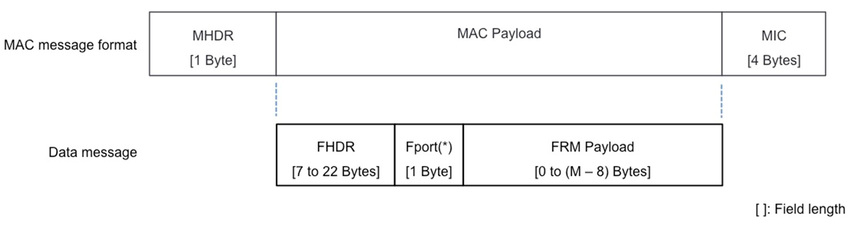
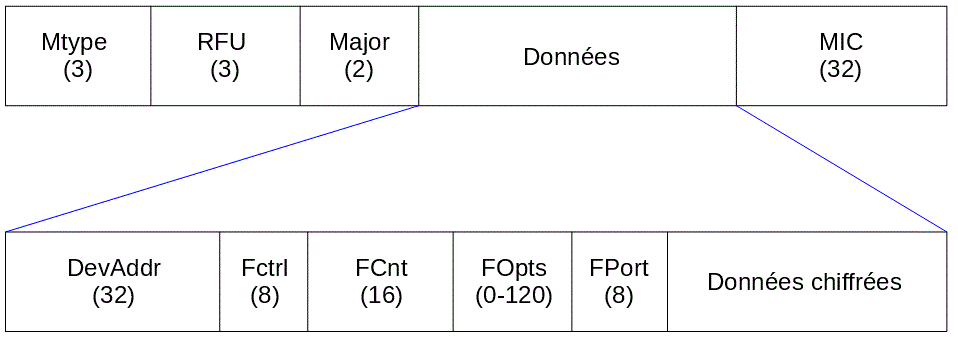
**Analysing payload’s maximum size and sensor’s parameters size**

Maximum size of my encrypted payload in the LoRaWAN data frame



**Fig.1 : Size of the fields in bytes [1]**

****

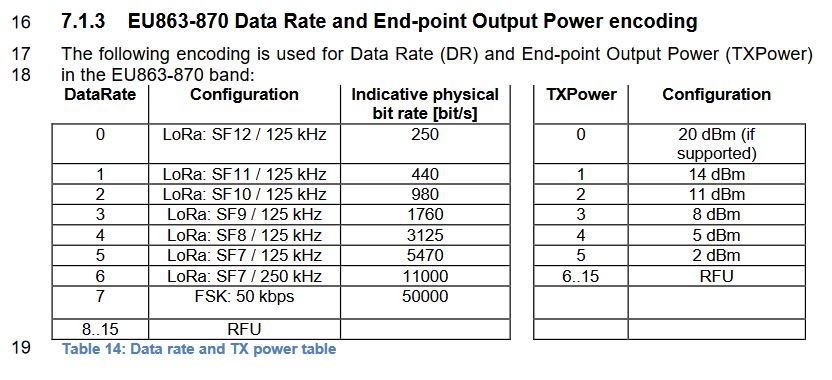
**Fig. 2 : Size of the fields in bits [14]**

Usually, 13 bytes are added to the packet (if the user didn’t specify any options) [2] [3] :

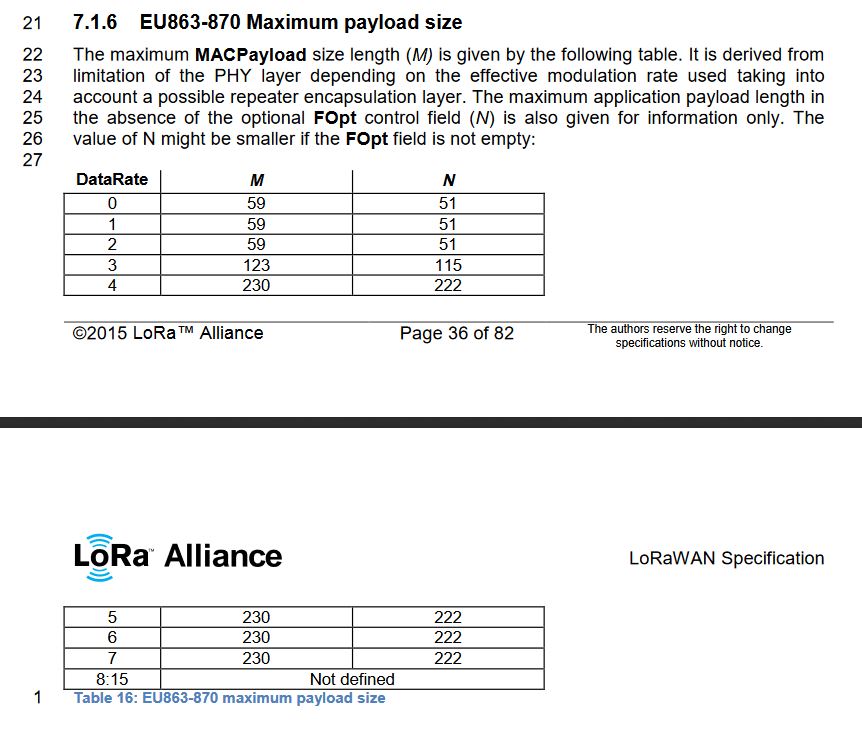
* MHDR (Mac Header) : 1 byte
* MIC (Message Integrity Code) : 4 bytes
* DevAddr (Device Address) : 4 bytes
* FCtrl (Control Field): 1 byte
* FCnt (Counter Field) : 2 bytes
* FPort (Port Field): 1 byte

The encrypted payload’s size varies from 0 to (M-8) bytes, where M is the maximum size of the MAC payload that changes with the data rate (the faster it is, the higher the value M is).

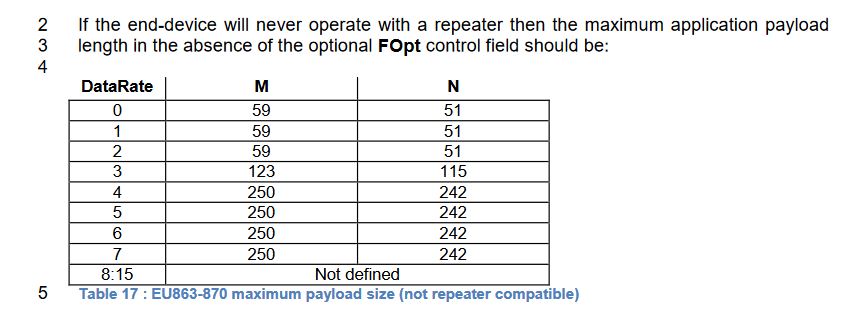
In the figure 3, we see the correspondence between the DataRate and the spreading factor. It is good to remind that when the spreading factor increases, the range increases but the data rate is slower.



**Fig. 3 : Correspondence between Data Rate and physical configuration [4] (page 35)**



**Fig. 4 : Maximum MACPayload size length (M) for a given data rate [4] (page 36 and 37)**



**Fig. 5 : Maximum MACPayload size without using repeaters [4] (page 37)**

However, since we will send data through The Things Network, we will be limited by the “fair-access policy” value of 11 bytes for our non-encrypted payload [15]

Focusing on the super-node

For our project, a super-node will be used and will have to include multiple sensors to measure the environmental parameters, such as the temperature, barometric pressure, humidity, …The first sensor is the “Pysense”, which is an expansion board packed with multiple sensors, that will be exposed further below. The LoPy that is used for this project can be easily attached to this expansion board, which makes the physical implementation easy [5].

**Humidity and temperature sensor (SI7006A20)**

According to the Pycom documentation [6], this sensor will return float values of humidity (%) and temperature (°C). One can use SI7006A20.humidity() or SI7006A20.temperature() to return a float value of the parameter to measure. According to the datasheet [8] of this component, the float values are coded with 16 bits (or 2 bytes). This means that 4 bytes are required for transmission in order to get the temperature and relative humidity from this sensor.

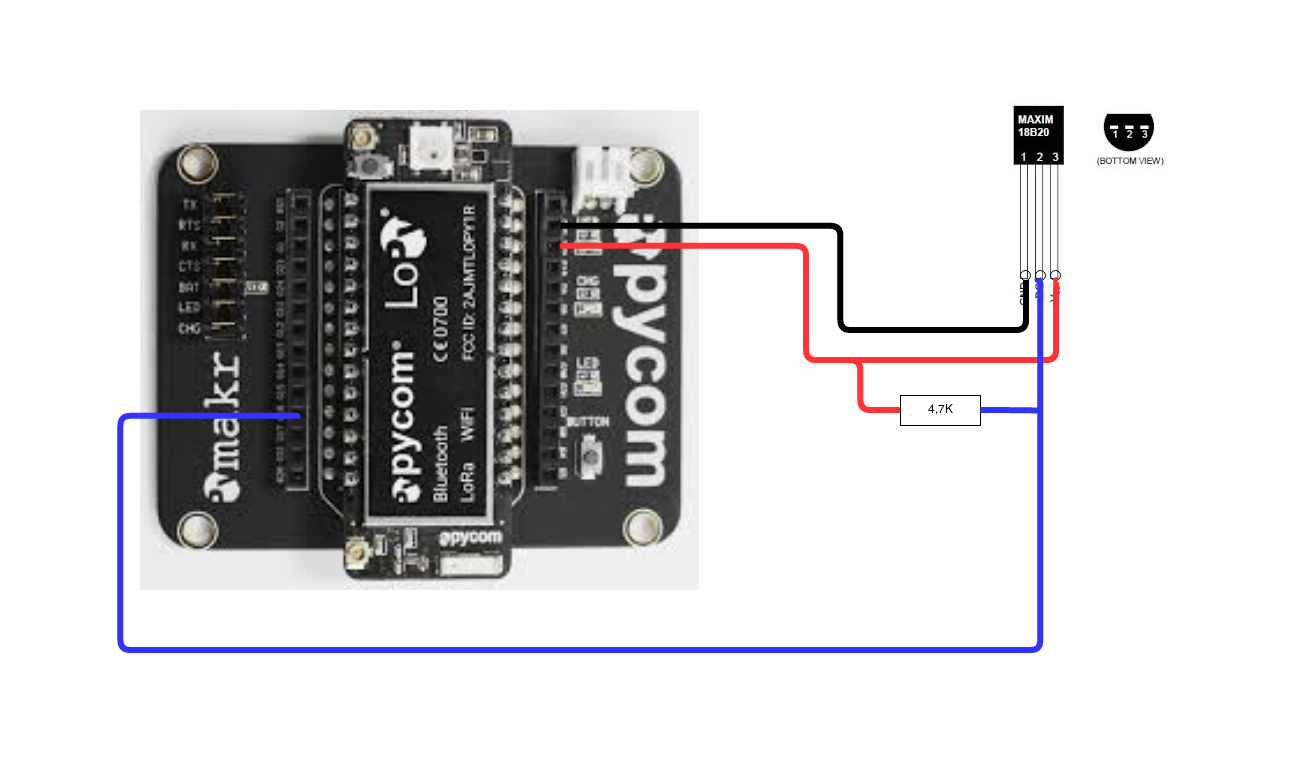
**Barometric pressure sensor with altimeter (MPL3115A2)**

According to the Pycom documentation [7], this sensor can return values of pressure, altitude and temperature (the last one will not be retrieved by this sensor). The command to retrieve the barometric pressure is MPL3115A2.pressure() (in Pa). The returned value is a float. The datasheet [9] says that the pressure is a 20-bit measurement, so the float value will be encoded on 32 bits (possibly an integer). This means that 4 bytes are required to get the barometric pressure from this sensor.

If the LoPy module is attached to the Pysense expansion board, a total of 8 bytes will be required to send the temperature, the relative humidity and the barometric pressure. This size can fit in the data frame and complies with The Things Network fair-access policy.

Other solutions for the super-node

**DS18B20:** a digital temperature sensor that outputs a temperature as a float number coded on 16 bits (2 bytes) [10]. An implementation of this sensor is presented in the figure below:



**Fig.6: Schematic of the LoPy on the Pymakr board, connected to the temp. sensor [11]**

The connections are made as followed:

* Connect the GND pin (1) of the sensor to the GND connector on the expansion board
* Connect the VDD pin (3) of the sensor to the 3v3 connector on the expansion board
* Connect the data line pin (2) of the sensor to the P9 (G16) connector on the board.

A resistor is also connected between data line and VDD (4.7 kOhms).

**BME280:** the BME280 sensor from adafruit can sense the temperature, humidity and the barometric pressure. The chip can communicate with the LoPy using I2C or SPI. The pressure (in Pa) is coded as a 32 bits integer, the temperature (in °C) and the relative humidity (in %) appear to be coded as 16 bits floats [12].



**Fig.7: Image of the BME280 sensor with the pins below [12]**

To use the sensor with the LoPy using I2C communication [12] [13]:

* Connect sensor’s VIN to 3v3 connector of the expansion board.
* Connect sensor’s GND to GND connector of the expansion board.
* Connect sensor’s SDI (I2C data line) to G16 connector of the board.
* Connect sensor’s SCK (I2C clock line) to G17 connector of the board.

Comments about parameter’s size

The previous sections have shown the technical characteristics of the data sent by the sensors. These are the technical limits that we cannot go over. However, it is useful to look at the needed size of environmental from a pragmatic point of view.

A 16 bits float roughly represents a number with 4 significant digits. For our project, the temperature measurement will be accurate enough with this precision. The measurements will be done somewhere around April, where the temperatures shouldn’t decrease under 5°C and increase over 30°C. A temperature that is like 20.15°C is accurate enough for our project.

The same conclusion applies to relative humidity. For this parameter, the values will go from 0 to 100%.

For the barometric pressure, 32 bits are needed. Not for accuracy, but because the sensors return values in Pa, which are usually big numbers (101 325 Pa) that cannot be represented with 16 bits (2^16 = 65536). However, if we know the offset of the sensor (this information is found in the datasheet), we could subtract this offset from the measured values and only send variations of pressure. This variation could be represented with 16 bits integers, because decimal values of pressure are extremely small (1 Pa = 1 N/m² which is approximately a force applied by a mass of 100 g over an area of 1 m²) and such small variations are most likely negligible for our project. This would reduce our payload by 2 bytes, with a final payload of 6 bytes (instead of 8 bytes).

Bibliography

[1] Modeling the Energy Performance of LoRaWAN (by Lluís Casals, Bernat Mir, Rafael Vidal and Carles Gomez) : <https://www.researchgate.net/publication/320435869_Modeling_the_energy_performance_of_LoRaWAN> (Viewed the 22.03.2019 at 19h45)

[2] <https://docs.allthingstalk.com/tutorials/lora-payload/> (Viewed the 22.03.2019 at 20h15)

[3] <https://www.thethingsnetwork.org/forum/t/spreadsheet-for-lora-airtime-calculation/1190/4> (Viewed the 22.03.2019 at 20h15)

[4] LoRaWAN specification V1.0 (by LoRa Alliance) : <https://www.rs-online.com/designspark/rel-assets/ds-assets/uploads/knowledge-items/application-notes-for-the-internet-of-things/LoRaWAN%20Specification%201R0.pdf> (Viewed the 22.03.2019 at 20h45)

[5] <https://docs.pycom.io/pytrackpysense/introduction.html#pysense> (Viewed the 23.03.2019 at 13h45)

[6] <https://docs.pycom.io/pytrackpysense/apireference/pysense.html#humidity-and-temperature-sensor-si7006a20> (Viewed the 23.03.2019 at 13h45)

[7] <https://docs.pycom.io/pytrackpysense/apireference/pysense.html#barometric-pressure-sensor-with-altimeter-mpl3115a2> (Viewed the 23.03.2019 at 13h45)

[8] Datasheet of the SI7006A20 sensor : <https://www.silabs.com/documents/public/data-sheets/si7006-a20.pdf> (Viewed the 23.03.2019 at 14h00)

[9] Datasheet of the MPL3115A2 sensor : <https://www.nxp.com/docs/en/data-sheet/MPL3115A2.pdf> (Viewed the 23.03.2019 at 14h00)

[10] Datasheet of the DS18B20 : <https://datasheets.maximintegrated.com/en/ds/DS18B20.pdf> (Viewed the 25.03.2019 at 14h15)

[11] Telenor start IoT : <https://startiot.telenor.com/learning/lorawan-temperature-sensor/> (Viewed the 25.03.2019 at 14h15)

[12] Adafruit BME280 sensor breakout : <https://www.mouser.com/ds/2/737/adafruit-bme280-humidity-barometric-pressure-tempe-740823.pdf> (Viewed the 25.03.2019 at 14h45)

[13] Telenor start IoT : <https://startiot.telenor.com/learning/lorawan-weather-station/> (Viewed the 25.03.2019 at 15h30)

[14] Wikipedia : Le protocole LoRaWAN <https://fr.wikipedia.org/wiki/LoRaWAN#Le_protocole_LoRaWAN> (Viewed the 25.03.2019 at 14h45)

[15] <https://www.thethingsnetwork.org/forum/t/limitations-data-rate-packet-size-30-seconds-uplink-and-10-messages-downlink-per-day-fair-access-policy/1300>