# LoRa-Based Wireless Network Offline

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**Abstract.**

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## 1 Introduction

The study of the environmental changes and their effects been one of the most important topics to study in the present usually in places with difficult access to the people like forest and deserts or rural places where is not easy to have an access to Ethernet, is necessary know some characteristics like temperature, humidity, precipitations, Water and air quality allows make models to the estimate or predict some changes like a forest fire or rivers states [1,2] for that reason is necessary a method to get data in these large environments without impact them, LPWAN technology is one of these methods that be used

The LPWAN technology is created for machine-to-machine (M2M) and internet of things (IoT) networks, LPWANs operate at a lower cost with greater power efficiency than traditional mobile networks. They are also able to support a greater number of connected devices over a larger area, LPWAN is not a single technology, but a group of various low-power, wide area network technologies that take many shapes and forms [3]. LPWANs usually it is used to get data in large areas and give it to a central point where a user can see and process to get some information that they wish [4], one of the most used LPWAN around the world is LoRaWAN and SigFox.

Some environments don't have an access point to Ethernet and is very difficult to build the structure to implement it because the cost and difficult to bring the equipment to this places for this is not possible to implement a IoT network to get data and take them to a central processing point base on this is proposed a network based on LPWAN than in any node of the net it can get the data in all the nodes that are available in the net and make some processing with it.

This article will show how it developed a LPWAN based on LoRa, in the first section show some projects that used LPWANs next the LoRa modulation and their characteristics after that the device that is used to create the nodes and the algorithm that have developed to create the network than can get to all the nodes of the net all the data in these and how a user can get it, for this we use the data of status of the nodes to verify the functionality of the net.

## 2 Related Work

Low power WAN networks known as LPWAN are the best basis for M2M and Internet of Things (IoT) applications develop their full potential. Currently, both environments have limitations due to the necessary investment as well as for issues related to the distance of the energy source. The LPWAN networks seem to solve these problems by offering low power consumption, reduced cost and long range, these networks make it possible to have many thousands of sensors collecting and sending data at lower cost, longer reach, and with better duration of the battery that other connectivity options between its applications we find:

At the University of Prague, Czech Republic, a work was presented by Lukas Krupka about LPWAN in this paper the terms of LPWAN are described and their representatives LoRa, SigFox and IQRF [5], where characteristics were inspected, topologies and some techniques to implement, from which LoRa and SigFox promise a great development and more than thousands of devices placed with the ability to cover a large area

LoRa being one of the alternatives implemented for an LPWAN in Brazil at 2017, a network of Long range modules (LoRa) was implemented for the monitoring of navigation [6], The system had a low packet loss rate below 6% and a long range of more than 2 km in flat areas but is influenced by obstacles such as tall buildings and trees, which lead to the high rate of packet loss of more than 34% in those areas with many obstacles

In the District University LoRa modules are used for communication between nodes generating a network of sensors on two rivers to monitor the warm water (EC, pH, TDS, T) [2], among the problems encountered arises due to impedance coupling, as well as the need for high power antennas to cover the land for the large distance.

## 3 LoRa Overview

LoRaWAN defines the communication protocol and system architecture of the network while the LoRa® physical layer allows the long-term communication link cancel The protocol and network architecture have the greatest influence on the determination of a node's battery life, network capacity, quality of service, security, and the variety of applications across the network. [7].

LoRa is the physical layer used to create long-distance communications links. Many systems use FSK modulation because it is very efficient for low power. LoRa uses CSS which is a modulation that maintains the same characteristics low power FSK but increases the communication distance range other characteristics of LoRa modulation is show in table 1.

Many existing deployed networks use a mesh network architecture. In a mesh network, at the end of the individual nodes will transmit the information of others nodes to increase the size of the communication range and the network cell. Yes, well this increases the range, but also adds complexity, reduces the ability to the network, and the battery life of the nodes.

| Modulation | Bandwidth | Max Rate Bits | Bidirectional | Max Frame Length | Range |
|---|---|---|---|---|---|
| LoRa | 125 Khz | 50 $Kbps$ | Half-Duplex | 12 bytes (UL) | 15 $Km\ Urban$ |
| FSK | 250 Khz | | | 8 bytes (DL) | 40 $Km\ Rural$ |

**Table 1.** Overview of LPWAN technologies: LoRa [21]

LoRa modulation provides alternatives for spread spectrum communication that are low power and low cost compared to conventional spread spectrum technique. LoRa modulation uses the chirp signal, which is a signal with a frequency that varies over time [8]. By using this method, complexity for the receiver side will be reduced. The output signal of this modulation matches the bandwidth used by the chirp signal.

Apart from bandwidth, there is also a diffusion factor. If the Bandwidth shows the speed of the chip, the Scatter Factor shows how much chip is used to represent a symbol. Apart from that, the Extension Factor also shows how many bits a symbol contains.

*Symbol.*

As discussed earlier, LoRa is an extended spectrum modulation of chirp. The transmitted data, which is a symbol, will be represented by a chirp signal with a frequency range of $f_{min}$ to $f_{max}$. In LoRa modulation, we can configure the symbol by changing the parameters of Extension factor and Bandwidth. According to the [9], a symbol will take $T_S$ per second to transmit as show in equation 1, which is a function of the bandwidth (BW) and the scatter factor (SF) can be displayed with:

$$T_S = 2^{SF}/BW \quad (1)$$

*Bandwidth*

Bandwidth is the frequency range of the chirp signal used to transport the baseband data. In Figure 1, the bandwidth can be seen from the frequency width used between $f_{min}$ to $f_{max}$. Apart from that, bandwidth can also represent the chip speed of the LoRa signal modulation.

*Spreading Factor*

The basic principle of spread spectrum is that each bit of information is encoded as multiple chirps. Within the given bandwidth the relationship between the bit and chirp rate for LoRa modulation may differ between spreading factor (SF) 7 to 12. The end-device may transmit on any channel available at any time, using any available data rate

The Spreading Factor shows how many tokens are used to represent a symbol , with an exponential factor of 2, 1 symbol can consist of N chip where N = $2^{SF}$. A cyclic change can be made to represent a bit and a sent symbol. If there are N number of chips, then the value of the resulting symbol may vary from 0 to N-1, or that symbol 1 may represent SF bits

*Coding Rate*

LoRa modulation also adds forward error correction (FEC) in each data transmission. This implementation is done by encoding 4-bit data with redundancies in 5 bits, 6 bits, 7 bits or even 8 bits. The use of this redundancy will allow the LoRa signal to support short interference. The value of the coding rate (CR) must be adjusted according to the conditions of the channel used for data transmission. If there is too much interference in the channel, it is recommended to increase the CR value. However, the increase in the CR value will also increase the duration of the transmission(ToA).

*Time on Air*

An important consequence of using a higher spreading factor for LoRa is a longer time on air (ToA). The LoRa Radio module needs more time to send the same amount of data. This means that power consumption increases with increasing Spreading Factor.

Base on LoRa Spread Spectrum the nominal bit rate of the data signals as show in equation 2 and the chip rate can define as show in the equation (3)

$$\mathrm{R_b} = SF * \left(\frac{\frac{4}{4+CR}}{\frac{2^{SF}}{BW}}\right) \tag{2}$$

$$\mathrm{R_c} = \frac{\mathrm{BW}}{2^{SF}} * 2^{SF} = \mathrm{BW\ chips/sec} \tag{3}$$

# 4 Methods and Data

In this section, we design, implement and prove the algorithm to create the offline network that can in any node get the data of the available nodes in the net, and in any of this nodes a user can get the data of all the nodes in this case the data will be the status of the node in the net.

## 4.1 Procedure – Methodology

We implement 5 nodes that have a device to generate que LoRa signal and a Single-board computer (SBC) that process the data, in the SBC also supervised the communication between the nodes as we see in the last section LoRa modulation have different characteristics like spreading factor (SF) and bandwidth(BW) that change the data that can send in one transmission, the time take to make it and the max range that can reach for that we used different combinations of SF and BW to prove the functionality of the net.

### 4.2 Design

It is proposed that each node of the network can be a center point that designates from which node it wants to request the information using polling ask all the nodes that have been established for the data in those, and at the end of the list of nodes, after the node finish polling the net pass the control of the network to another node that is available.

The topology of the network be based in M2M communication where a node can communicate with all the other nodes generate there a mesh connection, making a network like shown in figure 2 with this model is not fast to get the data if the net is big with more nodes is more slow the time necessary to get all the data of the net.

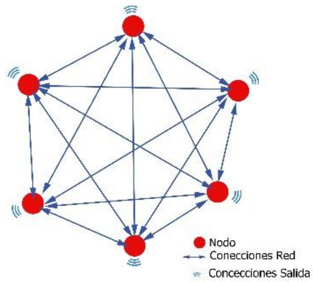


**Fig. 1.** Network topology

It was designed in this way since it is not expected to send much information in each transmission and not occupy the channel for a long time

### 4.3 Implementation

To make the network we used de module SX1272, it was carried out by means of an adapter, which allows direct control by means of the SX1272 library designed for Arduino, so it is necessary to implement the arduPi in the raspberry pi that allows to use Arduino libraries based on the documentation [10].

It is taken as the central node and is responsible for polling the other nodes of the network, through the SX1272, which has several functions for the transmission of information in this case, the "sendPacket" function was used where a packet is sent .At the time of polling, the message indicating that it expects to receive information from the node, in case of not finding a response from the node in the stipulated time, the polling will proceed to the next node in the network until it travels the other nodes in the net in each case communication is M2M, at the end of the polling it is sent a message “b” to the next node available on the net, thus establishing itself as the new central point of the network.

The nodes have been doing with a raspberry pi zero wireless on a bridge and the sx1272 module as show in the figure 1

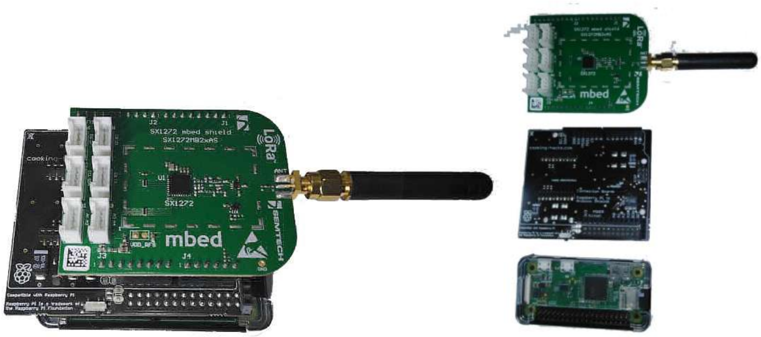

**Fig. 2.** Parts of the nodes (Raspberry pi Zero + sx1272 + Bridge)

### 4.4 Data

To evaluate the function of the net there are made some prove with different configurations on Number of Symbols, Bandwidth, Diffusion Factor and Data Rate knowing that's those variable depends on each other in the table 2 we see the different configurations to the nodes.

| | | | | |
|---|---|---|---|---|
| Bandwidth | 125 Hz | 125 Hz | 500 Hz | 500 Hz |
| Spreading Factor | 12 | 7 | 12 | 7 |

**Table 2.** Configurations by node of the LPWAN

### 4.5 Results

## 5 Conclusions

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