

CSCI 5380 - Network Virtualization and Orchestration

Lab 9 Automate VM, VN, Docker, and BGP path

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Summary:

In this lab, you will use what you have learned in previous labs and automate the processes into a single application.

Required technologies:

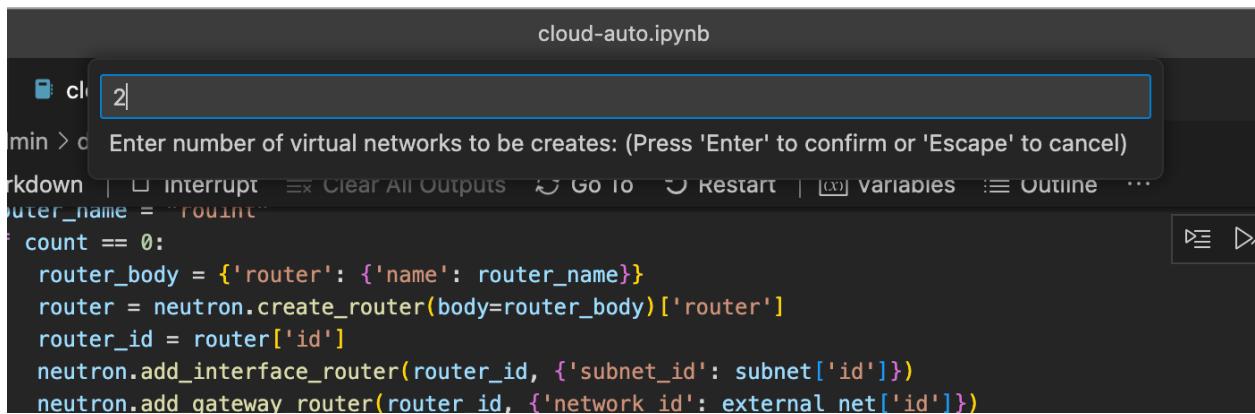
- BGP
- Hypervisor/Orchestrator (such as OpenStack)
- Containers
- SDN Controller
- Hardware server
- Service-chain

Objectives: Virtualized Network Automation

Create an application that meets the following functionality (each objective must be a separate Python module in your code i.e. your main .py file should import the different modules you write):

- 1) Automate the creation of multiple virtual networks (VNs) within the hypervisor and their connection to the public network.

Takes input from the users to mention the specifications of network(numbers of VNs, VMs, subnet name and CIDR)



The screenshot shows a Jupyter Notebook cell with the title "cloud-auto.ipynb". The cell contains the following Python code:

```
cloud-auto.ipynb
In [1]: cl 2
min > c Enter number of virtual networks to be creates: (Press 'Enter' to confirm or 'Escape' to cancel)
[1]: count = 0
      router_name = "router"
      if count == 0:
          router_body = {'router': {'name': router_name}}
          router = neutron.create_router(body=router_body)['router']
          router_id = router['id']
          neutron.add_interface_router(router_id, {'subnet_id': subnet['id']})
          neutron.add_gateway_router(router_id, {'network_id': external_net['id']})
```

```

cl sub1
n > c Enter Name of network that you want to create: (Press 'Enter' to confirm or 'Escape' to cancel)
own | ⚡ interrupt ⚡ Clear All Outputs ⚡ Go to ⚡ Restart | ☰ variables ☱ Outline ...
er_name = "routint"
ount == 0:
outer_body = {'router': {'name': router_name}}
outer = neutron.create_router(body=outer_body)['router']

cl 11.11.11.0/24
n > c Enter cidr of network that you want to create: (Press 'Enter' to confirm or 'Escape' to cancel)
own | ⚡ interrupt ⚡ Clear All Outputs ⚡ Go to ⚡ Restart | ☰ variables ☱ Outline ...
ance_id = 'my-vm-{}'.format(n+1)
= {'net-id': netw['id']}
vm = nova.servers.create(name=instance_id, image=im, flavor=fl,
key_name=key_name, nics=[nic])
| |
| |
| |

The python binding code in neutronclient will be deprecated in favor of OpenstackSDK, please use that!
2
sub1
Network a43d65be-398a-49bc-84fd-3a77abb953f3 created
11.11.11.0/24
Created subnet {'id': '79bcad46-f3b4-407e-b59d-d5b45c77b8af', 'name': '', 'tenant_id': '08df3e5bd70c451aa9c126f85507669', 'ne
<Server: my-vm-1>
2f9c2108-5520-4a8a-b66f-caa7628d8033
Port ID: a6d17290-3502-410c-a4dc-722898c3ee45
sub2
Network 9095ca60-685f-405f-8737-25b5528251ef created
22.22.22.0/24
Created subnet {'id': '70fddbf1-f783-40f4-be0e-687fcb523746', 'name': '', 'tenant_id': '08df3e5bd70c451aa9c126f85507669', 'ne
<Server: my-vm-2>
2f9c2108-5520-4a8a-b66f-caa7628d8033
Port ID: 8243fb8c-b27e-43ac-947a-da15caecec48
INNNN
{'port': {'id': 'a6d17290-3502-410c-a4dc-722898c3ee45', 'name': '', 'network_id': 'a43d65be-398a-49bc-84fd-3a77abb953f3', 'ter
{'port': {'id': 'a6d17290-3502-410c-a4dc-722898c3ee45', 'name': '', 'network_id': 'a43d65be-398a-49bc-84fd-3a77abb953f3', 'ter

```

```

nikhitha@nikhitha-PowerEdge-R430:~$ ping 172.24.4.85
PING 172.24.4.85 (172.24.4.85) 56(84) bytes of data.
64 bytes from 172.24.4.85: icmp_seq=1 ttl=63 time=7.77 ms
64 bytes from 172.24.4.85: icmp_seq=2 ttl=63 time=1.55 ms
^C
--- 172.24.4.85 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 1.552/4.663/7.774/3.111 ms
nikhitha@nikhitha-PowerEdge-R430:~$ 

```

Displaying 3 items

<input type="checkbox"/>	Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
<input type="checkbox"/>	my-vm-3	nat_mininet	22.22.22.73, 172.24.4.8	m1.large	containervm	Active	nova	None	Running	5 hours, 47 minutes	<button>Create Snapshot</button> ▾
<input type="checkbox"/>	my-vm-2	nat_mininet	22.22.22.97, 172.24.4.159	m1.large	containervm	Active	nova	None	Running	6 hours, 6 minutes	<button>Create Snapshot</button> ▾
<input type="checkbox"/>	my-vm-1	nat_mininet	11.11.11.229, 172.24.4.85	m1.large	containervm	Active	nova	None	Running	6 hours, 7 minutes	<button>Create Snapshot</button> ▾

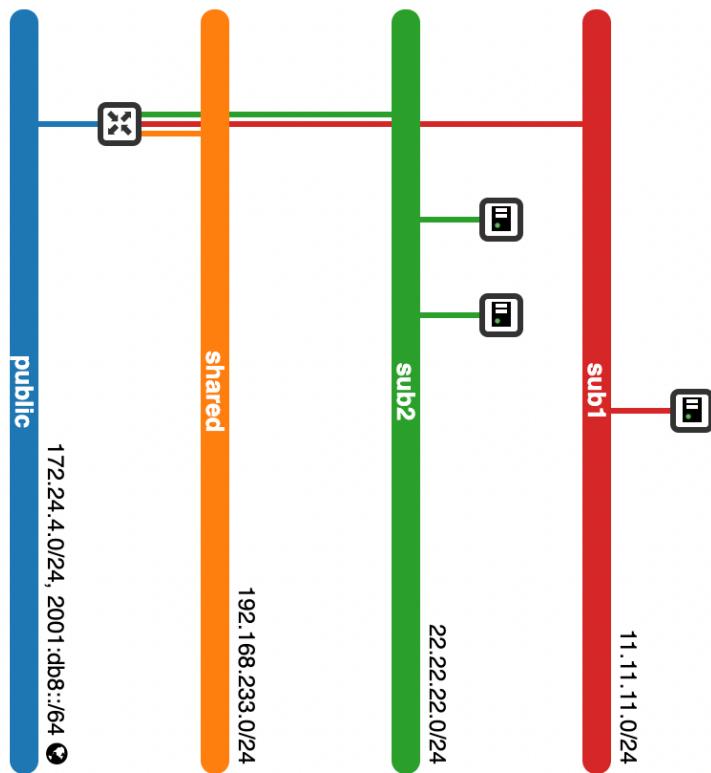
Displaying 3 items

Displaying 4 items

<input type="checkbox"/>	Name	Subnets Associated	Shared	External	Status	Admin State	Availability Zones	Actions
<input type="checkbox"/>	shared	shared-subnet 192.168.233.0/24	Yes	No	Active	UP	-	<button>Edit Network</button> ▾
<input type="checkbox"/>	sub2	22.22.22.0/24	Yes	No	Active	UP	-	<button>Edit Network</button> ▾
<input type="checkbox"/>	sub1	11.11.11.0/24	Yes	No	Active	UP	-	<button>Edit Network</button> ▾
<input type="checkbox"/>	public	public-subnet 172.24.4.0/24 ipv6-public-subnet 2001:db8::/64	No	Yes	Active	UP	-	<button>Edit Network</button> ▾

Displaying 4 items

2) Automate the creation of multiple VMs within the hypervisor-



- a) Both single tenant (same VN) and multi-tenant (different VNs).

Inter VM:

```
mininet@mininet-ofm:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN g
    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
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1442 qdisc pfifo_fast
    link/ether fa:16:3e:b7:1b:97 brd ff:ff:ff:ff:ff:ff
    inet 22.22.22.97/24 brd 22.22.22.255 scope global eth0
        valid_lft forever preferred_lft forever
mininet@mininet-ofm:~$ ping 22.22.22.97
PING 22.22.22.97 (22.22.22.97) 56(84) bytes of data.
64 bytes from 22.22.22.97: icmp_seq=1 ttl=64 time=0.084 ms
64 bytes from 22.22.22.97: icmp_seq=2 ttl=64 time=0.049 ms
^C
--- 22.22.22.97 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.049/0.066/0.084/0.019 ms
mininet@mininet-ofm:~$ ping 22.22.22.73
PING 22.22.22.73 (22.22.22.73) 56(84) bytes of data.
64 bytes from 22.22.22.73: icmp_seq=1 ttl=64 time=0.809 ms
64 bytes from 22.22.22.73: icmp_seq=2 ttl=64 time=0.393 ms
^C
--- 22.22.22.73 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 999ms
rtt min/avg/max/mdev = 0.393/0.601/0.809/0.208 ms
mininet@mininet-ofm:~$
```

Intra VM:

```
..... ping statistics
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 3.280/3.886/4.493/0.609 ms
[mininet@mininet-ofm:~$ ping 22.22.22.97
PING 22.22.22.97 (22.22.22.97) 56(84) bytes of data.
64 bytes from 22.22.22.97: icmp_seq=1 ttl=63 time=1.35 ms
64 bytes from 22.22.22.97: icmp_seq=2 ttl=63 time=0.283 ms
^C
--- 22.22.22.97 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.283/0.819/1.356/0.537 ms
mininet@mininet-ofm:~$
```

- b) All VMs should be accessible from the host server and be able to access the Internet.

```
[mininet@mininet-ofm:~$ ifconfig
eth0      Link encap:Ethernet  HWaddr fa:16:3e:23:1e:68
          inet addr:22.22.22.73  Bcast:22.22.22.255  Mask:255.255.255.0
                  UP BROADCAST RUNNING MULTICAST  MTU:1442  Metric:1
                  RX packets:82 errors:0 dropped:17 overruns:0 frame:0
                  TX packets:59 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:1000
                  RX bytes:12920 (12.9 KB)  TX bytes:8001 (8.0 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
                  UP LOOPBACK RUNNING  MTU:65536  Metric:1
                  RX packets:1156 errors:0 dropped:0 overruns:0 frame:0
                  TX packets:1156 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:0
                  RX bytes:92076 (92.0 KB)  TX bytes:92076 (92.0 KB)

[mininet@mininet-ofm:~$ ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=3.82 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=3.98 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=113 time=2.78 ms
^C
--- 8.8.8.8 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2002ms
rtt min/avg/max/mdev = 2.782/3.530/3.987/0.537 ms
mininet@mininet-ofm:~$ ]
```

```
[mininet@mininet-ofm:~$ ifconfig
eth0      Link encap:Ethernet HWaddr fa:16:3e:b7:1b:97
          inet addr:22.22.22.97 Bcast:22.22.22.255 Mask:255.255.255.
                  UP BROADCAST RUNNING MULTICAST MTU:1442 Metric:1
                  RX packets:82 errors:0 dropped:18 overruns:0 frame:0
                  TX packets:38 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:1000
                  RX bytes:13208 (13.2 KB) TX bytes:6215 (6.2 KB)

lo       Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
                  UP LOOPBACK RUNNING MTU:65536 Metric:1
                  RX packets:1196 errors:0 dropped:0 overruns:0 frame:0
                  TX packets:1196 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:0
                  RX bytes:95260 (95.2 KB) TX bytes:95260 (95.2 KB)

[mininet@mininet-ofm:~$ ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=4.96 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=4.03 ms
^C
--- 8.8.8.8 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 4.030/4.499/4.969/0.474 ms
mininet@mininet-ofm:~$ ]
```

```
[mininet@mininet-ofm:~$ ifconfig
eth0      Link encap:Ethernet HWaddr fa:16:3e:7a:5b:aa
          inet addr:11.11.11.229 Bcast:11.11.11.255 Mask:255.255.255.0
                  UP BROADCAST RUNNING MULTICAST MTU:1442 Metric:1
                  RX packets:81 errors:0 dropped:17 overruns:0 frame:0
                  TX packets:37 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:1000
                  RX bytes:13385 (13.3 KB) TX bytes:6145 (6.1 KB)

lo       Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
                  UP LOOPBACK RUNNING MTU:65536 Metric:1
                  RX packets:1236 errors:0 dropped:0 overruns:0 frame:0
                  TX packets:1236 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:0
                  RX bytes:98444 (98.4 KB) TX bytes:98444 (98.4 KB)

[mininet@mininet-ofm:~$ ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=4.49 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=3.28 ms
^C
--- 8.8.8.8 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 3.280/3.886/4.493/0.609 ms
mininet@mininet-ofm:~$ ]
```

```
* Documentation: https://help.ubuntu.com/
mininet@mininet-ofm:~$ ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=4.47 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=3.92 ms
^C
--- 8.8.8.8 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 3.927/4.198/4.470/0.279 ms
mininet@mininet-ofm:~$ ]
```

- 3) Automate the security groups and port security configuration to make intra-VN and inter-VN communication possible.

```

mininet@mininet-ofm:~$ ping 22.22.22.97
PING 22.22.22.97 (22.22.22.97) 56(84) bytes of data.
64 bytes from 22.22.22.97: icmp_seq=1 ttl=64 time=2.78 ms
64 bytes from 22.22.22.97: icmp_seq=2 ttl=64 time=0.481 ms
64 bytes from 22.22.22.97: icmp_seq=3 ttl=64 time=0.335 ms
^C
--- 22.22.22.97 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2000ms
rtt min/avg/max/mdev = 0.335/1.199/2.783/1.121 ms
mininet@mininet-ofm:~$
```

```

mininet@mininet-ofm:~$ ifconfig
eth0      Link encap:Ethernet HWaddr fa:16:3e:23:1e:68
          inet addr:22.22.22.73 Bcast:22.22.22.255 Mask:255.255.255.0
                  UP BROADCAST RUNNING MULTICAST MTU:1442 Metric:1
                  RX packets:34 errors:0 dropped:17 overruns:0 frame:0
                  TX packets:26 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:1000
                  RX bytes:5699 (5.6 KB) TX bytes:2700 (2.7 KB)

lo       Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
                  UP LOOPBACK RUNNING MTU:65536 Metric:1
                  RX packets:352 errors:0 dropped:0 overruns:0 frame:0
                  TX packets:352 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:0
                  RX bytes:28064 (28.0 KB) TX bytes:28064 (28.0 KB)

mininet@mininet-ofm:~$
```

```

mininet@mininet-ofm:~$ ping 172.24.4.159
PING 172.24.4.159 (172.24.4.159) 56(84) bytes of data.
64 bytes from 172.24.4.159: icmp_seq=1 ttl=62 time=2.42 ms
64 bytes from 172.24.4.159: icmp_seq=2 ttl=62 time=0.406 ms
64 bytes from 172.24.4.159: icmp_seq=3 ttl=62 time=0.411 ms
^C
--- 172.24.4.159 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2002ms
rtt min/avg/max/mdev = 0.406/1.080/2.425/0.951 ms
mininet@mininet-ofm:~$
```

- 4) Automate spinning up and configuring a Quagga/FRR BGP router as a Docker container.
 - a) Automate its BGP configuration to peer with the SDN controller in the next objective.

```

nich3472@instance-1:~/Desktop$ ls
Dockerfiles  Dockerfiles2
nich3472@instance-1:~/Desktop$
```

```
nich3472@instance-1:~/Desktop/Dockerfiles$ ls
Dockerfile Dockerfile bgp_auto_1.py
nich3472@instance-1:~/Desktop/Dockerfiles$
```

```
Dockerfile bgp_auto_2.py
nich3472@instance-1:~/Desktop/Dockerfiles2$ cat Dockerfile
FROM python:3.9-slim

# Install required packages
RUN apt-get update && apt-get install -y git libffi-dev

# Clone Ryu repository
RUN git clone https://github.com/osrg/ryu.git /ryu

# Install Ryu
RUN cd /ryu && python3 -m pip install .

# Expose the necessary ports
EXPOSE 6633 6653

# Start the Ryu controller
CMD [ "ryu-manager" ]

nich3472@instance-1:~/Desktop/Dockerfiles2$
```

```
# Start ExaBGP on container launch
#CMD ["exabgp"]
"""

# Create a new Dockerfile
with open("Dockerfile", "w") as f:
    f.write(dockerfile_content)

# Build a Docker image from the Dockerfile
image, build_logs = client.images.build(path='.', tag='exa_bgp')

# Print build logs
for log in build_logs:
    print(log)

# Save the Docker image to your local Docker registry
client.images.push('exa_bgp')
nich3472@instance-1:~/Desktop/Dockerfiles$
```

5) Automate spinning up and configuring an SDN controller as another Docker container.

a) Automate its BGP speaker configuration to peer with Quagga/FRR.

```
nich3472@instance-1:~/Desktop/Dockerfiles$ cat Dockerfile

# Use Ubuntu 20.04 as base image
FROM ubuntu:20.04

# Install necessary dependencies
#RUN apt-get update && apt-get install -y python3-pip git curl libssl-p
RUN apt-get update && apt-get install -y git build-essential libssl-p
    && rm -rf /var/lib/apt/lists/*

# Clone ExaBGP repository
RUN git clone https://github.com/Exa-Networks/exabgp.git /tmp/exabgp

# Install ExaBGP
RUN cd /tmp/exabgp && python3 setup.py install

# Clean up
RUN rm -rf /tmp/exabgp
#RUN pip3 install ExaBGP

# Copy ExaBGP configuration file
#COPY ./bgp.conf /etc/exabgp/

# Expose port for ExaBGP
EXPOSE 179

# Start ExaBGP on container launch
#CMD ["exabgp"]
nich3472@instance-1:~/Desktop/Dockerfiles$ █
```

```

root@e30e4346948e:/etc/exabgp# cat bgp.conf
#!/usr/bin/env exabgpcli

# Specify the local AS number
#process {
#    run /usr/bin/logger -t exabgp -p local0.notice
#    local-as 10;
#    router-id 172.17.0.3;
#}

# Specify the neighbor and advertise the network
neighbor 172.17.0.2 {
    router-id 172.17.0.3;
    local-address 172.17.0.3;
    local-as 10;
    peer-as 4;
    family {
        ipv4 unicast;
    }
}
root@e30e4346948e:/etc/exabgp#

```

```

exa control    /usr/local/run/exabgp/           instantiating app None or direct
cli control   - /usr/local/run/0/                creating context dpset
cli control   - /usr/local/run/                 creating context wsgi
cli control   - /usr/local/var/run/exabgp/      instantiating app ryu/app/simple_switch_13.py of SimpleSwitch13
cli control   - /usr/local/var/run/0/            instantiating app ryu/app/ofctl_rest.py of RestStatsApi
cli control   - /usr/local/var/run/             instantiating app ryu/services/protocols/bgp/application.py of RyuBGPSpeaker
cli control   please make them in one of the folder with the following co instantiating app ryu.controller.ofp_handler of OFPHandler
cli control   > mkfifo /root/run/exabgp.{in,out} API method core.start called with args: {'waiter': <ryu.lib.hub.Event object at 0x7f0100000000>, 'hosts': ['0.0.0.0', '::'], 'bgp_server_port': 179, 'refresh_stalepath_time': 0, 'al_as_in_count': 0, 'cluster_id': None, 'local_pref': 100}
cli control   > chmod 600 /root/run/exabgp.{in,out}
configuration performing reload of exabgp main
reactor      loaded new configuration successfully
outgoing-1   -----
outgoing-1   the connection can not carry the following family/families
outgoing-1   - exabgp is not configured for ipv6/mpls-vpn
outgoing-1   - exabgp is not configured for ipv6/unicast
outgoing-1   - exabgp is not configured for ipv4/mpls-vpn
outgoing-1   therefore no routes of this kind can be announced on the co (315) wsgi starting up on http://0.0.0.0:8080
outgoing-1   -----
reactor      connected to peer-1 with outgoing-1 172.17.0.3-172.17.0.2 Will try to reconnect to 172.17.0.3 after 30 secs: True
                                                               Will try to reconnect to 172.17.0.3 after 30 secs: True
                                                               Connection to peer: 172.17.0.3 established

```

Deliverable:

Create a personal GitHub page that demonstrates the required functionality.