

NC864 SDN - Assignment 3

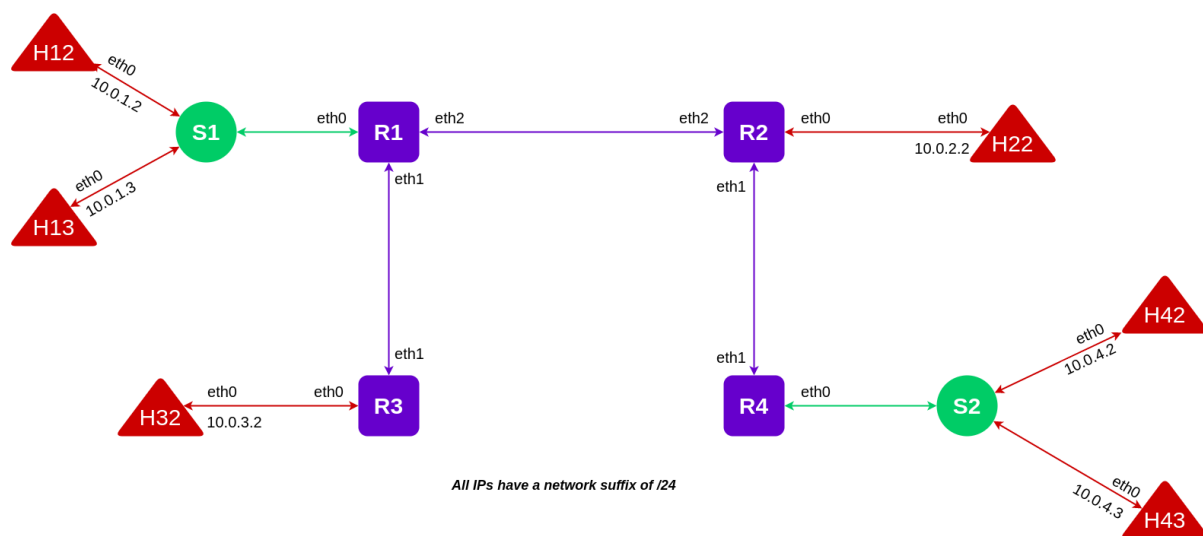


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Repository: github.com/Shathin/nc864-sdn

Target Network



The above diagram shows the target network,

Following are the different subnets and hosts in those networks -

- 10.0.1.0/24 → R1 – eth0, H12, H13 and S1.
- 10.0.2.0/24 → R2 – eth0 and H22
- 10.0.3.0/24 → R3 – eth0 and H32
- 10.0.4.0/24 → R4 – eth0, H42, H43 and S2.

Since there is no concept of routers in SDN and all data plane devices are simple forwarding devices, even the devices that were routers in the previous assignment i.e., R1, R2, R3 and R4 are now L2 switches and hence no IPs are assigned to their interfaces.

The Script

The `assignment3_topo.py` python script creates the above target network using the Python Mininet API.

The `DefaultController` ([OVS Test Controller](#)) was used in place of ODL (as required by the problem statement) as ODL was causing problems by showing various unexpected behaviours. The `DefaultController` does perform all the required actions like automatically installing flow rules when necessary.

The script can be run as follows -

```
sudo python3 assignment3_topo.py
```

Results

Default Flow Rules

A set of default flow rules is initially installed in each switch by the Controller. This default flow rules tells the switches to contact the controller if it receives a packet that doesn't have a matching flow rule. This flow helps the installation of new flow rules when necessary.

```
mininet> dpctl dump-flows
*** r1 -----
cookie=0x0, duration=16.525s, table=0, n_packets=131, n_bytes=15358, priority=0 actions=CONTROLLER:128
*** r2 -----
cookie=0x0, duration=16.527s, table=0, n_packets=131, n_bytes=15358, priority=0 actions=CONTROLLER:128
*** r3 -----
cookie=0x0, duration=16.532s, table=0, n_packets=131, n_bytes=15358, priority=0 actions=CONTROLLER:128
*** r4 -----
cookie=0x0, duration=16.538s, table=0, n_packets=132, n_bytes=15503, priority=0 actions=CONTROLLER:128
*** s1 -----
cookie=0x0, duration=16.541s, table=0, n_packets=135, n_bytes=15786, priority=0 actions=CONTROLLER:128
*** s4 -----
cookie=0x0, duration=16.546s, table=0, n_packets=133, n_bytes=15593, priority=0 actions=CONTROLLER:128
```

Default flow rules of each switch in the network.

Testing connectivity between the hosts

The connectivity between the hosts can be tested by ping one host from another. The process can be simplified by executing the `pingall` command in the mininet CLI which executes the `ping` command on each host automatically.

```
mininet> pingall
*** Ping: testing ping reachability
h12 -> h13 h22 h32 h42 h43
h13 -> h12 h22 h32 h42 h43
h22 -> h12 h13 h32 h42 h43
h32 -> h12 h13 h22 h42 h43
h42 -> h12 h13 h22 h32 h43
h43 -> h12 h13 h22 h32 h42
*** Results: 0% dropped (30/30 received)
```

All hosts are able to ping each other.

Automatically Installed Flow Rules

When the `pingall` command is executed, each switch communicates with the controller to get instructions about where to send the ICMP packets. As stated before, this is possible due to the default flow rules installed in each switch that tell the switch whom to connect with in case there is no matching flow rule of an in-bound packet.

Since a lot of rules have been added after the `pingall` command, it is not possible to show them all clearly in a screenshot and hence they've been pasted as regular text below.

Scroll to the last bottom of this document for the discussion about the flow rules

▼ Flow rules in Switch R1

```
cookie=0x0, duration=26.144s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:03, dl_dst=00:00:00:00:00:01, arp_spa=10.0.2.2, arp_tpa=10.0.1.2, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.132s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth1", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:04, dl_dst=00:00:00:00:00:01, arp_spa=10.0.3.2, arp_tpa=10.0.1.2, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.123s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:05, dl_dst=00:00:00:00:00:01, arp_spa=10.0.4.2, arp_tpa=10.0.1.2, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.116s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:06, dl_dst=00:00:00:00:00:01, arp_spa=10.0.4.3, arp_tpa=10.0.1.2, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.106s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:03, dl_dst=00:00:00:00:00:02, arp_spa=10.0.2.2, arp_tpa=10.0.1.3, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.100s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth1", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:04, dl_dst=00:00:00:00:00:02, arp_spa=10.0.3.2, arp_tpa=10.0.1.3, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.094s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:05, dl_dst=00:00:00:00:00:02, arp_spa=10.0.4.2, arp_tpa=10.0.1.3, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.087s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:06, dl_dst=00:00:00:00:00:02, arp_spa=10.0.4.3, arp_tpa=10.0.1.3, arp_op=2 actions=output:"r1-eth0"
cookie=0x0, duration=26.072s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth1", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:04, dl_dst=00:00:00:00:00:03, arp_spa=10.0.3.2, arp_tpa=10.0.2.2, arp_op=2 actions=output:"r1-eth2"
cookie=0x0, duration=26.042s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:05, dl_dst=00:00:00:00:00:04, arp_spa=10.0.4.2, arp_tpa=10.0.3.2, arp_op=2 actions=output:"r1-eth1"
cookie=0x0, duration=26.035s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:06, dl_dst=00:00:00:00:00:04, arp_spa=10.0.4.3, arp_tpa=10.0.3.2, arp_op=2 actions=output:"r1-eth1"
cookie=0x0, duration=21.067s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth1", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:04, dl_dst=00:00:00:00:00:01, arp_spa=10.0.3.2, arp_tpa=10.0.1.2, arp_op=1 actions=output:"r1-eth0"
cookie=0x0, duration=21.066s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth1", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:04, dl_dst=00:00:00:00:00:02, arp_spa=10.0.3.2, arp_tpa=10.0.1.3, arp_op=1 actions=output:"r1-eth0"
cookie=0x0, duration=21.066s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:03, dl_dst=00:00:00:00:00:01, arp_spa=10.0.2.2, arp_tpa=10.0.1.2, arp_op=1 actions=output:"r1-eth0"
cookie=0x0, duration=21.065s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp, in_port="r1-eth2", vlan_tci=0x0000/0x1fff, dl_src=00:00:00:00:00:03, dl_dst=00:00:00:00:00:02, arp_spa=10.0.2.2, arp_tpa=10.0.1.3, arp_op=1 actions=output:"r1-eth0"
cookie=0x0, duration=21.053s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
```



```

0"
  cookie=0x0, duration=26.024s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:02,d_l_dst=00:00:00:00:00:0
  0:05,nw_src=10.0.1.3,nw_dst=10.0.4.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r1-eth
  2"
  cookie=0x0, duration=26.015s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:05,d_l_dst=00:00:00:00:00:0
  0:04,nw_src=10.0.4.2,nw_dst=10.0.3.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r1-eth
  1"
  cookie=0x0, duration=26.014s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:04,d_l_dst=00:00:00:00:00:0
  0:05,nw_src=10.0.3.2,nw_dst=10.0.4.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r1-eth
  2"
  cookie=0x0, duration=26.008s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:0
  0:01,nw_src=10.0.4.3,nw_dst=10.0.1.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r1-eth
  0"
  cookie=0x0, duration=26.007s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:00:0
  0:06,nw_src=10.0.1.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r1-eth
  2"
  cookie=0x0, duration=26.003s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:0
  0:02,nw_src=10.0.4.3,nw_dst=10.0.1.3,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r1-eth
  0"
  cookie=0x0, duration=26.002s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:02,d_l_dst=00:00:00:00:00:0
  0:06,nw_src=10.0.1.3,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r1-eth
  2"
  cookie=0x0, duration=25.995s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:0
  0:04,nw_src=10.0.4.3,nw_dst=10.0.3.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r1-eth
  1"
  cookie=0x0, duration=25.994s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r1-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:04,d_l_dst=00:00:00:00:00:0
  0:06,nw_src=10.0.3.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r1-eth
  2"
  cookie=0x0, duration=852.321s, table=0, n_packets=358, n_bytes=37830, priority=0 actions=CO
  NTROLLER:128

```

▼ Flow rules in Switch R2

```

cookie=0x0, duration=26.168s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,a
  rp,in_port="r2-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:00:0
  1,arp_spa=10.0.2.2,arp_tpa=10.0.1.2,arp_op=2 actions=output:"r2-eth2"
  cookie=0x0, duration=26.143s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:05,d_l_dst=00:00:00:00:00:0
  01,arp_spa=10.0.4.2,arp_tpa=10.0.1.2,arp_op=2 actions=output:"r2-eth2"
  cookie=0x0, duration=26.136s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:0
  01,arp_spa=10.0.4.3,arp_tpa=10.0.1.2,arp_op=2 actions=output:"r2-eth2"
  cookie=0x0, duration=26.126s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:00:0
  02,arp_spa=10.0.2.2,arp_tpa=10.0.1.3,arp_op=2 actions=output:"r2-eth2"
  cookie=0x0, duration=26.114s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:05,d_l_dst=00:00:00:00:00:0
  02,arp_spa=10.0.4.2,arp_tpa=10.0.1.3,arp_op=2 actions=output:"r2-eth2"
  cookie=0x0, duration=26.107s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:0
  02,arp_spa=10.0.4.3,arp_tpa=10.0.1.3,arp_op=2 actions=output:"r2-eth2"
  cookie=0x0, duration=26.091s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,

```

[illegible]


```

04,arp_spa=10.0.2.2,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r2-eth2"
  cookie=0x0, duration=20.826s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:00:
05,arp_spa=10.0.2.2,arp_tpa=10.0.4.2,arp_op=2 actions=output:"r2-eth1"
  cookie=0x0, duration=20.826s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:00:
06,arp_spa=10.0.2.2,arp_tpa=10.0.4.3,arp_op=2 actions=output:"r2-eth1"
  cookie=0x0, duration=20.819s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:
04,arp_spa=10.0.4.3,arp_tpa=10.0.3.2,arp_op=1 actions=output:"r2-eth2"
  cookie=0x0, duration=20.812s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:04,d_l_dst=00:00:00:00:00:
05,arp_spa=10.0.3.2,arp_tpa=10.0.4.2,arp_op=2 actions=output:"r2-eth1"
  cookie=0x0, duration=20.802s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:04,d_l_dst=00:00:00:00:00:
06,arp_spa=10.0.3.2,arp_tpa=10.0.4.3,arp_op=2 actions=output:"r2-eth1"
  cookie=0x0, duration=26.160s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:0
0:03,nw_src=10.0.1.2,nw_dst=10.0.2.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r2-eth
0"
  cookie=0x0, duration=26.158s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:0
0:01,nw_src=10.0.2.2,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r2-eth
2"
  cookie=0x0, duration=26.142s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:0
0:05,nw_src=10.0.1.2,nw_dst=10.0.4.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r2-eth
1"
  cookie=0x0, duration=26.140s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:05,d_l_dst=00:00:00:00:0
0:01,nw_src=10.0.4.2,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r2-eth
2"
  cookie=0x0, duration=26.134s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:0
0:06,nw_src=10.0.1.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r2-eth
1"
  cookie=0x0, duration=26.132s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:0
0:01,nw_src=10.0.4.3,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r2-eth
2"
  cookie=0x0, duration=26.125s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:02,d_l_dst=00:00:00:00:0
0:03,nw_src=10.0.1.3,nw_dst=10.0.2.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r2-eth
0"
  cookie=0x0, duration=26.124s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:0
0:02,nw_src=10.0.2.2,nw_dst=10.0.1.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r2-eth
2"
  cookie=0x0, duration=26.113s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:02,d_l_dst=00:00:00:00:0
0:05,nw_src=10.0.1.3,nw_dst=10.0.4.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r2-eth
1"
  cookie=0x0, duration=26.112s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:05,d_l_dst=00:00:00:00:0
0:02,nw_src=10.0.4.2,nw_dst=10.0.1.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r2-eth
2"
  cookie=0x0, duration=26.107s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:02,d_l_dst=00:00:00:00:0
0:06,nw_src=10.0.1.3,nw_dst=10.0.4.3,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r2-eth
1"
  cookie=0x0, duration=26.105s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r2-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:0
0:02,nw_src=10.0.4.3,nw_dst=10.0.1.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r2-eth
2"

```



```
cookie=0x0, duration=852.339s, table=0, n_packets=358, n_bytes=37830, priority=0 actions=CONTROLLER:128
```

▼ Flow rules in Switch R3

```
cookie=0x0, duration=26.192s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
01,arp_spa=10.0.3.2,arp_tpa=10.0.1.2,arp_op=2 actions=output:"r3-eth1"
cookie=0x0, duration=26.161s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
02,arp_spa=10.0.3.2,arp_tpa=10.0.1.3,arp_op=2 actions=output:"r3-eth1"
cookie=0x0, duration=26.132s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
03,arp_spa=10.0.3.2,arp_tpa=10.0.2.2,arp_op=2 actions=output:"r3-eth1"
cookie=0x0, duration=26.101s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
04,arp_spa=10.0.4.2,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r3-eth0"
cookie=0x0, duration=26.095s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
04,arp_spa=10.0.4.3,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r3-eth0"
cookie=0x0, duration=21.129s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
01,arp_spa=10.0.3.2,arp_tpa=10.0.1.2,arp_op=1 actions=output:"r3-eth1"
cookie=0x0, duration=21.129s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
02,arp_spa=10.0.3.2,arp_tpa=10.0.1.3,arp_op=1 actions=output:"r3-eth1"
cookie=0x0, duration=21.104s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:
04,arp_spa=10.0.1.3,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r3-eth0"
cookie=0x0, duration=21.104s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:
04,arp_spa=10.0.1.2,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r3-eth0"
cookie=0x0, duration=20.875s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
03,arp_spa=10.0.3.2,arp_tpa=10.0.2.2,arp_op=1 actions=output:"r3-eth1"
cookie=0x0, duration=20.862s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
04,arp_spa=10.0.4.2,arp_tpa=10.0.3.2,arp_op=1 actions=output:"r3-eth0"
cookie=0x0, duration=20.857s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
05,arp_spa=10.0.3.2,arp_tpa=10.0.4.2,arp_op=2 actions=output:"r3-eth1"
cookie=0x0, duration=20.857s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:
04,arp_spa=10.0.2.2,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r3-eth0"
cookie=0x0, duration=20.852s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
04,arp_spa=10.0.4.3,arp_tpa=10.0.3.2,arp_op=1 actions=output:"r3-eth0"
cookie=0x0, duration=20.848s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
arp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
06,arp_spa=10.0.3.2,arp_tpa=10.0.4.3,arp_op=2 actions=output:"r3-eth1"
cookie=0x0, duration=26.190s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
icmp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:0
0:04,nw_src=10.0.1.2,nw_dst=10.0.3.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r3-eth
0"
cookie=0x0, duration=26.189s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
icmp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:0
0:01,nw_src=10.0.3.2,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r3-eth
1"
cookie=0x0, duration=26.159s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
icmp,in_port="r3-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:0
0:04,nw_src=10.0.1.3,nw_dst=10.0.3.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r3-eth
```



```
0"
  cookie=0x0, duration=26.053s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r3-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:
  06,nw_src=10.0.3.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r3-eth
  1"
  cookie=0x0, duration=852.378s, table=0, n_packets=316, n_bytes=34722, priority=0 actions=C0
  NTROLLER:128
```

▼ Flow rules in Switch R4

```
  cookie=0x0, duration=26.191s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
  01,arp_spa=10.0.4.2,arp_tpa=10.0.1.2,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=26.183s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
  01,arp_spa=10.0.4.3,arp_tpa=10.0.1.2,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=26.161s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
  02,arp_spa=10.0.4.2,arp_tpa=10.0.1.3,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=26.154s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
  02,arp_spa=10.0.4.3,arp_tpa=10.0.1.3,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=26.132s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
  03,arp_spa=10.0.4.2,arp_tpa=10.0.2.2,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=26.127s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
  03,arp_spa=10.0.4.3,arp_tpa=10.0.2.2,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=26.110s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
  04,arp_spa=10.0.4.2,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=26.102s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
  04,arp_spa=10.0.4.3,arp_tpa=10.0.3.2,arp_op=2 actions=output:"r4-eth1"
  cookie=0x0, duration=21.129s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
  01,arp_spa=10.0.4.2,arp_tpa=10.0.1.2,arp_op=1 actions=output:"r4-eth1"
  cookie=0x0, duration=21.129s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
  01,arp_spa=10.0.4.3,arp_tpa=10.0.1.2,arp_op=1 actions=output:"r4-eth1"
  cookie=0x0, duration=21.129s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:
  02,arp_spa=10.0.4.3,arp_tpa=10.0.1.3,arp_op=1 actions=output:"r4-eth1"
  cookie=0x0, duration=21.129s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
  02,arp_spa=10.0.4.2,arp_tpa=10.0.1.3,arp_op=1 actions=output:"r4-eth1"
  cookie=0x0, duration=21.105s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:
  05,arp_spa=10.0.1.2,arp_tpa=10.0.4.2,arp_op=2 actions=output:"r4-eth0"
  cookie=0x0, duration=21.105s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:
  06,arp_spa=10.0.1.2,arp_tpa=10.0.4.3,arp_op=2 actions=output:"r4-eth0"
  cookie=0x0, duration=21.105s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:
  05,arp_spa=10.0.1.3,arp_tpa=10.0.4.2,arp_op=2 actions=output:"r4-eth0"
  cookie=0x0, duration=21.105s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:
  06,arp_spa=10.0.1.3,arp_tpa=10.0.4.3,arp_op=2 actions=output:"r4-eth0"
  cookie=0x0, duration=20.879s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  arp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:
  03,arp_spa=10.0.4.2,arp_tpa=10.0.2.2,arp_op=1 actions=output:"r4-eth1"
```



```

1"
  cookie=0x0, duration=26.068s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r4-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:02,d_l_dst=00:00:00:00:00:
  0:06,nw_src=10.0.1.3,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r4-eth
  0"
  cookie=0x0, duration=26.065s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:
  0:03,nw_src=10.0.4.3,nw_dst=10.0.2.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r4-eth
  1"
  cookie=0x0, duration=26.064s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r4-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:00:
  0:06,nw_src=10.0.2.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r4-eth
  0"
  cookie=0x0, duration=26.061s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r4-eth0",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:
  0:04,nw_src=10.0.4.3,nw_dst=10.0.3.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r4-eth
  1"
  cookie=0x0, duration=26.060s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="r4-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:04,d_l_dst=00:00:00:00:00:
  0:06,nw_src=10.0.3.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r4-eth
  0"
  cookie=0x0, duration=852.387s, table=0, n_packets=335, n_bytes=36100, priority=0 actions=C0
  NTROLLER:128

```

▼ Flow rules in Switch S1

```

  cookie=0x0, duration=26.242s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,i
  cmp,in_port="s1-eth2",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:02,d_l_dst=00:00:00:00:00:
  01,nw_src=10.0.1.3,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"s1-eth1"
  cookie=0x0, duration=26.218s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:00:
  0:03,nw_src=10.0.1.2,nw_dst=10.0.2.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"s1-eth
  3"
  cookie=0x0, duration=26.213s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth3",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:00:
  0:01,nw_src=10.0.2.2,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"s1-eth
  1"
  cookie=0x0, duration=26.207s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:00:
  0:04,nw_src=10.0.1.2,nw_dst=10.0.3.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"s1-eth
  3"
  cookie=0x0, duration=26.204s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth3",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:04,d_l_dst=00:00:00:00:00:
  0:01,nw_src=10.0.3.2,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"s1-eth
  1"
  cookie=0x0, duration=26.198s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:00:
  0:05,nw_src=10.0.1.2,nw_dst=10.0.4.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"s1-eth
  3"
  cookie=0x0, duration=26.196s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth3",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:05,d_l_dst=00:00:00:00:00:
  0:01,nw_src=10.0.4.2,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"s1-eth
  1"
  cookie=0x0, duration=26.191s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth1",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:01,d_l_dst=00:00:00:00:00:
  0:06,nw_src=10.0.1.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"s1-eth
  3"
  cookie=0x0, duration=26.188s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
  icmp,in_port="s1-eth3",vlan_tci=0x0000/0x1fff,d_l_src=00:00:00:00:00:06,d_l_dst=00:00:00:00:00:
  0:01,nw_src=10.0.4.3,nw_dst=10.0.1.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"s1-eth
  1"

```


▼ Flow rules in Switch S4

NC864 SDN - Assignment 3


```

    cookie=0x0, duration=26.092s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
    icmp,in_port="s4-eth2",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:0
    0:04,nw_src=10.0.4.3,nw_dst=10.0.3.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"s4-eth
    3"
    cookie=0x0, duration=26.089s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
    icmp,in_port="s4-eth3",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:0
    0:06,nw_src=10.0.3.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"s4-eth
    2"
    cookie=0x0, duration=26.087s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
    icmp,in_port="s4-eth2",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:0
    0:05,nw_src=10.0.4.3,nw_dst=10.0.4.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"s4-eth
    1"
    cookie=0x0, duration=26.087s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1,
    icmp,in_port="s4-eth1",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:0
    0:06,nw_src=10.0.4.2,nw_dst=10.0.4.3,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"s4-eth
    2"
    cookie=0x0, duration=852.416s, table=0, n_packets=340, n_bytes=36582, priority=0 actions=C0
    NTRROLLER:128

```

Discussion about the flow rules

After the `pingall` a total of 3 types of rules are observed on each switch -

▼ The default flow rule (as discussed before)

Again, this flow rule tells the switch whom to contact when a packet arrives for which there is no corresponding flow rule.

The default flow rule from the switch *R1* →

```

    cookie=0x0, duration=852.321s, table=0, n_packets=358, n_bytes=37830, priority=0 actions=C0
    NTRROLLER:128

```

▼ Flow rule that matches ARP packets

Each flow rule matching ARP packets have the following key factors -

- Protocol → `arp`
- Opcode of ARP → `arp_op`: This determines what type of ARP packet is to be matched by the flow rule.
 - `arp_op=1` ⇒ ARP Request Packet
 - `arp_op=2` ⇒ ARP Response Packet
- Source IP Address of ARP → `arp_spa`: Address of the initiator of the ARP Request.
- Target IP Address of ARP → `arp_tpa`: Refers to intended target of the ARP Request

Flow rule matching an ARP Request on the Switch *R1* →

```

    cookie=0x0, duration=26.144s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, a
    rp,in_port="r1-eth2",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:0
    0:01,arp_spa=10.0.2.2,arp_tpa=10.0.1.2,arp_op=2 actions=output:"r1-eth0"

```

Flow rule matching an ARP Response on the Switch *R1* →

```
cookie=0x0, duration=21.066s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, arp,in_port="r1-eth2",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:01,arp_spa=10.0.2.2,arp_tpa=10.0.1.2,arp_op=1 actions=output:"r1-eth0"
```

▼ Flow rule that matches ICMP packets

Each flow rule matching ICMP (ping) packets have the following key factors -

- Protocol → `icmp`
- ICMP Type → `icmp_type`: Determines the type of ICMP message. In our flow rules, we see only two types of ICMP messages
 - `icmp_type=0` ⇒ Echo: `ping` request
 - `icmp_type=8` ⇒ Echo reply: Response to the `ping`
- ICMP Code → `icmp_code`: The ICMP Code for both of the observed ICMP Types is all of the flow rules is `icmp_code=0` which doesn't have meaning and stands for **no code**.

Flow rule matching the Echo ICMP packet from the host 10.0.1.2 to the host 10.0.2.2 going through switch *R1* →

```
cookie=0x0, duration=26.079s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, icmp,in_port="r1-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:03,nw_src=10.0.1.2,nw_dst=10.0.2.2,nw_tos=0,icmp_type=0,icmp_code=0 actions=output:"r1-eth2"
```

Flow rule matching the Echo Reply ICMP packet from the host 10.0.1.2 to the host 10.0.2.2 going through switch *R1* →

```
cookie=0x0, duration=26.141s, table=0, n_packets=0, n_bytes=0, idle_timeout=60, priority=1, icmp,in_port="r1-eth0",vlan_tci=0x0000/0x1fff,dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:03,nw_src=10.0.1.2,nw_dst=10.0.2.2,nw_tos=0,icmp_type=8,icmp_code=0 actions=output:"r1-eth2"
```

References


OpenFlow Protocol - Ryubook 1.0 documentation

This section describes match, instructions and actions defined in the OpenFlow protocol. There are a variety of conditions that can be specified to match, and it grows each time OpenFlow is updated. OpenFlow 1.0 had 12 types but in OpenFlow 1.3 as many as 40 types of conditions are defined.

https://osrg.github.io/ryu-book/en/html/openflow_protocol.html

Internet Control Message Protocol (ICMP) Parameters

Last Updated 2020-09-25 Available Formats XML HTML Plain text Registries included below Registration Procedure(s) IESG Approval or Standards Action Reference [RFC2780] Note The Internet Control Message Protocol (ICMP) has many messages that are identified by a "type" field.

 <https://www.iana.org/assignments/icmp-parameters/icmp-parameters.xhtml#icmp-parameters-types>

<http://www.openvswitch.org/support/dist-docs/ovs-dpctl.8.txt>