Διαχείριση Δικτύων

Εργασία 2η

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Στα επισυναπτόμενα αρχεία βρίσκονται οι υλοποιήσεις των πειραμάτων 1 και 2, όπως αυτά περιγράφονται στα αντίστοιχα επιστημονικά άρθρα.

**Πείραμα 1ο**

Δομή

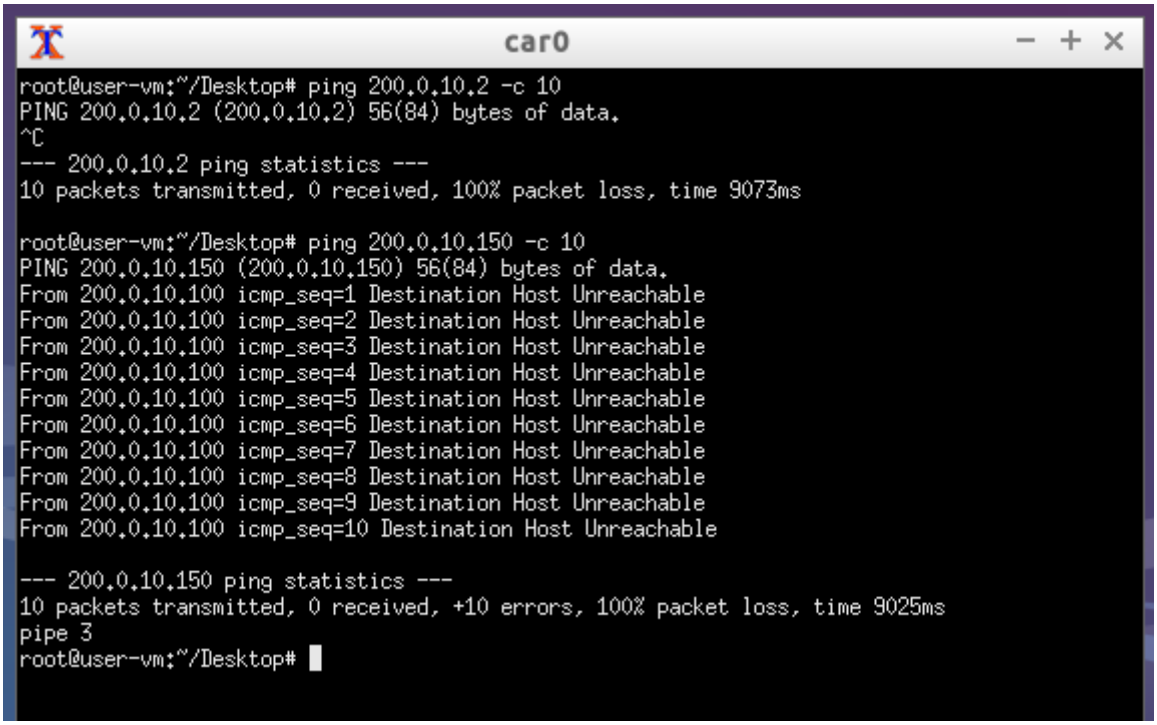
Το πείραμα 1 αποτελείται από 3 συναρτήσεις: graphic() – δημιουργία γραφήματος, apply_experiment(car,client,switch) – υλοποίηση του πειράματος σε στάδια και topology() – δημιουργία δικτύου και ρύθμιση κόμβων.

Λειτουργεία

Το car0 αποστέλλει στον client ένα βίντεο ζωντανά. Σε κάθε φάση του πειράματος, μετράται το throughput και τα packets και στο τέλος παράγεται το αντίστοιχο γράφημα. Jitter και Latency μετρούνται κατά τη διάρκεια του πειράματος από τα τερματικά των σχετικών κόμβων με τις εντολές ping και iperf.

Αποτελέσματα

→ 1η φάση: Το car0 επικοινωνεί με τον client μέσω του car3:

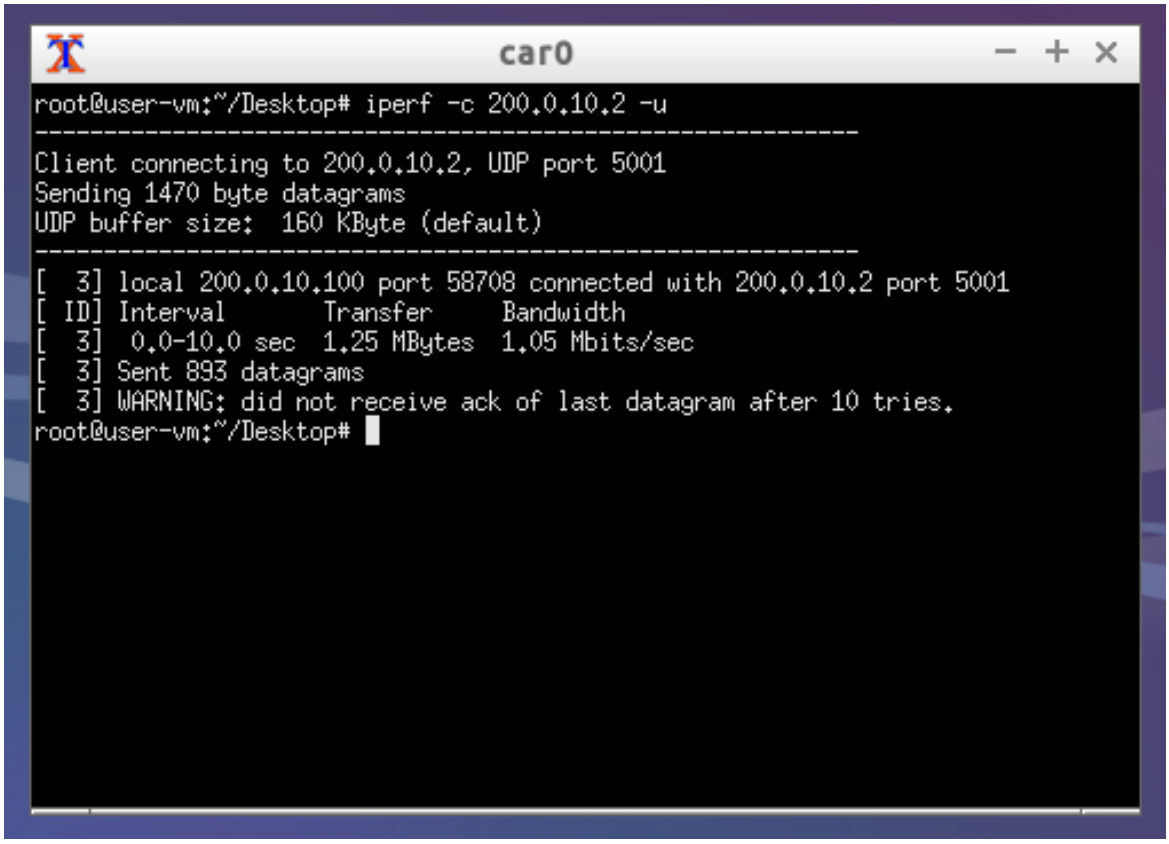


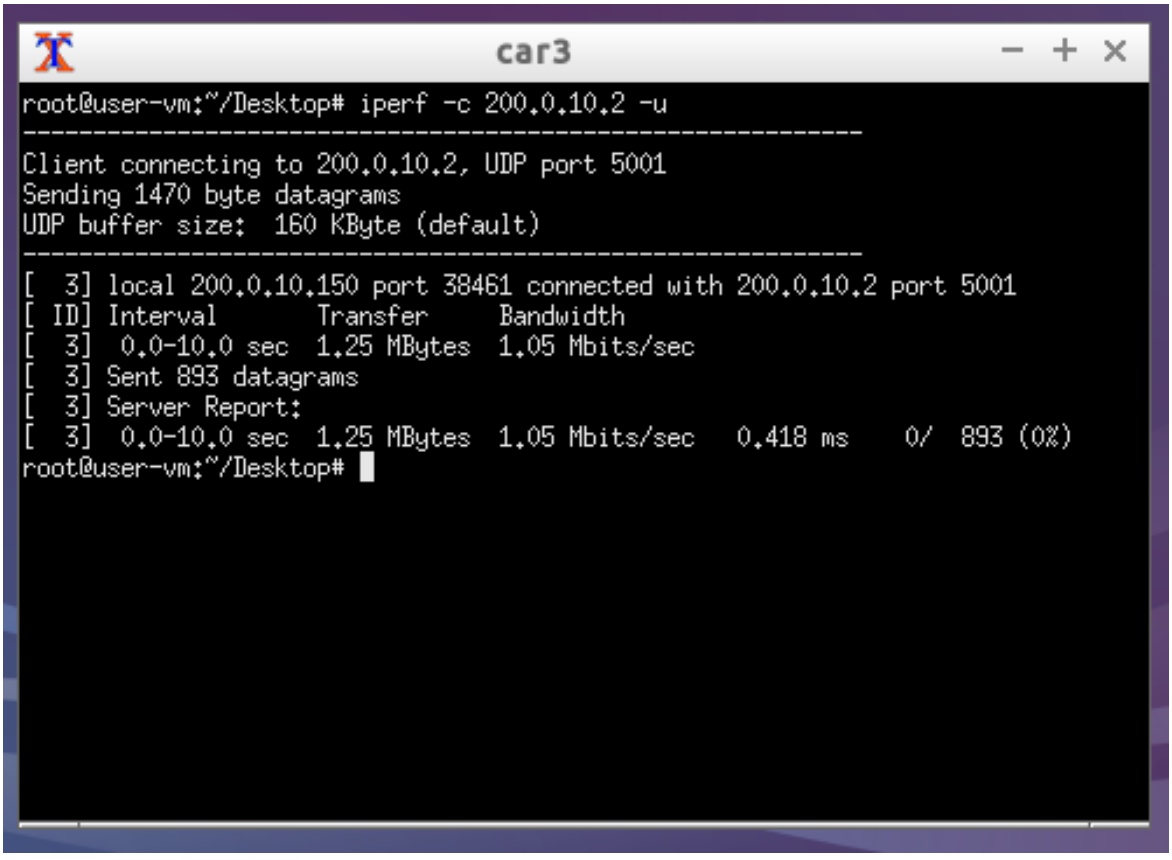
car3

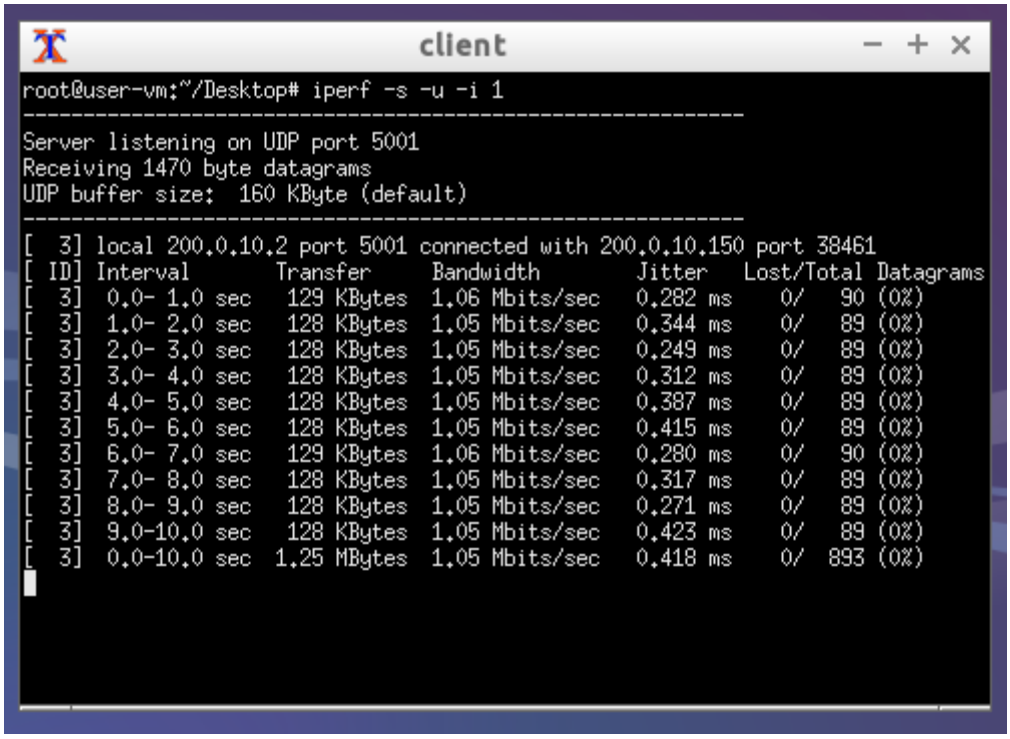
```
root@user-vm:~/Desktop# ping 200.0.10.2 -c 10
PING 200.0.10.2 (200.0.10.2) 56(84) bytes of data.
64 bytes from 200.0.10.2: icmp_seq=1 ttl=64 time=6.93 ms
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=5.19 ms
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=5.40 ms
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=5.04 ms
64 bytes from 200.0.10.2: icmp_seq=5 ttl=64 time=5.01 ms
64 bytes from 200.0.10.2: icmp_seq=6 ttl=64 time=5.03 ms
64 bytes from 200.0.10.2: icmp_seq=7 ttl=64 time=5.07 ms
64 bytes from 200.0.10.2: icmp_seq=8 ttl=64 time=4.98 ms
64 bytes from 200.0.10.2: icmp_seq=9 ttl=64 time=5.05 ms
64 bytes from 200.0.10.2: icmp_seq=10 ttl=64 time=5.07 ms

--- 200.0.10.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 4.981/5.281/6.938/0.567 ms
root@user-vm:~/Desktop# ping 200.0.10.150 -c 10
PING 200.0.10.150 (200.0.10.150) 56(84) bytes of data.
64 bytes from 200.0.10.150: icmp_seq=1 ttl=64 time=0.018 ms
64 bytes from 200.0.10.150: icmp_seq=2 ttl=64 time=0.016 ms
64 bytes from 200.0.10.150: icmp_seq=3 ttl=64 time=0.021 ms
64 bytes from 200.0.10.150: icmp_seq=4 ttl=64 time=0.032 ms
64 bytes from 200.0.10.150: icmp_seq=5 ttl=64 time=0.015 ms
64 bytes from 200.0.10.150: icmp_seq=6 ttl=64 time=0.016 ms
64 bytes from 200.0.10.150: icmp_seq=7 ttl=64 time=0.019 ms
64 bytes from 200.0.10.150: icmp_seq=8 ttl=64 time=0.013 ms
64 bytes from 200.0.10.150: icmp_seq=9 ttl=64 time=0.017 ms
64 bytes from 200.0.10.150: icmp_seq=10 ttl=64 time=0.033 ms

--- 200.0.10.150 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 8998ms
rtt min/avg/max/mdev = 0.013/0.020/0.033/0.006 ms
root@user-vm:~/Desktop#
```

client

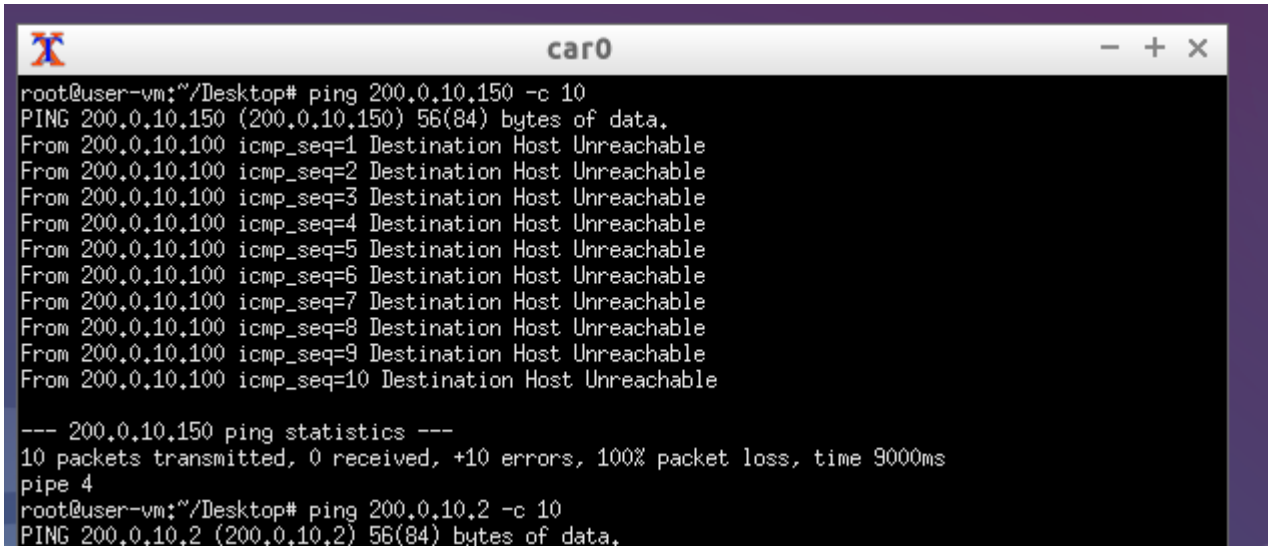
```
root@user-vm:~/Desktop# ping 200.0.10.100 -c 10
PING 200.0.10.100 (200.0.10.100) 56(84) bytes of data.

--- 200.0.10.100 ping statistics ---
10 packets transmitted, 0 received, 100% packet loss, time 9000ms

root@user-vm:~/Desktop# ping 200.0.10.150 -c 10
PING 200.0.10.150 (200.0.10.150) 56(84) bytes of data.
64 bytes from 200.0.10.150: icmp_seq=1 ttl=64 time=7.16 ms
64 bytes from 200.0.10.150: icmp_seq=2 ttl=64 time=5.44 ms
64 bytes from 200.0.10.150: icmp_seq=3 ttl=64 time=5.50 ms
64 bytes from 200.0.10.150: icmp_seq=4 ttl=64 time=5.01 ms
64 bytes from 200.0.10.150: icmp_seq=5 ttl=64 time=5.02 ms
64 bytes from 200.0.10.150: icmp_seq=6 ttl=64 time=5.07 ms
64 bytes from 200.0.10.150: icmp_seq=7 ttl=64 time=5.53 ms
64 bytes from 200.0.10.150: icmp_seq=8 ttl=64 time=5.12 ms
64 bytes from 200.0.10.150: icmp_seq=9 ttl=64 time=5.07 ms
64 bytes from 200.0.10.150: icmp_seq=10 ttl=64 time=5.25 ms

--- 200.0.10.150 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9012ms
rtt min/avg/max/mdev = 5.018/5.421/7.162/0.616 ms
root@user-vm:~/Desktop#
```


car0
root@user-vm:~/Desktop# iperf -c 200.0.10.2 -u
------------------------------------------------------------
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:  160 KByte (default)
------------------------------------------------------------
[  3] local 200.0.10.100 port 58708 connected with 200.0.10.2 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec
[  3] Sent 893 datagrams
[  3] WARNING: did not receive ack of last datagram after 10 tries.
root@user-vm:~/Desktop#

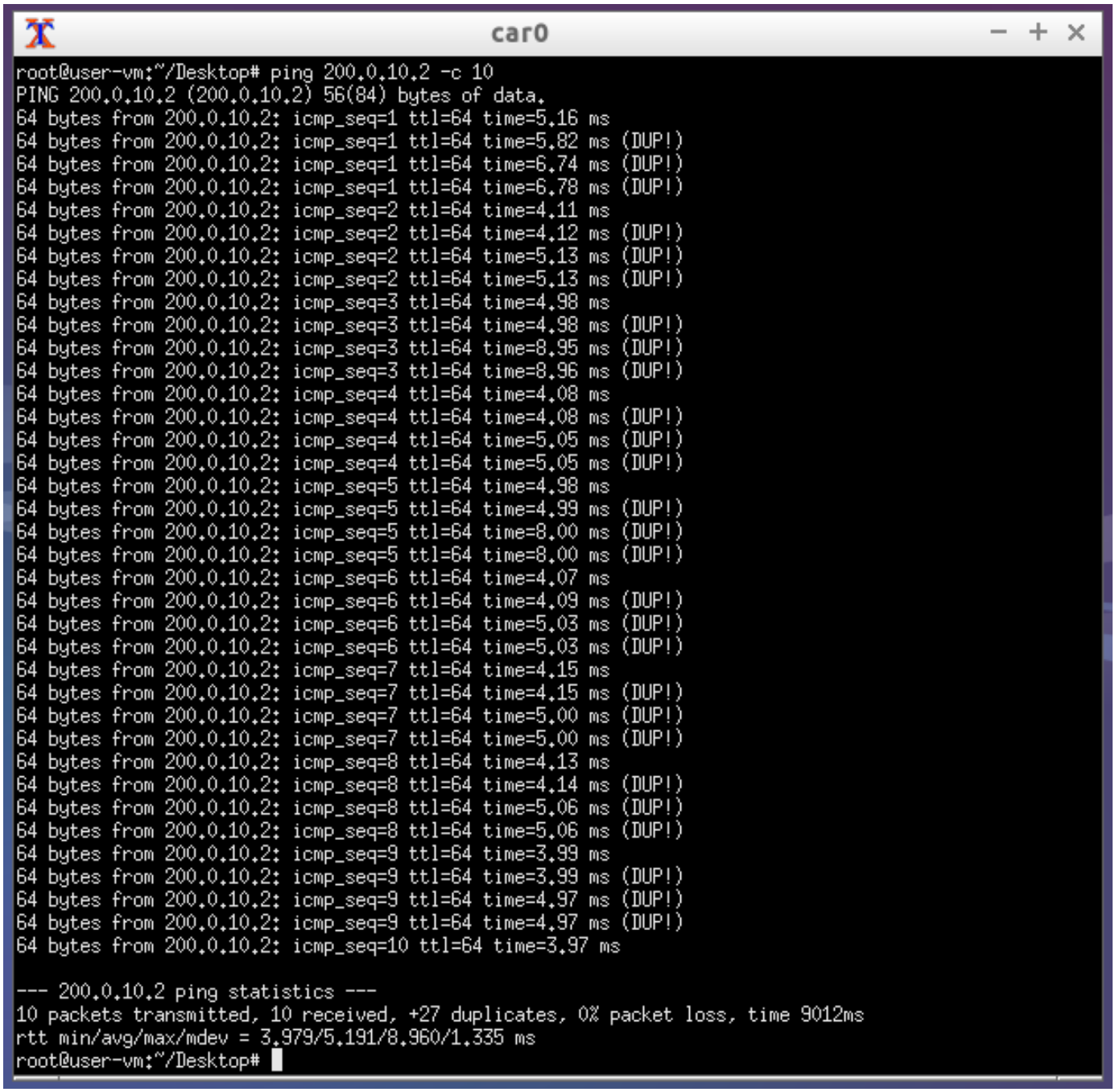

car3
root@user-vm:~/Desktop# iperf -c 200.0.10.2 -u
------------------------------------------------------------
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:  160 KByte (default)
------------------------------------------------------------
[  3] local 200.0.10.150 port 38461 connected with 200.0.10.2 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec
[  3] Sent 893 datagrams
[  3] Server Report:
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec   0.418 ms    0/  893 (0%)
root@user-vm:~/Desktop#

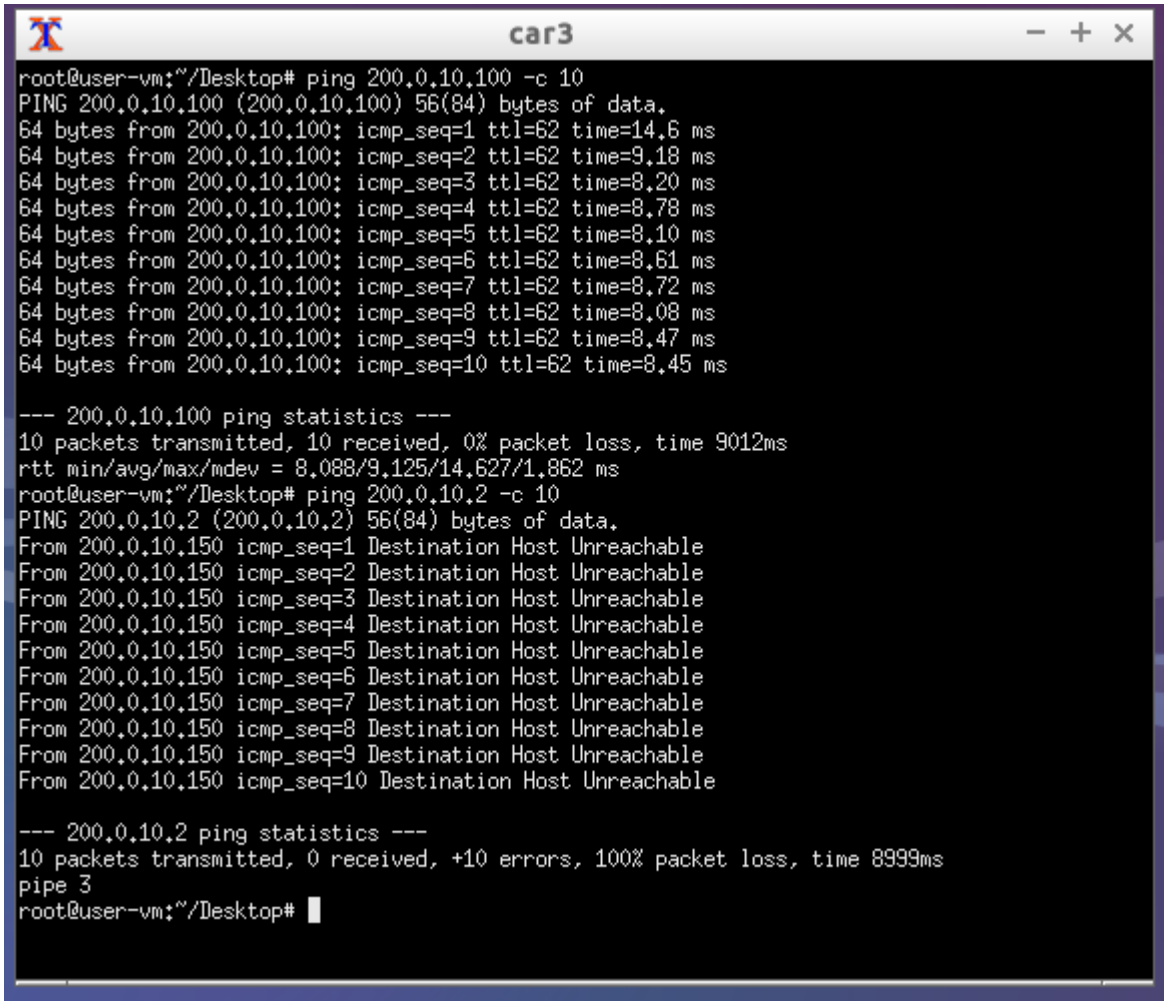



→ 2η φάση: Το car0 επικοινωνεί ταυτόχρονα με rsu1 και eNodeB2, με αποτέλεσμα τα διπλότυπα:

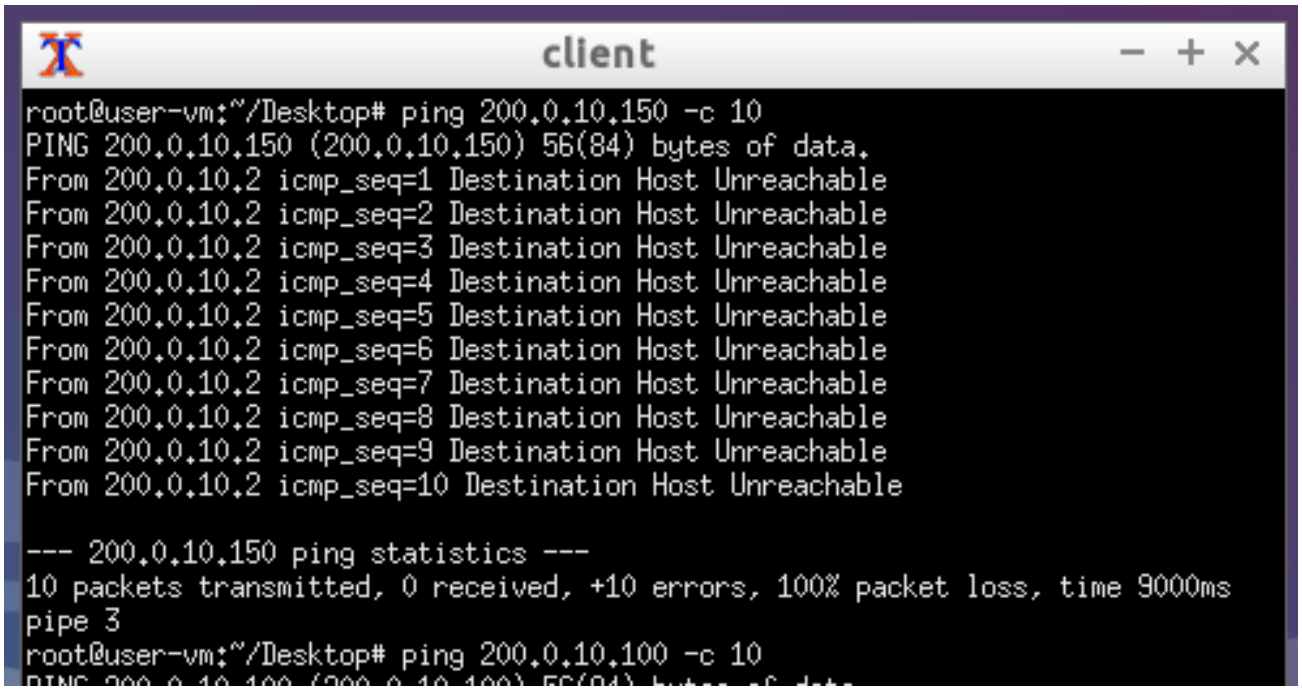


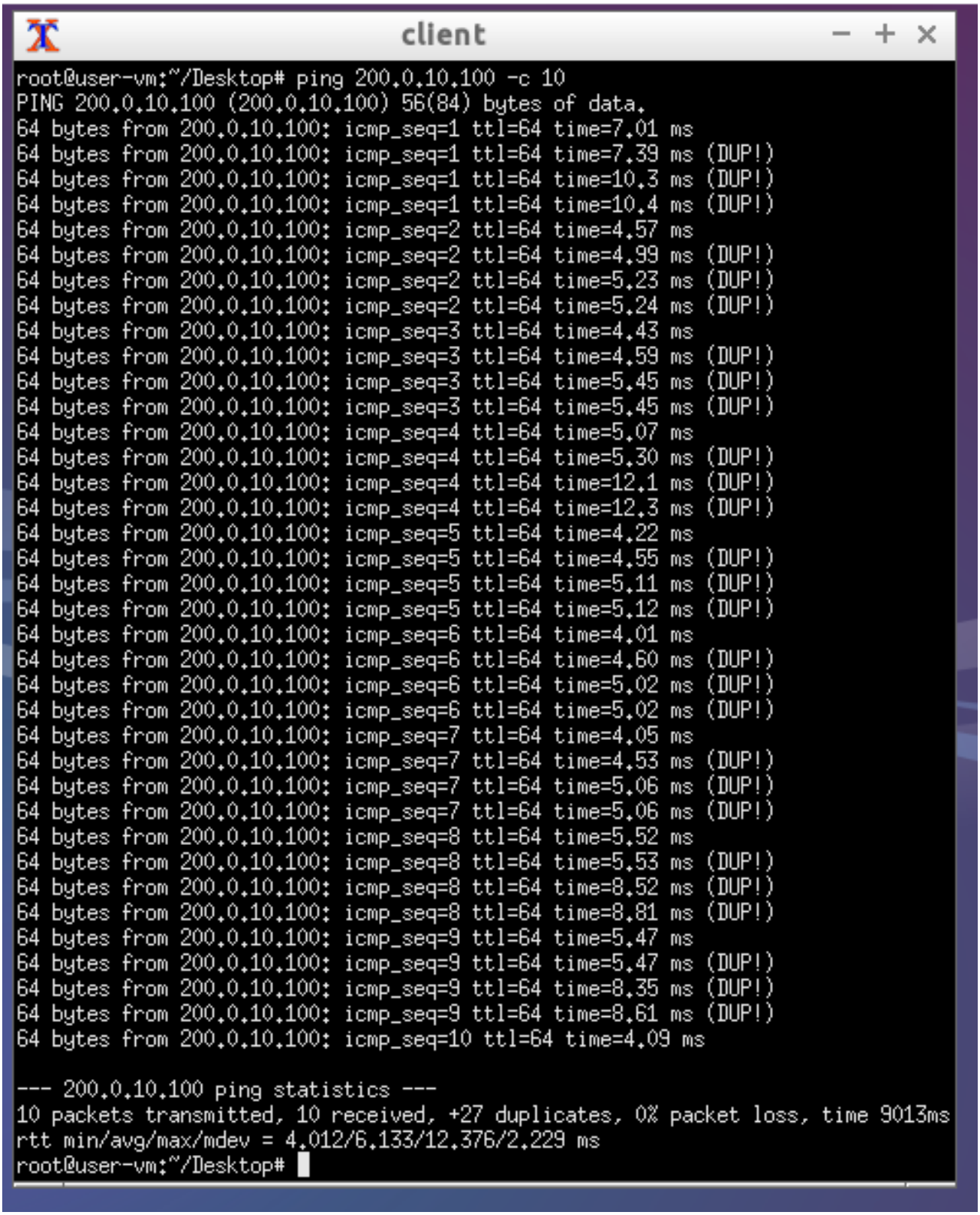

* car0 και car3 δεν επικοινωνούν πλέον.


car0
root@user-vm:~/Desktop# ping 200.0.10.2 -c 10
PING 200.0.10.2 (200.0.10.2) 56(84) bytes of data.
64 bytes from 200.0.10.2: icmp_seq=1 ttl=64 time=5.16 ms
64 bytes from 200.0.10.2: icmp_seq=1 ttl=64 time=5.82 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=1 ttl=64 time=6.74 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=1 ttl=64 time=6.78 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=4.11 ms
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=4.12 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=5.13 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=5.13 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=4.98 ms
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=4.98 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=8.95 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=8.96 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=4.08 ms
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=4.08 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=5.05 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=5.05 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=5 ttl=64 time=4.98 ms
64 bytes from 200.0.10.2: icmp_seq=5 ttl=64 time=4.99 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=5 ttl=64 time=8.00 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=5 ttl=64 time=8.00 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=6 ttl=64 time=4.07 ms
64 bytes from 200.0.10.2: icmp_seq=6 ttl=64 time=4.09 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=6 ttl=64 time=5.03 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=6 ttl=64 time=5.03 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=7 ttl=64 time=4.15 ms
64 bytes from 200.0.10.2: icmp_seq=7 ttl=64 time=4.15 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=7 ttl=64 time=5.00 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=7 ttl=64 time=5.00 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=8 ttl=64 time=4.13 ms
64 bytes from 200.0.10.2: icmp_seq=8 ttl=64 time=4.14 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=8 ttl=64 time=5.06 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=8 ttl=64 time=5.06 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=9 ttl=64 time=3.99 ms
64 bytes from 200.0.10.2: icmp_seq=9 ttl=64 time=3.99 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=9 ttl=64 time=4.97 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=9 ttl=64 time=4.97 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=10 ttl=64 time=3.97 ms
--- 200.0.10.2 ping statistics ---
10 packets transmitted, 10 received, +27 duplicates, 0% packet loss, time 9012ms
rtt min/avg/max/mdev = 3.979/5.191/8.960/1.335 ms
root@user-vm:~/Desktop#




* Το car3 έχει απομακρυνθεί  από την αλυσίδα της επικοινωνίας






car0 και client επικοινωνούν μέσω usr1 και eNodeB2, χωρίς άλλους ενδιάμεσους.

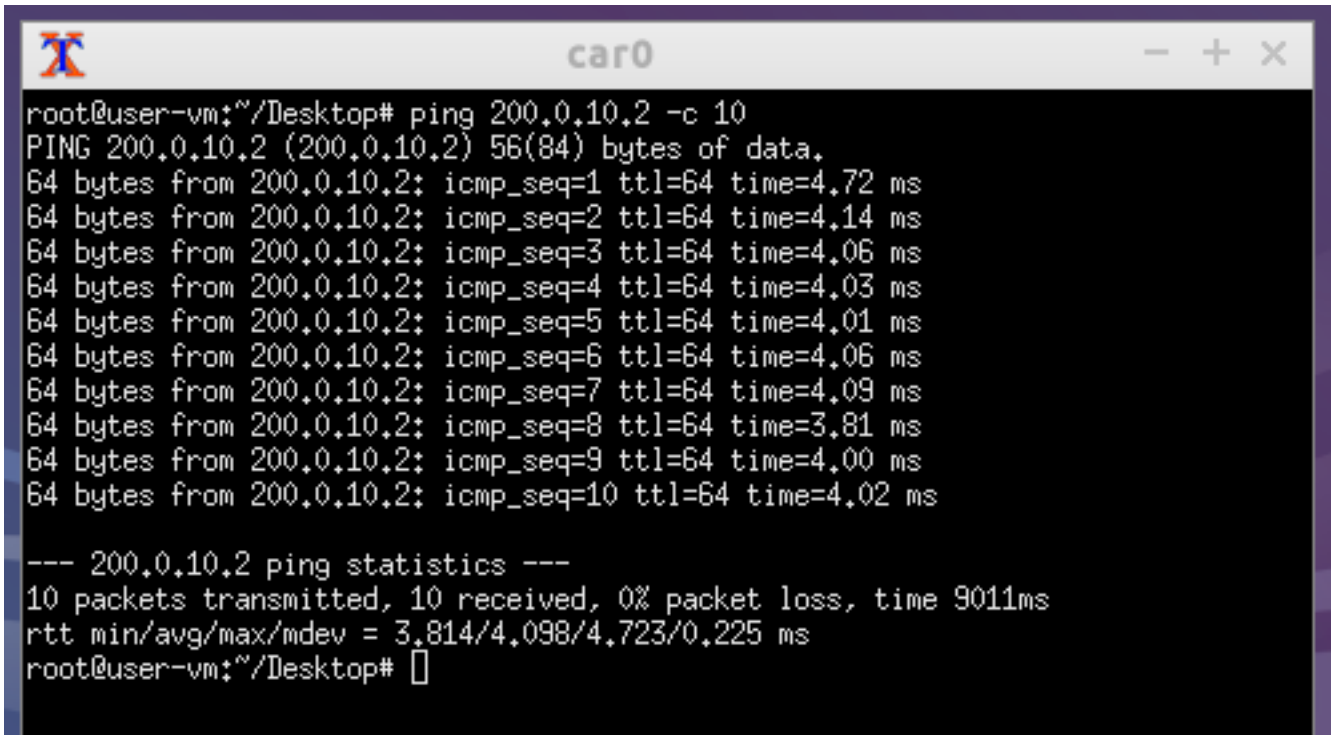
car0

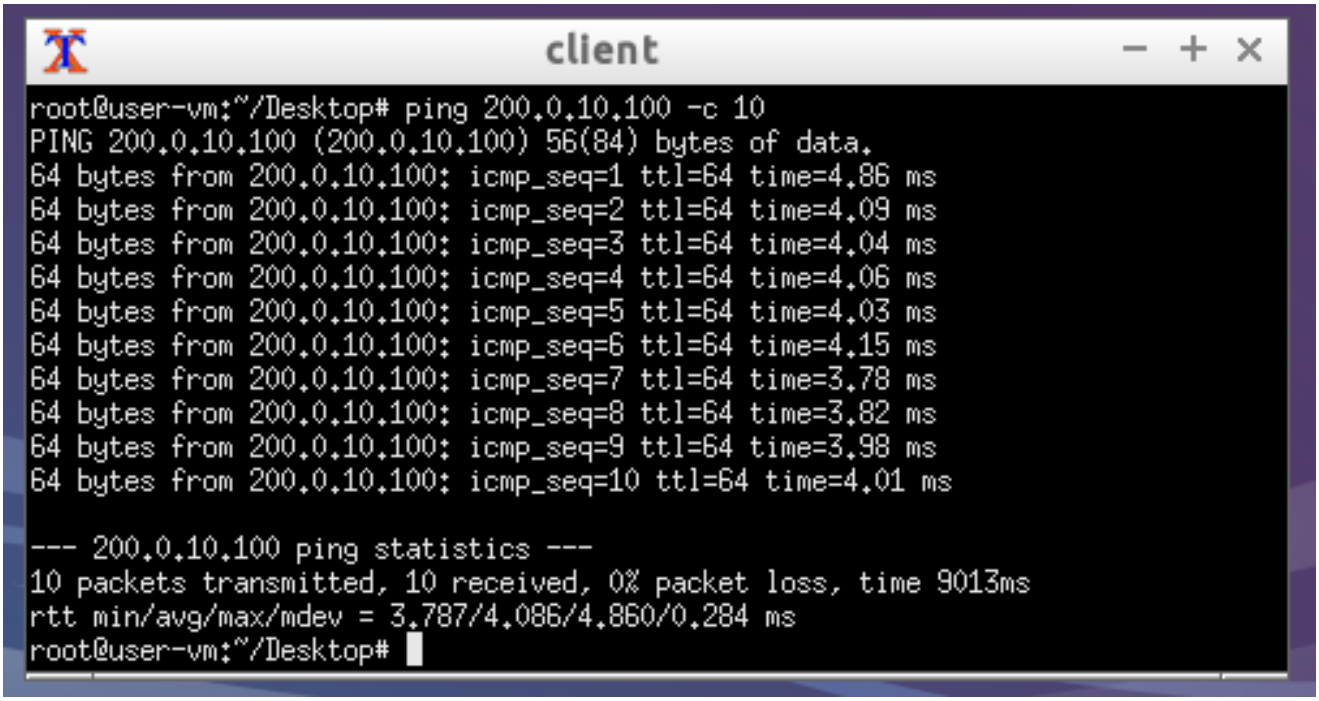
```
root@user-vm:~/Desktop# iperf -c 200.0.10.2 -u
------------------------------------------------------------
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:  160 KByte (default)
------------------------------------------------------------
[  3] local 200.0.10.100 port 46781 connected with 200.0.10.2 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec
[  3] Sent 893 datagrams
[  3] Server Report:
[  3]  0.0-10.0 sec  2.41 MBytes  2.02 Mbits/sec  688.120 ms    1/  893 (0.11%)
[  3]  0.0-10.0 sec  823 datagrams received out-of-order
root@user-vm:~/Desktop#
```

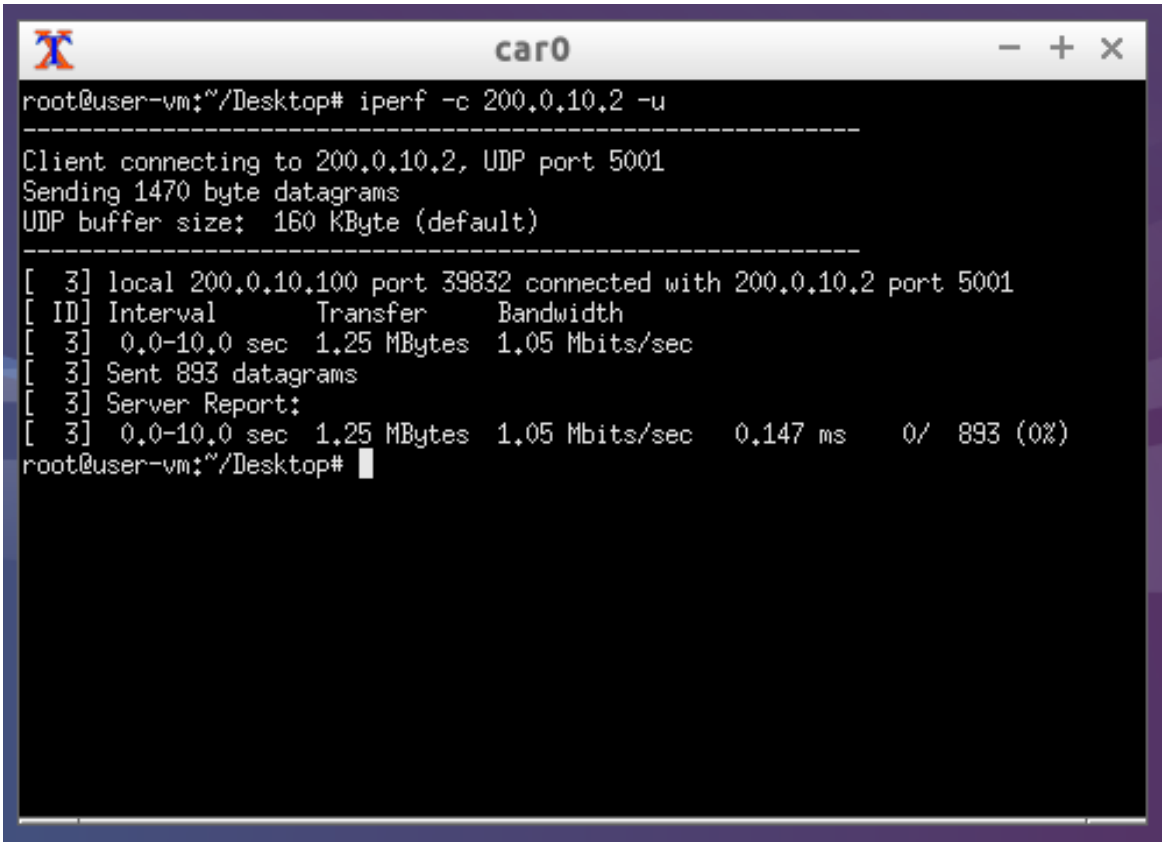
client

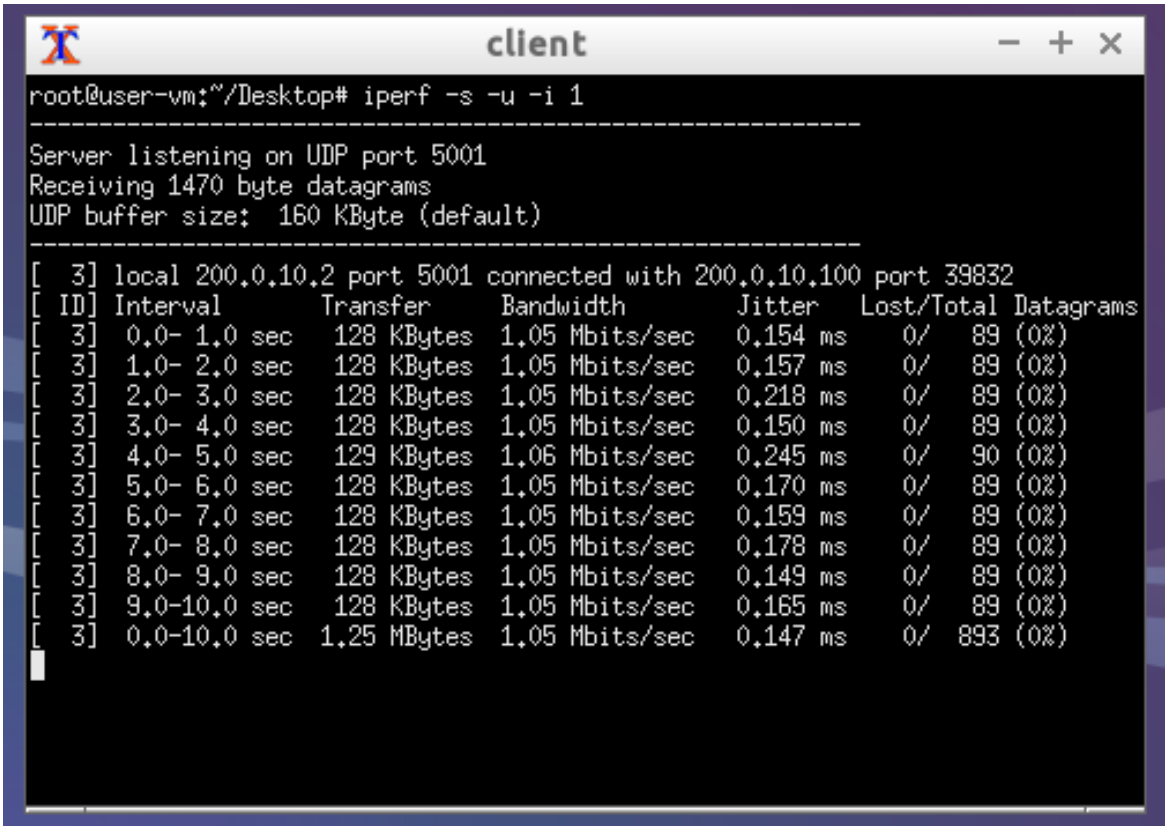
```
root@user-vm:~/Desktop# iperf -s -u -i 1
------------------------------------------------------------
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size:  160 KByte (default)
------------------------------------------------------------
[  3] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 46781
[ ID] Interval       Transfer     Bandwidth        Jitter   Lost/Total Datagrams
[  3]  0.0- 1.0 sec   248 KBytes  2.03 Mbits/sec  42.603 ms    0/   89 (0%)
[  3]  0.0- 1.0 sec  83 datagrams received out-of-order
[  3]  1.0- 2.0 sec   244 KBytes  2.00 Mbits/sec  132.470 ms    0/   89 (0%)
[  3]  1.0- 2.0 sec  81 datagrams received out-of-order
[  3]  2.0- 3.0 sec   243 KBytes  1.99 Mbits/sec  216.031 ms    0/   89 (0%)
[  3]  2.0- 3.0 sec  80 datagrams received out-of-order
[  3]  3.0- 4.0 sec   248 KBytes  2.03 Mbits/sec  246.770 ms    0/   89 (0%)
[  3]  3.0- 4.0 sec  84 datagrams received out-of-order
[  3]  4.0- 5.0 sec   248 KBytes  2.03 Mbits/sec  342.669 ms    0/   90 (0%)
[  3]  4.0- 5.0 sec  83 datagrams received out-of-order
[  3]  5.0- 6.0 sec   250 KBytes  2.05 Mbits/sec  334.687 ms    0/   89 (0%)
[  3]  5.0- 6.0 sec  85 datagrams received out-of-order
[  3]  6.0- 7.0 sec   245 KBytes  2.01 Mbits/sec  425.329 ms    0/   89 (0%)
[  3]  6.0- 7.0 sec  82 datagrams received out-of-order
[  3]  7.0- 8.0 sec   241 KBytes  1.98 Mbits/sec  529.962 ms    0/   89 (0%)
[  3]  7.0- 8.0 sec  79 datagrams received out-of-order
[  3]  8.0- 9.0 sec   251 KBytes  2.06 Mbits/sec  543.361 ms    1/   89 (1.1%)
[  3]  8.0- 9.0 sec  87 datagrams received out-of-order
[  3]  9.0-10.0 sec   240 KBytes  1.96 Mbits/sec  668.876 ms    0/   89 (0%)
[  3]  9.0-10.0 sec  78 datagrams received out-of-order
[  3]  0.0-10.0 sec  2.41 MBytes  2.02 Mbits/sec  688.120 ms    1/  893 (0.11%)
[  3]  0.0-10.0 sec  823 datagrams received out-of-order
read failed: Connection refused
[  4] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 46781
[  4]  0.0- 0.8 sec  97.6 KBytes  1.02 Mbits/sec   3.047 ms  825/  893 (92%)
read failed: Connection refused
```

→ 3η φάση: Car0 και client επικοινωνούν μόνο μέσω eNodeB2:




car0
root@user-vm:~/Desktop# iperf -c 200.0.10.2 -u
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)
[ 3] local 200.0.10.100 port 39832 connected with 200.0.10.2 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec
[ 3] Sent 893 datagrams
[ 3] Server Report:
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.147 ms 0/ 893 (0%)
root@user-vm:~/Desktop#


client
root@user-vm:~/Desktop# iperf -s -u -i 1
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 160 KByte (default)
[ 3] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 39832
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0- 1.0 sec 128 KBytes 1.05 Mbits/sec 0.154 ms 0/ 89 (0%)
[ 3] 1.0- 2.0 sec 128 KBytes 1.05 Mbits/sec 0.157 ms 0/ 89 (0%)
[ 3] 2.0- 3.0 sec 128 KBytes 1.05 Mbits/sec 0.218 ms 0/ 89 (0%)
[ 3] 3.0- 4.0 sec 128 KBytes 1.05 Mbits/sec 0.150 ms 0/ 89 (0%)
[ 3] 4.0- 5.0 sec 129 KBytes 1.06 Mbits/sec 0.245 ms 0/ 90 (0%)
[ 3] 5.0- 6.0 sec 128 KBytes 1.05 Mbits/sec 0.170 ms 0/ 89 (0%)
[ 3] 6.0- 7.0 sec 128 KBytes 1.05 Mbits/sec 0.159 ms 0/ 89 (0%)
[ 3] 7.0- 8.0 sec 128 KBytes 1.05 Mbits/sec 0.178 ms 0/ 89 (0%)
[ 3] 8.0- 9.0 sec 128 KBytes 1.05 Mbits/sec 0.149 ms 0/ 89 (0%)
[ 3] 9.0-10.0 sec 128 KBytes 1.05 Mbits/sec 0.165 ms 0/ 89 (0%)
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.147 ms 0/ 893 (0%)

**Πείραμα 2ο**

Προεργασία

Εγκατάσταση του floodlight controller και των προαπαιτούμενων στοιχείων. Πλέον ο έλεγχος γίνεται από Remote Controller (floodlight).

Δομή

Το πείραμα 2 αποτελείται επίσης από 3 συναρτήσεις: graphic() – δημιουργία γραφήματος, apply_experiment(car,client,switch) – υλοποίηση του πειράματος σε στάδια και topology() – δημιουργία δικτύου και ρύθμιση κόμβων.

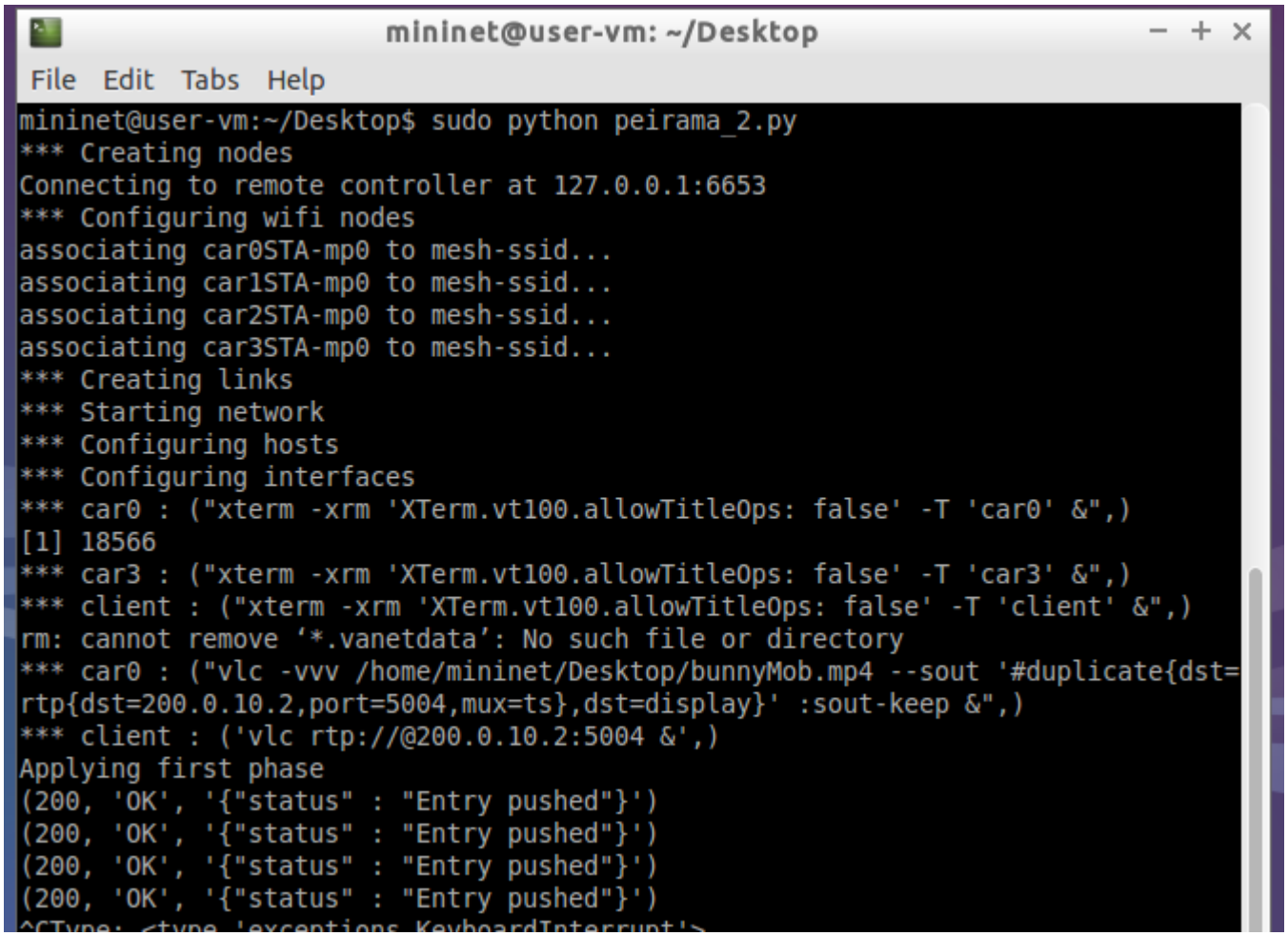
Λειτουργεία

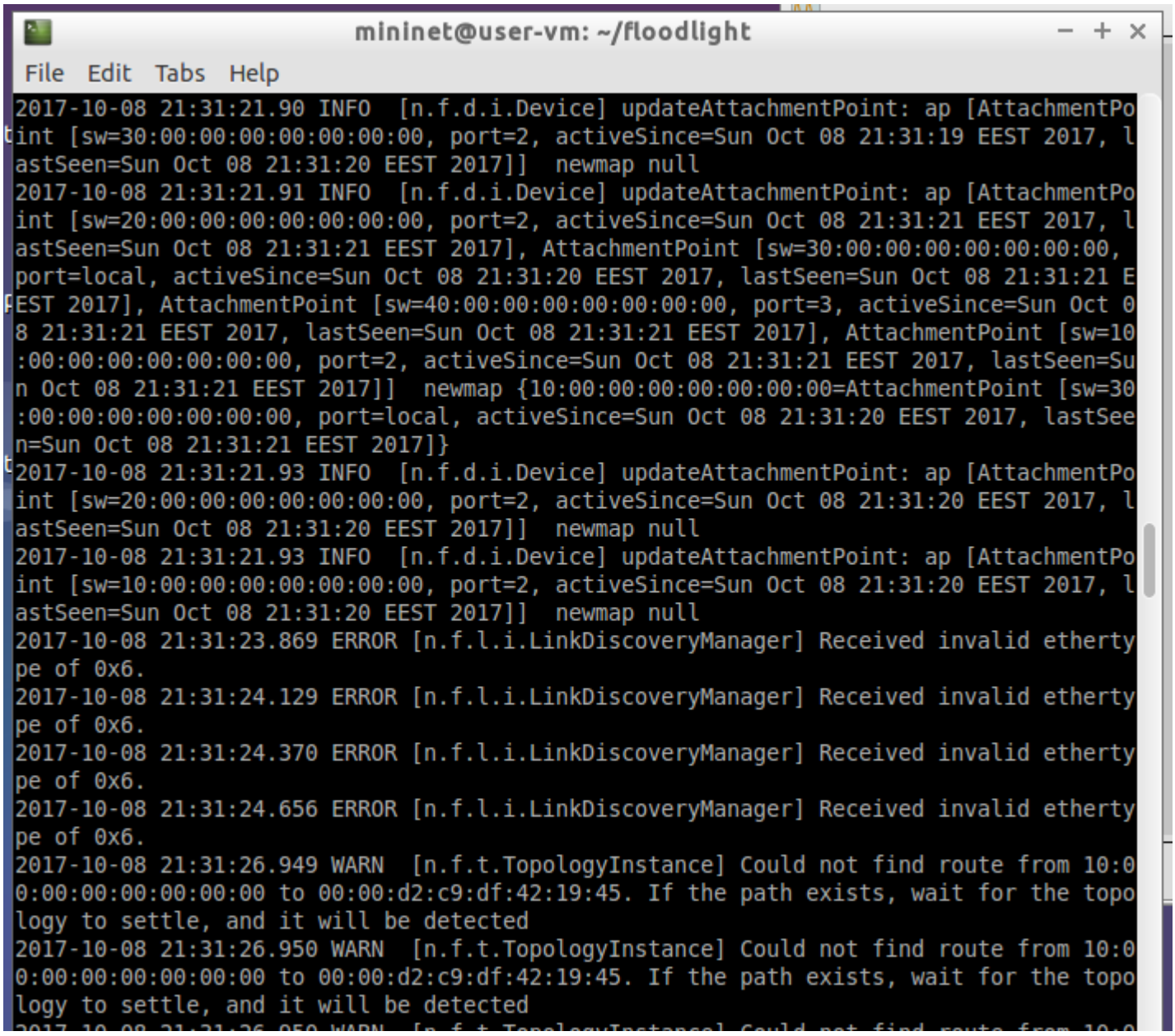
Το car0 αποστέλλει στον client ένα βίντεο ζωντανά. Σε κάθε φάση του πειράματος, μετράται το throughput και τα packets και στο τέλος παράγεται το αντίστοιχο γράφημα. Jitter και Latency μετρούνται κατά τη διάρκεια του πειράματος από τα τερματικά των σχετικών κόμβων με τις εντολές ping και iperf.

Κατά τη διάρκεια των δύο πρώτων φάσεων, το car0 χρησιμοποιεί bicasting για την επικοινωνία με τον client.

Αποτελέσματα

Το 2ο πείραμα δεν αναπαράχιηκε επιτυχώς λόγω αδυναμίας αναγνώρισης των flows από τον floodlight controller. Παρόλα αυτά, εντέλει λειτουργεί και το βίντεο φτάνει στον πελάτη με μεγαλύτερους ρυθμούς από τη 2η φάση και μετά.






Πηγές

- https://github.com/ramonfontes/reproducible-research/tree/master/mininet-wifi/The-Computer-Journal-2017
- https://github.com/ramonfontes/reproducible-research/tree/master/mininet-wifi/IEEE-Access-2017
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