Project LoRa1
LoRa-2-LoRa Communications

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Abstract. This paper consists on a report of LoRa1 Project. Where LoRa-2-LoRa communications, results and conclusions learned from the project will be covered.

1 Theoretical Introduction

LoRa is a radio frequency carrier signal based in the physical layer (PHY) that converts data to signals.

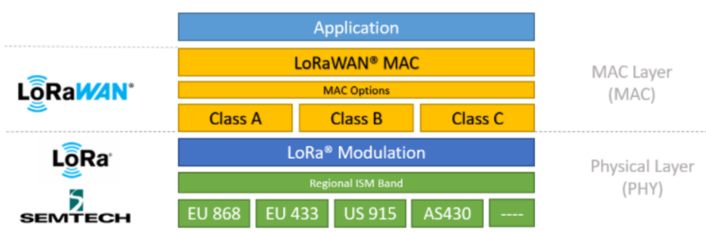

Fig. 1: LoRa protocol stack

Lora modulation is also known as CSS modulation (Chirp Spread Spectrum modulation). LoRa spread spectrum modulation is executed by representing each bit of payload data by several information chirps. The rate at which the spread information is sent is referred to as the symbol rate, the ratio of the nominal symbol rate to the chirp rate is the spread factor (SF) and represents the number of symbols sent per information bit. Spreading Factor (SF), allows the network to preserve the battery life of the nodes, optimizes the power level and data rate of an end node. Spreading factors range from 7 to 12. A higher SF increases the time-on-air, which increases power consumption, reduces the data rate and improves communication range.

LPWAN stands for Low Power Wide Area Network and this type of wireless communication is designed for sending small data packages over long distances, operating on a battery.

Technology	Wireless Communication	Range	Tx Power	Data Rates
LoRa	LPWAN	2-5 km (urban) 5-15 km (rural)	14dBm	up to 50kbps

LoRa operates in the unlicensed ISM (Industrial, Scientific and Medical) radio band that are available worldwide. The radio frequency band used in Europe varies between 433.05-434.79 MHz and 863-870 MHz and 873 MHz.

The Received Signal Strength Indication (RSSI) is the received signal power in milliwatts and is measured in dBm. Typical LoRa RSSI values are between -30dBm (signal is strong) and -120dBm (signal is weak).

Signal-to-Noise Ratio (SNR) is the ratio between the received power signal and the noise floor power level. The noise floor is an area of all unwanted interfering signal sources which can corrupt the transmitted signal.

- If SNR is greater than 0, the received signal operates above the noise floor.
- If SNR is smaller than 0, the received signal operates below the noise floor.

Typical LoRa SNR values are between -20dB (more corrupted) and +10dB (less corrupted).

LoRa-to-LoRa communication refers to LoRa communications that occur directly between end node devices (peer-to-peer), without requiring a gateway.

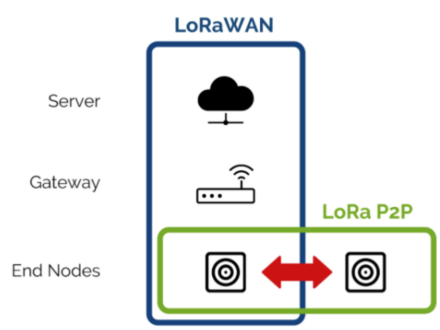

Fig. 2: LoRa-to-LoRa communication

Advantages of LoRa to LoRa communication:

- Increase the range of LoRaWAN coverage and flexibility of LoRaWAN network.

In some areas, LoRaWAN infrastructure may not be available and by connecting multiple nodes we can create a chain that extends the scope of LoRaWAN. The links between nodes are used to enhance the network.

2 Implementation

2.1 Components

The LoPy consists of several parts:

- The main board with the processor and the radio
- The expansion board, with LED, button and access to pins, USB, and power supply
- The antenna

For this project, a TMP36 temperature sensor, a breadboard, and wires to connect the sensor to the expansion board were also used. The temperature sensor was connected to the expansion board as follows, taking Fig.1 into account:

- Connect G3 (P16) on the expansion board to the middle pin on the TMP36.
- Connect 3V3 on the expansion board to the left pin on the TMP36.
- Connect GND on the expansion board to the right pin on the TMP36.

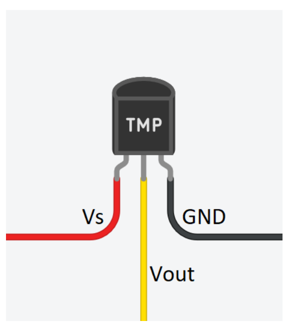

Fig. 3: Temperature sensor TMP36

2.2 Node A

To program node A the first step was to import all the necessary libraries, such as LoRa, socket, time, pycom, machine and math. Next step was to initialize the variable lora in the mode LoRa.LORA bypasses the LoRaWAN layer, allowing its usage using only the LoRa radio capabilities. After that, it was necessary to create a raw LoRa socket that will allow sending and receiving messages between the devices. And every 5 seconds the following is done:

- Using the lora_stats function, get RSSI, SNR and ToA;
- The heartbeat LED of Node A changes its color according to the value of the SNR: SNR greater than 5 dB, LED turns green; SNR greater than 0 dB, LED turns blue; and SNR less than or equal to 0 dB, LED turns red.
- Get temperature from pin G3=P16;
- Send message to node B, the message consists of a boolean, and the temperature ("true/false,temperature"). The parsing of the message is done at the Application Layer;
- Receive message from node B.

2.3 Node B

The Node B program is similar to Node A but instead of sending information, Node B waits for a message from Node A containing both the temperature and the next Led Value, after receiving the message, Node B answers with "Led is On" or "Led is Off" depending on the new Led state.

- Using socket.recv(64) receive Node A message;
- Using the lora_stats function, get RSSI, SNR and ToA;
- Decode the message from a sequence of octets to a sequence of Unicode characters (string) using message.decode().
- Parse message reading both the temperature and new Led State separated by a ',';
- Send a message to Node A ('[Node B] Led is Off' or '[Node B] Led is On');

3 Results

3.1 The impact of distance on RSSI

To test what effect the distance has on the RSSI, the nodes were moved further apart at intervals of 10 meters and the RSSI values were collected.

A graph was constructed, shown in the image below. Observing the graph, it is possible to conclude that as the distance between the nodes increases the RSSI decreases.

The tests were done for two different message sizes, 64 bytes and 518 bytes. But, the message size had no impact on the RSSI.

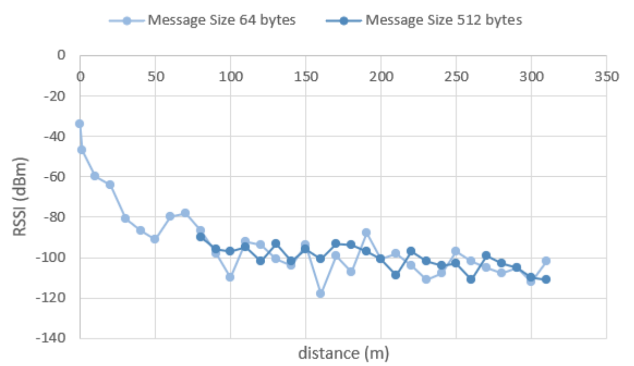

Fig. 4: Graph of the impact of distance on RSSI.

3.2 The impact of distance on SNR

To conclude on the impact of the distance on SNR, the same procedure was done, the nodes were moved about 10 meters apart.

The graph of SNR values in relation to the distance is shown in the figure below. Although for the first 200 meters the differences are not very noticeable, after 200 meters peaks in the SNR values were obtained, this may be due to interference. It may be due to the fact that for the test the nodes were not moved in a straight line, there was a slight curve near 300 meters. Also some interference from cars and other objects.

This test was done for two different message sizes, 64 and 518 bytes, and by analyzing the graph we can conclude that by changing the size of the message sent, the SNR does not change.

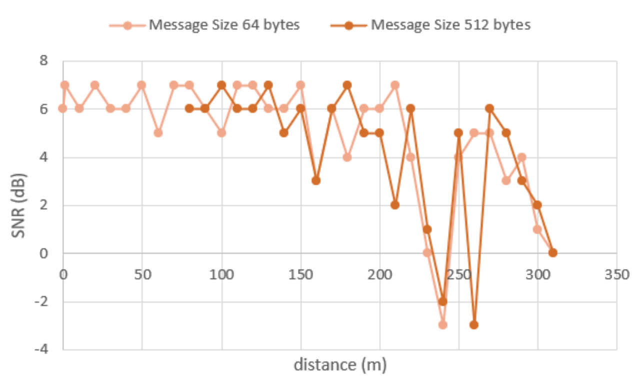

Fig. 5: Graph of the impact of distance on SNR.

At the end of the road there was a small turn with some trees, those trees may have caused some interference in the Radio Signal, causing the small spikes that we can see in the SNR graph.

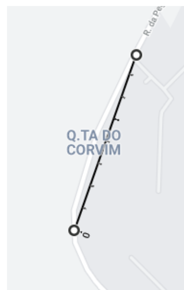

Fig. 6: Node A and Node B positions from the Map.

Fig. 7: Image from the Node A position.

3.3 The impact of message size on ToA

To test the impact of message size on Time On Air, messages between 10 and 250 bytes were sent. The results are shown in the graph that follows. And analyzing the graph it can be seen that the larger the message size, the larger the ToA.

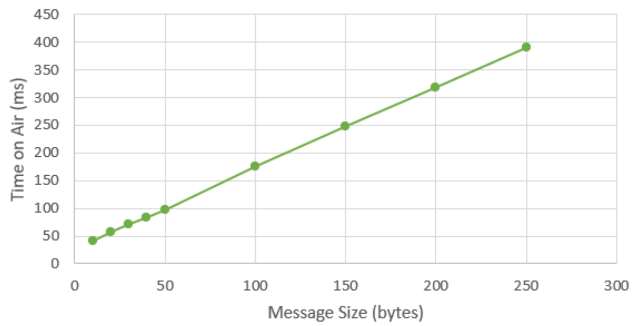

Fig. 8: Graph of the impact of message size on ToA.

4 Conclusion

In conclusion, for increasing distances the value of the RSSI and SNR will decrease. It was also possible to conclude that message size has no impact on the RSSI and SNR, but only on the value of ToA, this increases for larger message sizes.