

ELEC-C7420 Basic Principles in Networking Spring 2022

Assignment 1 - Wi-Fi measurement

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Check the configuration of the Wi-Fi network interface on your own computer.

```
researcher@YX-LAB20:~$ iwconfig
lo          no wireless extensions.

enp0s31f6   no wireless extensions.

wlp2s0      IEEE 802.11  ESSID:off/any
            Mode:Managed  Access Point: Not-Associated   Tx-Power=22 dBm
            Retry short limit:7   RTS thr:off   Fragment thr:off
            Power Management:on
```



Wifi Network Interface

Use command line to scan the Wi-Fi access points and record information of all the APs you observe from one location, including SSID, BSSID, used channel, band, network protocol (e.g. 802.11g/n/ac), supported data rates, signal strength and anything else you can get.

[illegible]

- SSID Psaltakis
- BSSID 50:D4:F7:5B:E6:14
- Used channel 10
- Band 2.457GHZ
- Network protocol 802.11i/WPA2
- Supported data rates 1,2,5.5,6,11,12,9,18,36,54,24,48
- Signal strength -38DB

Observe the changes in signal strength when moving around, and analyze the impact of distance and obstacles on wireless signal strength.

```
researcher@YX-LAB20:~$ sudo iwconfig wlp2s0
wlp2s0 IEEE 802.11 ESSID:"Psaltakis"
Mode:Managed Frequency:2.457 GHz Access Point: 50:D4:F7:5B:E6:14
Bit Rate=300 Mb/s Tx-Power=22 dBm
Retry short limit:7 RTS thr:off Fragment thr:off
Encryption key:off
Power Management:on
Link Quality=70/70 Signal level=-32 dBm
Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
Tx excessive retries:0 Invalid misc:20 Missed beacon:0
```

Reference Point. Distance Near AP -32dB

```
researcher@YX-LAB20:~$ sudo iwconfig wlp2s0
wlp2s0 IEEE 802.11 ESSID:"Psaltakis"
Mode:Managed Frequency:2.457 GHz Access Point: 50:D4:F7:5B:E6:14
Bit Rate=300 Mb/s Tx-Power=22 dBm
Retry short limit:7 RTS thr:off Fragment thr:off
Encryption key:off
Power Management:on
Link Quality=70/70 Signal level=-37 dBm
Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
Tx excessive retries:0 Invalid misc:20 Missed beacon:0
```

Same Distance with Door Obstacle -37dB

```
researcher@YX-LAB20:~$ sudo iwconfig wlp2s0
wlp2s0 IEEE 802.11 ESSID:"Psaltakis"
Mode:Managed Frequency:2.457 GHz Access Point: 50:D4:F7:5B:E6:14
Bit Rate=300 Mb/s Tx-Power=22 dBm
Retry short limit:7 RTS thr:off Fragment thr:off
Encryption key:off
Power Management:on
Link Quality=61/70 Signal level=-49 dBm
Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
Tx excessive retries:0 Invalid misc:22 Missed beacon:0
```

Further Away with Open Door (Obstacles wall) -49dB

```
researcher@YX-LAB20:~$ sudo iwconfig wlp2s0
wlp2s0 IEEE 802.11 ESSID:"Psaltakis"
Mode:Managed Frequency:2.457 GHz Access Point: 50:D4:F7:5B:E6:14
Bit Rate=300 Mb/s Tx-Power=22 dBm
Retry short limit:7 RTS thr:off Fragment thr:off
Encryption key:off
Power Management:on
Link Quality=52/70 Signal level=-58 dBm
Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
Tx excessive retries:0 Invalid misc:22 Missed beacon:0
```

Further Away with Closed Door (Obstacles wall) -58dB

```
researcher@YX-LAB20:~$ sudo iwconfig wlp2s0
wlp2s0 IEEE 802.11 ESSID:"Psaltakis"
Mode:Managed Frequency:2.457 GHz Access Point: 50:D4:F7:5B:E6:14
Bit Rate=1 Mb/s Tx-Power=22 dBm
Retry short limit:7 RTS thr:off Fragment thr:off
Encryption key:off
Power Management:on
Link Quality=46/70 Signal level=-64 dBm
Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
Tx excessive retries:0 Invalid misc:1 Missed beacon:0
```

Outside Apartment Two doors/walls Obstacles -64dB

Associate your phone or laptop with one Wi-Fi AP, and parse the beacon frames.

Check Network For Association

```
researcher@YX-LAB20:~$ iwconfig wlp2s0
wlp2s0 IEEE 802.11 ESSID:"Psaltakis"
        Mode:Managed Access Point: Not-Associated Tx-Power=22 dBm
        Retry short limit:7 RTS thr:off Fragment thr:off
        Power Management:on
```

Associate my laptop since its not associated with the AP

```
researcher@YX-LAB20:~$ sudo iwconfig wlp2s0 essid Psaltakis
researcher@YX-LAB20:~$ iwconfig wlp2s0
wlp2s0 IEEE 802.11 ESSID:"Psaltakis"
        Mode:Managed Frequency:2.457 GHz Access Point: 50:D4:F7:5B:E6:14
        Bit Rate=300 Mb/s Tx-Power=22 dBm
        Retry short limit:7 RTS thr:off Fragment thr:off
        Power Management:on
        Link Quality=70/70 Signal level=-38 dBm
        Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
        Tx excessive retries:0 Invalid misc:15 Missed beacon:0
```

Begginig Monitor for AP and Opening Wireshark

PHY	Interface	Driver	Chipset
phy0	wlp2s0	iwlwifi	Intel Corporation Wireless 8265 / 8275 (rev 78)

```
(mac80211 monitor mode vif enabled for [phy0]wlp2s0 on [phy0]wlp2s0mon)
(mac80211 station mode vif disabled for [phy0]wlp2s0)
```

```
researcher@YX-LAB20:~$ wireshark
researcher@YX-LAB20:~$ sudo wireshark
18:38:34.739 Main Warn QStandardPaths: XDG_RUNTIME_DIR not set, defaulting t
o '/tmp/runtime-root'
```

Capturing from wlp2s0mon

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
5970	53.101371521	Cisco-Li_ba:cb:ff	Broadcast	802.11	177	Beacon frame, SN=2459, FN=0, Flags=.....C, BI=...
5971	53.150551913	Tp-LinkT_5b:e6:14	Broadcast	802.11	318	Beacon frame, SN=1509, FN=0, Flags=.....C, BI=...
5972	53.203777096	Cisco-Li_ba:cb:ff	Broadcast	802.11	177	Beacon frame, SN=2460, FN=0, Flags=.....C, BI=...
5973	53.252933994	Tp-LinkT_5b:e6:14	Broadcast	802.11	318	Beacon frame, SN=1510, FN=0, Flags=.....C, BI=...
5974	53.313631581	Tp-LinkT_f2:f5:ff (...)	Broadcast	802.11	70	Acknowledgement, Flags=.....C
5975	53.355240483	Tp-LinkT_5b:e6:14	Broadcast	802.11	318	Beacon frame, SN=1511, FN=0, Flags=.....C, BI=...
5976	53.444936915	Google_e3:0e:8d	Tp-LinkT_5b:e6:14	802.11	84	Null function (No data), SN=2945, FN=0, Flags=...
5977	53.445619444	Google_e3:0e:8d	Tp-LinkT_5b:e6:14	802.11	84	Null function (No data), SN=2945, FN=0, Flags=...
5978	53.445789792	Google_e3:0e:8d (58...	Google_e3:0e:8d (58...	802.11	70	Acknowledgement, Flags=.....C
5979	53.445959487	Google_e3:0e:8d (58...	Tp-LinkT_5b:e6:14 (...)	802.11	76	Request-to-send, Flags=.....C
5980	53.445968862	Google_e3:0e:8d	Google_e3:0e:8d (58...	802.11	70	Clear-to-send, Flags=.....C
5981	53.446134209	Google_e3:0e:8d	Tp-LinkT_5b:e6:14	802.11	199	QoS Data, SN=1250, FN=0, Flags=.p....TC
5982	53.446146331	Google_e3:0e:8d	Tp-LinkT_5b:e6:14	802.11	999	QoS Data, SN=1251, FN=0, Flags=.p....TC

Adding Filter For Wireshark to show and Parse Beacon

wlan.fc.type_subtype==0x8

Time	Source	Destination	Protocol	Length	Info
45594	272.394584333	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=21, FN=0, Flags=.....C, BI=100,
45599	272.497116006	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=22, FN=0, Flags=.....C, BI=100,
45600	272.599554388	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=23, FN=0, Flags=.....C, BI=100,
45620	272.702034202	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=24, FN=0, Flags=.....C, BI=100,
45621	272.804351407	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=25, FN=0, Flags=.....C, BI=100,
45624	272.906580708	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=26, FN=0, Flags=.....C, BI=100,
45625	273.009174916	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=27, FN=0, Flags=.....C, BI=100,
45628	273.111597331	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=28, FN=0, Flags=.....C, BI=100,
45629	273.213841714	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=29, FN=0, Flags=.....C, BI=100,
45630	273.316360740	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=30, FN=0, Flags=.....C, BI=100,
45633	273.420689970	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=31, FN=0, Flags=.....C, BI=100,
45634	273.521192435	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=32, FN=0, Flags=.....C, BI=100,
45635	273.623583346	Tp-LinkT_5b:e6:14	Broadcast	802.11	318 Beacon frame, SN=33, FN=0, Flags=.....C, BI=100,

Frame 45621: 318 bytes on wire (2544 bits), 318 bytes captured (2544 bits) on interface wlp2s0mon, id 0

Interface id: 0 (wlp2s0mon)
Interface name: wlp2s0mon
Encapsulation type: IEEE 802.11 plus radiotap radio header (23)
Arrival Time: Feb 1, 2022 18:43:28.511331791 EET
[Time shift for this packet: 0.000000000 seconds]
Epoch Time: 1643733808.511331791 seconds
[Time delta from previous captured frame: 0.102317205 seconds]
[Time delta from previous displayed frame: 0.102317205 seconds]
[Time since reference or first frame: 272.804351407 seconds]
Frame Number: 45621
Frame Length: 318 bytes (2544 bits)

Send data from one station to another one connected to the same AP (check BSSID), and measure data rate.

Using Iperf and connecting Macbook with my Linux laptop. Listening on Mac, Found IP adress from Router settings and adding details on linux including the port and the ip adresse we found. Data Rate is 47 mb/s

```
researcher@YX-LAB20:~$ iperf -c 192.168.0.102 -p 5201
```

```
-----  
Client connecting to 192.168.0.102, TCP port 5201  
TCP window size: 85.0 KByte (default)  
-----
```

```
[ 3] local 192.168.0.104 port 47706 connected with 192.168.0.102 port 5201  
[ ID] Interval          Transfer      Bandwidth  
[ 3]  0.0-10.0 sec    56.1 MBytes  47.0 Mbits/sec
```

```
researcher@YX-LAB20:~$
```

```
georgepsaltakis@Georges-MacBook-Air ~ % /Applications/iperf3 -s
```

```
-----  
Server listening on 5201  
-----
```

Analyze the impact on data rate from signal strength. You can measure the data rate with three different levels of signal strength.



Went on the router advanced settings and adjusted the transmission power in three intervals

Did the same as above for the three different transmission powers

```
researcher@YX-LAB20:~$ iperf -c 192.168.0.102 -p 5201
```

```
-----  
Client connecting to 192.168.0.102, TCP port 5201  
TCP window size: 85.0 KByte (default)  
-----
```

```
[ 3] local 192.168.0.104 port 47792 connected with 192.168.0.102 port 5201  
[ ID] Interval      Transfer    Bandwidth  
[ 3]  0.0-10.2 sec  51.4 MBytes 42.3 Mbits/sec
```

Middle Power 37.2 Mb/s transmission rate is lower in comparison to the full strength

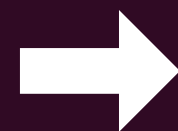
```
researcher@YX-LAB20:~$ iperf -c 192.168.0.102 -p 5201
```

```
-----  
Client connecting to 192.168.0.102, TCP port 5201  
TCP window size: 85.0 KByte (default)  
-----
```

```
[ 3] local 192.168.0.104 port 47796 connected with 192.168.0.102 port 5201  
[ ID] Interval      Transfer    Bandwidth  
[ 3]  0.0-10.2 sec  39.8 MBytes 32.8 Mbits/sec
```



High Power 42.3 Mb/s transmission rate is high as expected



```
researcher@YX-LAB20:~$ iperf -c 192.168.0.102 -p 5201
```

```
-----  
Client connecting to 192.168.0.102, TCP port 5201  
TCP window size: 85.0 KByte (default)  
-----
```

```
[ 3] local 192.168.0.104 port 47798 connected with 192.168.0.102 port 5201  
[ ID] Interval      Transfer    Bandwidth  
[ 3]  0.0-10.1 sec  44.6 MBytes 37.2 Mbits/sec
```



Low Power 32.8 Mb/s transmission rate is significant lower in comparison to the full strength

Generate interference and monitor noise level and signal-to-noise ratio. Analyze the impact of interference on throughput. Repeat the experiment to compare the impact from different levels of interference. Bonus (2p): Also measure and analyse MAC retransmission rate in your measurement

```
Interface
wlp2s0 (IEEE 802.11), phy 0, reg: n/a, SSID: Psaltakis
Levels
link quality: 100% (70/70)
=====

signal level: -37 dBm (0,20 uW)
=====

Statistics
RX: 196 (80,65 KiB), drop: 13 (6,6%)
TX: 101 (14,40 KiB), retries: 10 (9,9%)
Info
mode: Managed, connected to: 50:D4:F7:5B:E6:14, time: 2:43m, inactive: 5,6s
freq: 2427 MHz, ctrl: 2437 MHz, channel: 4 (width: 40 MHz)
rx rate: 1.0 Mbit/s, tx rate: 300.0 Mbit/s MCS 15 40MHz short GI
beacons: 1~@528, lost: 8, avg sig: -30 dBm, interval: 0,1s, DTIM: 1
power mgt: on, tx-power: 22 dBm (158,49 mW)
retry: short limit 7, rts/cts: off, frag: off
Network
wlp2s0 (UP RUNNING BROADCAST MULTICAST)
mac: AC:ED:5C:9D:7A:A6, qlen: 1000
ip: 192.168.0.104/24
```

Quality of signal (similar to signal to noise)
70/70
Signal: -37dB
Retransmission Rate
(drop/retries):13(6.6%),10(9.9%)

```
Interface
wlp2s0 (IEEE 802.11), phy 0, reg: n/a, SSID: Psaltakis
Levels
link quality: 90% (63/70)
=====

signal level: -47 dBm (0,02 uW)
=====

Statistics
RX: 349 (108,26 KiB), drop: 14 (4,0%)
TX: 117 (16,28 KiB), retries: 10 (8,5%)
Info
mode: Managed, connected to: 50:D4:F7:5B:E6:14, time: 5:44m, inactive: 6,8s
freq: 2427 MHz, ctrl: 2437 MHz, channel: 4 (width: 40 MHz)
rx rate: 300.0 Mbit/s MCS 15 40MHz short GI, tx rate: 300.0 Mbit/s MCS 15 40MHz short GI
beacons: 3~@097, lost: 8, avg sig: -48 dBm, interval: 0,1s, DTIM: 1
power mgt: on, tx-power: 22 dBm (158,49 mW)
retry: short limit 7, rts/cts: off, frag: off
Network
wlp2s0 (UP RUNNING BROADCAST MULTICAST)
mac: AC:ED:5C:9D:7A:A6, qlen: 1000
ip: 192.168.0.104/24
```

Quality of signal (similar to signal to noise)
63/70
Signal: -47dB
Retransmission Rate
(drop/retries): 14(4%),10(8.5%)

Used a "Faraday Cage" (A Deep Metal Bowl Covering Some percentage of the access point to almost completely on three integrals) to create interference

```

-Interface-
wlp2s0 (IEEE 802.11), phy 0, reg: n/a, SSID: Psaltakis
-Levels-

link quality: 79% (55/70)
=====

signal level: -55 dBm (3,16 nW)
=====

-Statistics-
RX: 380 (113,84 KiB), drop: 14 (3,7%)
TX: 118 (16,36 KiB), retries: 10 (8,5%)
-Info-
mode: Managed, connected to: 50:D4:F7:5B:E6:14, time: 6:14m, inactive: 6,8s
freq: 2427 MHz, ctrl: 2437 MHz, channel: 4 (width: 40 MHz)
rx rate: 300.0 Mbit/s MCS 15 40MHz short GI, tx rate: 300.0 Mbit/s MCS 15 40MHz short GI
beacons: 3~@370, lost: 8, avg sig: -55 dBm, interval: 0,1s, DTIM: 1
power mgt: on, tx-power: 22 dBm (158,49 mW)
retry: short limit 7, rts/cts: off, frag: off
-Network-
wlp2s0 (UP RUNNING BROADCAST MULTICAST)
mac: AC:ED:5C:9D:7A:A6, qlen: 1000
ip: 192.168.0.104/24

```

Quality of signal (similar to signal to noise)
55/70
Signal: -55dB
Retransmission Rate
(drop/retries):14(3.7%),10(8.5%)

```

-Interface-
wlp2s0 (IEEE 802.11), phy 0, reg: n/a, SSID: Psaltakis
-Levels-

link quality: 61% (43/70)
=====

signal level: -67 dBm (0,20 nW)
=====

-Statistics-
RX: 24 (3,30 KiB), drop: 1 (4,2%)
TX: 6 (737 B)
-Info-
mode: Managed, connected to: 50:D4:F7:5B:E6:14, time: 22 sec, inactive: 6,6s
freq: 2427 MHz, ctrl: 2437 MHz, channel: 4 (width: 40 MHz)
rx rate: 1.0 Mbit/s, tx rate: 180.0 Mbit/s MCS 12 40MHz short GI/s MCS 15 40MHz short GI
beacons: 215, lost: 11, avg sig: -62 dBm, interval: 0,1s, DTIM: 1
power mgt: on, tx-power: 22 dBm (158,49 mW)
retry: short limit 7, rts/cts: off, frag: off
-Network-
wlp2s0 (UP RUNNING BROADCAST MULTICAST)
mac: AC:ED:5C:9D:7A:A6, qlen: 1000
ip: 192.168.0.104/24

```

Quality of signal (similar to signal to noise)
43/70
Signal: -67dB
Retransmission Rate
(drop/retries):1(4.2%)

Tried with every tool available exact noise level in db cannot be calculated due to hardware limitations of either the wifi card of the laptop or the AP (Signal/Noise Ratio = Signal-Level (db) - Noise Level (db)) Quality is the closest we can measure to SNR.