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Lab 6: Network Monitoring with SDN

a) What is slice and flowspace? Illustrate using the given topology.

Slices can be defined by any combination of switch ports (layer 1), src/dst ethernet address or type (layer 2), src/dst IP address or type (layer 3), and src/dst TCP/UDP port or ICMP code/type (layer 4). FlowSpace defined by a collection of packet headers and assigned to "Slices":Src/Dst MAC Address, VLAN ID, Ethertype, IP Protocol, Src/Dst IP Address, ToS/DSCP, Src/Dst Port Number. The entire network is flowspace and includes Port 10001-10004. The particular Port connection is a slice of the flowspace, where it is assigned its own particular controller.

b) Include the controller's code.

```
from operator import attrgetter
from ryu.base import app_manager
from ryu.ofproto import ofproto_v1_0
from ryu.controller import ofp_event
from ryu.controller.handler import MAIN_DISPATCHER, DEAD_DISPATCHER
from ryu.controller.handler import set_ev_cls
from ryu.lib import hub


class SimpleMonitor(app_manager.RyuApp):

    OFP_VERSIONS = [ofproto_v1_0.OFP_VERSION]
    def __init__(self, *args, **kwargs):
        super(SimpleMonitor, self).__init__(*args, **kwargs)
        self.datapaths = {}
        self.monitor_thread = hub.spawn(self._monitor)

    @set_ev_cls(ofp_event.EventOFPStateChange,
                [MAIN_DISPATCHER, DEAD_DISPATCHER])
    def _state_change_handler(self, ev):
        datapath = ev.datapath
        if ev.state == MAIN_DISPATCHER:
            if not datapath.id in self.datapaths:
                self.logger.debug('register datapath: %016x', datapath.id)
                self.datapaths[datapath.id] = datapath
        elif ev.state == DEAD_DISPATCHER:
            if datapath.id in self.datapaths:
                self.logger.debug('unregister datapath: %016x', datapath.id)
                del self.datapaths[datapath.id]

    def _monitor(self):
        while True:
            for dp in self.datapaths.values():
```

```
            self._request_stats(dp)
        hub.sleep(10)

    def _request_stats(self, datapath):
        self.logger.debug('send stats request: %016x', datapath.id)
        ofproto = datapath.ofproto
        parser = datapath.ofproto_parser

        req = parser.OFPPortStatsRequest(datapath, 0, ofproto.OFPP_NONE)
        datapath.send_msg(req)

            match = parser.OFPMatch()
            table_id = 0xff
            out_port = ofproto.OFPP_NONE
            req = parser.OFPFlowStatsRequest(datapath,0,match,table_id,out_port)


    @set_ev_cls(ofp_event.EventOFPFlowStatsReply, MAIN_DISPATCHER)
    def _flow_stats_reply_handler(self, ev):
        body = ev.msg.body

        self.logger.info('datapath         ''in-port        eth-dst          ''out-port packets  bytes')
        self.logger.info('---------------- ''------------ ----------------- ''-------- -------  -----')
        for stat in sorted([flow for flow in body if flow.priority == 1],
                           key=lambda flow: (flow.match['in_port'],
                                             flow.match['eth_dst'])):
            self.logger.info('%016x  %8x  %17s  %8x  %8d  %8d  ', ev.msg.datapath.id, stat.match['in_port'],
stat.match['eth_dst'], stat.instructions[0].actions[0].port, stat.packet_count, stat.byte_count)

    @set_ev_cls(ofp_event.EventOFPPortStatsReply, MAIN_DISPATCHER)
    def _port_stats_reply_handler(self, ev):
        body = ev.msg.body

        self.logger.info('\n datapath         port        ''rx-pkts         rx-bytes         rx-error    ''tx-pkts         tx-
bytes        tx-error')
        self.logger.info('---------------------- ------------ ''------------------ ------------------- ------------ ''------------------ --------
-------- ------------')
        for stat in sorted(body, key=attrgetter('port_no')):
            self.logger.info('%016x \t''%8x \t''%8d \t''%8d \t''%8d \t''%8d \t''%8d \t''%8d \t',
ev.msg.datapath.id, stat.port_no, stat.rx_packets, stat.rx_bytes,                    stat.rx_errors,
stat.tx_packets, stat.tx_bytes, stat.tx_errors)
```

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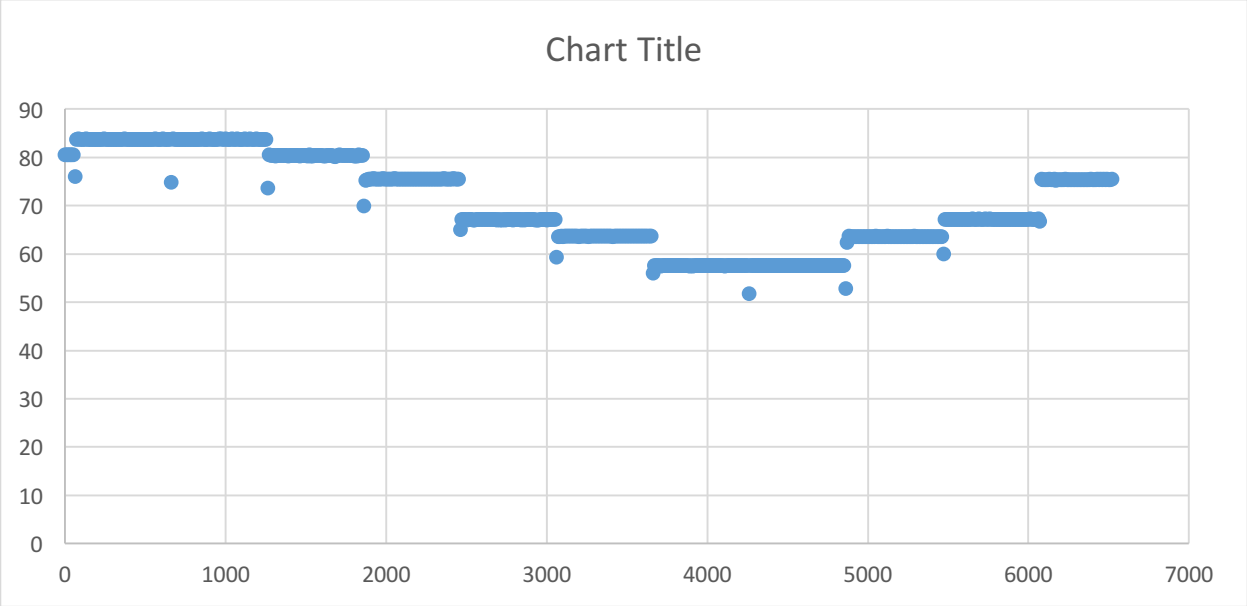
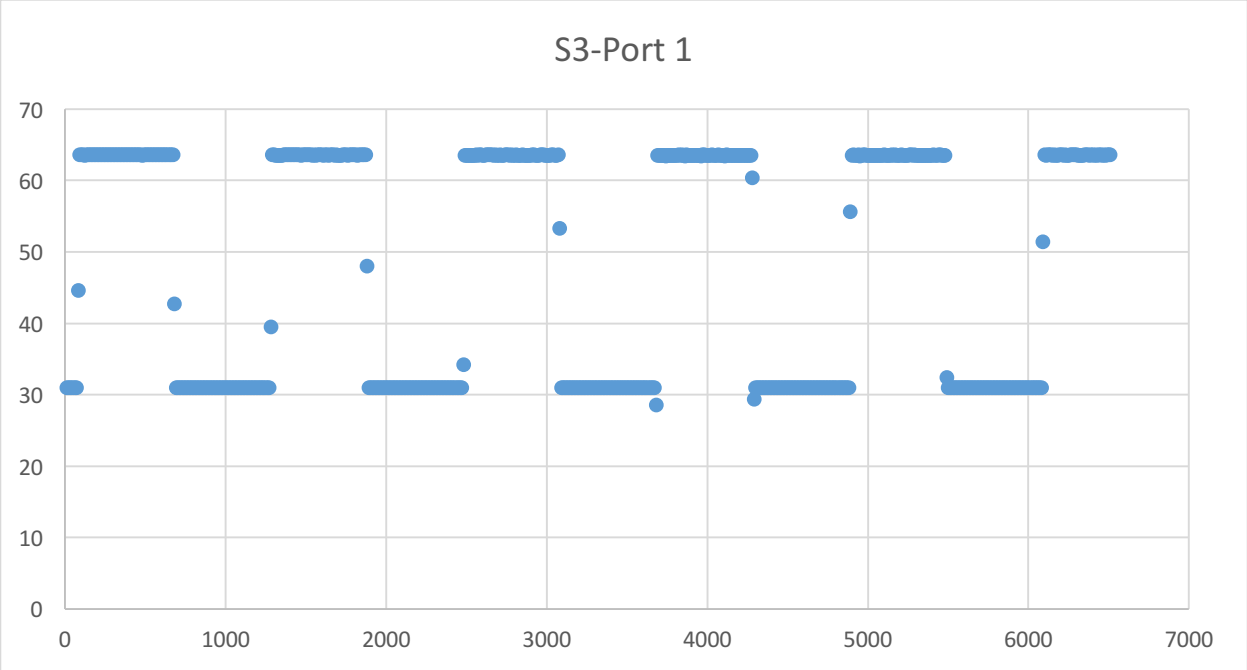
c) Traffic generators in the VMs repeats a traffic pattern every 2 hours.

• Draw a link utilization graph (link utilization vs. time) for link – 1, 2 and 3.

Switch 3 – Port 2 (Link 1)



Switch 3 - Port 1 (Link 3)



Link 2

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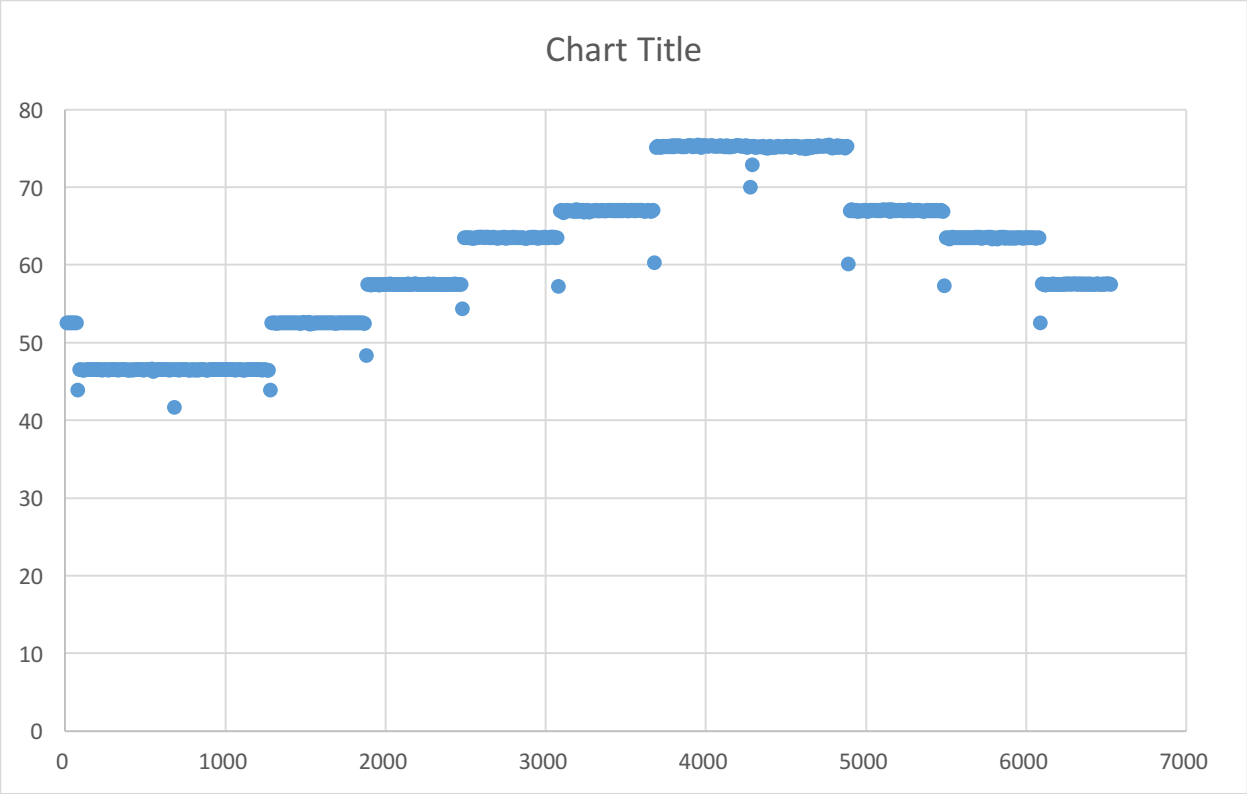

• Find over-utilized links. Over-utilized link is a link whose avg. utilization is more than 75 % for a given period. Please consider the same 2 hour time period for both.

As we can see in the above graphs Link 1 and Link 2 are over utilized.

d) Screenshots:

• Monitoring application successfully running at allocated IP address and Port # on Host 1.

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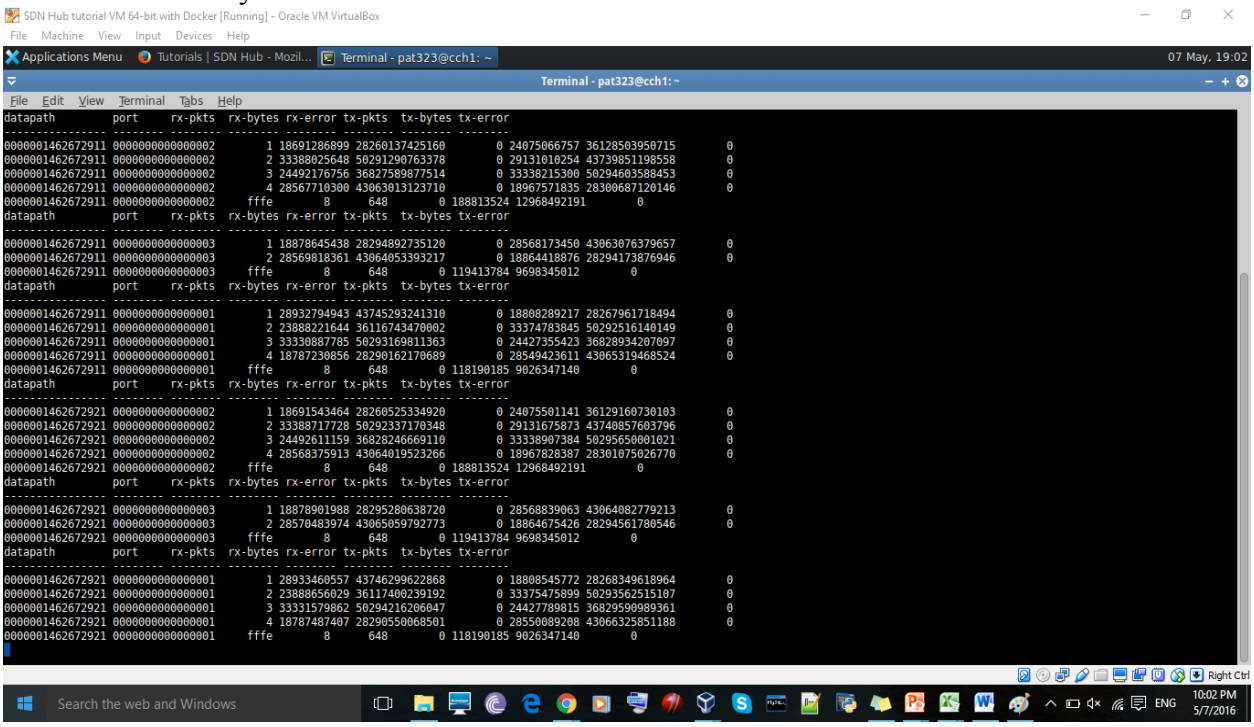
```
ubuntu@sdnhubvm:~[19:00]$ ssh pat323@128.238.147.208 -p 52001
pat323@128.238.147.208's password:
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.13.0-85-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
Last login: Sat May  7 23:31:06 2016 from 172.16.19.12
pat323@cch1:~$
pat323@cch1:~$
pat323@cch1:~$ ryu-manager --ofp-listen-host 127.0.0.1 --ofp-tcp-listen-port 10056 l6_switch.py
loading app l6_switch.py
loading app ryu.controller.ofp_handler
instantiating app l6_switch.py of SimpleMonitor
instantiating app ryu.controller.ofp_handler of OFPHandler
register datapath: 0000000000000003
register datapath: 0000000000000001
register datapath: 0000000000000002
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672911 0000000000000002        1 18691286899 28260137425160        0 24075066757 36128503950715        0
0000001462672911 0000000000000002        2 33388025648 50291290763378        0 29131010254 43739851198558        0
0000001462672911 0000000000000002        3 24492176756 36827589877514        0 33338215300 50294603588453        0
0000001462672911 0000000000000002        4 28567710300 43063013123710        0 18967571835 28300687120146        0
0000001462672911 0000000000000002     fffe        8      648        0 188813524 12968492191        0
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672911 0000000000000003        1 18878645438 28294892735120        0 28568173450 43063076379657        0
0000001462672911 0000000000000003        2 28569818361 43064053393217        0 18864418876 28294173876946        0
0000001462672911 0000000000000003     fffe        8      648        0 119413784 9698345012        0
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672911 0000000000000001        1 28932794943 43745293241310        0 18808289217 28267961718494        0
0000001462672911 0000000000000001        2 23888221644 36116743470002        0 33374783845 50292516140149        0
0000001462672911 0000000000000001        3 33330887785 50293169811363        0 24427355423 36828934207097        0
0000001462672911 0000000000000001        4 18787230856 28290162170689        0 28549423611 43065319468524        0
0000001462672911 0000000000000001     fffe        8      648        0 118190185 9026347140        0
```

• Screenshot of any 2 consecutive Link utilization for all links.



```
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672911 0000000000000002        1 18691286899 28260137425160        0 24075066757 36128503950715        0
0000001462672911 0000000000000002        2 33388025648 50291290763378        0 29131010254 43739851198558        0
0000001462672911 0000000000000002        3 24492176756 36827589877514        0 33338215300 50294603588453        0
0000001462672911 0000000000000002        4 28567710300 43063013123710        0 18967571835 28300687120146        0
0000001462672911 0000000000000002     fffe        8      648        0 188813524 12968492191        0
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672911 0000000000000003        1 18878645438 28294892735120        0 28568173450 43063076379657        0
0000001462672911 0000000000000003        2 28569818361 43064053393217        0 18864418876 28294173876946        0
0000001462672911 0000000000000003     fffe        8      648        0 119413784 9698345012        0
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672911 0000000000000001        1 28932794943 43745293241310        0 18808289217 28267961718494        0
0000001462672911 0000000000000001        2 23888221644 36116743470002        0 33374783845 50292516140149        0
0000001462672911 0000000000000001        3 33330887785 50293169811363        0 24427355423 36828934207097        0
0000001462672911 0000000000000001        4 18787230856 28290162170689        0 28549423611 43065319468524        0
0000001462672911 0000000000000001     fffe        8      648        0 118190185 9026347140        0
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672921 0000000000000002        1 18691543464 28260525334920        0 24075501141 36129160730103        0
0000001462672921 0000000000000002        2 33388717728 50292337170348        0 29131675873 43740857603796        0
0000001462672921 0000000000000002        3 24492611159 36828246669110        0 33338907384 50295650001021        0
0000001462672921 0000000000000002        4 28568375913 43064019523266        0 18967828387 28301075026770        0
0000001462672921 0000000000000002     fffe        8      648        0 188813524 12968492191        0
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672921 0000000000000003        1 18878901988 28295280638720        0 28568839063 43064082779213        0
0000001462672921 0000000000000003        2 28570483974 43065059792773        0 18864675426 28294561780546        0
0000001462672921 0000000000000003     fffe        8      648        0 119413784 9698345012        0
datapath         port     rx-pkts  rx-bytes rx-error tx-pkts  tx-bytes tx-error
---------------- -------- -------- -------- -------- -------- -------- --------
0000001462672921 0000000000000001        1 28933460557 43746299622868        0 18808545772 28268349618964        0
0000001462672921 0000000000000001        2 23888656029 36117400239192        0 33375475899 50293562515107        0
0000001462672921 0000000000000001        3 33331579862 50294216206047        0 24427789815 36829590989361        0
0000001462672921 0000000000000001        4 18787487407 28290550068501        0 28550089208 43066325851188        0
0000001462672921 0000000000000001     fffe        8      648        0 118190185 9026347140        0
```

e) Challenges you've encountered while doing this experiment, and explain how you manage to solve them. If you do not experience any problem, simply say no problems.

Internet connection tripped during the 2 hour data collection period. Had to learn excel all over again for data analyses and graph plotting.