

## ΔΙΑΧΕΙΡΙΣΗ ΔΙΚΤΥΩΝ 2017

ΑΒΡΑΜΙΔΟΥ ΔΗΜΗΤΡΑ 201400001

ΚΑΛΛΙΓΕΡΟΣ ΚΩΝΣΤΑΝΤΙΝΟΣ 201100166

ΛΥΚΟΥΔΗ ΙΩΑΝΝΑ 201400091 \*\*\*

### Πείραμα 1ο

1η φάση: Ξεκινάμε την πρώτη φάση του πειράματος μας προσθέτοντας τα κατάλληλα flows(rules). Έτσι έχουμε τα εξής: Συνδέουμε πρώτα τα port 1 με 4, καθώς και το 4 με 1, τα οποία αναφέρονται στην σύνδεση του car0 με την eNodeB1. Τα port που δεν χρησιμοποιούμε τα κάνουμε “drop”. Συνεχίζουμε, με την υλοποίηση των μετρήσεων. Με την βοήθεια ενός loop παίρνουμε όσες μετρήσεις χρειαζόμαστε για car0 & client, ούτως ώστε να σχεδιάσουμε την γραφική μας παράσταση. Παρακάτω παραθέτουμε τις μετρήσεις των latency & jitter τις οποίες βρίσκουμε από την υλοποίηση του πειράματος μας:

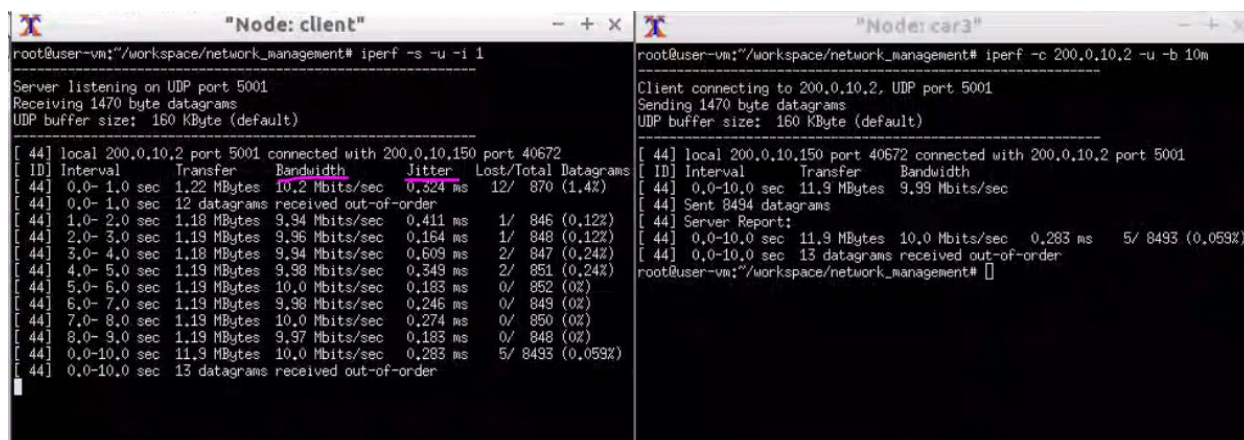
Για το Latency:

```
"Node: car0"
64 bytes from 10.0.0.4: icmp_seq=7 ttl=63 time=7.09 ms
64 bytes from 10.0.0.4: icmp_seq=8 ttl=63 time=7.23 ms
64 bytes from 10.0.0.4: icmp_seq=9 ttl=63 time=8.33 ms
64 bytes from 10.0.0.4: icmp_seq=10 ttl=63 time=7.41 ms
64 bytes from 10.0.0.4: icmp_seq=11 ttl=63 time=7.06 ms
64 bytes from 10.0.0.4: icmp_seq=12 ttl=63 time=7.03 ms
64 bytes from 10.0.0.4: icmp_seq=13 ttl=63 time=7.02 ms
64 bytes from 10.0.0.4: icmp_seq=14 ttl=63 time=12.5 ms
64 bytes from 10.0.0.4: icmp_seq=15 ttl=63 time=7.24 ms
64 bytes from 10.0.0.4: icmp_seq=16 ttl=63 time=7.10 ms
64 bytes from 10.0.0.4: icmp_seq=17 ttl=63 time=6.93 ms
64 bytes from 10.0.0.4: icmp_seq=18 ttl=63 time=7.44 ms
64 bytes from 10.0.0.4: icmp_seq=19 ttl=63 time=8.44 ms
64 bytes from 10.0.0.4: icmp_seq=20 ttl=63 time=7.42 ms
64 bytes from 10.0.0.4: icmp_seq=21 ttl=63 time=7.04 ms
64 bytes from 10.0.0.4: icmp_seq=22 ttl=63 time=7.65 ms
64 bytes from 10.0.0.4: icmp_seq=23 ttl=63 time=11.2 ms
64 bytes from 10.0.0.4: icmp_seq=24 ttl=63 time=7.53 ms
64 bytes from 10.0.0.4: icmp_seq=25 ttl=63 time=11.2 ms
^C
--- 10.0.0.4 ping statistics ---
25 packets transmitted, 25 received, 0% packet loss, time 24037ms
rtt min/avg/max/mdev = 6.937/8.196/12.570/1.755 ms
root@user-vm:~/workspace/network_management#
```

```
"Node: car3"
64 bytes from 200.0.10.2: icmp_seq=13 ttl=64 time=5.23 ms
64 bytes from 200.0.10.2: icmp_seq=14 ttl=64 time=5.51 ms
64 bytes from 200.0.10.2: icmp_seq=15 ttl=64 time=5.17 ms
64 bytes from 200.0.10.2: icmp_seq=16 ttl=64 time=5.17 ms
64 bytes from 200.0.10.2: icmp_seq=17 ttl=64 time=5.50 ms
64 bytes from 200.0.10.2: icmp_seq=18 ttl=64 time=5.04 ms
64 bytes from 200.0.10.2: icmp_seq=19 ttl=64 time=5.04 ms
64 bytes from 200.0.10.2: icmp_seq=20 ttl=64 time=5.12 ms
64 bytes from 200.0.10.2: icmp_seq=21 ttl=64 time=5.33 ms
64 bytes from 200.0.10.2: icmp_seq=22 ttl=64 time=5.20 ms
64 bytes from 200.0.10.2: icmp_seq=23 ttl=64 time=5.13 ms
64 bytes from 200.0.10.2: icmp_seq=24 ttl=64 time=5.17 ms
64 bytes from 200.0.10.2: icmp_seq=25 ttl=64 time=7.72 ms
64 bytes from 200.0.10.2: icmp_seq=26 ttl=64 time=7.13 ms
64 bytes from 200.0.10.2: icmp_seq=27 ttl=64 time=6.07 ms
64 bytes from 200.0.10.2: icmp_seq=28 ttl=64 time=5.06 ms
64 bytes from 200.0.10.2: icmp_seq=29 ttl=64 time=5.74 ms
64 bytes from 200.0.10.2: icmp_seq=30 ttl=64 time=5.18 ms
64 bytes from 200.0.10.2: icmp_seq=31 ttl=64 time=5.54 ms
^C
--- 200.0.10.2 ping statistics ---
31 packets transmitted, 31 received, 0% packet loss, time 30053ms
rtt min/avg/max/mdev = 5.042/5.673/10.153/1.028 ms
root@user-vm:~/workspace/network_management#
```

Συμπεραίνουμε ότι, το συνολικό latency είναι το άθροισμα των: avg από car0 σε car3(10.0.0.4) και του avg από car3 σε client. Latency=13.875 ms

Για το Jitter:



```
root@user-vm:~/workspace/network_management# iperf -s -u -i 1
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 160 KByte (default)

[ 44] local 200.0.10.2 port 5001 connected with 200.0.10.150 port 40672
[ ID] Interval      Transfer    Bandwidth    Jitter    Lost/Total  Datagrams
[ 44] 0.0- 1.0 sec  1.22 MBytes 10.2 Mbits/sec 0.324 ms  12/ 870 (1.4%)
[ 44] 0.0- 1.0 sec  12 datagrams received out-of-order
[ 44] 1.0- 2.0 sec  1.18 MBytes 9.94 Mbits/sec 0.411 ms  1/ 846 (0.12%)
[ 44] 2.0- 3.0 sec  1.19 MBytes 9.96 Mbits/sec 0.164 ms  1/ 848 (0.12%)
[ 44] 3.0- 4.0 sec  1.18 MBytes 9.94 Mbits/sec 0.609 ms  2/ 847 (0.24%)
[ 44] 4.0- 5.0 sec  1.19 MBytes 9.98 Mbits/sec 0.349 ms  2/ 851 (0.24%)
[ 44] 5.0- 6.0 sec  1.19 MBytes 10.0 Mbits/sec 0.183 ms  0/ 852 (0%)
[ 44] 6.0- 7.0 sec  1.19 MBytes 9.98 Mbits/sec 0.246 ms  0/ 849 (0%)
[ 44] 7.0- 8.0 sec  1.19 MBytes 10.0 Mbits/sec 0.274 ms  0/ 850 (0%)
[ 44] 8.0- 9.0 sec  1.19 MBytes 9.97 Mbits/sec 0.183 ms  0/ 848 (0%)
[ 44] 0.0-10.0 sec 11.9 MBytes 10.0 Mbits/sec 0.283 ms  5/ 8493 (0.059%)
[ 44] 0.0-10.0 sec 13 datagrams received out-of-order

root@user-vm:~/workspace/network_management#

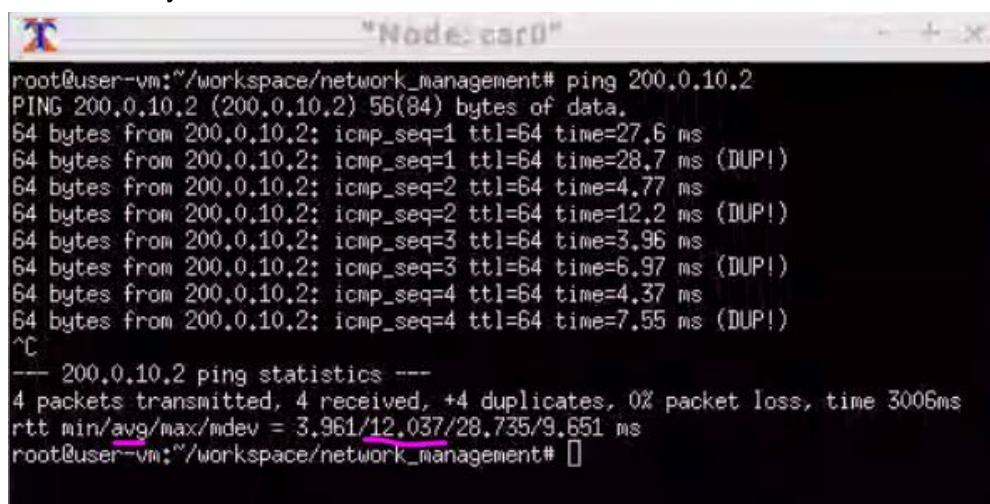
root@user-vm:~/workspace/network_management# iperf -c 200.0.10.2 -u -b 10m
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)

[ 44] local 200.0.10.150 port 40672 connected with 200.0.10.2 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 44] 0.0-10.0 sec 11.9 MBytes 9.99 Mbits/sec
[ 44] Sent 8494 datagrams
[ 44] Server Report:
[ 44] 0.0-10.0 sec 11.9 MBytes 10.0 Mbits/sec 0.283 ms  5/ 8493 (0.059%)
[ 44] 0.0-10.0 sec 13 datagrams received out-of-order
root@user-vm:~/workspace/network_management#
```

Κάναμε μετρήσεις iperf ανάμεσα σε car3 & client. Αν προσπαθήσουμε να κάνουμε ανάμεσα σε car0 & car3 δεν θα πάρουμε μετρήσεις εφόσον δεν υπάρχει switch ανάμεσα τους. Παρατηρούμε τις τιμές που λαμβάνει το bandwidth, jitter και τα χαμένα πακέτα.

2η φάση: Σε αυτήν την φάση συνδέουμε τα ports 2 & 4, 3 & 4 και αντίστροφα τους. Και εδώ ισχύει ότι αναφέρθηκε στην φάση 1 για τα υπόλοιπα port που δεν χρησιμοποιούνται και τις μετρήσεις που γίνονται μέσω του κώδικα μας.

Για το latency:



```
root@user-vm:~/workspace/network_management# ping 200.0.10.2
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=27.6 ms
64 bytes from 200.0.10.2: icmp_seq=1 ttl=64 time=28.7 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=4.77 ms
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=12.2 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=3.96 ms
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=6.97 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=4.37 ms
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=7.55 ms (DUP!)
^C
--- 200.0.10.2 ping statistics ---
4 packets transmitted, 4 received, +4 duplicates, 0% packet loss, time 3006ms
rtt min/avg/max/mdev = 3.961/12.037/28.735/9.651 ms
root@user-vm:~/workspace/network_management#
```

Οπότε έχει την τιμή 12.037 ms.

Για το jitter:

```
"Node: car0"
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)

[ 44] local 200.0.10.100 port 39870 connected with 200.0.10.2 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 44] 0.0-10.0 sec  10.5 MBytes  8.80 Mbits/sec
[ 44] Sent 7482 datagrams
[ 44] WARNING: did not receive ack of last datagram after 10 tries.
root@user-vm:/workspace/network_management# iperf -c 200.0.10.2 -u -b 10m

Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)

[ 44] local 200.0.10.100 port 45712 connected with 200.0.10.2 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 44] 0.0-10.0 sec  24.0 GBytes  20.6 Gbits/sec
[ 44] Sent 8421 datagrams
[ 44] Server Report:
[ 44] 0.0- 7.8 sec  10.4 MBytes  11.2 Mbits/sec  1570.157 ms  974/ 8420 (12%)
[ 44] 0.0- 7.8 sec  849 datagrams received out-of-order

"Node: client"
UDP buffer size: 160 KByte (default)

[ 44] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 45712
[ ID] Interval      Transfer    Bandwidth      Jitter    Lost/Total Datagrams
[ 44] 0.0- 1.0 sec  1.35 MBytes  11.3 Mbits/sec  384.794 ms  1706/ 2868 (64%)
[ 44] 1.0- 2.0 sec  1.34 MBytes  11.2 Mbits/sec  716.964 ms   1/  847 (0.12%)
[ 44] 2.0- 3.0 sec  1.34 MBytes  11.2 Mbits/sec  830.068 ms   2/  848 (0.24%)
[ 44] 3.0- 4.0 sec  1.32 MBytes  11.1 Mbits/sec  928.747 ms   1/  836 (0.12%)
[ 44] 4.0- 5.0 sec  1.33 MBytes  11.1 Mbits/sec  1126.258 ms   1/  839 (0.12%)
[ 44] 5.0- 6.0 sec  1.35 MBytes  11.3 Mbits/sec  1353.343 ms   0/  855 (0%)
[ 44] 6.0- 7.0 sec  1.33 MBytes  11.1 Mbits/sec  1425.403 ms   0/  840 (0%)
[ 44] 7.0- 8.0 sec  10.4 MBytes  11.2 Mbits/sec  1570.158 ms  974/ 8420 (12%)
[ 44] 0.0- 7.8 sec  849 datagrams received out-of-order
read failed: Connection refused
[ 45] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 45712
[ 45] 0.0- 0.0 sec  0.00 (null)s  106937646804113354123408 Bytes/sec  0.000 ms
1342009162/1342009163 (1e+02%)
```

Παρατηρούμε τις τιμές που λαμβάνει το bandwidth, jitter και τα χαμένα πακέτα.

3η φάση: Οι συνδέσεις που γίνονται εδώ είναι οι 2 & 4 και το αμφίδρομο τους. Ισχύουν όσα και στις προηγούμενες φάσεις.

Για το latency:

```
"Node: car0"
64 bytes from 200.0.10.2: icmp_seq=12 ttl=64 time=4.20 ms
64 bytes from 200.0.10.2: icmp_seq=13 ttl=64 time=4.05 ms
64 bytes from 200.0.10.2: icmp_seq=14 ttl=64 time=3.82 ms
64 bytes from 200.0.10.2: icmp_seq=15 ttl=64 time=3.93 ms
64 bytes from 200.0.10.2: icmp_seq=16 ttl=64 time=4.28 ms
64 bytes from 200.0.10.2: icmp_seq=17 ttl=64 time=3.80 ms
64 bytes from 200.0.10.2: icmp_seq=18 ttl=64 time=3.82 ms
64 bytes from 200.0.10.2: icmp_seq=19 ttl=64 time=3.82 ms
64 bytes from 200.0.10.2: icmp_seq=20 ttl=64 time=4.27 ms
64 bytes from 200.0.10.2: icmp_seq=21 ttl=64 time=4.19 ms
64 bytes from 200.0.10.2: icmp_seq=22 ttl=64 time=4.32 ms
64 bytes from 200.0.10.2: icmp_seq=23 ttl=64 time=4.16 ms
64 bytes from 200.0.10.2: icmp_seq=24 ttl=64 time=3.80 ms
64 bytes from 200.0.10.2: icmp_seq=25 ttl=64 time=3.93 ms
64 bytes from 200.0.10.2: icmp_seq=26 ttl=64 time=7.59 ms
64 bytes from 200.0.10.2: icmp_seq=27 ttl=64 time=3.90 ms
64 bytes from 200.0.10.2: icmp_seq=28 ttl=64 time=3.85 ms
64 bytes from 200.0.10.2: icmp_seq=29 ttl=64 time=4.00 ms
64 bytes from 200.0.10.2: icmp_seq=30 ttl=64 time=5.08 ms
^C
--- 200.0.10.2 ping statistics ---
30 packets transmitted, 30 received, 0% packet loss, time 29040ms
rtt min/avg/max/mdev = 3.801/4.926/24.032/3.622 ms
```

Οπότε έχει την τιμή 4.926 ms.



Για το jitter:

```

"Node: client"
root@user-vml:/workspace/network_management# iperf -s -u -i 1
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 160 KByte (default)

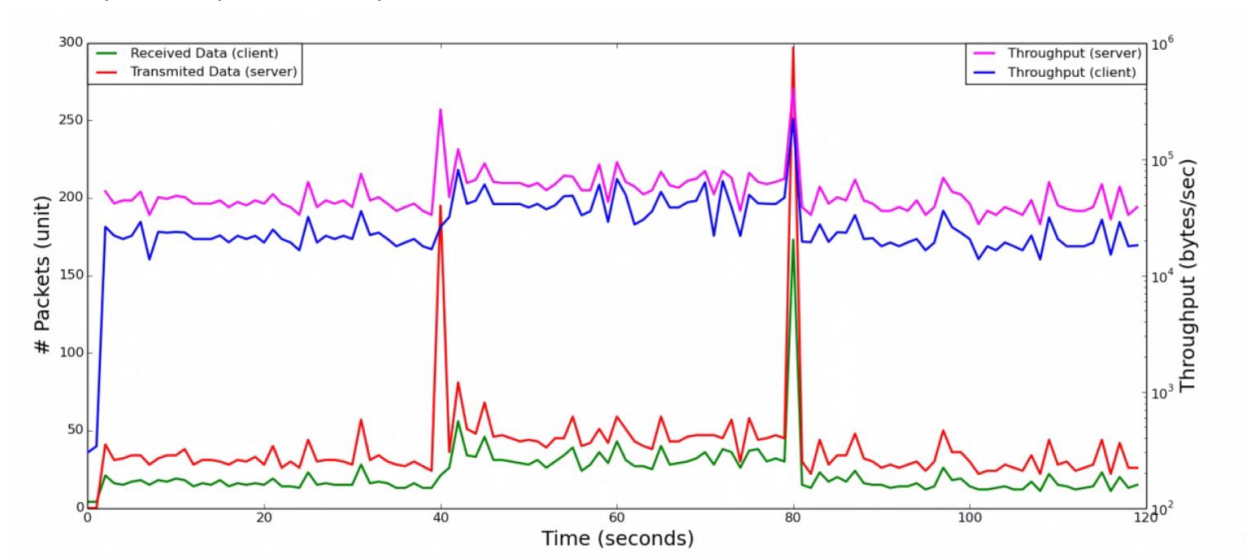
[ 8] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 54374
[ ID] Interval      Transfer      Bandwidth      Jitter    Lost/Totl  Datagrams
[ 0] 0.0- 1.0 sec  1.24 MBytes  10.4 Mbits/sec  0.595 ms  1843/ 2725 (68%)
[ 1] 1.0- 2.0 sec  1.19 MBytes  9.96 Mbits/sec  0.310 ms   1/ 848 (0.12%)
[ 2] 2.0- 3.0 sec  1.18 MBytes  9.94 Mbits/sec  0.477 ms   0/ 845 (0%)
[ 3] 3.0- 4.0 sec  1.18 MBytes  9.93 Mbits/sec  0.430 ms   2/ 846 (0.24%)
[ 4] 4.0- 5.0 sec  1.18 MBytes  9.91 Mbits/sec  0.703 ms   1/ 844 (0.12%)
[ 5] 5.0- 6.0 sec  1.18 MBytes  9.88 Mbits/sec  0.483 ms   1/ 841 (0.12%)
[ 6] 6.0- 7.0 sec  1.15 MBytes  9.85 Mbits/sec  0.343 ms   2/ 823 (0.24%)
[ 7] 7.0- 8.0 sec  9.22 MBytes  9.95 Mbits/sec  0.382 ms 1850/ 8427 (22%)
[ 8] 0.0- 7.8 sec  1 datagrams received out-of-order

"Node: car0"
root@user-vml:/workspace/network_management# iperf -c 200.0.10.2 -u -b 10m
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)

[ 8] local 200.0.10.100 port 54374 connected with 200.0.10.2 port 5001
[ ID] Interval      Transfer      Bandwidth
[ 0] 0.0-10.0 sec  32.0 GBytes  27.5 Gbits/sec
[ 8] Sent 8428 datagrams
[ 8] Server Report:
[ 0] 0.0- 7.8 sec  9.22 MBytes  9.95 Mbits/sec  0.382 ms 1850/ 8427 (22%)
[ 8] 0.0- 7.8 sec  1 datagrams received out-of-order
root@user-vml:/workspace/network_management#
```

Παρατηρούμε τις τιμές που λαμβάνει το bandwidth, jitter και τα χαμένα πακέτα.

Η τελική γραφική παράσταση:



Παρατηρούμε δύο μεγάλες αλλαγές στα δεδομένα που μεταφέρονται. Αυτό συμβαίνει γιατί σε αυτές τις δύο στιγμές γίνεται η εναλλαγή από την πρώτη στην δεύτερη φάση και από την δεύτερη στην τρίτη φάση

## Πείραμα 2ο

1η φάση: Σε αυτό το σημείο το car0 συνδέεται με το eNodeB1 & rsu1, που αποτελεί το πρώτο bicasting

Για το latency στο πρώτο bicasting:

```
"Node: car0"
64 bytes from 200.0.10.2: icmp_seq=20 ttl=64 time=6.34 ms
64 bytes from 200.0.10.2: icmp_seq=20 ttl=64 time=6.98 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=21 ttl=64 time=6.38 ms
64 bytes from 200.0.10.2: icmp_seq=21 ttl=64 time=7.03 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=22 ttl=64 time=7.13 ms
64 bytes from 200.0.10.2: icmp_seq=22 ttl=64 time=10.2 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=23 ttl=64 time=6.54 ms
64 bytes from 200.0.10.2: icmp_seq=23 ttl=64 time=7.02 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=24 ttl=64 time=6.05 ms
64 bytes from 200.0.10.2: icmp_seq=24 ttl=64 time=7.09 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=25 ttl=64 time=6.61 ms
64 bytes from 200.0.10.2: icmp_seq=25 ttl=64 time=7.03 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=26 ttl=64 time=7.35 ms
64 bytes from 200.0.10.2: icmp_seq=26 ttl=64 time=12.0 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=27 ttl=64 time=7.57 ms
64 bytes from 200.0.10.2: icmp_seq=27 ttl=64 time=10.1 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=28 ttl=64 time=6.96 ms
64 bytes from 200.0.10.2: icmp_seq=28 ttl=64 time=7.50 ms (DUP!)
^C
--- 200.0.10.2 ping statistics ---
28 packets transmitted, 28 received, +28 duplicates, 0% packet loss, time 27042ms
rtt min/avg/max/mdev = 5.812/8.179/27.791/4.088 ms
root@user-vm:~/workspace/network_management#
```

Οπότε έχει την τιμή 8.179 ms.

Για το jitter στο πρώτο bicasting:

```
"Node: car0"
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)
-----
[ 43] local 200.0.10.100 port 58846 connected with 200.0.10.2 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 43] 0.0-10.0 sec  16.0 GBytes 13.8 Gbits/sec
[ 43] Sent 8480 datagrams
[ 43] Server Report:
[ 43] 0.0- 8.1 sec  9.95 MBytes 10.3 Mbits/sec 246.161 ms 1381/ 8479 (16%)
[ 43] 0.0- 8.1 sec 234 datagrams received out-of-order
root@user-vm:~/workspace/network_management# iperf -c 200.0.10.2 -u -b 10m

Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)
-----
[ 43] local 200.0.10.100 port 43434 connected with 200.0.10.2 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 43] 0.0-10.0 sec  11.9 MBytes 9.97 Mbits/sec
[ 43] Sent 8477 datagrams
[ 43] Server Report:
[ 43] 0.0-10.0 sec  12.3 MBytes 10.3 Mbits/sec 537.815 ms 7/ 8476 (0.083%)
[ 43] 0.0-10.0 sec 289 datagrams received out-of-order
root@user-vm:~/workspace/network_management#
```

```
"Node: client"
[ 43] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 58846
[ ID] Interval      Transfer    Bandwidth      Jitter    Lost/Total Datagrams
[ 43] 0.0- 1.0 sec  1.24 MBytes 10.4 Mbits/sec 265.264 ms 1581/ 2469 (64%)
[ 43] 0.0- 1.0 sec 29 datagrams received out-of-order
[ 43] 1.0- 2.0 sec  1.24 MBytes 10.4 Mbits/sec 341.082 ms 0/ 852 (0%)
[ 43] 1.0- 2.0 sec 29 datagrams received out-of-order
[ 43] 2.0- 3.0 sec  1.22 MBytes 10.3 Mbits/sec 652.798 ms 1/ 845 (0.12%)
[ 43] 2.0- 3.0 sec 29 datagrams received out-of-order
[ 43] 3.0- 4.0 sec  1.21 MBytes 10.2 Mbits/sec 937.612 ms 0/ 835 (0%)
[ 43] 3.0- 4.0 sec 29 datagrams received out-of-order
[ 43] 4.0- 5.0 sec  1.25 MBytes 10.5 Mbits/sec 491.121 ms 1/ 866 (0.12%)
[ 43] 4.0- 5.0 sec 29 datagrams received out-of-order
[ 43] 5.0- 6.0 sec  1.23 MBytes 10.3 Mbits/sec 144.762 ms 1/ 850 (0.12%)
[ 43] 5.0- 6.0 sec 28 datagrams received out-of-order
[ 43] 6.0- 7.0 sec  1.23 MBytes 10.3 Mbits/sec 266.815 ms 0/ 846 (0%)
[ 43] 6.0- 7.0 sec 29 datagrams received out-of-order
[ 43] 7.0- 8.0 sec  1.23 MBytes 10.3 Mbits/sec 481.909 ms 2/ 847 (0.24%)
[ 43] 7.0- 8.0 sec 29 datagrams received out-of-order
[ 43] 8.0- 9.0 sec  9.95 MBytes 10.3 Mbits/sec 246.161 ms 1381/ 8479 (16%)
[ 43] 8.0- 9.0 sec 234 datagrams received out-of-order
read failed: Connection refused
[ 44] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 58846
[ 44] 0.0- 1.0 sec  40.2 KBytes 329 Kbits/sec 27.553 ms 292/ 320 (91%)
```

Παρατηρούμε τις τιμές που λαμβάνει το bandwidth, jitter και τα χαμένα πακέτα.

Στο δεύτερο bicasting, το car0 συνδέεται με το rsu1 & eNodeB2.

Για το latency στο δεύτερο bicasting:

```
"Node: car0"
64 bytes from 200.0.10.2: icmp_seq=11 ttl=64 time=4.20 ms
64 bytes from 200.0.10.2: icmp_seq=11 ttl=64 time=7.56 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=12 ttl=64 time=4.08 ms
64 bytes from 200.0.10.2: icmp_seq=12 ttl=64 time=5.79 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=13 ttl=64 time=4.25 ms
64 bytes from 200.0.10.2: icmp_seq=13 ttl=64 time=9.60 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=14 ttl=64 time=6.62 ms
64 bytes from 200.0.10.2: icmp_seq=14 ttl=64 time=10.0 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=15 ttl=64 time=4.02 ms
64 bytes from 200.0.10.2: icmp_seq=15 ttl=64 time=7.13 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=16 ttl=64 time=4.11 ms
64 bytes from 200.0.10.2: icmp_seq=16 ttl=64 time=6.58 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=17 ttl=64 time=6.17 ms
64 bytes from 200.0.10.2: icmp_seq=17 ttl=64 time=6.88 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=18 ttl=64 time=4.25 ms
64 bytes from 200.0.10.2: icmp_seq=18 ttl=64 time=10.7 ms (DUP!)
64 bytes from 200.0.10.2: icmp_seq=19 ttl=64 time=6.26 ms
64 bytes from 200.0.10.2: icmp_seq=19 ttl=64 time=11.5 ms (DUP!)
^C
--- 200.0.10.2 ping statistics ---
19 packets transmitted, 19 received, +19 duplicates, 0% packet loss, time 18029m
s:
rtt min/avg/max/mdev = 4.022/7.221/20.221/3.267 ms
root@user-vm:~/workspace/network_management#
```

Οπότε έχει την τιμή 7.221 ms.

Για το jitter στο δεύτερο bicasting:

```
"Node: car0"
root@user-vm:~/workspace/network_management# iperf -c 200.0.10.2 -u -b 10m
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)

[ 43] local 200.0.10.100 port 58202 connected with 200.0.10.2 port 5001
[ 10] Interval      Transfer      Bandwidth
[ 43] 0.0-1.0 sec    12.0 GBytes  10.3 Gbits/sec
[ 43] Sent 8261 datagrams
[ 43] Server Report:
[ 43] 0.0- 8.3 sec  11.0 MBytes  11.2 Mbits/sec 1330.156 ms 425/ 8261 (5.1%)
[ 43] 0.0- 8.3 sec  867 datagrams received out-of-order
root@user-vm:~/workspace/network_management#
```

```
"Node: client"
[ 43] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 58202
[ 10] Interval      Transfer      Bandwidth      Jitter      Lost/Total Datagrams
[ 43] 0.0- 1.0 sec  1.28 MBytes  10.7 Mbits/sec  188.075 ms 1182/ 2095 (56%)
[ 43] 0.0- 1.0 sec  101 datagrams received out-of-order
[ 43] 1.0- 2.0 sec  1.44 MBytes  12.0 Mbits/sec  979.174 ms 1/ 919 (0.11%)
[ 43] 1.0- 2.0 sec  106 datagrams received out-of-order
[ 43] 2.0- 3.0 sec  1.32 MBytes  11.1 Mbits/sec  800.410 ms 1/ 840 (0.12%)
[ 43] 2.0- 3.0 sec  105 datagrams received out-of-order
[ 43] 3.0- 4.0 sec  1.32 MBytes  11.1 Mbits/sec  778.566 ms 0/ 838 (0%)
[ 43] 3.0- 4.0 sec  106 datagrams received out-of-order
[ 43] 4.0- 5.0 sec  1.31 MBytes  11.0 Mbits/sec  1337.926 ms 4/ 836 (0.48%)
[ 43] 4.0- 5.0 sec  105 datagrams received out-of-order
[ 43] 5.0- 6.0 sec  1.33 MBytes  11.2 Mbits/sec  983.306 ms 2/ 847 (0.24%)
[ 43] 5.0- 6.0 sec  105 datagrams received out-of-order
[ 43] 6.0- 7.0 sec  1.28 MBytes  10.7 Mbits/sec  1147.874 ms 0/ 806 (0%)
[ 43] 6.0- 7.0 sec  106 datagrams received out-of-order
[ 43] 7.0- 8.0 sec  1.34 MBytes  11.2 Mbits/sec  1690.460 ms 1/ 851 (0.12%)
[ 43] 7.0- 8.0 sec  105 datagrams received out-of-order
[ 43] 0.0- 8.3 sec  11.0 MBytes  11.2 Mbits/sec  1330.156 ms 425/ 8261 (5.1%)
[ 43] 0.0- 8.3 sec  867 datagrams received out-of-order
read failed: Connection refused
[ 44] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 58202
[ 44] 0.0- 1.0 sec  151 KBytes  1.23 Mbits/sec  3.789 ms 1367/ 1472 (93%)
```

Παρατηρούμε τις τιμές που λαμβάνει το bandwidth, jitter και τα χαμένα πακέτα.



## 2η φάση:

Για το latency:

```
"Node: car0"
64 bytes from 200.0.10.2: icmp_seq=25 ttl=64 time=4.02 ms
64 bytes from 200.0.10.2: icmp_seq=26 ttl=64 time=3.92 ms
64 bytes from 200.0.10.2: icmp_seq=27 ttl=64 time=4.02 ms
64 bytes from 200.0.10.2: icmp_seq=28 ttl=64 time=3.85 ms
64 bytes from 200.0.10.2: icmp_seq=29 ttl=64 time=3.89 ms
64 bytes from 200.0.10.2: icmp_seq=30 ttl=64 time=4.40 ms
64 bytes from 200.0.10.2: icmp_seq=31 ttl=64 time=4.40 ms
64 bytes from 200.0.10.2: icmp_seq=32 ttl=64 time=3.95 ms
64 bytes from 200.0.10.2: icmp_seq=33 ttl=64 time=3.85 ms
64 bytes from 200.0.10.2: icmp_seq=34 ttl=64 time=4.70 ms
64 bytes from 200.0.10.2: icmp_seq=35 ttl=64 time=4.81 ms
64 bytes from 200.0.10.2: icmp_seq=36 ttl=64 time=4.33 ms
64 bytes from 200.0.10.2: icmp_seq=37 ttl=64 time=3.82 ms
64 bytes from 200.0.10.2: icmp_seq=38 ttl=64 time=3.87 ms
64 bytes from 200.0.10.2: icmp_seq=39 ttl=64 time=3.99 ms
64 bytes from 200.0.10.2: icmp_seq=40 ttl=64 time=4.59 ms
64 bytes from 200.0.10.2: icmp_seq=41 ttl=64 time=4.22 ms
64 bytes from 200.0.10.2: icmp_seq=42 ttl=64 time=3.91 ms
64 bytes from 200.0.10.2: icmp_seq=43 ttl=64 time=3.82 ms
^C
--- 200.0.10.2 ping statistics ---
43 packets transmitted, 43 received, 0% packet loss, time 42064ms
rtt min/avg/max/mdev = 3.786/4.185/6.909/0.548 ms
root@user-vm:~/workspace/network_management#
```

Οπότε το latency έχει την τιμή 4.185 ms

Για το jitter στο **bicasting**:

```
"Node: car0"
root@user-vm:~/workspace/network_management# iperf -c 200.0.10.2 -u -b 10m
Client connecting to 200.0.10.2, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 160 KByte (default)

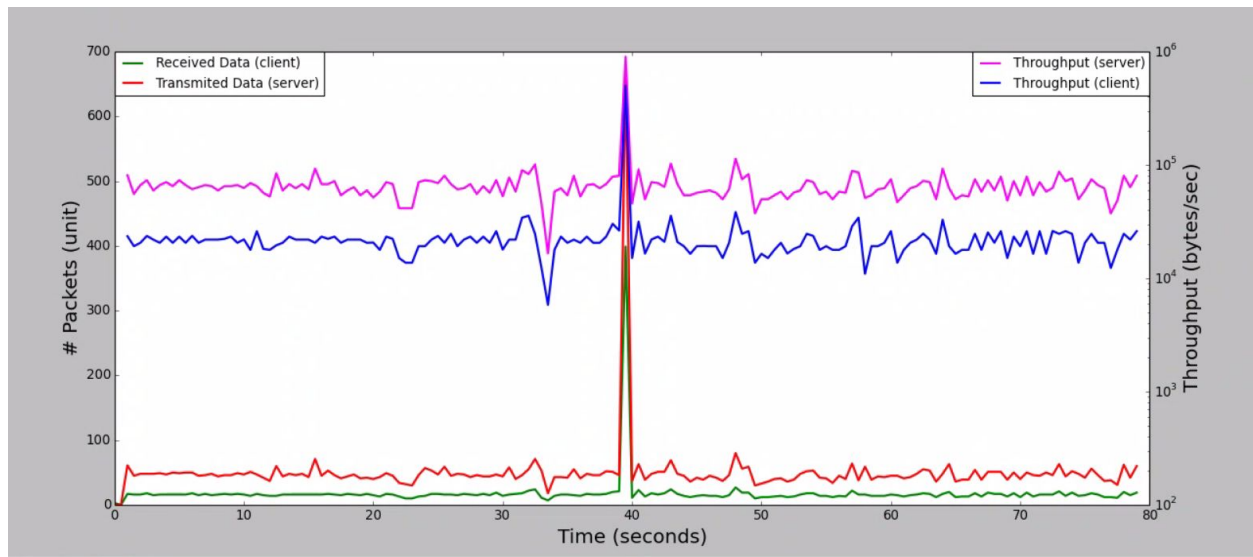
[ 43] local 200.0.10.100 port 32807 connected with 200.0.10.2 port 5001
[ ID] Interval      Transfer      Bandwidth
[ 43] 0.0-10.0 sec  16.0 GBytes  13.7 Gbits/sec
[ 43] Sent 8023 datagrams
[ 43] Server Report:
[ 43] 0.0- 8.1 sec  9.26 MBytes  9.54 Mbits/sec    0.996 ms 1419/ 8022 (18%)
[ 43] 0.0- 8.1 sec  1 datagrams received out-of-order
root@user-vm:~/workspace/network_management#
```

```
"Node: client"
root@user-vm:~/workspace/network_management# iperf -s -u -i 1
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 160 KByte (default)

[ 43] local 200.0.10.2 port 5001 connected with 200.0.10.100 port 32807
[ ID] Interval      Transfer      Bandwidth      Jitter      Lost/Total Datagrams
[ 43] 0.0- 1.0 sec  1.17 MBytes  9.83 Mbits/sec  0.693 ms 1413/ 2249 (63%)
[ 43] 1.0- 2.0 sec  1.15 MBytes  9.64 Mbits/sec  0.764 ms   0/ 820 (0%)
[ 43] 2.0- 3.0 sec  1.16 MBytes  9.71 Mbits/sec  0.866 ms   0/ 826 (0%)
[ 43] 3.0- 4.0 sec  1.11 MBytes  9.30 Mbits/sec  0.480 ms   1/ 792 (0.13%)
[ 43] 4.0- 5.0 sec  1.09 MBytes  9.17 Mbits/sec  1.171 ms   3/ 783 (0.38%)
[ 43] 5.0- 6.0 sec  1.13 MBytes  9.49 Mbits/sec  0.576 ms   2/ 809 (0.25%)
[ 43] 6.0- 7.0 sec  1.13 MBytes  9.47 Mbits/sec  0.415 ms   0/ 805 (0%)
[ 43] 7.0- 8.0 sec  1.16 MBytes  9.70 Mbits/sec  0.865 ms   1/ 826 (0.12%)
[ 43] 0.0- 8.1 sec  9.26 MBytes  9.54 Mbits/sec  0.997 ms 1419/ 8022 (18%)
[ 43] 0.0- 8.1 sec  1 datagrams received out-of-order
```

Παρατηρούμε τις τιμές που λαμβάνει το bandwidth, jitter και τα χαμένα πακέτα.

Και η γραφική μας παράσταση:



Και σε αυτήν την γραφική παράσταση υπάρχει μία αύξηση πακέτων κατά την αλλαγή των δύο φάσεων.

Γενικά, παρατηρούμε το εξής: όταν έχουμε multicasting το jitter αυξάνεται εμφανώς!

\*\*\* Να σημειωθεί το γεγονός ότι στην ομάδα μας ανήκει ακόμα ένα μέλος, το οποίο όμως δεν ασχολήθηκε και με δική του πρωτοβουλία ζήτησε να μην βαθμολογηθεί για αυτήν την εργασία.