

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

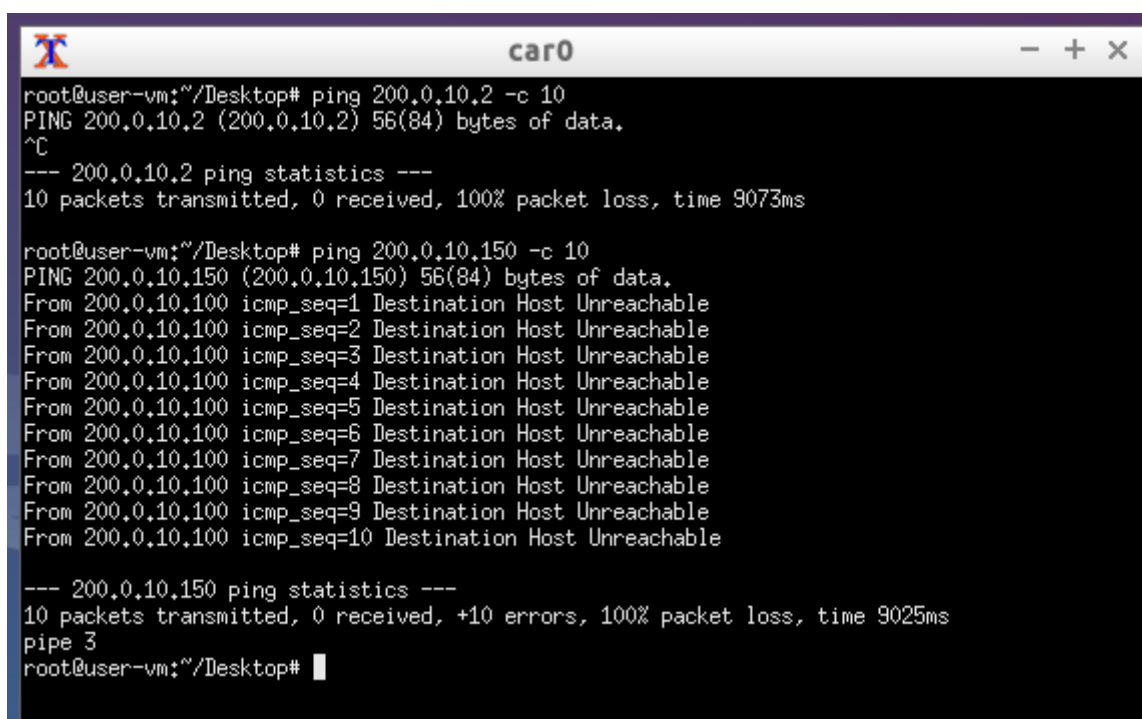
Το πείραμα 1 αποτελείται από 3 συναρτήσεις: `graphic()` - δημιουργία γραφήματος, `apply_experiment(car,client,switch)` - υλοποίηση του πειράματος σε στάδια και `topology()` - δημιουργία δικτύου και ρύθμιση κόμβων.

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`:



```
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.
^C
--- 200.0.10.2 ping statistics ---
10 packets transmitted, 0 received, 100% packet loss, time 9073ms

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.
From 200.0.10.100 icmp_seq=1 Destination Host Unreachable
From 200.0.10.100 icmp_seq=2 Destination Host Unreachable
From 200.0.10.100 icmp_seq=3 Destination Host Unreachable
From 200.0.10.100 icmp_seq=4 Destination Host Unreachable
From 200.0.10.100 icmp_seq=5 Destination Host Unreachable
From 200.0.10.100 icmp_seq=6 Destination Host Unreachable
From 200.0.10.100 icmp_seq=7 Destination Host Unreachable
From 200.0.10.100 icmp_seq=8 Destination Host Unreachable
From 200.0.10.100 icmp_seq=9 Destination Host Unreachable
From 200.0.10.100 icmp_seq=10 Destination Host Unreachable

--- 200.0.10.150 ping statistics ---
10 packets transmitted, 0 received, +10 errors, 100% packet loss, time 9025ms
pipe 3
root@user-vm:~/Desktop#
```

```
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#
```

```
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 200.0.10.150 port 38461
[ ID] Interval      Transfer    Bandwidth   Jitter    Lost/Total Datagrams
[ 3] 0.0- 1.0 sec   129 KBytes  1.06 Mbits/sec  0.282 ms  0/ 90 (0%)
[ 3] 1.0- 2.0 sec   128 KBytes  1.05 Mbits/sec  0.344 ms  0/ 89 (0%)
[ 3] 2.0- 3.0 sec   128 KBytes  1.05 Mbits/sec  0.249 ms  0/ 89 (0%)
[ 3] 3.0- 4.0 sec   128 KBytes  1.05 Mbits/sec  0.312 ms  0/ 89 (0%)
[ 3] 4.0- 5.0 sec   128 KBytes  1.05 Mbits/sec  0.387 ms  0/ 89 (0%)
[ 3] 5.0- 6.0 sec   128 KBytes  1.05 Mbits/sec  0.415 ms  0/ 89 (0%)
[ 3] 6.0- 7.0 sec   129 KBytes  1.06 Mbits/sec  0.280 ms  0/ 90 (0%)
[ 3] 7.0- 8.0 sec   128 KBytes  1.05 Mbits/sec  0.317 ms  0/ 89 (0%)
[ 3] 8.0- 9.0 sec   128 KBytes  1.05 Mbits/sec  0.271 ms  0/ 89 (0%)
[ 3] 9.0-10.0 sec   128 KBytes  1.05 Mbits/sec  0.423 ms  0/ 89 (0%)
[ 3] 0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec  0.418 ms  0/ 893 (0%)
```

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

```
car0
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.
From 200.0.10.100 icmp_seq=1 Destination Host Unreachable
From 200.0.10.100 icmp_seq=2 Destination Host Unreachable
From 200.0.10.100 icmp_seq=3 Destination Host Unreachable
From 200.0.10.100 icmp_seq=4 Destination Host Unreachable
From 200.0.10.100 icmp_seq=5 Destination Host Unreachable
From 200.0.10.100 icmp_seq=6 Destination Host Unreachable
From 200.0.10.100 icmp_seq=7 Destination Host Unreachable
From 200.0.10.100 icmp_seq=8 Destination Host Unreachable
From 200.0.10.100 icmp_seq=9 Destination Host Unreachable
From 200.0.10.100 icmp_seq=10 Destination Host Unreachable

--- 200.0.10.150 ping statistics ---
10 packets transmitted, 0 received, +10 errors, 100% packet loss, time 9000ms
pipe 4
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.
```

* car0 και car3 δεν επικοινωνούν πλέον.



caro

- + x

```
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#
```

```
car3
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.
64 bytes from 200.0.10.100: icmp_seq=1 ttl=62 time=14.6 ms
64 bytes from 200.0.10.100: icmp_seq=2 ttl=62 time=9.18 ms
64 bytes from 200.0.10.100: icmp_seq=3 ttl=62 time=8.20 ms
64 bytes from 200.0.10.100: icmp_seq=4 ttl=62 time=8.78 ms
64 bytes from 200.0.10.100: icmp_seq=5 ttl=62 time=8.10 ms
64 bytes from 200.0.10.100: icmp_seq=6 ttl=62 time=8.61 ms
64 bytes from 200.0.10.100: icmp_seq=7 ttl=62 time=8.72 ms
64 bytes from 200.0.10.100: icmp_seq=8 ttl=62 time=8.08 ms
64 bytes from 200.0.10.100: icmp_seq=9 ttl=62 time=8.47 ms
64 bytes from 200.0.10.100: icmp_seq=10 ttl=62 time=8.45 ms

--- 200.0.10.100 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9012ms
rtt min/avg/max/mdev = 8.088/9.125/14.627/1.862 ms
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.
From 200.0.10.150 icmp_seq=1 Destination Host Unreachable
From 200.0.10.150 icmp_seq=2 Destination Host Unreachable
From 200.0.10.150 icmp_seq=3 Destination Host Unreachable
From 200.0.10.150 icmp_seq=4 Destination Host Unreachable
From 200.0.10.150 icmp_seq=5 Destination Host Unreachable
From 200.0.10.150 icmp_seq=6 Destination Host Unreachable
From 200.0.10.150 icmp_seq=7 Destination Host Unreachable
From 200.0.10.150 icmp_seq=8 Destination Host Unreachable
From 200.0.10.150 icmp_seq=9 Destination Host Unreachable
From 200.0.10.150 icmp_seq=10 Destination Host Unreachable

--- 200.0.10.2 ping statistics ---
10 packets transmitted, 0 received, +10 errors, 100% packet loss, time 8999ms
pipe 3
root@user-vm:~/Desktop#
```

* Το car3 έχει απομακρυνθεί από την αλυσίδα της επικοινωνίας

```
client
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.
From 200.0.10.2 icmp_seq=1 Destination Host Unreachable
From 200.0.10.2 icmp_seq=2 Destination Host Unreachable
From 200.0.10.2 icmp_seq=3 Destination Host Unreachable
From 200.0.10.2 icmp_seq=4 Destination Host Unreachable
From 200.0.10.2 icmp_seq=5 Destination Host Unreachable
From 200.0.10.2 icmp_seq=6 Destination Host Unreachable
From 200.0.10.2 icmp_seq=7 Destination Host Unreachable
From 200.0.10.2 icmp_seq=8 Destination Host Unreachable
From 200.0.10.2 icmp_seq=9 Destination Host Unreachable
From 200.0.10.2 icmp_seq=10 Destination Host Unreachable

--- 200.0.10.150 ping statistics ---
10 packets transmitted, 0 received, +10 errors, 100% packet loss, time 9000ms
pipe 3
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.
```

```
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.
64 bytes from 200.0.10.100: icmp_seq=1 ttl=64 time=7.01 ms
64 bytes from 200.0.10.100: icmp_seq=1 ttl=64 time=7.39 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=1 ttl=64 time=10.3 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=1 ttl=64 time=10.4 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=2 ttl=64 time=4.57 ms
64 bytes from 200.0.10.100: icmp_seq=2 ttl=64 time=4.99 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=2 ttl=64 time=5.23 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=2 ttl=64 time=5.24 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=3 ttl=64 time=4.43 ms
64 bytes from 200.0.10.100: icmp_seq=3 ttl=64 time=4.59 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=3 ttl=64 time=5.45 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=3 ttl=64 time=5.45 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=4 ttl=64 time=5.07 ms
64 bytes from 200.0.10.100: icmp_seq=4 ttl=64 time=5.30 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=4 ttl=64 time=12.1 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=4 ttl=64 time=12.3 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=5 ttl=64 time=4.22 ms
64 bytes from 200.0.10.100: icmp_seq=5 ttl=64 time=4.55 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=5 ttl=64 time=5.11 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=5 ttl=64 time=5.12 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=6 ttl=64 time=4.01 ms
64 bytes from 200.0.10.100: icmp_seq=6 ttl=64 time=4.60 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=6 ttl=64 time=5.02 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=6 ttl=64 time=5.02 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=7 ttl=64 time=4.05 ms
64 bytes from 200.0.10.100: icmp_seq=7 ttl=64 time=4.53 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=7 ttl=64 time=5.06 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=7 ttl=64 time=5.06 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=8 ttl=64 time=5.52 ms
64 bytes from 200.0.10.100: icmp_seq=8 ttl=64 time=5.53 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=8 ttl=64 time=8.52 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=8 ttl=64 time=8.81 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=9 ttl=64 time=5.47 ms
64 bytes from 200.0.10.100: icmp_seq=9 ttl=64 time=5.47 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=9 ttl=64 time=8.35 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=9 ttl=64 time=8.61 ms (DUP!)
64 bytes from 200.0.10.100: icmp_seq=10 ttl=64 time=4.09 ms

--- 200.0.10.100 ping statistics ---
10 packets transmitted, 10 received, +27 duplicates, 0% packet loss, time 9013ms
rtt min/avg/max/mddev = 4.012/6.133/12.376/2.229 ms
root@user-vm:~/Desktop#
```

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# 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=4.72 ms
64 bytes from 200.0.10.2: icmp_seq=2 ttl=64 time=4.14 ms
64 bytes from 200.0.10.2: icmp_seq=3 ttl=64 time=4.06 ms
64 bytes from 200.0.10.2: icmp_seq=4 ttl=64 time=4.03 ms
64 bytes from 200.0.10.2: icmp_seq=5 ttl=64 time=4.01 ms
64 bytes from 200.0.10.2: icmp_seq=6 ttl=64 time=4.06 ms
64 bytes from 200.0.10.2: icmp_seq=7 ttl=64 time=4.09 ms
64 bytes from 200.0.10.2: icmp_seq=8 ttl=64 time=3.81 ms
64 bytes from 200.0.10.2: icmp_seq=9 ttl=64 time=4.00 ms
64 bytes from 200.0.10.2: icmp_seq=10 ttl=64 time=4.02 ms

--- 200.0.10.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9011ms
rtt min/avg/max/mdev = 3.814/4.098/4.723/0.225 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.
64 bytes from 200.0.10.100: icmp_seq=1 ttl=64 time=4.86 ms
64 bytes from 200.0.10.100: icmp_seq=2 ttl=64 time=4.09 ms
64 bytes from 200.0.10.100: icmp_seq=3 ttl=64 time=4.04 ms
64 bytes from 200.0.10.100: icmp_seq=4 ttl=64 time=4.06 ms
64 bytes from 200.0.10.100: icmp_seq=5 ttl=64 time=4.03 ms
64 bytes from 200.0.10.100: icmp_seq=6 ttl=64 time=4.15 ms
64 bytes from 200.0.10.100: icmp_seq=7 ttl=64 time=3.78 ms
64 bytes from 200.0.10.100: icmp_seq=8 ttl=64 time=3.82 ms
64 bytes from 200.0.10.100: icmp_seq=9 ttl=64 time=3.98 ms
64 bytes from 200.0.10.100: icmp_seq=10 ttl=64 time=4.01 ms

--- 200.0.10.100 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 3.787/4.086/4.860/0.284 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 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.

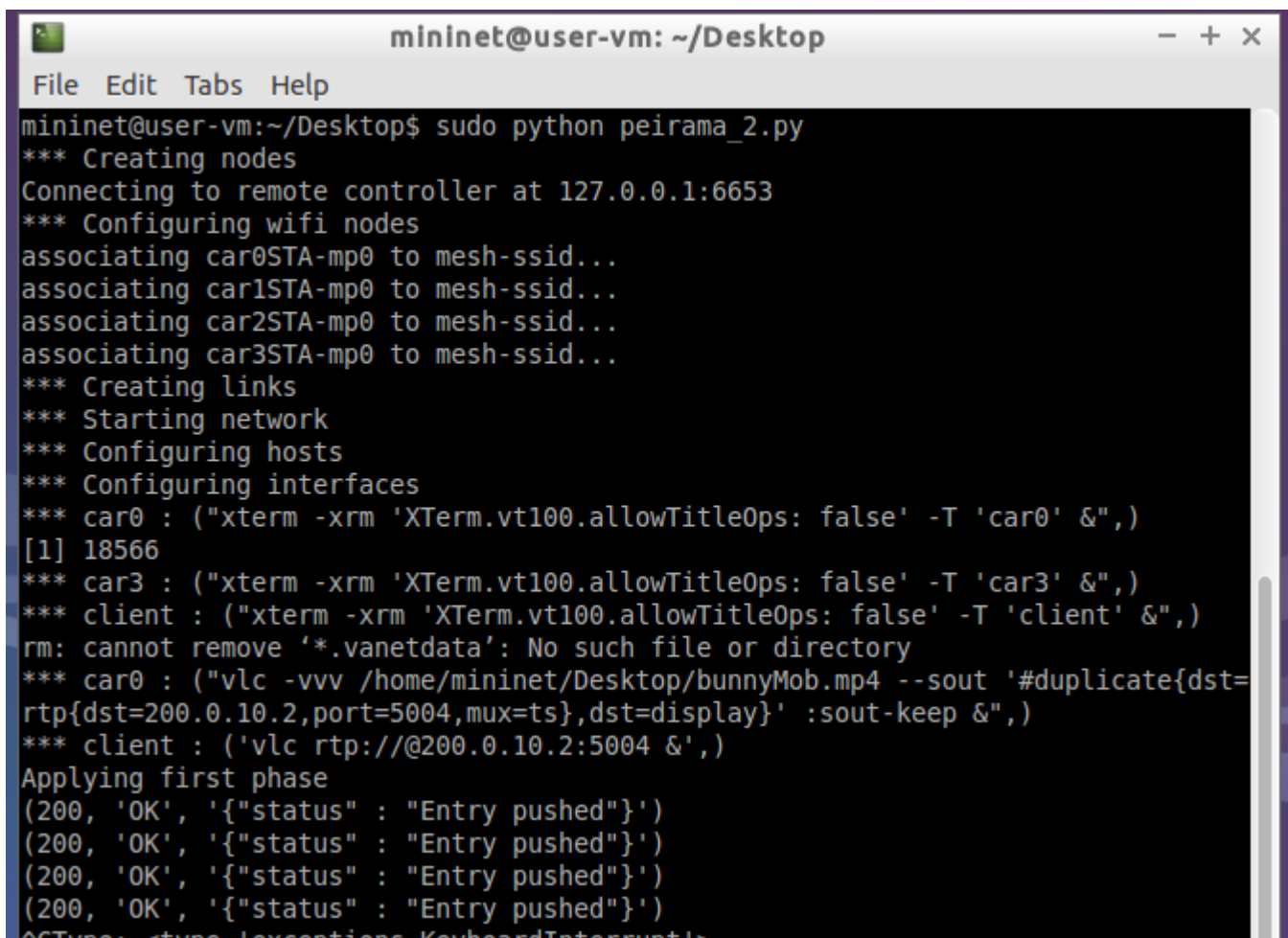
Λειτουργεία

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 αναπαράχθηκε 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.



```
mininet@user-vm: ~/Desktop
File Edit Tabs Help
mininet@user-vm:~/Desktop$ sudo python peirama_2.py
*** Creating nodes
Connecting to remote controller at 127.0.0.1:6653
*** Configuring wifi nodes
associating car0STA-mp0 to mesh-ssid...
associating car1STA-mp0 to mesh-ssid...
associating car2STA-mp0 to mesh-ssid...
associating car3STA-mp0 to mesh-ssid...
*** Creating links
*** Starting network
*** Configuring hosts
*** Configuring interfaces
*** car0 : ("xterm -xrm 'XTerm.vt100.allowTitleOps: false' -T 'car0' &",<
[1] 18566
*** car3 : ("xterm -xrm 'XTerm.vt100.allowTitleOps: false' -T 'car3' &",<
*** client : ("xterm -xrm 'XTerm.vt100.allowTitleOps: false' -T 'client' &",<
rm: cannot remove '*.vanetdata': No such file or directory
*** car0 : ("vlc -vvv /home/mininet/Desktop/bunnyMob.mp4 --sout '#duplicate{dst=
rtp{dst=200.0.10.2,port=5004,mux=ts},dst=display}' :sout-keep &",<
*** client : ('vlc rtp://@200.0.10.2:5004 &",<
Applying first phase
(200, 'OK', '{"status" : "Entry pushed"}')
(200, 'OK', '{"status" : "Entry pushed"}')
(200, 'OK', '{"status" : "Entry pushed"}')
(200, 'OK', '{"status" : "Entry pushed"}')
^CType: <type 'exceptions.KeyboardInterrupt'>
```

```
mininet@user-vm: ~/floodlight
File Edit Tabs Help
2017-10-08 21:31:21.90 INFO [n.f.d.i.Device] updateAttachmentPoint: ap [AttachmentPoint [sw=30:00:00:00:00:00:00:00, port=2, activeSince=Sun Oct 08 21:31:19 EEST 2017, lastSeen=Sun Oct 08 21:31:20 EEST 2017]] newmap null
2017-10-08 21:31:21.91 INFO [n.f.d.i.Device] updateAttachmentPoint: ap [AttachmentPoint [sw=20:00:00:00:00:00:00:00, port=2, activeSince=Sun Oct 08 21:31:21 EEST 2017, lastSeen=Sun Oct 08 21:31:21 EEST 2017], AttachmentPoint [sw=30:00:00:00:00:00:00:00, port=local, activeSince=Sun Oct 08 21:31:20 EEST 2017, lastSeen=Sun Oct 08 21:31:21 EEST 2017], AttachmentPoint [sw=40:00:00:00:00:00:00:00, port=3, activeSince=Sun Oct 08 21:31:21 EEST 2017, lastSeen=Sun Oct 08 21:31:21 EEST 2017], AttachmentPoint [sw=10:00:00:00:00:00:00:00, port=2, activeSince=Sun Oct 08 21:31:21 EEST 2017, lastSeen=Sun Oct 08 21:31:21 EEST 2017]] newmap {10:00:00:00:00:00:00:00=AttachmentPoint [sw=30:00:00:00:00:00:00:00, port=local, activeSince=Sun Oct 08 21:31:20 EEST 2017, lastSeen=Sun Oct 08 21:31:21 EEST 2017]}
2017-10-08 21:31:21.93 INFO [n.f.d.i.Device] updateAttachmentPoint: ap [AttachmentPoint [sw=20:00:00:00:00:00:00:00, port=2, activeSince=Sun Oct 08 21:31:20 EEST 2017, lastSeen=Sun Oct 08 21:31:20 EEST 2017]] newmap null
2017-10-08 21:31:21.93 INFO [n.f.d.i.Device] updateAttachmentPoint: ap [AttachmentPoint [sw=10:00:00:00:00:00:00:00, port=2, activeSince=Sun Oct 08 21:31:20 EEST 2017, lastSeen=Sun Oct 08 21:31:20 EEST 2017]] newmap null
2017-10-08 21:31:23.869 ERROR [n.f.l.i.LinkDiscoveryManager] Received invalid ethernet type of 0x6.
2017-10-08 21:31:24.129 ERROR [n.f.l.i.LinkDiscoveryManager] Received invalid ethernet type of 0x6.
2017-10-08 21:31:24.370 ERROR [n.f.l.i.LinkDiscoveryManager] Received invalid ethernet type of 0x6.
2017-10-08 21:31:24.656 ERROR [n.f.l.i.LinkDiscoveryManager] Received invalid ethernet type of 0x6.
2017-10-08 21:31:26.949 WARN [n.f.t.TopologyInstance] Could not find route from 10:00:00:00:00:00:00:00 to 00:00:d2:c9:df:42:19:45. If the path exists, wait for the topology to settle, and it will be detected
2017-10-08 21:31:26.950 WARN [n.f.t.TopologyInstance] Could not find route from 10:00:00:00:00:00:00:00 to 00:00:d2:c9:df:42:19:45. If the path exists, wait for the topology to settle, and it will be detected
2017-10-08 21:31:26.950 WARN [n.f.t.TopologyInstance] Could not find route from 10:00:00:00:00:00:00:00 to 00:00:d2:c9:df:42:19:45. If the path exists, wait for the topology to settle, and it will be detected
```

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>
- <http://www.brianlinkletter.com/mininet-wifi-software-defined-network-emulator-supports-wifi-networks/>
- <https://floodlight.atlassian.net/wiki/spaces/floodlightcontroller/pages/1343544/Installation+Guide>