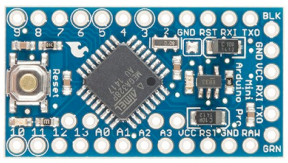
Congduc Pham, **http://cpham.perso.univ-pau.fr**

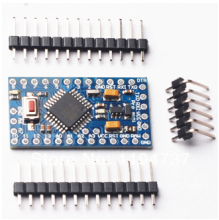
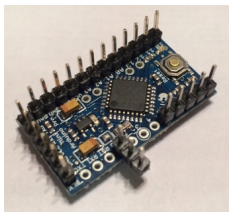
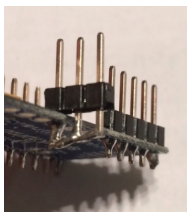
http://www.waziup.eu

The generic hardware platform

The Arduino Pro Mini

The Arduino Pro Mini is a compact form factor Arduino board based on the ATmega328P microcontroller
Use the **3.3v and 8MHz version** of the Arduino Pro Mini for lower power consumption



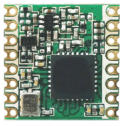
You can get the original board designed by Sparkfun or get one of the various clones available mainly from Chinese manufacturer. The last solution is very cost-effective as the Pro Mini board can be purchased for a bit more than 1€ a piece.

Depending on how many sensors you want to connect, the number of ground (GND) pins may be limited. You can extend a GND pin with a header pin where all pins are soldered together.

The LoRa radio module

There are various LoRa radio modules that are all based on the Semtech SX1272/1276 chips family

Fully tested LoRa radio modules


HopeRF RFM92W/95W

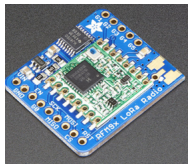

Libelium LoRa

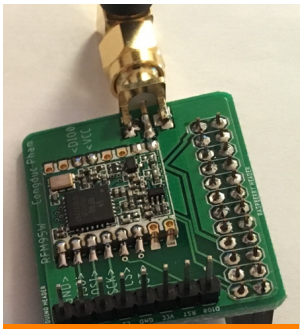

Modtronix inAir4/9/9B

NiceRF LoRa1276

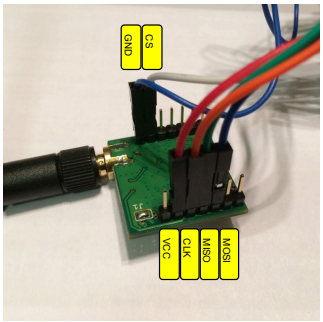
Most of SPI-based LoRa radio modules are supported. The Modtronix inAir model can come with header pins ready to be connected with Dupont wires, simplifiying the procedure.

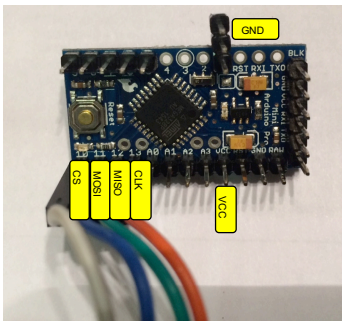
The RFM95W can be found assembled (Adafruit for instance) otherwise there are many breakout boards available. We have designed one that is freely available: https://github.com/CongducPham/LowCostLoRaGw#pcbs




https://github.com/CongducPham/LowCostLoRaGw#pcbs

Connect the LoRa radio module





Connect the corresponding SPI pins of the radio module to the SPI pins on the Pro Mini board. MOSI (blue) is pin 11, MISO (green) is pin 12, CS (white) is pin 10 and CLK (orange) is pin 13 (right picture). Then connect also the VCC (red) and the GND (black) of the radio module to the VCC and the GND of the board (right picture). The VCC of the Pro Mini board gets 3.3v from the on-board voltage regulator.

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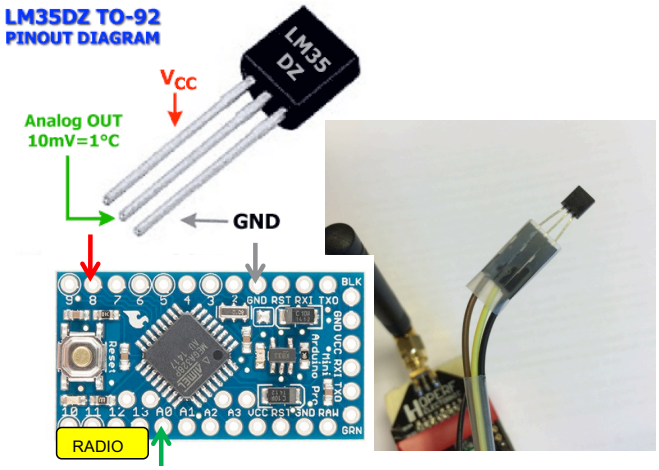
Connecting a sensor

Use a simple temperature sensor: LM35DZ

Connect sensor's VCC pin Pro Mini's digital pin 9 to power the sensor

Connect sensor's Analog OUT to Pro Mini's analog pin A0 to read value from sensor

Connect sensor's GND pin to one of Pro Mini's GND pin



Uploading our temperature template code

Get the Arduino libraries and code templates

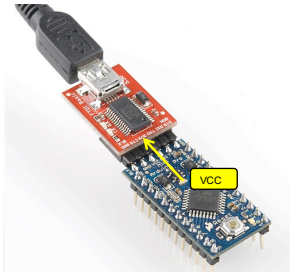
Get the entire ZIP archive of the **LowCostLoRaGw** github repository at https://github.com/CongducPham/LowCostLoRaGw

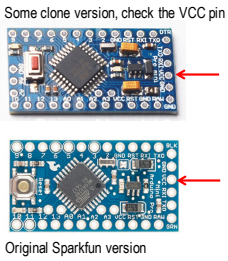
Unzip the archive and copy the content of the **Arduino** folder in your Arduino IDE sketch folder
If you already have a **libraries** folder in your sketch folder, copy the content of the new libraries folder in your libraries folder

Open the **Arduino_LoRa_Simple_temp** sketch and select the Arduino Pro Mini board in its 3.3V & 8MHz version

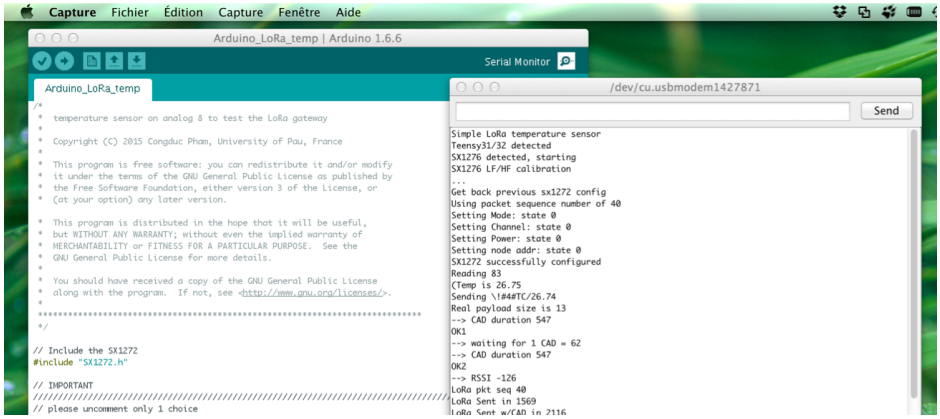
Connect the Arduino Pro Mini to an FTDI breakout USB cable (in 3.3v version). Check the VCC pin and make it to correspond to the VCC pin of the FTDI breakout

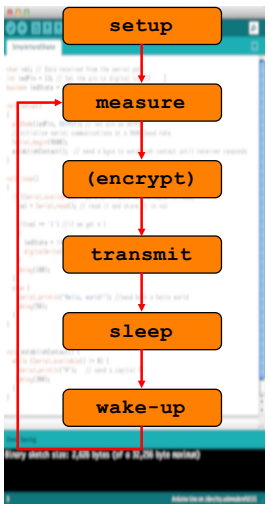
Connect the USB end to your computer and the USB port should be detected in the Arduino IDE. Select the serial port for your device. Then click on the « upload » button





Use the Serial Monitor to check the device output
The template will cycle through **measure-transmit-sleep(10min)-wakeup** with low-power mode





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Sending LoRa messages

Device default configuration

Default configuration uses BW=125kHz, CR=4/5, SF=12 i.e. LoRa mode 1

This configuration allows for the longest range

The default gateway radio configuration is similar

Range ↕ Throughput

LoRa mode	BW	CR	SF
1	125	4/5	12
2	250	4/5	12
3	125	4/5	10
4	500	4/5	12
5	250	4/5	10
6	500	4/5	11
7	250	4/5	9
8	500	4/5	9
9	500	4/5	8
10	500	4/5	7

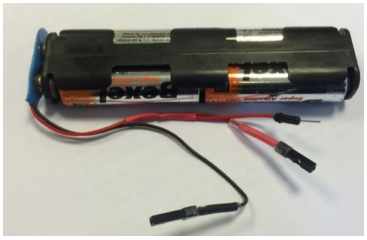
ch	F(MHz)	ch	F(MHz)	ch	F(MHz)
04	863.2*	00	903.08	**00**	**433.3***
05	863.5*	01	905.24	01	433.6*
06	863.8*	02	907.40	02	433.9*
07	864.1*	03	909.56	03	434.3*
08	864.4*	04	911.72	-	-
09	864.7*	**05**	**913.88**	-	-
10	**865.2**	06	916.04	-	-
11	865.5	07	918.20	-	-
12	865.8	08	920.36	-	-
13	866.1	09	922.52	-	-
14	866.4	10	924.68	-	-
15	867.7	11	926.84	-	-
16	867.0	12	915.00	-	-
17	868.0	-	-	-	-
18	868.1*	-	-	-	-

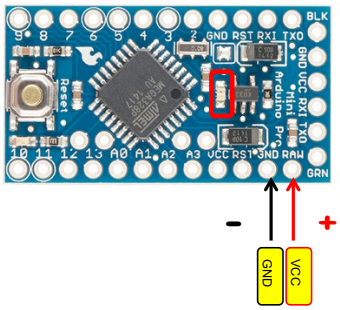
The default frequency at the end-device depends on the selected band. Using the default configuration (865.2 MHz) allows for out-of-the-box reception at the gateway

Achieving ultra low power consumption

Run on battery

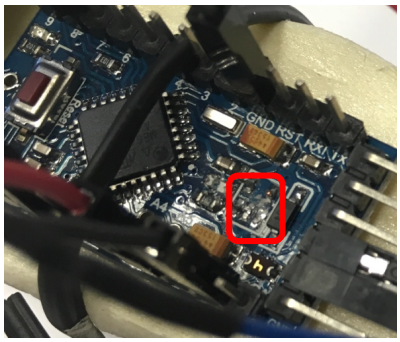
You can use 4 AA batteries to provide 4x1.5v=6v. This will be injected into the RAW pin of the board, using the on-board voltage regulator to get 3.3v. Remove the power led to greatly reduce power consumption: in sleep mode, the board draws about 5uA and can run for more than 2 years on the basis of 1 measure/hour





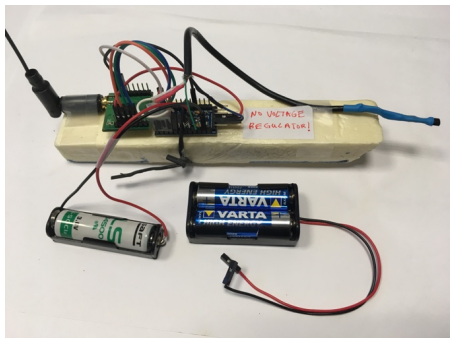
Ultra low power

Remove the voltage regulator and directly inject 3.1v – 3.6v to the VCC pin of the board



By removing the voltage regulator, you can use a single 3.6v Lithium-based battery or 2 regular AA batteries that provides about 3.1v

You can use the VCC pin on the programming header to power the board, as the other VCC pin is needed for the radio module



Additional ressources & tutorials

The general github repository **https://github.com/CongducPham/LowCostLoRaGw**
The WAZIUP github **https://github.com/Waziup**
IoT device video **https://www.youtube.com/watch?v=YsKbJeeav_M**
Gateway video **https://www.youtube.com/watch?v=peHkDhiH3IE**

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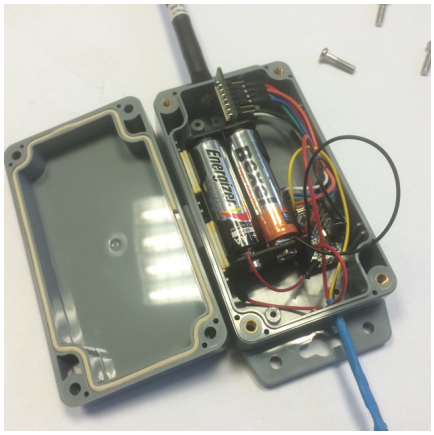
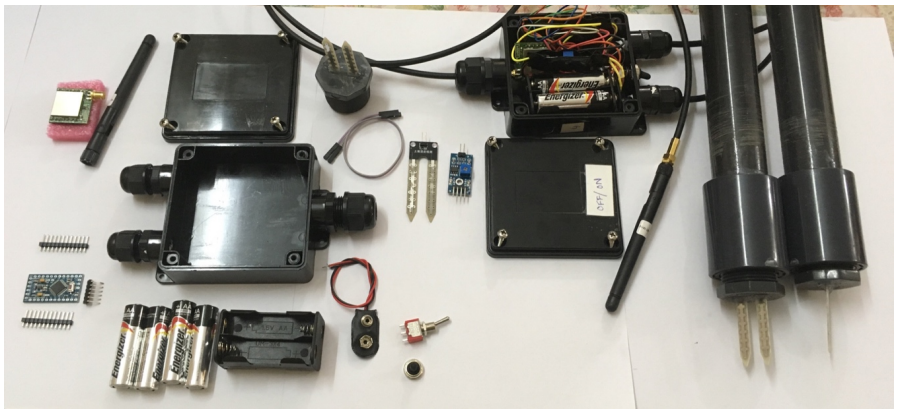
http://www.waziup.eu

Examples of integration into production device

Simple temperature device

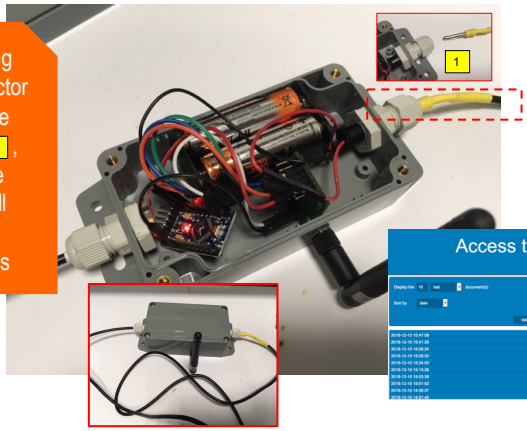


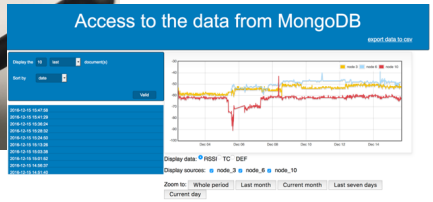
Multiple-level soil moisture device



Collar for cattle rustling applications

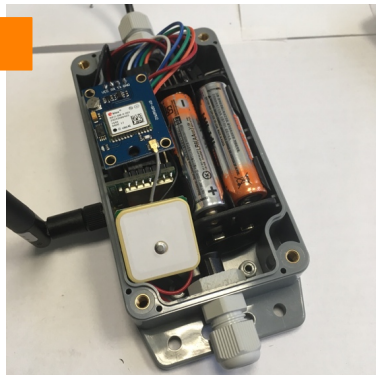
When connecting the male connector MC to the female connector FC 1, the board will be powered and will start sending periodic beacons





GPS version

Here, exact position can be obtained



Beacon's RSSI will be used to approximate collar distance

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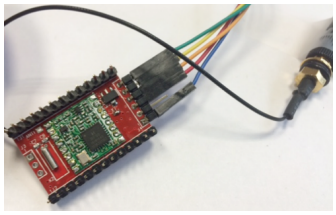
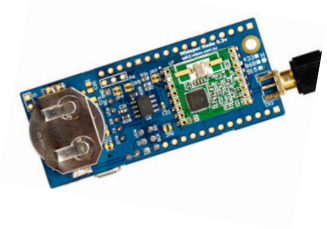
Using other platforms

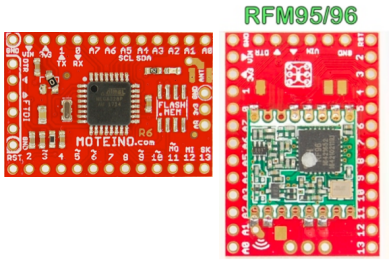
There are many boards that integrate a LoRa radio, mostly the HopeRF RFM95W radio module. These boards are often based on the ATmega328P (similar to the Arduino Pro Mini) or the ATmega32U4 where compatibility with the Arduino IDE is provided. They provide easier LoRa integration but are generally much more expensive than a Pro Mini + RFM95 radio module combination. We tested many of them and verified that our template code is working fine, including the low-power mode. Note that the Pro Mini with both power led and voltage regulator removed shows the lowest power consumption in sleep mode: 5uA.



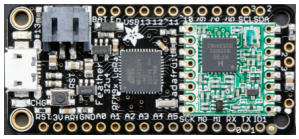
Ideetron Nexus
ATmega328P



Wisen WhisperNode
ATmega328P



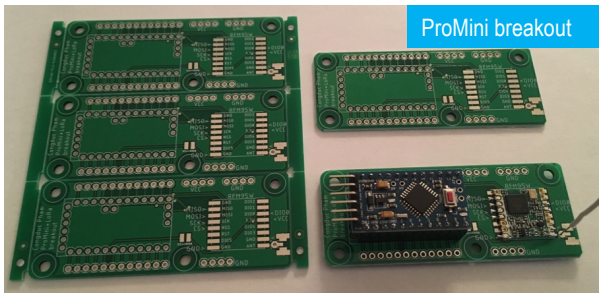
LowPowerLab Moteino
ATmega328P

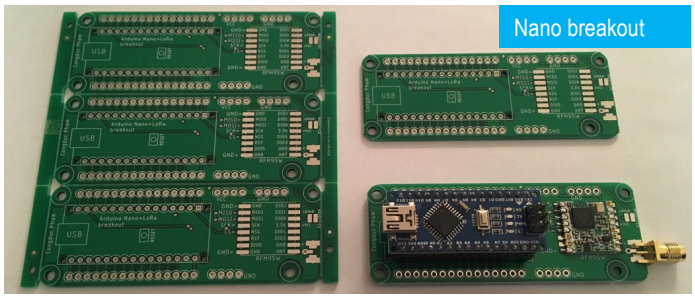


Adafruit Feather32U4
ATmega32U4

Using PCB design for easier integration

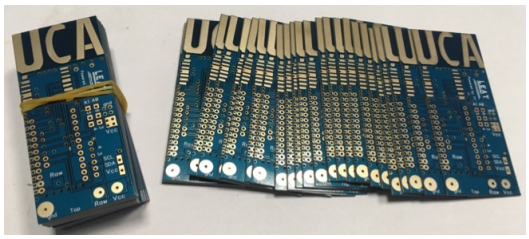
Simple PCBs can be designed to just facilitate the integration of the Arduino board and an RFM95W radio. We designed 2 simple PCBs to host an Arduino Nano (training purposes) and an Arduino ProMini. They are freely available at https://github.com/CongducPham/LowCostLoRaGw#pcbs

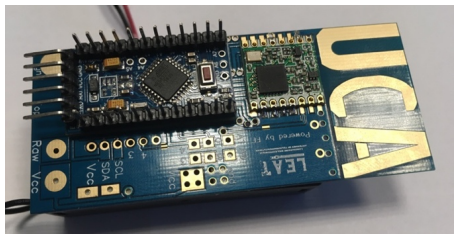




The open-source PCB from Fabien Ferrero of University of Nice, France, with an integrated antenna to avoid external fragile part when deploying the device

https://github.com/FabienFerrero/UCA_Board





WAZIDev

The WAZIDev board integrates the ATMega328P MCU with the FTDI chip and provide access to all pins of the MCU as well as proposing advanced features to ease integration on production IoT devices