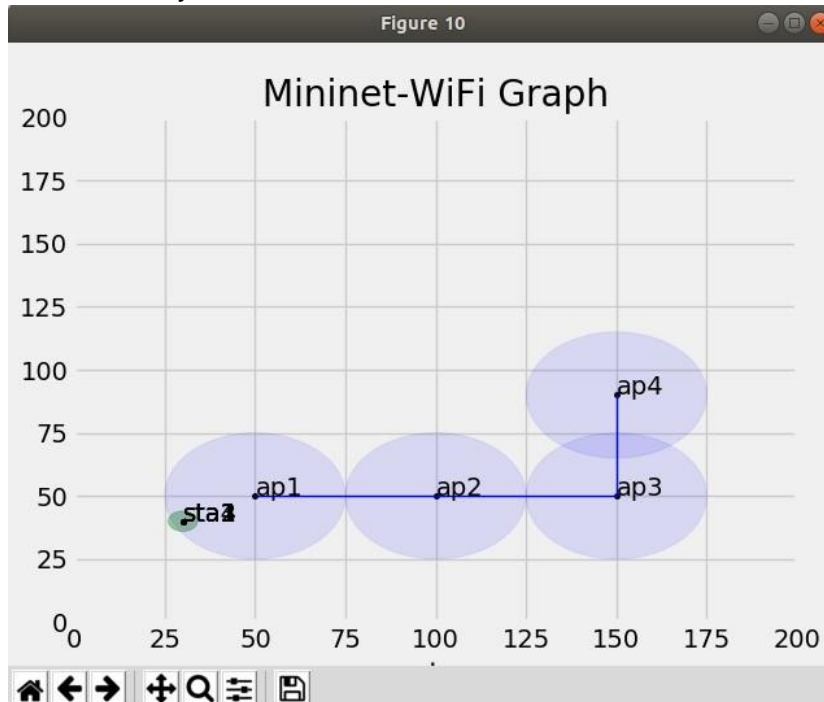
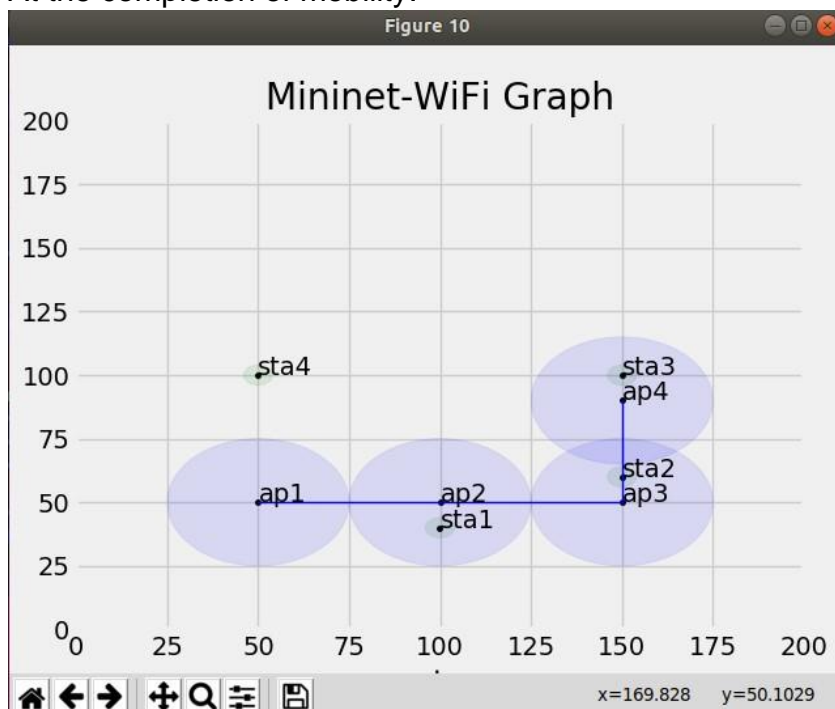


TASK 1

- Screenshot from the Mininet Wi-Fi GUI
 - Prior Mobility:

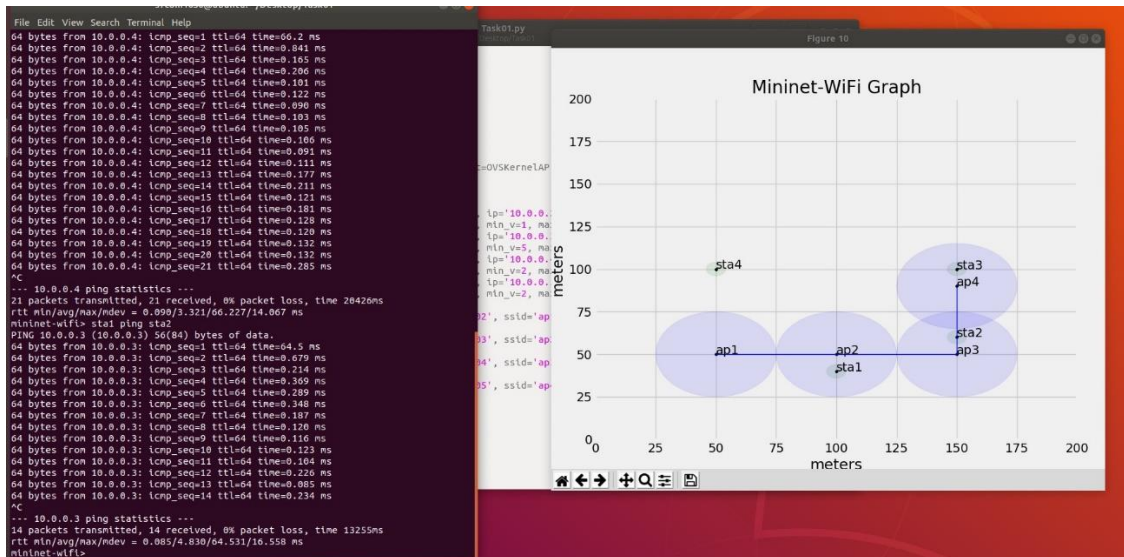


- At the completion of mobility:

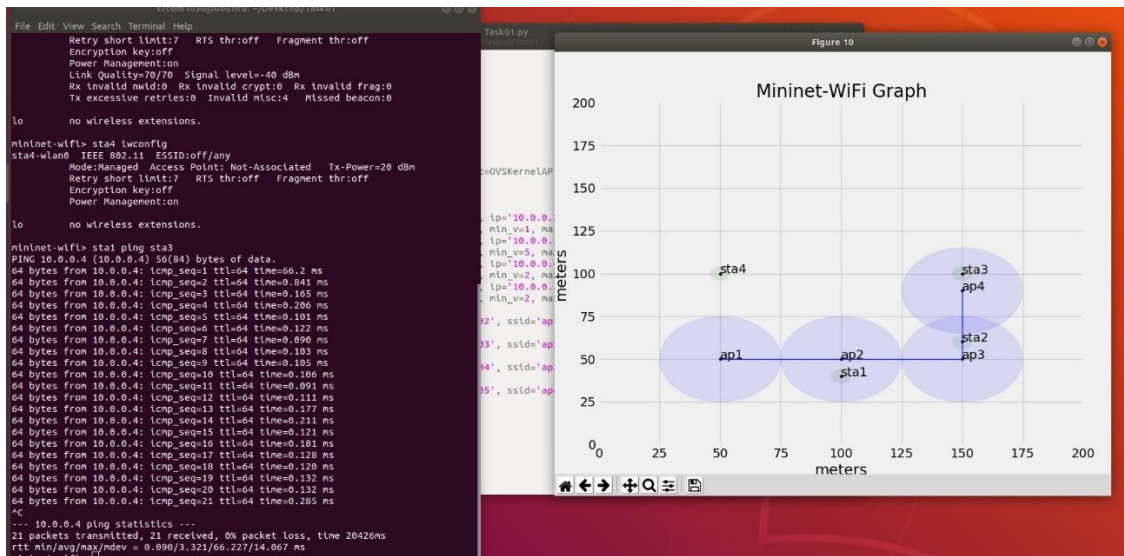


Ping results:

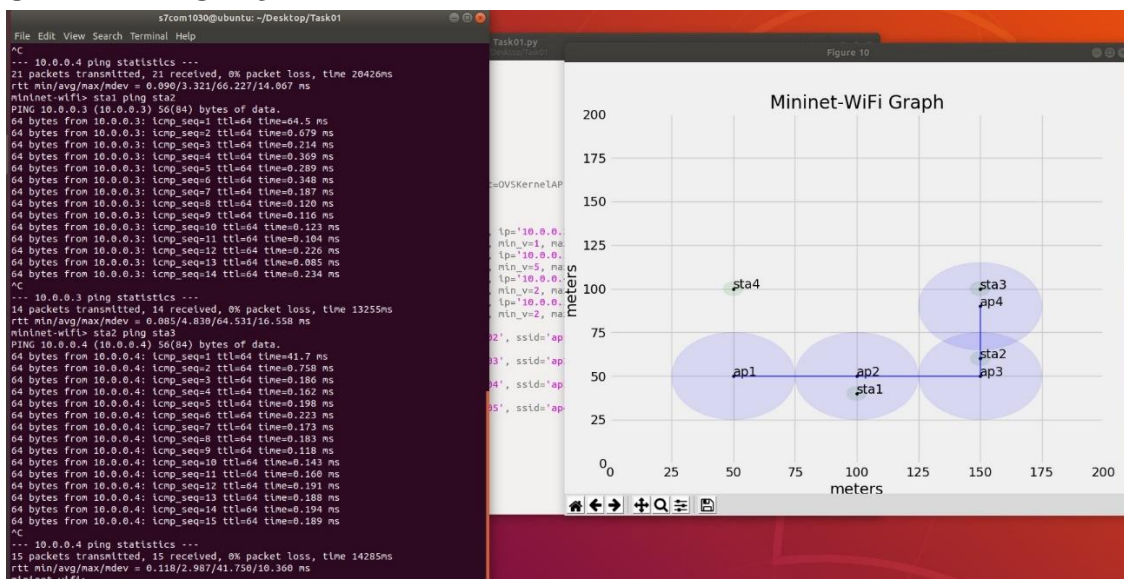
- STA1 <- - -> STA2



- STA2 <- - -> STA3



- STA1 <- - -> STA3



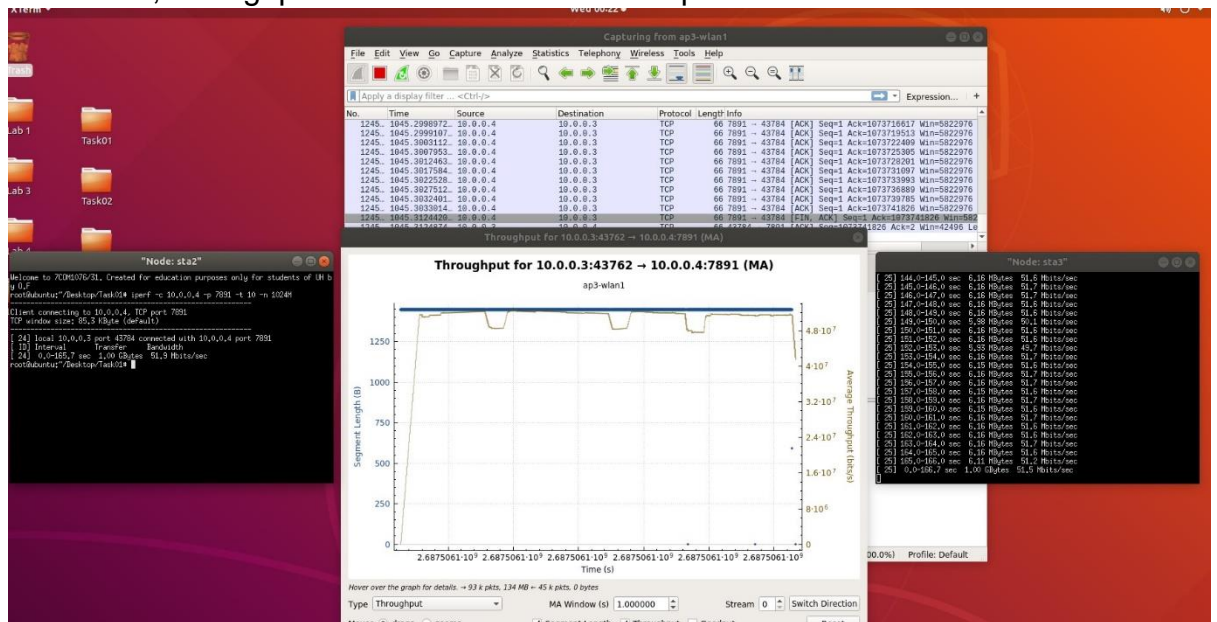
- A TCP flow of 1GB using the socket assigned:
- The server and the client statistics

The image shows two terminal windows. The left window, titled "Node: sta2", displays the output of the `iperf` command, showing a client connecting to 10.0.0.4 on TCP port 7891. The right window, titled "Node: sta3", shows a list of network statistics for various time intervals, including data transfer rates in Mbits/sec and MBytes/sec.

- Wireshark, while the transfer is in progress

The image shows a Wireshark capture of a TCP flow. The packet list on the left shows several ACK packets. The packet details pane in the center shows the TCP header and options. The packet bytes pane at the bottom shows the raw data. The status bar at the bottom indicates that 138982 packets have been captured and displayed.

- Wireshark, throughput when the transfer is complete



TASK 2

- ICMP stream
 - sta4ad < - - -> sta5ad

```
s7com1030@ubuntu: ~/Desktop/Task02
File Edit View Search Terminal Help
--- 10.0.0.4 ping statistics ---
5 packets transmitted, 0 received, +3 errors, 100% packet loss, time 4081ms
pipe 4
mininet-wifi> sta4ad ping sta5ad
PING 10.0.0.6 (10.0.0.6) 56(84) bytes of data.
64 bytes from 10.0.0.6: icmp_seq=1 ttl=64 time=0.213 ms
64 bytes from 10.0.0.6: icmp_seq=2 ttl=64 time=0.068 ms
64 bytes from 10.0.0.6: icmp_seq=3 ttl=64 time=0.055 ms
64 bytes from 10.0.0.6: icmp_seq=4 ttl=64 time=0.076 ms
64 bytes from 10.0.0.6: icmp_seq=5 ttl=64 time=0.100 ms
64 bytes from 10.0.0.6: icmp_seq=6 ttl=64 time=0.105 ms
64 bytes from 10.0.0.6: icmp_seq=7 ttl=64 time=0.093 ms
64 bytes from 10.0.0.6: icmp_seq=8 ttl=64 time=0.053 ms
64 bytes from 10.0.0.6: icmp_seq=9 ttl=64 time=0.073 ms
64 bytes from 10.0.0.6: icmp_seq=10 ttl=64 time=0.058 ms
64 bytes from 10.0.0.6: icmp_seq=11 ttl=64 time=0.104 ms
64 bytes from 10.0.0.6: icmp_seq=12 ttl=64 time=0.070 ms
64 bytes from 10.0.0.6: icmp_seq=13 ttl=64 time=0.055 ms
64 bytes from 10.0.0.6: icmp_seq=14 ttl=64 time=0.054 ms
64 bytes from 10.0.0.6: icmp_seq=15 ttl=64 time=0.088 ms
64 bytes from 10.0.0.6: icmp_seq=16 ttl=64 time=0.066 ms
64 bytes from 10.0.0.6: icmp_seq=17 ttl=64 time=0.085 ms
64 bytes from 10.0.0.6: icmp_seq=18 ttl=64 time=0.066 ms
```

-
- sta5ad < - - -> sta6ad

```
s7com1030@ubuntu: ~/Desktop/Task02
File Edit View Search Terminal Help
64 bytes from 10.0.0.6: icmp_seq=44 ttl=64 time=0.080 ms
^C
--- 10.0.0.6 ping statistics ---
44 packets transmitted, 44 received, 0% packet loss, time 44019ms
rtt min/avg/max/mdev = 0.048/0.094/0.517/0.074 ms
mininet-wifi> sta5ad ping sta6ad
PING 10.0.0.7 (10.0.0.7) 56(84) bytes of data.
64 bytes from 10.0.0.7: icmp_seq=1 ttl=64 time=0.183 ms
64 bytes from 10.0.0.7: icmp_seq=2 ttl=64 time=0.054 ms
64 bytes from 10.0.0.7: icmp_seq=3 ttl=64 time=0.205 ms
64 bytes from 10.0.0.7: icmp_seq=4 ttl=64 time=0.072 ms
64 bytes from 10.0.0.7: icmp_seq=5 ttl=64 time=0.118 ms
64 bytes from 10.0.0.7: icmp_seq=6 ttl=64 time=0.052 ms
64 bytes from 10.0.0.7: icmp_seq=7 ttl=64 time=0.053 ms
64 bytes from 10.0.0.7: icmp_seq=8 ttl=64 time=0.102 ms
64 bytes from 10.0.0.7: icmp_seq=9 ttl=64 time=0.052 ms
64 bytes from 10.0.0.7: icmp_seq=10 ttl=64 time=0.076 ms
64 bytes from 10.0.0.7: icmp_seq=11 ttl=64 time=0.192 ms
64 bytes from 10.0.0.7: icmp_seq=12 ttl=64 time=0.114 ms
64 bytes from 10.0.0.7: icmp_seq=13 ttl=64 time=0.101 ms
64 bytes from 10.0.0.7: icmp_seq=14 ttl=64 time=0.085 ms
64 bytes from 10.0.0.7: icmp_seq=15 ttl=64 time=0.080 ms
64 bytes from 10.0.0.7: icmp_seq=16 ttl=64 time=0.061 ms
```

-
- sta4ad < - - -> sta6ad

```
s7com1030@ubuntu: ~/Desktop/Task02
File Edit View Search Terminal Help
64 bytes from 10.0.0.7: icmp_seq=34 ttl=64 time=0.089 ms
64 bytes from 10.0.0.7: icmp_seq=35 ttl=64 time=0.071 ms
64 bytes from 10.0.0.7: icmp_seq=36 ttl=64 time=0.066 ms
^C
--- 10.0.0.7 ping statistics ---
36 packets transmitted, 36 received, 0% packet loss, time 35823ms
rtt min/avg/max/mdev = 0.051/0.095/0.205/0.044 ms
mininet-wifi> sta6ad ping sta7ad
ping: sta7ad: Name or service not known
mininet-wifi> sta4ad ping sta6ad
PING 10.0.0.7 (10.0.0.7) 56(84) bytes of data.
64 bytes from 10.0.0.7: icmp_seq=1 ttl=64 time=17.0 ms
64 bytes from 10.0.0.7: icmp_seq=2 ttl=64 time=0.080 ms
64 bytes from 10.0.0.7: icmp_seq=3 ttl=64 time=0.113 ms
64 bytes from 10.0.0.7: icmp_seq=4 ttl=64 time=0.069 ms
64 bytes from 10.0.0.7: icmp_seq=5 ttl=64 time=0.082 ms
64 bytes from 10.0.0.7: icmp_seq=6 ttl=64 time=0.055 ms
64 bytes from 10.0.0.7: icmp_seq=7 ttl=64 time=0.077 ms
64 bytes from 10.0.0.7: icmp_seq=8 ttl=64 time=0.059 ms
64 bytes from 10.0.0.7: icmp_seq=9 ttl=64 time=0.072 ms
64 bytes from 10.0.0.7: icmp_seq=10 ttl=64 time=0.057 ms
64 bytes from 10.0.0.7: icmp_seq=11 ttl=64 time=0.087 ms
64 bytes from 10.0.0.7: icmp_seq=12 ttl=64 time=0.149 ms
```

- sta7M < - - -> sta8M

```
s7com1030@ubuntu: ~/Desktop/Task02
File Edit View Search Terminal Help
64 bytes from 10.0.0.7: icmp_seq=23 ttl=64 time=0.069 ms
64 bytes from 10.0.0.7: icmp_seq=24 ttl=64 time=0.066 ms
64 bytes from 10.0.0.7: icmp_seq=25 ttl=64 time=0.061 ms
64 bytes from 10.0.0.7: icmp_seq=26 ttl=64 time=0.111 ms
64 bytes from 10.0.0.7: icmp_seq=27 ttl=64 time=0.073 ms
64 bytes from 10.0.0.7: icmp_seq=28 ttl=64 time=0.127 ms
64 bytes from 10.0.0.7: icmp_seq=29 ttl=64 time=0.083 ms
^C
--- 10.0.0.7 ping statistics ---
29 packets transmitted, 29 received, 0% packet loss, time 28632ms
rtt min/avg/max/mdev = 0.055/0.074/0.101/0.087 ms
mininet-wifi> sta7M ping sta8M
PING 10.0.0.9 (10.0.0.9) 56(84) bytes of data.
64 bytes from 10.0.0.9: icmp_seq=1 ttl=64 time=0.345 ms
64 bytes from 10.0.0.9: icmp_seq=2 ttl=64 time=0.081 ms
64 bytes from 10.0.0.9: icmp_seq=3 ttl=64 time=0.060 ms
64 bytes from 10.0.0.9: icmp_seq=4 ttl=64 time=0.095 ms
64 bytes from 10.0.0.9: icmp_seq=5 ttl=64 time=0.080 ms
64 bytes from 10.0.0.9: icmp_seq=6 ttl=64 time=0.068 ms
64 bytes from 10.0.0.9: icmp_seq=7 ttl=64 time=0.085 ms
64 bytes from 10.0.0.9: icmp_seq=8 ttl=64 time=0.057 ms
64 bytes from 10.0.0.9: icmp_seq=9 ttl=64 time=0.063 ms
64 bytes from 10.0.0.9: icmp_seq=10 ttl=64 time=0.210 ms
```

- Sta8M < - - -> sta9M

```
s7com1030@ubuntu: ~/Desktop/Task02
File Edit View Search Terminal Help
64 bytes from 10.0.0.9: icmp_seq=30 ttl=64 time=0.059 ms
64 bytes from 10.0.0.9: icmp_seq=31 ttl=64 time=0.058 ms
64 bytes from 10.0.0.9: icmp_seq=32 ttl=64 time=0.077 ms
64 bytes from 10.0.0.9: icmp_seq=33 ttl=64 time=0.079 ms
64 bytes from 10.0.0.9: icmp_seq=34 ttl=64 time=0.095 ms
64 bytes from 10.0.0.9: icmp_seq=35 ttl=64 time=0.059 ms
64 bytes from 10.0.0.9: icmp_seq=36 ttl=64 time=0.102 ms
^C
--- 10.0.0.9 ping statistics ---
36 packets transmitted, 36 received, 0% packet loss, time 35827ms
rtt min/avg/max/mdev = 0.056/0.096/0.345/0.058 ms
mininet-wifi> sta8M ping sta9M
PING 10.0.0.10 (10.0.0.10) 56(84) bytes of data.
64 bytes from 10.0.0.10: icmp_seq=1 ttl=64 time=0.457 ms
64 bytes from 10.0.0.10: icmp_seq=2 ttl=64 time=0.155 ms
64 bytes from 10.0.0.10: icmp_seq=3 ttl=64 time=0.171 ms
64 bytes from 10.0.0.10: icmp_seq=4 ttl=64 time=0.089 ms
64 bytes from 10.0.0.10: icmp_seq=5 ttl=64 time=0.075 ms
64 bytes from 10.0.0.10: icmp_seq=6 ttl=64 time=0.055 ms
64 bytes from 10.0.0.10: icmp_seq=7 ttl=64 time=0.087 ms
64 bytes from 10.0.0.10: icmp_seq=8 ttl=64 time=0.071 ms
64 bytes from 10.0.0.10: icmp_seq=9 ttl=64 time=0.055 ms
64 bytes from 10.0.0.10: icmp_seq=10 ttl=64 time=0.142 ms
```

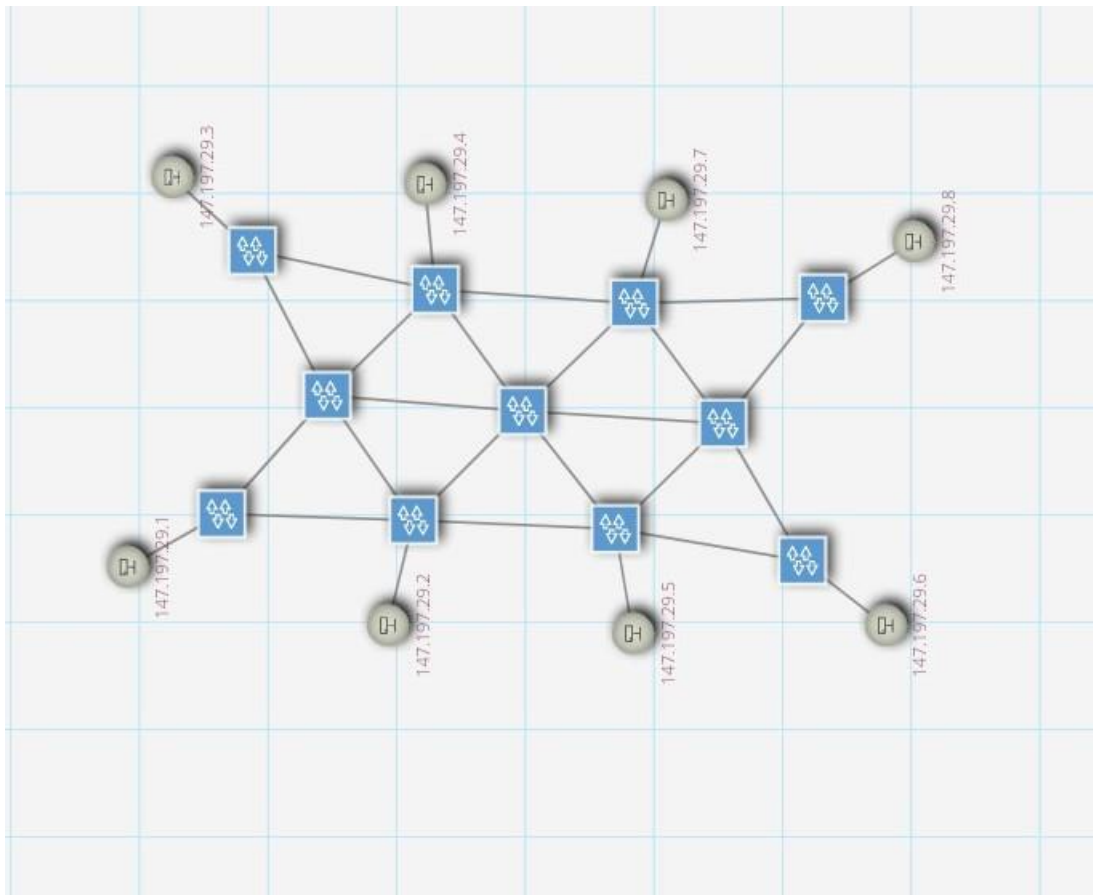
- sta7M < - - -> sta9M

```
s7com1030@ubuntu: ~/Desktop/Task02
File Edit View Search Terminal Help
64 bytes from 10.0.0.10: icmp_seq=27 ttl=64 time=0.067 ms
64 bytes from 10.0.0.10: icmp_seq=28 ttl=64 time=0.114 ms
64 bytes from 10.0.0.10: icmp_seq=29 ttl=64 time=0.111 ms
64 bytes from 10.0.0.10: icmp_seq=30 ttl=64 time=0.062 ms
64 bytes from 10.0.0.10: icmp_seq=31 ttl=64 time=0.072 ms
64 bytes from 10.0.0.10: icmp_seq=32 ttl=64 time=0.071 ms
64 bytes from 10.0.0.10: icmp_seq=33 ttl=64 time=0.066 ms
64 bytes from 10.0.0.10: icmp_seq=34 ttl=64 time=0.069 ms
^C
--- 10.0.0.10 ping statistics ---
34 packets transmitted, 34 received, 0% packet loss, time 33773ms
rtt min/avg/max/mdev = 0.055/0.107/0.457/0.073 ms
mininet-wifi> sta7M ping sta9M
PING 10.0.0.10 (10.0.0.10) 56(84) bytes of data.
64 bytes from 10.0.0.10: icmp_seq=1 ttl=64 time=0.316 ms
64 bytes from 10.0.0.10: icmp_seq=2 ttl=64 time=0.112 ms
64 bytes from 10.0.0.10: icmp_seq=3 ttl=64 time=0.102 ms
64 bytes from 10.0.0.10: icmp_seq=4 ttl=64 time=0.144 ms
64 bytes from 10.0.0.10: icmp_seq=5 ttl=64 time=0.076 ms
64 bytes from 10.0.0.10: icmp_seq=6 ttl=64 time=0.051 ms
64 bytes from 10.0.0.10: icmp_seq=7 ttl=64 time=0.070 ms
64 bytes from 10.0.0.10: icmp_seq=8 ttl=64 time=0.081 ms
64 bytes from 10.0.0.10: icmp_seq=9 ttl=64 time=0.081 ms
```

- Throughput, I/O graph, Total number of TCP packets and Total number of TCP flagged packets
 - o Screenshot of the statistic file from Wireshark
- Analysis
 - o Calculate TCP Success rate, this can be done by the statistics collected
 - o Critically evaluate the reason for success or failure of the ICMP streams between sta4ad < - - -> sta6ad and sta7M < - - -> sta9M. Conduct a discussion of the results with evidence (screenshots) and reference.
 - o If the nodes are in mobility during the transmission of the TCP stream, will the performance deviate from the collected in any way? Conduct a discussion based on this experiment. If needed add reference from background research to further support your claims.
 - o Critically evaluate why STA1 < - - -> STA4 ping fail in Task 1? How can a successful ping be achieved?

TASK 3

- Screenshot from the ONOS GUI



- Screenshot of the ICMP stream

```
s7com1030@ubuntu: ~/Desktop/Task03
File Edit View Search Terminal Help
ch1) (h2, Switch2) (h3, Switch3) (h4, Switch4) (h5, Switch5) (h6, Switch6) (h7,
Switch7) (h8, Switch8)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8
*** Starting controller
c0
*** Starting 11 switches
Switch1 Switch2 Switch3 Switch4 Switch5 Switch6 Switch7 Switch8 Switch9 Switch10
Switch11 ...
*** Starting CLI:
mininet-wifi> ping all
*** Unknown command: ping all
mininet-wifi> pingall
*** Ping: testing ping reachability
h1 -> X h3 X h5 X h7 X
h2 -> X X h4 X h6 X h8
h3 -> h1 X X h5 X h7 X
h4 -> X h2 X X h6 X h8
h5 -> h1 X h3 X X h7 X
h6 -> X h2 X h4 X X h8
h7 -> h1 X h3 X h5 X X
h8 -> X h2 X h4 X h6 X
*** Results: 57% dropped (24/56 received)
mininet-wifi>
```

- Screenshot of the Link configurations

```
s7com1030@ubuntu: ~/Desktop/Task03
File Edit View Search Terminal Help
s7com1030@ubuntu:~/Desktop/Task03$ sudo mn --controller remote,ip=127.0.0.1 --custom Task03.py --topo mytopo
*** Creating network
*** Adding controller
Connecting to remote controller at 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8
*** Adding switches:
Switch1 Switch2 Switch3 Switch4 Switch5 Switch6 Switch7 Switch8 Switch9 Switch10 Switch11
*** Adding links:
(Switch1, Switch2) (Switch1, Switch9) (Switch2, Switch5) (Switch2, Switch9) (Switch2, Switch10) (Switch4, Switch3) (Switch5, Switch
6) (Switch5, Switch10) (Switch5, Switch11) (Switch6, Switch11) (Switch7, Switch4) (Switch8, Switch7) (Switch9, Switch3) (Switch9, S
witch4) (Switch9, Switch10) (Switch10, Switch4) (Switch10, Switch7) (Switch10, Switch11) (Switch11, Switch7) (Switch11, Switch8) (h
1, Switch1) (h2, Switch2) (h3, Switch3) (h4, Switch4) (h5, Switch5) (h6, Switch6) (h7, Switch7) (h8, Switch8)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8
*** Starting controller
c0
*** Starting 11 switches
Switch1 Switch2 Switch3 Switch4 Switch5 Switch6 Switch7 Switch8 Switch9 Switch10 Switch11 ...
*** Starting CLI:
mininet-wifi> ping all
```

- Links:

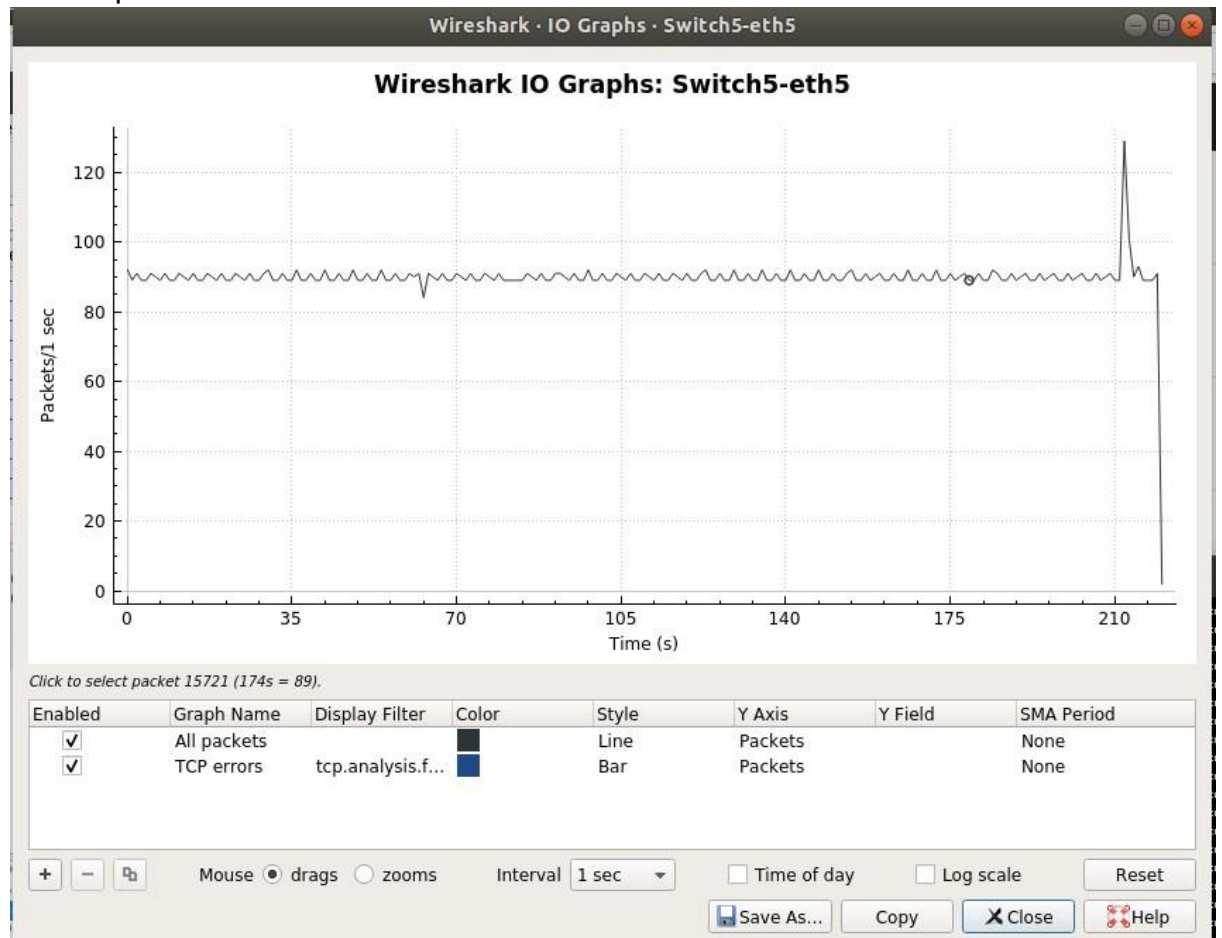
```
c0
mininet-wifi> links
Switch1-eth1<->Switch2-eth1 (OK OK)
Switch1-eth2<->Switch9-eth1 (OK OK)
Switch2-eth4<->Switch5-eth1 (OK OK)
Switch2-eth2<->Switch9-eth2 (OK OK)
Switch2-eth3<->Switch10-eth1 (OK OK)
Switch4-eth3<->Switch3-eth2 (OK OK)
Switch5-eth4<->Switch6-eth1 (OK OK)
Switch5-eth2<->Switch10-eth2 (OK OK)
Switch5-eth3<->Switch11-eth1 (OK OK)
Switch6-eth2<->Switch11-eth2 (OK OK)
Switch7-eth3<->Switch4-eth4 (OK OK)
Switch8-eth2<->Switch7-eth4 (OK OK)
Switch9-eth3<->Switch3-eth1 (OK OK)
Switch9-eth4<->Switch4-eth1 (OK OK)
Switch9-eth5<->Switch10-eth3 (OK OK)
Switch10-eth4<->Switch4-eth2 (OK OK)
Switch10-eth5<->Switch7-eth1 (OK OK)
Switch10-eth6<->Switch11-eth3 (OK OK)
Switch11-eth4<->Switch7-eth2 (OK OK)
Switch11-eth5<->Switch8-eth1 (OK OK)
h1-eth0.300<->Switch1-eth3 (OK OK)
h2-eth0.400<->Switch2-eth5 (OK OK)
h3-eth0.300<->Switch3-eth3 (OK OK)
h4-eth0.400<->Switch4-eth5 (OK OK)
h5-eth0.300<->Switch5-eth5 (OK OK)
h6-eth0.400<->Switch6-eth3 (OK OK)
h7-eth0.300<->Switch7-eth5 (OK OK)
h8-eth0.400<->Switch8-eth3 (OK OK)
mininet-wifi>
```


TASK 4

- UDP flow to total of 2GB traffic using the port assigned

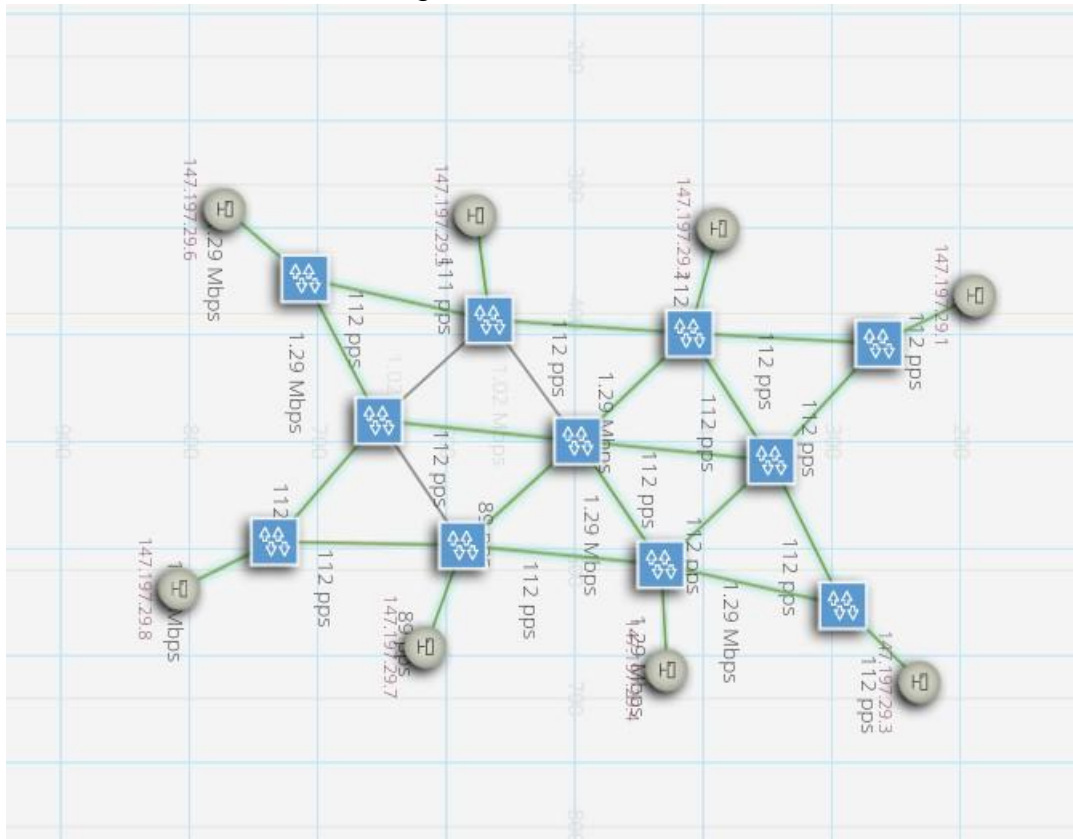
The screenshot displays the ONOS network management interface. A packet capture window titled "Capturing from Switch5-eth5" shows a list of captured packets. The packets are UDP flows from 127.0.0.1 to 147.197.29.7. A terminal window shows the execution of a script to generate traffic. Another terminal window shows the output of a netstat command.

-
- I/O Graph



- Video stream

- Packets route while streaming



-
-

Report:

- Your report must include the following:
 - o Modelling
 - A brief introduction to the environments (Mininet, ONOS, Wireshark, iPerf) not exceeding half a page.
 - Screenshots as mentioned in the deliverable section in each task, totalling the number of screenshots but not limited to 6
 - o Results
 - Mean throughput and mean jitter of the UDP transfer according to your statistic files in Task 4.1
 - Throughput graph obtained from video stream using Wireshark.
 - Total number of Packet loss from the video stream, screenshot of the statistic file from Wireshark
 - o Analysis
 - Should there be more packet loss and delay, should you expect the results to deviate from what you have acquired? Evaluate with references.
 - Comment on how the variables such as packet loss and delay have contributed towards the overall performance of your network. Evaluate with reference