IFN712: Research in IT Practices

Wi-Fi Interference Analysis for Scalable LoRa Communication

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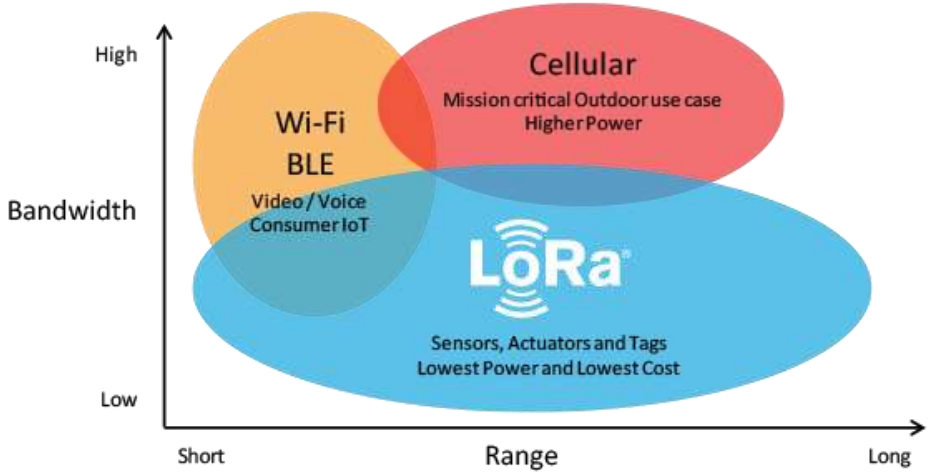
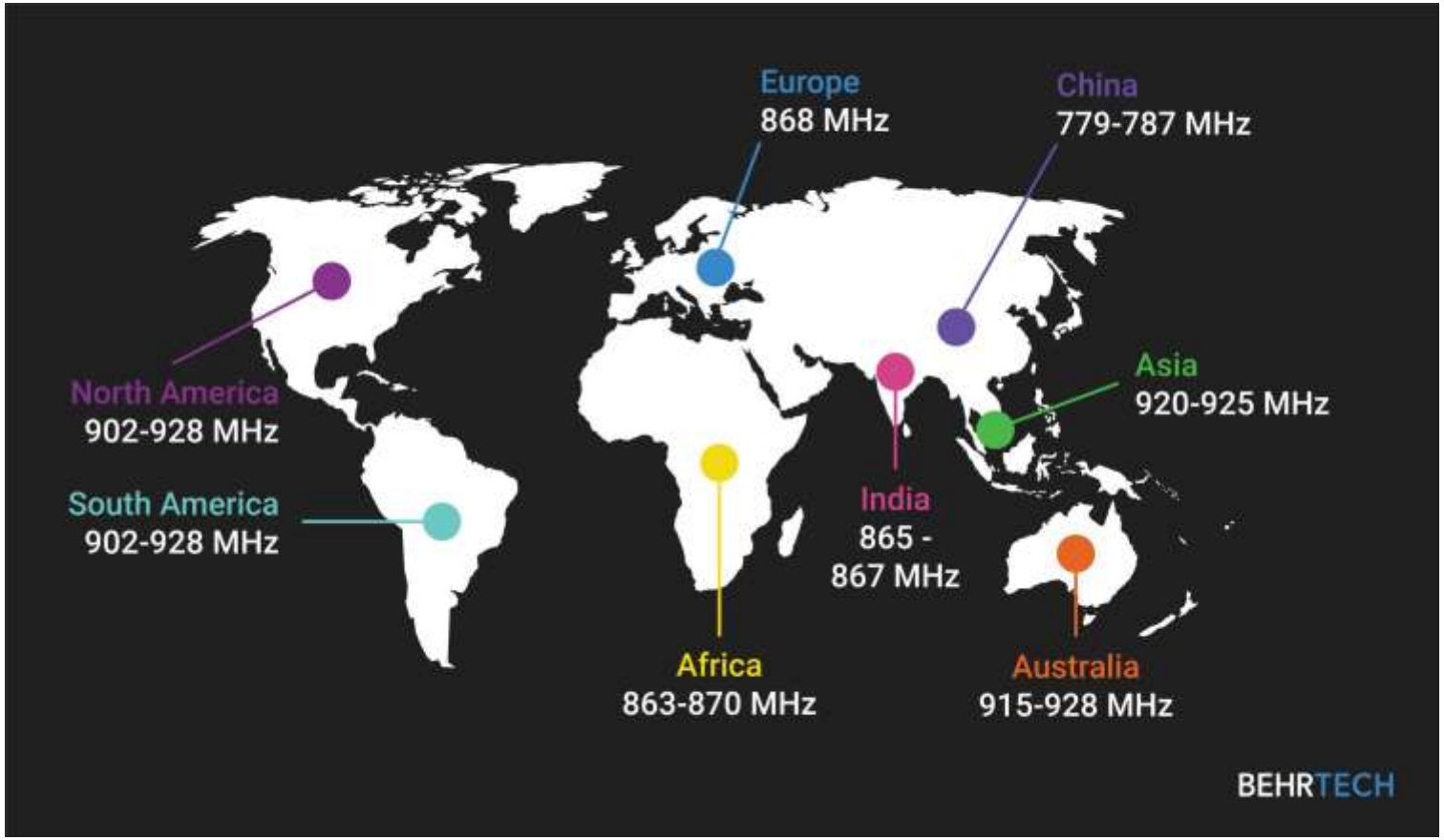
A brief about LoRa:

- Long Range.
- Ultra-Low Power.
- Low cost.
- High Capacity.
- License-free sub Ghz bands.
- Also, in 2.4Ghz now.



Spectrum Distribution in Older Generation Boards



About Hardware:

End Node

The end node is based on SX1280.

Which can be configured to work over 3 different frequencies.

But the transmission only happens 1 frequency at a time.

Gateway

The Gateway has 4 different channels 1 Transmission and 3 receiving channels.

The gateway can be configured to transmit and receive packets over different settings such as Spread factor, Frequencies.

The Gateway works in half duplex, So it can either receive or transfer at on time.

Detail about the Execution

The experiment revolves around the communication between the end node and gateway.

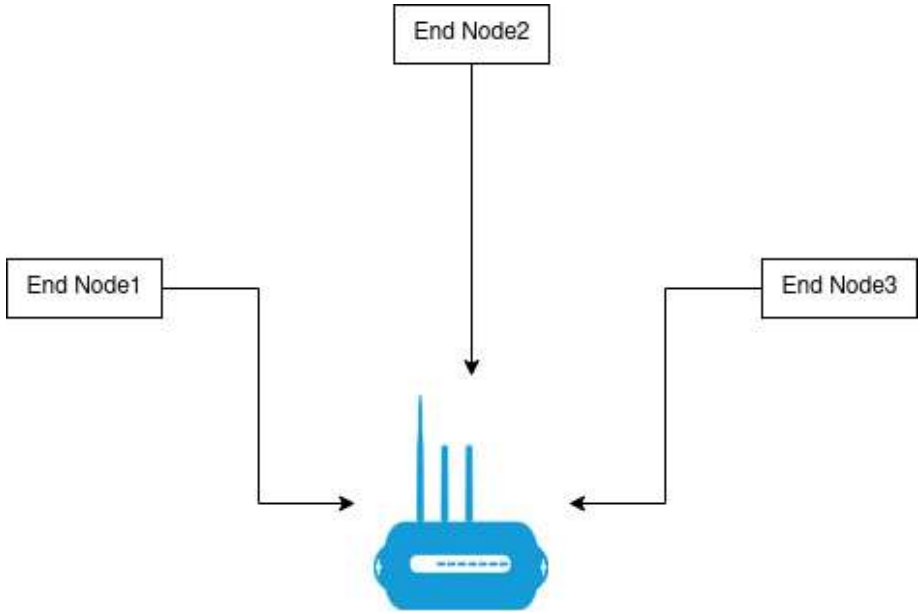
The LoRa nodes and gateway were configured to work on different frequencies to see the WIFI interference.

The testing was done in two different environment.

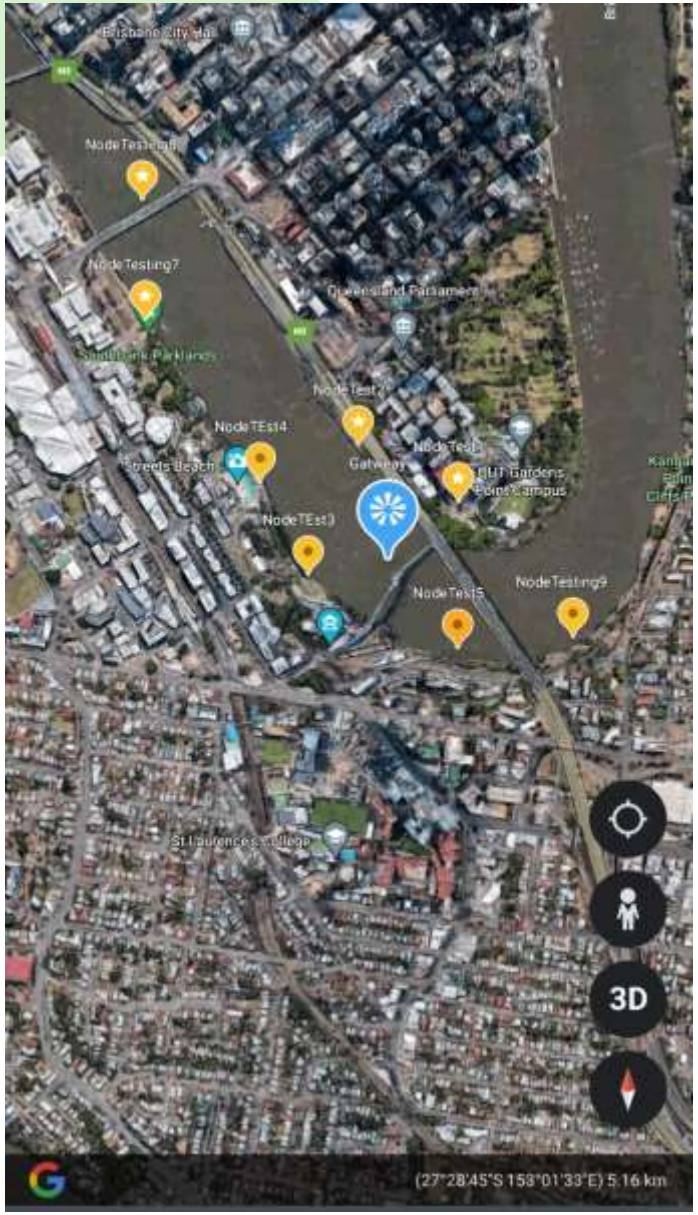
Different Spread factors were used.

Uplink Communication

- When end nodes send packets of information to the gateway over the given configuration.

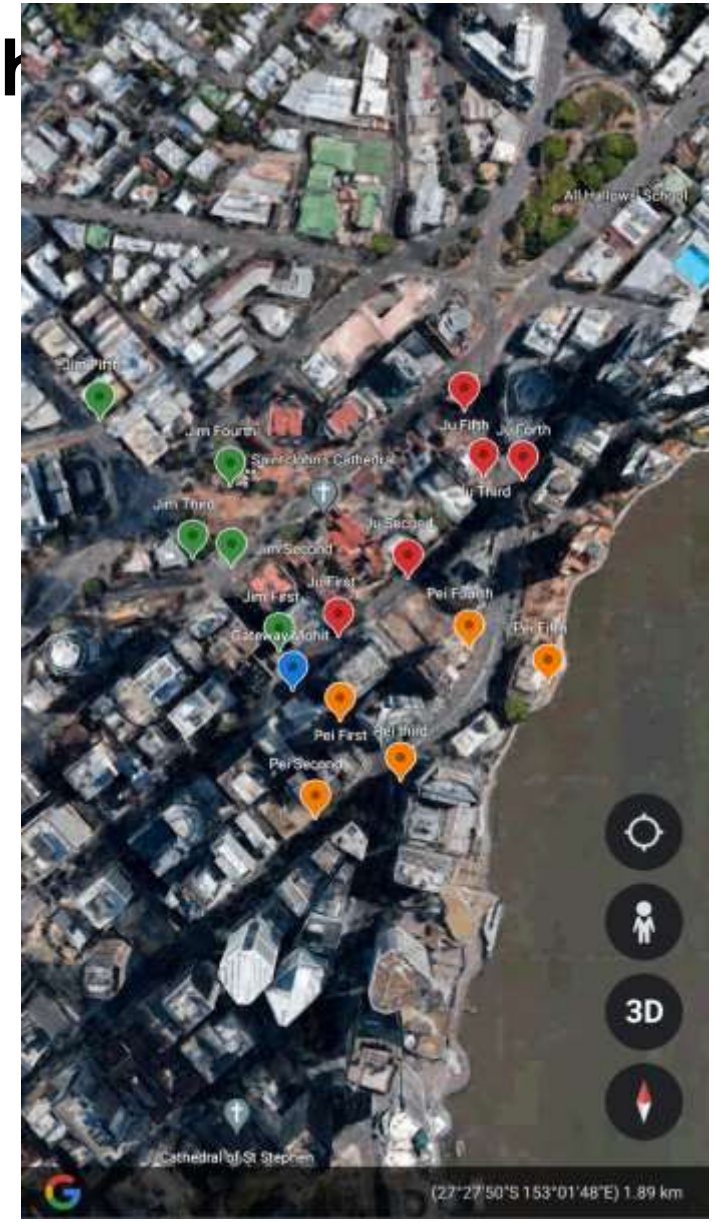


Testing Locations from Google Earth



Testing Area 1

Testing Area 2



A Little About the code

Certain abbreviation used
Such as:-
CH0: Channel 1
CH1: Channel 2
CH2: Channel 3
lsnr : LoRa signal to noise ratio
rssi : receiver signal strength indicator
Datr: it shows the Current Spread factor and Band.

TESTING SITE VIDEO

TESTING SITE VIDEO

Area Capabilities of LoRa in 2.4Ghz using Sx1280 chipset

Range between the Sender and the receiver depends on the Environment.

Range is Affected by many factors some of them are:

Line of Sight.	Spread Factor.	Band Width.

Location 1: Middle of the city

ThroughPut

Cycle 1

Frequencies	Spread Factor	Node	Packets Sent	Packets Received	Percentage
2479	12	1	35	33	94.28
2403	12	2	40	35	87.5
2425	12	3	38	37	97.36

Cycle 2

Frequencies	Spread Factor	Node	Packets Sent	Packets Received	Percentage
2412	10	1	52	40	76.92
2403	12	2	41	35	85.36
2451	10	3	60	38	63.33

Cycle 3

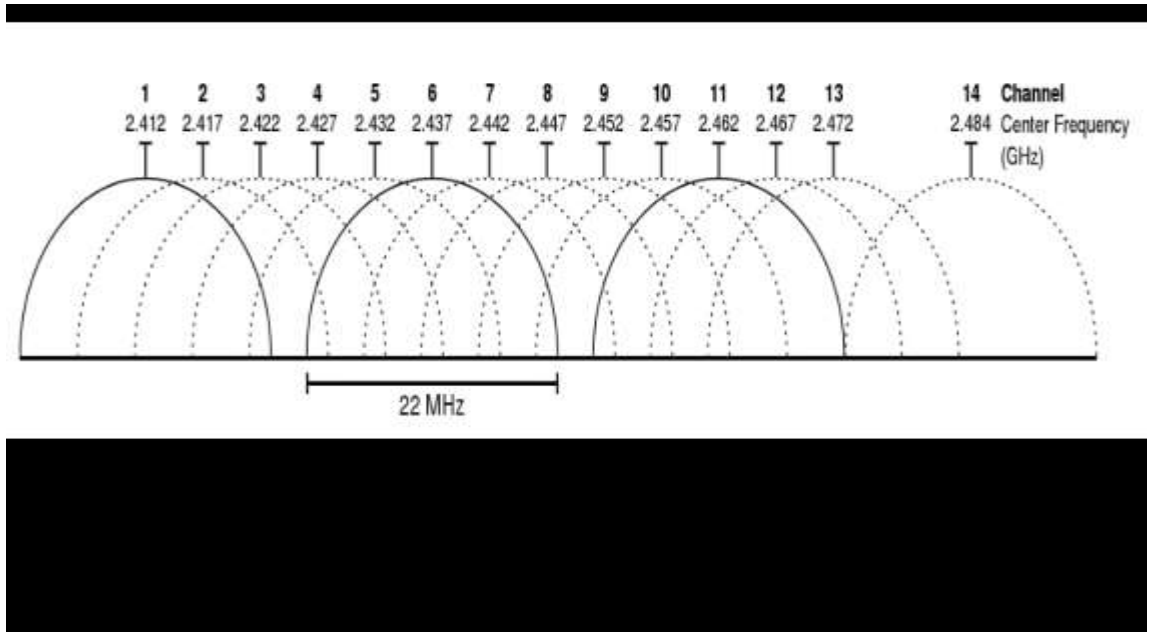
Frequencies	Spread Factor	Node	Packets Sent	Packets Received	Percentage
2439	7	1	59	35	59.32
2403	12	2	41	28	68.29
2463	7	3	65	30	46.15

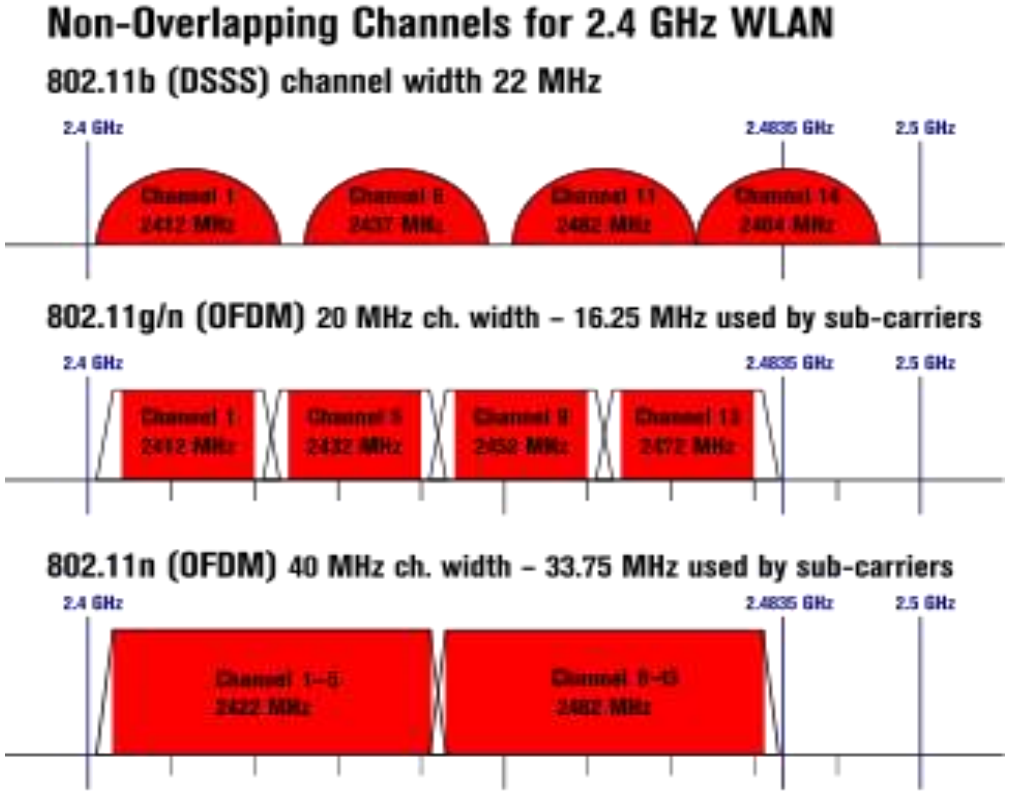
Location 2: Goodwill bridge and surrounding area

S.F	Location	Distance	Receive %	Comments
7	A	223 m	5/5	100% reception
7	B	312 m	5/5	Clear sight 100% reception
7	C	1200 m	0/5	Too far: Capability Exceeded
7	D	848 m	0/5	No clear line of sight
7	E	378 m	4/5	Almost clear sight
7	F	202 m	5/5	Clear sight 100% reception
7	G	250 m	5/5	Clear sight 100% reception
7	H	471 m	3/5	Not clear sight of reception

Spread Factor 10 and 12 tables are in the end of the slides

About WIFI Interference





Frequencies

- 6 different frequencies were used to compare the interference of the Wi-Fi.
- Frequencies:

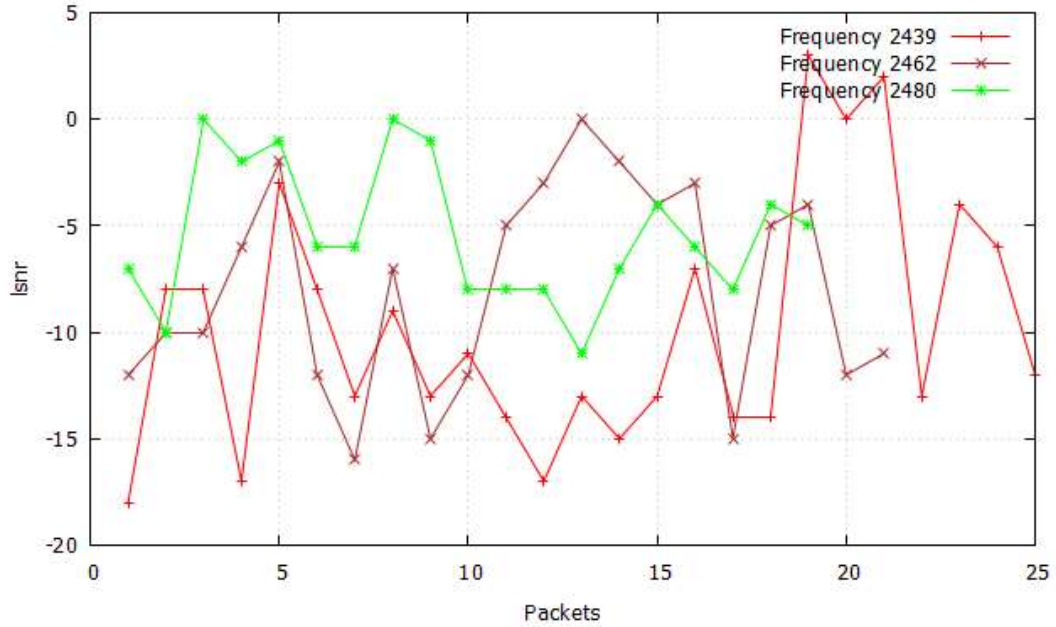
Frequencies	Spread Factor	Band Width
2439	7	812
2462	10	812
2480	12	812

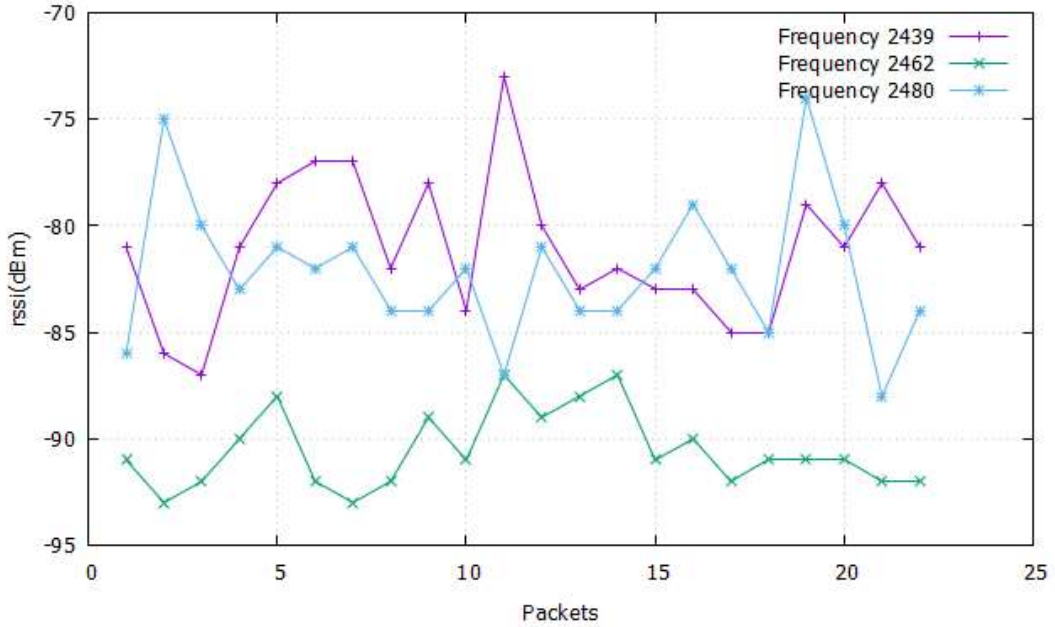
Maximum Receiver Sensitivity

- The above data is in accordance with

1. 1% Packet Error Rate,
2. packets with 23 bytes of payload
3. Code Rate 4/8Li.

Bandwidth	Receiver Sensitivity[dBm]					
	SF7	SF8	SF9	SF10	SF11	SF12
203	-115	-118	-121	-124	-127	-130
406	-113	-116	-119	-122	-125	-128
812	-112	-115	-117	-120	-123	-126
1625	-106	-109	-111	-114	-117	-120



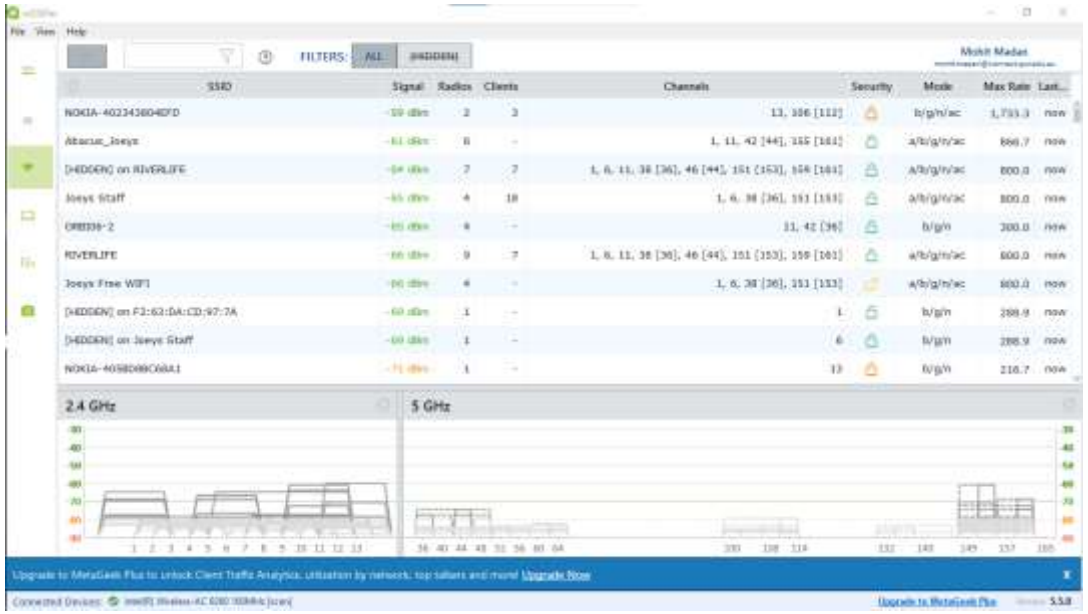


RSSI and LSNR in three different frequencies from min. to max. distance

Assessment 2: Self-Generated Interference Generated while transmission

- 2.4Ghz Mobile hotspot was introduced around the LoRa node and the gateway.
- To Analyse the change in the rssi and lsnr.
- 2 Frequencies were utilized

1. 2412[lie inside the channel 1 as the hotspot working]
2. 2450[outside the channel]

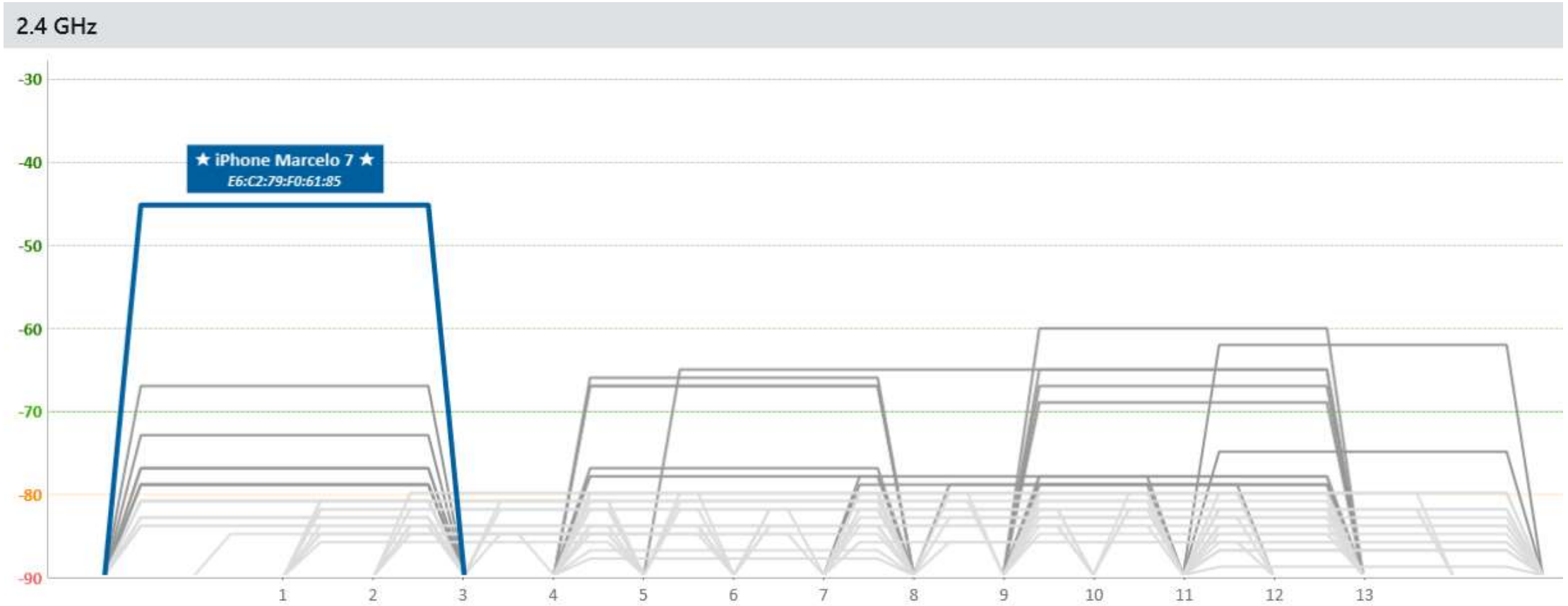


Before Wi-Fi Enabled

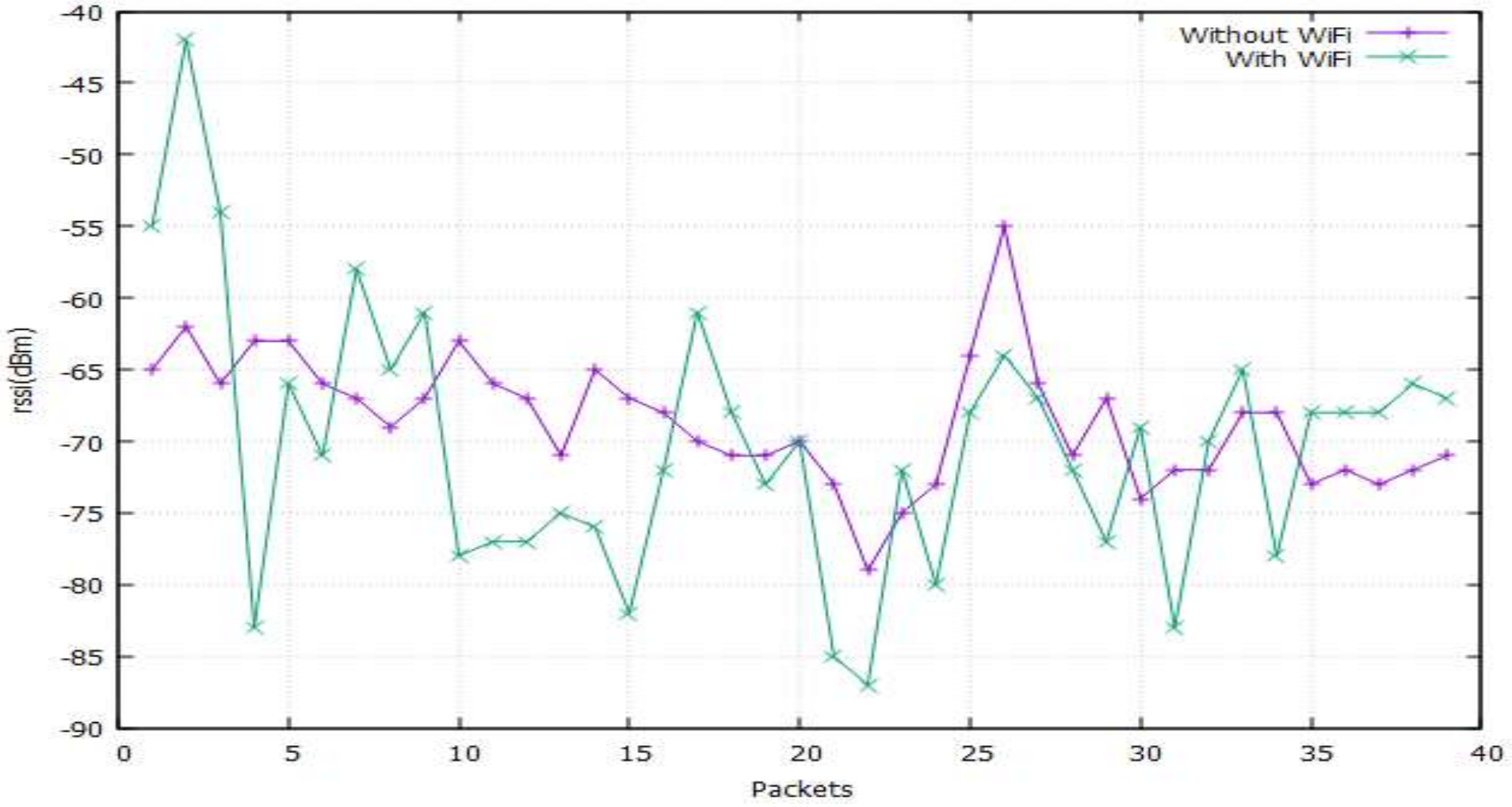
After Wi-Fi Enabled

Networks in the testing site

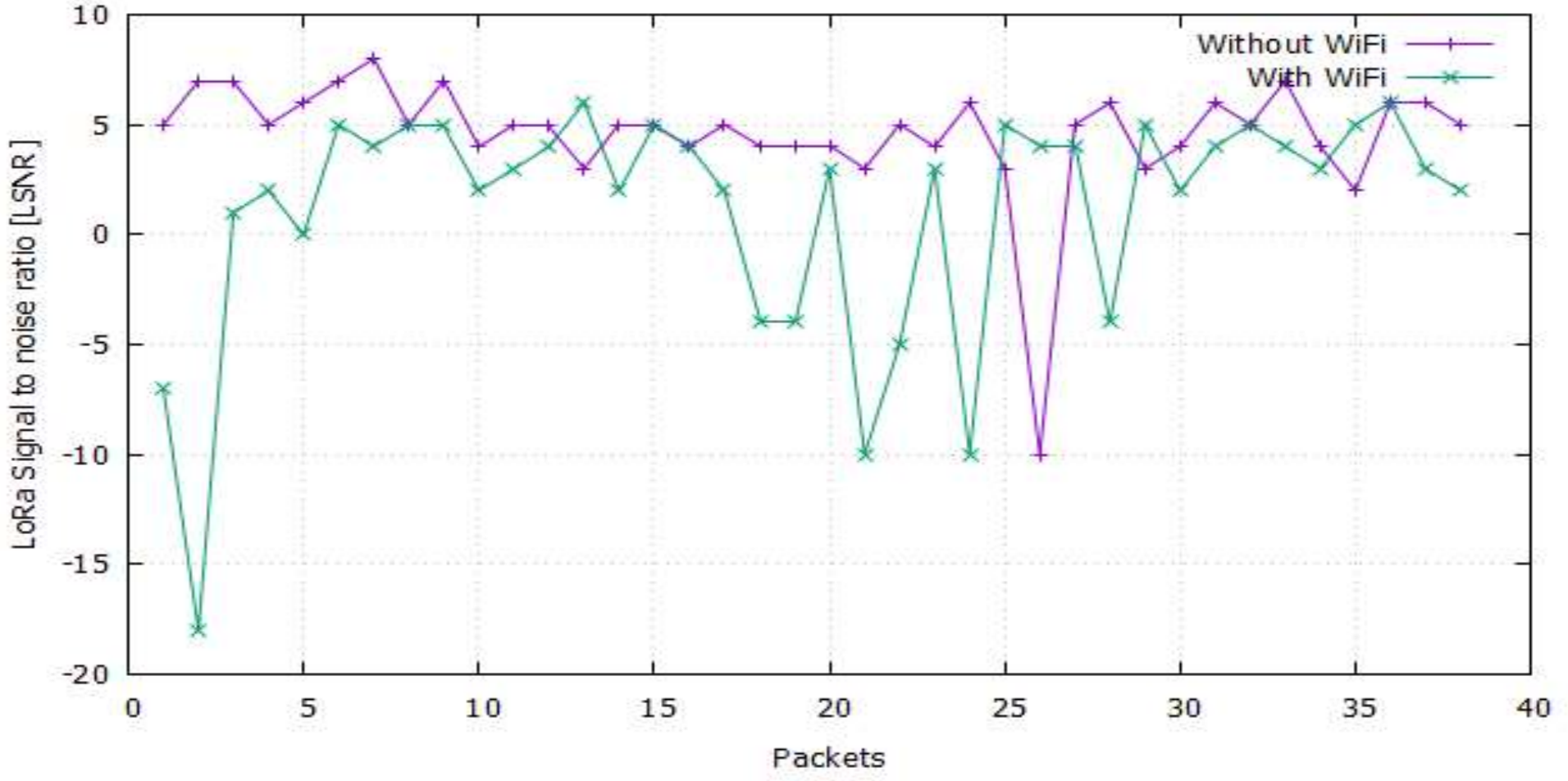
Wi-Fi Hotspot working in 2.4 Ghz



RSSI of 2412 with and without wifi Interference



LSNR with and without Wi-Fi interference in 2412



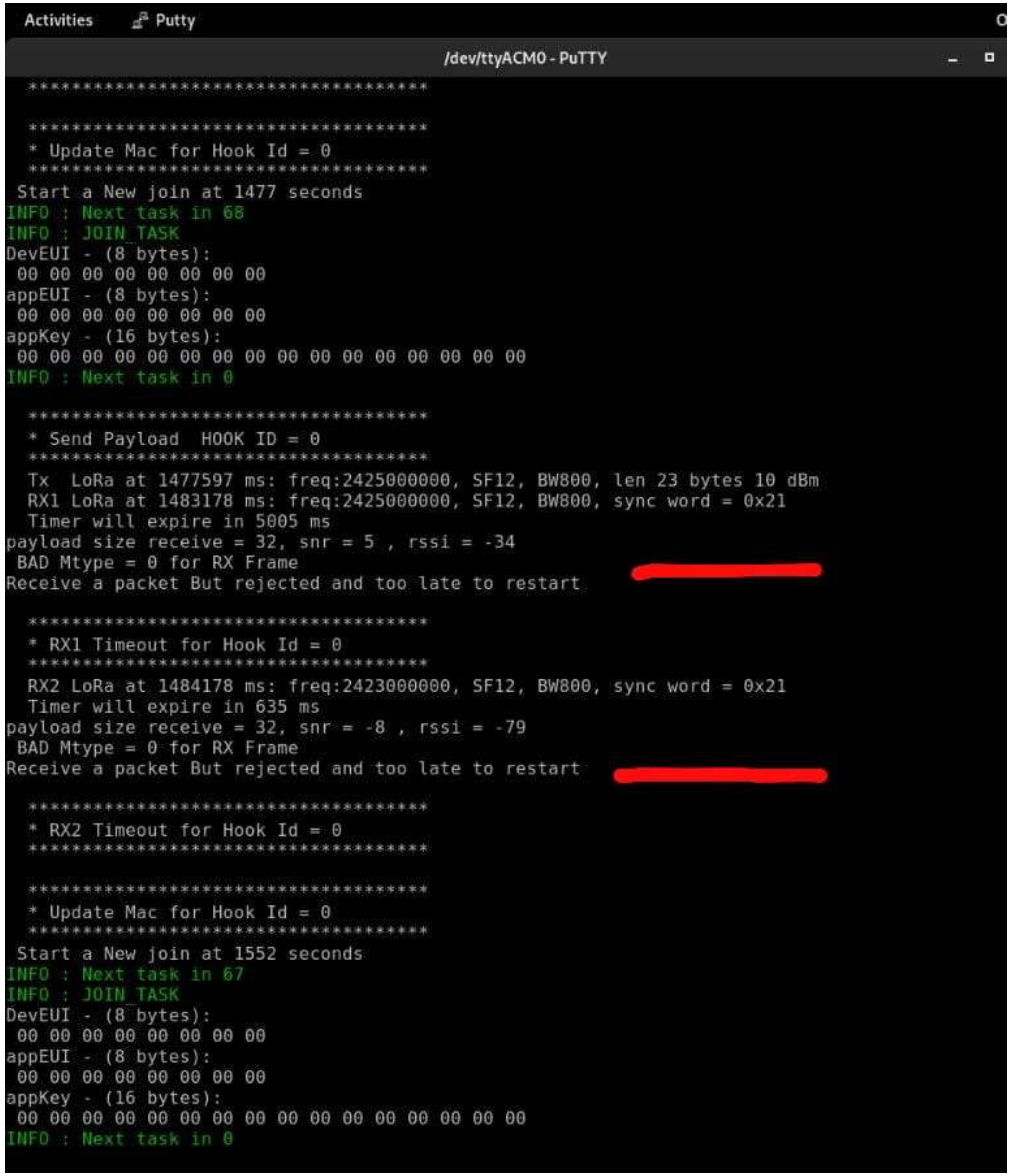
How to avoid Packet Loss

1. Clear line of Sight.
2. WIFI Immunity:-
    1. Frequency Separation.
    2. Spatial Separation
    3. Using Low Bandwidth.

Downlink Communication

- Point to Point downlink communication is not achievable for our end node devices yet.
- Valid token is required from the server LoRa WAN for the communication to take place
- Even if the package which is received is not read and rejected.
- This remains the question of further research in the downlink.

Error Example:- Downlink Error



Other Interesting Findings

- The end node can be programmed to work on different Bandwidth.
- The sx1280 gateway is designed to work in 812.5Khz. It will not work on any other Band such as 1625 and more.

Conclusion

LoRa can coexist in the 2.4Ghz ISM band.

We were able to successfully program the end-nodes and to communicate with the Gateway on different frequency and Spread Factors.

- The Interference from the Wi-Fi does affect the communication but there are certain strategies which we can follow to make with better.
- The packets are received over different range of communication with the help of spread factor.
- Percentage of packets being lost increase if there is WIFI Interference.

Research Outcomes Achieved

- Following Research Outcomes were achieved

1. How to program to effectively connect the SX1280 to the Lora gateway
2. How to overcome the problems of packet loss in the connections
3. How to overcome the problems of packet loss in the connections
4. How to schedule the uplink and downlink between multiple SX1280 sensors and one Lora gateway modem for the maximum efficiency of data transmission

Downlink communication between the nodes and the gateway is not yet possible without a Lora WAN server.

Further Testing Results

RSSI Value

- RSSI is measured in dBm and is a negative value.
- Range –30dBm to –120dBm .

LoRa Signal to Noise Ratio{LSNR}

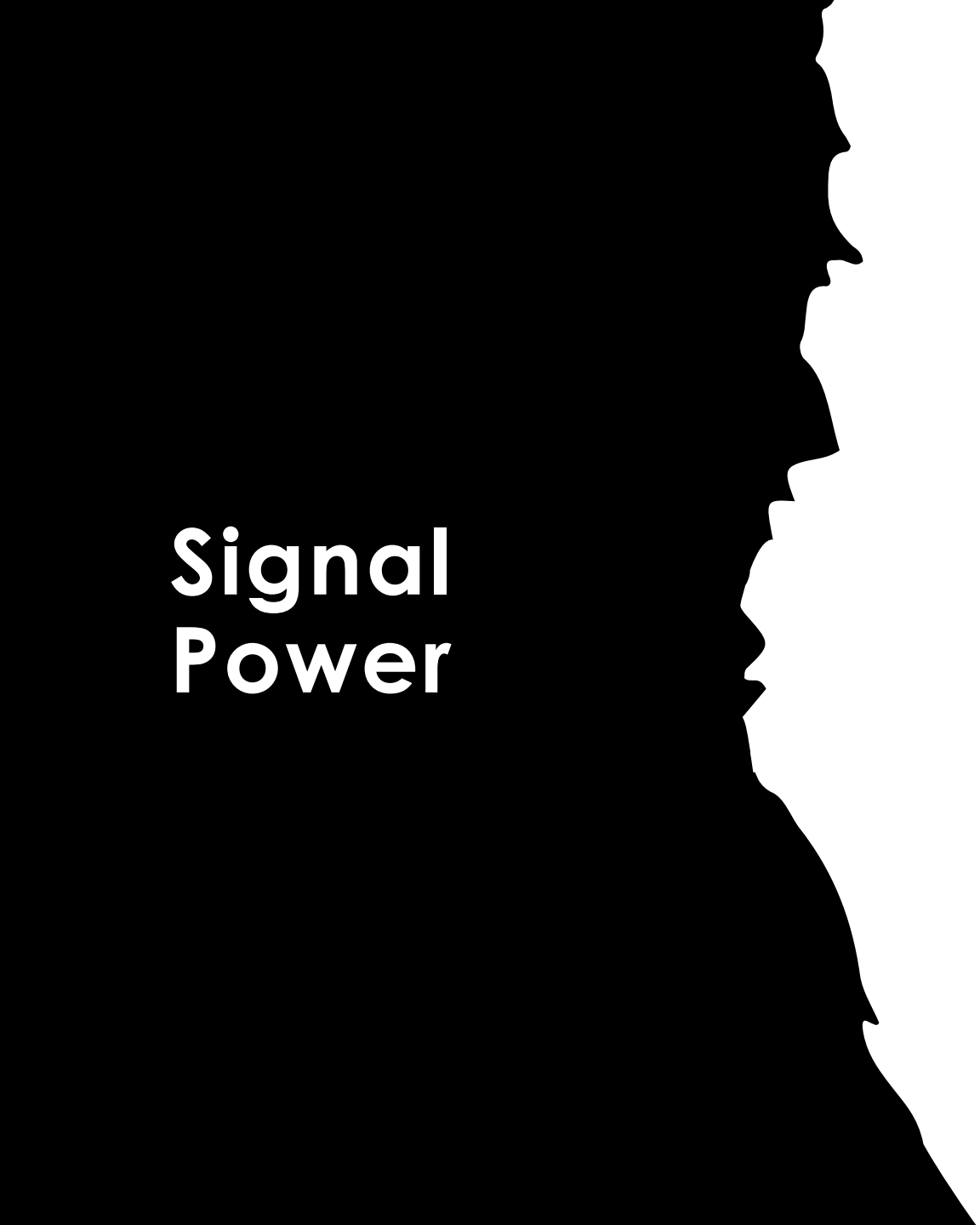
LSNR is the ratio between the received power signal and the noise floor power level.

Noise floor: all the unwanted interfering signal sources which can corrupt the transmitted signal.

SNR is greater than 0, the received signal operates above the noise floor.

SNR is lower than 0, the received signal operates below the noise floor.

[Range –20bB and +10dB]



Signal Power

Calculation of Signal Power is done as follows

rssi – LSNR (if LSNR is below 0)

Formula:-

= RSSI – lsnr(if –ve)

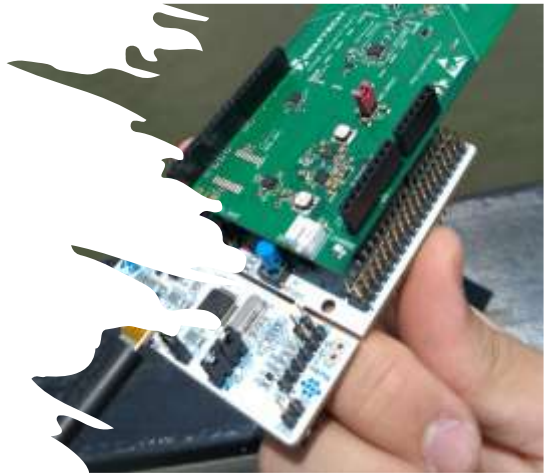
Spread Factor 12

S.F	Location	Distance	Receive %	Comments
12	A	223 m	5/5	Full reception
12	B	312 m	5/5	Full reception
12	C	1200 m	4/5	Clear sight, Almost full reception
12	D	848 m	3/5	No clear ;line of sight some reception
12	E	378 m	5/5	Full reception
12	F	202 m	5/5	Full reception.
12	G	250 m	5/5	Full reception.
12	H	471 m	5/5	Full reception.

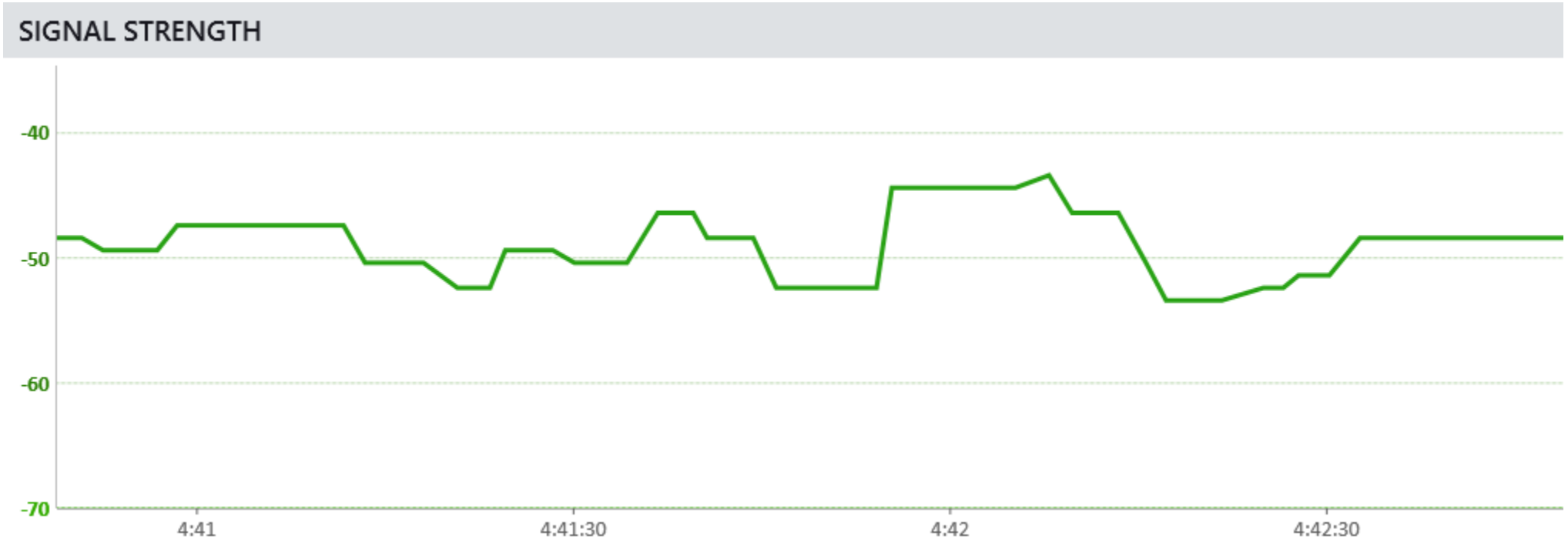
Spread Factor 10

S.F	Location	Distance	Receive %	Comments
10	A	223 m	2/5	Clear line of sight, But frequency lies in Wi-Fi window
10	B	312 m	4/5	Almost perfect connection
10	C	1200 m	3/5	Clear line of sight
10	D	848 m	0/5	No line of sight, No reception
10	E	378 m	5/5	Full reception.
10	F	202 m	5/5	Full reception.
10	G	250 m	5/5	Full reception.
10	H	471 m	4/5	Almost full reception.

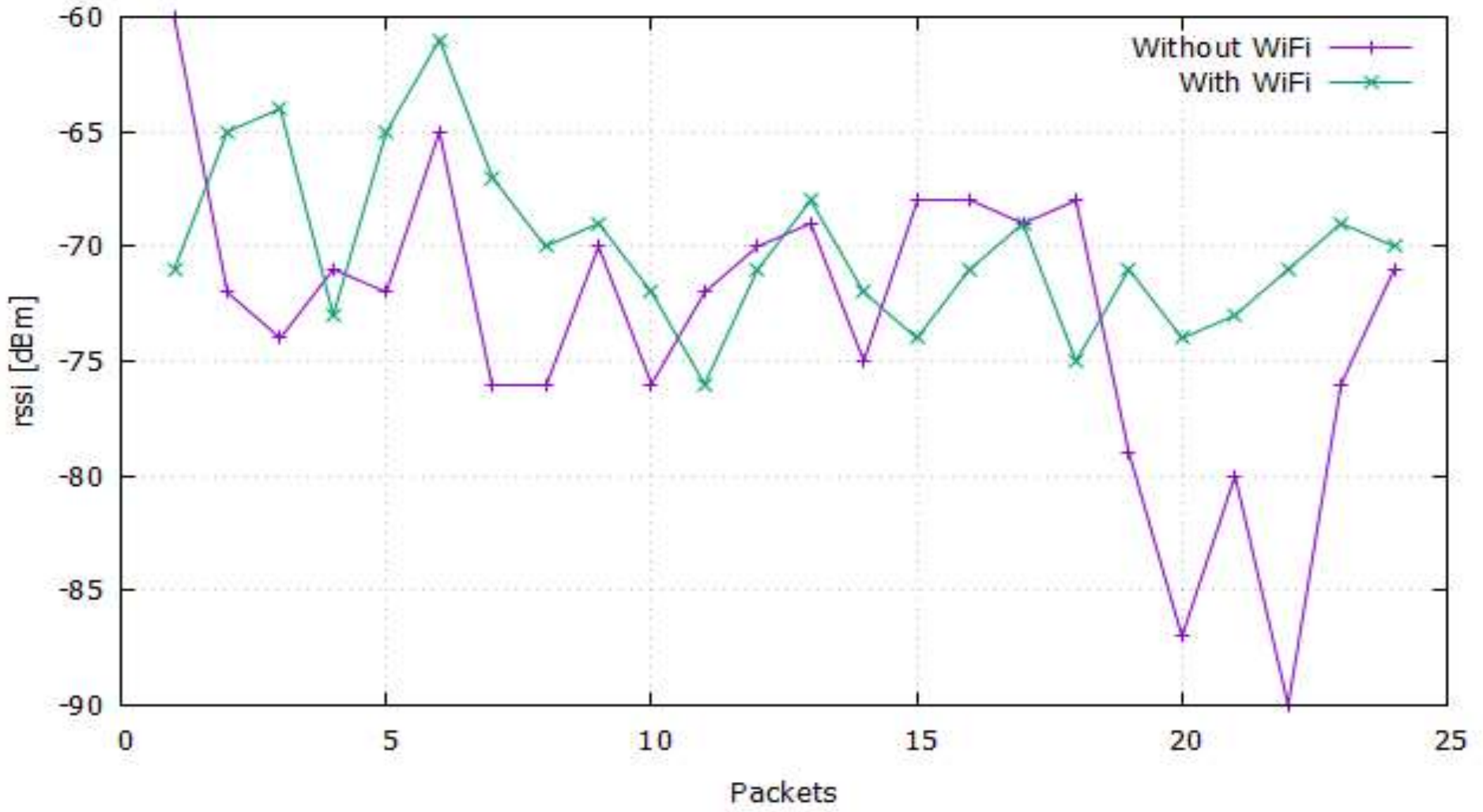
Images from testing Grounds



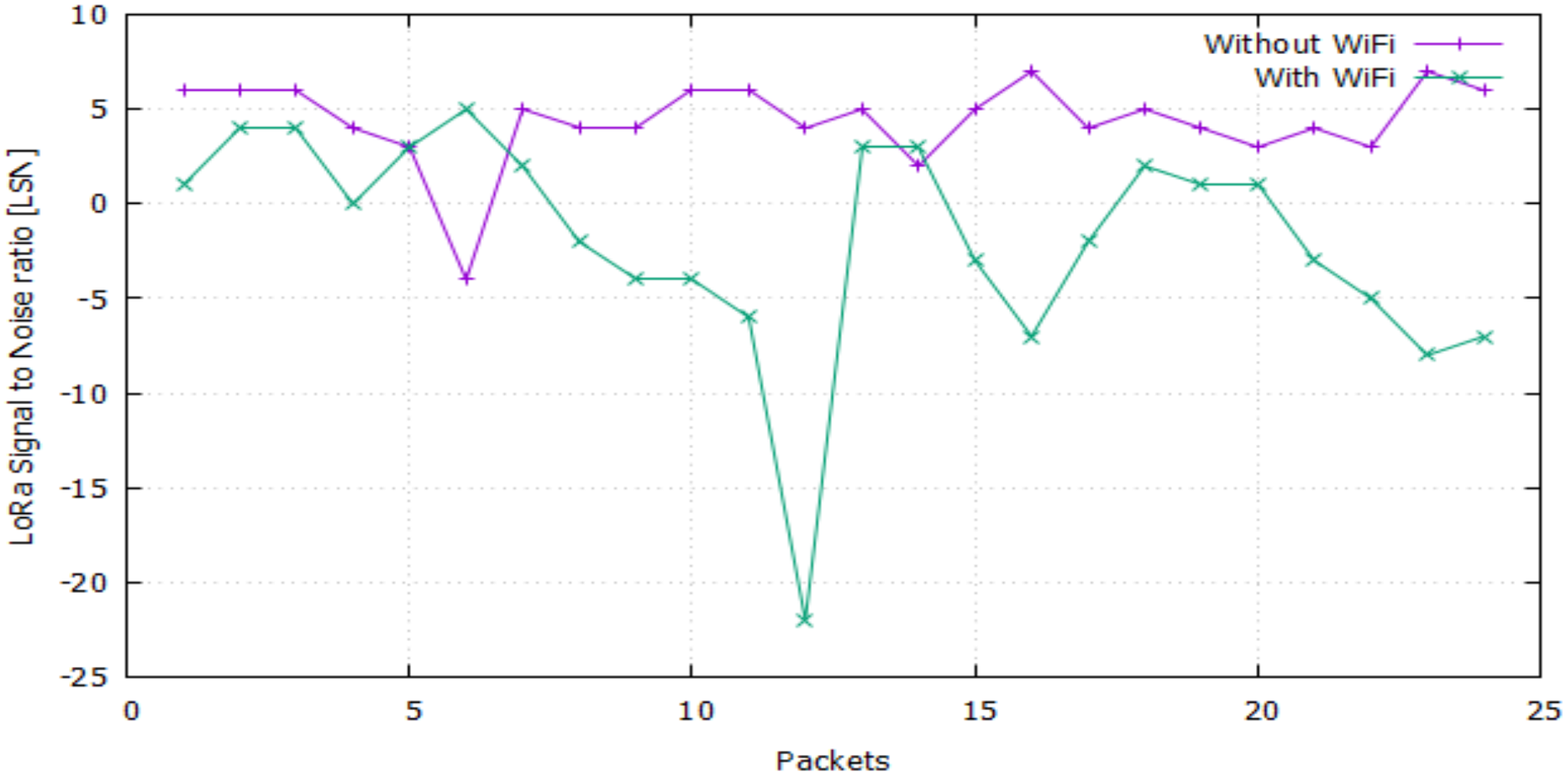
Hotspot Signal Strength indicator



Frequency 2450 RSSI with and without wifi Interference



Frequency 2450 LSNR with and without Wi-Fi Interference




THANK
YOU