THE HAGUE
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Faucet & Allied Telesis SDN Getting Started Guide

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Faucet

Allied Telesis

About this guide

This is a step by step guide on how to set up a simple Software Defined Networking(SDN) controller that controls a switch. An overview is included on how the SDN controller and switch work. Some additional set-up has been added to broaden the view of what is possible.

In this guide we will discuss how to set up an Allied Telesis switch with openflow in combination with a Faucet controller. We will start by discussing the basic material list and the software you'll need to get started. After that we'll show you our demo network set-up, that we'll be building step-by-step in this guide. This is a very basic network just to demonstrate the steps that are needed to get an automated deployment going. We'll be taking the following steps to realise this goal:

1. Set up a VM and install faucet
2. Configure the Allied Telesis switch
3. Set up the network and verify the connection between faucet and the switch
4. Install monitoring software

Notice: The makers of this guide do not represent Faucet or Allied Telesis. The switches used were provided by Allied Telesis to The Hague University of Applied Sciences for this project.

Material list

Please note the following:

- It is not necessary to have the exact set-up mentioned below. Any Allied Telesis switch that supports OpenFlow version 1.3 is sufficient for this set-up. Verifying software version details how to check the OpenFlow version of your switch.
- OpenFlow v1.3 is supported by Allied Telesis firmware version 5.4.7-0.x and above.

Hardware

Switch:

- Allied Telesis x510-28GTX running AlliedWare Plus (™) 5.4.9, Build: x510-5.4.9-1.6.rel
- OpenFlow 1.3 feature subscription license. This license is called AT-FL-[SERIES]-OF13-[1/5]YR, the license used in this guide is AT-FL-x510-OF13-1YR.

Computer:

3x Computer: 1 for the faucet controller and 2 for testing connectivity. Including the necessary cables and peripherals.

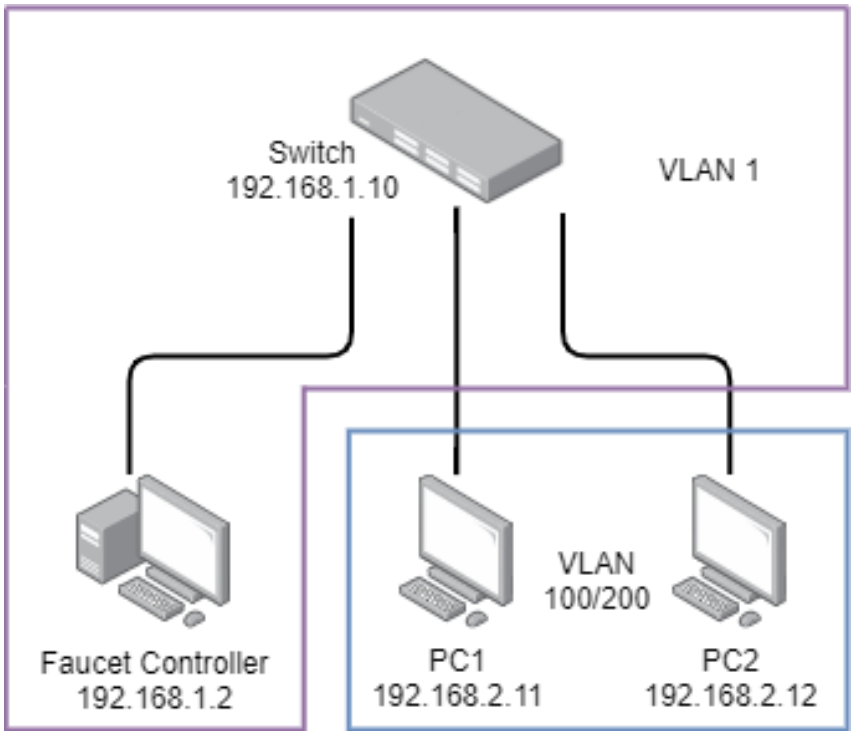
Cables and peripherals:

3x UTP cable
1x Power cable
1x Serial to console cable
1x USB to serial cable

Software

A list of the software used in this guide:
PuTTY
Virtualbox
Ubuntu 20.04 LTS(64bit)
Faucet
Gauge
Prometheus
Grafana
GNU nano

Network diagram



VLANs

Native VLAN 1 for managing the switches. This is normally done in a separate VLAN.
VLAN 100 is the native VLAN for the OpenFlow protocol.
VLAN 200 is configured in faucet as the host VLAN.

IP Addresses

VLAN 1 subnet 192.168.1.0/24
Faucet controller: 192.168.1.2/24
Switch: 192.168.1.10/24

VLAN 100/200 subnet 192.168.2.0/24
PC 1 192.168.2.11/24
PC 2 192.168.2.12/24

SDN Faucet Architecture

For this tutorial we will be using the all-in-one package from faucet. This consists of two programs made by faucet: faucet and gauge, and two open-source programs: Prometheus and Grafana. In this chapter we will describe what these programs do and how they can be used to create and monitor an SDN network.
Note that the Chapter "Set-up" will be focused on faucet. The configuration of the other programs will be discussed in the chapter "Additions".

Faucet

Faucet uploads the configuration to the switch and gives information about its instrumentation to Prometheus. The connection between faucet and the switch uses OpenFlow, this is an open source protocol for SDN. Faucet does not have a true northbound API. Editing the faucet configuration can be done manually or by using a program.

Gauge

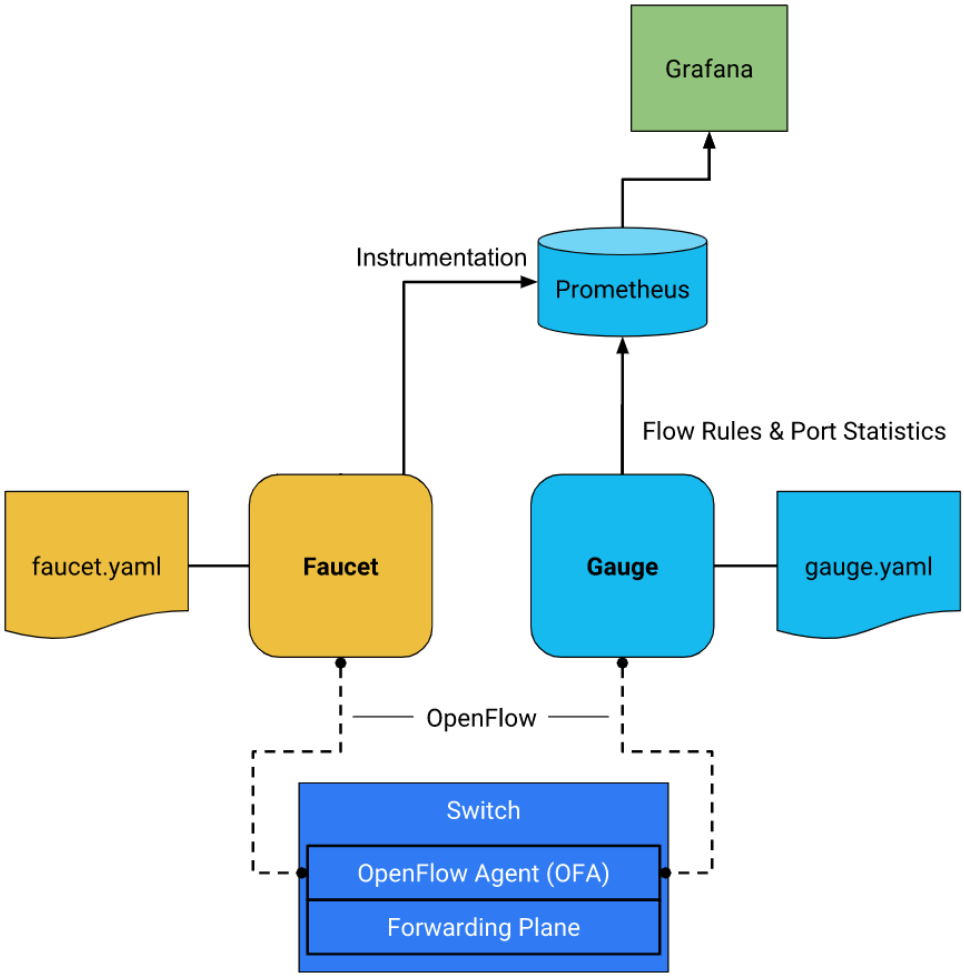
The function of gauge is to extract data from the switch like port statistics and flow state to present that data to other services. It does so by connecting to the switch using the openflow protocol. Gauge does not alter the switch behaviour. This has the advantage that you can upgrade your monitoring system without changing the behaviour of the network devices.

Prometheus

Prometheus is an open source monitoring system. Faucet can use this program to store instrumentation data. Gauge can also use this program to export its port statistics and flow state data to. Prometheus gathers all this data so it can be visualised in dashboards or used in other programs that need network data.

Grafana

Grafana is an open source program that is used to visualise data. In this case prometheus provides the data grafana uses.



The image above is an edited version of the faucet architecture. Unused features have been omitted for clarity.

Set-up

Faucet Set-up

This chapter will focus on the faucet set-up. You can find the set-up for the other programs in the chapter "Additions".

You can find an official guide for installing Faucet here "Installing faucet for the first time". Additionally if you do not have a physical switch we recommend you follow the faucet guide instead as they use virtual switches.

Installing Faucet

Faucet will be installed on an Ubuntu Virtual Machine (VM) that runs on windows. How to set up the VM is described in the appendix.

The all-in-one release of Faucet includes the following programs:

Program	Purpose
Faucet	Network controller
Gauge	Monitoring controller
Prometheus	Monitoring system & time series database
Grafana	Monitoring dashboard

Open a terminal with ctrl + alt + t and add the faucet official repo to the system by executing the following commands.

```
~$ 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 install the required packages with the following command.

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

Configure Faucet

Navigate to "etc/faucet/" and edit faucet.yaml in the terminal using nano or your text editor of choice.

Remove the default configuration and replace it with the following:

```
vlans:
    host:
       vid: 200
       description: "hostlan"
dps:
    Switch:
        dp_id: 0x1
        hardware: "Allied-Telesis"
        interfaces:
            3:
                name: "host1"
                native_vlan: host
            4:
                name: "host2"
                native_vlan: host
```

This configuration creates VLAN 200; host, and assigns this VLAN to port 3 and 4 on the switch with datapath ID 0x1.

Run the following command to verify that the configuration syntax is correct:

```
~$ check_faucet_config /etc/faucet/faucet.yaml
```

This script will check the configuration. If the configuration is correct it will return the entire faucet configuration, else it will output an error message.

Now reload faucet to apply the changes.

```
~$ sudo systemctl reload faucet
```

This command will compute the difference between the old and new configuration and apply the changes to the network in a hitless fashion if possible.

Check if the configuration was successfully reloaded by opening the faucet log located in at "/var/log/faucet/faucet.log"
It should contain the following lines:

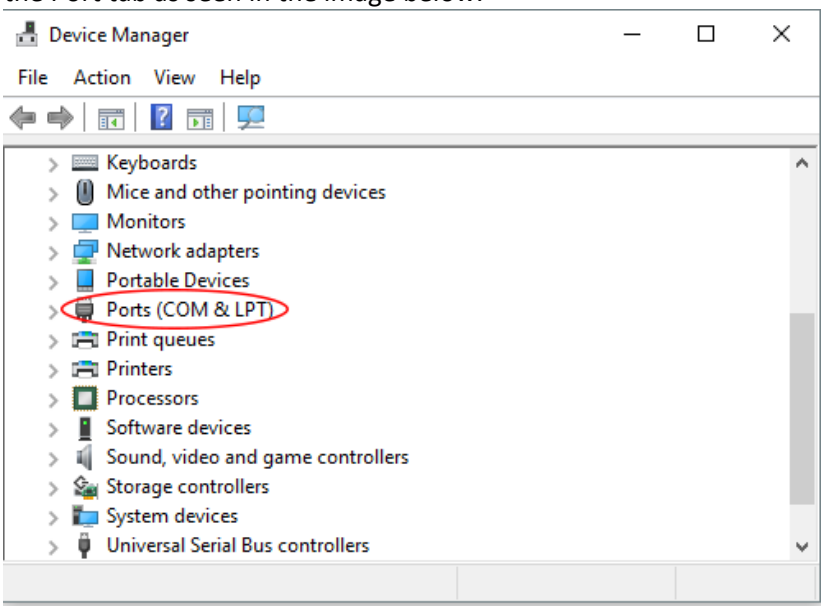
```
 faucet INFO     Reloading configuration
 faucet INFO     configuration /etc/faucet/faucet.yaml changed, analyzing differences
 faucet INFO     Add new datapath DPID 1 (0x1)
```

Switch set-up

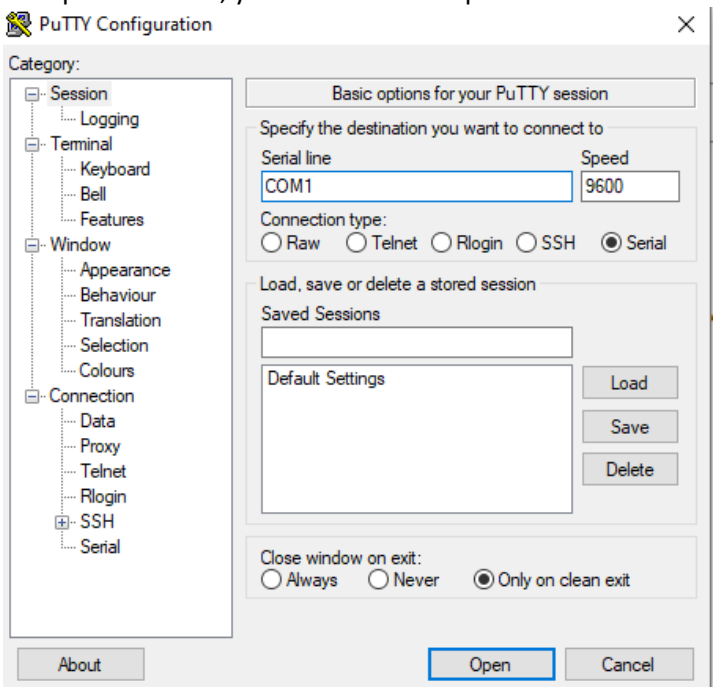
In this chapter we configure the hardware switch we will be using the X510-28GTX switch from Allied-Telesis.

Connecting to the switch

There are several ways of connecting to the switch. In this guide we will use a program called PuTTY. PuTTY is an open-source SSH and telnet client.
Depending on which port the serial cable is plugged into your computer, the communication port may vary. To check which COM port is used on your system, you open the Device Manager and check the Port tab as seen in the image below.



In this guide **COM1** is used as the Serial Line port. When you have entered the correct port and set the speed to 9600, you can click the 'Open' button. A new window should open.



Login

Once you are connected to switch u are prompted with a login.

```
awplus login:
```

The default username is “manager” and the password is “friend”.

Type enable to go to user privileged mode. We will be using this mode as a baseline for the next chapters.

```
awplus> enable
```

Reset

To ensure that there is no configuration on the switch, execute the following command to reset the switch:

```
awplus# erase factory-default
```

If you do not have the login credentials, and you want to reset the switch, contact Allied Telesis.

Verifying software version

Verify the software version by typing the following command, this should return a version of 5.4.7-0.x or above.

```
awplus# show version
```

Check the OpenFlow version of the switch using the following command:

```
awplus# show openflow status
```

The result should read (OF1.3). If it does not you can choose to switch to this version.
We recommend doing so to eliminate any issues with our guide. You can achieve this with the following command:

```
awplus# configure terminal
awplus# openflow version 1.3
```

Disable VCS

If the switch doesn't have this feature, skip this step.
Look for the ID that is displayed on the switch and execute the following commands:

```
awplus# configure terminal
awplus(config)# no stack [ID] enable
awplus(config)# y
awplus(config)# exit
awplus# write
awplus# reboot
awplus# y
```

This will disable VCS, save the configuration and reboot the switch to apply the save.

Set IP address

Give the switch an ip address so that it can be managed.

```
awplus# configure terminal
awplus(config)# int vlan1
awplus(config-if)# ip addr 192.168.1.10/24
awplus(config-if)# end
```

Set opflow controller and datapath-id

Configure the switch to use the faucet controller that is listening on port 6653. Change the datapath-id to 1 to simplify the faucet configuration.

```
awplus# configure terminal
awplus(config)# openflow controller faucet tcp 192.168.1.2 6653
awplus(config)# openflow datapath-id 1
awplus(config)# end
```

Native VLAN OpenFlow

Configure the ports 3-24 to use the Native OpenFlow VLAN, VLAN 100.

```
awplus# configure terminal
awplus(config)# vlan database
awplus(config-vlan)# vlan 100
awplus(config-vlan)# exit
awplus(config)# openflow native vlan 100
awplus(config)# interface port1.0.3-1.0.24
awplus(config-if)# openflow
awplus(config-if)# end
```

Other settings

In order for OpenFlow to work properly the settings for RSTP, IGMP and loop protection must be changed. This is done by entering the commands below.

```
awplus# configure terminal
awplus(config)# no spanning-tree rstp enable
awplus(config)# no loop-protection loop-detect
awplus(config)# interface vlan100
awplus(config-if)# no ip igmp snooping tcn query solicit
awplus(config-if)# end
```

Network set-up

Once the Faucet controller and the switch are configured they must be connected. If you do not have multiple network interfaces on the faucet controller, internet connection will be lost.

The computer running the VM must be connected to port 1 on the switch. Connect the 2 host PCs to port 3 and 4. Change the network setting of the VM and the PCs to manual and insert the following IP address and netmask, leave the default gateway blank:

	VM	**PC1**	**PC2**
Address	192.168.1.2	192.168.2.11	192.168.2.12
Netmask	255.255.255.0	255.255.255.0	255.255.255.0

Apply the network changes to the VM by disabling and re-enabling the network interface.

Verification

Service start on boot

To verify that a service (i.e. faucet, gauge, prometheus or grafana) starts on boot type the command below. Enter the name of the service you want to check at [SERVICE NAME].

```
~$ systemctl status [SERVICE NAME]
```

This should return something similar to the image below. Ensure the area highlighted in white shows as enabled.

```
~$ systemctl status faucet
● faucet.service - "Faucet OpenFlow switch controller"
    Loaded: loaded (/lib/systemd/system/faucet.service; enabled; vendor preset: enabled)
    Active: active (running) since [DATE] [TIME]; [X]min [Y]s ago
      Docs: https://docs.faucet.nz
  Main PID: 751 (ryu-manager)
     Tasks: 1 (limit: 4657)
    Memory: 74.9M
    CGroup: /system.slice/faucet.service
            └─751 /usr/bin/python3 /usr/bin/ryu-manager --config-file=/etc/faucet.yaml
```

Connectivity between hosts

Ensure that the firewall is disabled and open a terminal on PC1. Ping PC2 using the following command:

```
> ping 192.168.2.12
```

The resulting reply should be from IP address 192.168.2.12 (PC2).
Repeat this step for PC2, making sure to adjust the IP address in the command to that of PC1.

Faucet controller

Open the faucet log in "`/var/log/faucet.log`". It should include the lines below.

```
faucet.valve INFO    DPID 1 (0x1) Switch Port 3 (host1) up
faucet.valve INFO    DPID 1 (0x1) Switch Port 4 (host2) up
faucet.valve INFO    DPID 1 (0x1) Switch Port 3 (host1) configured
faucet.valve INFO    DPID 1 (0x1) Switch Port 4 (host2) configured
faucet.valve INFO    DPID 1 (0x1) Switch L2 learned on Port 3 [MAC ADDRESS]
faucet.valve INFO    DPID 1 (0x1) Switch L2 learned on Port 4 [MAC ADDRESS]
```

Switch

Verify that the switch is connected to the faucet controller using the "`show openflow configuration`" command. The value for "`is_connected`" should be "`true`".

```
awplus# show openflow configuration
e737fda0-cca8-465a-ad00-819b05d70774
    Bridge "of0"
        Controller: "tcp:192.168.1.2:6653"
            is_connected: true
            other_config: {aux_id="0", name=faucet}
```

If an error has occurred it will show "`fail_mode: secure`".

```
awplus# show openflow configuration
e737fda0-cca8-465a-ad00-819b05d70774
    Bridge "of0"
        Controller: "tcp:192.168.1.2:6653"
            is_connected: true
            other_config: {aux_id="0", name=faucet}
        fail_mode: secure
```

To save the switch configuration, so it persists on reboot, you must use the write command

```
awplus# write
Building configuration...
[OK]
```

Conclusion

This is the end of the set-up. There are many things to expand on. A few of these additions can be found in the next chapter. Additional tutorials may be found on the Faucet website.

Additions

Monitoring

To monitor the network we'll be using Gauge to connect to the switch and extract data. The data will then be stored by prometheus. Prometheus will also collect instrumentation data from Faucet. To display the data we will be using Grafana.

Gauge

Add the gauge controller to the switch set-up. Gauge will be listening on port 6654.

```
awplus# configure terminal
awplus(config)# openflow controller gauge tcp 192.168.1.2 6654
```

The Gauge configuration does not need to be altered. The configuration can be found here: /etc/faucet/gauge.yaml
The configuration should look like this:

```
# 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
```

This default configuration wil set up a prometheus exporter listening on port 0.0.0.0:9303 and write different kinds of gauge metrics to this exporter.

Gauge will need to restart in order to get the new faucet configuration:

```
~$ sudo systemctl restart gauge
```

Prometheus

There is a Prometheus configuration shipped with faucet located in:
/etc/faucet/prometheus/prometheus.yml

The configuration should look like the following:

```
# 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']
```

Change the file /etc/default/prometheus so that Prometheus will use the configuration that is shipped with faucet. See the changes below.

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

Restart Prometheus to apply the changes.

```
~$ sudo systemctl restart prometheus
```

Grafana

The configuration of grafana can stay the same. Enter the following commands to ensure grafana is running and keeps running.

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

Open a web browser and go to http://localhost:3000. Use the default username and password "admin". And either fill in a new password or skip.

Add a data source. This is done by going to configuration select "data sources". Press "Add data source" and select prometheus. Make sure that the following settings are correct:

Name	Prometheus
URL	<http://localhost:9090>

Press the button "Save & test" in the bottom. It should say that the data source is working.

Create 3 dashboards for instrumentation, inventory and port statistics. The configuration for these dashboards can be found in the 3 links below:
Instrumentation: Faucet resources usage.
Inventory: Connected devices.
Port Statistics: Simple port statistics.
Either download these links or copy the code. Then go to "Create" and select "import" or paste the code you just copied. Do this for all 3 dashboards.
These dashboards are also used in the "Installing faucet for the first time".

Routing

In this section a faucet set-up will be created to set routes to 2 hosts in different VLANS. Use the same network set-up as before.

The changes to the configuration are: a second VLAN, a gateway in both VLANS with an IP address and MAC address, a router function and PC2 is changed to a different VLAN. Change the IP addresses, netmask and gateway of the PCs to:

	PC1	**PC2**
Address	192.168.2.11	192.168.5.12
Netmask	255.255.255.0	255.255.255.0
Gateway	192.168.2.1	192.168.5.1

The configuration should look the following:
/etc/faucet/faucet.yaml

```
vlans:
    host:
       vid: 200
       description: "vlan200"
       faucet_vips: ["192.168.2.1/24"]
       faucet_mac: "00:00:00:00:00:11"
    host2:
       vid: 250
       description: "vlan250"
       faucet_vips: ["192.168.5.1/24"]
       faucet_mac: "00:00:00:00:00:22"

routers:
   router-1:
      vlans: [host, host2]

dps:
    switch:
        dp_id: 0x1
        hardware: "Allied-Telesis"
        interfaces:
            3:
                name: "host1"
                native_vlan: host
            4:
                name: "host2"
                native_vlan: host2
```

Run the following command to verify that the configuration syntax is correct:

```
~$ check_faucet_config /etc/faucet/faucet.yaml
```

Now reload faucet to apply the changes.

```
~$ sudo systemctl reload faucet
```

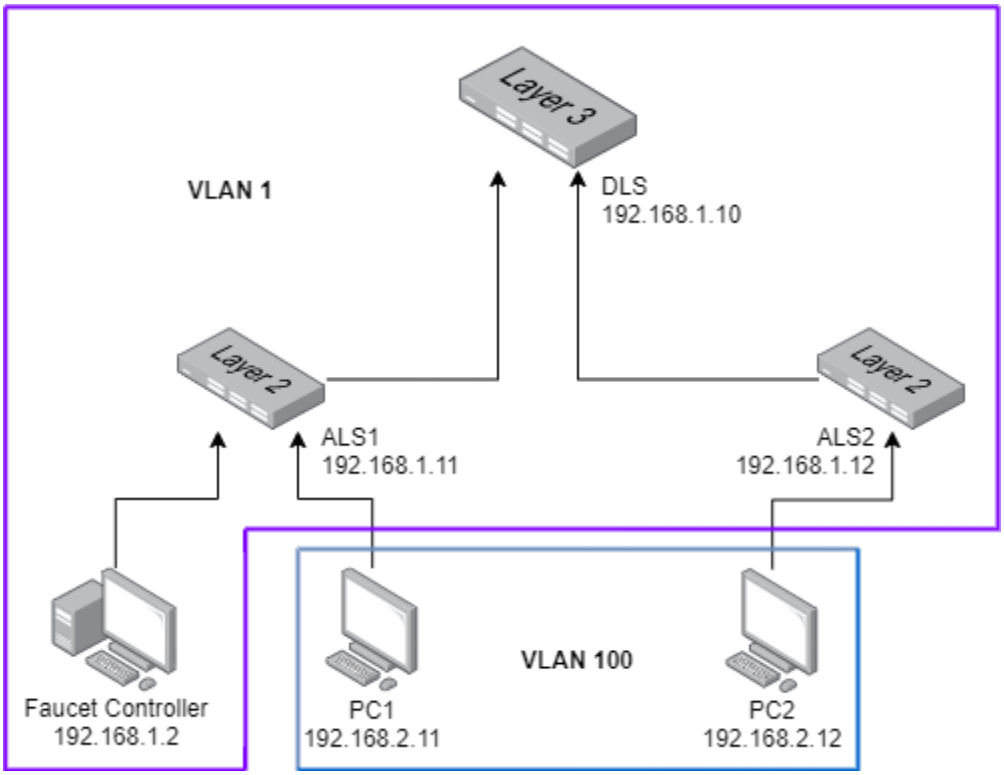
Verify that the setup works by opening a terminal on PC1 and ping PC2 using the following command:

```
> ping 192.168.5.12
```

The resulting reply should be from IP address 192.168.5.12 (PC2).

Multi switch set-up

This addition covers a different network set-up including 3 switches. It is slightly more complicated than the single switch set-up described in the main guide and requires more components.



Hardware

Switches

Allied Telesis X230-28GT running AlliedWare Plus (™) 5.4.9, Build: x230-5.4.9-1.6.rel
Allied Telesis X230-10GT running AlliedWare Plus (™) 5.5.0, Build: x230-5.5.0-0.4.rel
Allied Telesis x510-28GTX running AlliedWare Plus (™) 5.4.9, Build: x510-5.4.9-1.6.rel

Other

3x PCs including cables and peripherals

Cables and peripherals

5x UTP cable
3x Power cable
1x Serial to console cable
1x USB to serial cable

Note:
In a multi-switch set-up each switch requires a unique datapath ID, this must be configured on the switch.
The datapath IDs used in this set-up are shown in the table below.

	DLS	**AS1**	**AS2**
Datapath ID	0x1	0x2	0x3

Navigate to “etc/faucet/” and edit faucet.yaml in the terminal using nano or your text editor of choice.

Remove the configuration and replace it with the following:

```
vlans:
    host:
       vid: 200
       description: "hostlan"
dps:
    DLS:
        dp_id: 0x1
        hardware: "Allied-Telesis"
        interfaces:
            3:
                name: "trunk1"
                tagged_vlans: [host]
            4:
                name: "trunk2"
                tagged_vlans: [host]
    AS1:
        dp_id: 0x2
        hardware: "Allied-Telesis"
        interfaces:
            3:
                name: "trunk"
                tagged_vlans: [host]
            4:
                name: "host1"
                native_vlan: host
    AS2:
        dp_id: 0x3
        hardware: "Allied-Telesis"
        interfaces:
            3:
                name: "trunk"
                tagged_vlans: [host]
            4:
                name: "host2"
                native_vlan: host
```

Appendix

VM Set-up

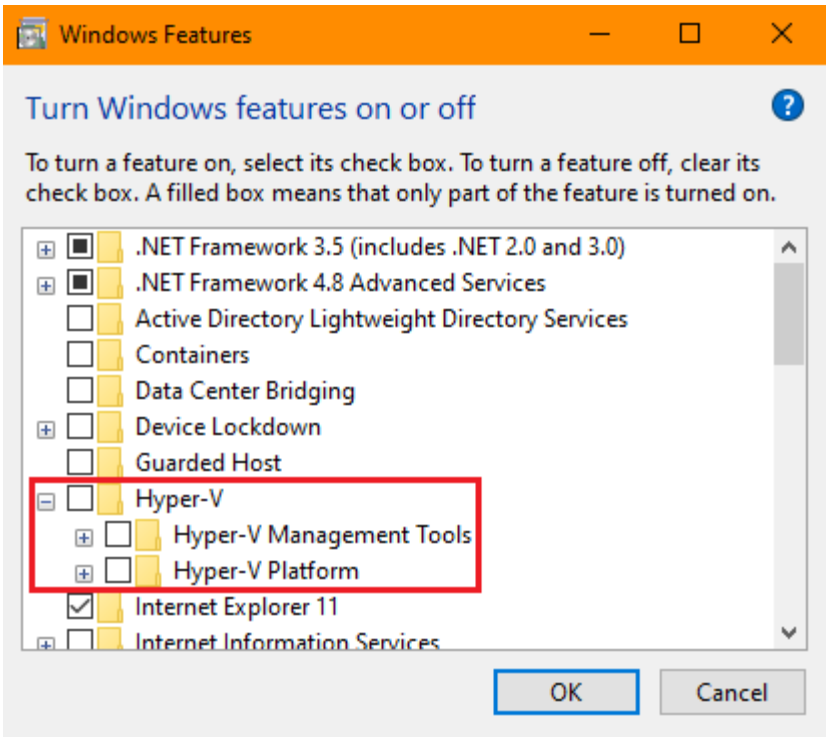
This section will briefly go over setting up a VM that runs faucet. If you already have a system to run faucet go to "Faucet set-up".

Virtualbox

Download and install VirtualBox and the Oracle VM VirtualBox Extension Pack.

Virtualisation

Disable Hyper V in Windows Features.



To enable virtualisation enter the BIOS settings, it should be either under advanced options or CPU options. Different vendors may use different names such as VT-x or SVM.

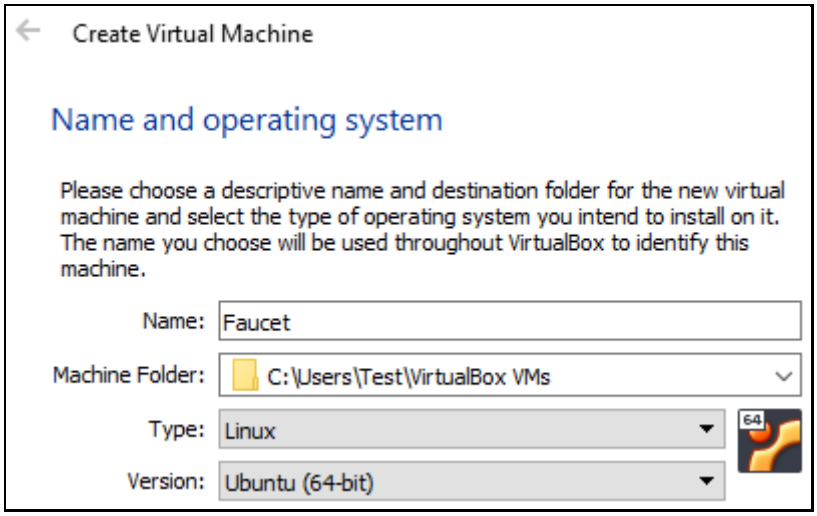
Download ubuntu

Download the latest stable version of Ubuntu. This is 20.04 LTS at the writing of this manual.

Configure the VM

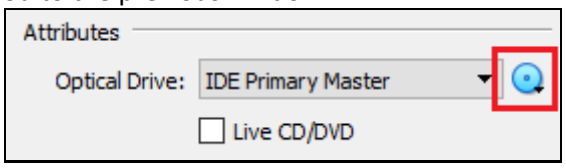
Open virtualbox and create a new VM. This is done by clicking the “New” button or pressing Ctrl+N.

Name and operating system
A new window will pop up. In this window enter a name of your choosing and the following:
Type: Linux
Version: Ubuntu 64 bit

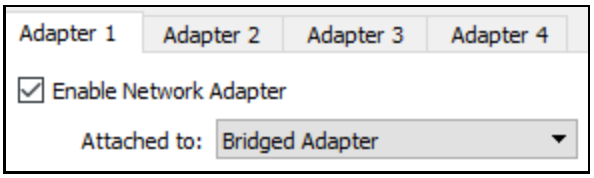


Memory size
The next window will prompt you to select the amount of memory allocated to the VM. Choose at least 4096 MB.
Hard disk
Select: “Create a virtual hard disk now” then click “create”.
Hard disk file type
In the new window that opens select “VDI” and select “Next”.
Storage on physical hard disk
Select “Fixed size” and click next.
File location and size
Select the location you wish to save the VDI and the size you need. For this tutorial a size of 10 GB was used. Press create, it may take some time.

VM settings
Right click on the VM once it has been created and select “Settings”. Go to “System -> Processor” and set the number of processors to 2. Then go to “Storage” and select “Empty Disk” Press the icon next to “Optical Drive” as seen in the image below and select “Choose/Create Virtual Optical Disk”. A window will open, press “Add” and select the Ubuntu image downloaded earlier. Then press “Choose”. This will return you to the previous window.



Lastly, go to “Network” and change the “Attached to” of Adapter 1 to “Bridged Adapter” as shown below. Then press “Ok”.



Starting the VM

Start the VM by double clicking it or pressing the Start button while the VM is selected. A new window will open. Wait for the VM to start up, you may need to select the Ubuntu image.

Installation

Follow the Ubuntu installation instructions, selecting the language and keyboard layout as you see fit. On the next window select “Minimal installation” and “Download updates while installing Ubuntu”. Press continue. Then select “Erase disk and install Ubuntu”. Press “Install now”. Follow further installation instructions such as setting your time zone, username and password.

The Ubuntu installation will take some time, it may be useful to start the switch set-up now. Restart the VM once Ubuntu has been installed. Press enter when prompted to “Please remove the installation medium ”. Log in and continue to faucet set-up.

Additional

To easily adjust the resolution and set-up guest additions on your VM (including copying and pasting between the VM and the host PC) follow the manual found here.