Libraries Documentation

Pau Garcia Calderó
EETAC - UPC
paugarcia32@gmail.com

Table of Contents

1. Introduction

In this document, I will compare and analyze which LoRa library is the best for this project. As I want to determine all the possible parameters, I will choose the library that allows the user to select and change more parameters.

All this analysis is considering the use of ESP32-S3 microcontrollers, utilizing the Arduino language and its related libraries.

2. Comparison Between Libraries LoRa Libraries

As of today, I have found only three different libraries that allow Arduino to use LoRa, either using embedded LoRa modules or external modules.

2.1. Unofficial Heltec

First, there is an `unofficial Heltec` library [1] that tries to implement all the functions related to Heltec Boards, because the official documentation is not intuitive.

This library, as the documentation says, is supposed to use the `SX-1262 LoRa module`, so I don't know if it would work if you try to use this library with any other module.

Also, in the documentation, we can find that this library reuses the `RadioLib` [2] library. As we will see in Section 2.3, the `RadioLib library` allows the use of many more `SX LoRa modules`, so it could allow us to implement other `SX LoRa modules`.

2.1.1. Unnoficial Heltec Modules

Module	Description
SX1262	Semtech SX1262 sub-GHz transceiver

Table 1: Heltec Modules List

2.2. Arduino LoRa

In second place, we have the `Arduino LoRa library` [3]. This library is also an unofficial library maintained by the comunity, which allows the `Semtech SX1276/77/78/79` based boards.

2.2.1. Arduino LoRa Modules

Module	Description
SX127x	series LoRa modules (SX1272, SX1273, SX1276, SX1277, SX1278, SX1279)
Dragino	Lora Shield
HopeRF	RFM95W, RFM96W, and RFM98W
Modtronix	inAir4, inAir9, and inAir9B

Table 2: Arduino LoRa Modules List

2.3. RadioLib

In third place, we have the `RadioLib library` [2]. `RadioLib` allows its users to integrate all sorts of different wireless communication modules & protocols into a single system.

RadioLib natively supports Arduino, but can run in non-Arduino environments as well.

2.3.1. RadioLib Modules

Module	Description
CC1101	FSK radio module
LLCC68	LoRa module
LR11x0	series LoRa/GFSK modules (LR1110, LR1120, LR1121)
nRF24L01	2.4 GHz module
RF69	FSK/OOK radio module
RFM2x	series FSK modules (RFM22, RFM23)
RFM9x	series LoRa modules (RFM95, RFM96, RFM97, RFM98)
Si443x	series FSK modules (Si4430, Si4431, Si4432)
STM32WL	integrated microcontroller/LoRa module
SX126x	series LoRa modules (SX1261, SX1262, SX1268)
SX127x	series LoRa modules (SX1272, SX1273, SX1276, SX1277, SX1278, SX1279)
SX128x	series LoRa/GFSK/BLE/FLRC modules (SX1280, SX1281, SX1282)
SX123x	FSK/OOK radio modules (SX1231, SX1233)

Table 3: RadioLib Modules List

2.4. Comparison table

	Unnoficial Heltec	Arduino LoRa	RadioLib
Frequency (MHz)	⊠	⊠	⊠
Spreading Factor	⊠	⊠	⊠
Signal Bandwidth (KHz)	⊠	⊠	⊠
Coding Rate		⊠	⊠
Preamble Length (bits)		⊠	⊠
P_{tx} (dBm)	⊠	⊠	⊠
Bus Type	SPI	SPI	SPI
Callbacks (Channel Activity Detection)	⊠	⊠	
Implicit / Explicit Header		⊠	⊠
Write data to the packet	⊠	⊠	⊠
RSSI		⊠	⊠
SNR		⊠	
Packet Frequency Error		⊠	
Radio modes		Idle Sleep	
Sync word		⊠	⊠
CRC		⊠	⊠
Invert IQ signals		⊠	
LNA gain		⊠	

Table 4: Library Table Comparison

2.5. Extra parameters to take into account

For this table, is has been taken into account the following:
- The library is considered updated if there has been some commit into the original repository in the last 12 months.
- The documentation is considered as good, if there are examples of code of how to use the API of the library and it helps to use the library.

	Unnoficial Heltec	Arduino LoRa	RadioLib
Library Updated	☒	☒	☒
Good Documentation	☒	☒	☒

Table 5: Extra Parameters Table

3. Comparison Between Libraries LoRaWAN Libraries

For LoRaWAN, I've found many different libraries, but a lot of them are only tested with very specific hardware, so on the following, you will find some of the most wide hardware tested libraries I've been able to find.

3.1. Beelan-LoRaWAN

In first place, there is the `Beelan LoRaWAN` [4] Library. This library is develop for be used in a generic platform, so is useful in our case.

3.1.1. Beelan Modules

Module	Description
SX127x	series LoRa modules (SX1273, SX1277, SX1278 and SX1279)

Table 6: Beelan Modules List

3.2. Arduino LoRaWAN

In second place, there is the `MCCI Arduino LoRaWAN` [5] Library. The `arduino-lorawan` library provides a structured way of using the arduino-lmic library to send sensor data over The Things Network or a similar LoRaWAN-based data network.

3.2.1. Arduino LoraWAN Modules

Module	Description
SX127x	series LoRa modules (SX1276-based)

Table 7: Arduino LoRaWAN Modules List

3.3. Comparison table between LoRaWAN libraries

	Beelan	Arduino LoRaWAN
Authentication Keys	☒	☒
OTAA Activation	☒	☒
LoRa Modules Sleep Mode	☒	
LoRaWAN Class	A & C	Only A

Table 8: LoRaWAN Library Table Comparison

3.4. Extra parameters to take into account

For this table, is has been taken into account the following:
- The library is considered updated if there has been some commit into the original repository in the last 12 months.
- The documentation is considered as good, if there are examples of code of how to use the API of the library and it helps to use the library.

	Beelan LoRaWAN	Arduino LoRaWAN
Library Updated	☒	☒
Good Documentation	☒	☒

Table 9: Extra Parameters Table

Bibliography

[1] R. Pihlakas, "Heltec ESP32 LoRa V3." [Online]. Available: https://github.com/ropg/heltec_esp32_lora_v3

[2] J. Gromeš, "RadioLib: Universal wireless communication library for Arduino." [Online]. Available: https://github.com/jgromes/RadioLib

[3] S. Mistry, "Arduino-LoRa." [Online]. Available: https://github.com/sandeepmistry/arduino-LoRa

[4] E. Cats, "Beelan-LoRaWAN." [Online]. Available: https://github.com/ElectronicCats/Beelan-LoRaWAN?tab=readme-ov-file

[5] M. Catena, "Arduino-LMIC LoRaWAN Library." [Online]. Available: https://github.com/mcci-catena/arduino-lorawan

Acronyms

Acronym	Meaning
LoRa	Long Range
MHz	Mega Hertz
KHz	Kilo Hertz
dBm	decibel-milliwatts
SNR	signal-to-noise ratio
RSSI	Received Signal Strength Indicator
CRC	Cyclic Redundancy Check
IQ	In-Phase and Quadrature
LNA	Low-Noise Amplifier