Wireless Communications 3rd Assignment

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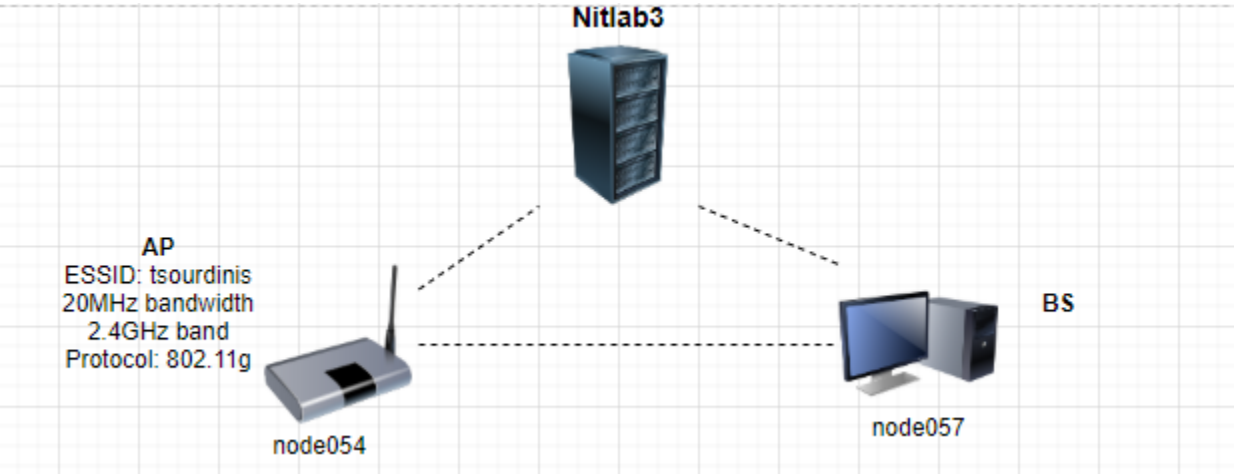


Configuration File

```
interface=wlan0
logger_syslog=-1
logger_syslog_level=2
logger_stdout=-1
logger_stdout_level=2
ctrl_interface=/var/run/hostapd
ctrl_interface_group=0
ssid=tsourdinis
hw_mode=g
channel=1
beacon_int=100
dtim_period=2
max_num_sta=255
rts_threshold=-1
fragm_threshold=-1
```

macaddr_acl=0

auth_algs=3

ignore_broadcast_ssid=0

wmm_enabled=1

wmm_ac_bk_cwmin=4

wmm_ac_bk_cwmax=10

wmm_ac_bk_aifs=7

wmm_ac_bk_txop_limit=0

wmm_ac_bk_acm=0

wmm_ac_be_aifs=3

wmm_ac_be_cwmin=4

wmm_ac_be_cwmax=10

wmm_ac_be_txop_limit=0

wmm_ac_be_acm=0

wmm_ac_vi_aifs=2

wmm_ac_vi_cwmin=3

wmm_ac_vi_cwmax=4

wmm_ac_vi_txop_limit=94

wmm_ac_vi_acm=0

wmm_ac_vo_aifs=2

wmm_ac_vo_cwmin=2

wmm_ac_vo_cwmax=3

wmm_ac_vo_txop_limit=47

wmm_ac_vo_acm=0

eapol_key_index_workaround

own_ip_addr=127.0.0.1

Throughput

Changing the beacon interval configuration

Executing iperf on AP (client logs):

```
root@node054:~# iperf -u -c 192.168.2.2 -t 500 -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)
------------------------------------------------------------
 local 192.168.2.1 port 39587 connected with 192.168.2.2 port 5001
 Interval       Transfer     Bandwidth
  0.0-500.0 sec  1.27 GBytes  21.7 Mbits/sec
 Sent 924374 datagrams
 Server Report:
  0.0-500.0 sec  1.15 GBytes  19.7 Mbits/sec   0.000 ms 84739/924374 (0%)
  0.00-500.04 sec  10 datagrams received out-of-order
```

On STA (Server Side of iperf):

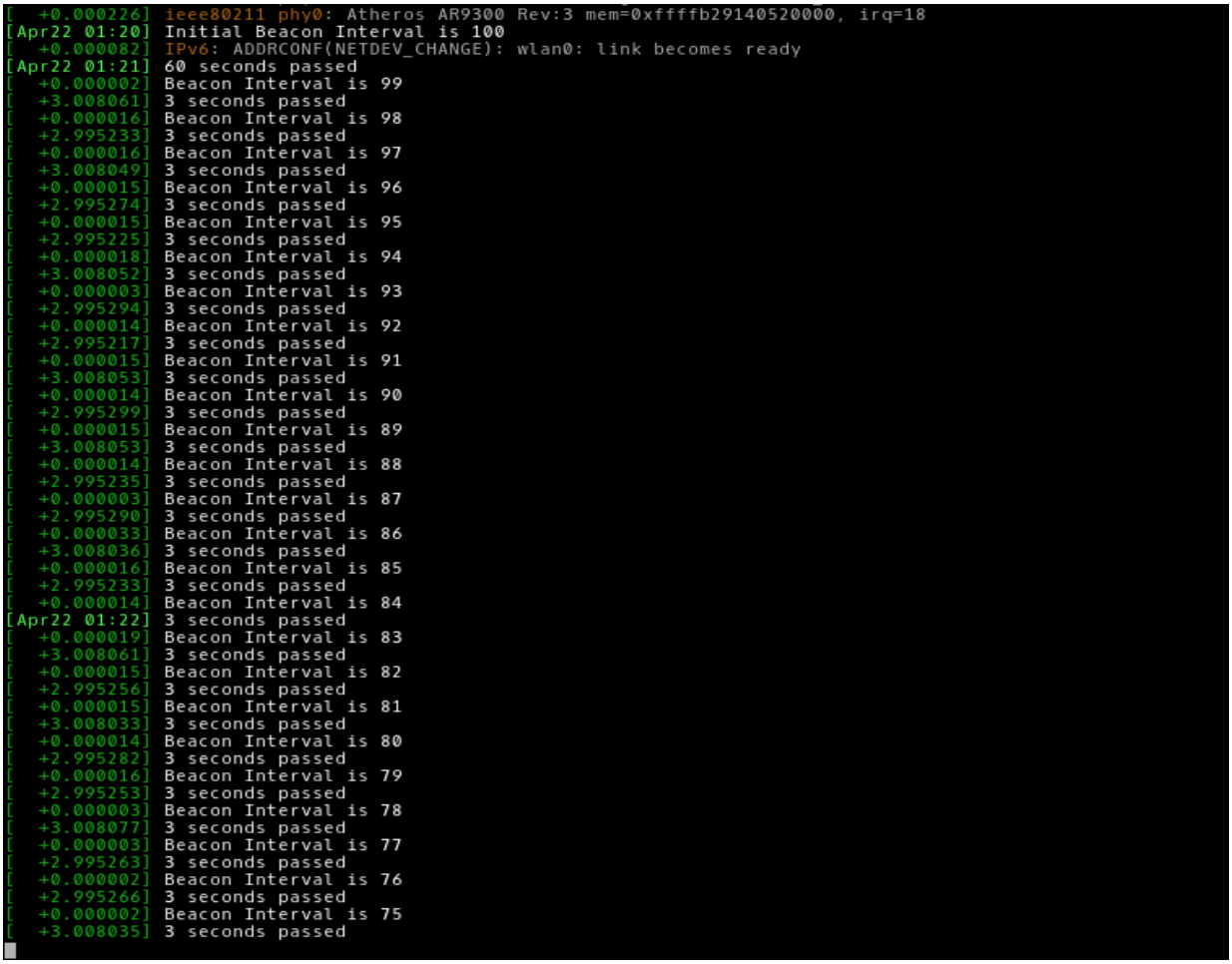
```
root@node057:~# iperf -s -u -i 1 | tee res.txt
```

By checking the res.txt file **it's important to note that in 40 seconds of the logs, 60 seconds of the initialization of the driver passed . So before 40 seconds we see that the max bandwidth is 27.9 Mbits/sec.** But after 40 seconds of iperf logging (60 seconds after initialization of our driver) is when we decrease the beacon interval every 3 seconds by 1ms. We can notice that the bandwidth slightly decreases too, as the time passes and at 325 seconds has 13.4 Mbits/sec. It's also important to know that **after 326 seconds of iperf logging we send our beacon frames with 1msec till 500sec constantly. We can notice that after 337 seconds, the bandwidth has it's lowest value (9.88 Mbits/sec)** and keep having low values (9.88 - 10.6 Mbits/sec) till the end.

Difference Between theoretical and practical bandwidth

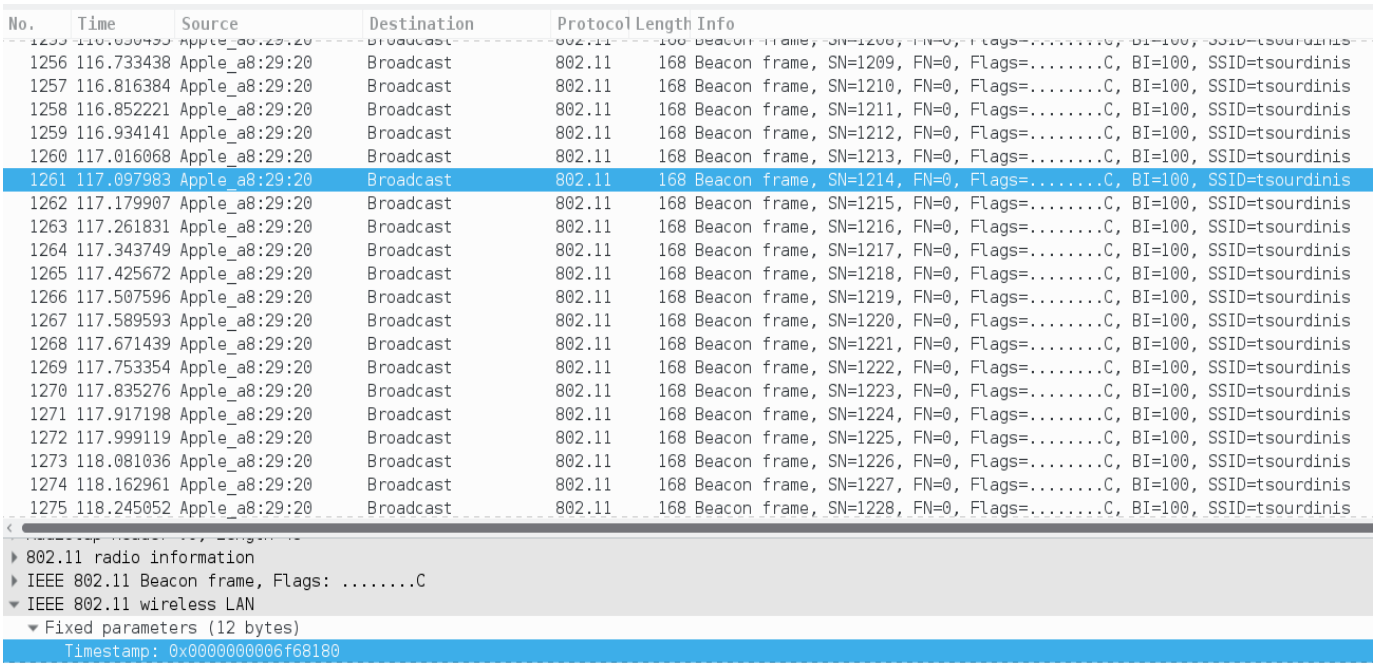
In our configuration file the 802.11g protocol was used (hw_mode=g). The theoretical bandwidth of 802.11g is 54 Mbps. However, in our case the max bandwidth is 27.9 Mbits/sec. The disparity between theoretical and practical bandwidth comes from network protocol overhead, radio interference, physical obstructions on the line of sight between nodes, and the distance between nodes.

Here,with the prints we confirm that the beacon interval decreases by 1ms every 3secs. Also by printing the beacon intervals we can distinguish the time differences between the time that has passed on driver and the time that has passed on iperf and checking the beacon intervals between those time periods in order to make observations.

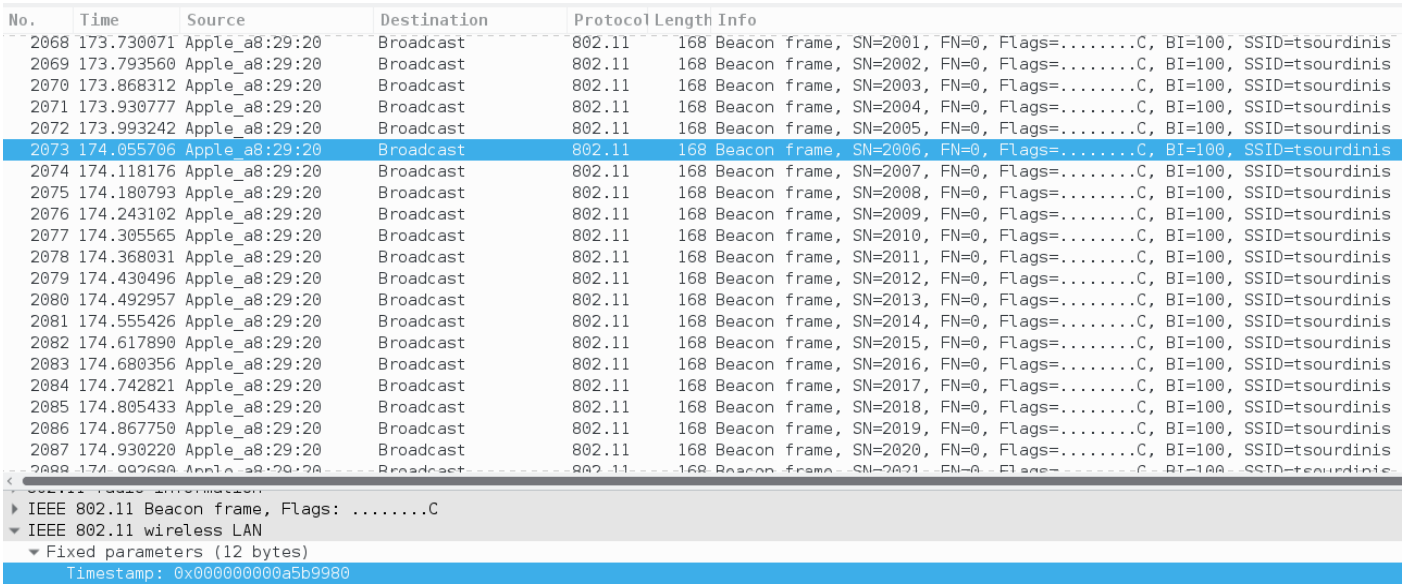


Wireshark Analyze

As we decrease Beacon Interval by 1 ms every 3 seconds , it's hard to see the beacon interval between 2 sequential packets with the naked eye . So we pick the time of 117 seconds in our pcap file when the beacon interval should be approximately 80 ms. We notice that the time difference (beacon interval) between packets no1261 and no1260 is nearly 80ms . The same result can be noticed between the next sequential packets.



Let's look at another screenshot in order to see the packets with beacon interval equal to 60 ms . That should be on 174 seconds in the pcap file. As we notice the the time difference (beacon interval) between packets no2073 and no2072 is nearly 60ms . The same result can be noticed between the next sequential packets



The impact of beacon interval on data frames

In this case the beacon interval is big enough (100 ms) so there is not so much impact on throughput of the data frames.

No.	Time	Source	Destination	Protocol	Length	Info
3395	1.509154	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3396	1.511122	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3397	1.511152	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3398	1.511162	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3399	1.511169	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3400	1.511175	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3401	1.513245	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3402	1.513270	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3403	1.513281	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3404	1.513288	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3405	1.513295	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3406	1.517400	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=70, FN=0, Flags=........C, BI=100, SSID=tsourdinis
3407	1.517419	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3408	1.517439	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3409	1.517447	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3410	1.517458	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3411	1.517464	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3412	1.519758	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3413	1.519785	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3414	1.519795	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3415	1.519803	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3416	1.519809	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3417	1.519815	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3418	1.522100	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3419	1.522124	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
3420	1.522132	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470

In this case the beacon interval is small enough (1 ms) so there is a collision between beacon frames and data frames . So the throughput decreases.

No.	Time	Source	Destination	Protocol	Length	Info
143893	68.347136	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=854, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143894	68.347155	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143895	68.347175	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143896	68.349193	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=855, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143897	68.349212	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143898	68.349232	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143899	68.351143	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=856, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143900	68.351162	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143901	68.351186	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143902	68.353144	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=857, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143903	68.353163	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143904	68.353183	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143905	68.355539	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=858, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143906	68.355558	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143907	68.355578	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143908	68.355592	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143909	68.357596	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=859, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143910	68.357615	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143911	68.357639	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143912	68.359526	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=860, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143913	68.359545	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143914	68.359569	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143915	68.361498	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=861, FN=0, Flags=........C, BI=100, SSID=tsourdinis
143916	68.361518	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143917	68.361538	192.168.2.1	192.168.2.3	UDP	1584	48726 → 5001 Len=1470
143918	68.363787	Apple_a8:29:20	Broadcast	802.11	168	Beacon frame, SN=862, FN=0, Flags=........C, BI=100, SSID=tsourdinis

Throughput Calculation through Wireshark

The 10 second space will be on 20sec – 30sec from the pcap file.

No.	Time	Source	Destination	Protocol	Length	Info
89658	19.999648	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
89659	19.999650		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
89660	19.999651	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
89661	19.999653		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
89662	19.999654	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
89663	19.999656		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
89664	20.001662	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
89665	20.001666		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
89666	20.001668	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
89667	20.001670		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
89668	20.001672	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
89669	20.001674		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
89670	20.001676	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470

No.	Time	Source	Destination	Protocol	Length	Info
133487	29.997176	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
133488	29.997190		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
133489	29.997192	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
133490	29.997194		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
133491	30.000823	Apple_56:bb:3a	Broadcast	802.11	168	Beacon frame, SN=384, FN=0, Flags
133492	30.000843	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
133493	30.000846		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
133494	30.000848	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470
133495	30.000849		Apple_56:bb:3a (e4:	802.11	62	Acknowledgement, Flags=........C
133496	30.000851	192.168.2.1	192.168.2.2	UDP	1584	39587 → 5001 Len=1470

First Packet: no89664

Last Packet: no133492

Total Packets: 133492 – 89664 = 43828 packets

Packets without ACK : $\frac{43828}{2} = 21914$ packets

Size of a Packet (only payload) = 1470 bytes = 0.011215 Megabits

$$Throughput = 21914 * \frac{0.011215}{10} = 24{,}57\ Mbits/sec$$

Comparing this throughput with the throughput from the iperf at 20-30 seconds period space (avg throughput (20-30) : 25.4 Mbits/sec) , we conclude that they're near to each other.