(),
                          'tagged_vlans': [],
                          'unicast_flood': True}},
 'lacp_timeout': 30,
 'learn_ban_timeout': 51,
 'learn_jitter': 51,
 'lldp_beacon': OrderedDict(),
 'low_priority': 9000,
 'lowest_priority': 0,
 'max_host_fib_retry_count': 10,
```

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```
  'max_hosts_per_resolve_cycle': 5,
  'max_resolve_backoff_time': 64,
  'max_wildcard_table_size': 1280,
  'metrics_rate_limit_sec': 0,
  'min_wildcard_table_size': 32,
  'multi_out': True,
  'nd_neighbor_timeout': 30,
  'ofchannel_log': None,
  'packetin_pps': None,
  'priority_offset': 0,
  'proactive_learn_v4': True,
  'proactive_learn_v6': True,
  'stack': None,
  'strict_packet_in_cookie': True,
  'table_sizes': OrderedDict(),
  'timeout': 300,
  'use_classification': False,
  'use_idle_timeout': False}]
```

3. Reload faucet

   To apply this configuration we can reload faucet which will cause it to compute the difference between the old and new configuration and apply the minimal set of changes to the network in a hitless fashion (where possible).

```
sudo systemctl reload faucet
```

4. Check logs

   To verify the configuration reload was successful we can check `/var/log/faucet/faucet.log` and make sure faucet successfully loaded the configuration we can check the faucet log file `/var/log/faucet/faucet.log`:

Listing 7: /var/log/faucet/faucet.log

```
faucet INFO     Loaded configuration from /etc/faucet/faucet.yaml
faucet INFO     Add new datapath DPID 1 (0x1)
faucet INFO     Add new datapath DPID 2 (0x2)
faucet INFO     configuration /etc/faucet/faucet.yaml changed, analyzing␣
↪differences
faucet INFO     Reconfiguring existing datapath DPID 1 (0x1)
faucet.valve INFO     DPID 1 (0x1) skipping configuration because datapath not up
faucet INFO     Deleting de-configured DPID 2 (0x2)
```

   If there were any issues (say faucet wasn't able to find a valid pathway from the old config to the new config) we could issue a faucet restart now which will cause a cold restart of the network.

Configure gauge

We will not need to edit the default gauge configuration that is shipped with faucet as it will be good enough to complete the rest of this tutorial. If you did need to modify it the path is `/etc/faucet/gauge.yaml` and the default configuration looks like:

Listing 8: gauge.yaml

```
# Recommended configuration is Prometheus for all monitoring, with all_dps: True
faucet_configs:
```

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```
    - '/etc/faucet/faucet.yaml'
watchers:
    port_status_poller:
        type: 'port_state'
        all_dps: True
        #dps: ['sw1', 'sw2']
        db: 'prometheus'
    port_stats_poller:
        type: 'port_stats'
        all_dps: True
        #dps: ['sw1', 'sw2']
        interval: 10
        db: 'prometheus'
        #db: 'influx'
    flow_table_poller:
        type: 'flow_table'
        all_dps: True
        interval: 60
        db: 'prometheus'
dbs:
    prometheus:
        type: 'prometheus'
        prometheus_addr: '0.0.0.0'
        prometheus_port: 9303
    ft_file:
        type: 'text'
        compress: True
        path: 'flow_tables'
    influx:
        type: 'influx'
        influx_db: 'faucet'
        influx_host: 'influxdb'
        influx_port: 8086
        influx_user: 'faucet'
        influx_pwd: 'faucet'
        influx_timeout: 10
```

This default configuration will setup a prometheus exporter listening on port `0.0.0.0:9303` and write all the different kind of gauge metrics to this exporter.

We will however need to restart the current gauge instance so it can pick up our new faucet configuration:

```
sudo systemctl restart gauge
```

Connect your first datapath

Now that we've set up all the different components let's connect our first switch (which we call a `datapath`) to faucet. We will be using Open vSwitch for this which is a production-grade software switch with very good OpenFlow support.

1. Add WAND Open vSwitch repo

   The bundled version of Open vSwitch in Ubuntu 16.04 is quite old so we will use WAND's package repo to install a newer version (if you're using a more recent debian or ubuntu release you can skip this step).

Note: If you're using a more recent debian or ubuntu release you can skip this step

```
sudo apt-get install apt-transport-https
echo "deb https://packages.wand.net.nz $(lsb_release -sc) main" | sudo␣
↪tee /etc/apt/sources.list.d/wand.list
sudo curl https://packages.wand.net.nz/keyring.gpg -o /etc/apt/trusted.
↪gpg.d/wand.gpg
sudo apt-get update
```

2. Install Open vSwitch

```
sudo apt-get install openvswitch-switch
```

3. Add network namespaces to simulate hosts

   We will use two linux network namespaces to simulate hosts and this will allow us to generate some traffic on our network.

   First let's define some useful bash functions by coping and pasting the following definitions into our bash terminal:

```
# Run command inside network namespace
as_ns () {
    NAME=$1
    NETNS=faucet-${NAME}
    shift
    sudo ip netns exec ${NETNS} $@
}
```

```
# Create network namespace
create_ns () {
    NAME=$1
    IP=$2
    NETNS=faucet-${NAME}
    sudo ip netns add ${NETNS}
    sudo ip link add dev veth-${NAME} type veth peer name veth0 netns $
↪{NETNS}
    sudo ip link set dev veth-${NAME} up
    as_ns ${NAME} ip link set dev lo up
    [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0 ${IP}
    as_ns ${NAME} ip link set dev veth0 up
}
```

   NOTE: all the tutorial helper functions can be defined by sourcing `helper-funcs` into your shell enviroment.

   Now we will create `host1` and `host2` and assign them some IPs:

```
create_ns host1 192.168.0.1/24
create_ns host2 192.168.0.2/24
```

2. Configure Open vSwitch

   We will now configure a single Open vSwitch bridge (which will act as our datapath) and add two ports to this bridge:

```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- add-port br0 veth-host2 -- set interface veth-host2 ofport_request=2 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

The Open vSwitch documentation is very good if you wish to find out more about configuring Open vSwitch.

3. Verify datapath is connected to faucet

   At this point everything should be working, we just need to verify that is the case. If we now load up some of the grafana dashboards we imported earlier, we should see the datapath is now listed in the `Faucet Inventory` dashboard.

   If you don't see the new datapath listed you can look at the faucet log files `/var/log/faucet/faucet.log` or the Open vSwitch log `/var/log/openvswitch/ovs-vswitchd.log` for clues.

4. Generate traffic between virtual hosts

   With `host1` and `host2` we can now test our network works and start generating some traffic which will show up in grafana.

   Let's start simple with a ping:

```
as_ns host1 ping 192.168.0.2
```

   If this test is successful this shows our Open vSwitch is forwarding traffic under faucet control, `/var/log/faucet/faucet.log` should now indicate those two hosts have been learnt:

Listing 9: /var/log/faucet/faucet.log

```
faucet.valve INFO     DPID 1 (0x1) L2 learned 22:a6:c7:20:ff:3b (L2 type␣
↪0x0806, L3 src 192.168.0.1, L3 dst 192.168.0.2) on Port 1 on VLAN 100␣
↪(1 hosts total)
faucet.valve INFO     DPID 1 (0x1) L2 learned 36:dc:0e:b2:a3:4b (L2 type␣
↪0x0806, L3 src 192.168.0.2, L3 dst 192.168.0.1) on Port 2 on VLAN 100␣
↪(2 hosts total)
```

   We can also use iperf to generate a large amount of traffic which will show up on the `Port Statistics` dashboard in grafana, just select `sw1` as the Datapath Name and `All` for the Port.

```
sudo apt-get install iperf3
as_ns host1 iperf3 --server --pidfile /run/iperf3-host1.pid --daemon
as_ns host2 iperf3 --client 192.168.0.1
```

Further steps

Now that you know how to setup and run faucet in a self-contained virtual environment you can build on this tutorial and start to make more interesting topologies by adding more Open vSwitch bridges, ports and network namespaces. Check out the faucet *Configuration* document for more information on features you can turn on and off. In future we will publish additional tutorials on layer 3 routing, inter-VLAN routing, ACLs.

You can also easily add real hardware into the mix as well instead of using a software switch. See the *Vendor-specific Documentation* section for information on how to configure a wide variety of different vendor devices for faucet.

1.2.2 ACL tutorial

In the *Installing faucet for the first time* tutorial we covered how to install and set-up Faucet. Next we are going to introduce Access Control Lists (ACLs).

ETA: ~25 minutes.

Prerequisites

- Install Faucet - *Package installation* steps 1 & 2
- Install Open vSwitch - *Connect your first datapath* steps 1 & 2
- Useful Bash Functions - Copy and paste the following definitions into your bash terminal, or to make them persistent between sessions add them to the bottom of your .bashrc and run 'source .bashrc'.

```
# Run command inside network namespace
as_ns () {
    NAME=$1
    NETNS=faucet-${NAME}
    shift
    sudo ip netns exec ${NETNS} $@
}
```

```
# Create network namespace
create_ns () {
    NAME=$1
    IP=$2
    NETNS=faucet-${NAME}
    sudo ip netns add ${NETNS}
    sudo ip link add dev veth-${NAME} type veth peer name veth0 netns $
↪{NETNS}
    sudo ip link set dev veth-${NAME} up
    as_ns ${NAME} ip link set dev lo up
    [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0 ${IP}
    as_ns ${NAME} ip link set dev veth0 up
}
```

Note: If not continuing on from the 'Installing Faucet for first time tutorial' to setup the hosts and switch run:

```
create_ns host1 192.168.0.1/24
create_ns host2 192.168.0.2/24
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- add-port br0 veth-host2 -- set interface veth-host2 ofport_request=2 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

And the faucet.yaml configuration file looks like:

Listing 10: /etc/faucet/faucet.yaml

```
vlans:
    office:
```

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```
        vid: 100
        description: "office network"

dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
                description: "host2 network namespace"
                native_vlan: office
            2:
                name: "host2"
                description: "host2 network namespace"
                native_vlan: office
```

Overview

Faucet ACLs are made up of lists of rules. The order of the rules in the list denote the priority with the first rules being highest and last lowest. The first rule that matches a packet, will set the actions for the packet. Each of these lists has a name (e.g. 'block-ping'), and can be used on multiple port or VLAN 'acls_in' fields. Again these are applied in order so all of 'block-ping' rules will be higher than 'allow-all'.

Each rule contains two main items 'matches' and 'actions'. Matches are any packet field such as MAC/IP/transport source/destination fields. For a full list visit the Ryu documentation. If no matches are specified, the rule will match all packets.

Actions are used to control what the packet does, for example normal L2 forwarding ('allow'), apply a 'meter' to rate limit traffic, and manipulation of the packet contents and output destination. The full list is available in the *Meters* section of the documentation.

The example below has defined two ACLs 'block-ping' & 'allow-all' these can be used on any and multiple ports or VLANs (more on VLANs later) using the 'acls_in' key. The block-ping ACL has two rules, one to block ICMP on IPv4 and another for ICMPv6 on IPv6. The allow-all ACL has one rule, which specifies no match fields, and therefore matches all packets, and the action 'allow'. The 'allow' action is a boolean, if it's True allow the packet to continue through the Faucet pipeline, if False drop the packet. 'allow' can be used in conjunction with the other actions to let the traffic flow with the expected layer 2 forwarding behaviour AND be mirrored to another port. The default 'allow' for ACLs is False (i.e. drop the packet). ACL rules will need to define 'allow: True' for those packets that are to be forwarded.

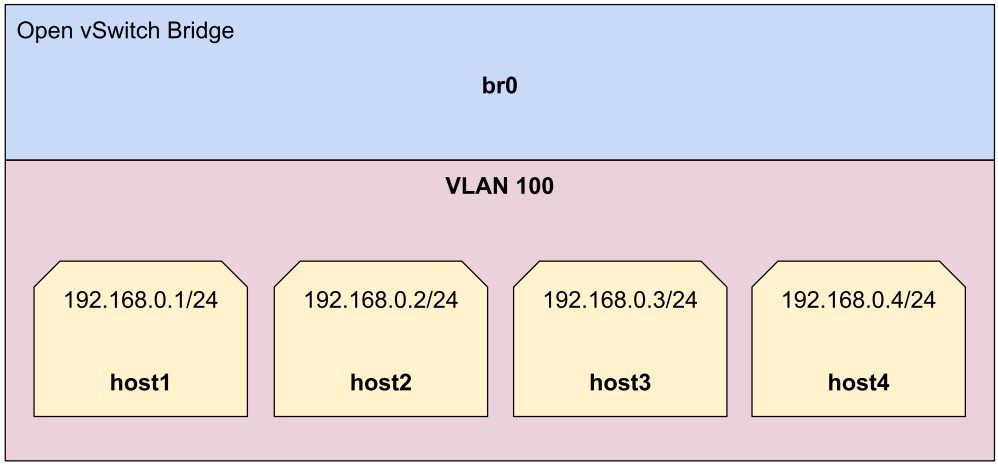
Network setup

We are going to create the following network:

First we will add two new hosts to our network:

```
create_ns host3 192.168.0.3/24
create_ns host4 192.168.0.4/24
```

And connect them to br0




```
sudo ovs-vsctl add-port br0 veth-host3 -- set interface veth-host3 ofport_request=3 \
            -- add-port br0 veth-host4 -- set interface veth-host4 ofport_request=4
```

The configuration below will block ICMP on traffic coming in on port 3, and allow everything else. Add this to `/etc/faucet/faucet.yaml` below the 'dps'.

Listing 11: /etc/faucet/faucet.yaml

```
            3:
                name: "host3"
                native_vlan: office
                acls_in: [block-ping, allow-all]
            4:
                name: "host4"
                native_vlan: office
acls:
    block-ping:
        - rule:
            dl_type: 0x800      # IPv4
            ip_proto: 1         # ICMP
            actions:
                allow: False
        - rule:
            dl_type: 0x86dd     # IPv6
            ip_proto: 58        # ICMPv6
            actions:
                allow: False
    allow-all:
        - rule:
            actions:
                allow: True
```

Now tell Faucet to reload its configuration, this can be done by restarting the application. But a better way is to send Faucet a SIGHUP signal.

```
check_faucet_config /etc/faucet/faucet.yaml
```

```
sudo systemctl reload faucet
```

Pings to/from host3 should now fail:

```
as_ns host1 ping 192.168.0.3
```

But the other three hosts should be fine:

```
as_ns host1 ping 192.168.0.2
as_ns host1 ping 192.168.0.4
```

ACL actions

Mirroring

Mirroring traffic is useful if we want to send it to an out of band NFV service (e.g. Intrusion Detection System, packet capture a port or VLAN). To do this Faucet provides two ACL actions: mirror & output.

The mirror action copies the packet, before any modifications, to the specified port.

Note: Mirroring is done in input direction only.

Let's add the mirror action to our block-ping ACL `/etc/faucet/faucet.yaml`

Listing 12: /etc/faucet/faucet.yaml

```
...
    block-ping:
        - rule:
            dl_type: 0x800
            ip_proto: 1
            actions:
                allow: False
                mirror: 4
        - rule:
            dl_type: 0x86dd
            ip_proto: 58
            actions:
                allow: False
                mirror: 4
```

And again send the sighup signal to Faucet

```
sudo systemctl reload faucet
```

To check this we will ping from host1 to host3, while performing a tcpdump on host4 who should receive the ping replies. It is a good idea to run each from a different terminal (screen, tmux, . . .)

```
as_ns host4 tcpdump -l -e -n -i veth0
```

```
as_ns host1 ping 192.168.0.3
```

Ping should have 100% packet loss.

```
$ as_ns host4 tcpdump -l -e -n -i veth0

tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
```

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```
listening on veth0, link-type EN10MB (Ethernet), capture size 262144 bytes
13:24:36.848331 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.3 > 192.168.0.1: ICMP echo reply, id 23660, seq 16, length 64
13:24:37.857024 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.3 > 192.168.0.1:   ICMP echo reply, id 23660, seq 17, length 64
13:24:38.865005 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.3 > 192.168.0.1: ICMP echo reply, id 23660, seq 18, length 64
13:24:39.873377 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.3 > 192.168.0.1: ICMP echo reply, id 23660, seq 19, length 64
13:24:40.881129 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.3 > 192.168.0.1: ICMP echo reply, id 23660, seq 20, length 64
```

Output

There is also the 'output' action which can be used to achieve the same thing.

Listing 13: /etc/faucet/faucet.yaml

```
block-ping:
    - rule:
        dl_type: 0x800
        ip_proto: 1
        actions:
            allow: False
            output:
                port: 4
    - rule:
        dl_type: 0x86dd
        ip_proto: 58
        actions:
            allow: False
            output:
                port: 4
```

The output action also allows us to change the packet by setting fields (mac/ip addresses, ...), VLAN operations (push/pop/swap VIDs). It can be used in conjunction with the other actions, e.g. output directly but do not allow through the Faucet pipeline (allow: false).

Let's create a new ACL for host2's port that will change the MAC source address.

Listing 14: /etc/faucet/faucet.yaml

```
dps:
    sw1:
        ...
        2:
            name: "host2"
            description: "host2 network namespace"
            native_vlan: office
            acls_in: [rewrite-mac, allow-all]
        ...
acls:
    rewrite-mac:
        - rule:
            actions:
```

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```
                allow: True
                output:
                    set_fields:
                        - eth_src: "00:00:00:00:00:02"
...
```

Again reload Faucet.

Start tcpdump on host1

```
as_ns host1 tcpdump -l -e -n -i veth0
```

Ping host1 from host2

```
as_ns host2 ping 192.168.0.1
```

Here we can see ICMP echo requests are coming from the MAC address "00:00:00:00:00:02" that we set in our output ACL. (The reply is destined to the actual MAC address of host2 thanks to ARP).

```
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode

listening on veth0, link-type EN10MB (Ethernet), capture size 262144 bytes
13:53:41.248235 00:00:00:00:00:02 > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.2 > 192.168.0.1: ICMP echo request, id 23711, seq 1, length 64
13:53:41.248283 06:5f:14:fc:47:02 > ce:bb:23:ce:d5:a0, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.1 > 192.168.0.2: ICMP echo reply, id 23711, seq 1, length 64
13:53:42.247106 00:00:00:00:00:02 > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.2 > 192.168.0.1: ICMP echo request, id 23711, seq 2, length 64
13:53:42.247154 06:5f:14:fc:47:02 > ce:bb:23:ce:d5:a0, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.1 > 192.168.0.2: ICMP echo reply, id 23711, seq 2, length 64
13:53:43.249726 00:00:00:00:00:02 > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.2 > 192.168.0.1: ICMP echo request, id 23711, seq 3, length 64
13:53:43.249757 06:5f:14:fc:47:02 > ce:bb:23:ce:d5:a0, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.1 > 192.168.0.2: ICMP echo reply, id 23711, seq 3, length 64
13:53:44.248713 00:00:00:00:00:02 > 06:5f:14:fc:47:02, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.2 > 192.168.0.1: ICMP echo request, id 23711, seq 4, length 64
13:53:44.248738 06:5f:14:fc:47:02 > ce:bb:23:ce:d5:a0, ethertype IPv4 (0x0800),␣
↪length 98: 192.168.0.1 > 192.168.0.2: ICMP echo reply, id 23711, seq 4, length 64
```

With the output action we could also use it to mirror traffic to a NFV server (like our fake mirror output action above), and use a VLAN tag to identify what port the traffic originated on on the switch. To do this we will use both the 'port' & 'vlan_vid' output fields.

Listing 15: /etc/faucet/faucet.yaml

```
block-ping:
    - rule:
        dl_type: 0x800
        ip_proto: 1
        actions:
            allow: False
            output:
                vlan_vid: 3
                port: 4
    - rule:
        dl_type: 0x86dd
        ip_proto: 58
```

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```
        actions:
            allow: False
            output:
                vlan_vid: 3
                port: 4
```

Again reload Faucet, start a tcpdump on host4, and ping from host1 to host3. Ping should still not be allowed through and the tcpdump output should be similar to below (Note the 802.1Q tag and VLAN 3):

```
$ as_ns host4 tcpdump -l -e -n -i veth0

tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on veth0, link-type EN10MB (Ethernet), capture size 262144 bytes
14:14:15.285329 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype 802.1Q (0x8100),␣
↪length 102: vlan 3, p 0, ethertype IPv4, 192.168.0.3 > 192.168.0.1: ICMP echo reply,
↪ id 23747, seq 1, length 64
14:14:16.293016 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype 802.1Q (0x8100),␣
↪length 102: vlan 3, p 0, ethertype IPv4, 192.168.0.3 > 192.168.0.1: ICMP echo reply,
↪ id 23747, seq 2, length 64
14:14:17.300898 2e:d4:1a:ca:54:4b > 06:5f:14:fc:47:02, ethertype 802.1Q (0x8100),␣
↪length 102: vlan 3, p 0, ethertype IPv4, 192.168.0.3 > 192.168.0.1: ICMP echo reply,
↪ id 23747, seq 3, length 64
```

1.2.3 VLAN tutorial

Next we are going to introduce VLANs.

ETA: ~30 mins.

Prerequisites

- Install Faucet - *Package installation* steps 1 & 2
- Install Open vSwitch - *Connect your first datapath* steps 1 & 2
- Useful Bash Functions - Copy and paste the following definitions into your bash terminal, or to make them persistent between sessions add them to the bottom of your .bashrc and run 'source .bashrc'.

```
# Run command inside network namespace
as_ns () {
    NAME=$1
    NETNS=faucet-${NAME}
    shift
    sudo ip netns exec ${NETNS} $@
}
```

```
# Create network namespace
create_ns () {
    NAME=$1
    IP=$2
    NETNS=faucet-${NAME}
    sudo ip netns add ${NETNS}
    sudo ip link add dev veth-${NAME} type veth peer name veth0 netns $
↪{NETNS}
```

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```
    sudo ip link set dev veth-${NAME} up
    as_ns ${NAME} ip link set dev lo up
    [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0 ${IP}
    as_ns ${NAME} ip link set dev veth0 up
}
```

```
# Clean up namespaces, bridges and processes created during faucet␣
↪tutorial
cleanup () {
    for NETNS in $(sudo ip netns list | grep "faucet-" | awk '{print $1}
↪'); do
        [ -n "${NETNS}" ] || continue
        NAME=${NETNS#faucet-}
        if [ -f "/run/dhclient-${NAME}.pid" ]; then
            # Stop dhclient
            sudo pkill -F "/run/dhclient-${NAME}.pid"
        fi
        if [ -f "/run/iperf3-${NAME}.pid" ]; then
            # Stop iperf3
            sudo pkill -F "/run/iperf3-${NAME}.pid"
        fi
        if [ -f "/run/bird-${NAME}.pid" ]; then
            # Stop bird
            sudo pkill -F "/run/bird-${NAME}.pid"
        fi
        # Remove netns and veth pair
        sudo ip link delete veth-${NAME}
        sudo ip netns delete ${NETNS}
    done
    for isl in $(ip -o link show | awk -F': ' '{print $2}' | grep -oE "^l-
↪br[0-9](_[0-9]*)?-br[0-9](_[0-9]*)?"); do
        # Delete inter-switch links
        sudo ip link delete dev $isl 2>/dev/null || true
    done
    for DNSMASQ in /run/dnsmasq-vlan*.pid; do
        [ -e "${DNSMASQ}" ] || continue
        # Stop dnsmasq
        sudo pkill -F "${DNSMASQ}"
    done
    # Remove faucet dataplane connection
    sudo ip link delete veth-faucet 2>/dev/null || true
    # Remove openvswitch bridges
    sudo ovs-vsctl --if-exists del-br br0
    sudo ovs-vsctl --if-exists del-br br1
    sudo ovs-vsctl --if-exists del-br br2
    sudo ovs-vsctl --if-exists del-br br3
}
```

```
# Add tagged VLAN interface to network namespace
add_tagged_interface () {
     NAME=$1
     VLAN=$2
     IP=$3
     NETNS=faucet-${NAME}
     as_ns ${NAME} ip link add link veth0 name veth0.${VLAN} type vlan id
↪${VLAN}
```

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```
    [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0.${VLAN} ${IP}
    as_ns ${NAME} ip link set dev veth0.${VLAN} up
    as_ns ${NAME} ip addr flush dev veth0
}
```

Overview

In this tutorial we will look at how to do the following tasks using Faucet:

- Use VLANs to segment traffic.
- Create VLAN Trunks.
- Apply an ACL to an entire VLAN.

Note: We cover *Routing between VLANs* in a later tutorial.

A port can be in several VLAN modes:

1. Native - where packets come into the switch with no 802.1Q tag.
2. Tagged - where packets come into the switch with a 802.1Q tag.
3. Mixed - where both native and tagged packets appear on the same port.

If a packet comes in with a tag for a VLAN that the port is not configured for it will be dropped.

Configuring VLANs

To demonstrate these tasks we will use a demo network where a single switch br0 connects to 9 hosts.

Ports 1, 2, 5, 6 will be native (untagged) ports. While ports 3, 4, 7, 8, and 9 will be tagged ports.

Here is the structure of the demo setup.

Tip: Keep this diagram nearby to simplify following the rest of the tutorial.

Network setup

Let's start. Keep host1, host2 on the native VLAN 100 (office VLAN) as in the first and second tutorials.

Note: To create the hosts and switch again run

```
cleanup
create_ns host1 192.168.0.1/24
create_ns host2 192.168.0.2/24
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
```

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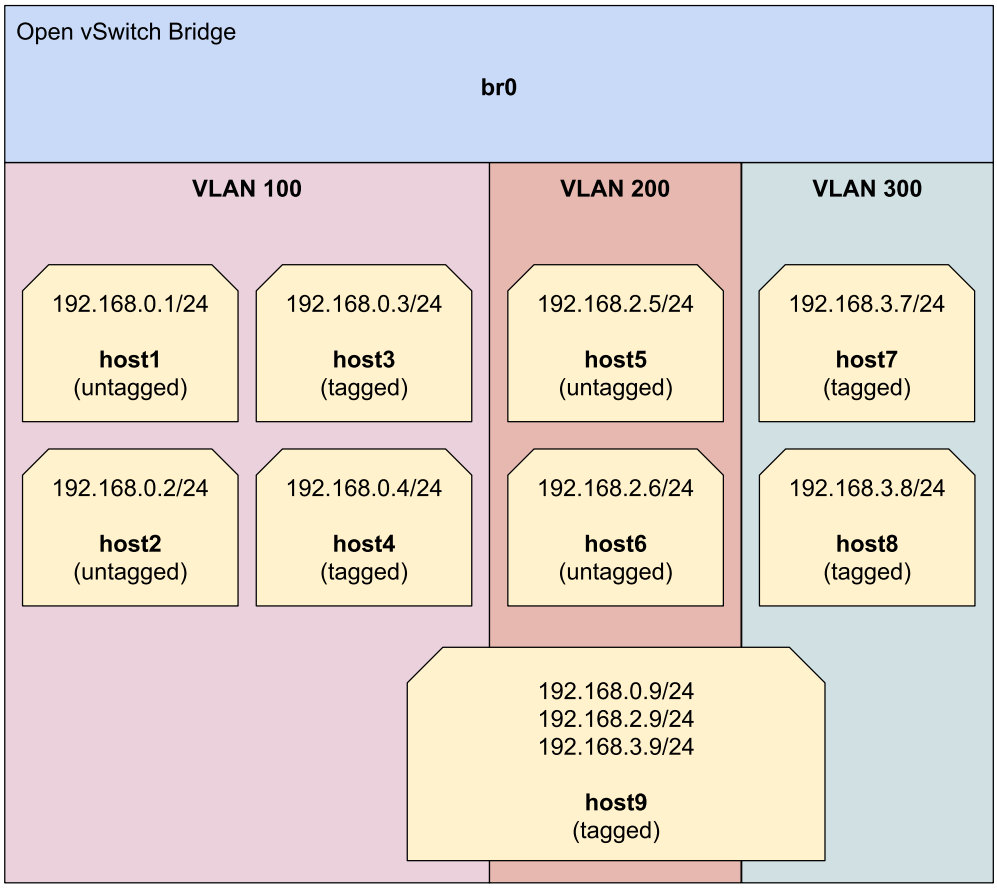
Open vSwitch Bridge
br0
VLAN 100
VLAN 200
VLAN 300
192.168.0.1/24
host1
(untagged)
192.168.0.3/24
host3
(tagged)
192.168.2.5/24
host5
(untagged)
192.168.3.7/24
host7
(tagged)
192.168.0.2/24
host2
(untagged)
192.168.0.4/24
host4
(tagged)
192.168.2.6/24
host6
(untagged)
192.168.3.8/24
host8
(tagged)
192.168.0.9/24
192.168.2.9/24
192.168.3.9/24
host9
(tagged)

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```
-- add-port br0 veth-host2 -- set interface veth-host2 ofport_request=2 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

Then add the following hosts with the corresponding VLAN:

- Assign host3 and host4 a VLAN interface (vid:100) as they are on a tagged port.

```
create_ns host3 0.0.0.0
create_ns host4 0.0.0.0
add_tagged_interface host3 100 192.168.0.3/24
add_tagged_interface host4 100 192.168.0.4/24
```

- Assign host5 and host6 an IP address from the VLAN 200 range.

```
create_ns host5 192.168.2.5/24
create_ns host6 192.168.2.6/24
```

- Assign host7 and host8 a VLAN interface (vid:300) as they are on a tagged port.

```
create_ns host7 0.0.0.0
create_ns host8 0.0.0.0
add_tagged_interface host7 300 192.168.3.7/24
add_tagged_interface host8 300 192.168.3.8/24
```

- Add host9 to all VLANs (100, 200, 300) to work as a NFV host.

```
create_ns host9 0.0.0.0
add_tagged_interface host9 100 192.168.0.9/24
add_tagged_interface host9 200 192.168.2.9/24
add_tagged_interface host9 300 192.168.3.9/24
```

Then connect all the hosts to the switch (br0)

```
sudo ovs-vsctl add-port br0 veth-host3 -- set interface veth-host3 ofport_request=3 \
-- add-port br0 veth-host4 -- set interface veth-host4 ofport_request=4 \
-- add-port br0 veth-host5 -- set interface veth-host5 ofport_request=5 \
-- add-port br0 veth-host6 -- set interface veth-host6 ofport_request=6 \
-- add-port br0 veth-host7 -- set interface veth-host7 ofport_request=7 \
-- add-port br0 veth-host8 -- set interface veth-host8 ofport_request=8 \
-- add-port br0 veth-host9 -- set interface veth-host9 ofport_request=9
```

Now we have everything to start working with faucet through its configuration file. Each time we will only need to change the configuration file and restart faucet (or send it HUP signal to reload the configuration file).

Basic VLAN settings

Change /etc/faucet/faucet.yaml to reflect our setting.

Listing 16: /etc/faucet/faucet.yaml

```
vlans:
    vlan100:
        vid: 100
    vlan200:
```

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```
        vid: 200
    vlan300:
        vid: 300
dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
                description: "host2 network namespace"
                native_vlan: vlan100
            2:
                name: "host2"
                description: "host2 network namespace"
                native_vlan: vlan100
            3:
                name: "host3"
                tagged_vlans: [vlan100]
            4:
                name: "host4"
                tagged_vlans: [vlan100]
            5:
                name: "host5"
                native_vlan: vlan200
            6:
                name: "host6"
                native_vlan: vlan200
            7:
                name: "host7"
                tagged_vlans: [vlan300]
            8:
                name: "host8"
                tagged_vlans: [vlan300]
            9:
                name: "host9"
                tagged_vlans: [vlan100,vlan200,vlan300]
```

Send SIGHUP signal to reload the configuration file, and check how its log the new configuration in /var/log/faucet/faucet.log

```
sudo systemctl reload faucet
cat /var/log/faucet/faucet.log
```

Let's do the following simple tests:

1. Ping between hosts in the same VLAN (all should work)

```
as_ns host1 ping 192.168.0.2
as_ns host3 ping 192.168.0.4
as_ns host5 ping 192.168.2.6
as_ns host7 ping 192.168.3.8
```

2. Ping between hosts in the same VLAN where the one host is native and the other is tagged should work also. In particular between host1 (native VLAN 100) to host3 (tagged VLAN 100).

```
as_ns host1 ping 192.168.0.3
```

3. Ping between hosts in different VLANs should fail. To test that let's add the IP address 192.168.0.5 to host5 (native VLAN 200) and try to ping it from host1 (native VLAN 100).

```
as_ns host5 ip address add 192.168.0.5 dev veth0
as_ns host1 ping 192.168.0.5
```

4. Now we can test the trunk link to host9 from different VLANs (all should work)

```
as_ns host1 ping 192.168.0.9
as_ns host3 ping 192.168.0.9
as_ns host5 ping 192.168.2.9
as_ns host7 ping 192.168.3.9
```

VLAN ACL

Let's apply an ACL on a particular VLAN (e.g. VLAN 300). We will block any ICMP packets on VLAN 300. First create an ACL to block the ping. Open /etc/faucet/faucet.yaml and add the 'acls' section.

Listing 17: /etc/faucet/faucet.yaml

```
acls:
    block-ping:
        - rule:
            dl_type: 0x800      # IPv4
            ip_proto: 1         # ICMP
            actions:
                allow: False
        - rule:
            dl_type: 0x86dd     # IPv6
            ip_proto: 58        # ICMPv6
            actions:
                allow: False
```

Then apply this ACL on VLAN 300.

Listing 18: /etc/faucet/faucet.yaml

```
vlans:
    vlan100:
        vid: 100
    vlan200:
        vid: 200
    vlan300:
        vid: 300
        acls_in: [block-ping] # Apply ACL only on vlan300
```

Just before we reload the configuration file. Let's verify that pinging is working between hosts in VLAN 300.

```
as_ns host7 ping 192.168.3.8
```

Now let's apply the configuration, send SIGHUP signal to reload the configuration file.

```
sudo systemctl reload faucet
```

Now if you try to ping from host7 and host8, it will not work as it is specified by their VLAN ACL.

```
as_ns host7 ping 192.168.3.8
```

1.2.4 Routing tutorial

This tutorial will cover routing with Faucet.

There are three types of routing we can use.

- Inter-VLAN routing
- Static routing
- BGP via an external application (Quagga, Bird, EXABGP, etc)

Prerequisites

- Install Faucet - *Package installation* steps 1 & 2
- Install Open vSwitch - *Connect your first datapath* steps 1 & 2
- Useful Bash Functions - Copy and paste the following definitions into your bash terminal, or to make them persistent between sessions add them to the bottom of your .bashrc and run 'source .bashrc'.

```
# Run command inside network namespace
as_ns () {
    NAME=$1
    NETNS=faucet-${NAME}
    shift
    sudo ip netns exec ${NETNS} $@
}
```

```
# Create network namespace
create_ns () {
    NAME=$1
    IP=$2
    NETNS=faucet-${NAME}
    sudo ip netns add ${NETNS}
    sudo ip link add dev veth-${NAME} type veth peer name veth0 netns $
↪{NETNS}
    sudo ip link set dev veth-${NAME} up
    as_ns ${NAME} ip link set dev lo up
    [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0 ${IP}
    as_ns ${NAME} ip link set dev veth0 up
}
```

```
# Clean up namespaces, bridges and processes created during faucet␣
↪tutorial
cleanup () {
    for NETNS in $(sudo ip netns list | grep "faucet-" | awk '{print $1}
↪'); do
        [ -n "${NETNS}" ] || continue
        NAME=${NETNS#faucet-}
        if [ -f "/run/dhclient-${NAME}.pid" ]; then
            # Stop dhclient
```

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```
            sudo pkill -F "/run/dhclient-${NAME}.pid"
        fi
        if [ -f "/run/iperf3-${NAME}.pid" ]; then
            # Stop iperf3
            sudo pkill -F "/run/iperf3-${NAME}.pid"
        fi
        if [ -f "/run/bird-${NAME}.pid" ]; then
            # Stop bird
            sudo pkill -F "/run/bird-${NAME}.pid"
        fi
        # Remove netns and veth pair
        sudo ip link delete veth-${NAME}
        sudo ip netns delete ${NETNS}
    done
    for isl in $(ip -o link show | awk -F': ' '{print $2}' | grep -oE "^l-
↪br[0-9](_[0-9]*)?-br[0-9](_[0-9]*)?"); do
        # Delete inter-switch links
        sudo ip link delete dev $isl 2>/dev/null || true
    done
    for DNSMASQ in /run/dnsmasq-vlan*.pid; do
        [ -e "${DNSMASQ}" ] || continue
        # Stop dnsmasq
        sudo pkill -F "${DNSMASQ}"
    done
    # Remove faucet dataplane connection
    sudo ip link delete veth-faucet 2>/dev/null || true
    # Remove openvswitch bridges
    sudo ovs-vsctl --if-exists del-br br0
    sudo ovs-vsctl --if-exists del-br br1
    sudo ovs-vsctl --if-exists del-br br2
    sudo ovs-vsctl --if-exists del-br br3
}
```

- Run the cleanup script to remove old namespaces and switches:

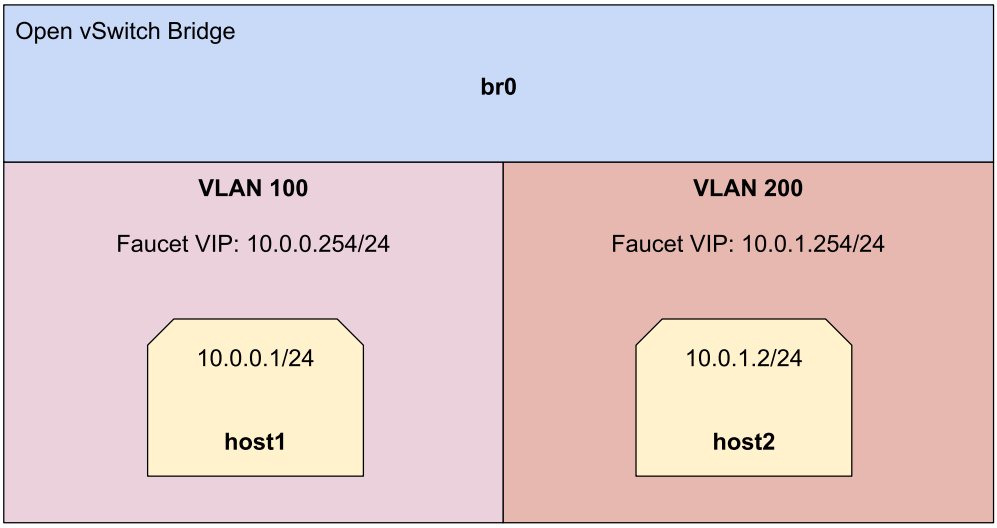
```
cleanup
```

Routing between VLANs

Let's start with a single switch connected to two hosts in two different VLANs.

```
create_ns host1 10.0.0.1/24
create_ns host2 10.0.1.2/24
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- add-port br0 veth-host2 -- set interface veth-host2 ofport_request=2 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

In this section we will be using faucet as a gateway for our two hosts and using faucet to route between them. To do this we are going to need to give faucet an IP address on the network. This is accomplished with by using two new options that we haven't seen before:



faucet_vips	The IP address for Faucet's routing interface on this VLAN. Multiple IP addresses (IPv4 & IPv6) can be used.
faucet_mac	The MAC address of Faucet's routing interface on this VLAN. If we do not set faucet_mac for each VLAN, routed packets will be dropped unless 'drop_spoofed_faucet_mac' is set to false.

Let's add the following faucet configuration which makes use of these options.

Listing 19: /etc/faucet/faucet.yaml

```
vlans:
    vlan100:
        vid: 100
        faucet_vips: ["10.0.0.254/24"]  # Faucet's virtual IP address for vlan100
        faucet_mac: "00:00:00:00:00:11"
    vlan200:
        vid: 200
        faucet_vips: ["10.0.1.254/24"]  # Faucet's virtual IP address for vlan200
        faucet_mac: "00:00:00:00:00:22"
dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
                description: "host1 network namespace"
                native_vlan: vlan100
            2:
                name: "host2"
                description: "host2 network namespace"
                native_vlan: vlan200
```

Now lets signal faucet to reload the configuration file.

```
sudo systemctl reload faucet
```

Add a default route on each host to set the gateway to the value we used for `faucet_vips` above.

```
as_ns host1 ip route add default via 10.0.0.254 dev veth0
as_ns host2 ip route add default via 10.0.1.254 dev veth0
```

By default traffic between our two hosts will be dropped since they are in different VLANs with different subnets. We can show that by doing the following:

```
as_ns host1 ping 10.0.1.2
```

We can change this by enabling inter-VLAN routing between these two VLANs. In faucet you do this by creating a router and specifying which VLANs can route between each other.

In our case we to enable routing between VLAN 100 and VLAN 200 so we add the following to our configuration file.

Listing 20: /etc/faucet/faucet.yaml

```
routers:
    router-1:                           # Router name
        vlans: [vlan100, vlan200]       # Names of vlans to allow routing between
```

Reload faucet to enable inter-VLAN routing.

```
sudo systemctl reload faucet
```

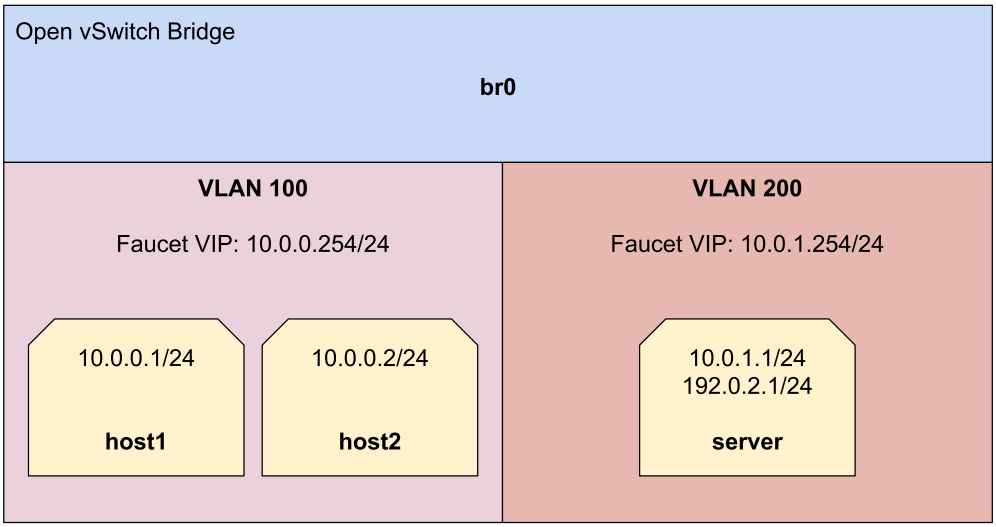
Our ping before from host1 to host2 should now work (the first few packets may get lost as faucet needs to resolve the MAC address of the next hop with ARP).

```
as_ns host1 ping 10.0.1.2
```

Inter-VLAN routing by default will allow all traffic to pass between VLANs, if we wanted to change this and restrict communication to a few different IP addresses or TCP/UDP ports, we could apply a VLAN ACL to each VLAN to limit the types of traffic that may pass and what should be dropped.

Static routing

For this we will set-up a Faucet switch with three hosts. One of these hosts will act like a server.



Run the cleanup script to remove old namespaces and switches.

```
cleanup
```

Create 3 hosts, in 2 different subnets:

```
create_ns host1 10.0.0.1/24
create_ns host2 10.0.0.2/24
create_ns server 10.0.1.1/24
```

Add a default route for each host to the gateway which is faucet's virtual IP address.

```
as_ns host1 ip route add default via 10.0.0.254
as_ns host2 ip route add default via 10.0.0.254
as_ns server ip route add default via 10.0.1.254
```

Create the bridge and add host1, host2 and the server to br0.

```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- add-port br0 veth-host2 -- set interface veth-host2 ofport_request=2 \
-- add-port br0 veth-server -- set interface veth-server ofport_request=3 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

For this Faucet configuration we will start from scratch. First we need to define 2 VLANs one for hosts and one for servers. We will also note that inside the configuration for the servers VLAN we see a static route that routes the subnet `192.0.2.0/24` to the server namespace (10.0.1.1).

Listing 21: /etc/faucet/faucet.yaml

```
vlans:
    hosts:
        vid: 100
        description: "vlan for clients"
        faucet_mac: "00:00:00:00:00:11"
        faucet_vips: ["10.0.0.254/24"]

    servers:
        vid: 200
        description: "vlan for servers"
        faucet_mac: "00:00:00:00:00:22"
        faucet_vips: ["10.0.1.254/24"]
        routes:
            - route:
                ip_dst: "192.0.2.0/24"
                ip_gw: '10.0.1.1'
routers:
    router-hosts-servers:
        vlans: [hosts, servers]
dps:
    br0:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
```

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```
            description: "host1 network namespace"
            native_vlan: hosts
        2:
            name: "host2"
            description: "host2 network namespace"
            native_vlan: hosts
        3:
            name: "server"
            description: "server network namespace"
            native_vlan: servers
```

Reload Faucet to apply the new configuration.

```
sudo systemctl reload faucet
```

We can verify the inter-VLAN Routing is working by pinging the IP address of the server namespace:

```
as_ns host1 ping 10.0.1.1
```

We also need to add an additional IP alias to server to test the static route works.

```
as_ns server ip address add 192.0.2.1/24 dev veth0
```

And we should now be able to ping our IP alias.

```
as_ns host1 ping 192.0.2.1
```

BGP routing

For this section we are going to change our static routes from above into BGP routes.

BGP (and other routing) is provided by a NFV service, here we will use BIRD. Other applications such as ExaBGP & Quagga could be used. Faucet imports all routes provided by this NFV service. This means we can use our service for other routing protocols (OSPF, RIP, etc) and apply filtering using the service's policy language.

Setup

Our data plane will end up looking like below, you may notice how we have the Faucet application connected to the control plane and dataplane.

Remove the following lines from `/etc/faucet/faucet.yaml` to remove the static route from faucet:

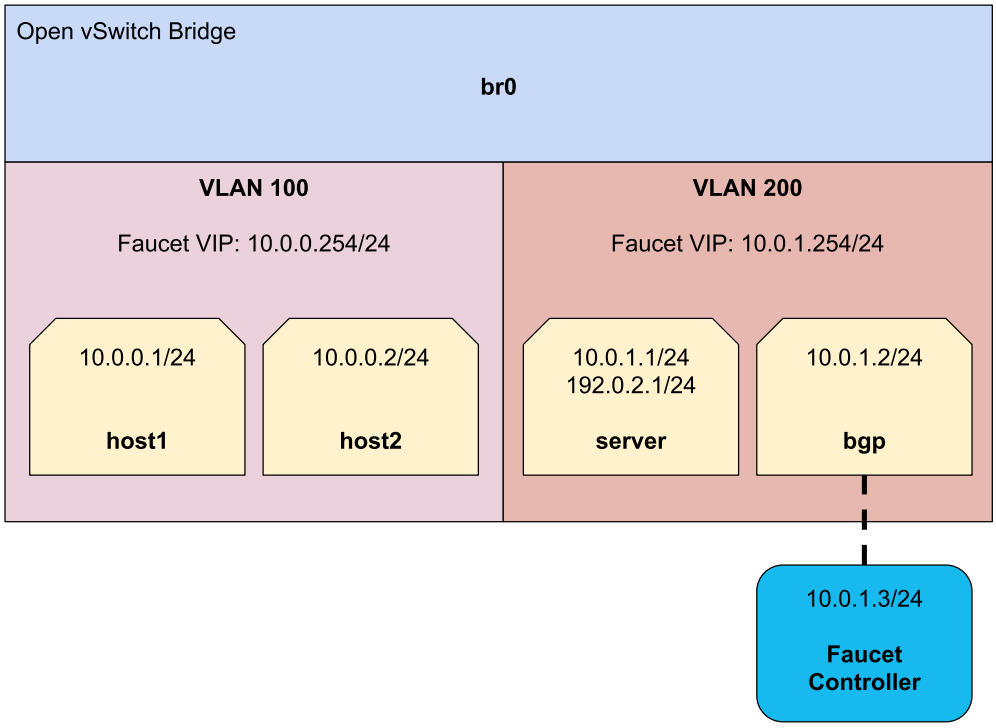
Listing 22: /etc/faucet/faucet.yaml

```
routes:
    - route:
      ip_dst: "192.0.2.0/24"
      ip_gw: '10.0.1.1'
```

Reload Faucet

```
sudo systemctl reload faucet
```

Verify that we can no longer ping the address we were previously static routing.




```
as_ns host1 ping 192.0.2.1
```

Let's add a new network namespace to run BIRD

```
create_ns bgp 10.0.1.2/24
sudo ovs-vsctl add-port br0 veth-bgp -- set interface veth-bgp ofport_request=4
```

Next we will add a dataplane connection for Faucet so that it can communicate with BIRD running on the bgp namespace.

```
sudo ip link add veth-faucet type veth peer name veth-faucet-ovs
sudo ovs-vsctl add-port br0 veth-faucet-ovs -- set interface veth-faucet-ovs ofport_
↪request=5
sudo ip addr add 10.0.1.3/24 dev veth-faucet
sudo ip link set veth-faucet up
sudo ip link set veth-faucet-ovs up
```

Now install BIRD on the system and stop it from running:

```
sudo apt-get install bird
sudo systemctl stop bird
sudo systemctl stop bird6
```

To configure BIRD add the following to `/etc/bird/bird.conf`, this will create a simple routing setup where BIRD originates a static route for 192.0.2.0/24 and sends this to faucet over BGP.

Listing 23: /etc/bird/bird.conf

```
protocol kernel {
    scan time 60;
```

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```
    import none;
}

protocol device {
    scan time 60;
}

# Generate static route inside bird
protocol static {
    route 192.0.2.0/24 via 10.0.1.1;
}

# BGP peer with faucet
# Import all routes and export our static route
protocol bgp faucet {
    local as 65001;
    neighbor 10.0.1.3 port 9179 as 65000;
    export all;
    import all;
}
```

We can now start BIRD inside the bgp namespace:

```
as_ns bgp bird -P /run/bird-bgp.pid
```

We'll configure Faucet to talk to BIRD by adding BGP configuration to `/etc/faucet/faucet.yaml`. Change the servers VLAN to look like the configuration below, leaving all other VLANs alone, and add a Faucet router.

Listing 24: /etc/faucet/faucet.yaml

```
routers:
    bird:
        vlans: servers
        bgp:
            as: 65000                           # Faucet's AS number
            port: 9179                          # BGP port for Faucet to listen on.
            routerid: '10.0.1.3'                # Faucet's Unique ID.
            server_addresses: ['10.0.1.3']      # Faucet's listen IP for BGP
            neighbor_addresses: ['10.0.1.2']    # Neighbouring IP addresses (IPv4/
↪IPv6)
            neighbor_as: 65001                  # Neighbour's AS number
vlans:
    servers:
        vid: 200
        description: "vlan for gw port"
        faucet_mac: "00:00:00:00:00:22"
        faucet_vips: ["10.0.1.254/24"]
...
```

And finally add the port configuration for the Faucet data plane interface (veth-faucet0).

Listing 25: /etc/faucet/facuet.yaml

```
dps:
    br0:
        ...
```

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```
        interfaces:
            ...
            4:
                name: "bgp"
                description: "BIRD BGP router"
                native_vlan: servers
            5:
                name: "faucet"
                description: "faucet dataplane connection"
                native_vlan: servers
```

Now reload Faucet.

```
sudo systemctl reload faucet
```

We can use the command line tool `birdc` to query the status of our peering connection, we should see that it is now established:

```
as_ns bgp birdc show protocols all faucet

name     proto    table    state  since       info
faucet   BGP      master   up     13:25:38    Established
  Preference:     100
  Input filter:   ACCEPT
  Output filter:  ACCEPT
  Routes:         1 imported, 1 exported, 1 preferred
  Route change stats:     received   rejected   filtered    ignored   accepted
    Import updates:              1          0          0          0          1
    Import withdraws:            0          0        ---          0          0
    Export updates:              2          1          0        ---          1
    Export withdraws:            0        ---        ---        ---          0
  BGP state:          Established
    Neighbor address: 10.0.1.3
    Neighbor AS:      65000
    Neighbor ID:      10.0.1.3
    Neighbor caps:    AS4
    Session:          external AS4
    Source address:   10.0.1.2
    Hold timer:       185/240
    Keepalive timer:  57/80
```

Using `birdc` we can also check what routes are being exported to faucet:

```
as_ns bgp birdc show route export faucet

192.0.2.0/24       via 10.0.1.1 on veth0 [static1 13:25:34] * (200)
```

And which routes bird receives from faucet:

```
as_ns bgp birdc show route protocol faucet

10.0.1.0/24        via 10.0.1.254 on veth0 [faucet 13:25:38 from 10.0.1.3] * (100) [i]
```

In `/var/log/faucet/faucet.log` we should now see log messages relating to BGP:

Listing 26: /var/log/faucet/faucet.log

```
Jan 16 13:25:17 faucet        INFO     Reloading configuration
Jan 16 13:25:17 faucet        INFO     configuration /etc/faucet/faucet.yaml changed,␣
↪analyzing differences
Jan 16 13:25:17 faucet        INFO     Add new datapath DPID 1 (0x1)
Jan 16 13:25:17 faucet        INFO     Adding BGP speaker key DP ID: 1, VLAN VID: 200,␣
↪IP version: 4 for VLAN servers vid:200 untagged: Port 3,Port 4,Port 5
Jan 16 13:25:38 faucet        INFO     BGP peer router ID 10.0.1.2 AS 65001 up
Jan 16 13:25:38 faucet        INFO     BGP add 192.0.2.0/24 nexthop 10.0.1.1
Jan 16 13:25:42 faucet.valve INFO     DPID 1 (0x1) br0 resolving 10.0.1.1 (1 flows)␣
↪on VLAN 200
Jan 16 13:25:42 faucet.valve INFO     DPID 1 (0x1) br0 Adding new route 192.0.2.0/24␣
↪via 10.0.1.1 (aa:97:cd:33:74:a9) on VLAN 200
```

Once confirming the BGP connection is up between BIRD and faucet and the correct routes are being advertised, we should now be able to ping the IP alias on the server namespace again:

```
as_ns host1 ping 192.0.2.1
```

1.2.5 Stacking tutorial

Faucet has two primary modes of operation: independent switching and distributed switching.

In independent mode each decision about the network (learning, routing, etc) is made in the context of each individual switch.

This tutorial will cover Faucet's distributed switching (a.k.a stacking) mode. Stacking allows decisions such as switching and routing to be made in the context of the whole network. This has great benefits for building resilient network topologies that can automatically recover from switch and port/cable failures. In this tutorial we will cover some of the new features and demonstrate how they work.

Prerequisites

- Knowledge of the VLAN and routing tutorial topics (*VLAN tutorial*, *Routing tutorial*)
- Install Faucet - *Package installation* steps 1 & 2
- Install Open vSwitch - *Connect your first datapath* steps 1 & 2
- Useful Bash Functions - Copy and paste the following definitions into your bash terminal, or to make them persistent between sessions add them to the bottom of your .bashrc and run 'source .bashrc'.

```
# Create network namespace
create_ns () {
    NAME=$1
    IP=$2
    NETNS=faucet-${NAME}
    sudo ip netns add ${NETNS}
    sudo ip link add dev veth-${NAME} type veth peer name veth0 netns $
↪{NETNS}
    sudo ip link set dev veth-${NAME} up
    as_ns ${NAME} ip link set dev lo up
    [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0 ${IP}
    as_ns ${NAME} ip link set dev veth0 up
}
```

```
# Run command inside network namespace
as_ns () {
    NAME=$1
    NETNS=faucet-${NAME}
    shift
    sudo ip netns exec ${NETNS} $@
}
```

```
# Add inter-switch link between two switches
inter_switch_link () {
    SW_A_NAME=$(echo $1 | cut -d ':' -f 1)
    SW_A_PORT=$(echo $1 | cut -d ':' -f 2)
    SW_B_NAME=$(echo $2 | cut -d ':' -f 1)
    SW_B_PORT=$(echo $2 | cut -d ':' -f 2)
    VETH_A=l-${SW_A_NAME}_${SW_A_PORT}-${SW_B_NAME}_${SW_B_PORT}
    VETH_B=l-${SW_B_NAME}_${SW_B_PORT}-${SW_A_NAME}_${SW_A_PORT}
    VETH_A=${VETH_A:0:15}
    VETH_B=${VETH_B:0:15}
    sudo ip link add dev ${VETH_A} type veth peer name ${VETH_B}
    sudo ip link set dev ${VETH_A} up
    sudo ip link set dev ${VETH_B} up
    sudo ovs-vsctl add-port ${SW_A_NAME} ${VETH_A} \
      -- set interface ${VETH_A} ofport_request=${SW_A_PORT}
    sudo ovs-vsctl add-port ${SW_B_NAME} ${VETH_B} \
      -- set interface ${VETH_B} ofport_request=${SW_B_PORT}
}
```

```
# Clean up namespaces, bridges and processes created during faucet␣
↪tutorial
cleanup () {
    for NETNS in $(sudo ip netns list | grep "faucet-" | awk '{print $1}
↪'); do
        [ -n "${NETNS}" ] || continue
        NAME=${NETNS#faucet-}
        if [ -f "/run/dhclient-${NAME}.pid" ]; then
            # Stop dhclient
            sudo pkill -F "/run/dhclient-${NAME}.pid"
        fi
        if [ -f "/run/iperf3-${NAME}.pid" ]; then
            # Stop iperf3
            sudo pkill -F "/run/iperf3-${NAME}.pid"
        fi
        if [ -f "/run/bird-${NAME}.pid" ]; then
            # Stop bird
            sudo pkill -F "/run/bird-${NAME}.pid"
        fi
        # Remove netns and veth pair
        sudo ip link delete veth-${NAME}
        sudo ip netns delete ${NETNS}
    done
    for isl in $(ip -o link show | awk -F': ' '{print $2}' | grep -oE "^l-
↪br[0-9](_[0-9]*)?-br[0-9](_[0-9]*)?"); do
        # Delete inter-switch links
        sudo ip link delete dev $isl 2>/dev/null || true
    done
    for DNSMASQ in /run/dnsmasq-vlan*.pid; do
        [ -e "${DNSMASQ}" ] || continue
```

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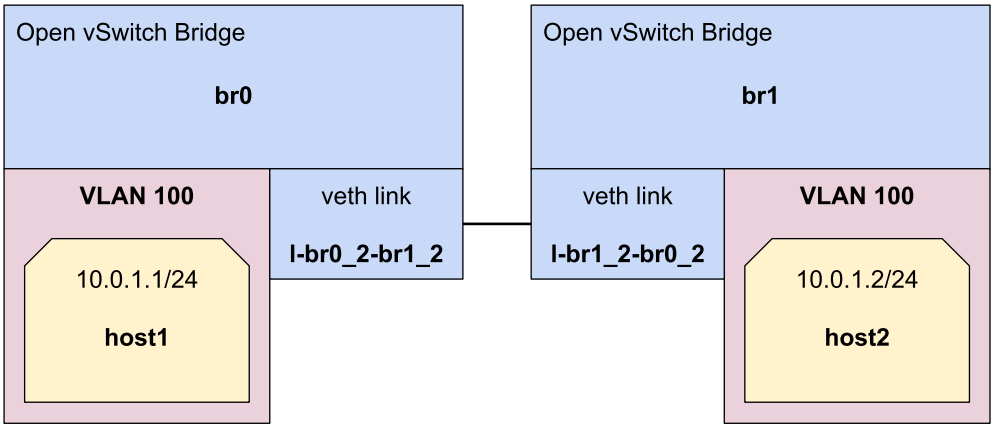
```
        # Stop dnsmasq
        sudo pkill -F "${DNSMASQ}"
    done
    # Remove faucet dataplane connection
    sudo ip link delete veth-faucet 2>/dev/null || true
    # Remove openvswitch bridges
    sudo ovs-vsctl --if-exists del-br br0
    sudo ovs-vsctl --if-exists del-br br1
    sudo ovs-vsctl --if-exists del-br br2
    sudo ovs-vsctl --if-exists del-br br3
}
```

- Run the cleanup script to remove old namespaces and switches:

```
cleanup
```

Basic stacking

We can start by considering two switches with one host on each switch on the same VLAN.



Let's define a simple base faucet.yaml to get started:

Listing 27: /etc/faucet/faucet.yaml

```
vlans:
    hosts:
        vid: 100
dps:
    br0:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                description: "host1 network namespace"
                native_vlan: hosts
    br1:
        dp_id: 0x2
        hardware: "Open vSwitch"
        interfaces:
```

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```
            1:
                description: "host2 network namespace"
                native_vlan: hosts
```

Now lets signal faucet to reload the configuration file.

```
sudo systemctl reload faucet
```

We need to create our two hosts, host1 and host2.

```
create_ns host1 10.0.1.1/24
create_ns host2 10.0.1.2/24
```

To setup multiple switches in Open vSwitch we can define two bridges with different datapath-ids and names. We'll be using br0 and br1.

```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br1 \
-- set bridge br1 other-config:datapath-id=0000000000000002 \
-- set bridge br1 other-config:disable-in-band=true \
-- set bridge br1 fail_mode=secure \
-- add-port br1 veth-host2 -- set interface veth-host2 ofport_request=1 \
-- set-controller br1 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

Since the switches are not connected it will be impossible to ping between the two hosts.

```
as_ns host1 ping 10.0.1.2
```

To connect the switches we can use the Faucet switch stacking feature. First, we need to define a root switch for our stack by setting a `stack priority` value for br0, the datapath with the lowest priority will be root. Second, we need to add stack interfaces connecting each datapath, we do this by defining the `stack` parameter on an interface. When defining a stack interface we say which datapath (dp) and port the other end of the cable is connected to.

Replace your base faucet.yaml from earlier with this version with stacking enabled:

Listing 28: /etc/faucet/faucet.yaml

```
vlans:
    hosts:
        vid: 100
dps:
    br0:
        dp_id: 0x1
        hardware: "Open vSwitch"
        stack:
            priority: 1
        interfaces:
            1:
                description: "host1 network namespace"
                native_vlan: hosts
```

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```
            2:
                description: "br0 stack link to br1"
                stack:
                    dp: br1
                    port: 2
    br1:
        dp_id: 0x2
        hardware: "Open vSwitch"
        interfaces:
            1:
                description: "host2 network namespace"
                native_vlan: hosts
            2:
                description: "br1 stack link to br0"
                stack:
                   dp: br0
                   port: 2
```

To connect two Open vSwitch bridges we can use a veth interface pair. We will use the `inter_switch_link` function we defined earlier to connect br0 port 2 to br1 port 2:

```
inter_switch_link br0:2 br1:2
```

Let's reload Faucet and see what happens.

```
sudo systemctl reload faucet
```

Faucet will start sending out LLDP beacons to connect up the stack ports. We can see this happening in the log file when the switches report that port 2 (the stack port) is UP.

Listing 29: /var/log/faucet/faucet.log

```
DPID 2 (0x2) br1 LLDP on 0e:00:00:00:00:01, Port 2 from 0e:00:00:00:00:01 (remote␣
↪DPID 1 (0x1), port 2) state 2
DPID 2 (0x2) br1 Stack Port 2 INIT
DPID 1 (0x1) br0 LLDP on 0e:00:00:00:00:01, Port 2 from 0e:00:00:00:00:01 (remote␣
↪DPID 2 (0x2), port 2) state 2
DPID 1 (0x1) br0 Stack Port 2 INIT
DPID 2 (0x2) br1 LLDP on 0e:00:00:00:00:01, Port 2 from 0e:00:00:00:00:01 (remote␣
↪DPID 1 (0x1), port 2) state 1
DPID 2 (0x2) br1 Stack Port 2 UP
DPID 2 (0x2) br1 1 stack ports changed state
DPID 1 (0x1) br0 LLDP on 0e:00:00:00:00:01, Port 2 from 0e:00:00:00:00:01 (remote␣
↪DPID 2 (0x2), port 2) state 1
DPID 1 (0x1) br0 Stack Port 2 UP
DPID 1 (0x1) br0 1 stack ports changed state
DPID 2 (0x2) br1 LLDP on 0e:00:00:00:00:01, Port 2 from 0e:00:00:00:00:01 (remote␣
↪DPID 1 (0x1), port 2) state 3
DPID 1 (0x1) br0 LLDP on 0e:00:00:00:00:01, Port 2 from 0e:00:00:00:00:01 (remote␣
↪DPID 2 (0x2), port 2) state 3
```

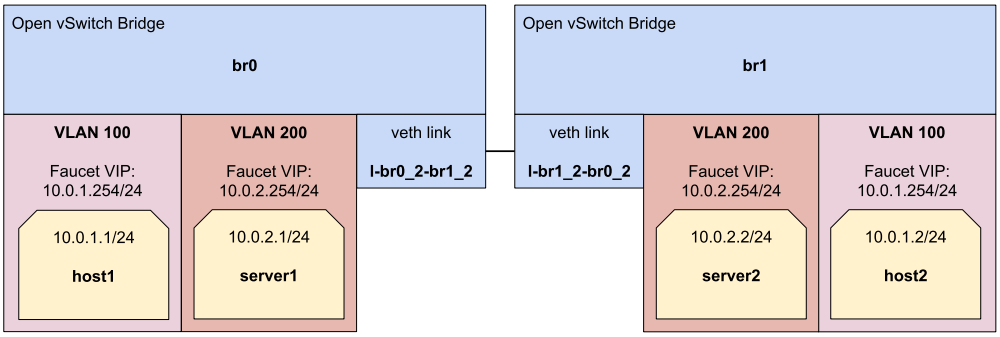
Note: If we were to accidentally cable our switches incorrectly faucet would report the incorrect cabling in the log file.

Now that the two switches are connected and our stack is up, we can ping between the two hosts.

```
as_ns host1 ping 10.0.1.2
```

Inter-VLAN routing with stacking

For this task we will see that inter-VLAN routing can work between hosts on different switches.



First run the cleanup.

```
cleanup
```

We can accomplish inter-VLAN routing between different switches by using the stacking feature. To do this we will be combining the methods from the *Basic stacking* and the *Routing between VLANs* tutorials. However, we need to set `drop_spoofed_faucet_mac` to false on each DP. Doing this will prevent a packet that has been routed and come from a stack port from being dropped.

Here is a full faucet.yaml you can copy and paste that sets up our stack topology and enables all the features we need.

Listing 30: /etc/faucet/faucet.yaml

```
vlans:
    hosts:
        vid: 100
        faucet_vips: ["10.0.1.254/24"]
        faucet_mac: "00:00:00:00:00:11"
    servers:
        vid: 200
        faucet_vips: ["10.0.2.254/24"]
        faucet_mac: "00:00:00:00:00:22"
routers:
    router-1:
        vlans: [hosts, servers]
dps:
    br0:
        dp_id: 0x1
        hardware: "Open vSwitch"
        stack:
            priority: 1
        drop_spoofed_faucet_mac: False
        interfaces:
            1:
                description: "host1 network namespace"
                native_vlan: hosts
            2:
```

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```
                description: "br0 stack link to br1"
                stack:
                    dp: br1
                    port: 2
            3:
                description: "server1 network namespace"
                native_vlan: servers

    br1:
        dp_id: 0x2
        hardware: "Open vSwitch"
        drop_spoofed_faucet_mac: False
        interfaces:
            1:
                description: "host2 network namespace"
                native_vlan: hosts
            2:
                description: "br1 stack link to br0"
                stack:
                   dp: br0
                   port: 2
            3:
                description: "server2 network namespace"
                native_vlan: servers
```

Reload faucet to enable inter-VLAN routing.

```
sudo systemctl reload faucet
```

As we have learnt previously. First, set up the hosts:

```
create_ns host1 10.0.1.1/24
create_ns host2 10.0.1.2/24
create_ns server1 10.0.2.1/24
create_ns server2 10.0.2.2/24
```

Now we can set-up the default routes for each host.

```
as_ns host1 ip route add default via 10.0.1.254
as_ns host2 ip route add default via 10.0.1.254
as_ns server1 ip route add default via 10.0.2.254
as_ns server2 ip route add default via 10.0.2.254
```

Next, we can create the bridges.

```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- add-port br0 veth-server1 -- set interface veth-server1 ofport_request=3 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br1 \
-- set bridge br1 other-config:datapath-id=0000000000000002 \
-- set bridge br1 other-config:disable-in-band=true \
```

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```
-- set bridge br1 fail_mode=secure \
-- add-port br1 veth-host2 -- set interface veth-host2 ofport_request=1 \
-- add-port br1 veth-server2 -- set interface veth-server2 ofport_request=3 \
-- set-controller br1 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

And finally, we can create the inter-switch links to connect the bridges to each other.

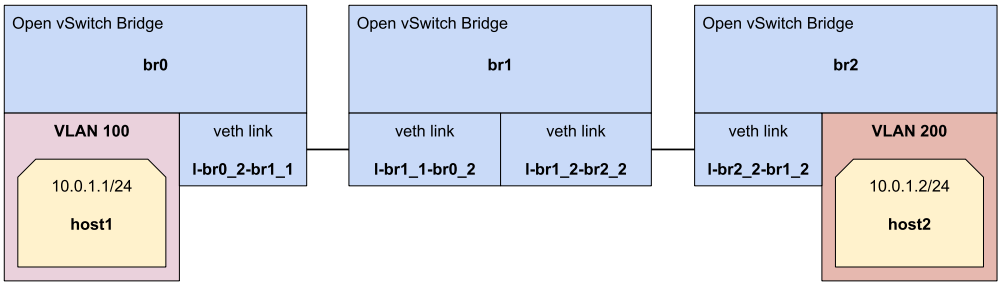
```
inter_switch_link br0:2 br1:2
```

Now it should be possible to ping between any combination of hosts on any VLAN after the LLDP has configured the stack ports as UP. For example host1 can ping to server1 on the same switch as well as server2 on the other switch via the use of the stack link.

```
as_ns host1 ping 10.0.2.1
as_ns host1 ping 10.0.2.2
```

Tunneling over a stack

Faucet has a feature that allows us to tunnel packets from one datapath to another without having to think about the underlying network topology. In this example we have three switches and two hosts. We will create a tunnel that runs over top of this topology connecting host1 and host2 together.



First run the cleanup.

```
cleanup
```

Now let's define our faucet.yaml that will make this network work. The configuration file below defines our faucet stack topology and ports for our host1 and host2. An important thing to note is that we define our two hosts on separate VLANs so they should not be able to communicate.

The other thing to notice is the two ACLs we define, `tunnel-to-host1` and `tunnel-to-host2`. At the moment these ACLs match all traffic (though we could easily add a match here to only tunnel a subset of traffic, see *ACL tutorial* for more details). Each tunnel sets the destination datapath and port for traffic matching the ACL, we currently support one type of tunnel, VLAN, and must reserve a tunnel VLAN here using the `tunnel_id` parameter (in future we could support different types of tunnels).

The two ACLs are then applied to the ports host1 and host2 are connected to.

Listing 31: /etc/faucet/faucet.yaml

```
acls:
   tunnel-to-host1:
       - rule:
           actions:
```

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```
                output:
                    tunnel:
                        type: 'vlan'
                        tunnel_id: 901
                        dp: br0
                        port: 1
    tunnel-to-host2:
        - rule:
            actions:
                output:
                    tunnel:
                        type: 'vlan'
                        tunnel_id: 902
                        dp: br2
                        port: 1
vlans:
    host1:
       vid: 101
    host2:
       vid: 102
dps:
    br0:
        dp_id: 0x1
        hardware: "Open vSwitch"
        stack:
            priority: 1
        interfaces:
            1:
                description: "host1 network namespace"
                native_vlan: host1
                acl_in: tunnel-to-host2
            2:
                description: "br0 stack link to br1"
                stack:
                    dp: br1
                    port: 1
    br1:
        dp_id: 0x2
        hardware: "Open vSwitch"
        interfaces:
            1:
                description: "br1 stack link to br0"
                stack:
                   dp: br0
                   port: 2
            2:
                description: "br1 stack link to br2"
                stack:
                    dp: br2
                    port: 2
    br2:
        dp_id: 0x3
        hardware: "Open vSwitch"
        interfaces:
            1:
                description: "host2 network namespace"
                native_vlan: host2
```

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```
            acl_in: tunnel-to-host1
        2:
            description: "br2 stack link to br1"
            stack:
                dp: br1
                port: 2
```

When we have updated our configuration to match above, signal to faucet to reload the configuration file.

```
sudo systemctl reload faucet
```

Then we can set up the hosts:

```
create_ns host1 10.0.1.1/24
create_ns host2 10.0.1.2/24
```

Next, we can create the bridges.

```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br1 \
-- set bridge br1 other-config:datapath-id=0000000000000002 \
-- set bridge br1 other-config:disable-in-band=true \
-- set bridge br1 fail_mode=secure \
-- set-controller br1 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br2 \
-- set bridge br2 other-config:datapath-id=0000000000000003 \
-- set bridge br2 other-config:disable-in-band=true \
-- set bridge br2 fail_mode=secure \
-- add-port br2 veth-host2 -- set interface veth-host2 ofport_request=1 \
-- set-controller br2 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

We also need to define inter-switch links that connect br0 and b1 as well as br1 and br2.

```
inter_switch_link br0:2 br1:1
inter_switch_link br1:2 br2:2
```

We should now be able to ping between host1 and host2 despite them being on different VLANs and datapaths because of the tunnel.

```
as_ns host1 ping 10.0.1.2
```

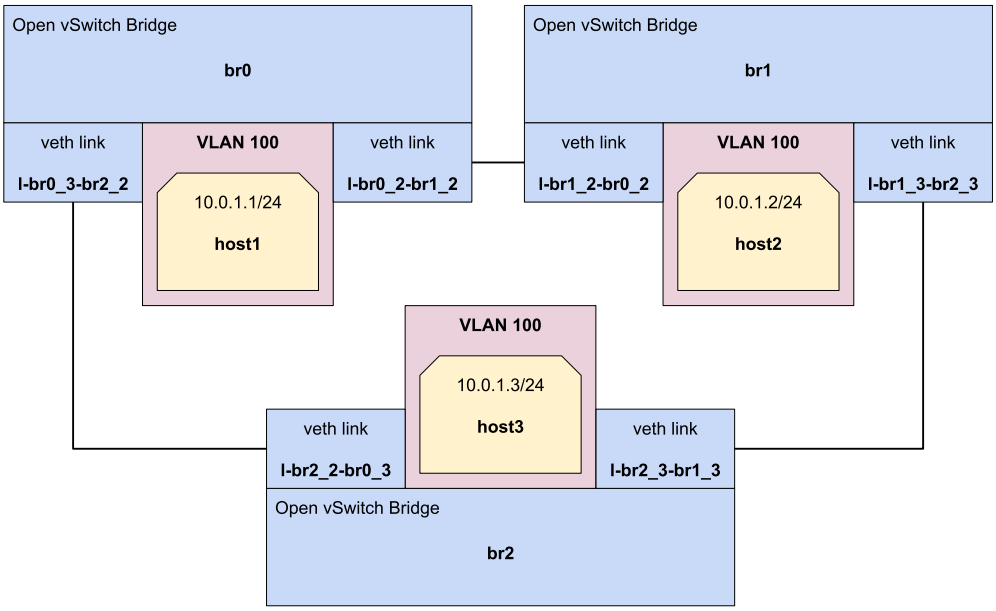
The reason the hosts can now communicate is that faucet is using the stack topology to find a path between the two hosts and automatically stitching up a tunnel. If we had a more complicated topology with multiple valid paths between the hosts, faucet will pick one and if the topology changes faucet will ensure the tunnel still goes over a valid path.

If we were to disable the ACLs on the port we would notice the hosts would no longer be able to ping.

Redundant stack links

Faucet is able to handle stack topologies with loops in them. This is because when faucet brings up a stack topology for the first time (or when it detects the network topology has changed), it has enough knowledge of the network to calculate a spanning tree for the network without the need for running a spanning tree protocol. Faucet uses this spanning tree to ensure broadcast packets aren't looped around the network.

This feature enables us to build fault-tolerant network architectures that can survive switch/port failures, a simple example is a ring topology:



To build this network, let's first cleanup from previous exercises.

```
cleanup
```

We should be quite familiar with configuring faucet for stacks now, let's define a faucet.yaml that matches our ring topology.

Listing 32: /etc/faucet/faucet.yaml

```
vlans:
    hosts:
       vid: 100
dps:
    br0:
        dp_id: 0x1
        hardware: "Open vSwitch"
        stack:
            priority: 1
        interfaces:
            1:
                description: "host1 network namespace"
                native_vlan: hosts
            2:
                description: "br0 stack link to br1"
                stack:
                    dp: br1
```

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```
                    port: 2
            3:
                description: "br0 stack link to br2"
                stack:
                    dp: br2
                    port: 2
    br1:
        dp_id: 0x2
        hardware: "Open vSwitch"
        interfaces:
            1:
                description: "host2 network namespace"
                native_vlan: hosts
            2:
                description: "br1 stack link to br0"
                stack:
                   dp: br0
                   port: 2
            3:
                description: "br1 stack link to br2"
                stack:
                    dp: br2
                    port: 3
    br2:
        dp_id: 0x3
        hardware: "Open vSwitch"
        interfaces:
            1:
                description: "host3 network namespace"
                native_vlan: hosts
            2:
                description: "br2 stack link to br0"
                stack:
                   dp: br0
                   port: 3
            3:
                description: "br2 stack link to br1"
                stack:
                    dp: br1
                    port: 3
```

We will define three hosts, one on each switch.

```
create_ns host1 10.0.1.1/24
create_ns host2 10.0.1.2/24
create_ns host3 10.0.1.3/24
```

Now let's define the three switches.

```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br1 \
```

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```
-- set bridge br1 other-config:datapath-id=0000000000000002 \
-- set bridge br1 other-config:disable-in-band=true \
-- set bridge br1 fail_mode=secure \
-- add-port br1 veth-host2 -- set interface veth-host2 ofport_request=1 \
-- set-controller br1 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br2 \
-- set bridge br2 other-config:datapath-id=0000000000000003 \
-- set bridge br2 other-config:disable-in-band=true \
-- set bridge br2 fail_mode=secure \
-- add-port br2 veth-host3 -- set interface veth-host3 ofport_request=1 \
-- set-controller br2 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

We also need to create the inter-switch links forming our ring network.

```
inter_switch_link br0:2 br1:2
inter_switch_link br0:3 br2:2
inter_switch_link br1:3 br2:3
```

Once the network is up we should be able to ping from all hosts to all other hosts.

```
as_ns host1 ping 10.0.1.2
as_ns host1 ping 10.0.1.3
```

Now let us intentionally introduce a fault into the network, our network should be able to survive a single cable failure and still have all devices reachable.

To test this we will manually disable the link between br0 and br2.

```
sudo ip link set down l-br0_3-br2_2
sudo ip link set down l-br2_2-br0_3
```

Which will force traffic between br0 and br2 to now go via br1, we can test this by ensuring host1 can still ping host3.

```
as_ns host1 ping 10.0.1.3
```

Multi-root stack

The previous exercise introduced the ability to survive cable failures, but you might have noticed in each exercise so far we have defined only a single root switch. If we were to lose this root switch the network would no longer function.

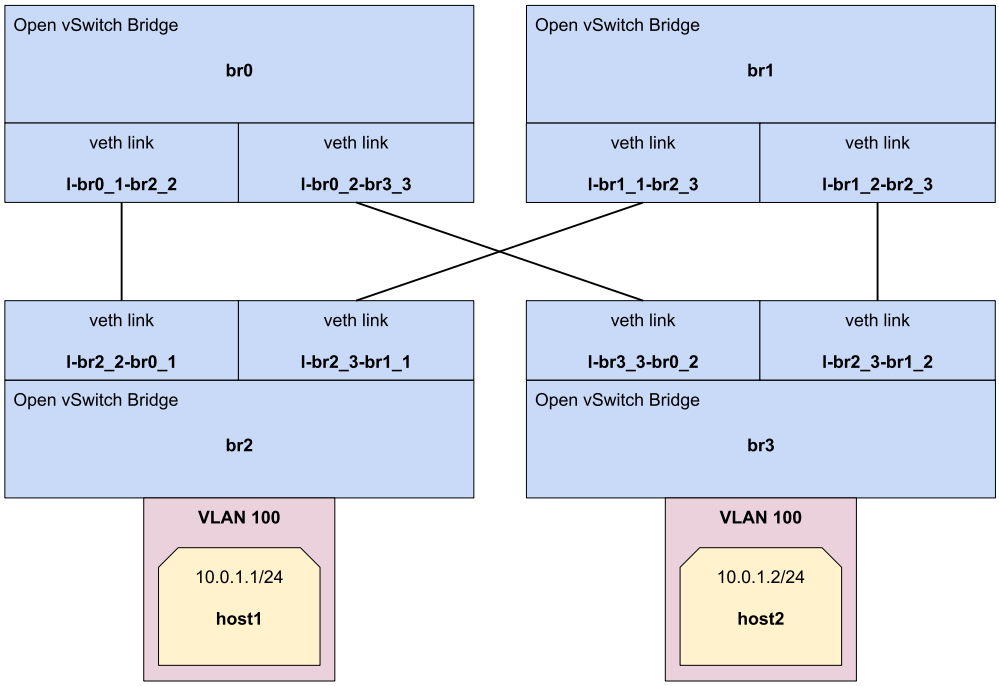
In this exercise we will introduce multi-root stacked networks which give us the ability to tolerate switch failures.

This example topology will allow us to survive any single cable failure or either of br0 or br1 failing.

Before we begin, let's do another cleanup.

```
cleanup
```

Our faucet.yaml will look familiar here, except for one difference, we now have two switches defined as `stack priority` 1. This signals to faucet that it has two equal priority root candidates it can use when selecting a root for the network.



Listing 33: /etc/faucet/faucet.yaml

```
vlans:
    hosts:
        vid: 100
dps:
    br0:
        dp_id: 0x1
        hardware: "Open vSwitch"
        stack:
            priority: 1
        interfaces:
            1:
                description: "br0 stack link to br2"
                stack:
                    dp: br2
                    port: 2
            2:
                description: "br0 stack link to br3"
                stack:
                    dp: br3
                    port: 3
            3:
                native_vlan: hosts
    br1:
        dp_id: 0x2
        hardware: "Open vSwitch"
        stack:
            priority: 1
        interfaces:
            1:
                description: "br1 stack link to br3"
                stack:
```

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```
                dp: br3
                port: 2
        2:
            description: "br1 stack link to br2"
            stack:
                dp: br2
                port: 3
br2:
    dp_id: 0x3
    hardware: "Open vSwitch"
    interfaces:
        1:
            description: "host1 network namespace"
            native_vlan: hosts
        2:
            description: "br2 stack link to br0"
            stack:
               dp: br0
               port: 1
        3:
            description: "br2 stack link to br1"
            stack:
                dp: br1
                port: 2
br3:
    dp_id: 0x4
    hardware: "Open vSwitch"
    interfaces:
        1:
            description: "host2 network namespace"
            native_vlan: hosts
        2:
            description: "br3 stack link to br1"
            stack:
               dp: br1
               port: 1
        3:
            description: "br3 stack link to br0"
            stack:
                dp: br0
                port: 2
```

When we have this new faucet.yaml loaded we will do a full restart this time instead of reloading to force a root election.

```
sudo systemctl restart faucet
```

We will create some hosts to let us test the failure scenarios of this topology.

```
create_ns host1 10.0.1.1/24
create_ns host2 10.0.1.2/24
```

We also need to define our four switches.

```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
```

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```
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br1 \
-- set bridge br1 other-config:datapath-id=0000000000000002 \
-- set bridge br1 other-config:disable-in-band=true \
-- set bridge br1 fail_mode=secure \
-- set-controller br1 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br2 \
-- set bridge br2 other-config:datapath-id=0000000000000003 \
-- set bridge br2 other-config:disable-in-band=true \
-- set bridge br2 fail_mode=secure \
-- add-port br2 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- set-controller br2 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654

sudo ovs-vsctl add-br br3 \
-- set bridge br3 other-config:datapath-id=0000000000000004 \
-- set bridge br3 other-config:disable-in-band=true \
-- set bridge br3 fail_mode=secure \
-- add-port br3 veth-host2 -- set interface veth-host2 ofport_request=1 \
-- set-controller br3 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

We need to fully mesh br0, br1, br2 and br3 to match our topology diagram above.

```
# Inter-switch links for br0
inter_switch_link br0:1 br2:2
inter_switch_link br0:2 br3:3

# Inter-switch links for br1
inter_switch_link br1:1 br3:2
inter_switch_link br1:2 br2:3
```

When everything is setup we should be able to ping between host1 and host2.

```
as_ns host1 ping 10.0.1.2
```

Now let's inspect the log file to find out which switch is currently our root.

```
$ grep -ai "stack root changed" /var/log/faucet/faucet.log | tail -n 1
Oct 08 04:19:24 faucet INFO     stack root changed from None to br0
```

Since br0 is the switch which is currently root, let's delete it to simulate a switch failure.

```
sudo ovs-vsctl del-br br0
```

If we look into the log file we should see faucet detects the switch is down and br1 takes over as the new root.

Listing 34: /var/log/faucet/faucet.yaml

```
Oct 08 04:22:52 faucet.valve WARNING  DPID 1 (0x1) br0 datapath down
Oct 08 04:23:03 faucet.valve INFO     DPID 1 (0x1) br0 LLDP for Port 1 inactive after␣
↪17s
Oct 08 04:23:03 faucet.valve INFO     DPID 1 (0x1) br0 LLDP for Port 2 inactive after␣
↪17s
Oct 08 04:23:03 faucet.valve ERROR    DPID 1 (0x1) br0 Stack Port 1 DOWN, too many␣
↪(3) packets lost, last received 17s ago
```

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```
Oct 08 04:23:03 faucet.valve INFO     DPID 2 (0x2) br1 shortest path to root is via
↪{Port 1}
Oct 08 04:23:03 faucet.valve INFO     DPID 4 (0x4) br3 shortest path to root is via
↪{Port 3}
Oct 08 04:23:03 faucet.valve INFO     DPID 3 (0x3) br2 shortest path to root is via
↪{Port 2}
Oct 08 04:23:03 faucet.valve ERROR    DPID 1 (0x1) br0 Stack Port 2 DOWN, too many␣
↪(3) packets lost, last received 17s ago
Oct 08 04:23:03 faucet.valve INFO     DPID 2 (0x2) br1 shortest path to root is via
↪{Port 1}
Oct 08 04:23:03 faucet.valve INFO     DPID 4 (0x4) br3 shortest path to root is via
↪{Port 2}
Oct 08 04:23:03 faucet.valve INFO     DPID 3 (0x3) br2 shortest path to root is via
↪{Port 3}
Oct 08 04:23:03 faucet.valve INFO     DPID 1 (0x1) br0 2 stack ports changed state
Oct 08 04:23:03 faucet.valve INFO     DPID 3 (0x3) br2 LLDP for Port 2 inactive after␣
↪17s
Oct 08 04:23:03 faucet.valve ERROR    DPID 3 (0x3) br2 Stack Port 2 DOWN, too many␣
↪(3) packets lost, last received 17s ago
Oct 08 04:23:03 faucet.valve INFO     DPID 2 (0x2) br1 shortest path to root is via
↪{Port 1}
Oct 08 04:23:03 faucet.valve INFO     DPID 4 (0x4) br3 shortest path to root is via
↪{Port 2}
Oct 08 04:23:03 faucet.valve INFO     DPID 3 (0x3) br2 shortest path to root is via
↪{Port 3}
Oct 08 04:23:03 faucet.valve INFO     DPID 3 (0x3) br2 1 stack ports changed state
Oct 08 04:23:03 faucet.valve INFO     DPID 4 (0x4) br3 LLDP for Port 3 inactive after␣
↪17s
Oct 08 04:23:03 faucet.valve ERROR    DPID 4 (0x4) br3 Stack Port 3 DOWN, too many␣
↪(3) packets lost, last received 17s ago
Oct 08 04:23:03 faucet.valve INFO     DPID 2 (0x2) br1 shortest path to root is via
↪{Port 1}
Oct 08 04:23:03 faucet.valve INFO     DPID 4 (0x4) br3 shortest path to root is via
↪{Port 2}
Oct 08 04:23:03 faucet.valve INFO     DPID 3 (0x3) br2 shortest path to root is via
↪{Port 3}
Oct 08 04:23:03 faucet.valve INFO     DPID 4 (0x4) br3 1 stack ports changed state
Oct 08 04:23:15 faucet INFO     stack root changed from br0 to br1
Oct 08 04:23:15 faucet INFO     root now br1 (all candidates ('br0', 'br1'), healthy [
↪'br1'])
```

We should also still be able to ping between host1 and host2 after the stack has recalculated.

```
as_ns host1 ping 10.0.1.2
```

1.2.6 NFV services tutorial

This tutorial will cover using faucet with Network Function Virtualisation (NFV) style services.

NFV services that will be demonstrated in this tutorial are:

- DHCP/DNS server
- Zeek (formerly known as Bro) Intrusion Detection System (IDS)

This tutorial demonstrates how the previous topics in this tutorial series can be combined to run real world services on our network.

Prerequisites

- A good understanding of the previous tutorial topics (*ACL tutorial*, *VLAN tutorial*, *Routing tutorial*)
- Install Faucet - *Package installation* steps 1 & 2
- Install Open vSwitch - *Connect your first datapath* steps 1 & 2
- Useful Bash Functions - Copy and paste the following definitions into your bash terminal, or to make them persistent between sessions add them to the bottom of your .bashrc and run 'source .bashrc'.

```
# Run command inside network namespace
as_ns () {
    NAME=$1
    NETNS=faucet-${NAME}
    shift
    sudo ip netns exec ${NETNS} $@
}
```

```
# Create network namespace
create_ns () {
    NAME=$1
    IP=$2
    NETNS=faucet-${NAME}
    sudo ip netns add ${NETNS}
    sudo ip link add dev veth-${NAME} type veth peer name veth0 netns $
↪{NETNS}
    sudo ip link set dev veth-${NAME} up
    as_ns ${NAME} ip link set dev lo up
    [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0 ${IP}
    as_ns ${NAME} ip link set dev veth0 up
}
```

```
# Clean up namespaces, bridges and processes created during faucet␣
↪tutorial
cleanup () {
    for NETNS in $(sudo ip netns list | grep "faucet-" | awk '{print $1}
↪'); do
        [ -n "${NETNS}" ] || continue
        NAME=${NETNS#faucet-}
        if [ -f "/run/dhclient-${NAME}.pid" ]; then
            # Stop dhclient
            sudo pkill -F "/run/dhclient-${NAME}.pid"
        fi
        if [ -f "/run/iperf3-${NAME}.pid" ]; then
            # Stop iperf3
            sudo pkill -F "/run/iperf3-${NAME}.pid"
        fi
        if [ -f "/run/bird-${NAME}.pid" ]; then
            # Stop bird
            sudo pkill -F "/run/bird-${NAME}.pid"
        fi
        # Remove netns and veth pair
        sudo ip link delete veth-${NAME}
        sudo ip netns delete ${NETNS}
    done
    for isl in $(ip -o link show | awk -F': ' '{print $2}' | grep -oE "^l-
↪br[0-9](_[0-9]*)?-br[0-9](_[0-9]*)?"); do
```

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```
        # Delete inter-switch links
        sudo ip link delete dev $isl 2>/dev/null || true
    done
    for DNSMASQ in /run/dnsmasq-vlan*.pid; do
        [ -e "${DNSMASQ}" ] || continue
        # Stop dnsmasq
        sudo pkill -F "${DNSMASQ}"
    done
    # Remove faucet dataplane connection
    sudo ip link delete veth-faucet 2>/dev/null || true
    # Remove openvswitch bridges
    sudo ovs-vsctl --if-exists del-br br0
    sudo ovs-vsctl --if-exists del-br br1
    sudo ovs-vsctl --if-exists del-br br2
    sudo ovs-vsctl --if-exists del-br br3
}
```

```
# Add tagged VLAN interface to network namespace
add_tagged_interface () {
     NAME=$1
     VLAN=$2
     IP=$3
     NETNS=faucet-${NAME}
     as_ns ${NAME} ip link add link veth0 name veth0.${VLAN} type vlan id
↪${VLAN}
     [ -n "${IP}" ] && as_ns ${NAME} ip addr add dev veth0.${VLAN} ${IP}
     as_ns ${NAME} ip link set dev veth0.${VLAN} up
     as_ns ${NAME} ip addr flush dev veth0
}
```

- Run the cleanup script to remove old namespaces and switches:

```
cleanup
```

Network setup

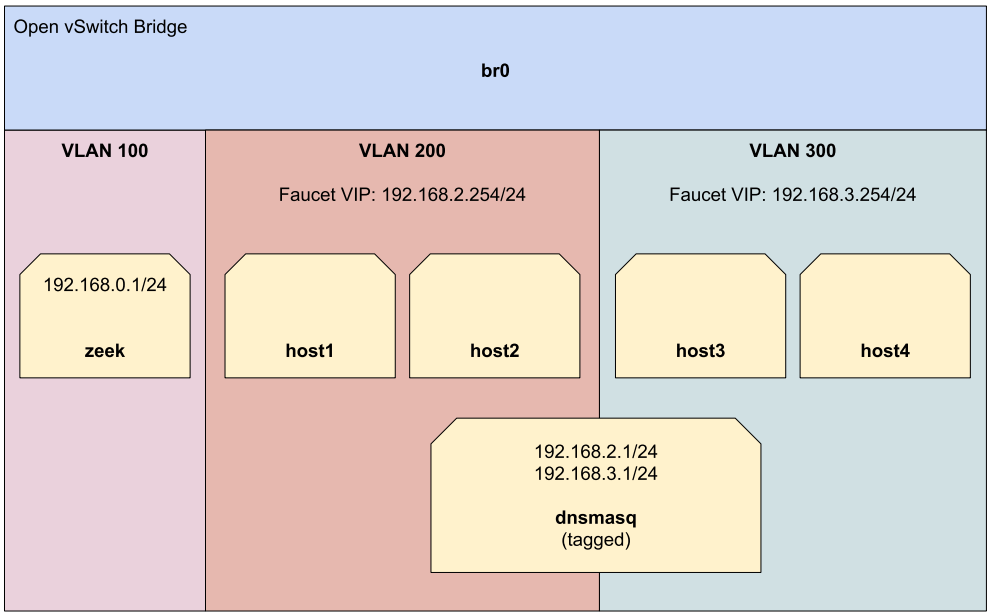
The network will be divided into three VLANs, two of which are client VLANs (200 & 300), with two clients in each and a DHCP/DNS server. There is also a separate VLAN 100 for the Zeek server which we will mirror traffic two from the other two VLANs.

To start, let's create our hosts and dnsmasq namespaces.

```
# DHCP/DNS server
create_ns dnsmasq 0.0.0.0
add_tagged_interface dnsmasq 200 192.168.2.1/24 # to serve VLAN 200
add_tagged_interface dnsmasq 300 192.168.3.1/24 # to serve VLAN 300

# VLAN 200 hosts
create_ns host1 0.0.0.0
create_ns host2 0.0.0.0
# VLAN 300 hosts
create_ns host3 0.0.0.0
create_ns host4 0.0.0.0
```

Then create an Open vSwitch bridge and connect all hosts to it.




```
sudo ovs-vsctl add-br br0 \
-- set bridge br0 other-config:datapath-id=0000000000000001 \
-- set bridge br0 other-config:disable-in-band=true \
-- set bridge br0 fail_mode=secure \
-- add-port br0 veth-host1 -- set interface veth-host1 ofport_request=1 \
-- add-port br0 veth-host2 -- set interface veth-host2 ofport_request=2 \
-- add-port br0 veth-host3 -- set interface veth-host3 ofport_request=3 \
-- add-port br0 veth-host4 -- set interface veth-host4 ofport_request=4 \
-- add-port br0 veth-dnsmasq -- set interface veth-dnsmasq ofport_request=5 \
-- set-controller br0 tcp:127.0.0.1:6653 tcp:127.0.0.1:6654
```

Dnsmasq setup

We will use dnsmasq to assign IP addresses to our host namespaces via the DHCP protocol. It will also serve as our DNS resolver for the hosts.

First install dnsmasq:

```
sudo apt-get install dnsmasq
sudo systemctl stop dnsmasq
```

Run the following two commands to start two dnsmasq instances inside the dnsmasq namespace. One instance will serve hosts on VLAN 200 and the other VLAN 300. We will be providing DHCP leases in the supplied ranges, the lease will set the gateway for each host to point at faucet's virtual IP and set dnsmasq as the DNS resolver. We also provide a fake `does.it.work` DNS name which we will later use to demonstrate DNS is working as expected.

```
# 192.168.2.0/24 for VLAN 200
as_ns dnsmasq dnsmasq \
                  --dhcp-range=192.168.2.10,192.168.2.20 \
                  --dhcp-sequential-ip \
                  --dhcp-option=option:router,192.168.2.254 \
                  --no-resolv \
                  --txt-record=does.it.work,yes \
```

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```
                    --bind-interfaces \
                    --except-interface=lo --interface=veth0.200 \
                    --dhcp-leasefile=/tmp/nfv-dhcp-vlan200.leases \
                    --log-facility=/tmp/nfv-dhcp-vlan200.log \
                    --pid-file=/run/dnsmasq-vlan200.pid \
                    --conf-file=

# 192.168.3.0/24 for VLAN 300
as_ns dnsmasq dnsmasq \
                    --dhcp-range=192.168.3.10,192.168.3.20 \
                    --dhcp-sequential-ip \
                    --dhcp-option=option:router,192.168.3.254 \
                    --no-resolv \
                    --txt-record=does.it.work,yes \
                    --bind-interfaces \
                    --except-interface=lo --interface=veth0.300 \
                    --dhcp-leasefile=/tmp/nfv-dhcp-vlan300.leases \
                    --log-facility=/tmp/nfv-dhcp-vlan300.log \
                    --pid-file=/run/dnsmasq-vlan300.pid \
                    --conf-file=
```

Now let's configure faucet.yaml.

Listing 35: /etc/faucet/faucet.yaml

```
vlans:
    vlan200:
        vid: 200
        description: "192.168.2.0/24 network"
        faucet_vips: ["192.168.2.254/24"]
        faucet_mac: "00:00:00:00:00:22"
    vlan300:
        vid: 300
        description: "192.168.3.0/24 network"
        faucet_vips: ["192.168.3.254/24"]
        faucet_mac: "00:00:00:00:00:33"
dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
                description: "host1 network namespace"
                native_vlan: vlan200
            2:
                name: "host2"
                description: "host2 network namespace"
                native_vlan: vlan200
            3:
                name: "host3"
                description: "host3 network namespace"
                native_vlan: vlan300
            4:
                name: "host4"
                description: "host4 network namespace"
                native_vlan: vlan300
```

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```
            5:
                name: "dnsmasq"
                description: "dnsmasq server network namespace"
                tagged_vlans: [vlan200, vlan300]
```

Now reload faucet configuration file.

```
sudo systemctl reload faucet
```

Use dhclient to configure host1 to host4 using DHCP (it may take a few seconds, but should return when successful).

```
as_ns host1 dhclient -v -pf /run/dhclient-host1.pid -lf /run/dhclient-host1.leases␣
↪veth0
as_ns host2 dhclient -v -pf /run/dhclient-host2.pid -lf /run/dhclient-host2.leases␣
↪veth0
as_ns host3 dhclient -v -pf /run/dhclient-host3.pid -lf /run/dhclient-host3.leases␣
↪veth0
as_ns host4 dhclient -v -pf /run/dhclient-host4.pid -lf /run/dhclient-host4.leases␣
↪veth0
```

If dhclient is unable to obtain an address you can check */tmp/nfv-dhcp-vlan<vlanid>.log* (e.g /tmp/nfv-dhcp-vlan300.leases) to check the log messages from dnsmasq.

To look up the address for each namespace we can run the following commands:

```
as_ns host1 ip address show dev veth0
as_ns host2 ip address show dev veth0
as_ns host3 ip address show dev veth0
as_ns host4 ip address show dev veth0
```

If the hosts have IPs then great our DHCP server works.

At the moment we should be able to ping inside VLAN 200 and VLAN 300:

```
as_ns host1 ping <ip of host2> # both in VLAN 200 should work
as_ns host3 ping <ip of host4> # both in VLAN 300 should work
```

Pinging between VLANs will not currently work as we didn't turn on inter-VLAN routing in our faucet configuration.

DNS

We can use faucet to enforce where protocols such as DNS go on the network. In this section we will use a faucet ACL to rewrite DNS packets to allow our dnsmasq namespace to answer DNS queries for any IP address.

Firstly, we can see that our dnsmasq server is correctly responding to DNS requests by manually querying them:

```
as_ns host1 host -t txt does.it.work 192.168.2.1
as_ns host3 host -t txt does.it.work 192.168.3.1
```

Both commands should return:

```
does.it.work descriptive text "yes"
```

But if we tried to query say `8.8.8.8` we would see this fail:

```
as_ns host1 host -t txt does.it.work 8.8.8.8
```

To make this work we first need the MAC address of the dnsmasq container:

```
as_ns dnsmasq cat /sys/class/net/veth0/address

00:11:22:33:44:55
```

We now replace our previous faucet configuration with the configuration below which adds an ACL that rewrites the MAC address of all DNS packets from the host namespaces and sends these to our dnsmasq namespace. Make sure to update the example MAC address of `00:11:22:33:44:55` with the one you get from running the previous command.

Listing 36: /etc/faucet/faucet.yaml

```
vlans:
    vlan200:
        vid: 200
        description: "192.168.2.0/24 network"
        faucet_vips: ["192.168.2.254/24"]
        faucet_mac: "00:00:00:00:00:22"
    vlan300:
        vid: 300
        description: "192.168.3.0/24 network"
        faucet_vips: ["192.168.3.254/24"]
        faucet_mac: "00:00:00:00:00:33"
dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
                description: "host1 network namespace"
                native_vlan: vlan200
                acls_in: [nfv-dns, allow-all]
            2:
                name: "host2"
                description: "host2 network namespace"
                native_vlan: vlan200
                acls_in: [nfv-dns, allow-all]
            3:
                name: "host3"
                description: "host3 network namespace"
                native_vlan: vlan300
                acls_in: [nfv-dns, allow-all]
            4:
                name: "host4"
                description: "host4 network namespace"
                native_vlan: vlan300
                acls_in: [nfv-dns, allow-all]
            5:
                name: "dnsmasq"
                description: "dnsmasq server network namespace"
                tagged_vlans: [vlan200, vlan300]
acls:
    nfv-dns:
        # Force UDP DNS to our DNS server
        - rule:
            dl_type: 0x800      # ipv4
```

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```
            nw_proto: 17         # udp
            udp_dst: 53          # dns
            actions:
                output:
                    set_fields:
                        - eth_dst: "00:11:22:33:44:55" # MAC address of dnsmasq␣
↪namespace
                allow: True
        # Force TCP DNS to our DNS server
        - rule:
            dl_type: 0x800       # ipv4
            nw_proto: 6          # tcp
            tcp_dst: 53          # dns
            actions:
                output:
                    set_fields:
                        - eth_dst: "00:11:22:33:44:55" # MAC address of dnsmasq␣
↪namespace
                allow: True
    allow-all:
        - rule:
            actions:
                allow: True
```

As usual reload faucet configuration file.

```
sudo systemctl reload faucet
```

The next step is to configure the namespace to be able to handle incoming DNS packets with any IP, this can be done by adding some rules to iptables that will NAT all DNS traffic to the IP address of the VLAN interface:

```
as_ns dnsmasq iptables -t nat -A PREROUTING -i veth0.200 -p udp --dport 53 -j DNAT --
↪to-destination 192.168.2.1
as_ns dnsmasq iptables -t nat -A PREROUTING -i veth0.200 -p tcp --dport 53 -j DNAT --
↪to-destination 192.168.2.1
as_ns dnsmasq iptables -t nat -A PREROUTING -i veth0.300 -p udp --dport 53 -j DNAT --
↪to-destination 192.168.3.1
as_ns dnsmasq iptables -t nat -A PREROUTING -i veth0.300 -p tcp --dport 53 -j DNAT --
↪to-destination 192.168.3.1
```

Now we should be able to query any IP address from the hosts and get a valid DNS response:

```
as_ns host1 host -t txt does.it.work 8.8.8.8
as_ns host2 host -t txt does.it.work 8.8.4.4
```

Zeek IDS

We will now add an IDS to our network on it's on separate VLAN and use faucet to mirror packets from VLAN 200 and 300 to the IDS VLAN.

Zeek installation

We need first to install Zeek (formerly known as Bro).

```
sudo apt-get install bro broctl
```

Configure Zeek

In /etc/bro/node.cfg, set veth0 as the interface to monitor

Listing 37: /etc/bro/node.cfg

```
[bro]
type=standalone
host=localhost
interface=veth0
```

Comment out MailTo in /etc/bro/broctl.cfg

Listing 38: /etc/bro/broctl.cfg

```
# Recipient address for all emails sent out by bro and BroControl.
# MailTo = root@localhost
```

Run Zeek

Firstly, let's create a namespace to run Zeek inside:

```
create_ns zeek 192.168.0.1
sudo ovs-vsctl add-port br0 veth-zeek -- set interface veth-zeek ofport_request=6
```

Since this is the first-time use of the Zeek command shell application, perform an initial installation of the BroControl configuration:

```
as_ns zeek broctl install
```

Then start Zeek instant

```
as_ns zeek broctl start
```

Check Zeek status

```
as_ns zeek broctl status

Name         Type       Host          Status    Pid    Started
bro          standalone localhost     running   15052  07 May 09:03:59
```

Now let's add a mirror ACL so all VLAN 200 & VLAN 300 traffic is sent to Zeek.

We will use a VLAN ACLs similar to the previous VLAN tutorial. Copy and paste the entire configuration below into faucet.yaml.

Listing 39: /etc/faucet/faucet.yaml

```
acls:
    mirror-acl:
        - rule:
            actions:
```

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```
                allow: true
                mirror: zeek
vlans:
    zeek-vlan:
        vid: 100
        description: "Zeek IDS network"
    vlan200:
        vid: 200
        description: "192.168.2.0/24 network"
        faucet_vips: ["192.168.2.254/24"]
        faucet_mac: "00:00:00:00:00:22"
        acls_in: [mirror-acl]
    vlan300:
        vid: 300
        description: "192.168.3.0/24 network"
        faucet_vips: ["192.168.3.254/24"]
        faucet_mac: "00:00:00:00:00:33"
        acls_in: [mirror-acl]
dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "host1"
                description: "host1 network namespace"
                native_vlan: vlan200
            2:
                name: "host2"
                description: "host2 network namespace"
                native_vlan: vlan200
            3:
                name: "host3"
                description: "host3 network namespace"
                native_vlan: vlan300
            4:
                name: "host4"
                description: "host4 network namespace"
                native_vlan: vlan300
            5:
                name: "dnsmasq"
                description: "dnsmasq server network namespace"
                tagged_vlans: [vlan200, vlan300]
            6:
                name: "zeek"
                description: "Zeek network namespace"
                native_vlan: zeek-vlan
```

As usual reload faucet configuration file.

```
sudo systemctl reload faucet
```

If we generate some DNS traffic on either of the hosts VLANs

```
as_ns host4 host -t txt does.it.work 192.168.3.1
```

Then if we inspect the Zeek logs for DNS `/var/log/bro/current/dns.log`, we should see that Zeek has seen

the DNS queries and logged these.

Listing 40: /var/log/bro/current/dns.log

```
#separator \x09
#set_separator      ,
#empty_field        (empty)
#unset_field        -
#path       dns
#open       2019-01-17-17-43-56
#fields     ts      uid     id.orig_h       id.orig_p       id.resp_h       id.resp_p␣
↪      proto   trans_id        rtt     query   qclass  qclass_name     qtype   qtype_
↪name       rcode   rcode_name      AA      TC      RD      RA      Z       answers␣
↪TTLs    rejected
#types      time    string  addr    port    addr    port    enum    count   interval ␣
↪      string  count   string  count   string  count   string  bool    bool    bool ␣
↪  bool    count   vector[string]  vector[interval]        bool
1547700236.794299   CsulWM1Px7fIyPpCVi      192.168.3.10    43428   192.168.3.1     ␣
↪53      udp     14288   0.006973does.it.work    1       C_INTERNET      16      TXT␣
↪    0       NOERROR T       F       T       T       2       TXT 3 yes       0.
↪000000        F
1547700379.311319   CZa11oBd3CgWBmgS8       192.168.3.11    45089   192.168.3.1     ␣
↪53      udp     64001   0.000336does.it.work    1       C_INTERNET      16      TXT␣
↪    0       NOERROR T       F       T       T       0       TXT 3 yes       0.
↪000000        F
```

You can also check if the traffic is being mirrored as expected using `tcpdump` in the `zeek` network namespace:

```
as_ns zeek sudo tcpdump -i veth0 -n -l
```

in one window, and then generating some more DNS traffic, eg:

```
as_ns host4 host -t txt does.it.work 192.168.3.1
```

then you should see something like:

Listing 41: zeek namespace tcpdump output

```
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on veth0, link-type EN10MB (Ethernet), capture size 262144 bytes
12:19:24.624244 IP 192.168.3.13.38174 > 192.168.3.1.53: 64571+ TXT? does.it.work. (30)
12:19:24.625109 IP 192.168.3.1.53 > 192.168.3.13.38174: 64571* 1/0/0 TXT "yes" (46)
```

1.3 Installation

We recommend installing faucet with apt for first time users and provide a *Installing faucet for the first time* tutorial which walks you through all the required steps for setting up faucet and gauge for the first time.

Once installed, see *Configuration* for documentation on how to configure faucet. Also, see *Vendor-specific Documentation* for documentation on how to configure your switch.

More advanced methods of installing faucet are also available here:

1. *Installation using APT*
2. *Installation with Docker*
3. *Installation with Pip*

4. *Installing on Raspberry Pi*
5. *Installing with Virtual Machine image*

1.3.1 Installation using APT

We maintain a apt repo for installing faucet and its dependencies on Debian-based Linux distributions.

Here is a list of packages we supply:

Package	Description
python3-faucet	Install standalone faucet/gauge python3 library
faucet	Install python3 library, systemd service and default config files
gauge	Install python3 library, systemd service and default config files
faucet-all-in-one	Install faucet, gauge, prometheus and grafana. Easy to use and good for testing faucet for the first time.

Installation on Debian/Raspbian 9+ and Ubuntu 16.04+

```
sudo apt-get install curl gnupg apt-transport-https lsb-release
echo "deb https://packagecloud.io/faucetsdn/faucet/$(lsb_release -si | awk '{print␣
↪tolower($0)}')/ $(lsb_release -sc) main" | sudo tee /etc/apt/sources.list.d/faucet.
↪list
curl -L https://packagecloud.io/faucetsdn/faucet/gpgkey | sudo apt-key add -
sudo apt-get update
```

Then to install all components for a fully functioning system on a single machine:

```
sudo apt-get install faucet-all-in-one
```

or you can install the individual components:

```
sudo apt-get install faucet
sudo apt-get install gauge
```

1.3.2 Installation with Docker

We provide official automated builds on Docker Hub so that you can easily run Faucet and it's components in a self-contained environment without installing on the main host system.

Installing docker

We recommend installing Docker Community Edition (CE) according to the official docker engine installation guide.

Configuring dockers

First, we need to create some configuration files on our host to mount inside the docker containers to configure faucet and gauge:

```
sudo mkdir -p /etc/faucet
sudo vi /etc/faucet/faucet.yaml
sudo vi /etc/faucet/gauge.yaml
```

See the *Configuration* section for configuration options.

Starting dockers

We use Docker tags to differentiate between versions of Faucet. The latest tag will always point to the latest stable release of Faucet. All tagged versions of Faucet in git are also available to use, for example using the `faucet/faucet:1.8.0` Docker will run the released version 1.8.0 of Faucet.

By default the Faucet and Gauge images are run as the *faucet* user under UID 0, GID 0. If you need to change that it can be overridden at runtime with the Docker flags: `-e LOCAL_USER_ID` and `-e LOCAL_GROUP_ID`.

To pull and run the latest version of Faucet:

```
mkdir -p /var/log/faucet/
docker pull faucet/faucet:latest
docker run -d \
    --name faucet \
    --restart=always \
    -v /etc/faucet/:/etc/faucet/ \
    -v /var/log/faucet/:/var/log/faucet/ \
    -p 6653:6653 \
    -p 9302:9302 \
    faucet/faucet
```

Port 6653 is used for OpenFlow, port 9302 is used for Prometheus - port 9302 may be omitted if you do not need Prometheus.

To pull and run the latest version of Gauge:

```
mkdir -p /var/log/faucet/gauge/
docker pull faucet/gauge:latest
docker run -d \
    --name gauge \
    --restart=always \
    -v /etc/faucet/:/etc/faucet/ \
    -v /var/log/faucet/:/var/log/faucet/ \
    -p 6654:6653 \
    -p 9303:9303 \
    faucet/gauge
```

Port 6654 is used for OpenFlow, port 9303 is used for Prometheus - port 9303 may be omitted if you do not need Prometheus.

Additional arguments

You may wish to run faucet under docker with additional arguments, for example: setting certificates for an encrypted control channel. This can be done by overriding the docker entrypoint like so:

```
docker run -d \
    --name faucet \
    --restart=always \
```

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```
    -v /etc/faucet/:/etc/faucet/ \
    -v /etc/ryu/ssl/:/etc/ryu/ssl/ \
    -v /var/log/faucet/:/var/log/faucet/ \
    -p 6653:6653 \
    -p 9302:9302 \
    faucet/faucet \
    faucet \
    --ctl-privkey /etc/ryu/ssl/ctrlr.key \
    --ctl-cert /etc/ryu/ssl/ctrlr.cert  \
    --ca-certs /etc/ryu/ssl/sw.cert
```

You can get a list of all additional arguments faucet supports by running:

```
docker run -it faucet/faucet faucet --help
```

Docker compose

This is an example docker-compose file that can be used to set up gauge to talk to Prometheus and InfluxDB with a Grafana instance for dashboards and visualisations.

It can be run with:

```
docker-compose pull
docker-compose up
```

The time-series databases with the default settings will write to `/opt/prometheus/` `/opt/influxdb/shared/data/db` you can edit these locations by modifying the `docker-compose.yaml` file.

On OSX, some of the default shared paths are not accessible, so to overwrite the location that volumes are written to on your host, export an environment varible name `FAUCET_PREFIX` and it will get prepended to the host paths. For example:

```
export FAUCET_PREFIX=/opt/faucet
```

When all the docker containers are running we will need to configure Grafana to talk to Prometheus and InfluxDB. First login to the Grafana web interface on port 3000 (e.g http://localhost:3000) using the default credentials of `admin:admin`.

Then add two data sources. Use the following settings for prometheus:

```
Name: Prometheus
Type: Prometheus
Url: http://prometheus:9090
```

And the following settings for InfluxDB:

```
Name: InfluxDB
Type: InfluxDB
Url: http://influxdb:8086
With Credentials: true
Database: faucet
User: faucet
Password: faucet
```

Check the connection using test connection.

From here you can add a new dashboard and a graphs for pulling data from the data sources. Hover over the + button on the left sidebar in the web interface and click `Import`.

We will import the following dashboards, just download the following links and upload them through the grafana dashboard import screen:

- Instrumentation
- Inventory
- Port Statistics

1.3.3 Installation with Pip

You can install the latest pip package, or you can install directly from git via pip.

Installing faucet

First, install some python dependencies:

```
apt-get install python3-dev python3-pip
pip3 install setuptools
pip3 install wheel
```

Then install the latest stable release of faucet from pypi, via pip:

```
pip3 install faucet
```

Or, install the latest development code from git, via pip:

```
pip3 install git+https://github.com/faucetsdn/faucet.git
```

Starting faucet manually

Faucet includes a start up script for starting Faucet and Gauge easily from the command line.

To run Faucet manually:

```
faucet --verbose
```

To run Gauge manually:

```
gauge --verbose
```

There are a number of options that you can supply the start up script for changing various options such as OpenFlow port and setting up an encrypted control channel. You can find a list of the additional arguments by running:

```
faucet --help
```

Starting faucet With systemd

Systemd can be used to start Faucet and Gauge at boot automatically:

```
$EDITOR /etc/systemd/system/faucet.service
$EDITOR /etc/systemd/system/gauge.service
systemctl daemon-reload
systemctl enable faucet.service
systemctl enable gauge.service
systemctl restart faucet
systemctl restart gauge
```

`/etc/systemd/system/faucet.service` should contain:

Listing 42: faucet.service

```
[Unit]
Description="Faucet OpenFlow switch controller"
After=network-online.target
Wants=network-online.target

[Service]
EnvironmentFile=/etc/default/faucet
User=faucet
Group=faucet
ExecStart=/usr/local/bin/faucet --ryu-config-file=${FAUCET_RYU_CONF} --ryu-ofp-tcp-
↪listen-port=${FAUCET_LISTEN_PORT}
ExecReload=/bin/kill -HUP $MAINPID
Restart=always

[Install]
WantedBy=multi-user.target
```

`/etc/systemd/system/gauge.service` should contain:

Listing 43: gauge.service

```
[Unit]
Description="Gauge OpenFlow statistics controller"
After=network-online.target
Wants=network-online.target

[Service]
EnvironmentFile=/etc/default/gauge
User=faucet
Group=faucet
ExecStart=/usr/local/bin/gauge --ryu-config-file=${GAUGE_RYU_CONF} --ryu-ofp-tcp-
↪listen-port=${GAUGE_LISTEN_PORT} --ryu-wsapi-host=${WSAPI_LISTEN_HOST} --ryu-
↪app=ryu.app.ofctl_rest
Restart=always

[Install]
WantedBy=multi-user.target
```

1.3.4 Installing on Raspberry Pi

We provide a Raspberry Pi image running FAUCET which can be retrieved from the latest faucet release page on GitHub. Download the faucet_VERSION_raspbian-lite.zip file.

The image can then be copied onto an SD card following the same steps from the official Raspberry Pi installation guide.

Once you have booted up the Raspberry Pi and logged in using the default credentials you can follow through the *Installing faucet for the first time* tutorial starting from *Configure prometheus* to properly configure each component.

Note: It is strongly recommended to use a Raspberry Pi 3 or better.

1.3.5 Installing with Virtual Machine image

We provide a VM image for running FAUCET for development and learning purposes. The VM comes pre-installed with FAUCET, GAUGE, prometheus and grafana.

Openstack's diskimage-builder (DIB) is used to build the VM images in many formats (qcow2,tgz,squashfs,vhd,raw).

Downloading pre-built images

Pre-built images are available on github, see the latest faucet release page on GitHub and download the faucet-amd64-VERSION.qcow2 file.

Building the images

If you don't want to use our pre-built images, you can build them yourself:

1. Install the latest disk-image-builder
2. Install a patched vhd-util
3. Run build-faucet-vm.sh

Security considerations

This VM is not secure by default, it includes no firewall and has a number of network services listening on all interfaces with weak passwords. It also includes a backdoor user (faucet) with weak credentials.

Services

The VM exposes a number of ports listening on all interfaces by default:

Service	Port
SSH	22
Faucet OpenFlow Channel	6653
Gauge OpenFlow Channel	6654
Grafana Web Interface	3000
Prometheus Web Interface	9090

Default Credentials

Service	Username	Password
VM TTY Console	faucet	faucet
SSH	faucet	faucet
Grafana Web Interface	admin	admin

Post-install steps

Grafana comes installed but unconfigured, you will need to login to the grafana web interface at `http://VM_IP:3000` and configure a data source and some dashboards.

After logging in with the default credentials shown above, the first step is to add a prometheus data source, use the following settings then click `Save & Test`:

```
Name:   Prometheus
Type:   Prometheus
URL:    http://localhost:9090
```

Next we want to add some dashboards so that we can later view the metrics from faucet.

Hover over the + button on the left sidebar in the web interface and click `Import`.

We will import the following dashboards, just download the following links and upload them through the grafana dashboard import screen:

- Instrumentation
- Inventory
- Port Statistics

You will need to supply your own faucet.yaml and gauge.yaml configuration in the VM. There are samples provided at /etc/faucet/faucet.yaml and /etc/faucet/gauge.yaml.

Finally you will need to point one of the supported OpenFlow vendors at the controller VM, port 6653 is the Faucet OpenFlow control channel and 6654 is the Gauge OpennFlow control channel for monitoring.

1.4 Configuration

1.4.1 Faucet configuration

Faucet is configured with a YAML-based configuration file, `faucet.yaml`. The following is example demonstrating a few common features:

Listing 44: faucet.yaml

```
include:
    - acls.yaml

vlans:
    office:
        vid: 100
        description: "office network"
        acls_in: [office-vlan-protect]
        faucet_mac: "0e:00:00:00:10:01"
        faucet_vips: ['10.0.100.254/24', '2001:100::1/64', 'fe80::c00:00ff:fe00:1001/
↪64']
        routes:
            - route:
                ip_dst: '192.168.0.0/24'
                ip_gw: '10.0.100.2'
    guest:
        vid: 200
```

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```
        description: "guest network"
        faucet_mac: "0e:00:00:00:20:01"
        faucet_vips: ['10.0.200.254/24', '2001:200::1/64', 'fe80::c00:00ff:fe00:2001/
↪64']

routers:
    router-office-guest:
        vlans: [office, guest]

dps:
    sw1:
        dp_id: 0x1
        hardware: "Open vSwitch"
        interfaces:
            1:
                name: "h1"
                description: "host1 container"
                native_vlan: office
                acls_in: [access-port-protect]
            2:
                name: "h2"
                description: "host2 container"
                native_vlan: office
                acls_in: [access-port-protect]
            3:
                name: "g1"
                description: "guest1 container"
                native_vlan: guest
                acls_in: [access-port-protect]
            4:
                name: "s1"
                description: "services container"
                native_vlan: office
                acls_in: [service-port-protect]
            5:
                name: "trunk"
                description: "VLAN trunk to sw2"
                tagged_vlans: [office]
                acls_in: [access-port-protect]
    sw2:
        dp_id: 0x2
        hardware: "Allied-Telesis"
        interfaces:
            1:
                name: "pi"
                description: "raspberry pi"
                native_vlan: office
                acls_in: [access-port-protect]
            2:
                name: "laptop"
                description: "guest laptop"
                native_vlan: guest
                acls_in: [access-port-protect]
            4:
                name: "s1"
                description: "services Laptop"
                native_vlan: guest
```

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```
                acls_in: [access-port-protect]
            24:
                name: "trunk"
                description: "VLAN trunk to sw1"
                tagged_vlans: [office, guest]
```

Listing 45: acls.yaml

```
acls:
    office-vlan-protect:
        # Prevent IPv4 communication betwen Office/Guest networks
        - rule:
            dl_type: 0x800      # ipv4
            ipv4_src: 10.0.100.0/24
            ipv4_dst: 10.0.200.0/24
            actions:
                allow: 0        # drop
        - rule:
            actions:
                allow: 1        # allow

    access-port-protect:
        # Drop dhcp servers
        - rule:
            dl_type: 0x800      # ipv4
            nw_proto: 17        # udp
            udp_src: 67         # bootps
            udp_dst: 68         # bootpc
            actions:
                allow: 0        # drop
        # Drop dhcpv6 servers
        - rule:
            dl_type: 0x86dd     # ipv6
            nw_proto: 17        # udp
            udp_src: 547        # dhcpv6-server
            udp_dst: 546        # dhcpv6-client
            actions:
                allow: 0        # drop
        # Drop icmpv6 RAs
        - rule:
            dl_type: 0x86dd     # ipv6
            nw_proto: 58        # icmpv6
            icmpv6_type: 134    # router advertisement
            actions:
                allow: 0        # drop
        # Drop SMTP
        - rule:
            dl_type: 0x800      # ipv4
            nw_proto: 6         # tcp
            tcp_dst: 25         # smtp
            actions:
                allow: 0        # drop
        # Force DNS to our DNS server
        - rule:
            dl_type: 0x800      # ipv4
            nw_proto: 17        # udp
```

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```
            udp_dst: 53         # dns
            actions:
                output:
                    set_fields:
                        - eth_dst: "72:b8:3c:4c:dc:4d"
                    port: "s1"  # s1 container
        # Force DNS to our DNS server
        - rule:
            dl_type: 0x800      # ipv4
            nw_proto: 6         # tcp
            tcp_dst: 53         # dns
            actions:
                output:
                    set_fields:
                        - eth_dst: "72:b8:3c:4c:dc:4d"
                    port: "s1"  # s1 container
        - rule:
            actions:
                allow: 1        # allow

    service-port-protect:
        # Drop icmpv6 RAs
        - rule:
            dl_type: 0x86dd     # ipv6
            nw_proto: 58        # icmpv6
            icmpv6_type: 134    # router advertisement
            actions:
                allow: 0        # drop
        # Drop SMTP
        - rule:
            dl_type: 0x800      # ipv4
            nw_proto: 6         # tcp
            tcp_dst: 25         # smtp
            actions:
                allow: 0        # drop
        - rule:
            actions:
                allow: 1        # allow
```

The datapath ID may be specified as an integer or hex string (beginning with 0x).

A port not explicitly defined in the YAML configuration file will be left down and will drop all packets.

Configuration options

Top Level

Table 1: Faucet.yaml

Attribute	Type	Default	Description
acls	dictionary	{}	Configuration specific to acls. The keys are names of each acl, and the values are config dictionaries holding the acl's configuration (see below).
dps	dictionary	{}	Configuration specific to datapaths. The keys are names or dp_ids of each datapath, and the values are config dictionaries holding the datapath's configuration (see below).
meters	dictionary	{}	Configuration specific to meters. The keys are names of each meter, and the values are config dictionaries holding the meter's configuration (see below).
routers	dictionary	{}	Configuration specific to routers. The keys are names of each router, and the values are config dictionaries holding the router's configuration (see below).
version	integer	2	The config version. 2 is the only supported version.
vlans	dictionary	{}	Configuration specific to vlans. The keys are names or vids of each vlan, and the values are config dictionaries holding the vlan's configuration (see below).

DP

DP configuration is entered in the 'dps' configuration block. The 'dps' configuration contains a dictionary of configuration blocks each containing the configuration for one datapath. The keys can either be string names given to the datapath, or the OFP datapath id.

Table 2: dps: <dp name or id>: {}

Attribute	Type	Default	Description
advertise_interval	integer	30	How often to advertise (eg. IPv6 RAs)
arp_neighbor_timeout	integer	250	ARP and neighbour timeout in seconds
description	string	name	Description of this datapath, strictly informational
dot1x	dictionary	{}	802.1X configuration (see below)
dp_id	integer	The configuration key	The OFP datapath-id of this datapath
drop_bpdu	boolean	True	If True, Faucet will drop all STP BPDUs arriving at the datapath. NB: Faucet does not handle BPDUs itself, if you disable this then you either need to configure an ACL to catch BDPUs or Faucet will forward them as though they were normal traffic.
drop_broadcast_source_address	boolean	True	If True, Faucet will drop any packet from a broadcast source address
drop_spoofed_faucet_mac	boolean	True	If True, Faucet will drop any packet it receives with an ethernet source address equal to a MAC address that Faucet is using.

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Table 2 – continued from previous page

Attribute	Type	Default	Description
group_table	boolean	False	If True, Faucet will use the OpenFlow Group tables to flood packets. This is an experimental feature that is not fully supported by all devices and may not interoperate with all features of faucet.
hardware	string	"Open vSwitch"	The hardware model of the datapath. Defaults to "Open vSwitch". Other options can be seen in the documentation for valve.py
high_priority	integer	low_priority + 1 (9001)	The high priority value.
highest_priority	integer	high_priority + 98 (9099)	The highest priority number to use.
ignore_learn_ins	integer	10	Ignore every approx nth packet for learning. 2 will ignore 1 out of 2 packets; 3 will ignore 1 out of 3 packets. This limits control plane activity when learning new hosts rapidly. Flooding will still be done by the dataplane even with a packet is ignored for learning purposes.
interfaces	dictionary	{}	Configuration block for interface specific config (see below)
interface_ranges	dictionary	{}	Contains the config blocks for sets of multiple interfaces. The configuration entered here will be used as the defaults for these interfaces. The defaults can be overwritten by configuring the interfaces individually, which will also inherit all defaults not specifically configured. For example, if the range specifies tagged_vlans: [1, 2, 3], and the individual interface specifies tagged_vlans: [4], the result will be tagged_vlans: [4]. The format for the configuration key is a comma separated string. The elements can either be the name or number of an interface or a range of port numbers eg: "1-6,8,port9".
learn_ban_timeout	integer	10	When a host is rapidly moving between ports Faucet will stop learning mac addresses on one of the ports for this number of seconds.
learn_jitter	integer	10	In order to reduce load on the controller Faucet will randomly vary the timeout for learnt mac addresses by up to this number of seconds.
lldp_beacon	dictionary	{}	Configuration block for LLDP beacons
low_priority	integer	low_priority + 9000 (9000)	The low priority value.
lowest_priority	integer	priority_offset (0)	The lowest priority number to use.

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Table 2 – continued from previous page

Attribute	Type	Default	Description
max_host_fib_retry_count	integer	10	Limit the number of times Faucet will attempt to resolve a next-hop's l2 address.
max_hosts_per_resolve_cycle	integer	5	Limit the number of hosts resolved per cycle.
max_resolve_backoff_time	integer	32	When resolving next hop l2 addresses, Faucet will back off exponentially until it reaches this value.
metrics_rate_limit_sec	integer	0	Rate limit metric updates - don't update metrics if last update was less than this many seconds ago.
name	string	The configuration key	A name to reference the datapath by.
ofchannel_log	string	None	Name of logfile for openflow logs
packetin_pps	integer	None	Ask switch to rate limit packet pps.
priority_offset	integer	0	Shift all priority values by this number.
proactive_learn_v4	boolean	True	Whether proactive learning is enabled for IPv4 nexthops
proactive_learn_v6	boolean	True	Whether proactive learning is enabled for IPv6 nexthops
stack	dictionary	{}	Configuration block for stacking config, for loop protection (see below)
timeout	integer	300	Timeout for MAC address learning
use_idle_timeout	boolean	False	Turn on/off the use of idle timeout for src_table, default OFF.
table_sizes	dictionary	{}	For TFM based switches, size of each FAUCET table (any may be specified)
port_table_scale_factor	float	1.0	For TFM based switches, and for tables that are sized by number of ports, scale size estimate.
global_vlan	int	2**11-1	When global routing is enabled, FIB VID used internally

Stacking (DP)

Stacking is configured in the dp configuration block and in the interface configuration block. At the dp level the following attributes can be configured within the configuration block 'stack':

Table 3: dps: <dp name or id>: stack: {}

Attribute	Type	Default	Description
priority	integer	0	Setting any value for stack priority indicates that this datapath should be the root for the stacking topology.

LLDP (DP)

LLDP beacons are configured in the dp and interface configuration blocks.

LLDP beacons can be used to, among other things, facilitate physical troubleshooting (e.g. so that a standard cable tester can display port information), verify FAUCET stacking topology, and cue a phone to use the right voice VLAN.

Note: While FAUCET can receive and log LLDP from other devices, FAUCET does not do spanning tree. Those LLDP packets will have no influence on FAUCET's forwarding decisions.

The following attributes can be configured within the 'lldp_beacon' configuration block at the dp level:

Table 4: dps: <dp name or id>: lldp_beacon: {}

Attribute	Type	Default	Description
system_name	string	The datapath name	System name inside LLDP packet
send_interval	integer	None	Seconds between sending beacons
max_per_interval	integer	None	The maximum number of beacons, across all ports to send each interval

Note: When stack ports are enabled FAUCET automatically configures LLDP with the default values for send_interval and max_per_interval to 5.

802.1X (DP)

Note: 802.1X support is experimental, and there may be incomplete features or bugs. If you find an issue please email the mailing list or create an Github issue.

Faucet implements 802.1X by forwarding EAPOL packets on the dataplane to a socket it is listening on. These packets are then passed through to a RADIUS server which performs the authentication and generates the reply message.

For each instance of Faucet there is only one 802.1X speaker. This 802.1X speaker is configured by the options below. Except for the 'nfv_sw_port' option, the configuration for the speaker is configured using the first dp's dot1x config dictionary. For all other dps only the 'nfv_sw_port' option is required with the others ignored.

A basic network and configuration with two hosts may look like:

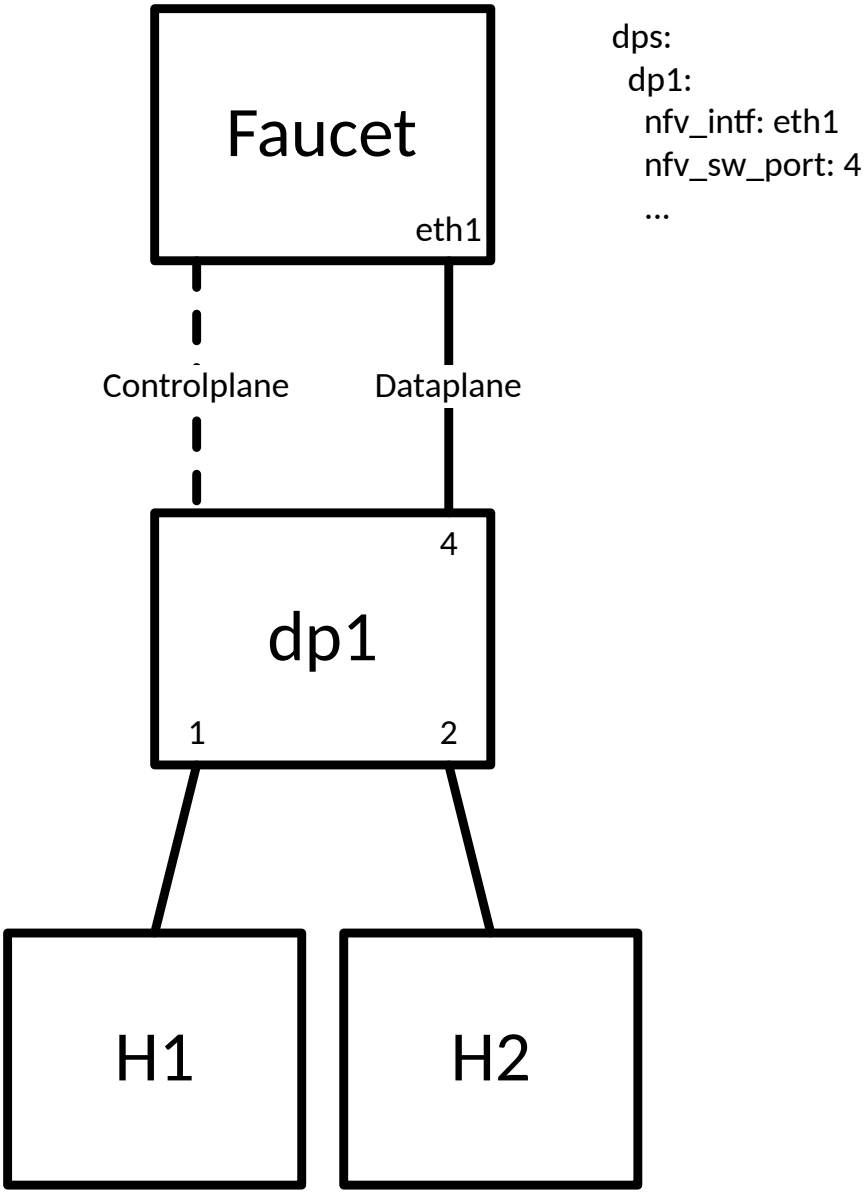
A brief overview of the current state of the implementation:

Implemented:

- EAP Types: MD5, PEAP, TLS, TTLS.
- Authentication session expiry default 3600 seconds. (configurable (per authentication) via returning the Session-Timeout attribute in the RADIUS Access-Accept message).
- Faucet connects to a single RADIUS server, and passes through all EAP messages.
- Client can end session with EAP-Logoff.
- Dynamic assignment of the native VLAN. Use RADIUS attribute Private-Group-Tunnel-ID in Radius Access-Accept with the name of the faucet VLAN.

Not Supported (yet):

- RADIUS Accounting.
- Multiple RADIUS Servers.


Faucet
eth1
Controlplane
Dataplane
4
dp1
1
2
H1
H2
dps:
dp1:
nfv_intf: eth1
nfv_sw_port: 4
...

- Other EAP types. E.g. FAST, . . .
- Dynamic assignment of ACL.

802.1X port authentication is configured in the dp configuration block and in the interface configuration block. At the dp level the following attributes can be configured with the configuration block 'dot1x':

Table 5: dps: <dp name or id>: dot1x: {}

Attribute	Type	Default	Description
nfv_intf	str		The interface for Faucet to listen for EAP packets from the dataplane. - NOTE: Faucet will only use the config from the first dp
nfv_sw_port	int		Switch port number that connects to the Faucet server's nfv_intf
radius_ip	str		IP address of RADIUS Server the 802.1X speaker will authenticate with. - NOTE: Faucet will only use the config from the first dp
radius_port	int	1812	UDP port of RADIUS Server the 802.1X speaker will authenticate with. - NOTE: Faucet will only use the config from the first dp
radius_secret	str		Shared secret used by the RADIUS server and the 802.1X speaker. - NOTE: Faucet will only use the config from the first dp
noauth_acl	str	None	The name of the defined ACL [refer to acls.yaml for more information] that will be set to all 802.1X ports by default, that is before any user is authenticated. - NOTE: Faucet will only use the config from the first dp
auth_acl	str	None	The name of the defined ACL [refer to acls.yaml for more information] that will be set to an 802.1X port when a user authenticates. - NOTE: Faucet will only use the config from the first dp
dot1x_assigned	boolean	False	True, if this ACL can be dynamically assigned by a RADIUS server during 802.1X authentication.

Interfaces

Configuration for each interface is entered in the 'interfaces' configuration block within the config for the datapath. Each interface configuration block is a dictionary keyed by the interface name.

Defaults for groups of interfaces can also be configured under the 'interface-ranges' attribute within the datapath configuration block. These provide default values for a number of interfaces which can be overwritten with the config block for an individual interface. These are keyed with a string containing a comma separated list of OFP port numbers, interface names or with OFP port number ranges (eg. 1-6).

Table 6: dps: <dp name or id>: interfaces: <interface name or OFP port number>: {}

Attribute	Type	Default	Description
acl_in	integer or string	None	Deprecated, replaced by acls_in which accepts a list. The acl that should be applied to all packets arriving on this port. referenced by name or list index
acls_in	a list of ACLs, as integers or strings	None	A list of ACLs that should be applied to all packets arriving on this port. referenced by name or list index. ACLs listed first take priority over those later in the list.
description	string	Name (which defaults to the configuration key)	Description, purely informational
dot1x	boolean	False	Enable 802.1X port authentication
dot1x_acl	boolean	False	Enable 802.1X ACL functionality on port (NOTE: Requires dot1x attribute)
dot1x_mab	boolean	False	Enable 802.1X Mac Authentication Bypass on port (NOTE: Requires dot1x attribute)
enabled	boolean	True	Enable 802.1X Per User ACLs on port (NOTE: Requires dot1x attribute and ACL with dot1x_assigned)
enabled	boolean	True	Allow packets to be forwarded through this port.
hairpin	boolean	False	If True it allows packets arriving on this port to be output to this port. This is necessary to allow routing between two vlans on this port, or for use with a WIFI radio port.
lldp_beacon	dictionary	{}	Configuration block for lldp configuration
loop_protect	boolean	False	if True, do simple (host/access port) loop protection on this port.
loop_protect_external	boolean	False	if True, do external (other switch) loop protection on this port.
max_hosts	integer	255	the maximum number of mac addresses that can be learnt on this port.
mirror	a list of integers or strings	None	Mirror all allowed packets recieved from (subject to ACLs), and all packets transmitted to, the ports specified (by name or by port number), to this port. If mirroring of denied by ACL packets is desired, use the ACL rule mirror option. The mirrored packets are from the perspective of hosts on the mirrored port (for example, a packet with a VLAN tag, transmitted to a host on a mirrored and untagged port, will be mirrored without its original VLAN tag).
name	string	The configuration key.	a name to reference this port by.
native_vlan	integer	None	The vlan associated with untagged packets arriving and leaving this interface.
number	integer	The configuration key.	The OFP port number for this port.
opstatus_reconf	boolean	True	If True, FAUCET will reconfigure the pipeline based on operational status of the port.
output_only	boolean	False	If True, no packets will be accepted from

Stacking (Interfaces)

Stacking port configuration indicates how datapaths are connected when using stacking. The configuration is found under the 'stack' attribute of an interface configuration block. The following attributes can be configured:

Table 7: dps: <dp name or id>: interfaces: <interface name or port number: stack: {}

Attribute	Type	Default	Description
dp	integer or string	None	The name or dp_id of the dp connected to this port
port	integer or string	None	The name or OFP port number of the interface on the remote dp connected to this interface.

LLDP (Interfaces)

Interface specific configuration for LLDP.

Table 8: dps: <dp name or id>: interfaces: <interface name or port number: lldp_beacon: {}

Attribute	Type	Default	Description
enable	boolean	False	Enable sending lldp beacons from this interface
org_tlvs	list	[]	Definitions of Organisational TLVs to add to LLDP beacons
port_descr	string	Interface description	Port description to use in beacons from this interface
system_name	string	lldp_beacon (dp) system name	The System Name to use in beacons from this interface

LLDP Organisational TLVs (Interfaces)

Faucet allows defining organisational TLVs for LLDP beacons. These are configured in a list under lldp_beacons/org_tlvs at the interfaces level of configuration.

Each list element contains a dictionary with the following elements:

Table 9: dps: <dp name or id>: interfaces: <interface name or port number: lldp_beacon: org_tlvs: - {}

Attribute	Type	Default	Description
info	string	None	The info field of the tlv, as a hex string
oui	integer	None	The Organisationally Unique Identifier
subtype	integer	None	The organizationally defined subtype

Router

Routers config is used to allow routing between VLANs, and optionally BGP. Routers configuration is entered in the 'routers' configuration block at the top level of the faucet configuration file. Configuration for each router is an entry

in the routers dictionary and is keyed by a name for the router. The following attributes can be configured:

Table 10: routers: <router name>: {}

Attribute	Type	Default	Description
vlans	list of integers or strings	None	Enables inter-vlan routing on the given VLANs.
bgp	BGP configuration.	None	See below for BGP configuration.

BGP

Routers config to enable BGP routing.

Table 11: routers: <router name>: {}

Attribute	Type	Default	Description
as	integer	None	The local AS number to used when speaking BGP
connect_mode	string	"passive"	Must be "passive"
neighbor_addresses	list of strings (IP addresses)	None	The list of BGP neighbours
neighbor_as	integer	None	The AS Number for the BGP neighbours
routerid	string (IP address)	None	BGP router ID.
server_addresses	list of strings (IP addresses)	None	IP addresses for FAUCET to listen for incoming BGP addresses.
port	integer	None	Port to use for BGP sessions
vlan	string	None	The VLAN to add/remove BGP routes from.

VLAN

VLANs are configured in the 'vlans' configuration block at the top level of the faucet config file. The config for each vlan is an entry keyed by its vid or a name. The following attributes can be configured:

Table 12: vlans: <vlan name or vid>: {}

Attribute	Type	Default	Description
acl_in	string or integer	None	Deprecated, replaced by acls_in which accepts a list. The acl to be applied to all packets arriving on this vlan.
acls_in	a list of ACLs, as integers or strings	None	The acl to be applied to all packets arriving on this vlan. ACLs listed first take priority over those later in the list.
description	string	None	Strictly informational
dot1x_assigned	bool	False	True, if this VLAN can be dynamically assigned by a RADIUS server during 802.1X authentication. Otherwise False
faucet_vips	list of strings (IP address prefixes)	None	The IP Address for Faucet's routing interface on this vlan
faucet_mac	string (MAC address)	None	Set MAC for FAUCET VIPs on this VLAN
max_hosts	integer	255	The maximum number of hosts that can be learnt on this vlan.
minimum_ip_size_check	boolean	True	If False, don't check that IP packets have a payload (must be False for OVS trace/tutorial to work)
name	string	the configuration key	A name that can be used to refer to this vlan.
proactive_arp_limit	integer	2052	Do not proactively ARP for hosts once this value has been reached (set to None for unlimited)
proactive_nd_limit	integer	2052	Don't proactively discover IPv6 hosts once this value has been reached (set to None for unlimited)
routes	list of routes	None	Static routes configured on this vlan (see below)
targeted_gw_resolution	boolean	False	If True, and a gateway has been resolved, target the first re-resolution attempt to the same port rather than flooding.
unicast_flood	boolean	True	If False packets to unknown ethernet destination MAC addresses will be dropped rather than flooded.
vid	integer	the configuration key	The vid for the vlan.

Static Routes

Static routes are given as a list. Each entry in the list contains a dictionary keyed with the keyword 'route' and contains a dictionary configuration block as follows:

Table 13: vlans: <vlan name or vid>: routes: - route: {}

Attribute	Type	Default	Description
ip_dst	string (IP subnet)	None	The destination subnet.
ip_gw	string (IP address)	None	The next hop for this route

Meters

Note: Meters are platform dependent and not all functions may be available.

Meters are configured under the 'meters' configuration block. The meters block contains a dictionary of individual meters each keyed by its name.

Table 14: meters: <meter name>:

Attribute	Type	Default	Description
meter_id	int		Unique identifier.
entry	dictionary		Defines the meter actions. Details Below.

Table 15: : meters: <meter name>: entry:

Attribute	Type	Default	Desciption
flags	string or list of strings	KBPS	Possible values are 'KBPS' (Rate value in kb/s (kilo-bit per second).), 'PKTPS' (Rate value in packet/sec.), 'BURST' (Do burst size), 'STATS' (Collect statistics)
bands	list of bands (which are dictionaries, see below)		

Table 16: : meters: <meter name>: entry: bands:

Attribute	Type	Default	Desciption
type	string		'DROP' - drop apckets when the band rate is exceeded, or 'DSCP_REMARK'- use a simple DiffServ policer to remark the DSCP field in the IP header of packets that exceed the band rate.
rate	int		Rate for dropping or remarking packets, depending on the above type. Value is in KBPS or PKTPS flag depending on the flag set.
burst_size	int		Only used if flags includes BURST. Indicates the length of packet or byte burst to consider for applying the meter.
prec_level	int		Only used if type is DSCP_REMARK. The amount by which the drop precedence should be increased.

ACLs

ACLs are configured under the 'acls' configuration block. The acls block contains a dictionary of individual acls each keyed by its name.

Each acl contains a list of rules: a packet will have the first matching rule applied to it.

Each rule is a dictionary containing the single key 'rule' with matches and actions. Matches are key/values based on the ryu RESTFul API. Actions is a dictionary of actions to apply upon match.

Table 17: : acls: <acl name>: - rule: actions: {}

Attribute	Type	Default	Description
allow	boolean	False	If True allow the packet to continue through the Faucet pipeline, if False drop the packet.
force_port_vlan	boolean	False	if True, don't verify VLAN/port association.
cookie	int, 0-2**16	defaults to datapath cookie value	If set, cookie on this flow will be set to this value.
meter	string	None	Meter to apply to the packet
mirror	string or integer	None	Copy the packet, before any modifications, to the specified port (NOTE: ACL mirroring is done in input direction only)
output	dictionary	None	Used to output a packet directly. Details below.

The output action contains a dictionary with the following elements:

Table 18: : acls: <acl name>: - rule: actions: output: {}

Attribute	Type	Default	Description
set_fields	list of dictionaries	None	A list of fields to set with values, eg. eth_dst: "1:2:3:4:5:6"
port	integer or string	None	The port to output the packet to.
ports	list of [integer or string]	None	The list of ports the packet will be output through.
pop_vlans	boolean	False	Pop vlan tag before output.
vlan_vid	integer	False	Push vlan tag before output.
swap_vid	integer	None	Rewrite the vlan vid of the packet when outputting
vlan_vids	list of [integer or {vid: integer, eth_type: integer}]	None	Push vlan tags on output, with optional eth_type.
failover	dictionary	None	Output with a failover port (see below).

Failover is an experimental option, but can be configured as follows:

Table 19: : acls: <acl name>: - rule: actions: output: failover: {}

Attribute	Type	Default	Description
group_id	integer	None	The OFP group id to use for the failover group
ports	list	None	The list of ports the packet can be output through.

1.4.2 Gauge configuration

Gauge is configured similarly with, `gauge.yaml`. The following is an example demonstrating a few common features:

Listing 46: gauge.yaml

```
# Recommended configuration is Prometheus for all monitoring, with all_dps: True
faucet_configs:
    - '/etc/faucet/faucet.yaml'
watchers:
    port_status_poller:
        type: 'port_state'
        all_dps: True
        #dps: ['sw1', 'sw2']
        db: 'prometheus'
    port_stats_poller:
        type: 'port_stats'
        all_dps: True
        #dps: ['sw1', 'sw2']
        interval: 10
        db: 'prometheus'
        #db: 'influx'
    flow_table_poller:
        type: 'flow_table'
        all_dps: True
        interval: 60
        db: 'prometheus'
dbs:
    prometheus:
        type: 'prometheus'
        prometheus_addr: '0.0.0.0'
        prometheus_port: 9303
    ft_file:
        type: 'text'
        compress: True
        path: 'flow_tables'
    influx:
        type: 'influx'
        influx_db: 'faucet'
        influx_host: 'influxdb'
        influx_port: 8086
        influx_user: 'faucet'
        influx_pwd: 'faucet'
        influx_timeout: 10
```

1.4.3 Verifying configuration

You can verify that your configuration is correct with the `check_faucet_config` script:

```
check_faucet_config /etc/faucet/faucet.yaml
```

1.4.4 Configuration examples

For complete working examples of configuration features, see the unit tests, `tests/faucet_mininet_test.py`. For example, `FaucetUntaggedACLTest` shows how to configure an ACL to block a TCP port, `FaucetTaggedIPv4RouteTest` shows how to configure static IPv4 routing.

1.4.5 Applying configuration updates

You can update FAUCET's configuration by sending it a HUP signal. This will cause it to apply the minimum number of flow changes to the switch(es), to implement the change.

```
pkill -HUP -f faucet.faucet
```

1.4.6 Configuration in separate files

Extra DP, VLAN or ACL data can also be separated into different files and included into the main configuration file, as shown below. The `include` field is used for configuration files which are required to be loaded, and Faucet will log an error if there was a problem while loading a file. Files listed on `include-optional` will simply be skipped and a warning will be logged instead.

Files are parsed in order, and both absolute and relative (to the configuration file) paths are allowed. DPs, VLANs or ACLs defined in subsequent files overwrite previously defined ones with the same name.

`faucet.yaml`

```
include:
    - /etc/faucet/dps.yaml
    - /etc/faucet/vlans.yaml

include-optional:
    - acls.yaml
```

`dps.yaml`

```
# Recursive include is allowed, if needed.
# Again, relative paths are relative to this configuration file.
include-optional:
    - override.yaml

dps:
    test-switch-1:
        ...
    test-switch-2:
        ...
```

1.4.7 Environment variables

You can use environment variables to override default behaviour of faucet such as paths for configuration files and port numbers.

Environment Variable	Type	Default	Description
FAUCET_CONFIG	Colon-separated list of file paths	/etc/faucet/faucet.yaml: /etc/ryu/faucet/faucet.yaml	Faucet will load its configuration from the first valid file in list
FAUCET_CONFIG_AUTO_REVERT	boolean	False	If true, Faucet will attempt to revert a bad config file back to the last known good version.
FAUCET_CONFIG_STAT_RELOAD	boolean	False	If true, faucet will automatically reload itself and apply new configuration when FAUCET_CONFIG changes
FAUCET_LOG_LEVEL	Python log level	INFO	Log verbosity
FAUCET_LOG	File path or STDOUT or STDERR	/var/log/faucet/faucet.log	Location for faucet to log messages to, can be special values STDOUT or STDERR
FAUCET_EXCEPTION_LOG	File path or STDOUT or STDERR	/var/log/faucet/faucet_exception.log	Location for faucet log to log exceptions to, can be special values STDOUT or STDERR
FAUCET_EVENT_SOCK	Socket path		Location to a UNIX socket where faucet will write events to, or empty to disable events
FAUCET_PROMETHEUS_PORT	Port	9302	TCP port to listen on for faucet prometheus client
FAUCET_PROMETHEUS_ADDR	IP address	0.0.0.0	IP address to listen on for faucet prometheus client
GAUGE_CONFIG	Colon-separated list of file paths	/etc/faucet/gauge.yaml: /etc/ryu/faucet/gauge.yaml	Guage will load it's configuration from the first valid file in list
GAUGE_CONFIG_STAT_RELOAD	boolean	False	If true, gauge will automatically reload itself and apply new configuration when GAUGE_CONFIG changes
GAUGE_LOG_LEVEL	Python log level	INFO	Log verbosity
GAUGE_LOG	File path or STDOUT or STDERR	/var/log/faucet/gauge.log	Location for gauge to log messages to, can be special values STDOUT or STDERR
GAUGE_EXCEPTION_LOG	File path or STDOUT or STDERR	/var/log/faucet/gauge_exception.log	Location for faucet log to log exceptions to, can be special values STDOUT or STDERR
GAUGE_PROMETHEUS_ADDR	IP address	0.0.0.0	IP address to listen on for gauge prometheus client

1.5 Monitoring

Faucet can be monitored in a number of ways. Both the faucet and gauge services export instrumentation data via a built-in Prometheus exporter which can be consumed by Prometheus. By default the Prometheus exporter is available on port 9302, this can be changed with *Environment variables* (`FAUCET_PROMETHEUS_PORT` and `FAUCET_PROMETHEUS_ADDR`).

Gauge also collects conventional switch statistics (port counters, port state, etc) and can export these to a number of different databases (including Prometheus). For information on configuring gauge see the *Gauge configuration* section.

1.5.1 Prometheus metrics

Below is a list of the metrics exported by faucet and gauge.

Exported by faucet

Table 20: Faucet prometheus metrics

Metric	Type	Description
faucet_pbr_version	gauge	Faucet PBR version
faucet_stack_root_dpid	gauge	set to current stack root DPID
faucet_config_reload_requests_total	counter	number of config reload requests
faucet_config_load_error	gauge	1 if last attempt to re/load config failed
faucet_config_hash	info	file hashes for last successful config
faucet_config_hash_func	gauge	algorithm used to compute config hashes
faucet_config_applied	gauge	fraction of DPs that we have tried to apply config to
faucet_event_id	gauge	highest/most recent event ID to be sent
faucet_config_reload_warm_total	counter	number of warm, differences only config reloads executed
faucet_config_reload_cold_total	counter	number of cold, complete reprovision config reloads executed
of_ignored_packet_ins_total	counter	number of OF packet_ins received but ignored from DP (due to rate limiting)
of_unexpected_packet_ins_total	counter	number of OF packet_ins received that are unexpected from DP (e.g. for unknown VLAN)
of_packet_ins_total	counter	number of OF packet_ins received from DP
of_non_vlan_packet_ins_total	counter	number of OF packet_ins received from DP, not associated with a FAUCET VLAN
of_vlan_packet_ins_total	counter	number of OF packet_ins received from DP, associated with a FAUCET VLAN
of_flowmsgs_sent_total	counter	number of OF flow messages (and packet outs) sent to DP
of_errors_total	counter	number of OF errors received from DP
of_dp_connections_total	counter	number of OF connections from a DP
of_dp_disconnections_total	counter	number of OF connections from a DP
vlan_hosts_learned	gauge	number of hosts learned on a VLAN
port_vlan_hosts_learned	gauge	number of hosts learned on a port and VLAN
vlan_neighbors	gauge	number of L3 neighbors on a VLAN (whether resolved to L2 addresses, or not)
vlan_learn_bans	gauge	number of times learning was banned on a VLAN
faucet_config_table_names	gauge	number to names map of FAUCET pipeline tables

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Metric	Type	Description
faucet_packet_in_secs	histogram	FAUCET packet in processing time
faucet_valve_service_secs	histogram	FAUCET valve service processing time
bgp_neighbor_uptime	gauge	BGP neighbor uptime in seconds
bgp_neighbor_routes	gauge	BGP neighbor route count
learned_macs	gauge	MAC address stored as 64bit number to DP ID, port, VLAN, and n (discrete index)
port_status	gauge	status of switch ports
port_stack_state	gauge	state of stacking on a port
port_learn_bans	gauge	number of times learning was banned on a port
port_lacp_status	gauge	status of LACP on port
dp_status	gauge	status of datapaths
of_dp_desc_stats	gauge	DP description (OFPDescStatsReply)
stack_cabling_errors_total	counter	number of cabling errors detected in all FAUCET stacks
stack_probes_received_total	counter	number of stacking messages received
dp_dot1x_success_total	counter	number of successful authentications on dp
dp_dot1x_failure_total	counter	number of authentications attempts failed on dp
dp_dot1x_logoff_total	counter	number of eap-logoff events on dp
port_dot1x_success_total	counter	number of successful authentications on port
port_dot1x_failure_total	counter	number of authentications attempts failed on port
port_dot1x_logoff_total	counter	number of eap-logoff events on port

Exported by gauge

Table 21: Gauge prometheus metrics

Metric	Type	Description
faucet_pbr_version	gauge	Faucet PBR version
dp_status	gauge	status of datapaths
of_port_tx_packets	gauge	
of_port_rx_packets	gauge	
of_port_tx_bytes	gauge	
of_port_rx_bytes	gauge	
of_port_tx_dropped	gauge	
of_port_rx_dropped	gauge	
of_port_rx_errors	gauge	
of_port_reason	gauge	
of_port_state	gauge	
of_port_curr_speed	gauge	
of_port_max_speed	gauge	
of_meter_flow_count	gauge	
of_meter_byte_in_count	gauge	
of_meter_packet_in_count	gauge	
of_meter_byte_band_count	gauge	
of_meter_packet_band_count	gauge	

1.6 Configuration Recipe Book

In this section we will cover some common network configurations and how you would configure these with the Faucet YAML configuration format.

1.6.1 Forwarding

1.6.2 Routing

1.6.3 Policy

1.7 Vendor-specific Documentation

1.7.1 Faucet on Allied Telesis products

Introduction

Allied Telesis has a wide portfolio of OpenFlow enabled switches that all support the Faucet pipeline. These OpenFlow enabled switches come in various port configurations of 10/18/28/52/96 with POE+ models as well. Here is a list of some of our most popular switches:

- AT-x930
- SBx908Gen2
- AT-x950
- AT-x510
- AT-x230

Setup

Switch

OpenFlow supported Firmware

OpenFlow has been supported since AlliedWarePlus version 5.4.6 onwards. To inquire more about compatibility of versions, you can contact our customer support team.

OpenFlow configuration

For a **Pure OpenFlow** deployment, we recommend the following configurations on the switch. Most of these configuration steps will be shown with an example.

```
/* Create an OpenFlow native VLAN */
awplus (config)# vlan database
awplus (config-vlan)# vlan 4090

/* Set an IP address for Control Plane(CP)
 * Here we will use vlan1 for Management/Control Plane */
awplus (config)# interface vlan1
awplus (config-if)# ip address 192.168.1.1/24

/* Configure the FAUCET controller
 * Let's use TCP port 6653 for connection to Faucet */
awplus (config)# openflow controller tcp 192.168.1.10 6653

/* (OPTIONAL) Configure GAUGE controller
 * Let's use TCP port 6654 for connection to Gauge */
awplus (config)# openflow controller tcp 192.168.1.10 6654
```

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```
/* NOTE - Starting from AlliedWarePlus version 5.4.8-2, we have added support for␣
↪controller name.
 * You can specify a controller name with the optional <name> parameter.
 * Users can still use the previous controller commands (without the name parameter)␣
↪and the switch will auto-generate
 * a suitable name (starting with "oc") in that case.
 * Here is an example to add a controller with name 'faucet' using TCP port 6653 */
awplus (config)# openflow controller faucet tcp 192.168.1.10 6653

/* User must set a dedicated native VLAN for OpenFlow ports
 * OpenFlow native VLAN MUST be created before it is set!
 * VLAN ID for this native VLAN must be different from the native VLAN for control␣
↪plane */
awplus (config)# openflow native vlan 4090

/* Enable OpenFlow on desired ports */
awplus (config)# interface port1.0.1-1.0.46
awplus (config-if)# openflow

/* Disable Spanning Tree Globally */
awplus (config)# no spanning-tree rstp enable

/* Disable Loop protection detection Globally */
awplus (config)# no loop-protection loop-detect

/* OpenFlow requires that ports under its control do not send any control traffic
 * So it is better to disable RSTP and IGMP Snooping TCN Query Solicitation.
 * Disable IGMP Snooping TCN Query Solicitation on the OpenFlow native VLAN */
awplus (config)# interface vlan4090
awplus (config-if)# no ip igmp snooping tcn query solicit
```

Once OpenFlow is up and running and connected to Faucet/Gauge controller, you should be able to verify the operation using some of our show commands.

```
/* To check contents of the DP flows */
awplus# show openflow flows

/* To check the actual rules as pushed by the controller */
awplus# show openflow rules

/* To check the OpenFlow configuration and other parameters */
awplus# show openflow status
awplus# show openflow config
awplus# show openflow coverage
```

Some other OPTIONAL configuration commands, that may be useful to modify some parameters, if needed.

```
/* Set the OpenFlow version other than default version(v1.3) */
awplus (config)# openflow version 1.0

/* Set IPv6 hardware filter size
 * User needs to configure the following command if a packet needs to be forwarded by␣
↪IPv6 address matching! */
awplus (config)# platform hwfilter-size ipv4-full-ipv6
```

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```
/* Set the datapath ID(DPID)
 * By default, we use the switch MAC address for datapath-ID.
 * To change the DPID to a hex value 0x1, use the following */
awplus (config)# openflow datapath-id 1

/* NOTE - For all software versions prior to 5.4.7, all data VLAN(s) must be included␣
↪in the vlan database config
 * on the switch before they can be used by OpenFlow.
 * Here is an example to create DP VLANs 2-100 */
awplus (config)# vlan database
awplus (config-vlan)# vlan 2-100

/* NOTE - Starting from software version 5.4.8-2, in order to negate a controller,␣
↪you need to specify the controller name.
 * In case you add the controller the legacy way (without the name), the newer␣
↪software will auto-generate a name which can be
 * used to delete the controller.
 * Here is an example to delete a controller with auto-generated name oc1 */
awplus (config)# no openflow controller oc1
```

Useful Switch related configurations

Note: If the Openflow controller is located in a different VLAN or Network segment, routing needs to be configured so that the switch can talk to the controller.

```
/* To set Timezone: Codes - https://www.timeanddate.com/time/zones/ */
/* For US Pacific Time zone */
awplus (config)# clock timezone NAPST minus 8

/* To set DNS, say a local Gateway also acting as a DNS forwarder 10.20.0.1 */
awplus (config)# ip name-server 10.20.0.1

/* To make sure that DNS and routing correctly work, Gateway address needs to be set.
 * Here, Gateway is set only to the management VLAN, vlan1; 255 is the max depth␣
↪allowed */
awplus (config)# ip route 0.0.0.0/0 vlan1 255
awplus (config)# ip route 0.0.0.0/0 10.20.0.1

/* To see the configured Route database */
awplus# show ip route database

/* To test routing, ping Google.com - note the name to ip resolution */
awplus# ping google.com
```

Setting up PKI Certs for secure connectivity between Switch and Openflow Controller

Note: There are many ways to get the keys and certificates into the box. Here, both private key (unencrypted PEM formatted) and corresponding Certificate (PEM) as trusted by the Openflow Controller is provided to the Switch Admin for installation.

Getting keys into the Switch flash partition

```
/* Here SCP is used to copy.  TFTP, USB, etc are other supported methods */
awplus# copy scp://user@10.20.5.5/home/user/switch-cert.pem switch-cert.pem
awplus# copy scp://user@10.20.5.5/home/user/switch-key_nopass.pem switch-key_nopass.
↪pem

/* Showing only relevant files */
awplus# dir
       1679 -rw- Dec 20 2017 09:04:35  switch-key_nopass.pem
      11993 -rw- Dec 20 2017 09:04:03  switch-cert.pem
```

Setting up Trustpoint for SSL connectivity to Openflow Controller

```
/* Create a local trustpoint */
awplus (config)# crypto pki trustpoint local

/* Point the switch to the OF controller */
awplus (config)# openflow controller ssl 192.168.1.10 6653

/* Allow OpenFlow to use local trustpoint */
awplus (config)# openflow ssl trustpoint local

/* Copy the new key and pvt keys to local trustpoint directory */
awplus# copy switch-key_nopass.pem .certs/pki/local/cakey.pem

Overwrite flash:/.certs/pki/local/cakey.pem (y/n)[n]:y
Copying...
Successful operation

awplus# copy switch-cert.pem .certs/pki/local/cacert.pem

Overwrite flash:/.certs/pki/local/cacert.pem (y/n)[n]:y
Copying...
Successful operation
```

Enabling SNMP for monitoring Management/Control Plane Port

Openflow enabled ports are monitored via Openflow Stats request/response protocol. This means that Management port (and if Openflow control channel port is separate), are not monitored on the switch. Hence, SNMP is used to monitor the same. SNMP v2 is the most widely used. As an example below, let us assume NMS is @ 10.20.30.71

```
/* Check contents of existing access-list */
awplus# show access-list

/* Enable the SNMP agent and enable the generation of authenticate
 * failure traps to monitor unauthorized SNMP access. */
awplus (config)# snmp-server enable trap auth

/* Creating a write access community called sfractalonprem1rw for use by
 * the central network management station at 10.20.30.71 */
awplus (config)# access-list 96 permit 10.20.30.71
awplus (config)# snmp-server community sfractalonprem1rw rw view atview 96

/* Enable link traps on VLANs or specific interfaces (in our case management port) */
awplus (config)# interface port1.0.1
awplus (config-if)# snmp trap link-status

/* Configuring Trap Hosts */
```

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```
awplus (config)# snmp-server host 10.20.30.71 version 2c sfractalonprem1rw

/* Confirm all SNMP settings */
awplus# show snmp-server
SNMP Server ......................... Enabled
IP Protocol ......................... IPv4, IPv6
SNMP Startup Trap Delay ............. 30 Seconds
SNMPv3 Engine ID (configured name) ... Not set
SNMPv3 Engine ID (actual) ............ 0x80001f8880a2977c410e3bb658

awplus# show snmp-server community
SNMP community information:
  Community Name ........... sfractalonprem1rw
    Access ................. Read-write
    View ................... atview

awplus# show run snmp
snmp-server
snmp-server enable trap auth
snmp-server community sfractalonprem1rw rw view atview 96
snmp-server host 10.20.30.71 version 2c sfractalonprem1rw
!

/* Check if the interface is configured for SNMP */
awplus# show interface port1.0.1
Interface port1.0.1
  Scope: both
  Link is UP, administrative state is UP
  Thrash-limiting
    Status Not Detected, Action learn-disable, Timeout 1(s)
  Hardware is Ethernet, address is 001a.eb96.6ef2
  index 5001 metric 1 mru 1500
  current duplex full, current speed 1000, current polarity mdi
  configured duplex auto, configured speed auto, configured polarity auto
  <UP,BROADCAST,RUNNING,MULTICAST>
  SNMP link-status traps: Sending (suppressed after 20 traps in 60 sec)
    Link-status trap delay: 0 sec
    input packets 14327037, bytes 3727488153, dropped 0, multicast packets 440768
    output packets 11172202, bytes 2028940085, multicast packets 233192 broadcast␣
↪packets 1889
  Time since last state change: 40 days 00:48:38

awplus# show access-list
Standard IP access list 96
   10 permit 10.20.30.71
```

Enabling sFlow for monitoring Management/Control Port

Openflow enabled ports are monitored via Openflow Stats request/response protocol. This means that Management port (and if Openflow control channel port is separate), are not monitored on the switch. Hence, sFlow is used to monitor the same. At this time, no TLS/SSL support is seen on the sFlow Controller channel.

```
/* Check for any existing sFlow configuration */
awplus# show running-config sflow
!

/* Enable sFlow globally */
```

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```
awplus (config)# sflow enable
% INFO: sFlow will not function until collector address is non-zero
% INFO: sFlow will not function until agent address is set
awplus# show running-config sflow
!
sflow enable
!

/* Confirm the new sFlow settings */
awplus# show sflow
sFlow Agent Configuration:                    Default Values
  sFlow Admin Status ........ Enabled         [Disabled]
  sFlow Agent Address ....... [not set]       [not set]
  Collector Address ......... 0.0.0.0         [0.0.0.0]
  Collector UDP Port ........ 6343            [6343]
  Tx Max Datagram Size ...... 1400            [1400]

sFlow Agent Status:
  Polling/sampling/Tx ....... Inactive because:
                                - Agent Addr is not set
                                - Collector Addr is 0.0.0.0
                                - Polling & sampling disabled on all ports

/* Agent IP MUST be the IP address of the management port of this switch */
awplus (config)# sflow agent ip 192.0.2.23

/* Default sFlow UDP collector port is 6343 */
awplus (config)# sflow collector ip 192.0.2.25 port 6343
awplus (config)# interface port1.0.1
awplus (config-if)# sflow polling-interval 120
awplus (config-if)# sflow sampling-rate 512

awplus# show running-config sflow
!
sflow agent ip 192.0.2.23
sflow collector ip 192.0.2.25
sflow enable
!
interface port1.0.1
 sflow polling-interval 120
 sflow sampling-rate 512
!
awplus#
```

Faucet

Edit the faucet configuration file (/etc/faucet/faucet.yaml) to add the datapath of the switch you wish to be managed by faucet. This yaml file also contains the interfaces that need to be seen by Faucet as openflow ports. The device type (hardware) should be set to `Allied-Telesis` in the configuration file.

```
:caption: /etc/faucet/faucet.yaml
:name: allied-telesis/faucet.yaml

      dps:
          allied-telesis:
```

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```
            dp_id: 0x0000eccd6d123456
            hardware: "Allied-Telesis"
            interfaces:
                1:
                    native_vlan: 100
                    name: "port1.0.1"
                2:
                    tagged_vlans: [2001,2002,2003]
                    name: "port1.0.2"
                    description: "windscale"
```

References

- Allied Telesis x930
- OpenFlow Configuration Guide
- Chapter 61 (SNMP)
- SNMP Feature Guide

1.7.2 Faucet on HPE-Aruba Switches

Introduction

All the Aruba's v3 generation of wired switches support the FAUCET pipeline. These switches include:

- 5400R
- 3810
- 2930F

The FAUCET pipeline is only supported from `16.03` release of the firmware onwards. HPE Aruba recommends use of the latest available firmware, which can be downloaded from HPE Support.

For any queries, please post your question on HPE's SDN forum.

Caveats

- IPv6 management of the switch, together OpenFlow is not supported.
- The `OFPAT_DEC_NW_TTL` action is not supported (when FAUCET is configured as a router, IP TTL will not be decremented).

Setup

In all configuration examples following, substitute 10.0.0.1 for your controller IP address, and 10.0.0.2 for your switch IP address, as appropriate. VLAN 2048 is used for the control plane - you can substitute this for another VID. In any case, the control plane VLAN VID you reserve cannot be used in FAUCET's configuration file (ie. it cannot be controlled by OpenFlow).

Switch

Chassis configuration (5400R only)

Skip this step if you have a fixed configuration system (2930 or 3810).

On a chassis system with insertable cards, new cards are configured to work in a backwards-compatible way (with reduced functionality) unless older cards are disabled in the chassis. To disable older (V2) cards and enable all functionality necessary to operate FAUCET, put the chassis into a mode where only V3 cards are allowed.

```
// Disable backwards compatibility, enable full Openflow flexibility
switch (config)# no allow-v2-modules
```

VLAN/port configuration

Aruba switches require the reservation of each VLAN VID you wish to use in FAUCET, on the switch. Some Aruba switches will allow you to reserve a large range of VIDs at once. If your switch has limited resources, then reserve just the VIDs you need.

The reservation of a VID is accomplished by defining a tagged VLAN. Note even you are using that VLAN VID untagged on a port in FAUCET, it must be reserved as tagged on the switch

- *Using OOBM control-plane (3810, 5400R)*

```
// Increase the maximum number of allowed VLANs on the box and save the configuration.
// If the switch cannot reserve the full range, reserve only the maximum you need.
switch (config)# max-vlans 4094
switch (config)# write mem

// Reboot the box for the new max-vlan configuration to take affect.
switch (config)# boot system

// Configure the control-plane IP address
switch (config)# oobm ip address 10.0.0.2/24

// Create maximum number of VLANs and tag every dataplane port available to each vlan.
↪ Takes up to 30 minutes.
// If the switch cannot reserve the full range, reserve only the VLANs needed␣
↪individually.
switch (config)# vlan 2-4094 tagged all
```

- *Using VLAN control-plane (2930)*

```
// Increase the maximum number of allowed VLANs on the box and save the configuration.
// If the switch cannot reserve the full range, reserve only the maximum you need.
switch (config)# max-vlans 2048
switch (config)# write mem

// Reboot the box for the new max-vlan configuration to take affect.
switch (config)# boot system

// Create a control-plane vlan and add a single control-plane port (port 48)
switch (config)# vlan 2048 untagged 48
switch (config)# vlan 2048 ip address 10.0.0.2/24

// Create maximum number of VLANs and tag every dataplane port available to each vlan,
// except for the control-plane vlan (above). Note that the command below assumes it
// is run on a 52-port switch, with port 48 as the control-plane. Takes up to 20␣
↪minutes.
```

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```
// If the switch cannot reserve the full range, reserve only the VLANs needed␣
↪individually.
switch (config)# vlan 2-2047 tagged 1-47,49-52
```

OpenFlow configuration

Aruba switches reference a controller by ID, so first configure the controllers which will be used. The controller-interface matches the control-plane configuration above.

- *Using OOBM control-plane (3810, 5400R)*

```
// Enter OpenFlow context
switch (config)# openflow

// Configure an OpenFlow controller connection for FAUCET over tcp-port 6653
switch(openflow)# controller-id 1 ip 10.0.0.1 port 6653 controller-interface oobm

// Configure an OpenFlow controller connection for Gauge over tcp-port 6654
switch(openflow)# controller-id 2 ip 10.0.0.1 port 6654 controller-interface oobm
```

- *Using VLAN control-plane (2930)*

```
// Enter OpenFlow context
switch (config)# openflow

// Configure an OpenFlow controller connection for FAUCET over tcp-port 6653
switch(openflow)# controller-id 1 ip 10.0.0.1 port 6653 controller-interface vlan 2048

// Configure an OpenFlow controller connection for Gauge over tcp-port 6654
switch(openflow)# controller-id 2 ip 10.0.0.1 port 6654 controller-interface vlan 2048
```

```
// Enter the OpenFlow instance context
switch(openflow)# instance aggregate

// Associate the controllers to the instance
switch(of-inst-aggregate)# controller-id 1
switch(of-inst-aggregate)# controller-id 2

// Associate the controllers in secure mode to the instance
switch(of-inst-aggregate)# controller-id 1 secure
switch(of-inst-aggregate)# controller-id 2 secure

// Configure the OpenFlow version to be 1.3
switch(of-inst-aggregate)# version 1.3 only

// Configure the pipeline model type of the instance. It is a must to set it to␣
↪custom.
switch(of-inst-aggregate)# pipeline-model custom

// Configure the payload in the packet-ins message to be sent in its original form.
switch(of-inst-aggregate)# packet-in vlan-tagging input-form

// Ensure the switch re-attempts an OpenFlow connection at least once
// every 10 seconds when connection is dropped/inactive.
switch(of-inst-aggregate)# max-backoff-interval 10

// Allow OpenFlow to override some protocols which are otherwise excluded from␣
↪OpenFlow processing in switch CPU.
```

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```
switch(of-inst-aggregate)# override-protocol all
WARNING: Overriding the protocol can also potentially lead to control packets
         of the protocol to bypass any of the security policies like ACL(s).
Continue (y/n)? y

// Enable the instance
switch(of-inst-aggregate)# enable
switch(of-inst-aggregate)# exit

// Enable OpenFlow globally
switch(openflow)# enable
switch(openflow)# exit

// To save the Configuration
switch# save
switch# write mem

// Show running Configuration
switch# show running-config

// Check the OpenFlow instance configuration (includes Datapath ID associated)
switch# show openflow instance aggregate
...

// Easier way to get the Datapath ID associated with the OpenFlow instance
switch# show openflow instance aggregate | include Datapath ID
               Datapath ID                  : 00013863bbc41800
```

At this point, OpenFlow is enabled and running on the switch. If the FAUCET controller is running and has connected to the switch successfully, you should see the FAUCET pipeline programmed on the switch.

NOTE: following is an example only, and may look different depending on FAUCET version and which FAUCET features have been enabled.

```
switch# show openflow instance aggregate flow-table

 OpenFlow Instance Flow Table Information

 Table                        Flow     Miss
 ID    Table Name             Count    Count          Goto Table
 ----- ---------------------- -------- -------------- -------------
 0     Port ACL               5        0              1, 2, 3, 4...
 1     VLAN                   10       0              2, 3, 4, 5...
 2     VLAN ACL               1        0              3, 4, 5, 6...
 3     Ethernet Source        2        0              4, 5, 6, 7, 8
 4     IPv4 FIB               1        0              5, 6, 7, 8
 5     IPv6 FIB               1        0              6, 7, 8
 6     VIP                    1        0              7, 8
 7     Ethernet Destination   2        0              8
 8     Flood                  21       0              *


 Table
 ID    Table Name             Available Free Flow Count
 ----- ---------------------- ------------------------------
 0     Port ACL               Ports 1-52          : 46
 1     VLAN                   Ports 1-52          : 91
```

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```
 2     VLAN ACL              Ports 1-52          : 50
 3     Ethernet Source       Ports 1-52          : 99
 4     IPv4 FIB              Ports 1-52          : 100
 5     IPv6 FIB              Ports 1-52          : 100
 6     VIP                   Ports 1-52          : 20
 7     Ethernet Destination  Ports 1-52          : 99
 8     Flood                 Ports 1-52          : 280

 * Denotes that the pipeline could end here.

switch# show openflow instance aggregate
                Configured OF Version         : 1.3 only
                Negotiated OF Version         : 1.3
                Instance Name                 : aggregate
                Data-path Description         : aggregate
                Administrator Status          : Enabled
                Member List                   : VLAN 1, 2, 3, 4, 5, 6, 7, 8, 9, 10,␣
↪11, 12,
                .............
                ...............

                Controller Id Connection Status Connection State Secure Role
                ------------- ----------------- ---------------- ------ ------
                1             Connected         Active           Yes    Equal
                2             Connected         Active           Yes    Equal

// To just get openflow controllers
switch (openflow)# show openflow controllers

                Controller Information

                Controller Id IP Address        Hostname          Port   Interface
                ------------- ----------------- ----------------- ------ -------------
↪-
                1             0.0.0.0           controller-1.t... 6653   VLAN 2048
                2             0.0.0.0           controller-1.t... 6654   VLAN 2048


// Copy Running Config to a TFTP Server
// (first enable TFTP client)
switch (config)# tftp client
```

Faucet

On the FAUCET configuration file (`/etc/faucet/faucet.yaml`), add the datapath of the switch you wish to be managed by FAUCET. The device type (hardware) MUST be set to `Aruba` in the configuration file.

Listing 47: /etc/faucet/faucet.yaml

```
    dps:
        aruba-3810:
            dp_id: <DP ID from *show openflow instance aggregate | include Datapath␣
↪ID*>
            hardware: "Aruba"
            interfaces:
```

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```
                1:
                    native_vlan: 100
                2:
                    native_vlan: 100
```

Debug

If you encounter a failure or unexpected behavior, it may help to enable debug output on Aruba switches. Debug output displays information about what OpenFlow is doing on the switch at message-level granularity.

```
switch# debug openflow
switch# debug destination session
switch# show debug

 Debug Logging

  Source IP Selection: Outgoing Interface
  Origin identifier: Outgoing Interface IP
  Destination:
   Session

  Enabled debug types:
   openflow
   openflow packets
   openflow events
   openflow errors
   openflow packets tx
   openflow packets rx
   openflow packets tx pkt_in
   openflow packets rx pkt_out
   openflow packets rx flow_mod
```

PKI setup on switch (OPTIONAL)

Only complete this section if you wish to secure the OpenFlow connection between switch and FAUCET with certificates.

Note: The root certificate container supports only one root certificate not a chain. So, install the one that the CSR (Certificate Signing Request) is signed with.

```
// Configure DNS.  Here DNS is set to a local LAN DNS server
switch (config)# ip dns server-address priority 1 10.0.0.1

switch# show crypto pki application

        Certificate Extension Validation :

        Application      SAN/CN
        ---------------- ------------
        openflow         Disabled
        syslog           Disabled
```

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```
// Here, we create CA profile
switch (config)# crypto pki ta-profile EXAMPLE_CA

// Copy the root certificate for the EXAMPLE_CA from a tftp server
switch#  copy tftp ta-certificate EXAMPLE_CA 10.0.0.1 myswitch.cert.pem

switch# show crypto pki ta-profile EXAMPLE_CA
        Profile Name    Profile Status                  CRL Configured  OCSP Configured
        --------------- ------------------------------ --------------- ---------------
        EXAMPLE_CA 1 certificate installed         No              No

        Trust Anchor:
        Version: 3 (0x2)
        Serial Number: 4096 (0x1000)
        Signature Algorithm: sha256withRSAEncryption
        ...
        ......

        // Now we are ready to create a CSR so that a switch identity certificate␣
↪that is accepted by the controller can be set up.

switch (config)# crypto pki identity-profile hpe_sf_switch1 subject common-name␣
↪myswitch org MyOrgName org-unit MyOrgUnit locality MyCity state CA country US

switch (config)# show crypto pki identity-profile
        Switch Identity:
          ID Profile Name    : hpe_sf_switch1
          Common Name (CN) : myswitch
        Org Unit (OU)     : MyOrgUnit
        Org Name (O)      : MyOrgName
        Locality (L)      : MyCity
        State (ST)        : CA
        Country (C)       : US

// Generate CSR
switch (config)# crypto pki create-csr certificate-name hpeswt_switch1_crt ta-profile␣
↪EXAMPLE_CA usage openflow

// Copy the printed CSR request and send it to "EXAMPLE_CA"

switch (config)# show crypto pki local-certificate summary
        Name                Usage         Expiration     Parent / Profile
        ------------------- ------------- -------------- --------------------
        hpeswt_switch1_crt   Openflow      CSR            EXAMPLE_CA

// Once the signed certificate is received, copy the same to switch.
switch (config)# copy tftp local-certificate 10.0.0.1  myswitch.cert.pem
        000M Transfer is successful

switch (config)# show crypto pki local-certificate summary
        Name                Usage         Expiration     Parent / Profile
        ------------------- ------------- -------------- --------------------
        hpeswt_switch1_crt   Openflow      2019/01/02     EXAMPLE_CA
```

References

- Aruba OpenFlow Administrator Guide (16.03)
- Aruba OS version as of Dec 2017 is 16.05
- Aruba Switches
- FAUCET
- Model 2390F Product Site
- 2930F top level documentation
- Password settings
- PKI Setup

1.7.3 Faucet on Lagopus

Introduction

Lagopus is a software OpenFlow 1.3 switch, that also supports DPDK.

FAUCET is supported as of Lagopus 0.2.11 (https://github.com/lagopus/lagopus/issues/107).

Setup

Lagopus install on a supported Linux distribution

Install Lagopus according to the quickstart guide. You don't need to install Ryu since we will be using FAUCET and FAUCET's installation takes care of that dependency.

These instructions are for Ubuntu 16.0.4 (without DPDK). In theory any distribution, with or without DPDK, that Lagopus supports will work with FAUCET.

Create lagopus.dsl configuration file

In this example, Lagopus is controlling two ports, enp1s0f0 and enp1s0f1, which will be known as OpenFlow ports 1 and 2 on DPID 0x1. FAUCET and Lagopus are running on the same host (though of course, they don't need to be).

Listing 48: /usr/local/etc/lagopus/lagopus.dsl

```
channel channel01 create -dst-addr 127.0.0.1 -protocol tcp

controller controller01 create -channel channel01 -role equal -connection-type main

interface interface01 create -type ethernet-rawsock -device enp1s0f0

interface interface02 create -type ethernet-rawsock -device enp1s0f1

port port01 create -interface interface01

port port02 create -interface interface02
```

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```
  bridge bridge01 create -controller controller01 -port port01 1 -port port02 2 -dpid␣
↪0x1
  bridge bridge01 enable
```

Create faucet.yaml

Listing 49: /etc/faucet/faucet.yaml

```
  vlans:
      100:
          name: "test"
  dps:
      lagopus-1:
          dp_id: 0x1
          hardware: "Lagopus"
          interfaces:
              1:
                  native_vlan: 100
              2:
                  native_vlan: 100
```

Start Lagopus

Start in debug mode, in a dedicated terminal.

```
lagopus -d
```

Run FAUCET

```
faucet --verbose --ryu-ofp-listen-host=127.0.0.1
```

Test connectivity

Host(s) on enp1s0f0 and enp1s0f1 in the same IP subnet, should now be able to communicate, and FAUCET's log file should indicate learning is occurring:

Listing 50: /var/log/faucet/faucet.log

```
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Configuring DP
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Delete VLAN vid:100 ports:1,2
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) VLANs changed/added: [100]
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Configuring VLAN vid:100 ports:1,
↪2
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Configuring VLAN vid:100 ports:1,
↪2
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Port 1 added
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Sending config for port 1
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Port 2 added
```

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```
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Sending config for port 2
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Packet_in src:00:16:41:6d:87:28␣
↪in_port:1 vid:100
  May 11 13:04:57 faucet.valve INFO     learned 1 hosts on vlan 100
  May 11 13:04:57 faucet.valve INFO     DPID 1 (0x1) Packet_in src:00:16:41:32:87:e0␣
↪in_port:2 vid:100
  May 11 13:04:57 faucet.valve INFO     learned 2 hosts on vlan 100
```

1.7.4 Faucet on ZodiacFX

Introduction

ZodiacFX is a small 4 port multi table OF1.3 switch from Northbound Networks.

Caveats

- ZodiacFX allows only one controller (so you cannot run Gauge).
- The default OF port is 6633; it is recommended to use 6653.
- It is recommended to enable ether type filtering to minimize corrupt packets.

Applying recommended config

You can use the following expect script to program the recommended configuration:

Listing 51: conf-zodiac.sh

```
#!/usr/bin/expect

##
## configure ZodiacFX with recommended settings.
##

# Serial port assigned to ZodiacFX
set port /dev/ttyACM0

# ZodiacFX network settings
set configip "10.0.1.99"
set configmask "255.255.255.0"
set configgateway "10.0.1.1"

# OpenFlow controller network settings
set configofcontroller "10.0.1.8"
set configofport 6653

set timeout 5
set prompt {Zodiac_FX\#}
set configprompt {Zodiac_FX\(config\)\#}
set spawned [spawn -open [open $port w+]]

send_user "get initial prompt\n"
send "\r"
```

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```
send "\r"
expect -re $prompt
send_user "found initial prompt\n"
send "config\r"
expect -re $configprompt
send_user "setting ethertype-filter\n"
send "set ethertype-filter enable\r"
expect -re $configprompt
send_user "setting IP address\n"
send "set ip-address $configip\r"
expect -re $configprompt
send "set netmask $configmask\r"
expect -re $configprompt
send "set gateway $configgateway\r"
expect -re $configprompt
send_user "setting OF controller\n"
send "set of-controller $configofcontroller\r"
expect -re $configprompt
send "set of-port $configofport\r"
expect -re $configprompt
send_user "save configuration\n"
send "show config\r"
expect -re $configprompt
send "save\r"
expect -re $configprompt
send "exit\r"
expect -re $prompt
send "restart\r"
expect -re "Restarting"
```

Example of running the script:

```
$ sudo ./conf-zodiac.sh
spawn [open ...]
get initial prompt


 ______                ___                  ________  __
/__  /  _____  _____/ (_)___ _______    / ____/ |/ /
  / /  / __ \/ __  / / __ `/ ___/  / /_   |   /
 / /__/ /_/ / /_/ / / /_/ / /__   / __/  /   |
/____/\____/\__,_/_/\__,_/\___/  /_/    /_/|_|
                by Northbound Networks


Type 'help' for a list of available commands

Zodiac_FX#
Zodiac_FX# found initial prompt
config
Zodiac_FX(config)# setting ethertype-filter
set ethertype-filter enable
EtherType Filtering Enabled
Zodiac_FX(config)# setting of-portset of-port 6653
OpenFlow Port set to 6653
Zodiac_FX(config)# save
Writing Configuration to EEPROM (197 bytes)
Zodiac_FX(config)# exit
```

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```
Zodiac_FX# restart
Restarting the Zodiac FX, please reopen your terminal application.
```

1.7.5 Faucet on ZodiacGX

Introduction

ZodiacGX is a small 5 port multi table OF1.3 switch from Northbound Networks. Please see the documentation for configuring OpenFlow on the switch, and use ZodiacGX as the FAUCET hardware type.

Caveats

- The default OF port is 6633; it is recommended to use 6653.
- Minium firmware required is v1.01

1.7.6 Faucet on NoviFlow

Introduction

NoviFlow provide a range of switches known to work with FAUCET.

These instructions have been tested on NS1248, NS1132, NS2116, NS2128, NS2122, NS2150, NS21100 switches, using NoviWare versions starting from NW400.5.4, running with FAUCET v1.8.14.

Compared to older versions of NoviWare and Faucet, where manual pipeline configuration was required, it is possible to use the `GenericTFM` Hardware type to make Faucet automatically program the tables based on the needs of its current configuration.

Setup

Configure the CPN on the switch

The only configuration required in the switch is the definition of the IP and ports on which the Faucet controller must be reached. Optionally it is also possible to change the switch DPID. In this example, the server running FAUCET is 10.0.1.8; configuration for CPN interfaces is not shown.

```
set config controller controllergroup faucet controllerid 1 priority 1 ipaddr 10.0.1.
↪8 port 6653 security none
set config controller controllergroup gauge controllerid 1 priority 1 ipaddr 10.0.1.8␣
↪port 6654 security none
set config switch dpid 0x1
```

Create faucet.yaml

In order to exploit the automatic pipeline configuration, the hardware specified in `faucet.yaml` must be `GenericTFM`

```
vlans:
    100:
        name: "test"
dps:
    noviflow-1:
        dp_id: 0x1
        hardware: "GenericTFM"
        interfaces:
            1:
                native_vlan: 100
            2:
                native_vlan: 100
        etc...
```

Run FAUCET

```
faucet --verbose
```

Using Older Faucet and NoviWare versions

Before the introduction of GenericTFM, Faucet used a static pipeline which needed to be configured in the switch before connecting to the controller. The following match configuration is known to pass the unit tests using NW400.4.3 with FAUCET 1.6.18, but take care to adjust ACL tables matches based on the type of ACL rules defined in the configuration file. Different FAUCET releases may also use different match fields in the other tables.

```
set config pipeline tablesizes 1524 1024 1024 5000 3000 1024 1024 5000 1024␣
↪tablewidths 80 40 40 40 40 40 40 40 40
set config table tableid 0 matchfields 0 3 4 5 6 10 11 12 13 14 23 29 31
set config table tableid 1 matchfields 0 3 4 5 6
set config table tableid 2 matchfields 0 5 6 10 11 12 14
set config table tableid 3 matchfields 0 3 4 5 6 10
set config table tableid 4 matchfields 5 6 12
set config table tableid 5 matchfields 5 6 27
set config table tableid 6 matchfields 3 5 10 23 29
set config table tableid 7 matchfields 3 6
set config table tableid 8 matchfields 0 3 6
```

Note that this table configuration will allow most of the automated test cases to pass, except FaucetIPv6TupleTest (which requires IPv6 Src and Dst matching in the ACL table). In order to run this test, table 0 must be configured as follows:

```
set config table tableid 0 matchfields 0 5 6 10 26 27 13 14
```

1.7.7 Faucet on Cisco Switches

Introduction

Cisco supports Openflow with faucet pipeline on the Catalyst 9000 Series switches.

Cisco IOS XE first introduced faucet support in version 16.9.1, however since faucet support is being continually improved on Cisco platforms we recommend running the latest stable release. Currently we would recommend running 16.12.1c or later.

For official Cisco documentation on OpenFlow and faucet support see the following configuration guide:

- Programmability Configuration Guide, Cisco IOS XE Gibraltar 16.12.x

Setup

Boot up in Openflow Mode

The Catalyst 9K will be in traditional switching mode by default. The below command will enable Openflow mode on the switch.

```
Switch-C9300#
Switch-C9300#configure terminal
Switch-C9300(config)#boot mode ?
openflow  openflow forwarding mode

Switch-C9300(config)#boot mode openflow
Changes to the boot mode preferences have been stored,
but it cannot take effect until the next reload.
Use "show boot mode" to check the boot mode currently
active.
Switch-C9300(config)#end

Switch-C9300#show boot mode
System initialized in normal switching mode
System configured to boot in openflow forwarding mode

Reload required to boot switch in configured boot mode.

Switch-C9300#reload
```

Configure Openflow

** Configure the Management interface communicate with controller. **

```
Switch-C9300#
Switch-C9300#configure terminal
Switch-C9300(config)#interface GigabitEthernet0/0
Switch-C9300(config-if)#vrf forwarding Mgmt-vrf
Switch-C9300(config-if)#ip address 192.168.0.41 255.255.255.0
Switch-C9300(config-if)#negotiation auto
Switch-C9300(config-if)#end
Switch-C9300#
```

** Configure the Openflow feature and controller connectivity. **

```
Switch-C9300#
Switch-C9300#configure terminal
Switch-C9300(config)#feature openflow
Switch-C9300(config)#openflow
Switch-C9300(config-openflow)#switch 1 pipeline 1
Switch-C9300(config-openflow-switch)#controller ipv4 192.168.0.91 port 6653 vrf Mgmt-
↪vrf security none
Switch-C9300(config-openflow-switch)#controller ipv4 192.168.0.91 port 6654 vrf Mgmt-
↪vrf security none
```

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```
Switch-C9300(config-openflow-switch)#datapath-id 0xABCDEF1234
Switch-C9300(config-openflow-switch)#end
Switch-C9300#
```

** Disable DTP/keepalive on OpenFlow ports which may interfere with FAUCET. **

The following example will disable DTP and keepalives for TenGigabitEthernet1/0/1-24; adjust the range as necessary.

```
Switch-C9300(config)#interface range TenGigabitEthernet1/0/1-24
Switch-C9300(config-if-range)#switchport mode trunk
Switch-C9300(config-if-range)#switchport nonegotiate
Switch-C9300(config-if-range)#spanning-tree bpdufilter enable
Switch-C9300(config-if-range)#no keepalive
Switch-C9300(config-if-range)#exit
```

Faucet

On the FAUCET configuration file (`/etc/faucet/faucet.yaml`), add the datapath of the switch you wish to be managed by FAUCET. The device type (hardware) should be set to `CiscoC9K` in the configuration file.

```
:caption: /etc/faucet/faucet.yaml
:name: cisco/faucet.yaml

      dps:
          Cisco-C9K:
              dp_id: 0xABCDEF1234
              hardware: "CiscoC9K"
              interfaces:
                  1:
                      native_vlan: 100
                      name: "port1"
                  2:
                      native_vlan: 100
                      name: "port2"
```

Troubleshooting

Command to check overall openflow configuration

```
Switch-C9300#
Switch-C9300#show openflow switch 1
Logical Switch Context
  Id: 1
  Switch type: Forwarding
  Pipeline id: 1
  Data plane: secure
  Table-Miss default: drop
  Configured protocol version: Negotiate
  Config state: no-shutdown
  Working state: enabled
  Rate limit (packet per second): 0
  Burst limit: 0
```

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```
  Max backoff (sec): 8
  Probe interval (sec): 5
  TLS local trustpoint name: not configured
  TLS remote trustpoint name: not configured
  Logging flow changes: Disabled
  Stats collect interval (sec): 5
  Stats collect Max flows: 9216
  Stats collect period (sec):  1
  Minimum flow idle timeout (sec):  10
  OFA Description:
         Manufacturer: Cisco Systems, Inc.
         Hardware: C9300-48P
         Software: Cisco IOS Software [Fuji], Catalyst L3 Switch Software (CAT9K_
↪IOSXE), Version 16.8.1GO3, RELEASE SOFTWARE (fc1)| openvswitch 2.1
         Serial Num: FCW2145L0FP
         DP Description: Faucet-C9300:sw1
  OF Features:
         DPID: 0x000000ABCDEF1234
         Number of tables: 9
         Number of buffers: 256
         Capabilities: FLOW_STATS TABLE_STATS PORT_STATS
  Controllers:
         192.168.0.91:6653, Protocol: TCP, VRF: Mgmt-vrf
         192.168.0.91:6654, Protocol: TCP, VRF: Mgmt-vrf
  Interfaces:
         GigabitEthernet1/0/1
         GigabitEthernet1/0/2
         ....
```

Command to check the openflow flows installed

```
Switch-C9300#
Switch-C9300#show openflow switch 1 flow list
    Logical Switch Id: 1
    Total flows: 9

    Flow: 1 Match: any Actions: drop, Priority: 0, Table: 0, Cookie: 0x0, Duration:␣
↪33812.029s, Packets: 46853, Bytes: 3636857
    ...
```

Command to check the state of the port status

```
Switch-C9300#
Switch-C9300#show openflow switch 1 ports
    Logical Switch Id: 1
    Port    Interface Name   Config-State     Link-State  Features
       1           Gi1/0/1        PORT_UP        LINK_UP  1GB-HD
       2           Gi1/0/2        PORT_UP      LINK_DOWN  1GB-HD
       3           Gi1/0/3        PORT_UP      LINK_DOWN  1GB-HD
       4           Gi1/0/4        PORT_UP      LINK_DOWN  1GB-HD
```

Command to check the status of the controller

```
Switch-C9300#
Switch-C9300#show openflow switch 1 controller
Logical Switch Id: 1
Total Controllers: 2
```

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```
  Controller: 1
    192.168.0.91:6653
    Protocol: tcp
    VRF: Mgmt-vrf
    Connected: Yes
    Role: Equal
    Negotiated Protocol Version: OpenFlow 1.3
    Last Alive Ping: 2018-10-03 18:43:07 NZST
    state: ACTIVE
    sec_since_connect: 13150

  Controller: 2
    192.16.0.91:6654
    Protocol: tcp
    VRF: Mgmt-vrf
    Connected: Yes
    Role: Equal
    Negotiated Protocol Version: OpenFlow 1.3
    Last Alive Ping: 2018-10-03 18:43:07 NZST
    state: ACTIVE
    sec_since_connect: 12960
```

Command to check controller statistics

```
Switch-C9300#
Switch-C9300#show openflow switch 1 controller stats
Logical Switch Id: 1
Total Controllers: 2

  Controller: 1
    address                          :  tcp:192.168.0.91:6653%Mgmt-vrf
    connection attempts              :  165
    successful connection attempts   :  61
    flow adds                        :  1286700
    flow mods                        :  645
    flow deletes                     :  909564
    flow removals                    :  0
    flow errors                      :  45499
    flow unencodable errors          :  0
    total errors                     :  45499
    echo requests                    :  rx: 842945, tx:205
    echo reply                       :  rx: 140, tx:842945
    flow stats                       :  rx: 0, tx:0
    barrier                          :  rx: 8324752, tx:8324737
    packet-in/packet-out             :  rx: 29931732, tx:8772758

  Controller: 2
    address                          :  tcp:192.168.0.91:6654%Mgmt-vrf
    connection attempts              :  11004
    successful connection attempts   :  3668
    flow adds                        :  0
    flow mods                        :  0
    flow deletes                     :  0
    flow removals                    :  0
    flow errors                      :  0
    flow unencodable errors          :  0
```

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```
    total errors                    :  0
    echo requests                   :  rx: 946257, tx:1420
    echo reply                      :  rx: 1420, tx:946257
    flow stats                      :  rx: 47330, tx:57870
    barrier                         :  rx: 0, tx:0
    packet-in/packet-out            :  rx: 377, tx:0
```

References

- Catalyst 9K at-a-glance
- Catalyst 9400 SUP1
- Catalyst 9400 Linecard

1.7.8 Faucet on OVS with DPDK

Introduction

Open vSwitch is a software OpenFlow switch, that supports DPDK. It is also the reference switching platform for FAUCET.

Setup

Install OVS on a supported Linux distribution

Install OVS and DPDK per the official OVS instructions, including enabling DPDK at compile time and in OVS's initial configuration.

These instructions are known to work for Ubuntu 16.0.4, with OVS 2.7.0 and DPDK 16.11.1, kernel 4.4.0-77. In theory later versions of these components should work without changes. A multiport NIC was used, based on the Intel 82580 chipset.

Bind NIC ports to DPDK

Note: If you have a multiport NIC, you must bind all the ports on the NIC to DPDK, even if you do not use them all.

From the DPDK source directory, determine the relationship between the interfaces you want to use with DPDK and their PCI IDs:

```
export DPDK_DIR=`pwd`
$DPDK_DIR/tools/dpdk-devbind.py --status
```

In this example, we want to use enp1s0f0 and enp1s0f1.

```
$ ./tools/dpdk-devbind.py --status

Network devices using DPDK-compatible driver
============================================
```

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```
<none>

Network devices using kernel driver
===================================
0000:01:00.0 '82580 Gigabit Network Connection' if=enp1s0f0 drv=igb unused=
0000:01:00.1 '82580 Gigabit Network Connection' if=enp1s0f1 drv=igb unused=
0000:01:00.2 '82580 Gigabit Network Connection' if=enp1s0f2 drv=igb unused=
0000:01:00.3 '82580 Gigabit Network Connection' if=enp1s0f3 drv=igb unused=
```

Still from the DPDK source directory:

```
export DPDK_DIR=`pwd`
modprobe vfio-pci
chmod a+x /dev/vfio
chmod 0666 /dev/vfio/*
$DPDK_DIR/tools/dpdk-devbind.py --bind=vfio-pci 0000:01:00.0 0000:01:00.1 0000:01:00.
↪2 0000:01:00.3
$DPDK_DIR/tools/dpdk-devbind.py --status
```

Confirm OVS has been configured to use DPDK

```
$ sudo /usr/local/share/openvswitch/scripts/ovs-ctl stop
* Exiting ovs-vswitchd (20510)
* Exiting ovsdb-server (20496)
$ sudo /usr/local/share/openvswitch/scripts/ovs-ctl start
* Starting ovsdb-server
* system ID not configured, please use --system-id
* Configuring Open vSwitch system IDs
EAL: Detected 4 lcore(s)
EAL: Probing VFIO support...
EAL: VFIO support initialized
EAL: PCI device 0000:01:00.0 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
EAL:   using IOMMU type 1 (Type 1)
EAL: PCI device 0000:01:00.1 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
EAL: PCI device 0000:01:00.2 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
EAL: PCI device 0000:01:00.3 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
EAL: PCI device 0000:02:00.0 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
EAL: PCI device 0000:02:00.1 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
EAL: PCI device 0000:02:00.2 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
EAL: PCI device 0000:02:00.3 on NUMA socket -1
EAL:   probe driver: 8086:150e net_e1000_igb
Zone 0: name:<rte_eth_dev_data>, phys:0x7ffced40, len:0x30100, virt:0x7f843ffced40,␣
↪socket_id:0, flags:0
* Starting ovs-vswitchd
* Enabling remote OVSDB managers
```

Configure an OVS bridge with the DPDK ports

```
ovs-vsctl add-br br0 -- set bridge br0 datapath_type=netdev protocols=OpenFlow13
ovs-vsctl add-port br0 dpdk0 -- set interface enp1s0f0 type=dpdk options:dpdk-
↪devargs=0000:01:00.0
ovs-vsctl add-port br0 dpdk1 -- set interface enp1s0f1 type=dpdk options:dpdk-
↪devargs=0000:01:00.1
ovs-vsctl set-fail-mode br0 secure
ovs-vsctl set-controller br0 tcp:127.0.0.1:6653
ovs-ofctl show br0
ovs-vsctl get bridge br0 datapath_id
```

Create faucet.yaml

Note: Change dp_id, to the value reported above, prefaced with "0x".

Listing 52: /etc/faucet/faucet.yaml

```
vlans:
    100:
        name: "test"
dps:
    ovsdpdk-1:
        dp_id: 0x000090e2ba7e7564
        hardware: "Open vSwitch"
        interfaces:
            1:
                native_vlan: 100
            2:
                native_vlan: 100
```

Run FAUCET

```
faucet --verbose --ryu-ofp-listen-host=127.0.0.1
```

Test connectivity

Host(s) on enp1s0f0 and enp1s0f1 in the same IP subnet, should now be able to communicate, and FAUCET's log file should indicate learning is occurring:

Listing 53: /var/log/faucet/faucet.log

```
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564)␣
↪Configuring DP
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) Delete␣
↪VLAN vid:100 ports:1,2
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) VLANs␣
↪changed/added: [100]
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564)␣
↪Configuring VLAN vid:100 ports:1,2
```

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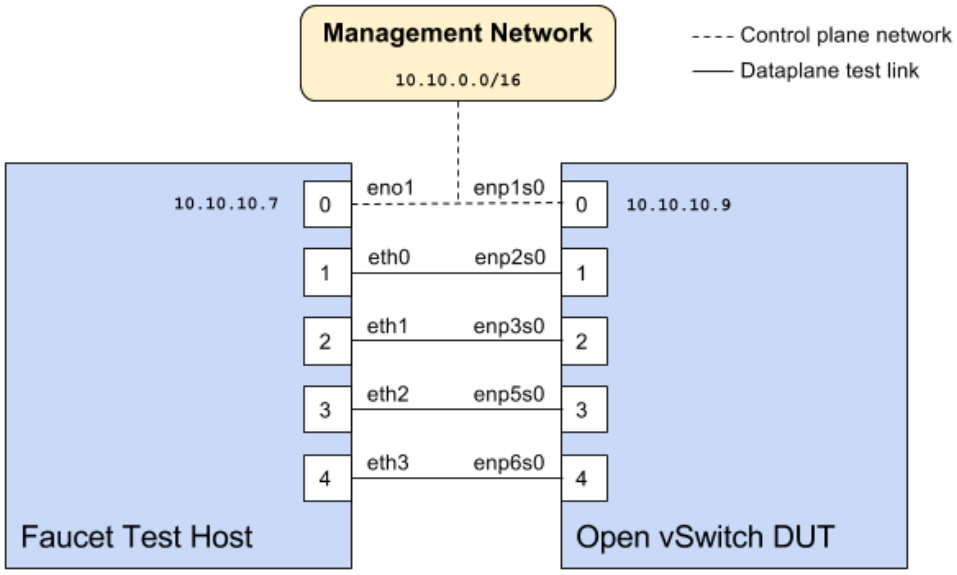
```
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564)␣
↪Configuring VLAN vid:100 ports:1,2
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) Port 1␣
↪added
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) Sending␣
↪config for port 1
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) Port 2␣
↪added
 May 11 14:53:32 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) Sending␣
↪config for port 2
 May 11 14:53:33 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) Packet_
↪in src:00:16:41:6d:87:28 in_port:1 vid:100
 May 11 14:53:33 faucet.valve INFO     learned 1 hosts on vlan 100
 May 11 14:53:33 faucet.valve INFO     DPID 159303465858404 (0x90e2ba7e7564) Packet_
↪in src:00:16:41:32:87:e0 in_port:2 vid:100
 May 11 14:53:33 faucet.valve INFO     learned 2 hosts on vlan 100
```

1.7.9 Faucet Testing with OVS on Hardware

Setup



Faucet configuration file

Listing 54: /etc/faucet/hw_switch_config.yaml

```
# Faucet Configuration file: /etc/faucet/hw_switch_config.yaml
#
# If hw_switch value set to True, map a hardware OpenFlow switch to ports on this␣
↪machine.
# Otherwise, run tests against OVS locally.
```

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```
hw_switch: True
hardware: 'Open vSwitch'
dp_ports:
  1: eth0
  2: eth1
  3: eth2
  4: eth3

# Hardware switch's DPID
dpid: 0xacd28f18b
cpn_intf: eno1
of_port: 6636
gauge_of_port: 6637
```

Hardware

1. For Network Interface Cards (NICs), prefer Intel branded models.
2. I have also used Hi-Speed USB to dual Ethernet which works great

Software

1. Ubuntu 16.04 Xenial
2. Open vSwitch 2.7.2+

Commands

Commands to be executed on each side - **Faucet Test host** and **Open vSwitch**.

Commands on Faucet Test Host

Run these commands as root on the Ubuntu system (v16.04 used)

```
$ sudo mkdir -p /usr/local/src/
$ sudo mkdir -p /etc/faucet/
$ sudo cd /usr/local/src/
$ sudo git clone https://github.com/faucetsdn/faucet.git
$ cd faucet
$ sudo ip address show
  1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default␣
↪qlen 1000
  link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
  inet 127.0.0.1/8 scope host lo
  valid_lft forever preferred_lft forever
  inet6 ::1/128 scope host
  valid_lft forever preferred_lft forever
  2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default␣
↪qlen 1000
  link/ether b4:96:91:00:88:a4 brd ff:ff:ff:ff:ff:ff
  inet6 fe80::b696:91ff:fe00:88a4/64 scope link
  valid_lft forever preferred_lft forever
```

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```
  3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default␣
↪qlen 1000
  link/ether b4:96:91:00:88:a5 brd ff:ff:ff:ff:ff:ff
  inet6 fe80::b696:91ff:fe00:88a5/64 scope link
  valid_lft forever preferred_lft forever
  4: eth2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default␣
↪qlen 1000
  link/ether b4:96:91:00:88:a6 brd ff:ff:ff:ff:ff:ff
  inet6 fe80::b696:91ff:fe00:88a6/64 scope link
  valid_lft forever preferred_lft forever
  5: eth3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default␣
↪qlen 1000
  link/ether b4:96:91:00:88:a7 brd ff:ff:ff:ff:ff:ff
  inet6 fe80::b696:91ff:fe00:88a7/64 scope link
  valid_lft forever preferred_lft forever
  6: eno1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default␣
↪qlen 1000
  link/ether 00:1e:67:ff:f6:80 brd ff:ff:ff:ff:ff:ff
  inet 10.10.10.7/16 brd 10.20.255.255 scope global eno1
  valid_lft forever preferred_lft forever
  inet6 cafe:babe::21e:67ff:feff:f680/64 scope global mngtmpaddr dynamic
  valid_lft 86398sec preferred_lft 14398sec
  inet6 fe80::21e:67ff:feff:f680/64 scope link
  valid_lft forever preferred_lft forever
```

Tip: To locate the corresponding physical port, you can make the port LED blink with *Ethtool*.

Commands on Open vSwitch

Login as `root` on the Ubuntu system and install OpenvSwitch and start `openvswitch-switch` service

```
$ sudo apt-get install openvswitch-switch
$ sudo systemctl status openvswitch-switch.service
$ sudo ovs-vsctl add-br ovs-br0
$ sudo ovs-vsctl add-port ovs-br0 enp2s0 -- set Interface enp2s0  ofport_request=1
$ sudo ovs-vsctl add-port ovs-br0 enp3s0 -- set Interface enp3s0  ofport_request=2
$ sudo ovs-vsctl add-port ovs-br0 enp5s0 -- set Interface enp5s0  ofport_request=3
$ sudo ovs-vsctl add-port ovs-br0 enp6s0 -- set Interface enp6s0  ofport_request=4
$ sudo ovs-vsctl set-fail-mode ovs-br0 secure
$ sudo ovs-vsctl set bridge ovs-br0 protocols=OpenFlow13
$ sudo ovs-vsctl set-controller ovs-br0 tcp:10.10.10.7:6636 tcp:10.10.10.7:6637
$ sudo ovs-vsctl get bridge ovs-br0 datapath_id
$ sudo ovs-vsctl show
  308038ec-495d-412d-9b13-fe95bda4e176
      Bridge "ovs-br0"
          Controller "tcp:10.10.10.7:6636"
          Controller "tcp:10.10.10.7:6637"
          Port "enp3s0"
              Interface "enp3s0"
             Port "enp2s0"
              Interface "enp2s0"
           Port "enp6s0"
              Interface "enp6s0"
```

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```
          Port "ovs-br0"
              Interface "ovs-br0"
                  type: internal
          Port "enp5s0"
              Interface "enp5s0"
                  type: system
      ovs_version: "2.7.0"

$ sudo ovs-vsctl -- --columns=name,ofport list Interface
  name                : "ovs-br0"
  ofport              : 65534

  name                : "enp5s0"
  ofport              : 3

  name                : "enp2s0"
  ofport              : 1

  name                : "enp6s0"
  ofport              : 4

  name                : "enp3s0"
  ofport              : 2
```

Tip: To locate the corresponding physical port, you can make the port LED blink with *Ethtool*.

Check port speed information to make sure that they are at least 1Gbps

```
$ sudo ovs-ofctl -O OpenFlow13 dump-ports-desc ovs-br0
    OFPST_PORT_DESC reply (OF1.3) (xid=0x2):
     1(enp2s0): addr:00:0e:c4:ce:77:25
         config:     0
         state:      0
         current:    1GB-FD COPPER AUTO_NEG
         advertised: 10MB-HD 10MB-FD 100MB-HD 100MB-FD 1GB-FD COPPER AUTO_NEG AUTO_
↪PAUSE
         supported:  10MB-HD 10MB-FD 100MB-HD 100MB-FD 1GB-FD COPPER AUTO_NEG AUTO_
↪PAUSE
         speed: 1000 Mbps now, 1000 Mbps max
     2(enp3s0): addr:00:0e:c4:ce:77:26
         config:     0
         state:      0
         current:    1GB-FD COPPER AUTO_NEG
         advertised: 10MB-HD 10MB-FD 100MB-HD 100MB-FD 1GB-FD COPPER AUTO_NEG AUTO_
↪PAUSE
         supported:  10MB-HD 10MB-FD 100MB-HD 100MB-FD 1GB-FD COPPER AUTO_NEG AUTO_
↪PAUSE
         speed: 1000 Mbps now, 1000 Mbps max
     3(enp5s0): addr:00:0e:c4:ce:77:27
         config:     0
         state:      0
         current:    1GB-FD COPPER AUTO_NEG
         advertised: 10MB-HD 10MB-FD 100MB-HD 100MB-FD 1GB-FD COPPER AUTO_NEG AUTO_
↪PAUSE
         supported:  10MB-HD 10MB-FD 100MB-HD 100MB-FD 1GB-FD COPPER AUTO_NEG AUTO_
↪PAUSE
```

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```
        speed: 1000 Mbps now, 1000 Mbps max
    4(enp6s0): addr:00:0a:cd:28:f1:8b
        config:     0
        state:      0
        current:    1GB-FD COPPER AUTO_NEG
        advertised: 10MB-HD COPPER AUTO_NEG AUTO_PAUSE AUTO_PAUSE_ASYM
        supported:  10MB-HD 10MB-FD 100MB-HD 100MB-FD 1GB-HD 1GB-FD COPPER AUTO_NEG
        speed: 1000 Mbps now, 1000 Mbps max
    LOCAL(ovs-br0): addr:00:0a:cd:28:f1:8b
        config:     PORT_DOWN
        state:      LINK_DOWN
        speed: 0 Mbps now, 0 Mbps max
```

Running the tests

Edit the */etc/faucet/hw_switch_config.yaml* file as shown earlier in this document setting `hw_switch=False` initially for testing.

```
$ sudo cp /usr/local/src/faucet/hw_switch_config.yaml /etc/faucet/hw_switch_config.
↪yaml
$ sudo $EDITOR /etc/faucet/hw_switch_config.yaml
$ cd /usr/local/src/faucet/
```

Install docker by following the *Installing docker* section and then run the hardware based tests by following the *Running the tests* section.

Once the above minitest version is successful with `hw_switch=False`, then edit the */etc/faucet/hw_switch_config.yaml* file and set `hw_switch=True`.

Run tests again, verify they all pass.

Debugging

TCPDump

Many times, we want to know what is coming in on a port. To check on interface `enp2s0`, for example, use

```
$ sudo tcpdump -A -w enp2s0_all.pcap -i enp2s0
```

Or

```
$ sudo tcpdump -A -w enp2s0_all.pcap -i enp2s0 'dst host <controller-ip-address> and␣
↪port 6653'
```

To read the pcap file, use

```
$ sudo tcpdump -r enp2s0_all.pcap
```

More detailed examples are available @ https://www.wains.be/pub/networking/tcpdump_advanced_filters.txt

---

Note: On which machine should one run tcpdump?

Depends, if you want to examine the packet_ins tht are sent from switch to controller, run on the switch listening on the interface that is talking to the controller. If you are interested on what is coming in on a particular test port, then run it on the Test Host on that interface.

Ethtool

To locate a physical port say `enp2s0`, make the LED blink for 5 seconds:

```
$ sudo ethtool -p enp2s0 5
```

To figure out speed on the interface. Note that if Speed on the interface is at least not 1G, then tests may not run correctly.

```
$ sudo ethtool enp2s0
$ sudo ethtool enp2s0 | grep Speed
```

References

https://www.garron.me/en/linux/ubuntu-network-speed-duplex-lan.html

1.8 External Resources

1.8.1 Online Tutorials

- http://docs.openvswitch.org/en/latest/tutorials/faucet/
- http://costiser.ro/2017/03/07/sdn-lesson-2-introducing-faucet-as-an-openflow-controller/
- https://inside-openflow.com/openflow-tracks/faucet-controller-application-technical-track/
- https://blog.cyberreboot.org/building-a-software-defined-network-with-raspberry-pis-and-a-zodiac-fx-switch-97184032cdc1

1.8.2 Tutorial Videos

- https://www.youtube.com/watch?v=fuqzzjmcwlI

CHAPTER

TWO

DEVELOPER DOCUMENTATION

2.1 Developer Guide

This file contains an overview of architecture, coding design/practices, testing and style.

2.1.1 Before submitting a PR

- If you have general questions, feel free to reach out to the faucet-dev mailing list.
- If you are new to FAUCET, or are contemplating a major change, it's recommended to open a github issue with the proposed change. This will enable broad understanding of your work including being able to catch any potential snags very early (for example, adding new dependencies). Architectural and approach questions are best settled at this stage before any code is written.
- Please send relatively small, tightly scoped PRs (approx 200-300 LOC or less). This makes review and analysis easier and lowers risk, including risk of merge conflicts with other PRs. Larger changes must be refactored into incremental changes.
- You must add a test if FAUCET's functionality changes (ie. a new feature, or correcting a bug).
- All unit and integration tests must pass (please use the docker based tests; see *Software switch testing with docker*). Where hardware is available, please also run the hardware based integration tests also.
- In order to speed up acceptance of your PR we recommend enabling TravisCI on your own github repo, and linking the test results in the body of the PR. This enables the maintainers to quickly verify that your changes pass all tests in a pristine environment while conserving our TravisCI resources on the main branch (by minimizing resources used on potentially failing test runs which could be caught before opening a PR on the main branch).
- You must use the github feature branches (see https://gist.github.com/vlandham/3b2b79c40bc7353ae95a), for your change and squash commits (https://blog.github.com/2016-04-01-squash-your-commits/) when creating the PR.
- Please use the supplied git pre-commit hook (see `../git-hook/pre-commit`), to automatically run the unit tests and pylint for you at git commit time, which will save you TravisCI resources also.
- pylint must show no new errors or warnings.
- Code must conform to the style guide (see below).

2.1.2 PR handling guidelines

This section documents general guidelines for the maintainers in handling PRs. The overall intent is, to enable quality contributions with as low overhead as possible, maximizing the use of tools such as static analysis and unit/integration

testing, and supporting rapid and safe advancement of the overall project.

In addition to the above PR submission guidelines, above:

- PRs require a positive review per github's built in gating feature. The approving reviewer executes the merge.
- PRs that should not be merged until some other criteria are met (e.g. not until release day) must include DO NOT MERGE in the title, with the details in PR comments.
- A typical PR review/adjust/merge cycle should be 2-3 days (timezones, weekends, etc permitting). If a PR upon review appears too complex or requires further discussion it is recommended it be refactored into smaller PRs or discussed in another higher bandwidth forum (e.g. a VC) as appropriate.
- A PR can be submitted at any time, but to simplify release logistics PR merges might not be done before release, on release days.

2.1.3 Code style

Please use the coding style documented at https://github.com/google/styleguide/blob/gh-pages/pyguide.md. Existing code not using this style will be incrementally migrated to comply with it. New code should comply.

2.1.4 Faucet Development Environment

A common way of developing faucet is inside a virtualenv with an IDE such as PyCharm.

Instructions on setting up PyCharm for developing faucet are below.

If you would rather develop on the command line directly, a short summary of the command line setup for development in a `venv` with Python 3.6+ is included after the PyCharm instructions.

Create a new project in PyCharm

Set the `Location` of the project to the directory where a checked out copy of the faucet code from git is, for this tutorial I will assume the path is `/Dev/faucet/`.

Ignore the `Project Interpreter` settings for now, we will set those up after the project is created.

Click `Create` when you have completed these steps.

When asked `Would you like to create a project from existing sources instead?` click `Yes`.

Create virtual environment

Now that the project is created and source code imported, click the `File -> Settings` menu. In the dialog box that opens click the `Project: faucet -> Project Interpreter` sub menu.

Click the cog and select `Add...`

Under `Virtualenv Environment` you want to select `New environment` and select a `Location` for the virtualenv (which can be inside the directory where the faucet code lives, e.g `/Dev/faucet/venv`).

The `Base interpreter` should be set to /usr/bin/python3.

Click `Ok` which will create the virtualenv.

Now while that virtualenv builds and we still have the settings dialog open we will tweak a few project settings to make them compatible with our code style. Click on the `Tools -> Python Integrated Tools` menu and change the `Docstring format` to `Google`.

Finally, click `Ok` again to get back to the main screen of PyCharm.

Install requirements

Inside the PyCharm editor window if we open one of the code files for faucet (e.g. faucet/faucet.py) we should now get a bar at the top of the window telling us of missing package requirements, click the `Install requirements` option to install the dependencies for faucet.

Create log and configuration directories

Now we need to create a log and configuration directory so that faucet can start:

```
mkdir -p /Dev/faucet/venv/var/log/faucet/
mkdir -p /Dev/faucet/venv/etc/faucet/
```

Copy the sample faucet configuration file from `/Dev/faucet/etc/faucet/faucet.yaml` to `/Dev/faucet/venv/etc/faucet/` and edit this configuration file as necessary.

Copy the sample gauge configuration file from `/Dev/faucet/etc/faucet/gauge.yaml` to `/Dev/faucet/venv/etc/faucet/` and edit this configuration file as necessary.

If you are using the sample configuration "as is" you will also need to copy `/Dev/faucet/etc/faucet/acls.yaml` to `/Dev/faucet/venv/etc/faucet/` as that included by the sample `faucet.yaml` file, and without it the sample `faucet.yaml` file cannot be loaded.

You may also wish to copy `/Dev/faucet/etc/faucet/ryu.conf` to `/Dev/faucet/venv/etc/faucet/` as well so everything can be referenced in one directory inside the Python virtual environment.

Configure PyCharm to run faucet and gauge

Now we need to configure PyCharm to run faucet, gauge and the unit tests.

First, click the `Run -> Run..` menu, then select the `Edit Configurations...` option to get to the build settings dialog.

We will now add run configuration for starting `faucet` and `gauge`. Click the + button in the top left hand corner of the window. First, change the name from `Unnamed` to `faucet`. Change the `Script path` to point to ryu-manager inside the virtualenv, for me this was `../venv/bin/ryu-manager`. Then set the `Parameters` to `faucet.faucet`. Make sure the working directory is set to `/Dev/faucet/faucet/`.

We will use the same steps as above to add a run configuration for `gauge`. Changing the `Script path` to `../venv/bin/ryu-manager` and setting the `Parameters` this time to `faucet.gauge`. Make sure the working directory is set to `/Dev/faucet/faucet/`.

Configure PyCharm to run unit tests

For running tests we need a few additional dependencies installed, I couldn't work out how to do this through PyCharm so run this command from a terminal window to install the correct dependencies inside the virtualenv:

```
/Dev/faucet/venv/bin/pip3 install -r /Dev/faucet/test-requirements.txt
```

To add the test run configuration we will again click the + button in the top left hand corner, select `Python tests -> Unittests`. You can provide a `Name` of `Faucet Unit Tests` for the run configuration. For `Target` select `Script path` and enter the path `/Dev/faucet/tests/unit/faucet`. For `Pattern` enter `test_*.py`.

We will also add test run configuration for gauge using the same steps as above. Use `Gauge Unit Tests` as the `Name` and for `Target` select `Script path` and enter the path `/Dev/faucet/tests/unit/gauge`. For `Pattern` enter `test_*.py`.

You can click `Apply` and `Close` now that we've added all our new run configuration.

Now that everything is setup you can run either the faucet controller, gauge controller and test suite from the `Run` menu.

Developing with a Python 3.6+ venv

If you would prefer not to use PyCharm and are comfortable developing Python directly on the command line, these steps should get you started. They have been tested with Ubuntu 18.04 LTS, which includes Python 3.6, but similar instructions should work on other platforms that include Python 3.6+.

Install C/C++ compilers and Python development environment packages:

```
sudo apt-get install python3-venv libpython3.6-dev gcc g++ make
```

If you have not already, clone the faucet git repository:

```
git clone https://github.com/faucetsdn/faucet.git
```

Then create a Python `venv` environment within it:

```
cd faucet
python3 -m venv "${PWD}/venv"
```

and activate that virtual environment for all following steps:

```
. venv/bin/activate
```

Ensure that the faucet config is present within the virtual environment, copying from the default config files if required:

```
mkdir -p "${VIRTUAL_ENV}/var/log/faucet"
mkdir -p "${VIRTUAL_ENV}/etc/faucet"

for FILE in {acls,faucet,gauge}.yaml ryu.conf; do
  if [ -f "${VIRTUAL_ENV}/etc/faucet/${FILE}" ]; then
    echo "Preserving existing ${FILE}"
  else
    echo "Installing template ${FILE}"
    cp -p "etc/faucet/${FILE}" "${VIRTUAL_ENV}/etc/faucet/${FILE}"
  fi
done
```

Then install the runtime and development requirements

```
"${VIRTUAL_ENV}/bin/pip3" install wheel   # For bdist_wheel targets
"${VIRTUAL_ENV}/bin/pip3" install -r "${VIRTUAL_ENV}/../test-requirements.txt
↪"
```

Finally install faucet in an editable form:

```
pip install -e .
```

And then confirm that you can run the unit tests:

```
pytest tests/unit/faucet/
pytest tests/unit/gauge/
```

2.1.5 Makefile

Makefile is provided at the top level of the directory. Output of `make` is normally stored in `dist` directory. The following are the targets that can be used:

- **uml**: Uses `pyreverse` to provide code class diagrams.
- **codefmt**: Provides command line usage to "Code Style" the Python file
- **codeerrors**: Uses `pylint` on all Python files to generate a code error report and is placed in `dist` directory.
- **stats**: Provides a list of all commits since the last release tag.
- **release**: Used for releasing FAUCET to the next version, Requires `version` and `next_version` variables.

To *directly install* faucet from the cloned git repo, you could use `sudo python setup.py install` command from the root of the directory.

To *build pip installable package*, you could use `python setup.py sdist` command from the root of the directory.

To *remove* any temporarily created directories and files, you could use `rm -rf dist *egg-info` command.

Building Documentation

The documentation is built with Sphinx, from within the `docs` directory.

To be able to build the documentation ensure you have the relevant packages installed:

```
cd docs
sudo apt-get install librsvg2-bin make
pip3 install -r requirements.txt
```

and then you can build HTML documentation with:

```
cd docs
make html
```

and the documentation will be found under `_build/html` in the `docs` directory.

2.1.6 Key architectural concepts/assumptions:

FAUCET's architecture depends on key assumptions, which must be kept in mind at all times.

- FAUCET is the only controller for the switch, that can add or remove flows.
- All supported dataplanes must implement OpenFlow functionally (hardware, software or both) identically. No TTP or switch specific drivers.

In addition:

- FAUCET provisions default deny flows (all traffic not explicitly programmed is dropped).
- Use of packet in is minimized.

FAUCET depends upon these assumptions to guarantee that the switch is always in a known and consistent state, which in turn is required to support high availability (FAUCET provides high availability, through multiple FAUCET controllers using the same version of configuration - any FAUCET can give the switch a consistent response - no state sharing between controllers is required). The FAUCET user can program customized flows to be added to the switch using FAUCET ACLs (see below).

FAUCET also programs the dataplane to do flooding (where configured). This minimizes the use of packet in. This is necessary to reduce competition between essential control plane messages (adding and removing flows), and traffic from the dataplane on the limited bandwidth OpenFlow control channel. Unconstrained packet in messages impact the switch CPU, may overwhelm the OpenFlow control channel, and will expose the FAUCET controller to unvalidated dataplane packets, all of which are security and reliability concerns. In future versions, packet in will be eliminated altogether. The FAUCET user is expected to use policy based forwarding (eg ACLs that redirect traffic of interest to high performance dataplane ports for NFV offload), not packet in.

FAUCET requires all supported dataplanes to implement OpenFlow (specifically, a subset of OpenFlow 1.3) in a functionally identical way. This means that there is no switch-specific driver layer - the exact same messages are sent, whether the switch is OVS or hardware. While this does prevent some earlier generation OpenFlow switches from being supported, commercially available current hardware does not have as many restrictions, and eliminating the need for a switch-specific (or TTP) layer greatly reduces implementation complexity and increases controller programmer productivity.

2.2 Architecture

2.2.1 Faucet Design and Architecture

Faucet enables practical SDN for the masses (see http://queue.acm.org/detail.cfm?id=3015763).

- Drop in/replacement for non-SDN L2/L3 IPv4/IPv6 switch/router (easy migration)
- Packet forwarding/flooding/multicasting done entirely by switch hardware (controller only notified on topology change)
- BGP and static routing (other routing protocols provided by NFV)
- Multi vendor/platform support using OpenFlow 1.3 multi table
- Multi switch, vendor neutral "stacking" (Faucet distributed switching, loop free topology without spanning tree)
- ACLs, as well as allow/drop, allow packets to be copied/rewritten for external NFV applications
- Monitored with Prometheus
- Small code base with high code test coverage and automated testing both hardware and software

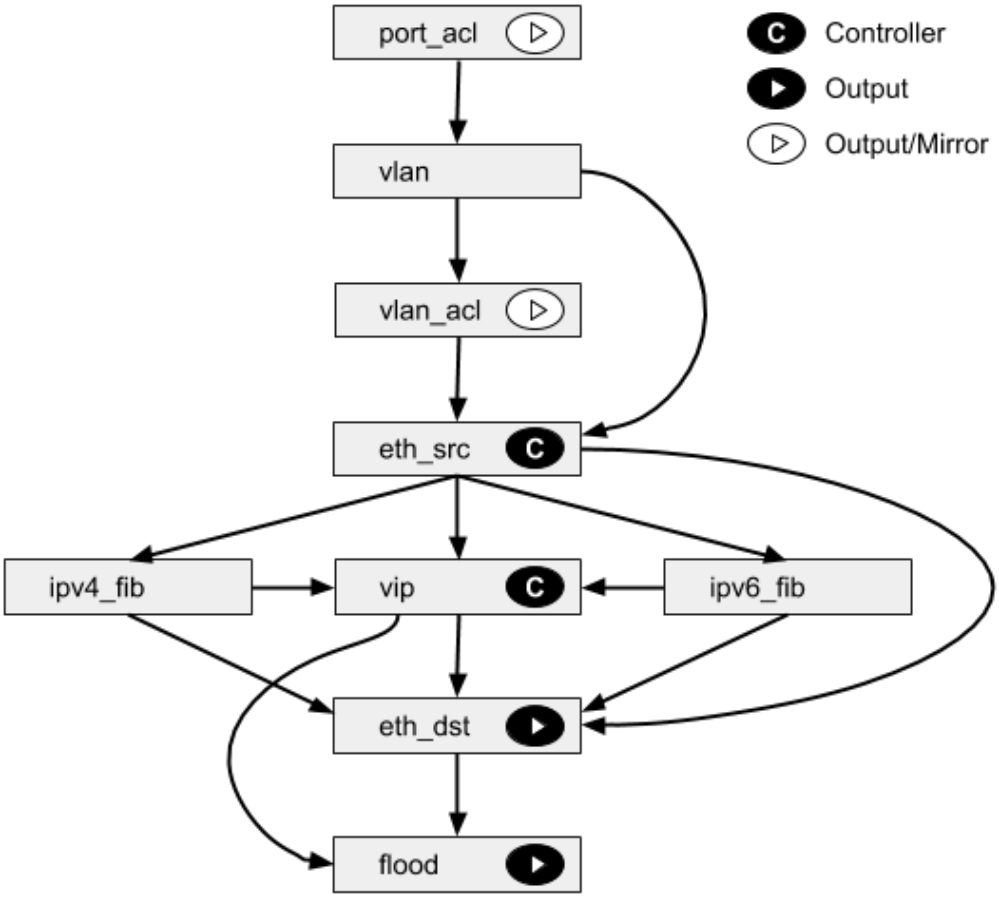
See unit and integration tests for working configuration examples.

2.2.2 Faucet Openflow Switch Pipeline

This summarizes the global FAUCET pipeline; however, certain tables may be omitted if the functionality is not required. For example, if routing is not configured, neither FIB table nor the VIP table will be provisioned.

Usually the OpenFlow table IDs will be allocated sequentially for the tables actually used, so tables should be referenced by their name rather than the table ID in this diagram.

See also canonical pipeline definitions in `faucet_pipeline.py`.


port_acl
vlan
vlan_acl
eth_src
ipv4_fib
vip
ipv6_fib
eth_dst
flood
C
Controller
Output
Output/Mirror

PORT_ACL Table

- Apply user supplied ACLs to a port and send to next table

VLAN Table

- Match fields: `eth_dst, eth_type, in_port, vlan_vid`
- **Operations:**
  - Drop unwanted L2 protocol traffic (and spoofing of Faucet's virtual MAC)
  - **For tagged ports**
    - Match VLAN_VID and send to next table
  - **For untagged ports**
    - Push VLAN frame onto packet with VLAN_VID representing ports native VLAN and send to next table
  - Interception of L2 control traffic (e.g. LACP, LLDP if configured).
  - Unknown traffic is dropped

VLAN_ACL Table

- Apply user supplied ACLs to a VLAN and send to next table

ETH_SRC Table

- Match fields: `eth_dst, eth_src, eth_type, in_port, vlan_vid`
- **Operations:**
  - For IPv4/IPv6 traffic where Faucet is the next hop, send to IPV4_FIB or IPV6_FIB (route)
  - For known source MAC, send to ETH_DST (switch)
  - For unknown source MACs, copy header to controller via packet in (for learning) and send to FLOOD

IPV4_FIB Table

- Match fields: `eth_type, ipv4_dst, vlan_vid`
- **Operations:**
  - Route IPv4 traffic to a next-hop for each route we have learned
  - Set eth_src to Faucet's magic MAC address
  - Set eth_dst to the resolved MAC address for the next-hop
  - Decrement TTL
  - Send to ETH_DST/HAIRPIN/VIP table
  - Unknown traffic is dropped

IPV6_FIB Table

- Match fields: `eth_type, ipv6_dst, vlan_vid`
- **Operations:**
  - Route IPv4 traffic to a next-hop for each route we have learned
  - Set eth_src to Faucet's magic MAC address
  - Set eth_dst to the resolved MAC address for the next-hop
  - Decrement TTL
  - Send to ETH_DST/HAIRPIN/VIP table
  - Unknown traffic is dropped

VIP Table

- Match fields: `arp_tpa, eth_dst, eth_type, icmpv6_type, ip_proto`
- **Operations:**
  - Send traffic destined for FAUCET VIPs including IPv4 ARP and IPv6 ND to the controller, and traffic for unresolved hosts in connected IP subnets (if proactively learning).
  - IPv4 ARP/IPv6 ND traffic may be flooded also (sent to FLOOD)

ETH_DST_HAIRPIN Table

- Exact match (no wildcards)
- Match fields: `eth_dst, in_port, vlan_vid`
- **Operations:**
  - For destination MAC addresses we have learned output packet towards that host (popping VLAN frame if we are outputting on an untagged port), and where hairpinning is desired (e.g. routing between hosts on the same port, but different VLANS).
  - Unknown traffic is sent to ETH_DST table.

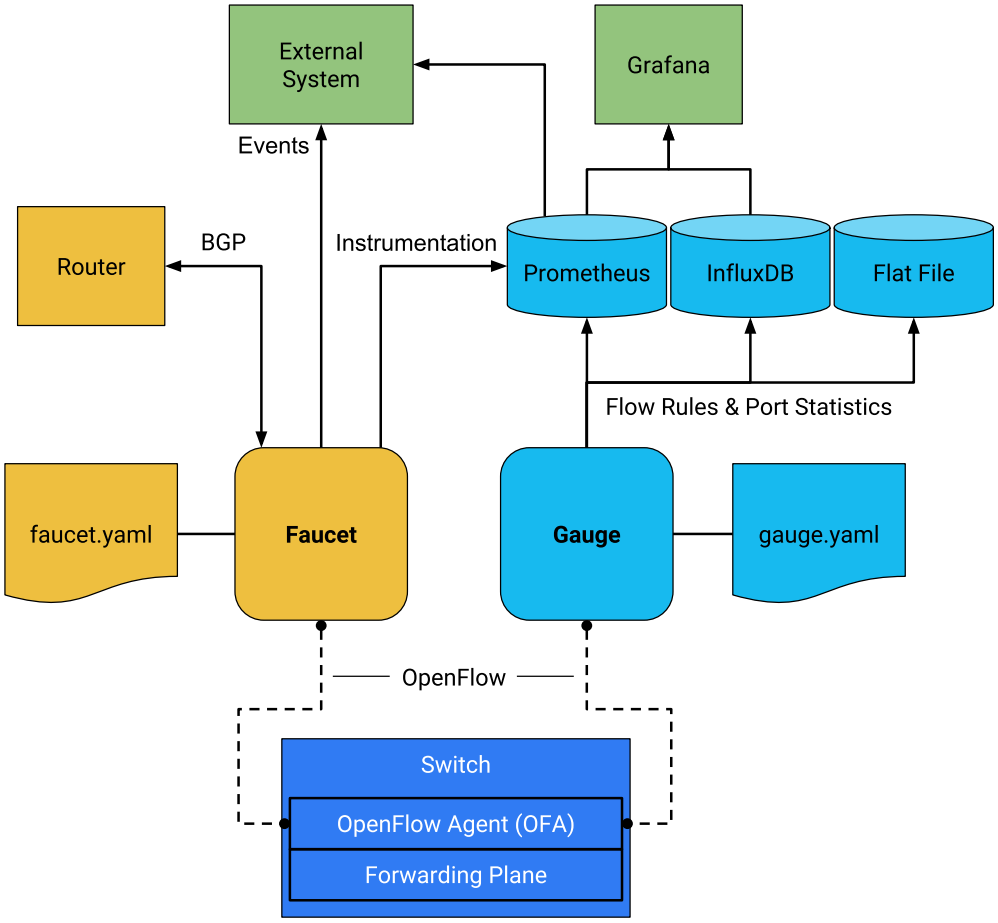
ETH_DST Table

- Exaxct match (no wildcards)
- Match fields: `eth_dst, vlan_vid`
- **Operations:**
  - For destination MAC addresses we have learned output packet towards that host (popping VLAN frame if we are outputting on an untagged port)
  - Unknown traffic is sent to FLOOD table

FLOOD Table

- Match fields: `eth_dst, in_port, vlan_vid`
- **Operations:**
  - Flood broadcast within VLAN
  - Flood multicast within VLAN
  - Unknown traffic is flooded within VLAN

2.2.3 Faucet Architecture



2.3 Testing

2.3.1 Installing docker

First, get yourself setup with docker based on our *Installing docker* documentation.

2.3.2 Software switch testing with docker

You can build and run the mininet tests with the following commands:

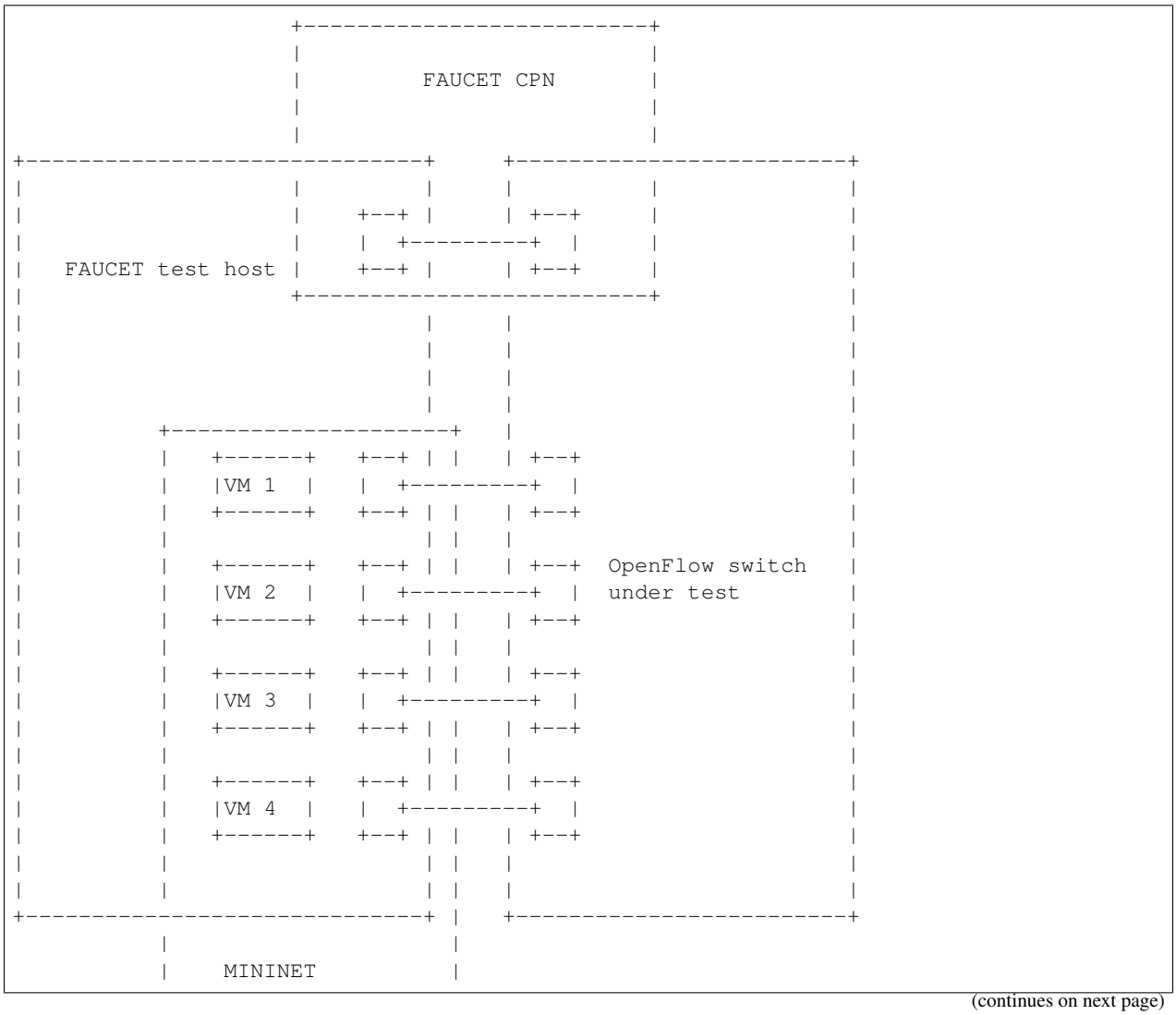
```
sudo docker build --pull -t faucet/tests -f Dockerfile.tests .
sudo apparmor_parser -R /etc/apparmor.d/usr.sbin.tcpdump
sudo modprobe openvswitch
sudo docker run --sysctl net.ipv6.conf.all.disable_ipv6=0 --privileged --rm \
                -v /var/local/lib/docker:/var/lib/docker \
                -v /tmp/faucet-pip-cache:/var/tmp/pip-cache \
                -ti faucet/tests
```

The apparmor command is currently required on Ubuntu hosts to allow the use of tcpdump inside the container.

If you need to use a proxy, the following to your docker run command.

```
--build-arg http_proxy=http://your.proxy:port
```

2.3.3 Hardware switch testing with docker



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```
            |                      |
            |                      |
            +----------------------+
```

Requirements

Your test host, requires at least 5 interfaces. 4 interfaces to connect to the dataplane, and one for the CPN for OpenFlow. You will need to assign an IP address to the CPN interface on the host, and configure the switch with a CPN IP address and establish that they can reach each other (eg via ping).

You will need to configure the switch with two OpenFlow controllers, both with the host's CPN IP address, but with different ports (defaults are given below for *of_port* and *gauge_of_port*).

Note: It is very important to disable any process that could cause any traffic on the dataplane test interfaces, and the test interfaces should have all IPv4/IPv6 dynamic address assignment disabled. To achieve this, on Ubuntu for example, you can set the interfaces to "unmanaged" in Network Manager, and make sure processes like Avahi ignores the test interfaces.

Note: Hardware tests must not be run from virtualized hosts (such as under VMware). The tests need to control physical port status, and need low level L2 packet access (eg. to rewrite Ethernet source and destination addresses) which virtualization may interfere with.

Note: Hardware tests require the test switch to have all non-OpenFlow switching/other features (eg. RSTP, DHCP) disabled on the dataplane test interfaces. These features will conflict with the functions FAUCET itself provides (and in turn the tests).

It is assumed that you execute all following commands from your FAUCET source code directory (eg one you have git cloned).

Test configuration

Create a directory for the test configuration:

```
mkdir -p /etc/faucet
$EDITOR /etc/faucet/hw_switch_config.yaml
```

`hw_switch_config.yaml` should contain the correct configuration for your switch:

```
hw_switch: True
hardware: 'Open vSwitch'
# Map ports on the hardware switch, to physical ports on this machine.
dp_ports:
  1: enp1s0f0
  2: enp1s0f1
  3: enp1s0f2
  4: enp1s0f3
# Hardware switch's DPID
dpid: 0xeccd6d9936ed
```

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```
# Port on this machine that connects to hardware switch's CPN port.
# Hardware switch must use IP address of this port as controller IP.
cpn_intf: enp5s0
# There must be two controllers configured on the hardware switch,
# with same IP (see cpn_intf), but different ports - one for FAUCET,
# one for Gauge.
of_port: 6636
gauge_of_port: 6637
# If you wish to test OF over TLS to the hardware switch,
# set the following parameters per Ryu documentation.
# https://github.com/osrg/ryu/blob/master/doc/source/tls.rst
# ctl_privkey: ctl-privkey.pem
# ctl_cert: ctl-cert.pem
# ca_certs: /usr/local/var/lib/openvswitch/pki/switchca/cacert.pem
```

Running the tests

Before starting the hardware test suite for the first time, you will need to install ebtables on the host machine:

```
sudo apt-get install ebtables
```

After every reboot of your host machine you will also need to manually load the `openvswitch` and `ebtables` kernel modules. If using apparmor you will also need to disable the profile for tcpdump:

```
sudo modprobe openvswitch
sudo modprobe ebtables
sudo apparmor_parser -R /etc/apparmor.d/usr.sbin.tcpdump
```

Then you can build and run the test suite:

```
sudo docker build --pull -t faucet/tests -f Dockerfile.tests .
sudo docker run --privileged --rm --net=host --cap-add=NET_ADMIN \
                -v /var/local/lib/docker:/var/lib/docker \
                -v /tmp/faucet-pip-cache:/var/tmp/pip-cache \
                -v /etc/faucet:/etc/faucet \
                -v /var/tmp:/var/tmp \
                -ti faucet/tests
```

2.3.4 Test suite options

In both the software and hardware version of the test suite we can provide flags inside the `FAUCET_TESTS` environment variable to run specific parts of the test suite.

> **Note:** Multiple flags can be added to FAUCET_TESTS, below are just some examples of how individual flags work.

Running specific integration tests

If specific test names are listed in the `FAUCET_TESTS` environment then only these integration tests will be run and all others skipped.

If we add the following to either of the previous docker run commands then only the `FaucetUntaggedTest` will be run.

```
-e FAUCET_TESTS="FaucetUntaggedTest"
```

Running only the integration tests

Sometimes you will want to skip the pytype, linting and documentation tests in order to complete a faucet test suite run against hardware quicker.

```
-e FAUCET_TESTS="-i"
```

Skip code checks

Sometimes you will want to skip the pytype, linting and documentation tests.

This can be done with with the `-n` flag:

```
-e FAUCET_TESTS="-n"
```

Skip unit tests

Sometimes you will want to skip the unit tests which are small tests that verify small chunks of the code base return the correct values. If these are skipped the integration tests (which spin up virtual networks and tests faucet controllers under different configurations) will still be run.

This can be done with with the `-u` flag:

```
-e FAUCET_TESTS="-u"
```

Checking test results

If a test fails, you can look in /var/tmp - there will be subdirectories created for each test, which will contain all the logs and debug information (including tcpdumps).

By default the test suite cleans up these files but if we use the `-k` flag the test suite will keep these files.

```
-e FAUCET_TESTS="-k"
```

2.3.5 Repeatedly running tests until failure

You can run tests until a failure is detected (eg, to diagnose an unreliable test). Tests will continue to run forever until at least one fails or the test is interrupted.

```
-e FAUCET_TESTS="-r"
```

2.4 Fuzzing

2.4.1 Fuzzing faucet config with docker

First, get yourself setup with docker based on our *Installing docker* documentation.

Then you can build and run the afl-fuzz tests:

```
docker build -t faucet/config-fuzzer -f Dockerfile.fuzz-config .

docker run -d \
  -u $(id -u $USER) \
  --name config-fuzzer \
  -v /var/log/afl/:/var/log/afl/ \
  faucet/config-fuzzer
```

AFL then will run indefinitely. You can find the output in /var/log/afl/. You will then need to run the output configs with faucet to see the error produced.

2.4.2 Fuzzing faucet packet handling with docker

Build and run the afl-fuzz tests:

```
docker build -t faucet/packet-fuzzer -f Dockerfile.fuzz-packet .

docker run -d \
  -u $(id -u $USER) \
  --name packet-fuzzer \
  -v /var/log/afl/:/var/log/afl/ \
  -v /var/log/faucet/:/var/log/faucet/ \
  -p 6653:6653 \
  -p 9302:9302 \
  faucet/packet-fuzzer
```

AFL will then fuzz the packet handling indefinitely. The afl output can be found in /var/log/afl/. To check the error produced by an afl crash file use display_packet_crash:

```
python3 tests/fuzzer/display_packet_crash.py /var/log/afl/crashes/X
```

Where X is the name of the crash file. The output can then be found in the faucet logs (/var/log/faucet/).

2.5 Source Code

2.5.1 faucet

faucet package

Submodules

faucet.acl module

Configuration for ACLs.

class faucet.acl.**ACL**(*_id*, *dp_id*, *conf*)

Bases: *faucet.conf.Conf*

Contains the state for an ACL, including the configuration.

ACL Config

ACLs are configured under the 'acls' configuration block. The acls block contains a dictionary of individual acls each keyed by its name.

Each acl contains a list of rules, a packet will have the first matching rule applied to it.

Each rule is a dictionary containing the single key 'rule' with the value the matches and actions for the rule.

The matches are key/values based on the ryu RESTFul API. The key 'actions' contains a dictionary with keys/values as follows:

- allow (int): if 1 allow the packet to continue through the Faucet pipeline, if 0 drop the packet.
- force_port_vlan (int): if 1, do not verify the VLAN/port association for this packet and override any VLAN ACL on the forced VLAN.
- meter (str): meter to apply to the packet
- output (dict): used to output a packet directly. details below.
- cookie (int): set flow cookie to this value on this flow

The output action contains a dictionary with the following elements:

- tunnel (dict): the tunnel formation, creates a tunnel from the applied port(s) to the specified destination
- port (int or string): the port to output the packet to
- ports (list): a list of the ports (int or string) to output the packet to
- set_fields (list): a list of fields to set with values
- pop_vlans: (int): pop the packet vlan before outputting
- vlan_vid: (int): push the vlan vid on the packet when outputting
- vlan_vids: (list): push the list of vlans on the packet when outputting, with option eth_type
- swap_vid (int): rewrite the vlan vid of the packet when outputting
- failover (dict): Output with a failover port (experimental)

actions_types = {'allow': <class 'int'>, 'force_port_vlan': <class 'int'>, 'meter':

build(*meters*, *vid*, *port_num*)

Check that ACL can be built from config.

check_config()

Check config at instantiation time for errors, typically via assert.

defaults = {'dot1x_assigned': False, 'exact_match': False, 'rules': None}

defaults_types = {'dot1x_assigned': <class 'bool'>, 'exact_match': <class 'bool'>, '

finalize()

Configuration parsing marked complete.

get_in_port_match(*tunnel_id*)

Returns a port number of the src_port of the tunnel that the ingress tunnel ACL will need to match to. :param tunnel_id: tunnel identifier to obtain the src_port :type tunnel_id: int

Returns src_port number if it exists, None otherwise

Return type int OR None

get_meters()

get_mirror_destinations()

get_tunnel_id(*rule_index*)
Gets the tunnel ID for the rule :param rule_index: Index of the tunnel rule in the self.rules list :type rule_index: int

Returns Identifier for the tunnel

Return type tunnel_id (int)

get_tunnel_rule_indices()
Get the rules from the rule conf that contain tunnel outputs :returns: list of integer indices into the self.rules rule list that contain tunnel information :rtype: rules (list)

output_actions_types = {'failover': <class 'dict'>, 'pop_vlans': <class 'int'>, 'por

remove_non_tunnel_rules()
Removes all non-tunnel rules from the ACL and removes all match fields and non-tunnel required actions from the tunnel rules

resolve_ports(*resolve_port_cb*, *resolve_tunnel_objects*)

rule_types = {'actions': <class 'dict'>, 'arp_op': (<class 'str'>, <class 'int'>), '

tunnel_types = {'dp': <class 'str'>, 'port': (<class 'str'>, <class 'int'>), 'tunnel

unpack_tunnel(*tunnel_id*)
Retrieves the information from the tunnel dict for the tunnel with id :param tunnel_id: Identifier for the tunnel :type tunnel_id: int

Returns Tunnel information

Return type (src_dp, src_port, dst_dp, dst_port)

update_tunnel_acl_conf(*dp*)
Update the ACL rule conf if the DP is in the path :param dp: The dp that this tunnel acl object belongs to :type dp: DP

Returns True if any value was updated

Return type bool

verify_tunnel_rules(*dp*)
Verify the actions in the tunnel ACL to by making sure the user hasn't specified an action/match that will create a clash. :param dp: The dp that this tunnel acl object belongs to :type dp: DP

TODO: Choose what combinations of matches & actions to disallow with a tunnel

faucet.check_faucet_config module

Standalone script to check FAUCET configuration, return 0 if provided config OK.

faucet.check_faucet_config.**check_config**(*conf_files*, *debug_level*, *check_output_file*)
Return True and successful config dict, if all config can be parsed.

faucet.check_faucet_config.**main**()
Mainline.

faucet.conf module

Base configuration implementation.

class faucet.conf.**Conf**(*_id*, *dp_id*, *conf=None*)
Bases: object

Base class for FAUCET configuration.

check_config()
Check config at instantiation time for errors, typically via assert.

conf_diff(*other*)
Return text diff between two Confs.

conf_hash(*dyn=False*, *subconf=True*, *ignore_keys=None*)
Return hash of keys configurably filtering attributes.

defaults = None

defaults_types = None

dyn_finalized = False

dyn_hash = None

finalize()
Configuration parsing marked complete.

ignore_subconf(*other*, *ignore_keys=None*)
Return True if this config same as other, ignoring sub config.

merge_dyn(*other_conf*)
Merge dynamic state from other conf object.

mutable_attrs = frozenset({})

set_defaults(*defaults=None*, *conf=None*)
Set default values and run any basic sanity checks.

to_conf()
Return configuration as a dict.

update(*conf*)
Parse supplied YAML config and sanity check.

exception faucet.conf.**InvalidConfigError**
Bases: Exception

This error is thrown when the config file is not valid.

faucet.conf.**test_config_condition**(*cond*, *msg*)
Evaluate condition and raise InvalidConfigError if condition not True.

faucet.config_parser module

Implement configuration file parsing.

faucet.config_parser.**dp_parser**(*config_file*, *logname*, *meta_dp_state=None*)
Parse a config file into DP configuration objects with hashes of config include/files.

faucet.config_parser.**dp_preparsed_parser**(*top_confs*, *meta_dp_state*)
Parse a preparsed (after include files have been applied) FAUCET config.

faucet.config_parser.**get_config_for_api**(*valves*)
Return config as dict for all DPs.

faucet.config_parser.**watcher_parser**(*config_file*, *logname*, *prom_client*)
Return Watcher instances from config.

faucet.config_parser_util module

Utility functions supporting FAUCET/Gauge config parsing.

class faucet.config_parser_util.**UniqueKeyLoader**(*stream*)
Bases: yaml.loader.Loader

construct_mapping(*node*, *deep=False*)
Check for duplicate YAML keys.

faucet.config_parser_util.**config_changed**(*top_config_file*, *new_top_config_file*, *config_hashes*)
Return True if configuration has changed.

Parameters

- **top_config_file** (*str*) – name of FAUCET config file
- **new_top_config_file** (*str*) – name, possibly new, of FAUCET config file.
- **config_hashes** (*dict*) – map of config file/includes and hashes of contents.

Returns True if the file, or any file it includes, has changed.

Return type bool

faucet.config_parser_util.**config_file_hash**(*config_file_name*)
Return hash of YAML config file contents.

faucet.config_parser_util.**dp_config_path**(*config_file*, *parent_file=None*)
Return full path to config file.

faucet.config_parser_util.**dp_include**(*config_hashes*, *config_contents*, *config_file*, *logname*, *top_confs*)
Handles including additional config files

faucet.config_parser_util.**get_logger**(*logname*)
Return logger instance for config parsing.

faucet.config_parser_util.**read_config**(*config_file*, *logname*)
Return a parsed YAML config file or None.

faucet.dp module

Configuration for a datapath.

class faucet.dp.**DP**(*_id*, *dp_id*, *conf*)
Bases: *faucet.conf.Conf*

Stores state related to a datapath controlled by Faucet, including configuration.

DEFAULT_LLDP_MAX_PER_INTERVAL = 5

DEFAULT_LLDP_SEND_INTERVAL = 5

add_acl(*acl_ident*, *acl*)
Add an ACL to this DP.

add_port(*port*)
Add a port to this DP.

add_router(*router_ident*, *router*)
Add a router to this DP.

classmethod add_stack_link(*graph*, *dp*, *port*)
Add a stack link to the stack graph.

all_lags_up()
Return True if all LAGs have at least one port up.

any_stack_port_up()
Return True if any stack port is up.

base_prom_labels()
Return base Prometheus labels for this DP.

bgp_routers()
Return list of routers with BGP enabled.

static canonical_port_order(*ports*)

check_config()
Check config at instantiation time for errors, typically via assert.

classification_table()
Returns classification table

clone_dyn_state(*prev_dp*)

coprocessor_ports()
Return list of coprocessor ports.

default_table_sizes_types = {'classification': <class 'int'>, 'eth_dst': <class 'int

defaults = {'advertise_interval': 30, 'arp_neighbor_timeout': 30, 'cache_update_guar

defaults_types = {'advertise_interval': <class 'int'>, 'arp_neighbor_timeout': <clas

dot1x_defaults_types = {'auth_acl': <class 'str'>, 'nfv_intf': <class 'str'>, 'nfv_s

dot1x_ports()
Return list of ports with 802.1x enabled.

finalize()
Need to configure OF tables as very last step.

finalize_config(*dps*)
Perform consistency checks after initial config parsing.

finalize_tunnel_acls(*dps*)
Turn off ACLs not in use and resolve the ACL src dp and port.

Parameters **dps** (*list*) – DPs.

get_config_changes(*logger*, *new_dp*)
Detect any config changes.

Parameters

- **logger** (ValveLogger) – logger instance

- **new_dp** (DP) – new dataplane configuration.

Returns

changes tuple containing:

deleted_ports (set): deleted port numbers. changed_ports (set): changed/added port numbers. changed_acl_ports (set): changed ACL only port numbers. deleted_vlans (set): deleted VLAN IDs. changed_vlans (set): changed/added VLAN IDs. all_ports_changed (bool): True if all ports changed.

Return type (tuple)

get_config_dict()
Return DP config as a dict for API call.

get_native_vlan(*port_num*)
Return native VLAN for a port by number, or None.

get_tables()
Return tables as dict for API call.

in_port_tables()
Return list of tables that specify in_port as a match.

is_in_path(*src_dp*, *dst_dp*)
Return True if the current DP is in the path from src_dp to dst_dp

Parameters

- **src_dp** (DP) – DP
- **dst_dp** (DP) – DP

Returns True if self is in the path from the src_dp to the dst_dp.

Return type bool

is_stack_edge()
Return True if this DP is a stack edge.

is_stack_root()
Return True if this DP is the root of the stack.

is_stack_root_candidate()
Return True if this DP could be a root of the stack.

lacp_forwarding(*port*)
Return 1 if should signal forwarding on a LACP bundle on this DP.

lacp_ports()
Return ports that have LACP.

lacp_up_ports()
Return ports that have LACP up.

lags()
Return dict of LAGs mapped to member ports.

lags_up()
Return dict of LAGs mapped to member ports that have LACP up.

lldp_beacon_defaults_types = {'max_per_interval': <class 'int'>, 'send_interval': <c

lldp_beacon_send_ports(*now*)
Return list of ports to send LLDP packets; stacked ports always send LLDP.

match_tables(*match_type*)
Return list of tables with matches of a specific match type.

static modify_stack_topology(*graph*, *dp*, *port*, *add=True*)
Add/remove an edge to the stack graph which originates from this dp and port.

mutable_attrs = frozenset({'stack', 'vlans'})

non_vlan_ports()
Ports that don't have VLANs on them.

output_table()
Returns first output table

output_tables()
Return tables that cause a packet to be forwarded.

peer_stack_up_ports(*peer_dp*)
Return list of stack ports that are up towards a peer.

port_labels(*port_no*)
Return port name and description labels for a port number.

port_no_valid(*port_no*)
Return True if supplied port number valid on this datapath.

classmethod remove_stack_link(*graph*, *dp*, *port*)
Remove a stack link to the stack graph.

reset_refs(*vlans=None*)
Resets VLAN references.

resolve_port(*port_name*)
Resolve a port by number or name.

resolve_stack_topology(*dps*, *meta_dp_state*)
Resolve inter-DP config for stacking.

restricted_bcast_arpnd_ports()
Return ports that have restricted broadcast set.

set_defaults()
Set default values and run any basic sanity checks.

shortest_path(*dest_dp*, *src_dp=None*)
Return shortest path to a DP, as a list of DPs.

shortest_path_port(*dest_dp*)
Return first port on our DP, that is the shortest path towards dest DP.

shortest_path_to_root()
Return shortest path to root DP, as list of DPs.

stack_defaults_types = {'priority': <class 'int'>}

stack_longest_path_to_root_len()
Return length of the longest path to root in the stack.

table_by_id(*table_id*)
Gets first table with table id

faucet.faucet module

RyuApp shim between Ryu and Valve.

class faucet.faucet.**EventFaucetAdvertise**
Bases: ryu.controller.event.EventBase

Event used to trigger periodic network advertisements (eg IPv6 RAs).

class faucet.faucet.**EventFaucetExperimentalAPIRegistered**
Bases: ryu.controller.event.EventBase

Event used to notify that the API is registered with Faucet.

class faucet.faucet.**EventFaucetFastAdvertise**
Bases: ryu.controller.event.EventBase

Event used to trigger periodic fast network advertisements (eg LACP).

class faucet.faucet.**EventFaucetFastStateExpire**
Bases: ryu.controller.event.EventBase

Event used to trigger fast expiration of state in controller.

class faucet.faucet.**EventFaucetMaintainStackRoot**
Bases: ryu.controller.event.EventBase

Event used to maintain stack root.

class faucet.faucet.**EventFaucetMetricUpdate**
Bases: ryu.controller.event.EventBase

Event used to trigger update of metrics.

class faucet.faucet.**EventFaucetResolveGateways**
Bases: ryu.controller.event.EventBase

Event used to trigger gateway re/resolution.

class faucet.faucet.**EventFaucetStateExpire**
Bases: ryu.controller.event.EventBase

Event used to trigger expiration of state in controller.

class faucet.faucet.**Faucet**(**args*, ***kwargs*)
Bases: *faucet.valve_ryuapp.RyuAppBase*

A RyuApp that implements an L2/L3 learning VLAN switch.

Valve provides the switch implementation; this is a shim for the Ryu event handling framework to interface with Valve.

bgp = None

desc_stats_reply_handler(*ryu_event*)
Handle OFPDescStatsReply from datapath.

Parameters **ryu_event** (*ryu.controller.ofp_event.EventOFPDescStatsReply*) – trigger.

error_handler(*ryu_event*)
Handle an OFPError from a datapath.

Parameters **ryu_event** (*ryu.controller.ofp_event.EventOFPErrorMsg*) – trigger

exc_logname = 'faucet.exception'

features_handler(*ryu_event*)
Handle receiving a switch features message from a datapath.

Parameters **ryu_event** (*ryu.controller.ofp_event.EventOFPStateChange*) – trigger.

flowremoved_handler(*ryu_event*)
Handle a flow removed event.

Parameters **ryu_event** (*ryu.controller.ofp_event.EventOFPFlowRemoved*) – trigger.

get_config()
FAUCET experimental API: return config for all Valves.

get_tables(*dp_id*)
FAUCET experimental API: return config tables for one Valve.

logname = 'faucet'

metric_update(*_*)
Handle a request to update metrics in the controller.

metrics = None

notifier = None

packet_in_handler(*ryu_event*)
Handle a packet in event from the dataplane.

Parameters **ryu_event** (*ryu.controller.event.EventReplyBase*) – packet in message.

port_status_handler(*ryu_event*)
Handle a port status change event.

Parameters **ryu_event** (*ryu.controller.ofp_event.EventOFPPortStatus*) – trigger.

reload_config(*ryu_event*)
Handle a request to reload configuration.

start()
Start controller.

valves_manager = None

faucet.faucet_bgp module

BGP implementation for FAUCET.

class faucet.faucet_bgp.**BgpSpeakerKey**(*dp_id*, *vlan_vid*, *ipv*)
Bases: object

Uniquely describe a BGP speaker.

class faucet.faucet_bgp.**FaucetBgp**(*logger*, *exc_logname*, *metrics*, *send_flow_msgs*)
Bases: object

Wrapper for Ryu BGP speaker.

exc_logname = None

reset(*valves*)
Set up a BGP speaker for every VLAN that requires it.

shutdown_bgp_speakers()
Shutdown any active BGP speakers.

update_metrics(*_now*)
Update BGP metrics.

faucet.faucet_dot1x module

802.1x implementation for FAUCET.

class faucet.faucet_dot1x.**FaucetDot1x**(*logger*, *exc_logname*, *metrics*, *send_flow_msgs*)
Bases: object

Wrapper for experimental Chewie 802.1x authenticator.

auth_handler(*address*, *port_id*, **args*, ***kwargs*)
Callback for when a successful auth happens.

create_flow_pair(*dp_id*, *dot1x_port*, *nfv_sw_port*, *valve*)
Creates the pair of flows that redirects the eapol packets to/from the supplicant and nfv port

Parameters

- **dp_id**(*int*) –
- **dot1x_port**(Port) –
- **nfv_sw_port**(Port) –
- **valve**(Valve) –

Returns list

create_mab_flow(*dp_id*, *dot1x_port*, *nfv_sw_port*, *valve*)
Creates a flow that mirrors UDP packets from port 68 (DHCP) from the supplicant to the nfv port

Parameters

- **dp_id**(*int*) –
- **dot1x_port**(Port) –
- **nfv_sw_port**(Port) –
- **valve**(Valve) –

Returns list

exc_logname = None

failure_handler(*address*, *port_id*)
Callback for when a EAP failure happens.

log_auth_event(*valve*, *port_num*, *mac_str*, *status*)
Log an authentication attempt event

log_port_event(*event_type*, *port_type*, *valve*, *port_num*)
Log a dot1x port event

logoff_handler(*address*, *port_id*)
Callback for when an EAP logoff happens.

nfv_sw_port_up(*dp_id*, *dot1x_ports*, *nfv_sw_port*)
Setup the dot1x forward port acls when the nfv_sw_port comes up. :param dp_id: :type dp_id: int :param dot1x_ports: :type dot1x_ports: Iterable of Port objects :param nfv_sw_port: :type nfv_sw_port: Port

Returns list of flowmods

port_down(*dp_id*, *dot1x_port*, *nfv_sw_port*)
Remove the acls added by FaucetDot1x.get_port_acls :param dp_id: :type dp_id: int :param dot1x_port: :type dot1x_port: Port :param nfv_sw_port: :type nfv_sw_port: Port

Returns list of flowmods

port_up(*dp_id*, *dot1x_port*, *nfv_sw_port*)
Setup the dot1x forward port acls. :param dp_id: :type dp_id: int :param dot1x_port: :type dot1x_port: Port :param nfv_sw_port: :type nfv_sw_port: Port

Returns list of flowmods

reset(*valves*)
Set up a dot1x speaker.

set_mac_str(*valve*, *valve_index*, *port_num*)

Parameters

- **valve** (Valve) –
- **valve_index** (*int*) –
- **port_num** (*int*) –

Returns str

faucet.faucet_dot1x.**get_mac_str**(*valve_index*, *port_num*)
Gets the mac address string for the valve/port combo :param valve_index: The internally used id of the valve. :type valve_index: int :param port_num: port number :type port_num: int

Returns str

faucet.faucet_event module

FAUCET event notification.

class faucet.faucet_event.**FaucetEventNotifier**(*socket_path*, *metrics*, *logger*)
Bases: object

Event notification, via Unix domain socket.

check_path(*socket_path*)
Check that socket_path is valid.

notify(*dp_id*, *dp_name*, *event_dict*)
Notify of an event.

start()
Start socket server.

class faucet.faucet_event.**NonBlockLock**
Bases: object

Non blocking lock that can be used as a context manager.

acquire_nonblock()
Attempt to acquire a lock.

release()
Release lock when done.

faucet.faucet_experimental_api module

Implement experimental API.

class faucet.faucet_experimental_api.**FaucetExperimentalAPI**(*_args*, ***_kwargs*)
Bases: object

An experimental API for communicating with Faucet.

Contains methods for interacting with a running Faucet controller from within a RyuApp. This app should be run together with Faucet in the same ryu-manager process.

add_port_acl(*port*, *acl*)
Add an ACL to a port.

add_vlan_acl(*vlan*, *acl*)
Add an ACL to a VLAN.

delete_port_acl(*port*, *acl*)
Delete an ACL from a port.

delete_vlan_acl(*vlan*, *acl*)
Delete an ACL from a VLAN.

get_config()
Get the current running config of Faucet as a python dictionary.

get_tables(*dp_id*)
Get current FAUCET tables as a dict of table name: table no.

is_registered()
Return True if registered and ready to serve API requests.

push_config(*config*)
Push supplied config to FAUCET.

reload_config()
Reload config from config file in FAUCET_CONFIG env variable.

faucet.faucet_metadata module

This module contains code relating to the use of OpenFlow Metadata within Faucet.

faucet.faucet_metadata.**get_egress_metadata**(*port_num*, *vid*)
Return the metadata value to output a packet to port port_num on vlan vid

faucet.faucet_metrics module

Implement Prometheus statistics.

class faucet.faucet_metrics.**FaucetMetrics**(*reg=None*)
Bases: *faucet.prom_client.PromClient*

Container class for objects that can be exported to Prometheus.

inc_var(*var*, *labels*, *val=1*)

reset_dpid(*dp_labels*)
Set all DPID-only counter/gauges to 0.

faucet.faucet_pipeline module

Standard FAUCET pipeline.

class faucet.faucet_pipeline.**ValveTableConfig**(*name*, *table_id*, *exact_match=None*, *meter=None*, *output=True*, *miss_goto=None*, *size=None*, *match_types=None*, *set_fields=None*, *dec_ttl=None*, *vlan_scale=None*, *vlan_port_scale=None*, *next_tables=None*, *metadata_match=0*, *metadata_write=0*)
Bases: object

Configuration for a single table.

faucet.fctl module

Report state based on FAUCET/Gauge/Prometheus variables.

faucet.fctl.**decode_value**(*metric_name*, *value*)
Convert values to human readible format based on metric name

faucet.fctl.**get_samples**(*endpoints*, *metric_name*, *label_matches*, *nonzero_only=False*, *retries=3*)
return a list of Prometheus samples for a given metric

Prometheus Sample objects are named tuples with the fields: name, labels, value, timestamp, exemplar.

Parameters

- **endpoints** (*list of strings*) – the prometheus endpoints to query
- **metric_name** (*string*) – the metric to retrieve
- **label_matches** (*dict*) – filters results by label
- **nonzero_only** (*bool*) – only return samples with non-zero values
- **retries** (*int*) – number of retries when querying

Returns list of Prometheus Sample objects

faucet.fctl.**main**()

faucet.fctl.**parse_args**(*sys_args*)
Parse and return CLI args.

faucet.fctl.**report_label_match_metrics**(*report_metrics*, *metrics*, *display_labels=None*, *nonzero_only=False*, *delim='\t'*, *label_matches=None*)
Text report on a list of Prometheus metrics.

faucet.fctl.**scrape_prometheus**(*endpoints*, *retries=3*, *err_output_file=<_io.TextIOWrapper name='<stdout>' mode='w' encoding='UTF-8'>*)
Scrape a list of Prometheus/FAUCET/Gauge endpoints and aggregate results.

faucet.gauge module

RyuApp shim between Ryu and Gauge.

class faucet.gauge.**Gauge**(**args*, ***kwargs*)
Bases: *faucet.valve_ryuapp.RyuAppBase*

Ryu app for polling Faucet controlled datapaths for stats/state.

It can poll multiple datapaths. The configuration files for each datapath should be listed, one per line, in the file set as the environment variable GAUGE_CONFIG. It logs to the file set as the environment variable GAUGE_LOG,

exc_logname = 'gauge.exception'

logname = 'gauge'

prom_client = None

reload_config(*ryu_event*)
Handle request for Gauge config reload.

update_watcher_handler(*ryu_event*)
Handle any kind of stats/change event.

Parameters **ryu_event** (*ryu.controller.event.EventReplyBase*) – stats/change event.

faucet.gauge_influx module

Library for interacting with InfluxDB.

class faucet.gauge_influx.**GaugeFlowTableInfluxDBLogger**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugeFlowTablePoller*, *faucet.gauge_influx.InfluxShipper*

Example

```
> use faucet
Using database faucet
> show series where table_id = '0' and in_port = '2'
key
---
flow_byte_count,dp_name=windscale-faucet-1,eth_type=2048,in_port=2,ip_proto=17,
↪priority=9099,table_id=0,udp_dst=53
flow_byte_count,dp_name=windscale-faucet-1,eth_type=2048,in_port=2,ip_proto=6,
↪priority=9098,table_id=0,tcp_dst=53
flow_byte_count,dp_name=windscale-faucet-1,in_port=2,priority=9097,table_id=0
flow_packet_count,dp_name=windscale-faucet-1,eth_type=2048,in_port=2,ip_proto=17,
↪priority=9099,table_id=0,udp_dst=53
flow_packet_count,dp_name=windscale-faucet-1,eth_type=2048,in_port=2,ip_proto=6,
↪priority=9098,table_id=0,tcp_dst=53
flow_packet_count,dp_name=windscale-faucet-1,in_port=2,priority=9097,table_id=0
> select * from flow_byte_count where table_id = '0' and in_port = '2' and ip_
↪proto = '17' and time > now() - 5m
name: flow_byte_count
time                arp_tpa dp_name            eth_dst eth_src eth_type icmpv6_
↪type in_port ip_proto ipv4_dst ipv6_dst priority table_id tcp_dst udp_dst value␣
↪vlan_vid
```

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```
----                  -------- --------             -------- -------- -------- -----------
↪- ------- -------- -------- -------- -------- -------- -------- -------- ----- ---
↪-----
1501154797000000000         windscale-faucet-1                 2048
↪  2       17                        9099     0                53       9414
1501154857000000000         windscale-faucet-1                 2048
↪  2       17                        9099     0                53       10554
1501154917000000000         windscale-faucet-1                 2048
↪  2       17                        9099     0                53       10554
1501154977000000000         windscale-faucet-1                 2048
↪  2       17                        9099     0                53       12164
1501155037000000000         windscale-faucet-1                 2048
↪  2       17                        9099     0                53       12239
```

class faucet.gauge_influx.**GaugePortStateInfluxDBLogger**(*conf*, *logname*, *prom_client*)

Bases: *faucet.gauge_pollers.GaugePortStatePoller*, *faucet.gauge_influx.InfluxShipper*

Example

```
> use faucet
Using database faucet
> precision rfc3339
> select * from port_state_reason where port_name = 'port1.0.1' order by time␣
↪desc limit 10;
name: port_state_reason
-----------------------
time                    dp_name                 port_name       value
2017-02-21T02:12:29Z    windscale-faucet-1      port1.0.1       2
2017-02-21T02:12:25Z    windscale-faucet-1      port1.0.1       2
2016-07-27T22:05:08Z    windscale-faucet-1      port1.0.1       2
2016-05-25T04:33:00Z    windscale-faucet-1      port1.0.1       2
2016-05-25T04:32:57Z    windscale-faucet-1      port1.0.1       2
2016-05-25T04:31:21Z    windscale-faucet-1      port1.0.1       2
2016-05-25T04:31:18Z    windscale-faucet-1      port1.0.1       2
2016-05-25T04:27:07Z    windscale-faucet-1      port1.0.1       2
2016-05-25T04:27:04Z    windscale-faucet-1      port1.0.1       2
2016-05-25T04:24:53Z    windscale-faucet-1      port1.0.1       2
```

class faucet.gauge_influx.**GaugePortStatsInfluxDBLogger**(*conf*, *logname*, *prom_client*)

Bases: *faucet.gauge_pollers.GaugePortStatsPoller*, *faucet.gauge_influx.InfluxShipper*

Periodically sends a port stats request to the datapath and parses and outputs the response.

Example

```
> use faucet
Using database faucet
> show measurements
name: measurements
------------------
bytes_in
bytes_out
```

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```
dropped_in
dropped_out
errors_in
packets_in
packets_out
port_state_reason
> precision rfc3339
> select * from packets_out where port_name = 'port1.0.1' order by time desc␣
↪limit 10;
name: packets_out
-----------------
time                    dp_name                 port_name       value
2017-03-06T05:21:42Z    windscale-faucet-1      port1.0.1       76083431
2017-03-06T05:21:33Z    windscale-faucet-1      port1.0.1       76081172
2017-03-06T05:21:22Z    windscale-faucet-1      port1.0.1       76078727
2017-03-06T05:21:12Z    windscale-faucet-1      port1.0.1       76076612
2017-03-06T05:21:02Z    windscale-faucet-1      port1.0.1       76074546
2017-03-06T05:20:52Z    windscale-faucet-1      port1.0.1       76072730
2017-03-06T05:20:42Z    windscale-faucet-1      port1.0.1       76070528
2017-03-06T05:20:32Z    windscale-faucet-1      port1.0.1       76068211
2017-03-06T05:20:22Z    windscale-faucet-1      port1.0.1       76065982
2017-03-06T05:20:12Z    windscale-faucet-1      port1.0.1       76063941
```

class faucet.gauge_influx.**InfluxShipper**

Bases: object

Convenience class for shipping values to InfluxDB.

Inheritors must have a WatcherConf object as conf.

conf = None

logger = None

static make_point(*tags*, *rcv_time*, *stat_name*, *stat_val*)

Make an InfluxDB point.

make_port_point(*dp_name*, *port_name*, *rcv_time*, *stat_name*, *stat_val*)

Make an InfluxDB point about a port measurement.

ship_error_prefix = 'error shipping points: '

ship_points(*points*)

Make a connection to InfluxDB and ship points.

faucet.gauge_pollers module

Library for polling dataplanes for statistics.

class faucet.gauge_pollers.**GaugeFlowTablePoller**(*conf*, *logname*, *prom_client*)

Bases: *faucet.gauge_pollers.GaugeThreadPoller*

Periodically dumps the current datapath flow table as a yaml object.

Includes a timestamp and a reference ($DATAPATHNAME-flowtables). The flow table is dumped as an OFFlowStatsReply message (in yaml format) that matches all flows.

send_req()

Send a stats request to a datapath.

class faucet.gauge_pollers.**GaugeMeterStatsPoller**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugeThreadPoller*

Poll for all meter stats.

send_req()
Send a stats request to a datapath.

class faucet.gauge_pollers.**GaugePoller**(*conf*, *logname*, *prom_client*)
Bases: object

Abstraction for a poller for statistics.

static is_active()
Return True if the poller is controlling the request loop for its stat

no_response()
Called when a polling cycle passes without receiving a response.

report_dp_status(*dp_status*)
Report DP status.

running()
Return True if the poller is running.

send_req()
Send a stats request to a datapath.

start(*ryudp*, *active*)
Start the poller.

stop()
Stop the poller.

update(*rcv_time*, *msg*)
Handle the responses to requests.

Called when a reply to a stats request sent by this object is received by the controller.

It should acknowledge the receipt by setting self.reply_pending to false.

Parameters

- **rcv_time** – the time the response was received
- **msg** – the stats reply message

class faucet.gauge_pollers.**GaugePortStatePoller**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugePoller*

Abstraction for port state poller.

no_response()
Called when a polling cycle passes without receiving a response.

send_req()
Send a stats request to a datapath.

class faucet.gauge_pollers.**GaugePortStatsPoller**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugeThreadPoller*

Periodically sends a port stats request to the datapath and parses and outputs the response.

send_req()
Send a stats request to a datapath.

class faucet.gauge_pollers.**GaugeThreadPoller**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugePoller*

A ryu thread object for sending and receiving OpenFlow stats requests.

The thread runs in a loop sending a request, sleeping then checking a response was received before sending another request.

The methods send_req, update and no_response should be implemented by subclasses.

is_active()
Return True if the poller is controlling the request loop for its stat

send_req()
Send a stats request to a datapath.

start(*ryudp*, *active*)
Start the poller.

stop()
Stop the poller.

faucet.gauge_prom module

Prometheus for Gauge.

class faucet.gauge_prom.**GaugeFlowTablePrometheusPoller**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugeFlowTablePoller*

Export flow table entries to Prometheus.

update(*rcv_time*, *msg*)
Handle the responses to requests.

Called when a reply to a stats request sent by this object is received by the controller.

It should acknowledge the receipt by setting self.reply_pending to false.

Parameters

- **rcv_time** – the time the response was received
- **msg** – the stats reply message

class faucet.gauge_prom.**GaugeMeterStatsPrometheusPoller**(*conf*, *logger*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugePortStatsPoller*

Exports meter stats to Prometheus.

update(*rcv_time*, *msg*)
Handle the responses to requests.

Called when a reply to a stats request sent by this object is received by the controller.

It should acknowledge the receipt by setting self.reply_pending to false.

Parameters

- **rcv_time** – the time the response was received
- **msg** – the stats reply message

class faucet.gauge_prom.**GaugePortStatePrometheusPoller**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugePortStatePoller*

Export port state changes to Prometheus.

update(*rcv_time*, *msg*)
Handle the responses to requests.

Called when a reply to a stats request sent by this object is received by the controller.

It should acknowledge the receipt by setting self.reply_pending to false.

Parameters

- **rcv_time** – the time the response was received
- **msg** – the stats reply message

class faucet.gauge_prom.**GaugePortStatsPrometheusPoller**(*conf*, *logger*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugePortStatsPoller*

Exports port stats to Prometheus.

update(*rcv_time*, *msg*)
Handle the responses to requests.

Called when a reply to a stats request sent by this object is received by the controller.

It should acknowledge the receipt by setting self.reply_pending to false.

Parameters

- **rcv_time** – the time the response was received
- **msg** – the stats reply message

class faucet.gauge_prom.**GaugePrometheusClient**(*reg=None*)
Bases: *faucet.prom_client.PromClient*

Wrapper for Prometheus client that is shared between all pollers.

reregister_flow_vars(*table_name*, *table_tags*)
Register the flow variables needed for this client

faucet.meter module

Configure meters.

class faucet.meter.**Meter**(*_id*, *dp_id*, *conf*)
Bases: *faucet.conf.Conf*

Implement FAUCET configuration for an OpenFlow meter.

defaults = {'entry': None, 'meter_id': None}

defaults_types = {'entry': <class 'dict'>, 'meter_id': <class 'int'>}

entry = None

entry_msg = None

meter_id = None

faucet.port module

Port configuration.

class faucet.port.**Port**(*_id*, *dp_id*, *conf=None*)
Bases: *faucet.conf.Conf*

Stores state for ports, including the configuration.

check_config()
Check config at instantiation time for errors, typically via assert.

coprocessor_defaults_types = {'strategy': <class 'str'>, 'vlan_vid_base': <class 'int

defaults = {'acl_in': None, 'acls_in': None, 'coprocessor': {}, 'description': Non

defaults_types = {'acl_in': (<class 'str'>, <class 'int'>), 'acls_in': <class 'list'

finalize()
Configuration parsing marked complete.

hosts(*vlans=None*)
Return all host cache entries this port has learned (on all or specified VLANs).

hosts_count(*vlans=None*)
Return count of all hosts this port has learned (on all or specified VLANs).

is_stack_admin_down()
Return True if port is in ADMIN_DOWN state.

is_stack_down()
Return True if port is in DOWN state.

is_stack_init()
Return True if port is in INIT state.

is_stack_up()
Return True if port is in UP state.

lldp_beacon_defaults_types = {'enable': <class 'bool'>, 'org_tlvs': <class 'list'>,

lldp_beacon_enabled()
Return True if LLDP beacon enabled on this port.

lldp_org_tlv_defaults_types = {'info': (<class 'str'>, <class 'bytearray'>), 'oui':

mirror_actions()
Return OF actions to mirror this port.

running()
Return True if port enabled and up.

set_defaults()
Set default values and run any basic sanity checks.

stack_admin_down()
Change the current stack state to ADMIN_DOWN.

stack_defaults_types = {'dp': <class 'str'>, 'port': (<class 'str'>, <class 'int'>)}

stack_descr()
"Return stacking annotation if this is a stacking port.

stack_down()
Change the current stack state to DOWN.

stack_init()
Change the current stack state to INIT_DOWN.

stack_up()
Change the current stack state to UP.

vlans()
Return all VLANs this port is in.

faucet.prom_client module

Implement Prometheus client.

class faucet.prom_client.**PromClient**(*reg=None*)
Bases: object

Prometheus client.

REQUIRED_LABELS = ['dp_id', 'dp_name']

start(*prom_port*, *prom_addr*, *use_test_thread=False*)
Start webserver.

faucet.prom_client.**make_wsgi_app**(*registry*)
Create a WSGI app which serves the metrics from a registry.

faucet.router module

Configure routing between VLANs.

class faucet.router.**Router**(*_id*, *dp_id*, *conf*)
Bases: *faucet.conf.Conf*

Implement FAUCET configuration for a router.

bgp_as()
Return BGP AS.

bgp_connect_mode()
Return BGP connect mode.

bgp_defaults_types = {'as': <class 'int'>, 'connect_mode': <class 'str'>, 'neighbor_

bgp_ipvs()
Return list of IP versions for BGP configured on this VLAN.

bgp_neighbor_addresses()
Return BGP neighbor addresses.

bgp_neighbor_addresses_by_ipv(*ipv*)
Return BGP neighbor addresses with specified IP version on this VLAN.

bgp_neighbor_as()
Return BGP neighbor AS number.

bgp_port()
Return BGP port.

bgp_routerid()
Return BGP router ID.

bgp_server_addresses()
Return BGP server addresses.

bgp_server_addresses_by_ipv(*ipv*)
Return BGP server addresses with specified IP version on this VLAN.

bgp_vlan()
Return BGP VLAN.

check_config()
Check config at instantiation time for errors, typically via assert.

defaults = {'bgp': {}, 'vlans': None}

defaults_types = {'bgp': <class 'dict'>, 'vlans': <class 'list'>}

finalize()
Configuration parsing marked complete.

ipaddress_fields = ('neighbor_addresses', 'server_addresses')

set_bgp_vlan(*vlan*)
Set BGP VLAN.

set_defaults(*defaults=None*, *conf=None*)
Set default values and run any basic sanity checks.

vip_map(*ipa*)
Return VIP for IP address, if any.

faucet.tfm_pipeline module

Configure switch tables with TFM messages.

faucet.tfm_pipeline.**fill_required_properties**(*new_table*)
Ensure TFM has all required properties.

faucet.tfm_pipeline.**init_table**(*table_id*, *name*, *max_entries*, *metadata_match*, *metadata_write*)
Initialize a TFM.

faucet.tfm_pipeline.**load_tables**(*dp*, *valve_cl*, *max_table_id*, *min_max_flows*, *use_oxm_ids*, *fill_req*)
Configure switch tables with TFM messages.

faucet.valve module

Implementation of Valve learning layer 2/3 switch.

class faucet.valve.**AlliedTelesis**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: *faucet.valve.OVSValve*

Valve implementation for AT.

DEC_TTL = False

acl_manager

dot1x

dp

flood_manager

host_manager

logger

logname

metrics

notifier

ofchannel_logger

pipeline

recent_ofmsgs

class faucet.valve.**ArubaValve**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: *faucet.valve.TfmValve*

Valve implementation for Aruba.

DEC_TTL = False

FILL_REQ = False

acl_manager

dot1x

dp

flood_manager

host_manager

logger

logname

metrics

notifier

ofchannel_logger

pipeline

recent_ofmsgs

class faucet.valve.**CiscoC9KValve**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: *faucet.valve.TfmValve*

Valve implementation for C9K.

acl_manager

dot1x

dp

flood_manager

host_manager

logger

logname

metrics

notifier

ofchannel_logger

pipeline

recent_ofmsgs

class faucet.valve.**NoviFlowValve**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: *faucet.valve.Valve*

Valve implementation for NoviFlow with static pipeline.

STATIC_TABLE_IDS = True

USE_BARRIERS = True

acl_manager

dot1x

dp

flood_manager

host_manager

logger

logname

metrics

notifier

ofchannel_logger

pipeline

recent_ofmsgs

class faucet.valve.**OVSTfmValve**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: *faucet.valve.TfmValve*

Valve implementation for OVS.

MAX_TABLE_ID = 253

MIN_MAX_FLOWS = 1000000

USE_BARRIERS = False

USE_OXM_IDS = False

acl_manager

dot1x

dp

flood_manager

host_manager

logger

logname

metrics

notifier

ofchannel_logger

pipeline

recent_ofmsgs

class faucet.valve.**OVSValve**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: *faucet.valve.Valve*

Valve implementation for OVS.

USE_BARRIERS = False

acl_manager

dot1x

dp

flood_manager

host_manager

logger

logname

metrics

notifier

ofchannel_logger

pipeline

recent_ofmsgs

class faucet.valve.**TfmValve**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: *faucet.valve.Valve*

Valve implementation that uses OpenFlow send table features messages.

FILL_REQ = True

MAX_TABLE_ID = 0

MIN_MAX_FLOWS = 0

USE_OXM_IDS = True

acl_manager

dot1x

dp

flood_manager

host_manager

logger

logname

metrics

notifier

ofchannel_logger

pipeline

recent_ofmsgs

class faucet.valve.**Valve**(*dp*, *logname*, *metrics*, *notifier*, *dot1x*)
Bases: object

Generates the messages to configure a datapath as a l2 learning switch.

Vendor specific implementations may require sending configuration flows. This can be achieved by inheriting from this class and overwriting the function switch_features.

DEC_TTL = True

GROUPS = True

STATIC_TABLE_IDS = False

USE_BARRIERS = True

acl_manager

add_dot1x_native_vlan(*port_num*, *vlan_name*)

add_route(*vlan*, *ip_gw*, *ip_dst*)
Add route to VLAN routing table.

advertise(*now*, *_other_values*)
Called periodically to advertise services (eg. IPv6 RAs).

close_logs()
Explicitly close any active loggers.

datapath_connect(*now*, *discovered_up_ports*)
Handle Ryu datapath connection event and provision pipeline.

Parameters

- **now** (*float*) – current epoch time.
- **discovered_up_ports** (*set*) – datapath port numbers that are up.

Returns OpenFlow messages to send to datapath.

Return type list

datapath_disconnect()
Handle Ryu datapath disconnection event.

del_dot1x_native_vlan(*port_num*)

del_route(*vlan*, *ip_dst*)
Delete route from VLAN routing table.

dot1x

dot1x_event(*event_dict*)

dp

dp_init(*new_dp=None*)
Initialize datapath state at connection/re/config time.

fast_advertise(*now*, *_other_valves*)
Called periodically to send LLDP/LACP packets.

fast_state_expire(*now*, *other_valves*)
Called periodically to verify the state of stack ports.

flood_manager

floods_to_root()
Return True if our dp floods (only) to root switch

flow_timeout(*now*, *table_id*, *match*)
Call flow timeout message handler:

Parameters

- **now** (*float*) – current epoch time.
- **table_id** (*int*) – ID of table where flow was installed.
- **match** (*dict*) – match conditions for expired flow.

Returns OpenFlow messages, if any.

Return type list

get_config_dict()
Return datapath config as a dict for experimental API.

get_tunnel_flowmods()
Returns flowmods for the tunnels

host_manager

lacp_down(*port*, *cold_start=False*)
Return OpenFlow messages when LACP is down on a port.

lacp_handler(*now*, *pkt_meta*)
Handle a LACP packet.

We are a currently a passive, non-aggregateable LACP partner.

Parameters

- **now** (*float*) – current epoch time.
- **pkt_meta** (PacketMeta) – packet for control plane.

Returns OpenFlow messages, if any by Valve.

Return type dict

lacp_up(*port*)
Return OpenFlow messages when LACP is up on a port.

learn_host(*now*, *pkt_meta*, *other_valves*)
Possibly learn a host on a port.

Parameters

- **now** (*float*) – current epoch time.
- **pkt_meta** (PacketMeta) – PacketMeta instance for packet received.
- **other_valves** (*list*) – all Valves other than this one.

Returns OpenFlow messages, if any.

Return type list

lldp_handler(*now*, *pkt_meta*, *other_valves*)
Handle an LLDP packet.

Parameters **pkt_meta** (PacketMeta) – packet for control plane.

logger

logname

metrics

notifier

notify(*event_dict*)
Send an event notification.

ofchannel_log(*ofmsgs*)
Log OpenFlow messages in text format to debugging log.

ofchannel_logger

ofdescstats_handler(*body*)
Handle OF DP description.

oferror(*msg*)
Correlate OFError message with flow we sent, if any.

Parameters **msg** (*ryu.controller.ofp_event.EventOFPMsgBase*) – message from datapath.

parse_pkt_meta(*msg*)
Parse OF packet-in message to PacketMeta.

parse_rcv_packet(*in_port*, *vlan_vid*, *eth_type*, *data*, *orig_len*, *pkt*, *eth_pkt*, *vlan_pkt*)
Parse a received packet into a PacketMeta instance.

Parameters

- **in_port** (*int*) – port packet was received on.
- **vlan_vid** (*int*) – VLAN VID of port packet was received on.
- **eth_type** (*int*) – Ethernet type of packet.
- **data** (*bytes*) – Raw packet data.
- **orig_len** (*int*) – Original length of packet.
- **pkt** (*ryu.lib.packet.packet*) – parsed packet received.
- **ekt_pkt** (*ryu.lib.packet.ethernet*) – parsed Ethernet header.
- **vlan_pkt** (*ryu.lib.packet.vlan*) – parsed VLAN Ethernet header.

Returns PacketMeta instance.

pipeline

port_add(*port_num*)
Handle addition of a single port.

Parameters **port_num** (*list*) – list of port numbers.

Returns OpenFlow messages, if any.

Return type list

port_delete(*port_num*)
Return flow messages that delete port from pipeline.

port_status_handler(*port_no*, *reason*, *state*, *_other_valves*)
Return OpenFlow messages responding to port operational status change.

ports_add(*port_nums*, *cold_start=False*, *log_msg='up'*)
Handle the addition of ports.

Parameters

- **port_num** (*list*) – list of port numbers.
- **cold_start** (*bool*) – True if configuring datapath from scratch.

Returns OpenFlow messages, if any.

Return type list

ports_delete(*port_nums*, *log_msg='down'*)
Handle the deletion of ports.

Parameters **port_nums** (*list*) – list of port numbers.

Returns OpenFlow messages, if any.

Return type list

prepare_send_flows(*flow_msgs*)
Prepare to send flows to datapath.

Parameters **flow_msgs** (*list*) – OpenFlow messages to send.

rate_limit_packet_ins(*now*)
Return True if too many packet ins this second.

rcv_packet(*now*, *other_valves*, *pkt_meta*)
Handle a packet from the dataplane (eg to re/learn a host).

The packet may be sent to us also in response to FAUCET initiating IPv6 neighbor discovery, or ARP, to resolve a nexthop.

Parameters

- **other_valves** (*list*) – all Valves other than this one.
- **pkt_meta** (PacketMeta) – packet for control plane.

Returns OpenFlow messages, if any by Valve.

Return type dict

recent_ofmsgs

reload_config(*_now*, *new_dp*)
Reload configuration new_dp.

Following config changes are currently supported:

- **Port config: support all available configs** (e.g. native_vlan, acl_in) & change operations (add, delete, modify) a port
- **ACL config:support any modification, currently reload all** rules belonging to an ACL
- VLAN config: enable, disable routing, etc...

Parameters

- **now** (*float*) – current epoch time.
- **new_dp** (DP) – new dataplane configuration.

Returns OpenFlow messages.

Return type ofmsgs (list)

resolve_gateways(*now*, *_other_valves*)
Call route managers to re/resolve gateways.

Returns OpenFlow messages, if any by Valve.

Return type dict

router_learn_host(*pkt_meta*)
Add L3 forwarding rule.

Parameters **pkt_meta** (PacketMeta) – PacketMeta instance for packet received.

Returns OpenFlow messages, if any.

Return type list

router_rcv_packet(*now*, *pkt_meta*)
Process packets destined for router or run resolver.

Parameters

- **now** (*float*) – current epoch time.
- **pkt_meta** (PacketMeta) – packet for control plane.

Returns OpenFlow messages.

Return type list

router_vlan_for_ip_gw(*vlan*, *ip_gw*)

send_flows(*ryu_dp*, *flow_msgs*)
Send flows to datapath (or disconnect an OF session).

Parameters

- **ryu_dp** (*ryu.controller.controller.Datapath*) – datapath.
- **flow_msgs** (*list*) – OpenFlow messages to send.

state_expire(*now*, *other_valves*)
Expire controller caches/state (e.g. hosts learned).

Parameters

- **now** (*float*) – current epoch time.
- **other_valves** (*list*) – all Valves other than this one.

Returns OpenFlow messages, if any by Valve.

Return type dict

switch_features(*_msg*)
Send configuration flows necessary for the switch implementation.

Parameters **msg** (*OFPSwitchFeatures*) – msg sent from switch.

Vendor specific configuration should be implemented here.

update_config_metrics()
Update table names for configuration.

update_metrics(*now*, *updated_port=None*, *rate_limited=False*)
Update Gauge/metrics.

update_tunnel_flowrules()
Update tunnel ACL rules because the stack topology has changed

class faucet.valve.**ValveLogger**(*logger*, *dp_id*, *dp_name*)
Bases: object

Logger for a Valve that adds DP ID.

debug(*log_msg*)
Log debug level message.

error(*log_msg*)
Log error level message.

info(*log_msg*)
Log info level message.

warning(*log_msg*)
Log warning level message.

faucet.valve.**valve_factory**(*dp*)
Return a Valve object based dp's hardware configuration field.

Parameters **dp** (DP) – DP instance with the configuration for this Valve.

faucet.valve_acl module

Compose ACLs on ports.

class faucet.valve_acl.**ValveAclManager**(*port_acl_table*, *vlan_acl_table*, *egress_acl_table*, *pipeline*, *meters*, *dp_acls=None*)
Bases: *faucet.valve_manager_base.ValveManagerBase*

Handle installation of ACLs on a DP

add_authed_mac(*port_num*, *mac*)
Add authed mac address

add_port(*port*)
Install port acls if configured

add_port_acl(*acl*, *port_num*, *mac=None*)
Create ACL openflow rules for Port

add_vlan(*vlan*)
Install vlan acls if configured

cold_start_port(*port*)
Reload acl for a port by deleting existing rules and calling add_port

create_acl_tunnel(*dp*)
Create tunnel acls from ACLs that require applying in DP Returns flowmods for the tunnel :param dp: DP that contains the tunnel acls to build :type dp: DP

create_dot1x_flow_pair(*port_num*, *nfv_sw_port_num*, *mac*)
Create dot1x flow pair

create_mab_flow(*port_num*, *nfv_sw_port_num*, *mac*)

Create MAB ACL for sending IP Activity to Chewie NFV Returns flowmods to send all IP traffic to Chewie

Parameters

- **port_num** (*int*) – Number of port in

- **nfv_sw_port_num** (*int*) – Number of port out
- **mac** (*str*) – MAC address of the valve/port combo

del_authed_mac(*port_num*, *mac=None*, *strict=True*)
remove authed mac address

del_dot1x_flow_pair(*port_num*, *nfv_sw_port_num*, *mac*)
Deletes dot1x flow pair

del_mab_flow(*port_num*, *nfv_sw_port_num*, *mac*)

Remove MAB ACL for sending IP Activity to Chewie NFV Returns flowmods to send all IP traffic to Chewie

Parameters

- **port_num** (*int*) – Number of port in
- **nfv_sw_port_num** (*int*) – Number of port out
- **mac** (*str*) – MAC address of the valve/port combo

del_port_acl(*acl*, *port_num*, *mac=None*)
Delete ACL rules for Port

initialise_tables()
Install dp acls if configured

faucet.valve_acl.**add_mac_address_to_match**(*match*, *eth_src*)
Add or change the value of a match type

faucet.valve_acl.**build_acl_entry**(*acl_table*, *rule_conf*, *meters*, *acl_allow_inst*, *acl_force_port_vlan_inst*, *port_num=None*, *vlan_vid=None*)
Build flow/groupmods for one ACL rule entry.

faucet.valve_acl.**build_acl_ofmsgs**(*acls*, *acl_table*, *acl_allow_inst*, *acl_force_port_vlan_inst*, *highest_priority*, *meters*, *exact_match*, *port_num=None*, *vlan_vid=None*)
Build flow/groupmods for all entries in an ACL.

faucet.valve_acl.**build_acl_port_of_msgs**(*acl*, *vid*, *port_num*, *acl_table*, *goto_table*, *priority*)
A Helper function for building Openflow Mod Messages for Port ACLs

faucet.valve_acl.**build_output_actions**(*acl_table*, *output_dict*)
Implement actions to alter packet/output.

faucet.valve_acl.**push_vlan**(*acl_table*, *vlan_vid*)
Push a VLAN tag with optional selection of eth type.

faucet.valve_acl.**rewrite_vlan**(*acl_table*, *output_dict*)
Implement actions to rewrite VLAN headers.

faucet.valve_flood module

Manage flooding to ports on VLANs.

class faucet.valve_flood.**ValveFloodManager**(*logger*, *flood_table*, *pipeline*, *use_group_table*, *groups*, *combinatorial_port_flood*, *canonical_port_order*, *restricted_bcast_arpnd*)
Bases: *faucet.valve_manager_base.ValveManagerBase*

Implement dataplane based flooding for standalone dataplanes.

FLOOD_DSTS = ((True, None, None, None), (False, None, '01:80:c2:00:00:00', 'ff:ff:ff:0

RESTRICTED_FLOOD_DISTS = ((False, 2054, 'ff:ff:ff:ff:ff:ff', 'ff:ff:ff:ff:ff:ff'), (Fa

add_vlan(*vlan*)
install flows in response to a new VLAN

build_flood_rules(*vlan*, *modify=False*)
Add flows to flood packets to unknown destinations on a VLAN.

del_vlan(*vlan*)
delete flows in response to a VLAN removal

static edge_learn_port(*_other_valves*, *pkt_meta*)
Possibly learn a host on a port.

Parameters

- **other_valves** (*list*) – All Valves other than this one.
- **pkt_meta** (PacketMeta) – PacketMeta instance for packet received.

Returns port to learn host on.

floods_to_root(*_dp_obj*)
Return True if the given dp floods (only) to root switch

initialise_tables()
Initialise the flood table with filtering flows.

static update_stack_topo(*event*, *dp*, *port=None*)
Update the stack topology. It has nothing to do for non-stacking DPs.

update_vlan(*vlan*)
flows in response to updating an existing VLAN.

class faucet.valve_flood.**ValveFloodStackManagerBase**(*logger*, *flood_table*, *pipeline*, *use_group_table*, *groups*, *combinatorial_port_flood*, *canonical_port_order*, *restricted_bcast_arpnd*, *stack_ports*, *has_externals*, *dp_shortest_path_to_root*, *shortest_path_port*, *is_stack_root*, *is_stack_root_candidate*, *is_stack_edge*, *graph*)

Bases: *faucet.valve_flood.ValveFloodManager*

Base class for dataplane based flooding on stacked dataplanes.

edge_learn_port(*other_valves*, *pkt_meta*)
Find a port towards the edge DP where the packet originated from

Parameters

- **other_valves** (*list*) – All Valves other than this one.
- **pkt_meta** (PacketMeta) – PacketMeta instance for packet received.

Returns port to learn host on, or None.

update_stack_topo(*event*, *dp*, *port=None*)
Update the stack topo according to the event.

class faucet.valve_flood.**ValveFloodStackManagerNoReflection**(*logger*, *flood_table*, *pipeline*, *use_group_table*, *groups*, *combinatorial_port_flood*, *canonical_port_order*, *restricted_bcast_arpnd*, *stack_ports*, *has_externals*, *dp_shortest_path_to_root*, *shortest_path_port*, *is_stack_root*, *is_stack_root_candidate*, *is_stack_edge*, *graph*)

Bases: *faucet.valve_flood.ValveFloodStackManagerBase*

Stacks of size 2 - all switches directly connected to root.

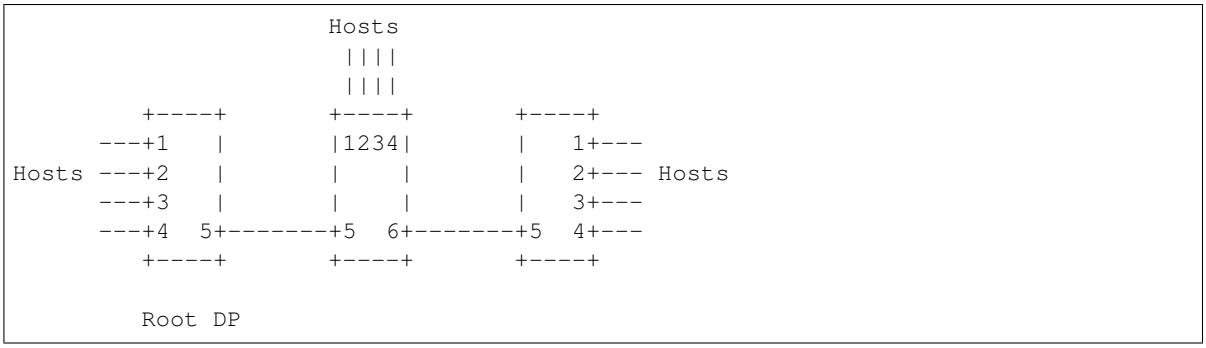
Root switch simply floods to all other switches.

Non-root switches simply flood to the root.

class faucet.valve_flood.**ValveFloodStackManagerReflection**(*logger*, *flood_table*, *pipeline*, *use_group_table*, *groups*, *combinatorial_port_flood*, *canonical_port_order*, *restricted_bcast_arpnd*, *stack_ports*, *has_externals*, *dp_shortest_path_to_root*, *shortest_path_port*, *is_stack_root*, *is_stack_root_candidate*, *is_stack_edge*, *graph*)

Bases: *faucet.valve_flood.ValveFloodStackManagerBase*

Stacks size > 2 reflect floods off of root (selective flooding).



Non-root switches flood only to the root. The root switch reflects incoming floods back out. Non-root switches flood packets from the root locally and to switches further away from the root. Flooding is entirely implemented in the dataplane.

A host connected to a non-root switch can receive a copy of its own flooded packet (because the non-root switch does not know it has seen the packet already).

A host connected to the root switch does not have this problem (because flooding is always away from the root). Therefore, connections to other non-FAUCET stacking networks should only be made to the root.

On the root switch (left), flood destinations are:

1: 2 3 4 5(s) 2: 1 3 4 5(s) 3: 1 2 4 5(s) 4: 1 2 3 5(s) 5: 1 2 3 4 5(s, note reflection)

On the middle switch:

1: 5(s) 2: 5(s) 3: 5(s) 4: 5(s) 5: 1 2 3 4 6(s) 6: 5(s)

On the rightmost switch:

1: 5(s) 2: 5(s) 3: 5(s) 4: 5(s) 5: 1 2 3 4

faucet.valve_host module

Manage host learning on VLANs.

class faucet.valve_host.**ValveHostFlowRemovedManager**(*logger*, *ports*, *vlans*, *eth_src_table*, *eth_dst_table*, *eth_dst_hairpin_table*, *pipeline*, *learn_timeout*, *learn_jitter*, *learn_ban_timeout*, *cache_update_guard_time*, *idle_dst*, *stack*, *has_externals*, *stack_root_flood_reflection*)

Bases: *faucet.valve_host.ValveHostManager*

Trigger relearning on flow removed notifications.

Note: not currently reliable.

---

expire_hosts_from_vlan(*_vlan*, *_now*)
Expire hosts from VLAN cache.

flow_timeout(*now*, *table_id*, *match*)
Handle a flow timed out message from dataplane.

learn_host_timeouts(*port*, *eth_src*)
Calculate flow timeouts for learning on a port.

class faucet.valve_host.**ValveHostManager**(*logger*, *ports*, *vlans*, *eth_src_table*, *eth_dst_table*, *eth_dst_hairpin_table*, *pipeline*, *learn_timeout*, *learn_jitter*, *learn_ban_timeout*, *cache_update_guard_time*, *idle_dst*, *stack*, *has_externals*, *stack_root_flood_reflection*)

Bases: *faucet.valve_manager_base.ValveManagerBase*

Manage host learning on VLANs.

add_port(*port*)
install flows in response to a new port

ban_rules(*pkt_meta*)
Limit learning to a maximum configured on this port/VLAN.

Parameters **pkt_meta** – PacketMeta instance.

Returns OpenFlow messages, if any.

Return type list

del_port(*port*)
delete flows in response to a port removal

delete_host_from_vlan(*eth_src*, *vlan*)
Delete a host from a VLAN.

expire_hosts_from_vlan(*vlan*, *now*)
Expire hosts from VLAN cache.

flow_timeout(*_now*, *_table_id*, *_match*)
Handle a flow timed out message from dataplane.

initialise_tables()
initialise tables controlled by this manager.

learn_host_intervlan_routing_flows(*port*, *vlan*, *eth_src*, *eth_dst*)

Returns flows for the eth_src_table that enable packets that have been routed to be accepted from an adjacent DP and then switched to the destination. Eth_src_table flow rule to match on port, eth_src, eth_dst and vlan

Parameters

- **port** (Port) – Port to match on.
- **vlan** (VLAN) – VLAN to match on
- **eth_src** – source MAC address (should be the router MAC)
- **eth_dst** – destination MAC address

learn_host_on_vlan_port_flows(*port*, *vlan*, *eth_src*, *delete_existing*, *refresh_rules*, *src_rule_idle_timeout*, *src_rule_hard_timeout*, *dst_rule_idle_timeout*)
Return flows that implement learning a host on a port.

learn_host_on_vlan_ports(*now*, *port*, *vlan*, *eth_src*, *delete_existing=True*, *last_dp_coldstart_time=None*)
Learn a host on a port.

learn_host_timeouts(*port*, *eth_src*)
Calculate flow timeouts for learning on a port.

faucet.valve_manager_base module

Valve Manager base class

class faucet.valve_manager_base.**ValveManagerBase**
Bases: object

Base class for ValveManager objects.

Expected to control the installation of flows into datapath tables.

Ideally each datapath table should be controlled by 1 manager only.

add_port(*port*)
install flows in response to a new port

add_vlan(*vlan*)
install flows in response to a new VLAN

del_port(*port*)
delete flows in response to a port removal

del_vlan(*vlan*)
delete flows in response to a VLAN removal

initialise_tables()
initialise tables controlled by this manager.

update_vlan(*vlan*)
flows in response to updating an existing VLAN.

faucet.valve_of module

Utility functions to parse/create OpenFlow messages.

faucet.valve_of.**apply_actions**(*actions*)
Return instruction that applies action list.

Parameters **actions** (*list*) – list of OpenFlow actions.

Returns instruction of actions.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPInstruction

faucet.valve_of.**apply_meter**(*meter_id*)
Return instruction to apply a meter.

faucet.valve_of.**barrier**()
Return OpenFlow barrier request.

Returns barrier request.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPBarrierRequest

faucet.valve_of.**bucket**(*weight=0*, *watch_port=4294967295*, *watch_group=4294967295*, *actions=None*)
Return a group action bucket with provided actions.

faucet.valve_of.**build_group_flood_buckets**(*vlan_flood_acts*)
Return a list of group buckets to implement flooding on a VLAN.

faucet.valve_of.**build_match_dict**(*in_port=None*, *vlan=None*, *eth_type=None*, *eth_src=None*, *eth_dst=None*, *eth_dst_mask=None*, *icmpv6_type=None*, *nw_proto=None*, *nw_dst=None*, *metadata=None*, *metadata_mask=None*, *vlan_pcp=None*, *udp_src=None*, *udp_dst=None*)

faucet.valve_of.**controller_pps_meteradd**(*datapath=None*, *pps=0*)
Add a PPS meter towards controller.

faucet.valve_of.**controller_pps_meterdel**(*datapath=None*)
Delete a PPS meter towards controller.

faucet.valve_of.**dec_ip_ttl**()
Return OpenFlow action to decrement IP TTL.

Returns decrement IP TTL.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionDecNwTtl

faucet.valve_of.**dedupe_ofmsgs**(*input_ofmsgs*)
Return deduplicated ofmsg list.

faucet.valve_of.**dedupe_output_port_acts**(*output_port_acts*)
Deduplicate parser.OFPActionOutputs (because Ryu doesn't define __eq__).

Parameters **of ryu.ofproto.ofproto_v1_3_parser.OFPActionOutput** (*list*) – output to port actions.

Returns output to port actions.

Return type list of ryu.ofproto.ofproto_v1_3_parser.OFPActionOutput

faucet.valve_of.**desc_stats_request**(*datapath=None*)
Query switch description.

faucet.valve_of.**devid_present**(*vid*)
Return VLAN VID without VID_PRESENT flag set.

Parameters **vid** (*int*) – VLAN VID with VID_PRESENT.

Returns VLAN VID.

Return type int

faucet.valve_of.**faucet_async**(*datapath=None*, *notify_flow_removed=False*, *packet_in=True*, *port_status=True*)
Return async message config for FAUCET/Gauge

faucet.valve_of.**faucet_config**(*datapath=None*)
Return switch config for FAUCET.

faucet.valve_of.**flood_port_outputs**(*tagged_ports*, *untagged_ports*, *in_port=None*, *exclude_ports=None*)
Return actions for both tagged and untagged ports.

faucet.valve_of.**flood_tagged_port_outputs**(*ports*, *in_port=None*, *exclude_ports=None*)
Return list of actions necessary to flood to list of tagged ports.

faucet.valve_of.**flood_untagged_port_outputs**(*ports*, *in_port=None*, *exclude_ports=None*)
Return list of actions necessary to flood to list of untagged ports.

faucet.valve_of.**flowmod**(*cookie*, *command*, *table_id*, *priority*, *out_port*, *out_group*, *match_fields*, *inst*, *hard_timeout*, *idle_timeout*, *flags=0*)

faucet.valve_of.**goto_table**(*table*)
Return instruction to goto table.

Parameters **table** (ValveTable) – table to goto.

Returns goto instruction.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPInstruction

faucet.valve_of.**group_act**(*group_id*)
Return an action to run a group.

faucet.valve_of.**groupadd**(*datapath=None*, *type_=0*, *group_id=0*, *buckets=None*)
Add a group.

faucet.valve_of.**groupadd_ff**(*datapath=None*, *group_id=0*, *buckets=None*)
Add a fast failover group.

faucet.valve_of.**groupdel**(*datapath=None*, *group_id=4294967292*)
Delete a group (default all groups).

faucet.valve_of.**groupmod**(*datapath=None*, *type_=0*, *group_id=0*, *buckets=None*)
Modify a group.

faucet.valve_of.**groupmod_ff**(*datapath=None*, *group_id=0*, *buckets=None*)
Modify a fast failover group.

faucet.valve_of.**ignore_port**(*port_num*)
Return True if FAUCET should ignore this port.

Parameters **port_num** (*int*) – switch port.

Returns True if FAUCET should ignore this port.

Return type bool

faucet.valve_of.**is_apply_actions**(*instruction*)
Return True if an apply action.

Parameters **instruction** – OpenFlow instruction.

Returns True if an apply action.

Return type bool

faucet.valve_of.**is_flowdel**(*ofmsg*)
Return True if flow message is a FlowMod and a delete.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a FlowMod delete/strict.

Return type bool

faucet.valve_of.**is_flowmod**(*ofmsg*)
Return True if flow message is a FlowMod.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a FlowMod

Return type bool

faucet.valve_of.**is_global_flowdel**(*ofmsg*)
Is a delete of all flows in all tables.

faucet.valve_of.**is_global_groupdel**(*ofmsg*)
Is a delete of all groups.

faucet.valve_of.**is_global_meterdel**(*ofmsg*)
Is a delete of all meters.

faucet.valve_of.**is_groupadd**(*ofmsg*)
Return True if OF message is a GroupMod and command is add.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a GroupMod add

Return type bool

faucet.valve_of.**is_groupdel**(*ofmsg*)
Return True if OF message is a GroupMod and command is delete.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a GroupMod delete

Return type bool

faucet.valve_of.**is_groupmod**(*ofmsg*)
Return True if OF message is a GroupMod.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a GroupMod

Return type bool

faucet.valve_of.**is_meter**(*instruction*)
Return True if a meter.

Parameters **instruction** – OpenFlow instruction.

Returns True if a meter.

Return type bool

faucet.valve_of.**is_meteradd**(*ofmsg*)
Return True if OF message is a MeterMod and command is add.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a MeterMod add

Return type bool

faucet.valve_of.**is_meterdel**(*ofmsg*)
Return True if OF message is a MeterMod and command is delete.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a MeterMod delete

Return type bool

faucet.valve_of.**is_metermod**(*ofmsg*)
Return True if OF message is a MeterMod.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a MeterMod

Return type bool

faucet.valve_of.**is_output**(*ofmsg*)
Return True if flow message is an action output message.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a OFPActionOutput.

Return type bool

faucet.valve_of.**is_packetout**(*ofmsg*)
Return True if OF message is a PacketOut

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a PacketOut

Return type bool

faucet.valve_of.**is_set_field**(*action*)

faucet.valve_of.**is_table_features_req**(*ofmsg*)
Return True if flow message is a TFM req.

Parameters **ofmsg** – ryu.ofproto.ofproto_v1_3_parser message.

Returns True if is a TFM req.

Return type bool

faucet.valve_of.**match**(*match_fields*)
Return OpenFlow matches from dict.

Parameters **match_fields** (*dict*) – match fields and values.

Returns matches.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPMatch

faucet.valve_of.**match_from_dict**(*match_dict*)

faucet.valve_of.**metadata_goto_table**(*metadata*, *mask*, *table*)
Return instructions to write metadata and goto table.

Parameters

- **metadata** (*int*) – metadata to write to packet
- **maks** (*int*) – mask to apply to metadata
- **table** (ValveTable) – table to goto.

Returns list of OFPInstructions

faucet.valve_of.**meteradd**(*meter_conf*)
Add a meter based on YAML configuration.

faucet.valve_of.**meterdel**(*datapath=None*, *meter_id=4294967295*)
Delete a meter (default all meters).

faucet.valve_of.**output_controller**(*max_len=194*)
Return OpenFlow action to packet in to the controller.

Parameters **max_len** (*int*) – max number of bytes from packet to output.

Returns packet in action.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionOutput

faucet.valve_of.**output_in_port**()
Return OpenFlow action to output out input port.

Returns ryu.ofproto.ofproto_v1_3_parser.OFPActionOutput.

faucet.valve_of.**output_port**(*port_num*, *max_len=0*)
Return OpenFlow action to output to a port.

Parameters

- **port_num** (*int*) – port to output to.
- **max_len** (*int*) – maximum length of packet to output (default no maximum).

Returns output to port action.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionOutput

faucet.valve_of.**packetout**(*port_num*, *data*)
Return OpenFlow action to packet out to dataplane from controller.

Parameters

- **port_num** (*int*) – port to output to.
- **data** (*str*) – raw packet to output.

Returns packet out action.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionOutput

faucet.valve_of.**packetouts**(*port_nums*, *data*)
Return OpenFlow action to mulltiply packet out to dataplane from controller.

Parameters

- **port_num** (*list*) – ints, ports to output to.
- **data** (*str*) – raw packet to output.

Returns packet out action.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionOutput

faucet.valve_of.**pop_vlan**()
Return OpenFlow action to pop outermost Ethernet 802.1Q VLAN header.

Returns Pop VLAN.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionPopVlan

faucet.valve_of.**port_status_from_state**(*state*)
Return True if OFPPS_LINK_DOWN is not set.

faucet.valve_of.**push_vlan_act**(*table*, *vlan_vid*, *eth_type=33024*)
Return OpenFlow action list to push Ethernet 802.1Q header with VLAN VID.

Parameters **vid** (*int*) – VLAN VID

Returns actions to push 802.1Q header with VLAN VID set.

Return type list

faucet.valve_of.**set_field**(***kwds*)
Return action to set any field.

Parameters **kwds** (*dict*) – exactly one field to set

Returns set field action.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionSetField

faucet.valve_of.**table_features**(*body*)

faucet.valve_of.**valve_flowreorder**(*input_ofmsgs*, *use_barriers=True*)
Reorder flows for better OFA performance.

faucet.valve_of.**valve_match_vid**(*value*)

faucet.valve_of.**vid_present**(*vid*)
Return VLAN VID with VID_PRESENT flag set.

Parameters **vid** (*int*) – VLAN VID

Returns VLAN VID with VID_PRESENT.

Return type int

faucet.valve_of_old module

Deprecated OF matches.

faucet.valve_packet module

Utility functions for parsing and building Ethernet packet/contents.

class faucet.valve_packet.**PacketMeta**(*data*, *orig_len*, *pkt*, *eth_pkt*, *vlan_pkt*, *port*, *valve_vlan*, *eth_src*, *eth_dst*, *eth_type*)

Bases: object

Original, and parsed Ethernet packet metadata.

ETH_TYPES_PARSERS = {2048: (4, <function ipv4_parseable>, <class 'ryu.lib.packet.ipv4

MAX_ETH_TYPE_PKT_SIZE = {2048: 174, 2054: 64}

MIN_ETH_TYPE_PKT_SIZE = {2048: 38, 2054: 46, 34525: 58}

data

eth_dst

eth_pkt

eth_src

eth_type

ip_ver()
Return IP version number.

l3_dst

l3_pkt

l3_src

log()

orig_len

packet_complete()
True if we have the complete packet.

pkt

port

reparse(*max_len*)
Reparse packet using data up to the specified maximum length.

reparse_all()
Reparse packet with all available data.

reparse_ip(*payload=0*)
Reparse packet with specified IP header type and optionally payload.

vlan

vlan_pkt

faucet.valve_packet.**arp_reply**(*vid*, *eth_src*, *eth_dst*, *src_ip*, *dst_ip*)
Return an ARP reply packet.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – Ethernet source address.
- **eth_dst** (*str*) – destination Ethernet MAC address.
- **src_ip** (*ipaddress.IPv4Address*) – source IPv4 address.
- **dst_ip** (*ipaddress.IPv4Address*) – destination IPv4 address.

Returns serialized ARP reply packet.

Return type ryu.lib.packet.arp

faucet.valve_packet.**arp_request**(*vid*, *eth_src*, *eth_dst*, *src_ip*, *dst_ip*)
Return an ARP request packet.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – Ethernet source address.
- **eth_dst** (*str*) – Ethernet destination address.
- **src_ip** (*ipaddress.IPv4Address*) – source IPv4 address.
- **dst_ip** (*ipaddress.IPv4Address*) – requested IPv4 address.

Returns serialized ARP request packet.

Return type ryu.lib.packet.arp

faucet.valve_packet.**build_pkt_header**(*vid*, *eth_src*, *eth_dst*, *dl_type*)
Return an Ethernet packet header.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – source Ethernet MAC address.
- **eth_dst** (*str*) – destination Ethernet MAC address.
- **dl_type** (*int*) – EtherType.

Returns Ethernet packet with header.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**echo_reply**(*vid*, *eth_src*, *eth_dst*, *src_ip*, *dst_ip*, *data*)
Return an ICMP echo reply packet.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – Ethernet source address.
- **eth_dst** (*str*) – destination Ethernet MAC address.
- **src_ip** (*ipaddress.IPv4Address*) – source IPv4 address.
- **dst_ip** (*ipaddress.IPv4Address*) – destination IPv4 address.

Returns serialized ICMP echo reply packet.

Return type ryu.lib.packet.icmp

faucet.valve_packet.**faucet_lldp_stack_state_tlvs**(*dp*, *port*)
Return a LLDP TLV for state of a stack port.

faucet.valve_packet.**faucet_lldp_tlvs**(*dp*)
Return LLDP TLVs for a datapath.

faucet.valve_packet.**faucet_oui**(*mac*)
Return first 3 bytes of MAC address (given as str).

faucet.valve_packet.**faucet_tlvs**(*lldp_pkt*, *faucet_dp_mac*)
Return list of TLVs with FAUCET OUI.

faucet.valve_packet.**icmpv6_echo_reply**(*vid*, *eth_src*, *eth_dst*, *src_ip*, *dst_ip*, *hop_limit*, *id_*, *seq*, *data*)
Return IPv6 ICMP echo reply packet.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – source Ethernet MAC address.
- **eth_dst** (*str*) – destination Ethernet MAC address.
- **src_ip** (*ipaddress.IPv6Address*) – source IPv6 address.
- **dst_ip** (*ipaddress.IPv6Address*) – destination IPv6 address.
- **hop_limit** (*int*) – IPv6 hop limit.
- **id_** (*int*) – identifier for echo reply.
- **seq** (*int*) – sequence number for echo reply.
- **data** (*str*) – payload for echo reply.

Returns Serialized IPv6 ICMP echo reply packet.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**int_from_mac**(*mac*)

faucet.valve_packet.**int_in_mac**(*mac*, *to_int*)

faucet.valve_packet.**ipv4_parseable**(*ip_header_data*)
Return True if an IPv4 packet we could parse.

faucet.valve_packet.**ipv6_link_eth_mcast**(*dst_ip*)
Return an Ethernet multicast address from an IPv6 address.

See RFC 2464 section 7.

Parameters **dst_ip** (*ipaddress.IPv6Address*) – IPv6 address.

Returns Ethernet multicast address.

Return type str

faucet.valve_packet.**ipv6_solicited_node_from_ucast**(*ucast*)
Return IPv6 solicited node multicast address from IPv6 unicast address.

See RFC 3513 section 2.7.1.

Parameters **ucast** (*ipaddress.IPv6Address*) – IPv6 unicast address.

Returns IPv6 solicited node multicast address.

Return type ipaddress.IPv6Address

faucet.valve_packet.**lacp_actor_up**(*lacp_pkt*)
Return 1 if remote LACP link is up.

faucet.valve_packet.**lacp_reqreply**(*eth_src*, *actor_system*, *actor_key*, *actor_port*, *actor_state_synchronization=0*, *actor_state_activity=0*, *actor_state_collecting=1*, *actor_state_distributing=1*, *partner_system='00:00:00:00:00:00'*, *partner_key=0*, *partner_port=0*, *partner_system_priority=0*, *partner_port_priority=0*, *partner_state_defaulted=0*, *partner_state_expired=0*, *partner_state_timeout=0*, *partner_state_collecting=0*, *partner_state_distributing=0*, *partner_state_aggregation=0*, *partner_state_synchronization=0*, *partner_state_activity=0*)
Return a LACP frame.

Parameters

- **eth_src** (*str*) – source Ethernet MAC address.
- **actor_system** (*str*) – actor system ID (MAC address)
- **actor_key** (*int*) – actor's LACP key assigned to this port.
- **actor_port** (*int*) – actor port number.
- **actor_state_synchronization** (*int*) – 1 if we will use this link.
- **actor_state_activity** (*int*) – 1 if actively sending LACP.
- **actor_state_collecting** (*int*) – 1 if receiving on this link.
- **actor_state_distibuting** (*int*) – 1 if transmitting on this link.
- **partner_system** (*str*) – partner system ID (MAC address)
- **partner_key** (*int*) – partner's LACP key assigned to this port.
- **partner_port** (*int*) – partner port number.
- **partner_system_priority** (*int*) – partner's system priority.
- **partner_port_priority** (*int*) – partner's port priority.
- **partner_state_defaulted** (*int*) – 1 if partner reverted to defaults.
- **partner_state_expired** (*int*) – 1 if partner thinks LACP expired.
- **partner_state_timeout** (*int*) – 1 if partner has short timeout.
- **partner_state_collecting** (*int*) – 1 if partner receiving on this link.
- **partner_state_distributing** (*int*) – 1 if partner transmitting on this link.
- **partner_state_aggregation** (*int*) – 1 if partner can aggregate this link.
- **partner_state_synchronization** (*int*) – 1 if partner will use this link.
- **partner_state_activity** (*int*) – 1 if partner actively sends LACP.

Returns Ethernet packet with header.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**lldp_beacon**(*eth_src*, *chassis_id*, *port_id*, *ttl*, *org_tlvs=None*, *system_name=None*, *port_descr=None*)
Return an LLDP frame suitable for a host/access port.

Parameters

- **eth_src** (*str*) – source Ethernet MAC address.
- **chassis_id** (*str*) – Chassis ID.
- **port_id** (*int*) – port ID,
- **TTL** (*int*) – TTL for payload.
- **org_tlvs** (*list*) – list of tuples of (OUI, subtype, info).

Returns Ethernet packet with header.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**mac_addr_all_zeros**(*mac_addr*)
Returns True if mac_addr is all zeros.

Parameters **mac_addr** (*str*) – MAC address.

Returns True if all zeros.

Return type bool

faucet.valve_packet.**mac_addr_is_unicast**(*mac_addr*)
Returns True if mac_addr is a unicast Ethernet address.

Parameters **mac_addr** (*str*) – MAC address.

Returns True if a unicast Ethernet address.

Return type bool

faucet.valve_packet.**mac_byte_mask**(*mask_bytes=0*)
Return a MAC address mask with n bytes masked out.

faucet.valve_packet.**mac_mask_bits**(*mac_mask*)
Return number of bits in MAC mask or 0.

faucet.valve_packet.**nd_advert**(*vid*, *eth_src*, *eth_dst*, *src_ip*, *dst_ip*)
Return IPv6 neighbor avertisement packet.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – source Ethernet MAC address.
- **eth_dst** (*str*) – destination Ethernet MAC address.
- **src_ip** (*ipaddress.IPv6Address*) – source IPv6 address.
- **dst_ip** (*ipaddress.IPv6Address*) – destination IPv6 address.

Returns Serialized IPv6 neighbor discovery packet.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**nd_request**(*vid*, *eth_src*, *eth_dst*, *src_ip*, *dst_ip*)
Return IPv6 neighbor discovery request packet.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – source Ethernet MAC address.
- **eth_dst** (*str*) – Ethernet destination address.
- **src_ip** (*ipaddress.IPv6Address*) – source IPv6 address.

- **dst_ip** (*ipaddress.IPv6Address*) – requested IPv6 address.

Returns Serialized IPv6 neighbor discovery packet.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**parse_eth_pkt**(*pkt*)
Return parsed Ethernet packet.

Parameters **pkt** (*ryu.lib.packet.packet*) – packet received from dataplane.

Returns Ethernet packet.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**parse_faucet_lldp**(*lldp_pkt*, *faucet_dp_mac*)
Parse and return FAUCET TLVs from LLDP packet.

faucet.valve_packet.**parse_lacp_pkt**(*pkt*)
Return parsed LACP packet.

Parameters **pkt** (*ryu.lib.packet.packet*) – packet received from dataplane.

Returns LACP packet.

Return type ryu.lib.packet.lacp

faucet.valve_packet.**parse_lldp**(*pkt*)
Return parsed LLDP packet.

Parameters **pkt** (*ryu.lib.packet.packet*) – packet received from dataplane.

Returns LLDP packet.

Return type ryu.lib.packet.lldp

faucet.valve_packet.**parse_packet_in_pkt**(*data*, *max_len*, *eth_pkt=None*, *vlan_pkt=None*)
Parse a packet received via packet in from the dataplane.

Parameters

- **data** (*bytearray*) – packet data from dataplane.
- **max_len** (*int*) – max number of packet data bytes to parse.

Returns raw packet ryu.lib.packet.ethernet: parsed Ethernet packet. int: Ethernet type of packet (inside VLAN) int: VLAN VID (or None if no VLAN)

Return type ryu.lib.packet.packet

faucet.valve_packet.**router_advert**(*vid*, *eth_src*, *eth_dst*, *src_ip*, *dst_ip*, *vips*, *pi_flags=6*)
Return IPv6 ICMP Router Advert.

Parameters

- **vid** (*int or None*) – VLAN VID to use (or None).
- **eth_src** (*str*) – source Ethernet MAC address.
- **eth_dst** (*str*) – dest Ethernet MAC address.
- **src_ip** (*ipaddress.IPv6Address*) – source IPv6 address.
- **vips** (*list*) – prefixes (ipaddress.IPv6Address) to advertise.
- **pi_flags** (*int*) – flags to set in prefix information field (default set A and L)

Returns Serialized IPv6 ICMP RA packet.

Return type ryu.lib.packet.ethernet

faucet.valve_packet.**tlv_cast**(*tlvs*, *tlv_attr*, *cast_func*)
Return cast'd attribute of first TLV or None.

faucet.valve_packet.**tlvs_by_subtype**(*tlvs*, *subtype*)
Return list of TLVs with matching type.

faucet.valve_packet.**tlvs_by_type**(*tlvs*, *tlv_type*)
Return list of TLVs with matching type.

faucet.valve_pipeline module

Manages movement of packets through the faucet pipeline.

class faucet.valve_pipeline.**ValvePipeline**(*dp*)
Bases: *faucet.valve_manager_base.ValveManagerBase*

Responsible for maintaing the integrity of the Faucet pipeline for a single valve.

Controls what packets a module sees in its tables and how it can pass packets through the pipeline.

Responsible for installing flows in the vlan, egress and classification tables

accept_to_classification(*actions=None*)
Get instructions to forward packet through the pipeline to classification table. :param actions: (optional) list of actions to apply to packet.

Returns list of instructions

accept_to_egress(*actions=None*)
Get instructions to forward packet through the pipeline to egress table

Raises an assertion error if egress pipeline is not configured

Parameters **actions** – (optional) list of actions to apply to the packet

Returns

Return type list of instructions

accept_to_l2_forwarding(*actions=None*)
Get instructions to forward packet through the pipeline to l2 forwarding. :param actions: (optional) list of actions to apply to packet.

Returns list of instructions

accept_to_vlan(*actions=None*)
Get instructions to forward packet through the pipeline to vlan table. :param actions: (optional) list of actions to apply to packet.

Returns list of instructions

add_port(*port*)
install flows in response to a new port

del_port(*port*)
delete flows in response to a port removal

filter_packets(*match_dict*, *priority_offset=0*)
get a list of flow modification messages to filter packets from the pipeline. :param match_dict: a dictionary specifying the match fields :param priority_offset: used to prevent overlapping entries

initialise_tables()
Install rules to initialise the classification_table

output(*port*, *vlan*, *hairpin=False*, *external_forwarding_requested=None*)
Get instructions list to output a packet through the regular pipeline.

Parameters

- **port** – Port object of port to output packet to
- **vlan** – Vlan object of vlan to output packet on
- **hairpin** – if True, hairpinning is required
- **apply_egress_acl** – if True the packet will be sent to the egress acl table before being output

Returns list of Instructions

remove_filter(*match_dict*, *strict=True*, *priority_offset=0*)
retrieve flow mods to remove a filter from the classification table

select_packets(*target_table*, *match_dict*, *actions=None*, *priority_offset=0*)
retrieve rules to redirect packets matching match_dict to table

faucet.valve_route module

Valve IPv4/IPv6 routing implementation.

class faucet.valve_route.**AnonVLAN**(*vid*)
Bases: object

class faucet.valve_route.**NextHop**(*eth_src*, *port*, *now*)
Bases: object

Describes a directly connected (at layer 2) nexthop.

age(*now*)
Return age of this nexthop.

cache_time

dead(*max_fib_retries*)
Return True if this nexthop is considered dead.

eth_src

last_retry_time

next_retry(*now*, *max_resolve_backoff_time*)
Increment state for next retry.

next_retry_time

port

resolution_due(*now*, *max_age*)
Return True if this nexthop is due to be re resolved/retried.

resolve_retries

class faucet.valve_route.**ValveIPv4RouteManager**(*logger*, *notify*, *global_vlan*, *neighbor_timeout*, *max_hosts_per_resolve_cycle*, *max_host_fib_retry_count*, *max_resolve_backoff_time*, *proactive_learn*, *dec_ttl*, *multi_out*, *fib_table*, *vip_table*, *pipeline*, *routers*)

Bases: *faucet.valve_route.ValveRouteManager*

Implement IPv4 RIB/FIB.

CONTROL_ETH_TYPES = (2048, 2054)

ETH_TYPE = 2048

ICMP_SIZE = 174

ICMP_TYPE = 1

IPV = 4

IP_PKT
alias of ryu.lib.packet.ipv4.ipv4

active

advertise(*_vlan*)

control_plane_handler(*now*, *pkt_meta*)
Handle packets destined for router otherwise proactively learn host information

dec_ttl

fib_table

global_routing

global_vlan

logger

max_host_fib_retry_count

max_hosts_per_resolve_cycle

max_resolve_backoff_time

multi_out

neighbor_timeout

notify

pipeline

proactive_learn

route_priority

routers

vip_table

class faucet.valve_route.**ValveIPv6RouteManager**(*logger*, *notify*, *global_vlan*, *neighbor_timeout*, *max_hosts_per_resolve_cycle*, *max_host_fib_retry_count*, *max_resolve_backoff_time*, *proactive_learn*, *dec_ttl*, *multi_out*, *fib_table*, *vip_table*, *pipeline*, *routers*)

Bases: *faucet.valve_route.ValveRouteManager*

Implement IPv6 FIB.

CONTROL_ETH_TYPES = (34525,)

ETH_TYPE = 34525

ICMP_SIZE = 194

ICMP_TYPE = 58

IPV = 6

IP_PKT
alias of ryu.lib.packet.ipv6.ipv6

active

advertise(*vlan*)

control_plane_handler(*now*, *pkt_meta*)
Resolve packets destined for router or proactively learn host information

dec_ttl

fib_table

global_routing

global_vlan

logger

max_host_fib_retry_count

max_hosts_per_resolve_cycle

max_resolve_backoff_time

multi_out

neighbor_timeout

notify

pipeline

proactive_learn

route_priority

routers

vip_table

class faucet.valve_route.**ValveRouteManager**(*logger*, *notify*, *global_vlan*, *neighbor_timeout*, *max_hosts_per_resolve_cycle*, *max_host_fib_retry_count*, *max_resolve_backoff_time*, *proactive_learn*, *dec_ttl*, *multi_out*, *fib_table*, *vip_table*, *pipeline*, *routers*)

Bases: *faucet.valve_manager_base.ValveManagerBase*

Base class to implement RIB/FIB.

CONTROL_ETH_TYPES = ()

ETH_TYPE = None

ICMP_SIZE = None

ICMP_TYPE = None

IPV = 0

IP_PKT = None

MAX_PACKET_IN_SIZE = 194

active

add_host_fib_route_from_pkt(*now*, *pkt_meta*)
Add a host FIB route given packet from host.

Parameters

- **now** (*float*) – seconds since epoch.
- **pkt_meta** (PacketMeta) – received packet.

Returns OpenFlow messages.

Return type list

add_route(*vlan*, *ip_gw*, *ip_dst*)
Add a route to the RIB.

Parameters

- **vlan** (*vlan*) – VLAN containing this RIB.
- **ip_gw** (*ipaddress.ip_address*) – IP address of nexthop.
- **ip_dst** (*ipaddress.ip_network*) – destination IP network.

Returns OpenFlow messages.

Return type list

add_vlan(*vlan*)
install flows in response to a new VLAN

advertise(*vlan*)

control_plane_handler(*now*, *pkt_meta*)

dec_ttl

del_route(*vlan*, *ip_dst*)
Delete a route from the RIB.

Only one route with this exact destination is supported.

Parameters

- **vlan** (*vlan*) – VLAN containing this RIB.
- **ip_dst** (*ipaddress.ip_network*) – destination IP network.

Returns OpenFlow messages.

Return type list

expire_port_nexthops(*port*)
Expire all hosts on a port

fib_table

global_routing

global_vlan

logger

max_host_fib_retry_count

max_hosts_per_resolve_cycle

max_resolve_backoff_time

multi_out

neighbor_timeout

nexthop_dead(*nexthop_cache_entry*)
Returns true if the nexthop_cache_entry is considered dead

notify

notify_learn(*pkt_meta*)

pipeline

proactive_learn

resolve_expire_hosts(*vlan*, *now*, *resolve_all=True*)
Re/resolve hosts.

Parameters

- **vlan** (*vlan*) – VLAN containing this RIB/FIB.
- **now** (*float*) – seconds since epoch.
- **resolve_all** (*bool*) – attempt to resolve all unresolved gateways.

Returns OpenFlow messages.

Return type list

resolve_gateways(*vlan*, *now*, *resolve_all=True*)
Re/resolve gateways.

Parameters

- **vlan** (*vlan*) – VLAN containing this RIB/FIB.
- **now** (*float*) – seconds since epoch.
- **resolve_all** (*bool*) – attempt to resolve all unresolved gateways.

Returns OpenFlow messages.

Return type list

route_priority

router_vlan_for_ip_gw(*vlan*, *ip_gw*)
Return router VLAN for IP gateway (or None).

Parameters

- **vlan** (*vlan*) – VLAN containing this RIB.
- **ip_gw** (*ipaddress.ip_address*) – IP address of nexthop.

Returns VLAN for this gateway or None.

routers

vip_table

faucet.valve_ryuapp module

RyuApp base class for FAUCET/Gauge.

class faucet.valve_ryuapp.**EventReconfigure**
Bases: ryu.controller.event.EventBase

Event sent to controller to cause config reload.

class faucet.valve_ryuapp.**RyuAppBase**(**args*, ***kwargs*)
Bases: ryu.base.app_manager.RyuApp

RyuApp base class for FAUCET/Gauge.

OFP_VERSIONS = [4]

connect_or_disconnect_handler(*ryu_event*)
Handle connection or disconnection of a datapath.

Parameters **ryu_event** (*ryu.controller.dpset.EventDP*) – trigger.

exc_logname = ''

get_setting(*setting*, *path_eval=False*)
Return config setting prefaced with logname.

logname = ''

reconnect_handler(*ryu_event*)
Handle reconnection of a datapath.

Parameters **ryu_event** (*ryu.controller.dpset.EventDPReconnected*) – trigger.

reload_config(*_ryu_event*)
Handle reloading configuration.

signal_handler(*sigid*, *_*)
Handle signals.

Parameters **sigid** (*int*) – signal received.

start()
Start controller.

exception faucet.valve_ryuapp.**ValveDeadThreadException**
Bases: Exception

Exception raised when a dead thread is detected.

faucet.valve_table module

Abstraction of an OF table.

class faucet.valve_table.**ValveGroupEntry**(*table*, *group_id*, *buckets*)
Bases: object

Abstraction for a single OpenFlow group entry.

add()
Return flows to add this entry to the group table.

delete()
Return flow to delete an existing group entry.

modify()
Return flow to modify an existing group entry.

update_buckets(*buckets*)
Update entry with new buckets.

class faucet.valve_table.**ValveGroupTable**
Bases: object

Wrap access to group table.

delete_all()
Delete all groups.

entries = None

get_entry(*group_id*, *buckets*)
Update entry with group_id with buckets, and return the entry.

static group_id_from_str(*key_str*)
Return a group ID based on a string key.

class faucet.valve_table.**ValveTable**(*name*, *table_config*, *flow_cookie*, *notify_flow_removed=False*, *next_tables=None*)
Bases: object

Wrapper for an OpenFlow table.

flowcontroller(*match=None*, *priority=None*, *inst=None*, *max_len=96*)
Add flow outputting to controller.

flowdel(*match=None*, *priority=None*, *out_port=4294967295*, *strict=False*)
Delete matching flows from a table.

flowdrop(*match=None*, *priority=None*, *hard_timeout=0*)
Add drop matching flow to a table.

flowmod(*match=None*, *priority=None*, *inst=None*, *command=0*, *out_port=0*, *out_group=0*, *hard_timeout=0*, *idle_timeout=0*, *cookie=None*)
Helper function to construct a flow mod message with cookie.

goto(*next_table*)
Add goto next table instruction.

goto_miss(*next_table*)
Add miss goto table instruction.

goto_this()

static match(*in_port=None*, *vlan=None*, *eth_type=None*, *eth_src=None*, *eth_dst=None*, *eth_dst_mask=None*, *icmpv6_type=None*, *nw_proto=None*, *nw_dst=None*, *metadata=None*, *metadata_mask=None*, *vlan_pcp=None*, *udp_src=None*, *udp_dst=None*)
Compose an OpenFlow match rule.

set_external_forwarding_requested()
Set field for external forwarding requested.

set_field(***kwds*)
Return set field action.

set_no_external_forwarding_requested()
Set field for no external forwarding requested.

set_vlan_vid(*vlan_vid*)
Set VLAN VID with VID_PRESENT flag set.

Parameters **vid** (*int*) – VLAN VID

Returns set VID with VID_PRESENT.

Return type ryu.ofproto.ofproto_v1_3_parser.OFPActionSetField

faucet.valve_util module

Utility functions for FAUCET.

faucet.valve_util.**close_logger**(*logger*)
Close all handlers on logger object.

faucet.valve_util.**dpid_log**(*dpid*)
Log a DP ID as hex/decimal.

faucet.valve_util.**get_logger**(*logname*, *logfile*, *loglevel*, *propagate*)
Create and return a logger object.

faucet.valve_util.**get_setting**(*name*, *path_eval=False*)
Returns value of specified configuration setting.

faucet.valve_util.**get_sys_prefix**()
Returns an additional prefix for log and configuration files when used in a virtual environment

faucet.valve_util.**kill_on_exception**(*logname*)
decorator to ensure functions will kill ryu when an unhandled exception occurs

faucet.valve_util.**stat_config_files**(*config_hashes*)
Return dict of a subset of stat attributes on config files.

faucet.valve_util.**utf8_decode**(*msg_str*)
Gracefully decode a possibly UTF-8 string.

faucet.valves_manager module

Manage a collection of Valves.

class faucet.valves_manager.**ConfigWatcher**
Bases: object

Watch config for file or content changes.

config_file = None

config_file_stats = None

config_hashes = None

content_changed(*new_config_file*)
Return True if config file content actually changed.

files_changed()
Return True if any config files changed.

update(*new_config_file*, *new_config_hashes=None*)
Update state with new config file/hashes.

class faucet.valves_manager.**MetaDPState**
Bases: object

Contains state/config about all DPs.

class faucet.valves_manager.**ValvesManager**(*logname*, *logger*, *metrics*, *notifier*, *bgp*, *dot1x*, *config_auto_revert*, *send_flows_to_dp_by_id*)
Bases: object

Manage a collection of Valves.

datapath_connect(*now*, *valve*, *discovered_up_ports*)
Handle connection from DP.

healthy_stack_roots(*now*, *candidate_dps*)
Return list of healthy stack root names.

load_configs(*now*, *new_config_file*, *delete_dp=None*)
Load/apply new config to all Valves.

maintain_stack_root(*now*)
Maintain current stack root and return True if stack root changes.

new_valve(*new_dp*)

parse_configs(*new_config_file*)
Return parsed configs for Valves, or None.

port_status_handler(*valve*, *msg*)
Handle a port status change message.

request_reload_configs(*now*, *new_config_file*, *delete_dp=None*)
Process a request to load config changes.

revert_config()
Attempt to revert config to last known good version.

update_config_applied(*sent=None*, *reset=False*)
Update faucet_config_applied from {dpid: sent} dict, defining applied == sent == enqueued via Ryu

update_metrics(*now*)
Update metrics in all Valves.

valve_flow_services(*now*, *valve_service*)
Call a method on all Valves and send any resulting flows.

valve_packet_in(*now*, *valve*, *msg*)
Time a call to Valve packet in handler.

valves = None

faucet.vlan module

VLAN configuration.

class faucet.vlan.**AnyVLAN**
Bases: object

Placeholder any tagged VLAN.

name = 'Any VLAN'

vid = 4096

class faucet.vlan.**HostCacheEntry**(*eth_src*, *port*, *cache_time*)
Bases: object

Association of a host with a port.

cache_time

eth_src

eth_src_int

port

class faucet.vlan.**NullVLAN**
Bases: object

Placeholder null VLAN.

name = 'Null VLAN'

vid = 0

class faucet.vlan.**OFVLAN**(*name*, *vid*)
Bases: object

class faucet.vlan.**VLAN**(*_id*, *dp_id*, *conf=None*)
Bases: *faucet.conf.Conf*

Contains state for one VLAN, including its configuration.

add_cache_host(*eth_src*, *port*, *cache_time*)
Add/update a host to the cache on a port at at time.

add_route(*ip_dst*, *ip_gw*)
Add an IP route.

all_ip_gws(*ipv*)
Return all IP gateways for specified IP version.

cached_host(*eth_src*)
Return host from cache or None.

cached_host_on_port(*eth_src*, *port*)
Return host cache entry if host in cache and on specified port.

cached_hosts_count_on_port(*port*)
Return count of all hosts learned on a port.

cached_hosts_on_port(*port*)
Return all hosts learned on a port.

check_config()
Check config at instantiation time for errors, typically via assert.

clear_cache_hosts_on_port(*port*)
Clear all hosts learned on a port.

defaults = {'acl_in': None, 'acl_out': None, 'acls_in': None, 'acls_out': None, 'd

defaults_types = {'acl_in': (<class 'int'>, <class 'str'>), 'acl_out': (<class 'int'

del_route(*ip_dst*)
Delete an IP route.

exclude_native_if_dot1x()
Don't output on native vlan, if dynamic (1x) vlan is in use

exclude_same_lag_member_ports(*in_port=None*)
Ensure output on only one member of a LAG.

expire_cache_host(*eth_src*)
Expire a host from caches.

expire_cache_hosts(*now*, *learn_timeout*)
Expire stale host entries.

faucet_vips_by_ipv(*ipv*)
Return VIPs with specified IP version on this VLAN.

flood_pkt(*packet_builder*, *multi_out=True*, **args*)
Return Packet-out actions via flooding

static flood_ports(*configured_ports*, *exclude_unicast*)
Return configured ports that allow flooding

from_connected_to_vip(*src_ip*, *dst_ip*)
Return True if src_ip in connected network and dst_ip is a VIP.

Parameters

- **src_ip** (*ipaddress.ip_address*) – source IP.
- **dst_ip** (*ipaddress.ip_address*) – destination IP

Returns True if local traffic for a VIP.

get_ports()
Return all ports on this VLAN.

hairpin_ports()
Return all ports with hairpin enabled.

hosts_count()
Return number of hosts learned on this VLAN.

ip_dsts_for_ip_gw(*ip_gw*)
Return list of IP destinations, for specified gateway.

ip_in_vip_subnet(*ipa*, *faucet_vip=None*)
Return faucet_vip if IP in same IP network as a VIP on this VLAN.

ipvs()
Return IP versions configured on this VLAN.

is_faucet_vip(*ipa*, *faucet_vip=None*)
Return True if IP is a VIP on this VLAN.

is_host_fib_route(*host_ip*)
Return True if IP destination is a host FIB route.

Parameters **host_ip** – (ipaddress.ip_address): potential host FIB route.

Returns True if a host FIB route (and not used as a gateway).

lacp_ports()
Return ports that have LACP on this VLAN.

lacp_up_ports()
Return ports that have LACP up on this VLAN.

lags()
Return dict of LAGs mapped to member ports.

lags_up()
Return dict of LAGs mapped to member ports that have LACP up.

link_and_other_vips(*ipv*)
Return link local and non-link local VIPs.

loop_protect_external_ports()
Return ports wth external loop protection set.

loop_protect_external_ports_up()
Return up ports with external loop protection set.

mirrored_ports()
Return ports that are mirrored on this VLAN.

mutable_attrs = frozenset({'dot1x_untagged', 'tagged', 'untagged'})

neigh_cache_by_ipv(*ipv*)
Return neighbor cache for specified IP version on this VLAN.

neigh_cache_count_by_ipv(*ipv*)
Return number of hosts in neighbor cache for specified IP version on this VLAN.

output_port(*port*, *hairpin=False*, *output_table=None*, *external_forwarding_requested=None*)

pkt_out_port(*packet_builder*, *port*, **args*)
Return packet-out actions with VLAN tag if port is tagged

port_is_tagged(*port*)
Return True if port number is an tagged port on this VLAN.

port_is_untagged(*port*)
Return True if port number is an untagged port on this VLAN.

reset_caches()
Reset dynamic caches.

reset_ports(*ports*)
Reset tagged and untagged port lists.

restricted_bcast_arpnd_ports()
Return all ports with restricted broadcast enabled.

route_count_by_ipv(*ipv*)
Return route table count for specified IP version on this VLAN.

routes_by_ipv(*ipv*)
Return route table for specified IP version on this VLAN.

set_defaults()
Set default values and run any basic sanity checks.

tagged_flood_ports(*exclude_unicast*)

untagged_flood_ports(*exclude_unicast*)

static vid_valid(*vid*)
Return True if VID valid.

vip_map(*ipa*)
Return the vip containing ipa

faucet.watcher module

Gauge watcher implementations.

class faucet.watcher.**GaugeFlowTableLogger**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugeFlowTablePoller*

Periodically dumps the current datapath flow table as a yaml object.

Includes a timestamp and a reference ($DATAPATHNAME-flowtables). The flow table is dumped as an OFFlowStatsReply message (in yaml format) that matches all flows.

optionally the output can be compressed by setting compressed: true in the config for this watcher

class faucet.watcher.**GaugeMeterStatsLogger**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugeMeterStatsPoller*

Abstraction for meter statistics logger.

class faucet.watcher.**GaugePortStateLogger**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugePortStatePoller*

Abstraction for port state logger.

static no_response()
Called when a polling cycle passes without receiving a response.

static send_req()
Send a stats request to a datapath.

class faucet.watcher.**GaugePortStatsLogger**(*conf*, *logname*, *prom_client*)
Bases: *faucet.gauge_pollers.GaugePortStatsPoller*

Abstraction for port statistics logger.

faucet.watcher.**watcher_factory**(*conf*)
Return a Gauge object based on type.

Parameters **conf** (*GaugeConf*) – object with the configuration for this valve.

faucet.watcher_conf module

Gauge watcher configuration.

class faucet.watcher_conf.**WatcherConf**(*_id*, *dp_id*, *conf*, *prom_client*)
Bases: *faucet.conf.Conf*

Stores the state and configuration to monitor a single stat.

Watcher Config

Watchers are configured in the watchers config block in the config for gauge.

The following elements can be configured for each watcher, at the level of /watchers/<watcher name>/:

- type (string): The type of watcher (IE what stat this watcher monitors). The types are 'port_state', 'port_stats' or 'flow_table'.
- dps (list): A list of dps that should be monitored with this watcher.
- db (string): The db that will be used to store the data once it is retreived.
- interval (int): if this watcher requires polling the switch, it will monitor at this interval.

The config for a db should be created in the gauge config file under the dbs config block.

The following elements can be configured for each db, at the level of /dbs/<db name>/:

- type (string): the type of db. The available types are 'text' and 'influx' for port_state, 'text', 'influx'and 'prometheus' for port_stats and 'text' and flow_table.

The following config elements then depend on the type. For text:

- file (string): the filename of the file to write output to.
- path (string): path where files should be written when writing to muiltiple files
- compress (bool): compress (with gzip) flow_table output while writing it

For influx:

- influx_db (str): The name of the influxdb database. Defaults to 'faucet'.
- influx_host (str): The host where the influxdb is reachable. Defaults to 'localhost'.
- influx_port (int): The port that the influxdb host will listen on. Defaults to 8086.
- influx_user (str): The username for accessing influxdb. Defaults to ''.
- influx_pwd (str): The password for accessing influxdb. Defaults to ''.
- influx_timeout (int): The timeout in seconds for connecting to influxdb. Defaults to 10.
- influx_retries (int): The number of times to retry connecting to influxdb after failure. Defaults to 3.

For Prometheus:

- prometheus_port (int): The port used to export prometheus data. Defaults to 9303.
- prometheus_addr (ip addr str): The address used to export prometheus data. Defaults to '127.0.0.1'.

add_db(*db_conf*)
Add database config to this watcher.

add_dp(*dp*)
Add a datapath to this watcher.

check_config()
Check config at instantiation time for errors, typically via assert.

```
db_defaults = {'compress': False, 'file': None, 'influx_db': 'faucet', 'influx_host
db_defaults_types = {'compress': <class 'bool'>, 'file': <class 'str'>, 'influx_db':
defaults = {'all_dps': False, 'db': None, 'db_type': 'text', 'dbs': None, 'dps': N
defaults_types = {'all_dps': <class 'bool'>, 'db': <class 'str'>, 'db_type': <class
```

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