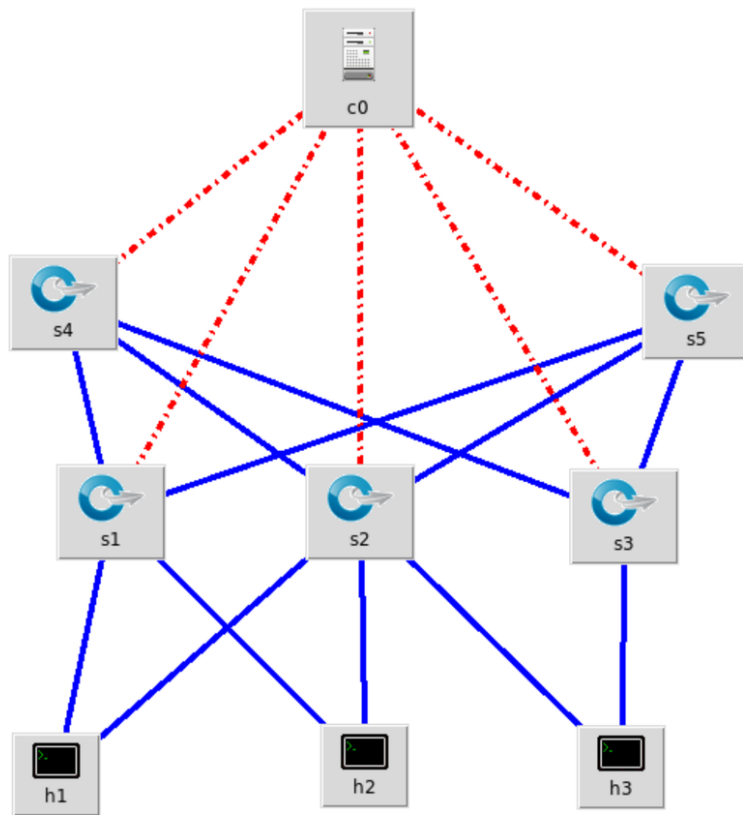
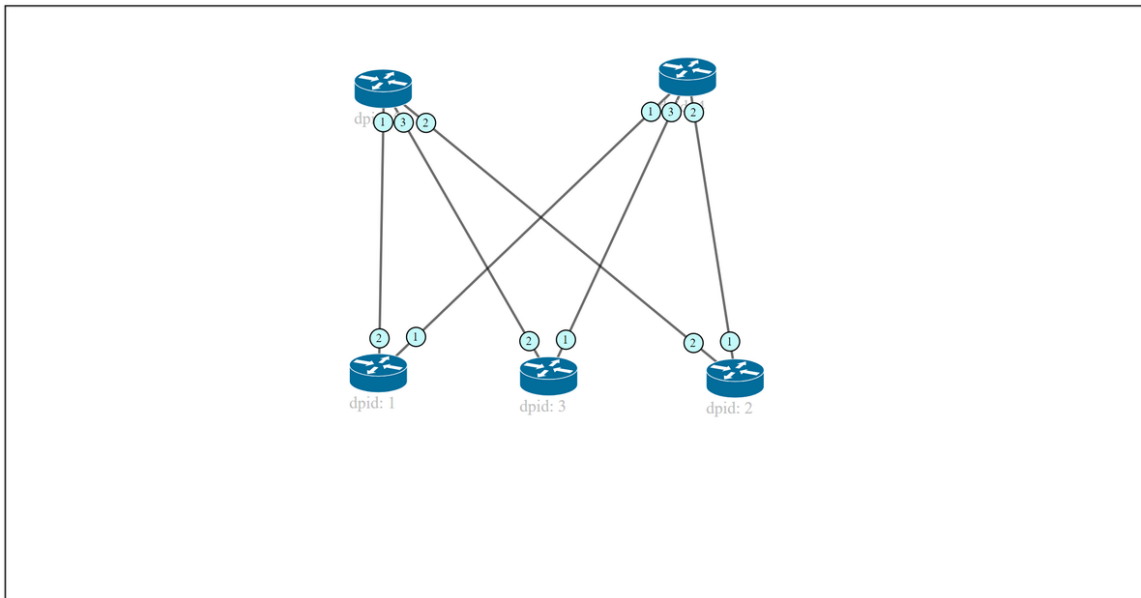


# [Capstone Update]

Network Topology



## Ryu Topology Viewer



### Spinning Mininet Topology

```
mininet@mininet-ofm:~$ sudo python nodered.py
*** Adding controller
*** Add switches
*** Add hosts
*** Add links
*** Starting network
*** Configuring hosts
h2 h3 h1
*** Starting controllers
*** Starting switches
*** Post configure switches and hosts
*** Starting CLI:
mininet> dump
<Host h2: h2-eth0:10.0.0.2,h2-eth1:None pid=16222>
<Host h3: h3-eth0:10.0.0.3,h3-eth1:None pid=16224>
<Host h1: h1-eth0:10.0.0.1,h1-eth1:None pid=16226>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None,s3-eth3:None pid=16205>
<OVSSwitch s4: lo:127.0.0.1,s4-eth1:None,s4-eth2:None,s4-eth3:None pid=16208>
<OVSSwitch s5: lo:127.0.0.1,s5-eth1:None,s5-eth2:None,s5-eth3:None pid=16211>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None,s2-eth4:None,s2-eth5:None pid=16214>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None,s1-eth4:None pid=16217>
<RemoteController c0: 192.168.31.5:6633 pid=16198>
mininet>
mininet> links
s1-eth1<->s4-eth1 (OK OK)
s1-eth2<->s5-eth1 (OK OK)
s4-eth2<->s2-eth1 (OK OK)
s5-eth2<->s2-eth2 (OK OK)
s4-eth3<->s3-eth1 (OK OK)
s5-eth3<->s3-eth2 (OK OK)
h1-eth0<->s1-eth3 (OK OK)
s2-eth3<->h1-eth1 (OK OK)
s1-eth4<->h2-eth0 (OK OK)
s2-eth4<->h2-eth1 (OK OK)
s2-eth5<->h3-eth0 (OK OK)
s3-eth3<->h3-eth1 (OK OK)
mininet>
```

Successful Connection to the Controller

```
mininet> sh ovs-vsctl show
97060324-da2c-4cc5-ac47-5e2006b159a7
    Bridge "s4"
        Controller "tcp:192.168.31.5:6633"
            is_connected: true
        fail_mode: secure
        Port "s4-eth3"
            Interface "s4-eth3"
        Port "s4"
            Interface "s4"
                type: internal
        Port "s4-eth2"
            Interface "s4-eth2"
        Port "s4-eth1"
            Interface "s4-eth1"
    Bridge "s5"
        Controller "tcp:192.168.31.5:6633"
            is_connected: true
        fail_mode: secure
        Port "s5"
            Interface "s5"
                type: internal
        Port "s5-eth2"
            Interface "s5-eth2"
        Port "s5-eth1"
            Interface "s5-eth1"
        Port "s5-eth3"
            Interface "s5-eth3"
    Bridge "s1"
        Controller "tcp:192.168.31.5:6633"
            is_connected: true
        fail_mode: secure
        Port "s1"
            Interface "s1"
                type: internal
        Port "s1-eth2"
            Interface "s1-eth2"
        Port "s1-eth1"
            Interface "s1-eth1"
        Port "s1-eth4"
            Interface "s1-eth4"
        Port "s1-eth3"
            Interface "s1-eth3"
    Bridge "s2"
```

Controller Uses Ildp to Topology Discovery

```

sdn@sdn-controllers:~/ryu/ryu/apps$ sudo ryu-manager rest_topology.py ofctl_rest.py improve_heals.py --observe-links
loading app rest_topology.py
loading app ofctl_rest.py
loading app improve_heals.py
loading app ryu.topology.switches
loading app ryu.controller.ofp_handler
instantiating app None of DPSet
creating context dpset
creating context wsgi
instantiating app improve_heals.py of SelfHeal13
instantiating app ryu.topology.switches of Switches
instantiating app rest_topology.py of TopologyAPI
instantiating app ryu.controller.ofp_handler of OFPHandler
instantiating app ofctl_rest.py of RestStatsApi
(1345) wsgi starting up on http://0.0.0.0:8080
(1345) accepted ('192.168.31.5', 37106)
192.168.31.5 - - [23/Apr/2020 22:16:04] "GET /v1.0/topology/links HTTP/1.1" 200 2822 0.036339
Check #####
[{'src': {'hw_addr': 'u'da:64:44:35:5b:15', 'name': 'u's1-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000001'}, 'dst': {'hw_addr': 'u'9e:2f:b4:40:49:0e', 'name': 'u's4-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000004'}, {'src': {'hw_addr': 'u'56:12:73:54:f8:6f', 'name': 'u's3-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000003'}, 'dst': {'hw_addr': 'u'4a:ff:00:64:33:f9', 'name': 'u's5-eth3', 'port_no': 'u'00000003', 'dpid': 'u'0000000000000005'}, {'src': {'hw_addr': 'u'ce:4c:d0:02:26:04', 'name': 'u's1-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000001'}, 'dst': {'hw_addr': 'u'32:d6:48:dc:71:24', 'name': 'u's5-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000005'}, {'src': {'hw_addr': 'u'7a:52:8a:66:bf:93', 'name': 'u's5-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000002'}, 'dst': {'hw_addr': 'u'ee:cc:bc:92:e3:93', 'name': 'u's3-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000003'}, 'dst': {'hw_addr': 'u'c2:29:74:18:75:92', 'name': 'u's4-eth3', 'port_no': 'u'00000003', 'dpid': 'u'0000000000000004'}, {'src': {'hw_addr': 'u'9e:2f:b4:40:49:0e', 'name': 'u's4-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000001'}, 'dst': {'hw_addr': 'u'da:64:44:35:5b:15', 'name': 'u's1-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000001'}, {'src': {'hw_addr': 'u'32:d6:48:dc:71:24', 'name': 'u's5-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000005'}, 'dst': {'hw_addr': 'u'ce:4c:d0:02:26:04', 'name': 'u's1-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000001'}, {'src': {'hw_addr': 'u'da:8d:60:d2:be:3a', 'name': 'u's4-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000004'}, 'dst': {'hw_addr': 'u'5e:66:b6:85:c0:3c', 'name': 'u's2-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000002'}, {'src': {'hw_addr': 'u'4a:ff:00:64:33:f9', 'name': 'u's5-eth3', 'port_no': 'u'00000003', 'dpid': 'u'0000000000000005'}, 'dst': {'hw_addr': 'u'56:12:73:54:f8:6f', 'name': 'u's3-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000003'}, {'src': {'hw_addr': 'u'7e:24:4a:8e:d4:a3', 'name': 'u's2-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000005'}, 'dst': {'hw_addr': 'u'7a:52:8a:66:bf:93', 'name': 'u's5-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000005'}, {'src': {'hw_addr': 'u'c2:29:74:18:75:92', 'name': 'u's4-eth3', 'port_no': 'u'00000003', 'dpid': 'u'0000000000000004'}, 'dst': {'hw_addr': 'u'ee:cc:bc:92:e3:93', 'name': 'u's3-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000003'}, {'src': {'hw_addr': 'u'5e:66:b6:85:c0:3c', 'name': 'u's2-eth1', 'port_no': 'u'00000001', 'dpid': 'u'0000000000000002'}, 'dst': {'hw_addr': 'u'da:8d:60:d2:be:3a', 'name': 'u's4-eth2', 'port_no': 'u'00000002', 'dpid': 'u'0000000000000004'}}]
Getting into Link List
Switches and Links ##### Topology
[1, 2, 3, 4, 5]
[1, 4, {'in': 1, 'out': 1}], (3, 5, {'in': 3, 'out': 2}), (1, 5, {'in': 1, 'out': 2}), (5, 2, {'in': 2, 'out': 2}), (3, 4, {'in': 3, 'out': 1}), (4, 1, {'in': 1, 'out': 1}), (5, 1, {'in': 2, 'out': 1}), (4, 2, {'in': 1, 'out': 2}), (5, 3, {'in': 2, 'out': 3}), (2, 5, {'in': 2, 'out': 2}), (4, 3, {'in': 1, 'out': 3}), (2, 4, {'in': 2, 'out': 1})]
Nodes and Edges ##### Networkx
[1, 2, 3, 4, 5]

```

When H1 Ping H2

```

mininet@mininet-ofm:~$ sudo python nodered.py
*** Adding controller
*** Add switches
*** Add hosts
*** Add links
*** Starting network
*** Configuring hosts
h2 h3 h1
*** Starting controllers
*** Starting switches
*** Post configure switches and hosts
*** Starting CLI:
mininet>
mininet>
mininet> h1 ping h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.165 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.024 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.031 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.031 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.048 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.023 ms
^C
--- 10.0.0.2 ping statistics ---
9 packets transmitted, 6 received, 33% packet loss, time 8023ms
rtt min/avg/max/mdev = 0.023/0.053/0.165/0.051 ms
mininet>

```

What happens in the back end  
Calculate Shortest Path on the Fly

```

#####
Datapath
3
in_port
Message Match
OFFMatch(oxm_fields={'in_port': 2})
2
Packet
ethernet(dst='ff:ff:ff:ff:ff:ff', ethertype=2054, src='00:00:00:00:00:01', arp(dst_ip='10.0.0.2', dst_mac='00:00:00:00:00:00', hlen=6, hwtype=1, opcode=1, plen=4, proto=2048, src_ip='10.0.0.1', src_mac='00:00:00:00:00:01'))
Packet Type
<class 'ryu.lib.packet.packet.Packet'>
Eth
ethernet(dst='ff:ff:ff:ff:ff:ff', ethertype=2054, src='00:00:00:00:00:01')
This is an ARP Message
Destined for ARP
10:0:0:2
[[1, '00:00:00:00:00:01', 3, 4, 5, '00:00:00:00:00:02'], 2]
[[1, '00:00:00:00:00:02'], (1, '00:00:00:00:00:01'), (1, 4), (1, 5), (3, 4), (3, 5), (4, 2), (5, 2)]
[[1, 4, {'in': 1, 'out': 1}], (4, 1, {'in': 1, 'out': 1}), (1, 5, {'in': 1, 'out': 2}), (5, 2, {'in': 2, 'out': 2}), (3, 4, {'in': 3, 'out': 1}), (3, 5, {'in': 3, 'out': 2}), (5, 1, {'in': 1, 'out': 1}), (4, 2, {'in': 1, 'out': 2}), (5, 3, {'in': 2, 'out': 3}), (2, 5, {'in': 2, 'out': 2}), (4, 3, {'in': 1, 'out': 3}), (2, 4, {'in': 2, 'out': 1}), (1, '00:00:00:00:00:01', {'out': 3}), (1, '00:00:00:00:00:02', {'out': 4})]
#####
Datapath
1
in_port
Message Match
OFFMatch(oxm_fields={'in_port': 3})
3
Packet
ethernet(dst='00:00:00:00:00:02', ethertype=2048, src='00:00:00:00:00:01', ipv4(csum=55357, dst='10.0.0.2', flags=2, header_length=5, identification=20073, offset=0, option=None, proto=1, src='10.0.0.1', tos=0, total_length=84, ttl=64, version=4), icmp(code=0, csum=51573, data=echo(data='\x11\xa6\x12\xd9\x06\x00\x08\t\n\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d\x1e\x1f' * 5, '\x01234567', id=4669, seq=1), type=8))
Packet Type
<class 'ryu.lib.packet.packet.Packet'>
Eth
ethernet(dst='00:00:00:00:00:02', ethertype=2048, src='00:00:00:00:00:01')
Calculate Shortest Path on the Fly
['00:00:00:00:00:01', 1, '00:00:00:00:00:02']
We are going to add flows
From 1 To 00:00:00:00:00:02 Through 4
#####

```

Flows are added instantaneously

```

mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s1
OFFST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=7.439s, table=0, n_packets=16, n_bytes=960, priority=65535,d1_dst=01:80:c2:00:00:0e,d1_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s2
OFFST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=9.696s, table=0, n_packets=22, n_bytes=1320, priority=65535,d1_dst=01:80:c2:00:00:0e,d1_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s3
OFFST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=11.334s, table=0, n_packets=26, n_bytes=1560, priority=65535,d1_dst=01:80:c2:00:00:0e,d1_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s4
OFFST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=12.661s, table=0, n_packets=42, n_bytes=2520, priority=65535,d1_dst=01:80:c2:00:00:0e,d1_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s5
OFFST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=13.948s, table=0, n_packets=46, n_bytes=2760, priority=65535,d1_dst=01:80:c2:00:00:0e,d1_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s1
OFFST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x6aa077b2ba977f62, duration=10.384s, table=0, n_packets=11, n_bytes=966, idle_timeout=10, priority=100,in_port=4,d1_src=00:00:00:00:00:02,d1_dst=00:00:00:00:00:01 actions=output:3
 cookie=0xed4a3d83928cdde, duration=9.36s, table=0, n_packets=10, n_bytes=924, idle_timeout=10, priority=100,in_port=3,d1_src=00:00:00:00:00:01,d1_dst=00:00:00:00:00:02 actions=output:4
 cookie=0x0, duration=36.038s, table=0, n_packets=78, n_bytes=4680, priority=65535,d1_dst=01:80:c2:00:00:0e,d1_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$

```

When H2 ping H3

```

mininet> h2 ping h3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.031 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.033 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.039 ms
64 bytes from 10.0.0.3: icmp_seq=4 ttl=64 time=0.071 ms
64 bytes from 10.0.0.3: icmp_seq=5 ttl=64 time=0.039 ms
64 bytes from 10.0.0.3: icmp_seq=6 ttl=64 time=0.039 ms
^C
--- 10.0.0.3 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5001ms
rtt min/avg/max/mdev = 0.031/0.042/0.071/0.013 ms
mininet>

```

Path → 2 → 4 → 3

```
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s1
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=69.926s, table=0, n_packets=154, n_bytes=9240, priority=65535,dl_dst=01:80:c2:00:00:0e,dl_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s2
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x6c6289554b8d1d26, duration=35.69s, table=0, n_packets=25, n_bytes=2394, idle_timeout=10, priority=100,in_port=3,dl_src=00:00:00:00:02,dl_dst=00:00:00:00:03 actions=output:1
 cookie=0x6c6289554b8d1d26, duration=39.689s, table=0, n_packets=25, n_bytes=2282, idle_timeout=10, priority=100,in_port=1,dl_src=00:00:00:00:03,dl_dst=00:00:00:00:02 actions=output:3
 cookie=0x0, duration=72.088s, table=0, n_packets=160, n_bytes=9600, priority=65535,dl_dst=01:80:c2:00:00:0e,dl_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s3
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0xd4424e65d6356c49, duration=49.193s, table=0, n_packets=30, n_bytes=2548, idle_timeout=10, priority=100,in_port=3,dl_src=00:00:00:00:03,dl_dst=00:00:00:00:02 actions=output:1
 cookie=0x4630f9c9d7de0b2d, duration=35.228s, table=0, n_packets=24, n_bytes=2296, idle_timeout=10, priority=100,in_port=1,dl_src=00:00:00:00:02,dl_dst=00:00:00:00:03 actions=output:3
 cookie=0x0, duration=73.596s, table=0, n_packets=164, n_bytes=9840, priority=65535,dl_dst=01:80:c2:00:00:0e,dl_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s4
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0xc21dddbcc9d5a09a, duration=37.657s, table=0, n_packets=27, n_bytes=2590, idle_timeout=10, priority=100,in_port=2,dl_src=00:00:00:00:02,dl_dst=00:00:00:00:03 actions=output:3
 cookie=0x3dfb3adfd0eb9bf9, duration=46.629s, table=0, n_packets=30, n_bytes=2660, idle_timeout=10, priority=100,in_port=3,dl_src=00:00:00:00:03,dl_dst=00:00:00:00:02 actions=output:2
 cookie=0x0, duration=75.026s, table=0, n_packets=251, n_bytes=15060, priority=65535,dl_dst=01:80:c2:00:00:0e,dl_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s5
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=78.974s, table=0, n_packets=264, n_bytes=15840, priority=65535,dl_dst=01:80:c2:00:00:0e,dl_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$
```

Breaking path b/w S2 and S4

```
mininet>
mininet> h2 ping h3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
 64 bytes from 10.0.0.3: icmp_seq=6 ttl=64 time=0.146 ms
 64 bytes from 10.0.0.3: icmp_seq=7 ttl=64 time=0.033 ms
 64 bytes from 10.0.0.3: icmp_seq=8 ttl=64 time=0.040 ms
 64 bytes from 10.0.0.3: icmp_seq=9 ttl=64 time=0.031 ms
 64 bytes from 10.0.0.3: icmp_seq=10 ttl=64 time=0.054 ms
 64 bytes from 10.0.0.3: icmp_seq=11 ttl=64 time=0.043 ms
 64 bytes from 10.0.0.3: icmp_seq=12 ttl=64 time=0.035 ms
^C
--- 10.0.0.3 ping statistics ---
12 packets transmitted, 7 received, 41% packet loss, time 11037ms
rtt min/avg/max/mdev = 0.031/0.054/0.146/0.038 ms
mininet>
mininet> link s2 s4 down
mininet>
mininet> h2 ping h3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
 64 bytes from 10.0.0.3: icmp_seq=7 ttl=64 time=0.108 ms
 64 bytes from 10.0.0.3: icmp_seq=8 ttl=64 time=0.032 ms
 64 bytes from 10.0.0.3: icmp_seq=9 ttl=64 time=0.037 ms
 64 bytes from 10.0.0.3: icmp_seq=10 ttl=64 time=0.049 ms
 64 bytes from 10.0.0.3: icmp_seq=11 ttl=64 time=0.048 ms
 64 bytes from 10.0.0.3: icmp_seq=12 ttl=64 time=0.034 ms
 64 bytes from 10.0.0.3: icmp_seq=13 ttl=64 time=0.046 ms
^C
--- 10.0.0.3 ping statistics ---
13 packets transmitted, 7 received, 46% packet loss, time 12045ms
rtt min/avg/max/mdev = 0.032/0.050/0.108/0.025 ms
mininet>
mininet>
```

New Path

S2 → S5 → S3



```

mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s1
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=299.594s, table=0, n_packets=664, n_bytes=39840, priority=65535,d_l_dst=01:80:c2:00:00:0e,d_l_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s2
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0xec04f0ddca8265, duration=13.557s, table=0, n_packets=15, n_bytes=1358, idle_timeout=10, priority=100,in_port=3,d_l_src=00:00:00:00:02,d_l_dst=00:00:00:00:03 actions=output:2
 cookie=0x3ce88d9c6cee2687, duration=8.519s, table=0, n_packets=10, n_bytes=868, idle_timeout=10, priority=100,in_port=2,d_l_src=00:00:00:00:03,d_l_dst=00:00:00:00:02 actions=output:3
 cookie=0x0, duration=301.283s, table=0, n_packets=613, n_bytes=36780, priority=65535,d_l_dst=01:80:c2:00:00:0e,d_l_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s3
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x40d0db18ca831a96, duration=14.09s, table=0, n_packets=15, n_bytes=1358, idle_timeout=10, priority=100,in_port=2,d_l_src=00:00:00:00:02,d_l_dst=00:00:00:00:03 actions=output:3
 cookie=0x7bee079d59cdd453, duration=13.08s, table=0, n_packets=14, n_bytes=1260, idle_timeout=10, priority=100,in_port=3,d_l_src=00:00:00:00:00:03,d_l_dst=00:00:00:00:00:02 actions=output:2
 cookie=0x0, duration=303.827s, table=0, n_packets=676, n_bytes=40560, priority=65535,d_l_dst=01:80:c2:00:00:0e,d_l_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s4
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=306.189s, table=0, n_packets=959, n_bytes=57540, priority=65535,d_l_dst=01:80:c2:00:00:0e,d_l_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$ sudo ovs-ofctl dump-flows -O OpenFlow13 s5
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0xad7e177579f878e7, duration=18.896s, table=0, n_packets=20, n_bytes=1848, idle_timeout=10, priority=100,in_port=2,d_l_src=00:00:00:00:02,d_l_dst=00:00:00:00:03 actions=output:3
 cookie=0x5498e825d50db521, duration=15.871s, table=0, n_packets=17, n_bytes=1554, idle_timeout=10, priority=100,in_port=3,d_l_src=00:00:00:00:03,d_l_dst=00:00:00:00:02 actions=output:2
 cookie=0x0, duration=307.626s, table=0, n_packets=1025, n_bytes=61500, priority=65535,d_l_dst=01:80:c2:00:00:0e,d_l_type=0x88cc actions=CONTROLLER:65535
mininet@mininet-ofm:~$
mininet@mininet-ofm:~$

```

## Re-Routing Feature for Link and Node redundancy

### Re-Learn Topology and Add new Flows

```

ethernet(dst='00:00:00:00:00:02',ethertype=2054,src='00:00:00:00:00:03')
This is an ARP Message
Destined for ARP
10.0.0.2
['00:00:00:00:00:03', 1, 2, 3, 4, 5, '00:00:00:00:00:02']
[('00:00:00:00:00:03', 3), (1, 4), (1, 5), (2, '00:00:00:00:00:02'), (2, 4), (2, 5), (3, 4), (3, 5)]
[(1, 4, {'in': 1, 'out': 1}), (4, 1, {'in': 1, 'out': 1}), (1, 5, {'in': 1, 'out': 2}), (5, 2, {'in': 2, 'out': 2}), (3, 4, {'in': 3, 'out': 1}), (3, 5, {'in': 3, 'out': 2}), (5, 1, {'in': 2, 'out': 1}), (4, 2, {'in': 1, 'out': 2}), (5, 3, {'in': 2, 'out': 3}), (2, 5, {'in': 2, 'out': 2}), (4, 3, {'in': 1, 'out': 3}), (2, 4, {'in': 2, 'out': 1}), (2, '00:00:00:00:00:02', {'out': 3}), (3, '00:00:00:00:00:03', {'out': 3})]
Calculate Shortest Path on the Fly
['00:00:00:00:00:03', 3, 4, 2, '00:00:00:00:00:02']
We are going to add flows
From 2 To 00:00:00:00:00:02 Through 3
Port Change Status Alert !!!!!!! #####
version=0x4,msg_type=0xc,msg_len=0x50,xid=0x0,OFPPortStatus(desc=OFPPort(port_no=2,hw_addr='ca:43:c5:4f:94:a9',name='s4-eth2',config=1,state=1,curr=2112,advertised=0,supported=0,peer=0,curr_speed=10000000,max_speed=0),reason=2)
Datapath ID
4
Port Changed
2
Port State Change
1
Updating Topology
['00:00:00:00:00:03', 1, 2, 3, 4, 5, '00:00:00:00:00:02']
[('00:00:00:00:00:03', 3), (1, 4), (1, 5), (2, '00:00:00:00:00:02'), (2, 5), (3, 4), (3, 5)]
Port Change Status Alert !!!!!!! #####
version=0x4,msg_type=0xc,msg_len=0x50,xid=0x0,OFPPortStatus(desc=OFPPort(port_no=1,hw_addr='96:57:f3:4d:56:5c',name='s2-eth1',config=1,state=1,curr=2112,advertised=0,supported=0,peer=0,curr_speed=10000000,max_speed=0),reason=2)
Datapath ID
2
Port Changed
1
Port State Change
1
Updating Topology
['00:00:00:00:00:03', 1, 2, 3, 4, 5, '00:00:00:00:00:02']
[('00:00:00:00:00:03', 3), (1, 4), (1, 5), (2, '00:00:00:00:00:02'), (2, 5), (3, 4), (3, 5)]
#####

```