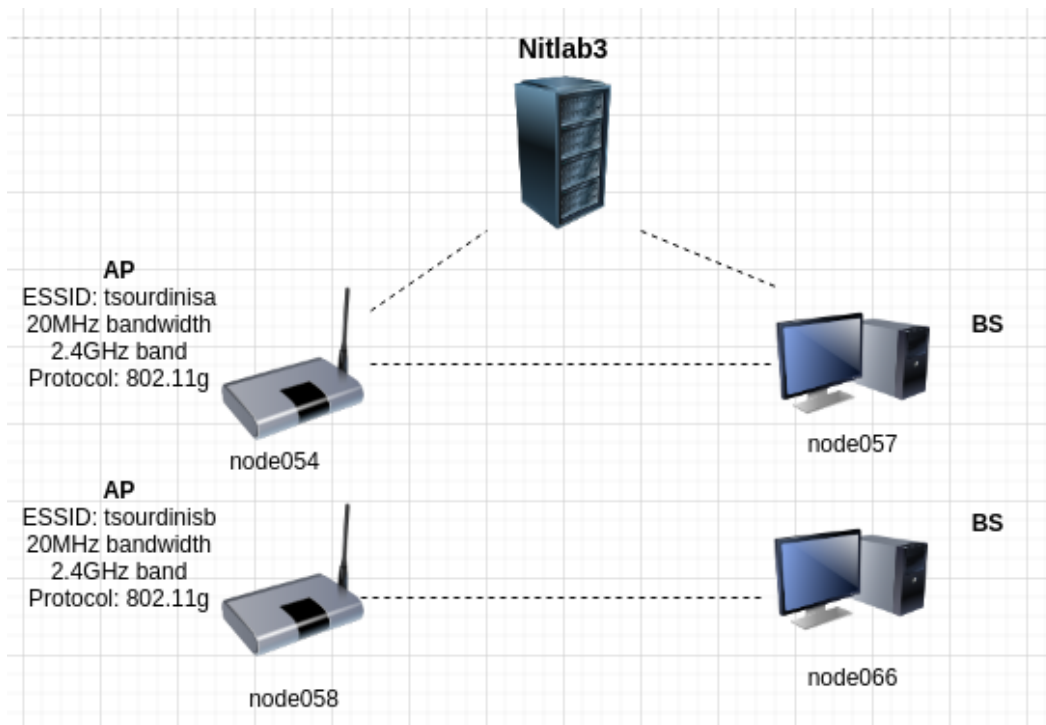


Ασύρματες Επικοινωνίες

2ο Σετ Εργασιών

Θεόδωρος Τσουρδίνης 2303



Concepts

1. First pair : AP on channel 2. Generation of UDP traffic (via iperf) for 150 sec and bandwidth: 75 Mbps

Second pair : AP on channel 2 . Generation of UDP traffic for 125 sec and bandwidth :

$$(70 + (2303/1000) + (2303 \bmod 2)) = 73.303 \text{ Mbps}$$

2. First pair: same as concept 1

Second pair: same as concept 1 but now AP on channel 8

1) Lines Changed in configuration file (hostap.conf):

Access Point at node054:

ssid=tsourdinisa

channel=2

hw_mode=g

driver=nl80211

Access Point at node058:

ssid=tsourdinisb

channel=2 / channel=8

hw_mode=g

driver=nl80211

We can confirm our configurations by : `iw dev wlan0 info`

```
root@node054:~# iw dev wlan0 info
Interface wlan0
    ifindex 4
    wdev 0x1
    addr e4:ce:8f:56:bb:3a
    ssid tsourdinisa
    type AP
    wiphy 0
    channel 2 (2417 MHz), width: 20 MHz (no HT), center1: 2417 MHz
    txpower 15.00 dBm
root@node054:~#
```

```
root@node058:~# iw dev wlan0 info
Interface wlan0
    ifindex 4
    wdev 0x1
    addr 7c:c3:a1:a8:29:20
    ssid tsourdinisb
    type AP
    wiphy 0
    channel 2 (2417 MHz), width: 20 MHz (no HT), center1: 2417 MHz
    txpower 15.00 dBm
root@node058:~#
```

```
root@node058:~# iw dev wlan0 info
Interface wlan0
    ifindex 4
    wdev 0x1
    addr 7c:c3:a1:a8:29:20
    ssid tsourdinisb
    type AP
    wiphy 0
    channel 8 (2447 MHz), width: 20 MHz (no HT), center1: 2447 MHz
    txpower 15.00 dBm
root@node058:~#
```

2) iperf commands for the 2 pairs

1st pair (node054 , node057) :

At base station : `iperf -u -s -i 1`

At AP : `iperf -u -c 192.168.2.2 -t 150 -b 75M`

2nd pair (node058 , node066) :

At base station : `iperf -u -s -i 1`

At AP : `iperf -u -c 192.168.2.4 -t 125 -b 73.3M`

The bandwidth used in iperf at AP on the 2nd pair calculated as:

$$(70 + (2303/1000) + (2303 \bmod 2)) = 73.3$$

3) iperf logs

- All pairs on channel 2

Initial iperf logs (1st case) after starting the second pair as the first pair started running 75 seconds before

```
root@node054: ~ 105x26
root@node054:~# echo 6 > /sys/kernel/debug/ieee802211/phy0/rc/fixed_rate
-bash: /sys/kernel/debug/ieee802211/phy0/rc/fixed_rate: No such file or directory
root@node054:~# iperf -u -c 192.168.2.2 -t 150 -b 75M
.....
Client connecting to 192.168.2.2, UDP port 5001
Sending 1470 byte datagrams, IPG target: 149.54 us (kalman adjust)
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.1 port 46207 connected with 192.168.2.2 port 5001
[
```

```
root@node057: ~ 87x26
[ 3] 57.0-58.0 sec 3.09 MBytes 25.9 Mbits/sec 0.586 ms 0/ 2201 (0%)
[ 3] 58.0-59.0 sec 3.06 MBytes 25.7 Mbits/sec 1.086 ms 0/ 2182 (0%)
[ 3] 59.0-60.0 sec 3.03 MBytes 25.4 Mbits/sec 0.957 ms 0/ 2163 (0%)
[ 3] 60.0-61.0 sec 3.11 MBytes 26.0 Mbits/sec 0.838 ms 0/ 2215 (0%)
[ 3] 61.0-62.0 sec 2.99 MBytes 25.1 Mbits/sec 0.637 ms 0/ 2136 (0%)
[ 3] 62.0-63.0 sec 3.08 MBytes 25.8 Mbits/sec 0.781 ms 0/ 2196 (0%)
[ 3] 63.0-64.0 sec 2.98 MBytes 25.0 Mbits/sec 0.692 ms 0/ 2124 (0%)
[ 3] 64.0-65.0 sec 3.04 MBytes 25.5 Mbits/sec 0.696 ms 0/ 2171 (0%)
[ 3] 65.0-66.0 sec 2.92 MBytes 24.5 Mbits/sec 1.667 ms 0/ 2083 (0%)
[ 3] 66.0-67.0 sec 3.10 MBytes 26.0 Mbits/sec 1.295 ms 2/ 2211 (0.09%)
[ 3] 67.0-68.0 sec 3.03 MBytes 25.4 Mbits/sec 1.732 ms 0/ 2161 (0%)
[ 3] 68.0-69.0 sec 3.11 MBytes 26.1 Mbits/sec 1.425 ms 0/ 2216 (0%)
[ 3] 69.0-70.0 sec 3.11 MBytes 26.0 Mbits/sec 1.247 ms 0/ 2215 (0%)
[ 3] 70.0-71.0 sec 3.04 MBytes 25.5 Mbits/sec 1.143 ms 0/ 2165 (0%)
[ 3] 71.0-72.0 sec 3.08 MBytes 25.9 Mbits/sec 1.704 ms 0/ 2199 (0%)
[ 3] 72.0-73.0 sec 2.98 MBytes 25.0 Mbits/sec 1.255 ms 1/ 2124 (0.047%)
[ 3] 73.0-74.0 sec 3.09 MBytes 25.9 Mbits/sec 1.767 ms 0/ 2201 (0%)
[ 3] 74.0-75.0 sec 3.03 MBytes 25.4 Mbits/sec 0.675 ms 0/ 2160 (0%)
[ 3] 75.0-76.0 sec 3.08 MBytes 25.9 Mbits/sec 0.560 ms 8/ 2208 (0.36%)
[ 3] 76.0-77.0 sec 1.53 MBytes 12.8 Mbits/sec 2.241 ms 13/ 1101 (1.2%)
[ 3] 77.0-78.0 sec 1.50 MBytes 12.6 Mbits/sec 2.054 ms 60/ 1130 (5.3%)
[ 3] 78.0-79.0 sec 1.41 MBytes 11.8 Mbits/sec 1.291 ms 111/ 1115 (10%)
[ 3] 79.0-80.0 sec 1.55 MBytes 13.0 Mbits/sec 1.388 ms 161/ 1264 (13%)
[ 3] 80.0-81.0 sec 1.49 MBytes 12.5 Mbits/sec 1.500 ms 211/ 1273 (17%)
[ 3] 81.0-82.0 sec 1.40 MBytes 11.8 Mbits/sec 2.426 ms 260/ 1262 (21%)
[
```

```
root@node058: ~ 104x26
tsourdinis@nitlab3:~$ ssh root@node058
The authenticity of host 'node058 (10.0.1.58)' can't be established.
ECDSA key fingerprint is e2:96:5f:3a:57:f6:45:cd:28:6b:94:1a:15:71:8c:27.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/tsourdinis/.ssh/known_hosts).
Last login: Fri Apr 3 23:22:44 2020 from 10.0.1.200
root@node058:~# iperf -u -c 192.168.2.4 -t 125 -b 73.3M
.....
Client connecting to 192.168.2.4, UDP port 5001
Sending 1470 byte datagrams, IPG target: 153.00 us (kalman adjust)
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.3 port 40548 connected with 192.168.2.4 port 5001
[
```

```
root@node066: ~ 87x26
root@node066:~# iperf -s -u -i 1
.....
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.4 port 5001 connected with 192.168.2.3 port 40548
[ ID] Interval      Transfer    Bandwidth   Jitter    Lost/Total Datagrams
[ 3] 0.0- 1.0 sec  1.18 MBytes  9.94 Mbits/sec  1.253 ms  27/ 872 (3.1%)
[ 3] 1.0- 2.0 sec  1.79 MBytes  15.0 Mbits/sec  2.414 ms  78/ 1353 (5.8%)
[ 3] 2.0- 3.0 sec  1.56 MBytes  13.1 Mbits/sec  2.161 ms  127/ 1239 (10%)
[ 3] 3.0- 4.0 sec  1.79 MBytes  15.0 Mbits/sec  0.906 ms  177/ 1454 (12%)
[ 3] 4.0- 5.0 sec  1.66 MBytes  14.0 Mbits/sec  1.188 ms  228/ 1415 (16%)
[ 3] 5.0- 6.0 sec  1.84 MBytes  15.5 Mbits/sec  2.373 ms  217/ 1533 (14%)
[
```

Final iperf logs for the first case (both AP , BS)

```
root@node058: ~
root@node054: ~ 105x26
root@node054:~# echo 6 > /sys/kernel/debug/ieee80211/phy0/rc/fixed_rate
-bash: /sys/kernel/debug/ieee80211/phy0/rc/fixed_rate: No such file or directory
root@node054:~# iperf -u -c 192.168.2.2 -t 150 -b 75M
.....
Client connecting to 192.168.2.2, UDP port 5001
Sending 1470 byte datagrams, IPG target: 149.54 us (kalman adjust)
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.1 port 46207 connected with 192.168.2.2 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 3] 0.0-150.0 sec  373 MBytes  20.8 Mbits/sec
[ 3] Sent 265857 datagrams
[ 3] Server Report:
[ 3] 0.0-150.0 sec  338 MBytes  18.9 Mbits/sec  0.000 ms 25103/265857 (0%)
root@node054:~#
```

```
root@node057: ~ 87x26
[ 3] 126.0-127.0 sec 1.32 MBytes 11.1 Mbits/sec 2.960 ms 488/ 1428 (34%)
[ 3] 127.0-128.0 sec 1.44 MBytes 12.1 Mbits/sec 2.470 ms 478/ 1508 (32%)
[ 3] 128.0-129.0 sec 1.46 MBytes 12.3 Mbits/sec 1.385 ms 409/ 1453 (28%)
[ 3] 129.0-130.0 sec 1.36 MBytes 11.4 Mbits/sec 1.795 ms 312/ 1285 (24%)
[ 3] 130.0-131.0 sec 1.45 MBytes 12.2 Mbits/sec 1.588 ms 227/ 1264 (18%)
[ 3] 131.0-132.0 sec 1.41 MBytes 11.8 Mbits/sec 1.574 ms 277/ 1283 (22%)
[ 3] 132.0-133.0 sec 1.47 MBytes 12.3 Mbits/sec 1.442 ms 328/ 1377 (24%)
[ 3] 133.0-134.0 sec 1.44 MBytes 12.1 Mbits/sec 2.152 ms 377/ 1402 (27%)
[ 3] 134.0-135.0 sec 1.44 MBytes 12.1 Mbits/sec 1.781 ms 374/ 1403 (27%)
[ 3] 135.0-136.0 sec 1.47 MBytes 12.3 Mbits/sec 2.803 ms 331/ 1381 (24%)
[ 3] 136.0-137.0 sec 1.35 MBytes 11.3 Mbits/sec 3.603 ms 214/ 1174 (18%)
[ 3] 137.0-138.0 sec 1.41 MBytes 11.9 Mbits/sec 1.475 ms 262/ 1270 (21%)
[ 3] 138.0-139.0 sec 1.33 MBytes 11.1 Mbits/sec 1.742 ms 315/ 1261 (25%)
[ 3] 139.0-140.0 sec 1.44 MBytes 12.1 Mbits/sec 2.322 ms 289/ 1318 (22%)
[ 3] 140.0-141.0 sec 1.37 MBytes 11.5 Mbits/sec 1.763 ms 359/ 1337 (27%)
[ 3] 141.0-142.0 sec 1.43 MBytes 12.0 Mbits/sec 1.475 ms 409/ 1428 (29%)
[ 3] 142.0-143.0 sec 1.39 MBytes 11.7 Mbits/sec 2.514 ms 460/ 1454 (32%)
[ 3] 143.0-144.0 sec 1.47 MBytes 12.3 Mbits/sec 1.420 ms 431/ 1479 (29%)
[ 3] 144.0-145.0 sec 1.48 MBytes 12.4 Mbits/sec 1.408 ms 430/ 1488 (29%)
[ 3] 145.0-146.0 sec 1.43 MBytes 12.0 Mbits/sec 1.568 ms 242/ 1261 (19%)
[ 3] 146.0-147.0 sec 1.41 MBytes 11.9 Mbits/sec 2.438 ms 302/ 1310 (23%)
[ 3] 147.0-148.0 sec 1.41 MBytes 11.8 Mbits/sec 1.248 ms 352/ 1356 (26%)
[ 3] 148.0-149.0 sec 1.48 MBytes 12.4 Mbits/sec 1.387 ms 404/ 1458 (28%)
[ 3] 149.0-150.0 sec 1.41 MBytes 11.8 Mbits/sec 2.385 ms 452/ 1455 (31%)
[ 3] 0.0-150.0 sec 338 MBytes 18.9 Mbits/sec 2.890 ms 25103/265857 (9.4%)
```

```
root@node058: ~ 104x26
tsourdinis@nitlab3:~$ ssh root@node058
The authenticity of host 'node058 (10.0.1.58)' can't be established.
ECDSA key fingerprint is e2:96:5f:3a:57:f6:45:cd:28:6b:94:1a:15:71:8c:27.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/tsourdinis/.ssh/known_hosts).
Last login: Fri Apr 3 23:22:44 2020 from 10.0.1.200
root@node058:~# iperf -u -c 192.168.2.4 -t 125 -b 73.3M
.....
Client connecting to 192.168.2.4, UDP port 5001
Sending 1470 byte datagrams, IPG target: 153.00 us (kalman adjust)
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.3 port 40548 connected with 192.168.2.4 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 3] 0.0-125.0 sec  313 MBytes  21.0 Mbits/sec
[ 3] Sent 223083 datagrams
[ 3] Server Report:
[ 3] 0.0-125.0 sec  290 MBytes  19.5 Mbits/sec  0.000 ms 15999/223083 (0%)
root@node058:~#
```

```
root@node066: ~ 87x26
[ 3] 101.0-102.0 sec 3.22 MBytes 27.0 Mbits/sec 0.920 ms 0/ 2285 (0%)
[ 3] 102.0-103.0 sec 3.21 MBytes 26.9 Mbits/sec 1.585 ms 0/ 2287 (0%)
[ 3] 103.0-104.0 sec 3.24 MBytes 27.2 Mbits/sec 1.365 ms 0/ 2311 (0%)
[ 3] 104.0-105.0 sec 3.12 MBytes 26.2 Mbits/sec 1.253 ms 0/ 2228 (0%)
[ 3] 105.0-106.0 sec 3.25 MBytes 27.3 Mbits/sec 0.587 ms 0/ 2318 (0%)
[ 3] 106.0-107.0 sec 3.17 MBytes 26.6 Mbits/sec 0.528 ms 0/ 2259 (0%)
[ 3] 107.0-108.0 sec 3.18 MBytes 26.6 Mbits/sec 1.987 ms 0/ 2266 (0%)
[ 3] 108.0-109.0 sec 3.30 MBytes 27.7 Mbits/sec 1.195 ms 0/ 2353 (0%)
[ 3] 109.0-110.0 sec 3.06 MBytes 25.7 Mbits/sec 0.709 ms 0/ 2182 (0%)
[ 3] 110.0-111.0 sec 3.22 MBytes 27.0 Mbits/sec 0.684 ms 0/ 2300 (0%)
[ 3] 111.0-112.0 sec 3.17 MBytes 26.6 Mbits/sec 0.626 ms 0/ 2261 (0%)
[ 3] 112.0-113.0 sec 3.25 MBytes 27.3 Mbits/sec 1.591 ms 0/ 2321 (0%)
[ 3] 113.0-114.0 sec 3.20 MBytes 26.8 Mbits/sec 0.700 ms 0/ 2280 (0%)
[ 3] 114.0-115.0 sec 3.22 MBytes 27.0 Mbits/sec 0.918 ms 0/ 2294 (0%)
[ 3] 115.0-116.0 sec 3.15 MBytes 26.4 Mbits/sec 1.255 ms 0/ 2245 (0%)
[ 3] 116.0-117.0 sec 3.18 MBytes 26.7 Mbits/sec 0.867 ms 47/ 2318 (2%)
[ 3] 117.0-118.0 sec 3.26 MBytes 27.3 Mbits/sec 0.563 ms 0/ 2325 (0%)
[ 3] 118.0-119.0 sec 3.17 MBytes 26.6 Mbits/sec 0.510 ms 0/ 2259 (0%)
[ 3] 119.0-120.0 sec 3.25 MBytes 27.2 Mbits/sec 1.247 ms 0/ 2316 (0%)
[ 3] 120.0-121.0 sec 3.10 MBytes 26.0 Mbits/sec 0.934 ms 3/ 2217 (0.14%)
[ 3] 121.0-122.0 sec 3.23 MBytes 27.1 Mbits/sec 1.034 ms 0/ 2302 (0%)
[ 3] 122.0-123.0 sec 3.13 MBytes 26.2 Mbits/sec 1.256 ms 18/ 2250 (0.8%)
[ 3] 123.0-124.0 sec 3.21 MBytes 26.9 Mbits/sec 0.803 ms 36/ 2323 (1.5%)
[ 3] 124.0-125.0 sec 3.13 MBytes 26.2 Mbits/sec 1.350 ms 53/ 2285 (2.3%)
[ 3] 0.0-125.0 sec 290 MBytes 19.5 Mbits/sec 1.677 ms 15999/223083 (7.2%)
```

- 1st pair on channel 2 and 2nd pair on channel 8

Initial iperf logs (2nd case) after starting the second pair as the first pair started running 75 seconds before

```

root@node054: ~ 105x26
root@node054:~# iperf -u -c 192.168.2.2 -t 150 -b 75M
.....
Client connecting to 192.168.2.2, UDP port 5001
Sending 1470 byte datagrams, IPG target: 149.54 us (kalman adjust)
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.1 port 53483 connected with 192.168.2.2 port 5001

```

```

root@node057: ~ 87x26
[ 3] 61.0-62.0 sec 3.18 MBytes 26.7 Mbits/sec 0.852 ms 0/ 2270 (0%)
[ 3] 62.0-63.0 sec 3.13 MBytes 26.2 Mbits/sec 0.627 ms 0/ 2231 (0%)
[ 3] 63.0-64.0 sec 3.12 MBytes 26.2 Mbits/sec 1.155 ms 0/ 2225 (0%)
[ 3] 64.0-65.0 sec 3.17 MBytes 26.6 Mbits/sec 0.978 ms 0/ 2259 (0%)
[ 3] 65.0-66.0 sec 3.10 MBytes 26.0 Mbits/sec 0.902 ms 0/ 2213 (0%)
[ 3] 66.0-67.0 sec 3.15 MBytes 26.5 Mbits/sec 1.338 ms 0/ 2250 (0%)
[ 3] 67.0-68.0 sec 3.06 MBytes 25.7 Mbits/sec 0.692 ms 0/ 2183 (0%)
[ 3] 68.0-69.0 sec 3.18 MBytes 26.7 Mbits/sec 0.545 ms 0/ 2271 (0%)
[ 3] 69.0-70.0 sec 3.08 MBytes 25.8 Mbits/sec 0.806 ms 0/ 2194 (0%)
[ 3] 70.0-71.0 sec 3.19 MBytes 26.8 Mbits/sec 0.570 ms 0/ 2276 (0%)
[ 3] 71.0-72.0 sec 3.13 MBytes 26.3 Mbits/sec 0.985 ms 0/ 2236 (0%)
[ 3] 72.0-73.0 sec 3.11 MBytes 26.1 Mbits/sec 0.715 ms 0/ 2216 (0%)
[ 3] 73.0-74.0 sec 3.14 MBytes 26.4 Mbits/sec 1.055 ms 0/ 2242 (0%)
[ 3] 74.0-75.0 sec 3.07 MBytes 25.7 Mbits/sec 0.650 ms 0/ 2188 (0%)
[ 3] 75.0-76.0 sec 3.19 MBytes 26.7 Mbits/sec 1.207 ms 0/ 2273 (0%)
[ 3] 76.0-77.0 sec 1.84 MBytes 15.4 Mbits/sec 9.903 ms 6/ 1319 (0.45%)
[ 3] 77.0-78.0 sec 1019 KBytes 8.35 Mbits/sec 5.311 ms 49/ 759 (6.5%)
[ 3] 78.0-79.0 sec 924 KBytes 7.57 Mbits/sec 3.000 ms 107/ 751 (14%)
[ 3] 79.0-80.0 sec 1.20 MBytes 10.1 Mbits/sec 2.023 ms 149/ 1007 (15%)
[ 3] 80.0-81.0 sec 1.24 MBytes 10.4 Mbits/sec 1.451 ms 172/ 1060 (16%)
[ 3] 81.0-82.0 sec 972 KBytes 7.96 Mbits/sec 1.559 ms 243/ 920 (26%)
[ 3] 82.0-83.0 sec 1.23 MBytes 10.3 Mbits/sec 1.634 ms 293/ 1167 (25%)
[ 3] 83.0-84.0 sec 1.17 MBytes 9.83 Mbits/sec 2.818 ms 340/ 1176 (29%)
[ 3] 84.0-85.0 sec 999 KBytes 8.18 Mbits/sec 4.051 ms 251/ 947 (27%)
[ 3] 85.0-86.0 sec 983 KBytes 8.06 Mbits/sec 3.035 ms 137/ 822 (17%)

```

```

root@node058: ~ 105x26
root@node058:~# iperf -u -c 192.168.2.4 -t 125 -b 73.3M
.....
Client connecting to 192.168.2.4, UDP port 5001
Sending 1470 byte datagrams, IPG target: 153.00 us (kalman adjust)
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.3 port 59766 connected with 192.168.2.4 port 5001

```

```

root@node066: ~ 87x26
root@node066:~# iperf -s -u -i 1
.....
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 208 KByte (default)
.....
[ 3] local 192.168.2.4 port 5001 connected with 192.168.2.3 port 59766
[ ID] Interval      Transfer      Bandwidth      Jitter  Lost/Total Datagrams
[ 3] 0.0- 1.0 sec  1.29 MBytes  10.8 Mbits/sec  0.921 ms  11/ 928 (1.2%)
[ 3] 0.00-1.00 sec  15 datagrams received out-of-order
[ 3] 1.0- 2.0 sec  2.80 MBytes  23.5 Mbits/sec  1.221 ms  0/ 1995 (0%)
[ 3] 2.0- 3.0 sec  2.42 MBytes  20.3 Mbits/sec  2.160 ms  5/ 1732 (0.29%)
[ 3] 3.0- 4.0 sec  2.39 MBytes  20.0 Mbits/sec  1.098 ms  3/ 1707 (0.18%)
[ 3] 4.0- 5.0 sec  2.42 MBytes  20.3 Mbits/sec  1.788 ms  4/ 1733 (0.23%)
[ 3] 5.0- 6.0 sec  2.36 MBytes  19.8 Mbits/sec  1.430 ms  7/ 1692 (0.41%)
[ 3] 6.0- 7.0 sec  2.44 MBytes  20.5 Mbits/sec  1.095 ms  5/ 1749 (0.29%)
[ 3] 7.0- 8.0 sec  2.30 MBytes  19.3 Mbits/sec  1.066 ms  9/ 1649 (0.55%)
[ 3] 8.0- 9.0 sec  2.70 MBytes  22.6 Mbits/sec  1.109 ms  4/ 1927 (0.21%)

```

Final iperf logs for the second case (both AP ,BS)

<pre>root@node054: ~ 105x26 root@node054:~# iperf -u -c 192.168.2.2 -t 150 -b 75M ----- Client connecting to 192.168.2.2, UDP port 5001 Sending 1470 byte datagrams, IPG target: 149.54 us (kalman adjust) UDP buffer size: 208 KByte (default) ----- [3] local 192.168.2.1 port 53483 connected with 192.168.2.2 port 5001 [ID] Interval Transfer Bandwidth [3] 0.0-150.0 sec 339 MBytes 19.0 Mbits/sec [3] Sent 242022 datagrams [3] Server Report: [3] 0.0-150.1 sec 313 MBytes 17.5 Mbits/sec 0.000 ms 18509/242022 (0%) root@node054:~#</pre>	<pre>root@node057: ~ 87x26 [3] 126.0-127.0 sec 952 KBytes 7.80 Mbits/sec 2.142 ms 281/ 944 (30%) [3] 127.0-128.0 sec 956 KBytes 7.83 Mbits/sec 2.142 ms 334/ 1000 (33%) [3] 128.0-129.0 sec 1.09 MBytes 9.16 Mbits/sec 3.737 ms 384/ 1163 (33%) [3] 129.0-130.0 sec 959 KBytes 7.86 Mbits/sec 1.847 ms 431/ 1099 (39%) [3] 130.0-131.0 sec 1.13 MBytes 9.44 Mbits/sec 2.033 ms 422/ 1225 (34%) [3] 131.0-132.0 sec 1.08 MBytes 9.04 Mbits/sec 2.640 ms 325/ 1094 (30%) [3] 132.0-133.0 sec 1.11 MBytes 9.30 Mbits/sec 3.588 ms 127/ 918 (14%) [3] 133.0-134.0 sec 1.01 MBytes 8.51 Mbits/sec 1.891 ms 189/ 913 (21%) [3] 134.0-135.0 sec 1.04 MBytes 8.73 Mbits/sec 2.048 ms 228/ 970 (24%) [3] 135.0-136.0 sec 835 KBytes 6.84 Mbits/sec 1.117 ms 244/ 826 (30%) [3] 136.0-137.0 sec 1.25 MBytes 10.5 Mbits/sec 2.761 ms 300/ 1193 (25%) [3] 137.0-138.0 sec 1.02 MBytes 8.56 Mbits/sec 13.774 ms 329/ 1057 (31%) [3] 138.0-139.0 sec 1.25 MBytes 10.5 Mbits/sec 1.435 ms 424/ 1319 (32%) [3] 139.0-140.0 sec 940 KBytes 7.70 Mbits/sec 3.168 ms 196/ 851 (23%) [3] 140.0-141.0 sec 1.19 MBytes 10.0 Mbits/sec 1.966 ms 63/ 913 (6.9%) [3] 141.0-142.0 sec 1.29 MBytes 10.8 Mbits/sec 4.667 ms 111/ 1033 (11%) [3] 142.0-143.0 sec 979 KBytes 8.02 Mbits/sec 2.742 ms 162/ 844 (19%) [3] 143.0-144.0 sec 1.23 MBytes 10.3 Mbits/sec 1.895 ms 175/ 1052 (17%) [3] 144.0-145.0 sec 1.11 MBytes 9.35 Mbits/sec 3.314 ms 240/ 1035 (23%) [3] 145.0-146.0 sec 1.22 MBytes 10.2 Mbits/sec 1.451 ms 255/ 1125 (23%) [3] 146.0-147.0 sec 1.07 MBytes 8.94 Mbits/sec 2.690 ms 192/ 952 (20%) [3] 147.0-148.0 sec 1011 KBytes 8.28 Mbits/sec 8.663 ms 161/ 865 (19%) [3] 148.0-149.0 sec 1.14 MBytes 9.53 Mbits/sec 1.167 ms 194/ 1004 (19%) [3] 149.0-150.0 sec 1.39 MBytes 11.7 Mbits/sec 2.214 ms 175/ 1168 (15%) [3] 0.0-150.1 sec 313 MBytes 17.5 Mbits/sec 4.116 ms 18509/242022 (7.6%)</pre>
<pre>root@node058: ~ 105x26 root@node058:~# iperf -u -c 192.168.2.4 -t 125 -b 73.3M ----- Client connecting to 192.168.2.4, UDP port 5001 Sending 1470 byte datagrams, IPG target: 153.00 us (kalman adjust) UDP buffer size: 208 KByte (default) ----- [3] local 192.168.2.3 port 59766 connected with 192.168.2.4 port 5001 [ID] Interval Transfer Bandwidth [3] 0.0-125.0 sec 352 MBytes 23.6 Mbits/sec [3] Sent 251063 datagrams [3] Server Report: [3] 0.0-125.0 sec 351 MBytes 23.5 Mbits/sec 0.000 ms 728/251063 (0%) [3] 0.0-125.02 sec 15 datagrams received out-of-order root@node058:~#</pre>	<pre>root@node066: ~ 87x26 [3] 102.0-103.0 sec 3.23 MBytes 27.1 Mbits/sec 0.644 ms 0/ 2307 (0%) [3] 103.0-104.0 sec 3.26 MBytes 27.3 Mbits/sec 0.981 ms 0/ 2322 (0%) [3] 104.0-105.0 sec 3.23 MBytes 27.1 Mbits/sec 0.935 ms 0/ 2304 (0%) [3] 105.0-106.0 sec 3.16 MBytes 26.5 Mbits/sec 0.549 ms 73/ 2327 (3.1%) [3] 106.0-107.0 sec 3.20 MBytes 26.9 Mbits/sec 0.835 ms 0/ 2284 (0%) [3] 107.0-108.0 sec 3.32 MBytes 27.8 Mbits/sec 0.594 ms 0/ 2368 (0%) [3] 108.0-109.0 sec 3.24 MBytes 27.1 Mbits/sec 1.204 ms 0/ 2308 (0%) [3] 109.0-110.0 sec 3.24 MBytes 27.1 Mbits/sec 1.598 ms 0/ 2308 (0%) [3] 110.0-111.0 sec 3.11 MBytes 26.1 Mbits/sec 1.136 ms 0/ 2216 (0%) [3] 111.0-112.0 sec 3.24 MBytes 27.2 Mbits/sec 0.804 ms 0/ 2309 (0%) [3] 112.0-113.0 sec 3.27 MBytes 27.4 Mbits/sec 0.538 ms 0/ 2330 (0%) [3] 113.0-114.0 sec 3.19 MBytes 26.8 Mbits/sec 0.906 ms 0/ 2275 (0%) [3] 114.0-115.0 sec 3.25 MBytes 27.3 Mbits/sec 0.612 ms 0/ 2319 (0%) [3] 115.0-116.0 sec 3.22 MBytes 27.0 Mbits/sec 0.751 ms 0/ 2296 (0%) [3] 116.0-117.0 sec 3.26 MBytes 27.3 Mbits/sec 0.783 ms 0/ 2325 (0%) [3] 117.0-118.0 sec 3.19 MBytes 26.8 Mbits/sec 1.192 ms 0/ 2275 (0%) [3] 118.0-119.0 sec 3.32 MBytes 27.8 Mbits/sec 0.607 ms 0/ 2366 (0%) [3] 119.0-120.0 sec 3.16 MBytes 26.5 Mbits/sec 0.645 ms 58/ 2315 (2.5%) [3] 120.0-121.0 sec 3.22 MBytes 27.0 Mbits/sec 0.576 ms 0/ 2294 (0%) [3] 121.0-122.0 sec 3.21 MBytes 26.9 Mbits/sec 0.728 ms 0/ 2290 (0%) [3] 122.0-123.0 sec 3.18 MBytes 26.7 Mbits/sec 0.615 ms 0/ 2270 (0%) [3] 123.0-124.0 sec 3.16 MBytes 26.5 Mbits/sec 0.651 ms 0/ 2256 (0%) [3] 124.0-125.0 sec 3.17 MBytes 26.6 Mbits/sec 0.523 ms 0/ 2263 (0%) [3] 0.0-125.0 sec 351 MBytes 23.5 Mbits/sec 1.610 ms 728/251063 (0.29%) [3] 0.0-125.02 sec 15 datagrams received out-of-order</pre>

3) Observations

- The bandwidth that the pairs had when they were running separately was nearly 25-27 Mbits/sec and the packet loss was nearly 0%. This is normal as the pairs don't share any channel as they were running separately thus they don't have any interference. Pairs don't have the bandwidth of the iperf command has , because of the capabilities of the wireless chipset and the complexity of the wireless communications as the contentions and the noise of the medium can be the bottleneck in some cases.
- In the first concept when all the pairs were on channel 2, in the first pair , the bandwidth we had was approximately 12 Mbits/sec while on the second pair the bandwidth was approximately 14 Mbits/sec and by seeing the final logs of iperf the packet loss was 9.4% for the 1st pair and 7.2% for the 2nd pair. This behavior can be explained as both pairs share the same channel so there is an interference between them and CSMA/CA works as we expect, as the nodes sense the channel before they transmit so a lot of packets can be lost through a collision.
- In the second concept when the first pair was on channel 2 and the other pair on channel 8, we can see that the 2nd pair dropped his packet loss dramatically in relation with the first case (7.2% → 0.29%). Also the 2nd pair had approximately 20 Mbits/sec. This is because the pairs were running on a different channels in different frequencies that were not overlapping (channel 2: 2406 -2428 GHz and channel 8: 2436 -2458 GHz) and based on CSMA/CA the nodes listen only themselves through carrier sensing. We should expect the same results for the first pair but the packet loss dropped slightly in relation with the first case. (9.4% → 7.6%) but this can be caused by some interference that might node54 has with other nodes on different channels and CSMA/CA fails to detect it .