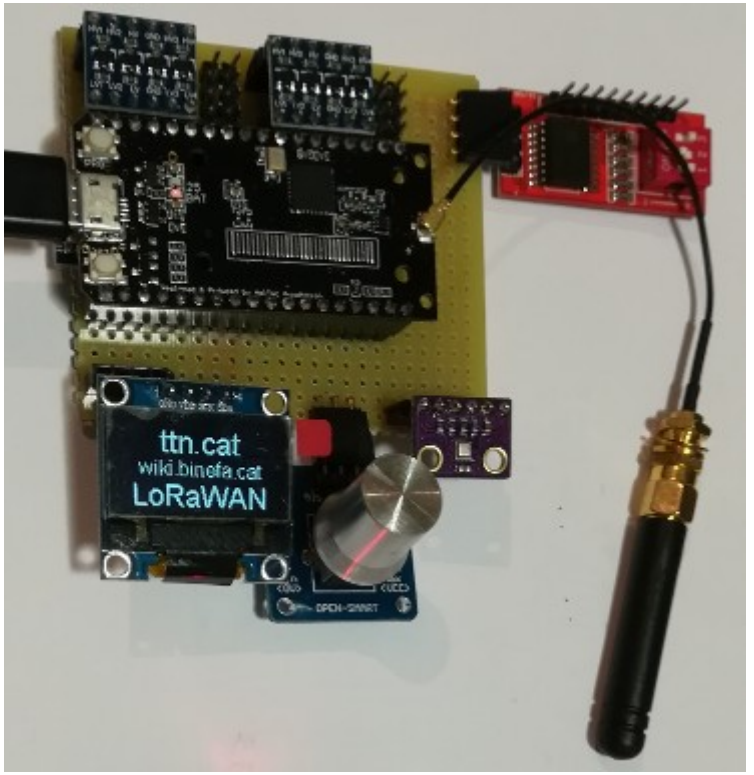
LoRaWAN™



THE THINGS NETWORK CATALUNYA

Esborrany v0.4

electronics.cat
OPEN SOURCE HARDWARE & TRAINING

JESUÏTES El Clot
Escola del Clot

http://www.thomasclausen.net/wp-content/uploads/2016/09/2016-A-Study-of-LoRa-Long-Range-Low-Power-Networks-for-the-Internet-of-Things.pdf

Què és?

LoRaWAN™ is a Low Power Wide Area Network (**LPWAN**) specification intended for wireless battery operated Things in a regional, national or global network. **LoRaWAN** targets key requirements of **Internet of Things** such as **secure bi-directional communication**, mobility and localization services.

https://www.lora-alliance.org/what-is-lora

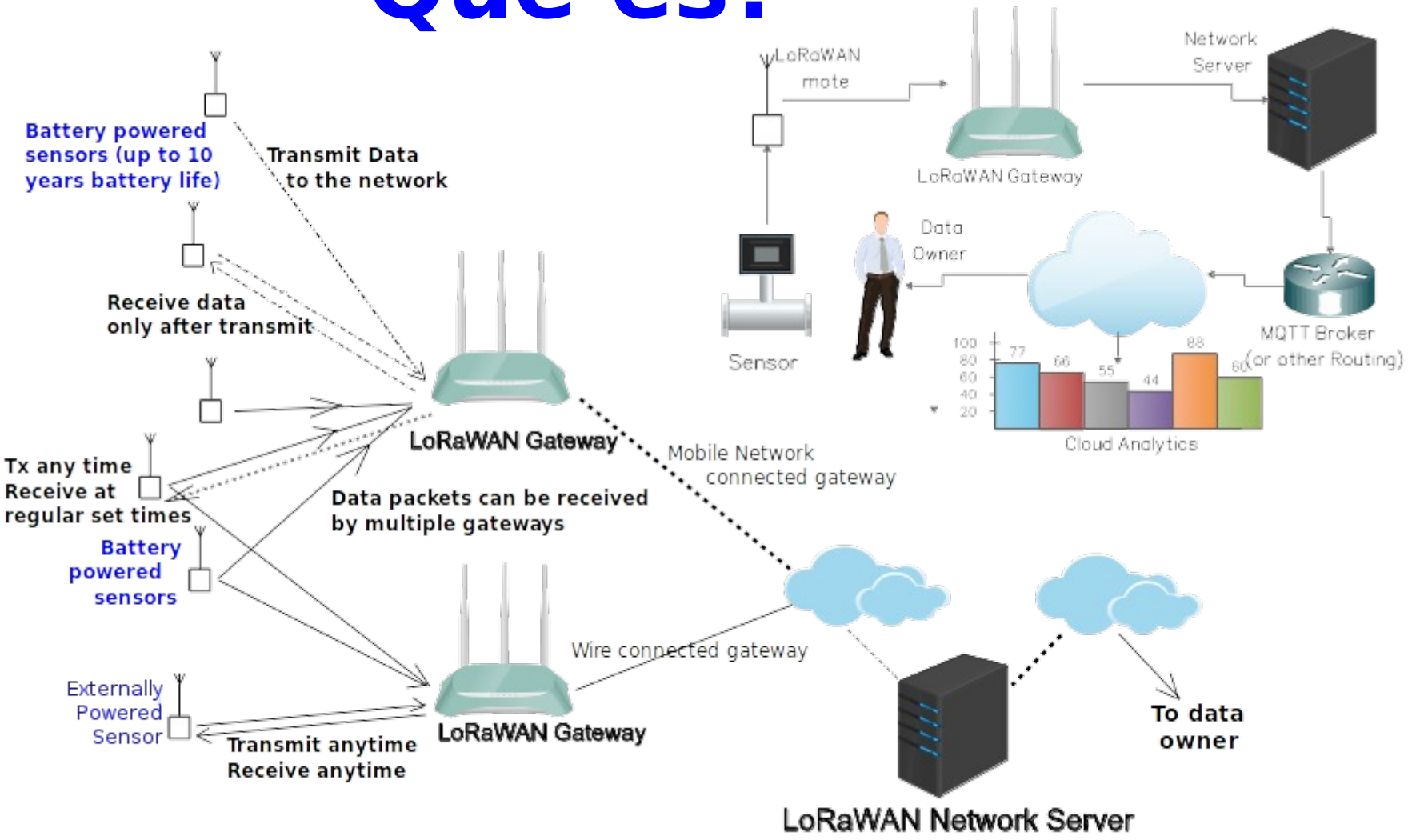
Què és?

LoRaWAN™ és una especificació d'una xarxa **LPWAN** (Low Power Wide Area Network) proposada per la **LoRa Alliance** i pensada per comunicar dispositius de baix cost i baix consum alimentats per bateries.
L'especificació cobreix les **capes PHY i MAC** de la xarxa, deixant les capes superiors a les aplicacions.

https://thethingsnetwork.cat/index.php/LoRaWAN

LoRaWAN™

Què és?



https://aprendiendoarduino.wordpress.com/tag/lorawan/

LoRaWAN™

Terminologia

Terminology

End Device, Node, Mote - an object with an embedded low-power communication device.

Gateway - antennas that receive broadcasts from End Devices and send data back to End Devices.

Network Server - servers that route messages from End Devices to the right Application, and back.

Application - a piece of software, running on a server.

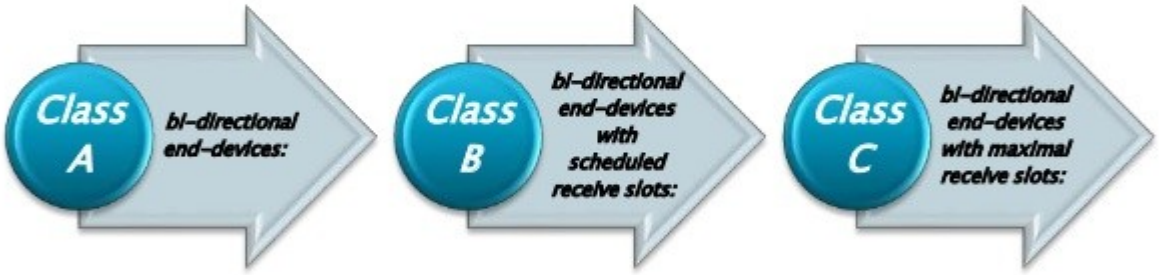
Uplink Message - a message from a Device to an Application.

Downlink Message - a message from an Application to a Device.

Classes de dispositius finals

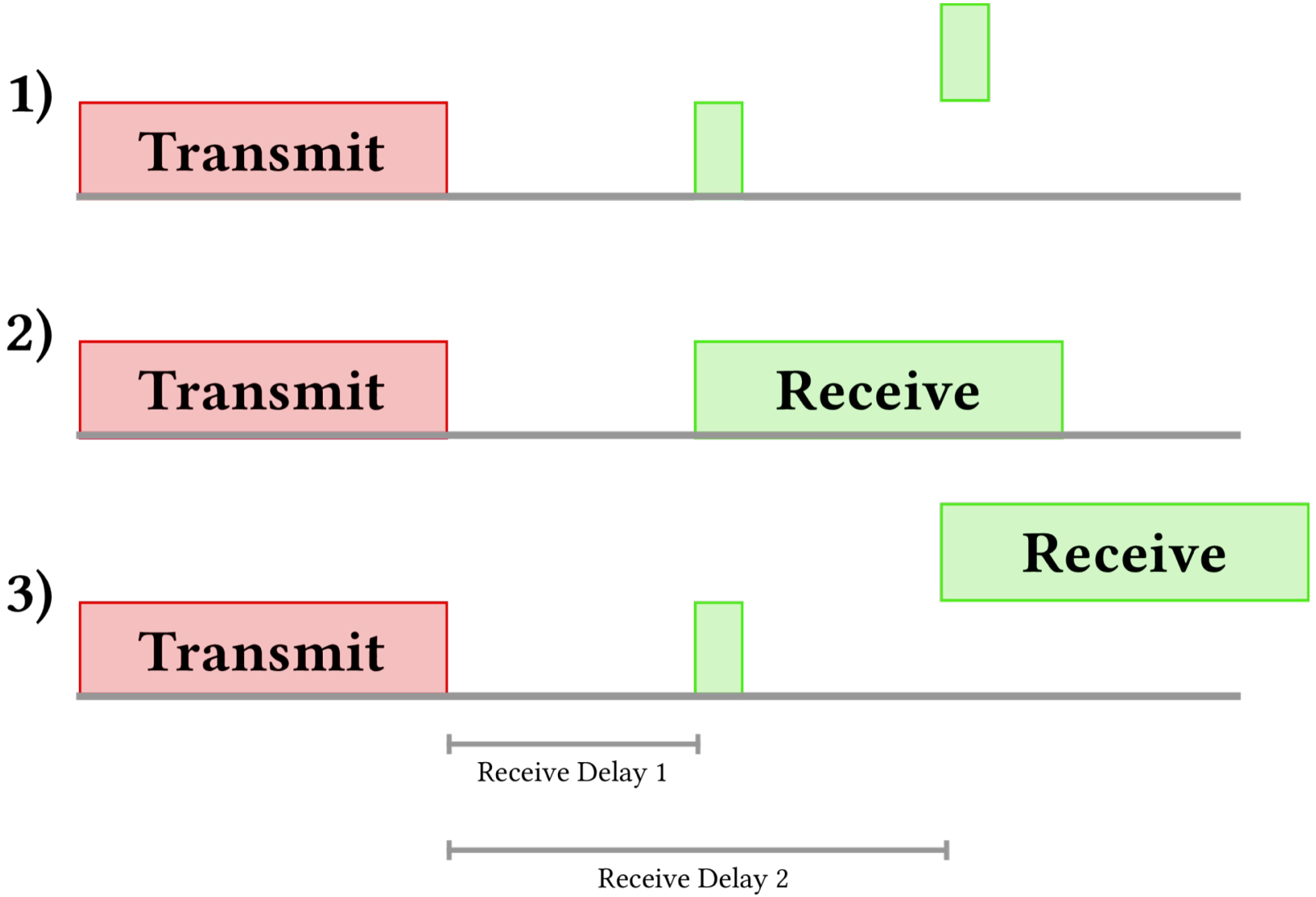
LoRaWAN endpoint classes

Accordingly the LoRaWAN supports three classes of endpoints:



https://www.slideshare.net/UTPALSINHA1/m2-m-iot-and-smart-city-solution-on-lorawan

Classe A de dispositius finals

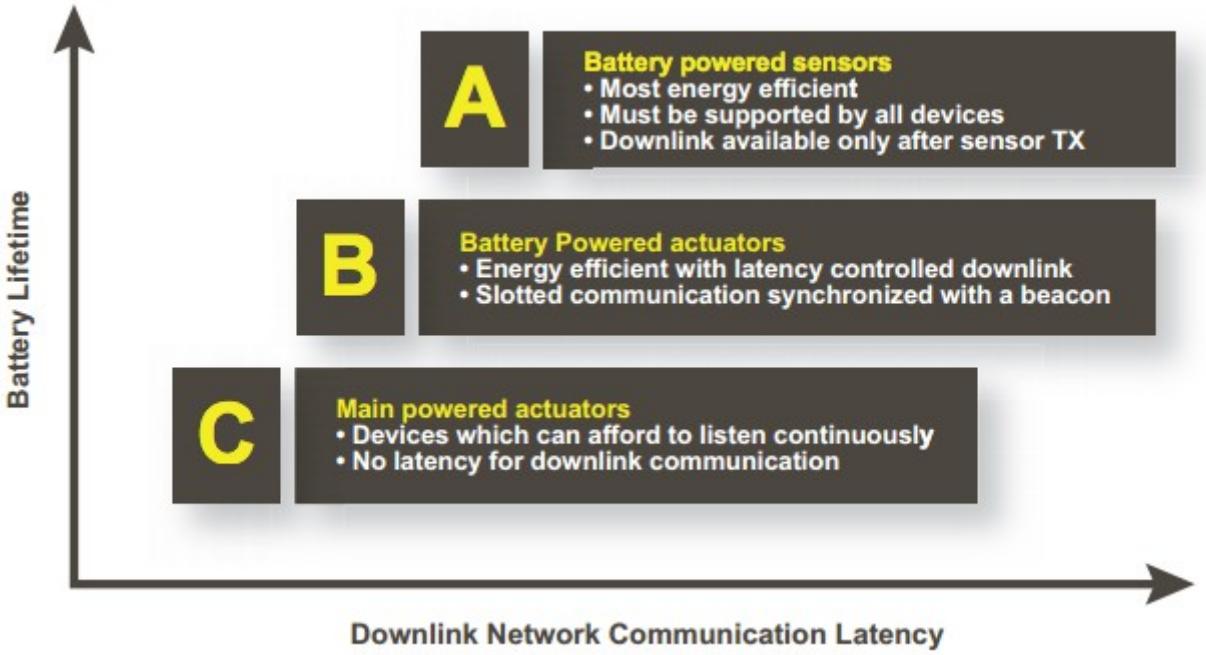


Classes de dispositius finals

CLASS NAME	INTENDED USAGE
A (« all »)	**Battery powered sensors**, or actuators with no latency constraint Most energy efficient communication class. Must be supported by all devices
B (« beacon »)	**Battery powered actuators** Energy efficient communication class for latency controlled downlink. Based on slotted communication synchronized with a network beacon.
C (« continuous »)	**Mains powered actuators** Devices which can afford to listen continuously. No latency for downlink communication.

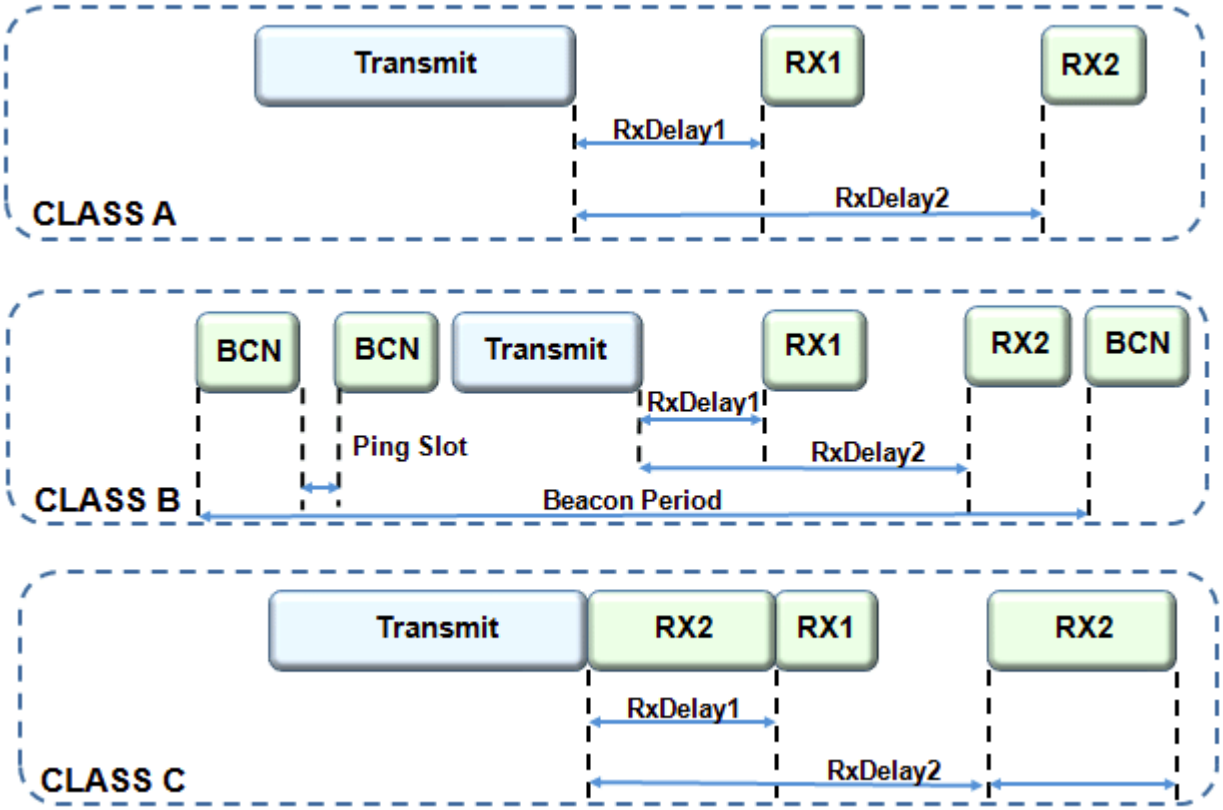
https://medium.com/iotforall/your-primer-for-lora-lorawan-33f1e0eb4215

Classes de dispositius finals



https://www.leverege.com/research-papers/lora-lorawan-primer

Classes de dispositius finals



https://www.researchgate.net/figure/Power-Consumption-vs-Range-for-Bluetooth-LE-Cellular-LoRaWan-and-Wi-Fi-technologies_fig3_318866065

LoRaWAN™

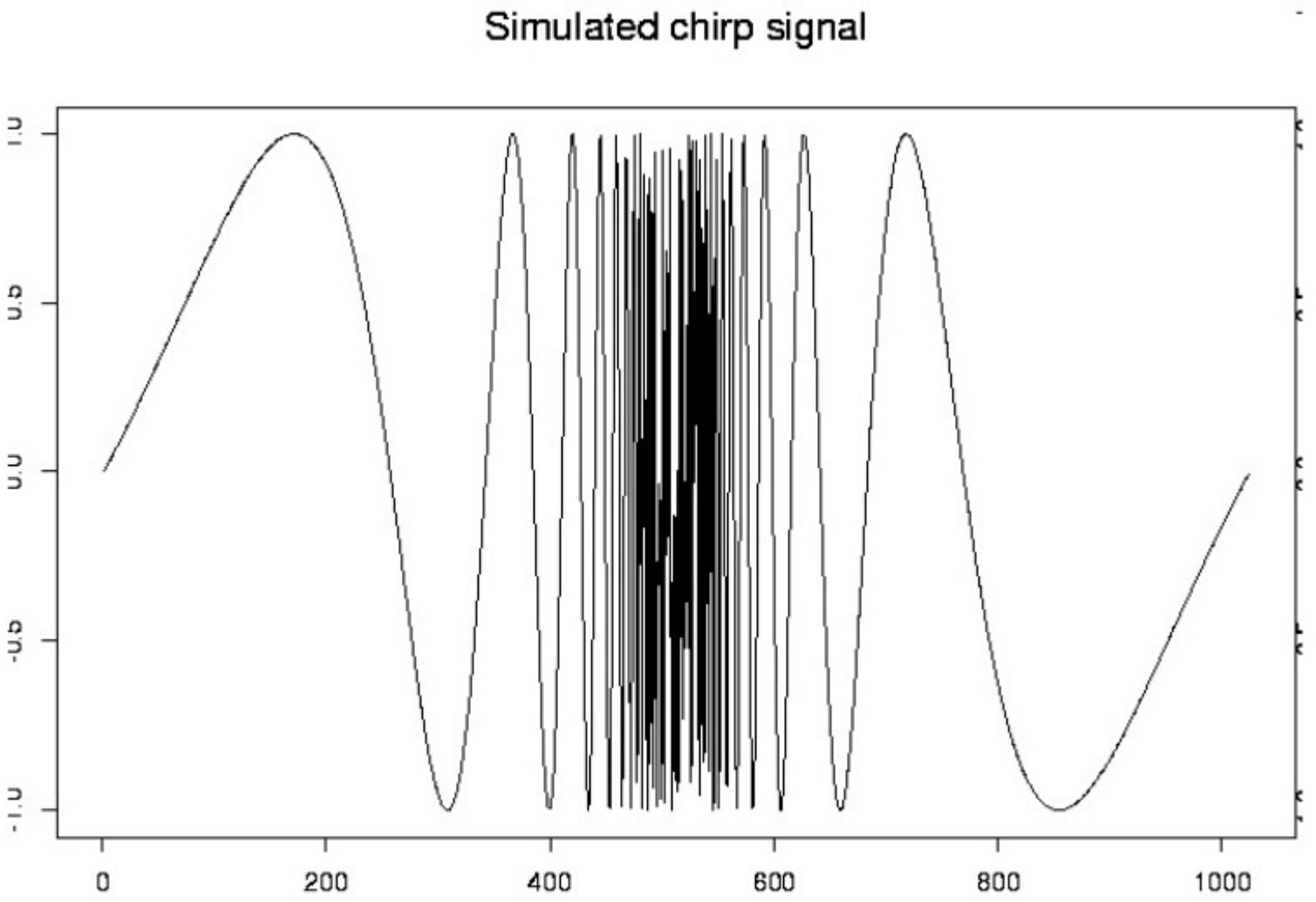
Modulació CHIRP

Chirp

- A **chirp** is a signal in which the frequency increases ('up-chirp') or decreases ('down-chirp') with time.
- In some sources, the term **chirp** is used interchangeably with **sweep signal**.
- It is commonly used in sonar and radar, but has other applications, such as in spread spectrum communications.
- In spread spectrum usage, SAW devices such as RACs are often used to generate and demodulate the chirped signals.
- In optics, ultrashort laser pulses also exhibit chirp, which, in optical transmission systems interacts with the dispersion properties of the materials, increasing or decreasing total pulse dispersion as the signal propagates.

https://www.slideshare.net/ajal4u/chirps

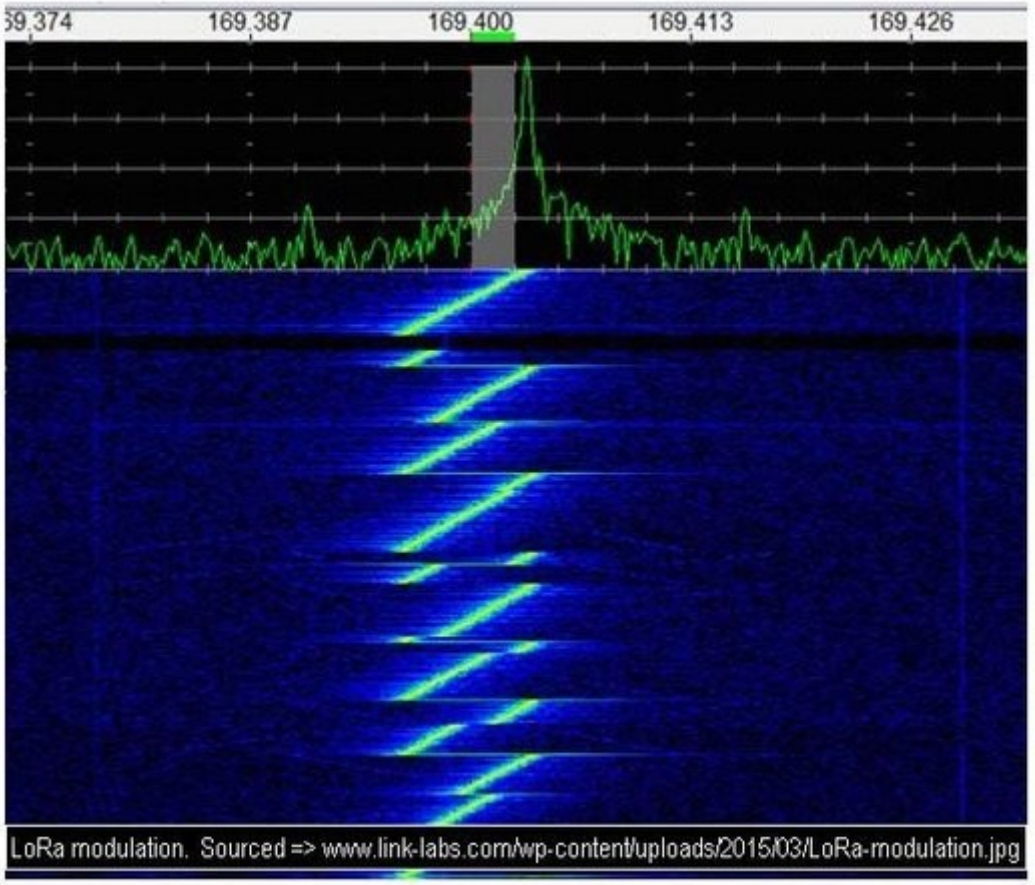
Modulació CHIRP

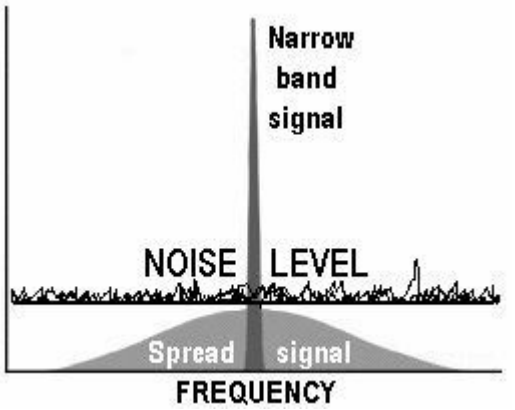


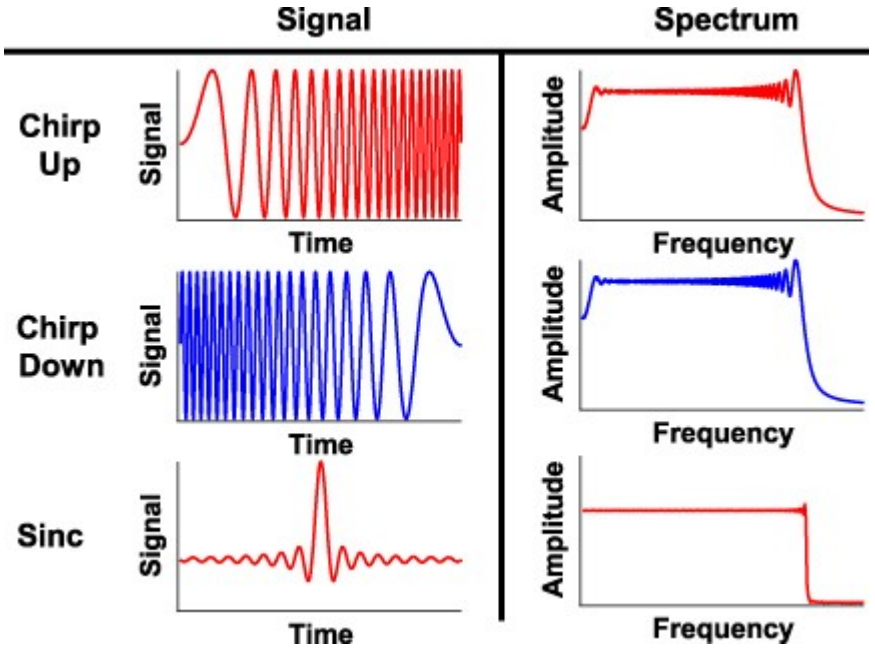
https://www.slideshare.net/ajal4u/chirps

LoRaWAN™

Modulació CHIRP



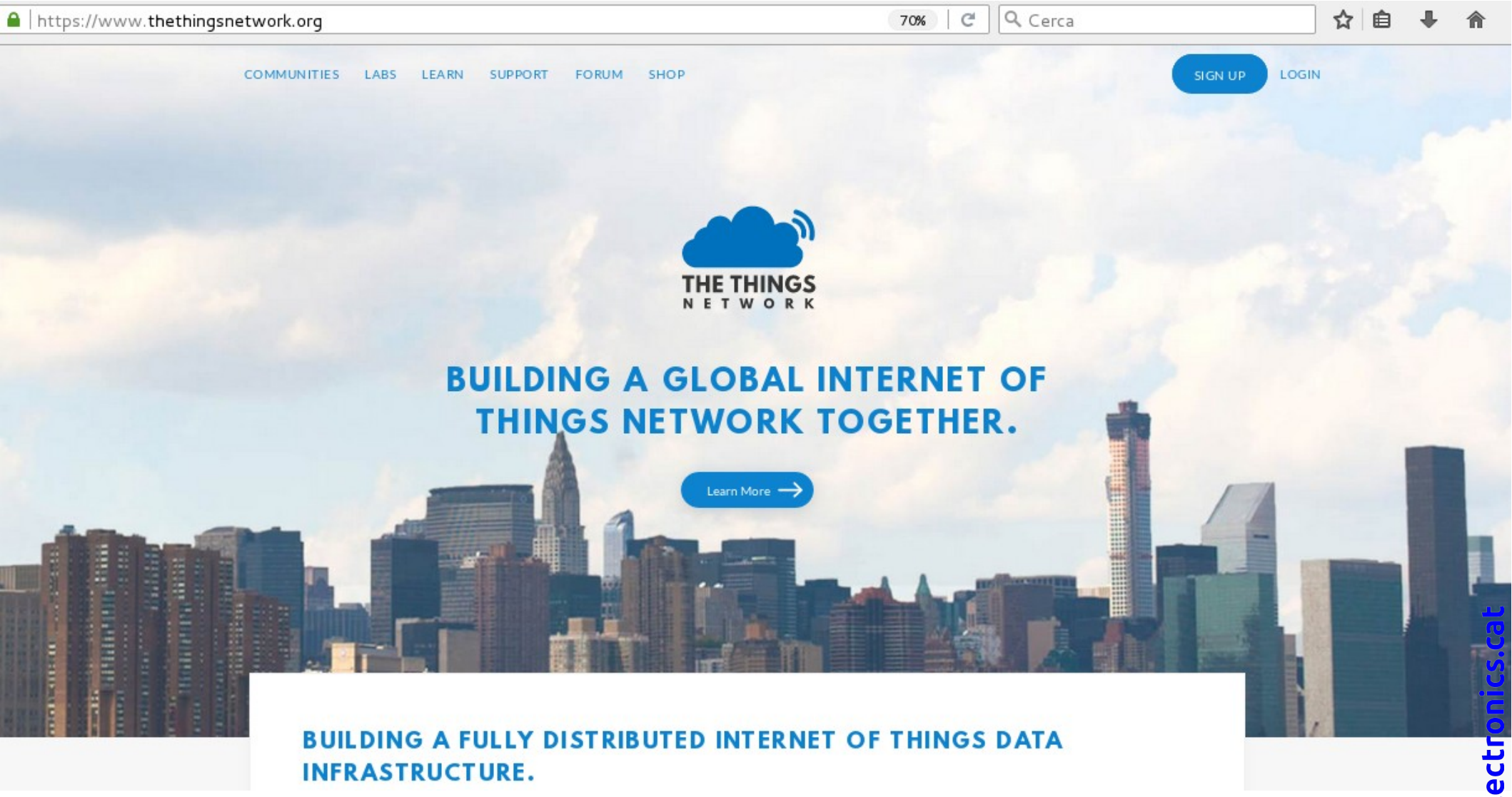




http://www.instructables.com/id/Introducing-LoRa-/
http://iopscience.iop.org/article/10.1088/0957-4484/23/1/015706

LoRaWAN™

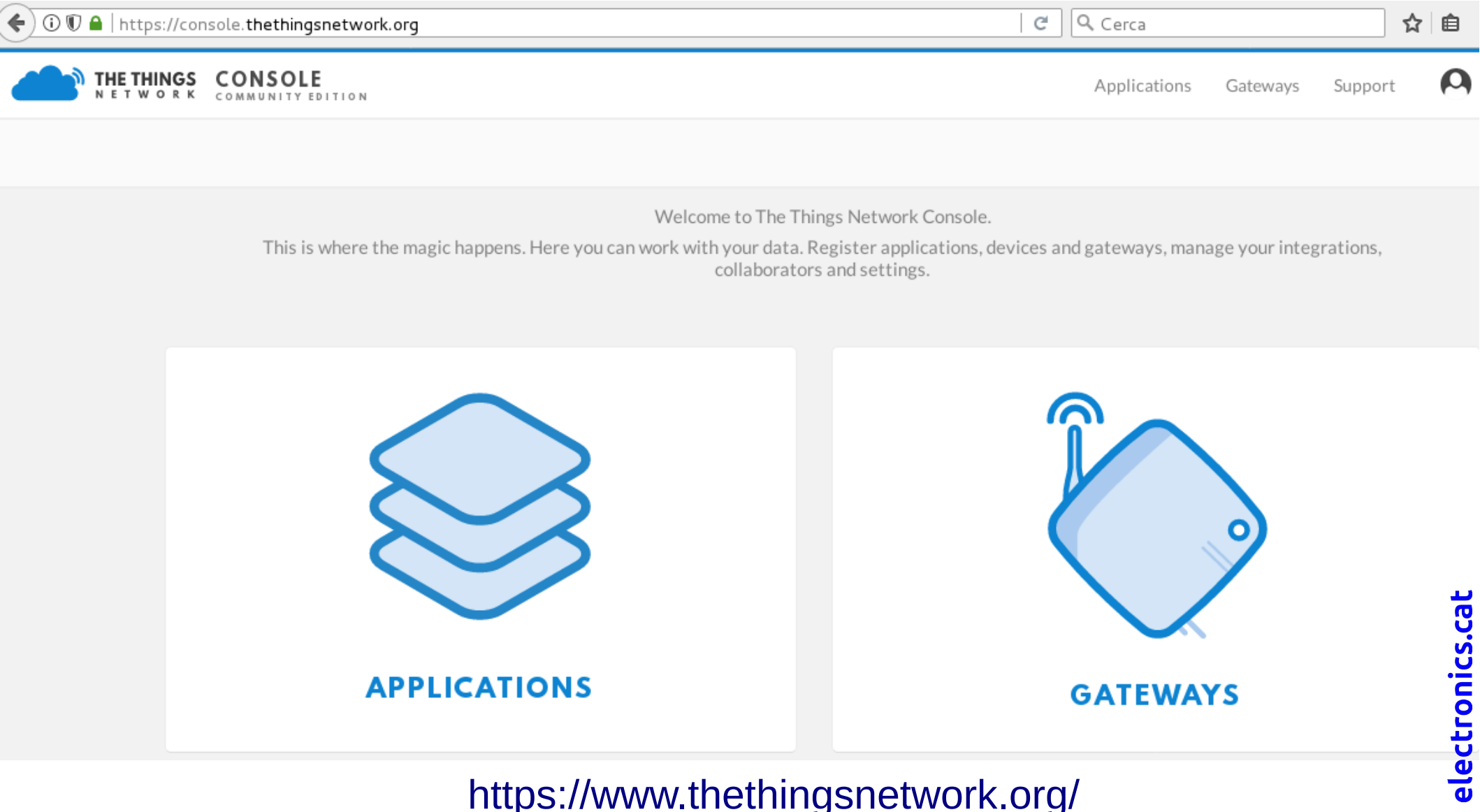
The Things Network



https://www.thethingsnetwork.org/

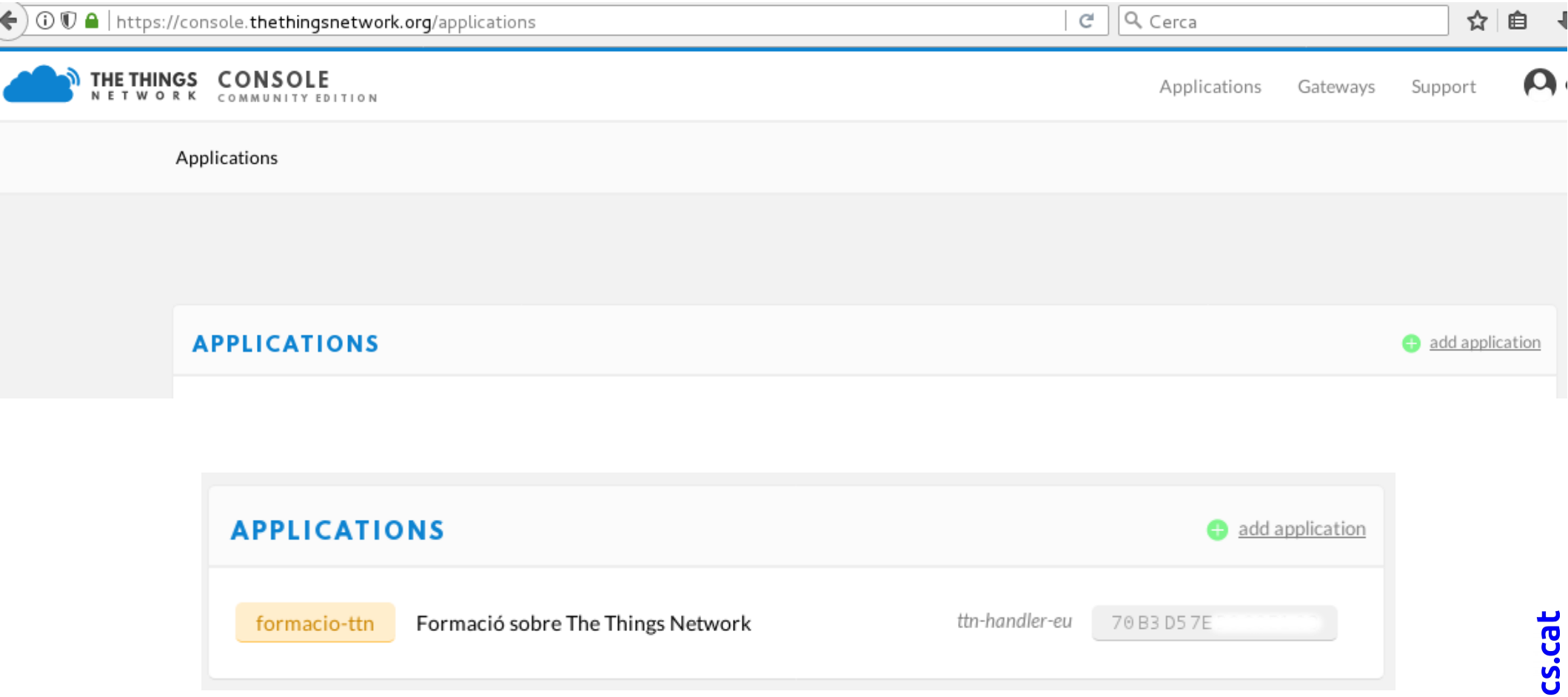
LoRaWAN™

La cònsola de The Things Network

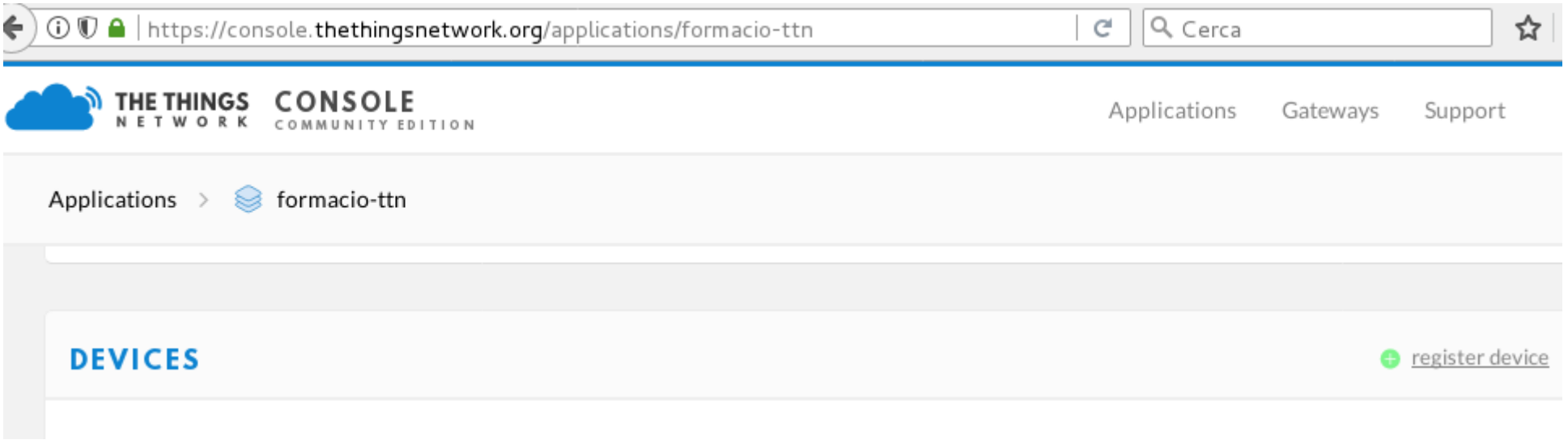


https://www.thethingsnetwork.org/

Nova aplicació a The Things Network

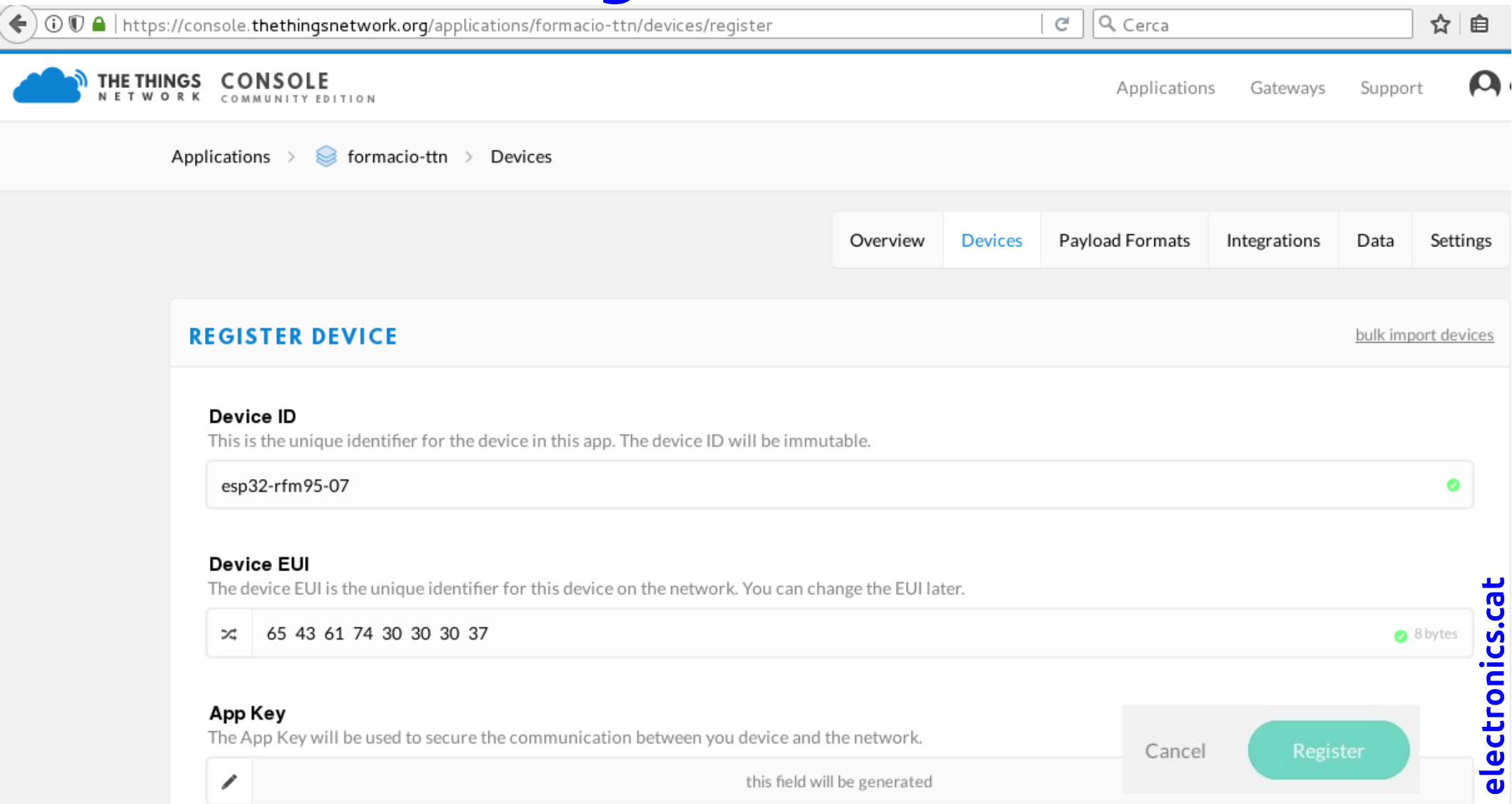


Registre de dispositiu a l'aplicació a The Things Network

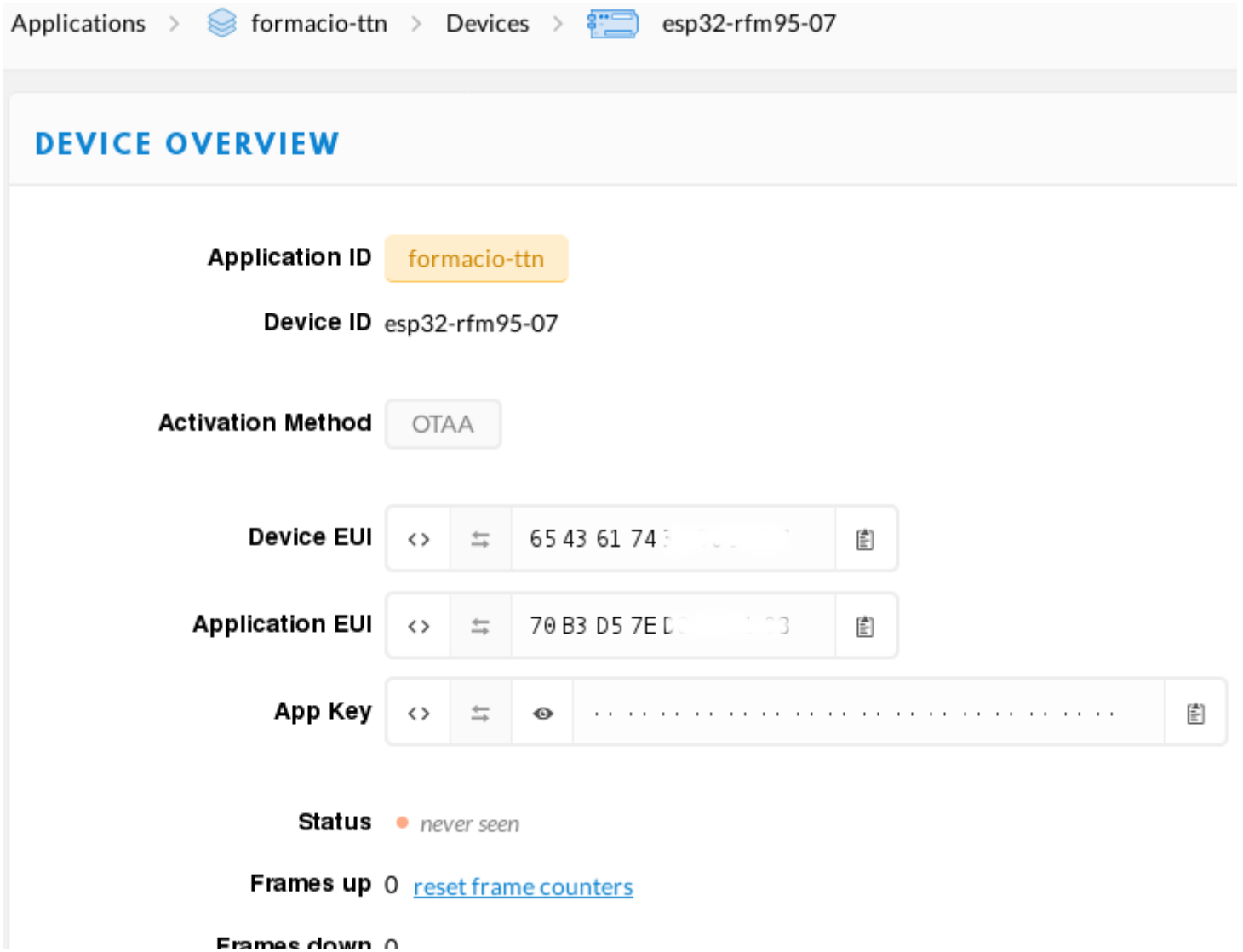


LoRaWAN™

Registre de dispositiu a l'aplicació a The Things Network (TTN)



Registre de dispositiu a l'aplicació a TTN

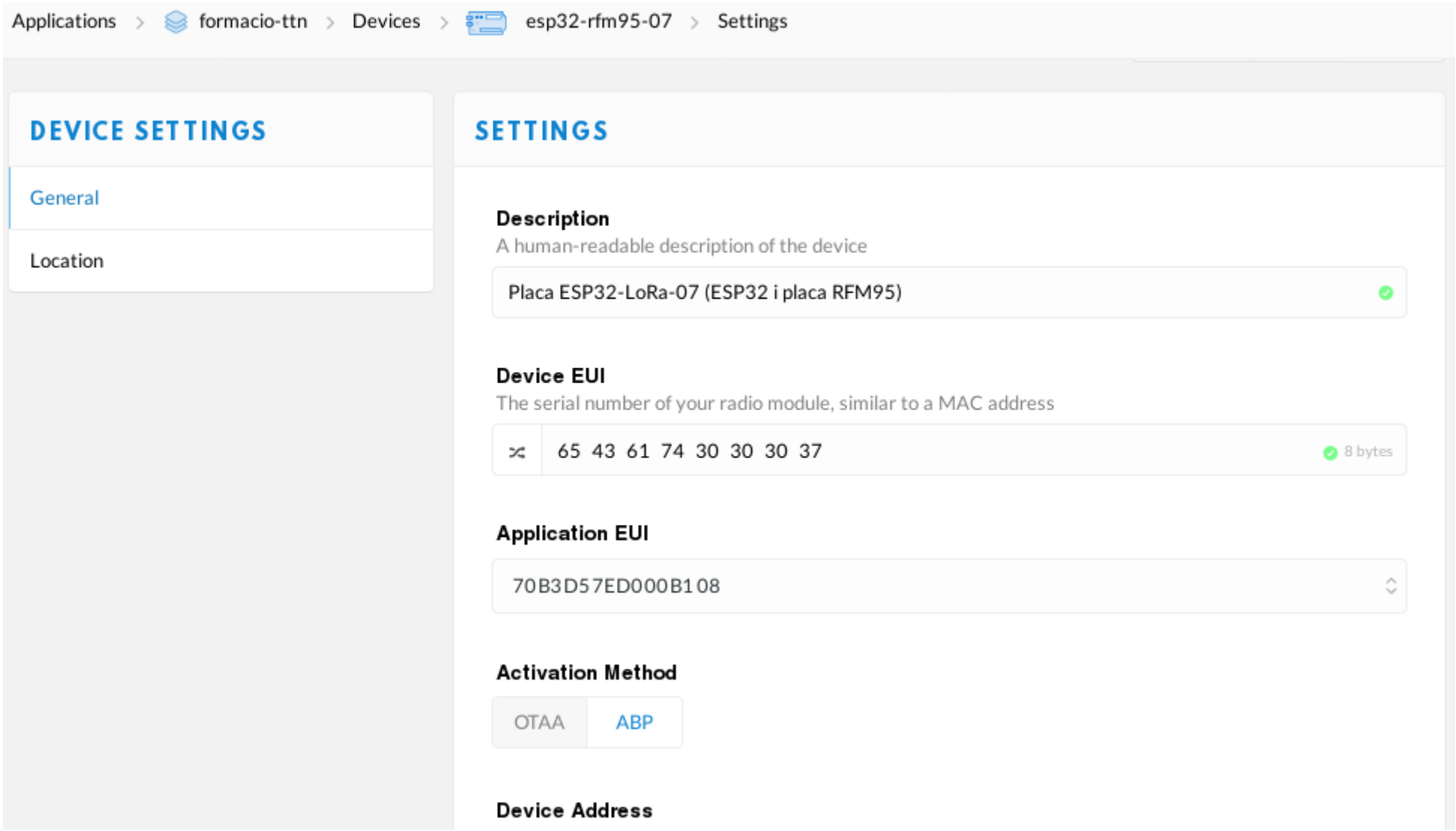


OTAA i ABP

OTAA (Over The Air Authentication): Aquest mètode consisteix en que un node prova de connectar-se a una passarel·la LoRaWAN emprant les claus **APPEUI** i **APPKEY**. Si les claus són correctes, la passarel·la contestarà al node amb un missatge d'acceptació (join) i des d'aquest moment el node pot rebre i trametre des de la passarel·la.

ABP (Authentication By Personalisation): L'autenticació per personalització consisteix en que les claus de xifratge es configuren manualment al dispositiu, permetent la comunicació directa a les passarel·les LoRaWAN sense necessitat de demanar permís.

Registre de dispositiu a l'aplicació a TTN



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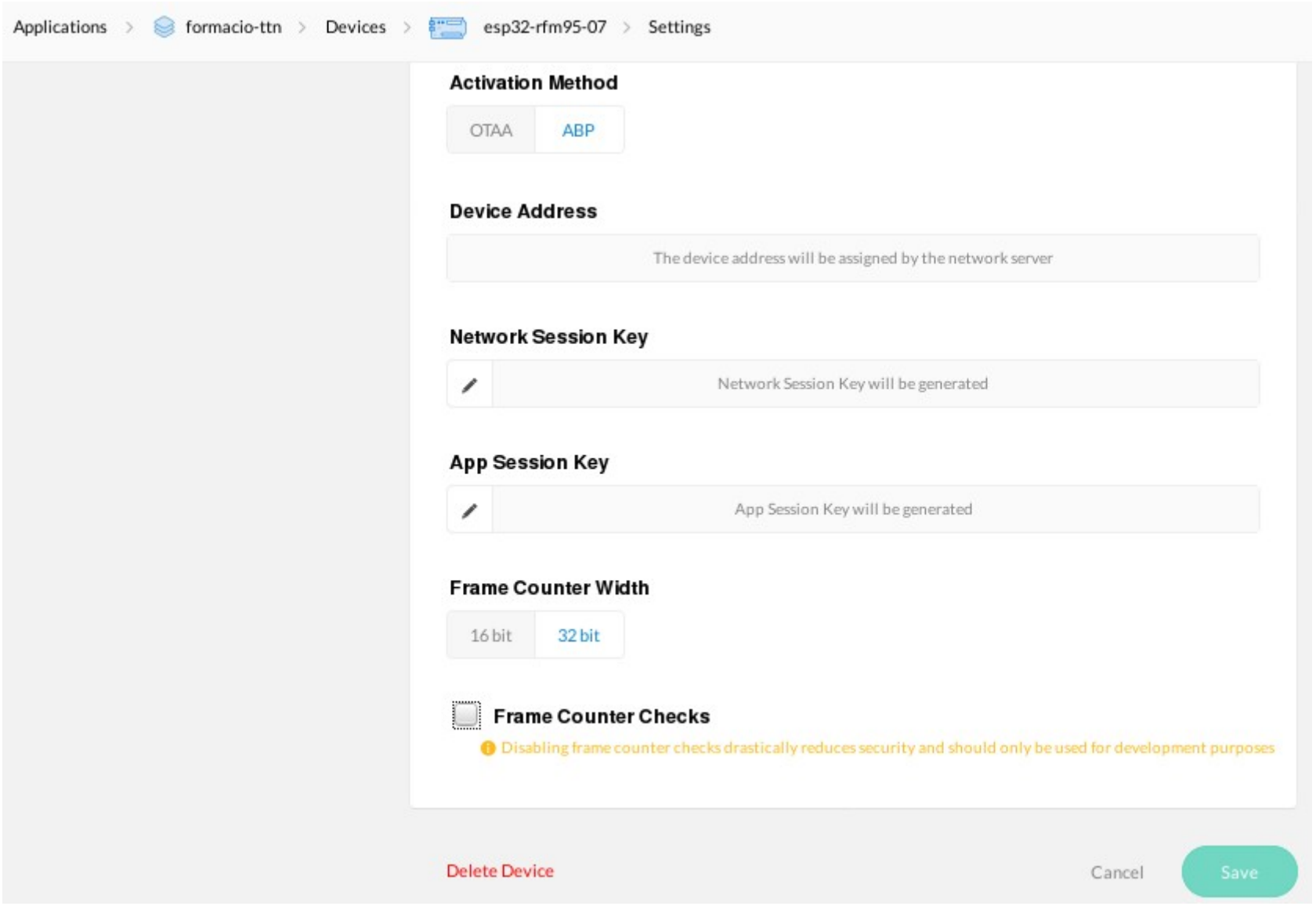

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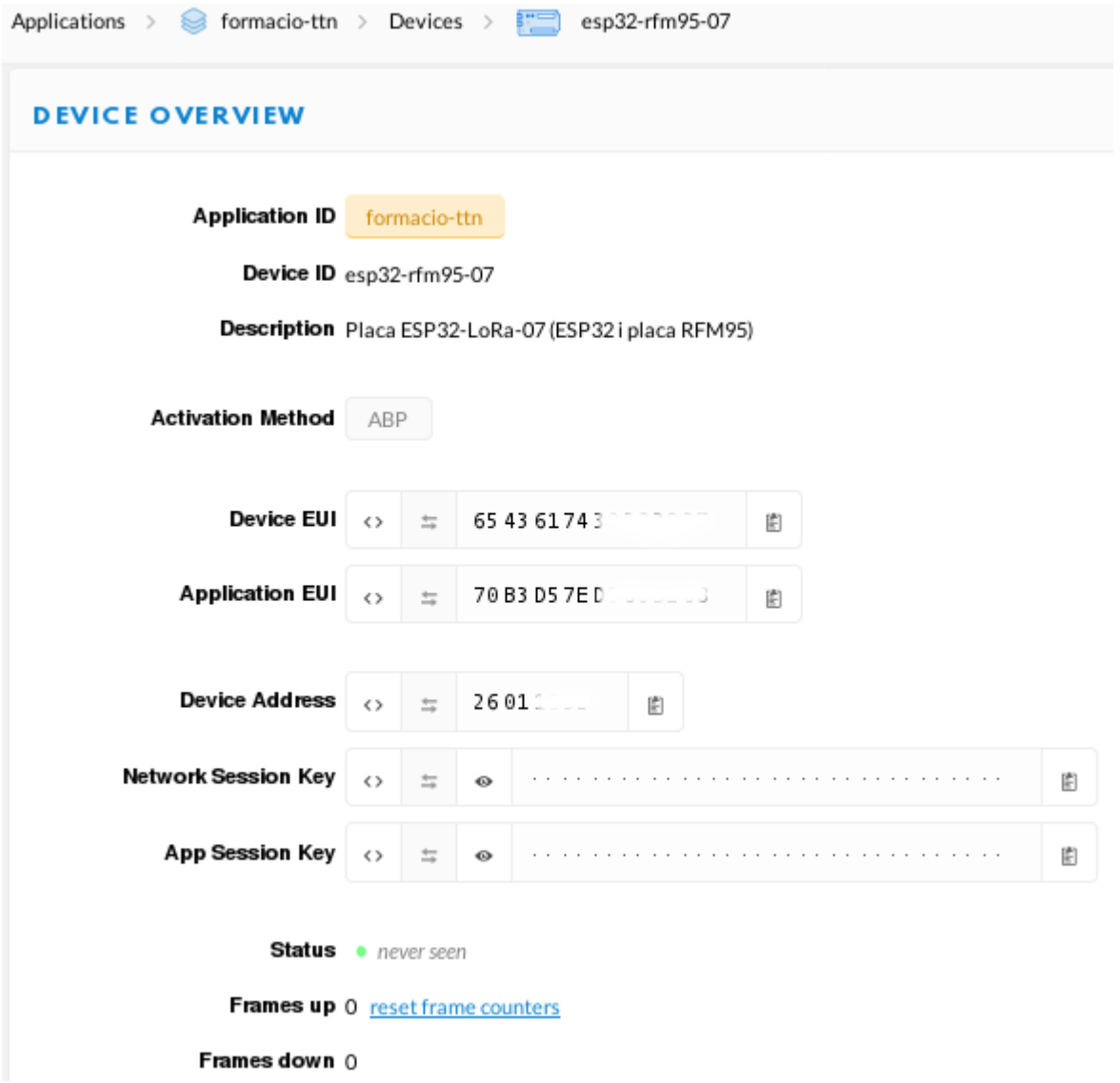
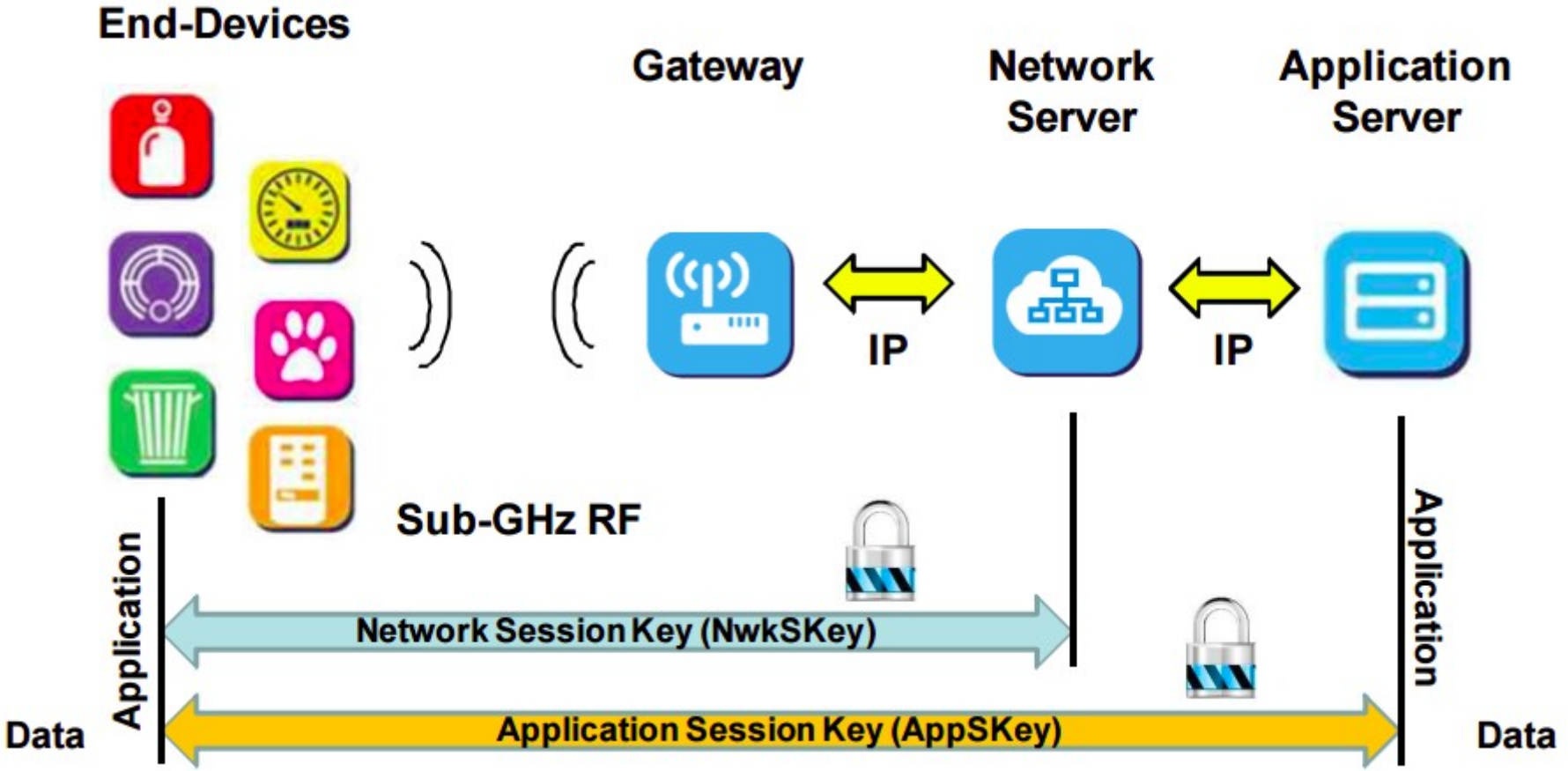


LoRaWAN™



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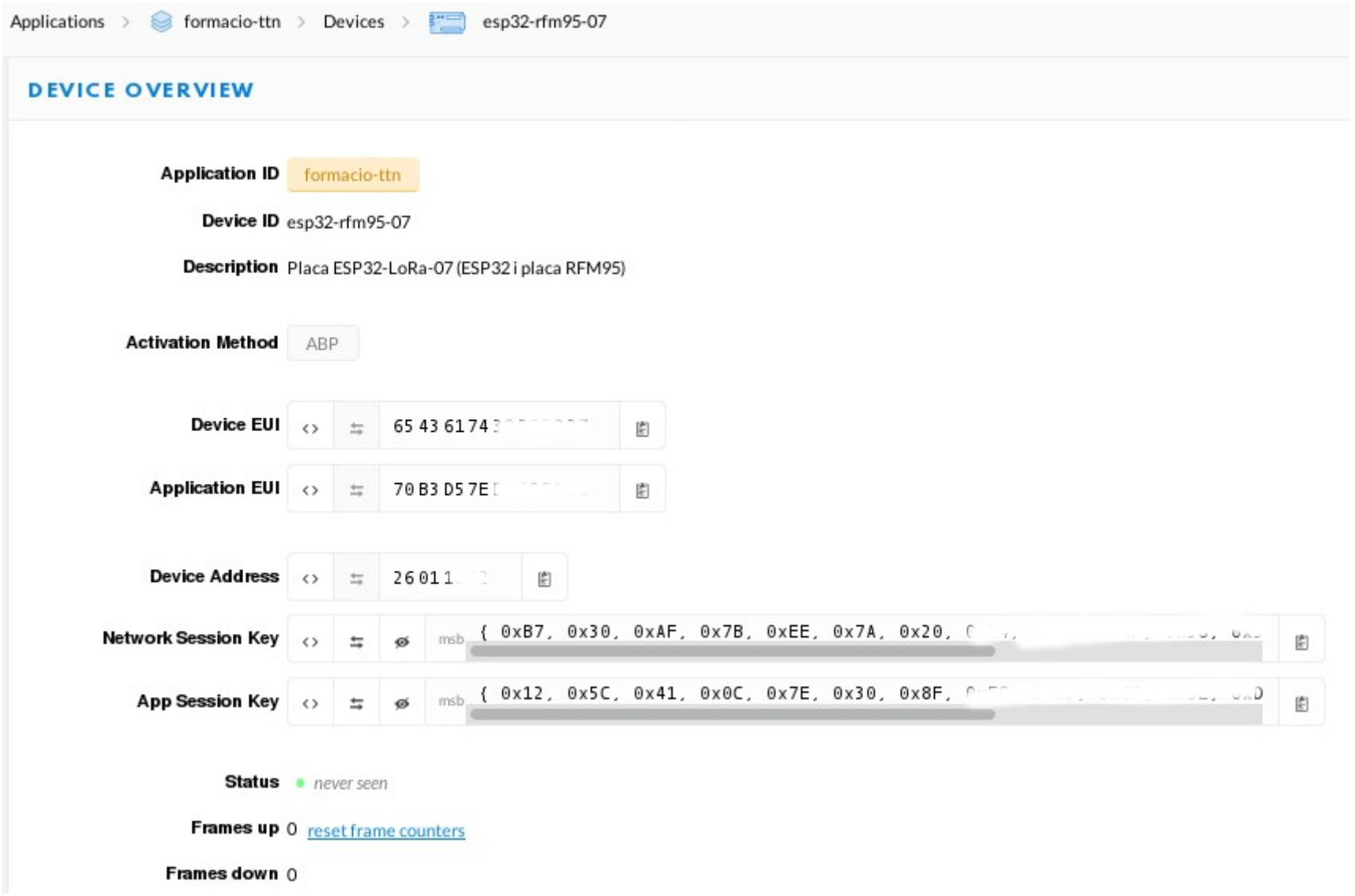


Registre de dispositiu a l'aplicació a TTN

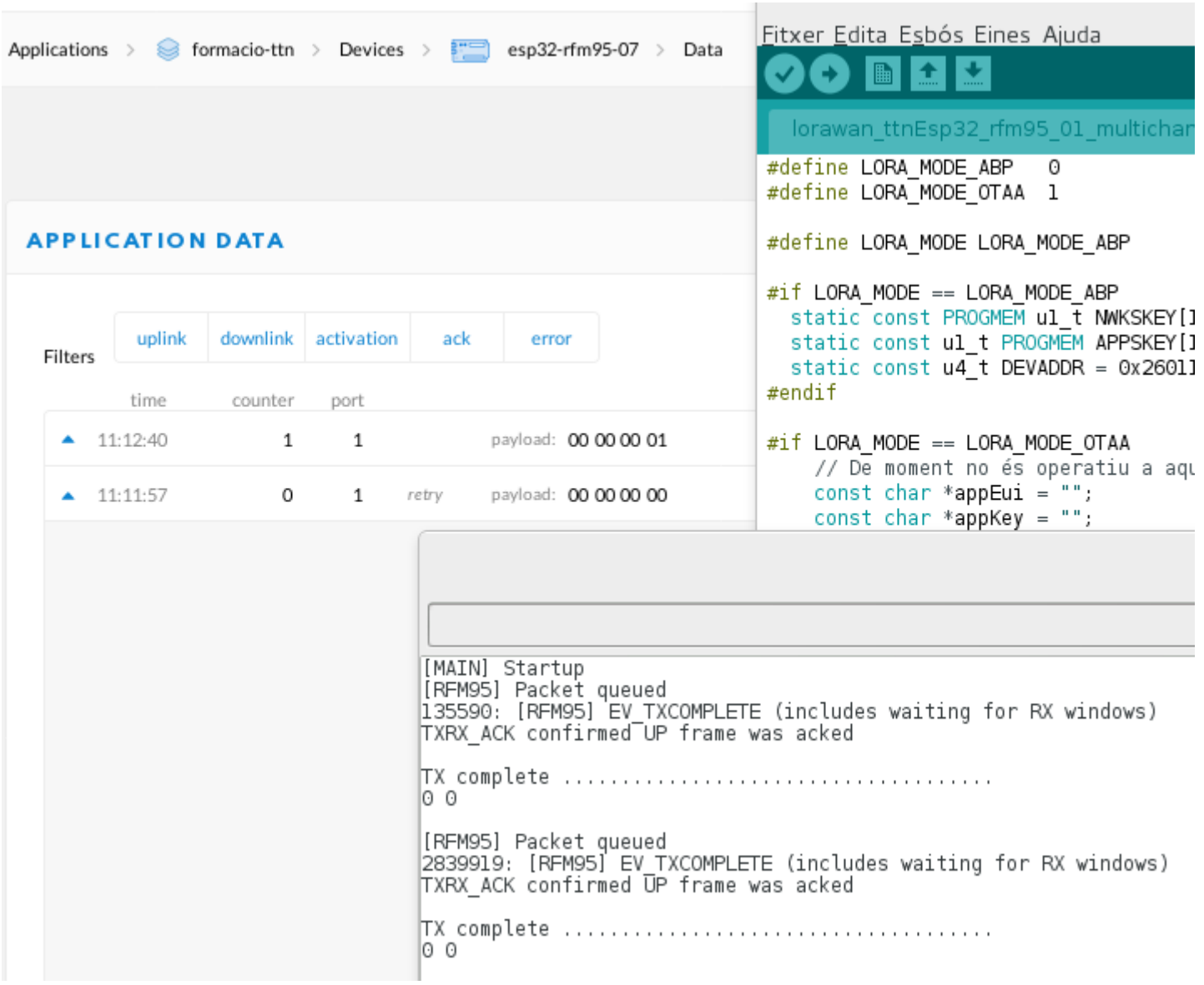
lorawan_ttnEsp32_rfm95_01_multichannel-esp32-rfm95-07 - credentials.h | Arduino 1.8.5

Fitxer Edita Esbós Eines Ajuda

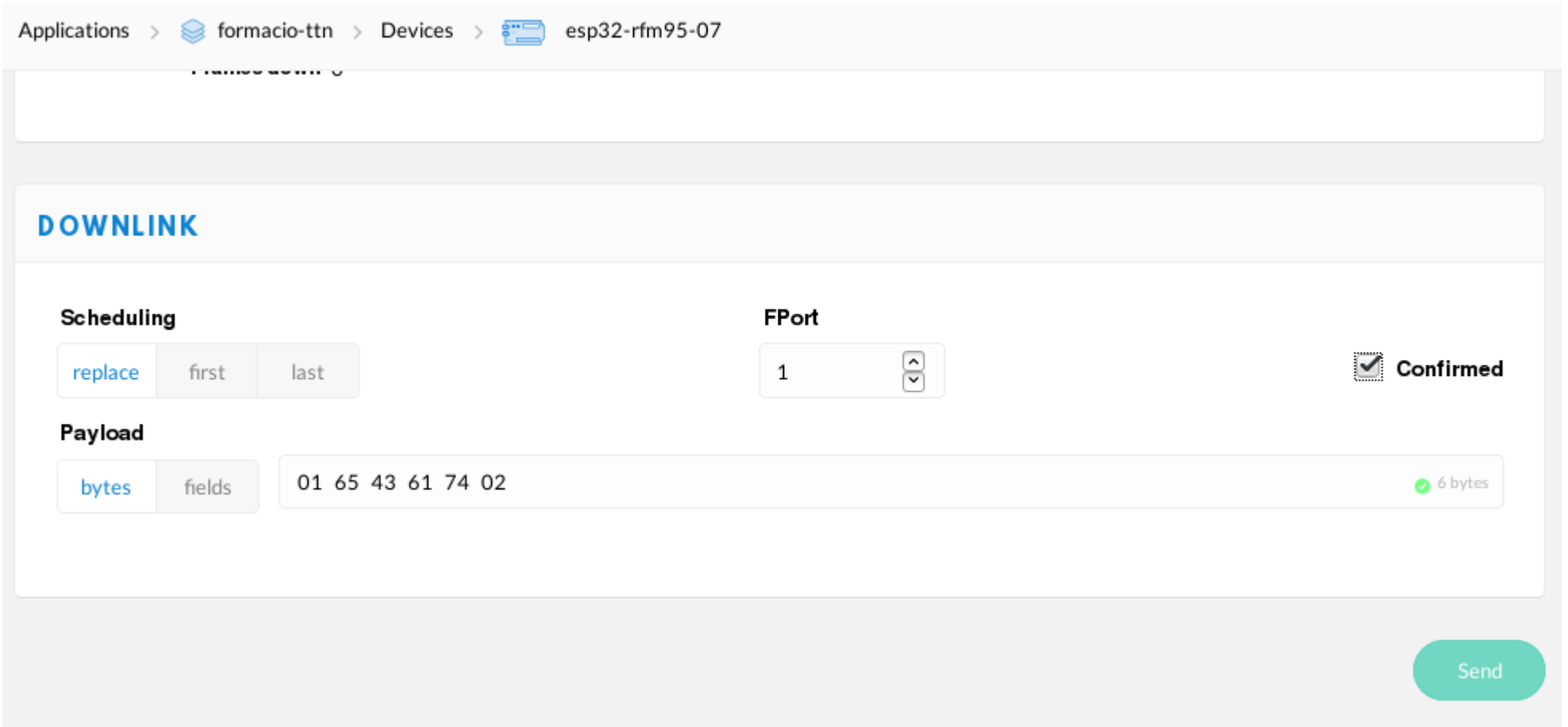
lorawan_ttnEsp32_rfm95_01_multichannel-esp32-rfm95-07 | credentials.h | pinMapping.h

```
#define LORA_MODE_ABP   0
#define LORA_MODE_OTAA  1

#define LORA_MODE LORA_MODE_ABP

#if LORA_MODE == LORA_MODE_ABP
  static const PROGMEM u1_t NWKSKEY[16] = { 0xB7, 0x30, 0xAF, 0x7B, 0xEE, 0x7A, 0x20, 0
  static const u1_t PROGMEM APPSKEY[16] = { 0x12, 0x5C, 0x41, 0x0C, 0x7E, 0x30, 0x8F,
  static const u4_t DEVADDR = 0x2601
#endif

#if LORA_MODE == LORA_MODE_OTAA
    // De moment no és operatiu a aquesta versió
    const char *appEui = "";
    const char *appKey = "";
#endif
```

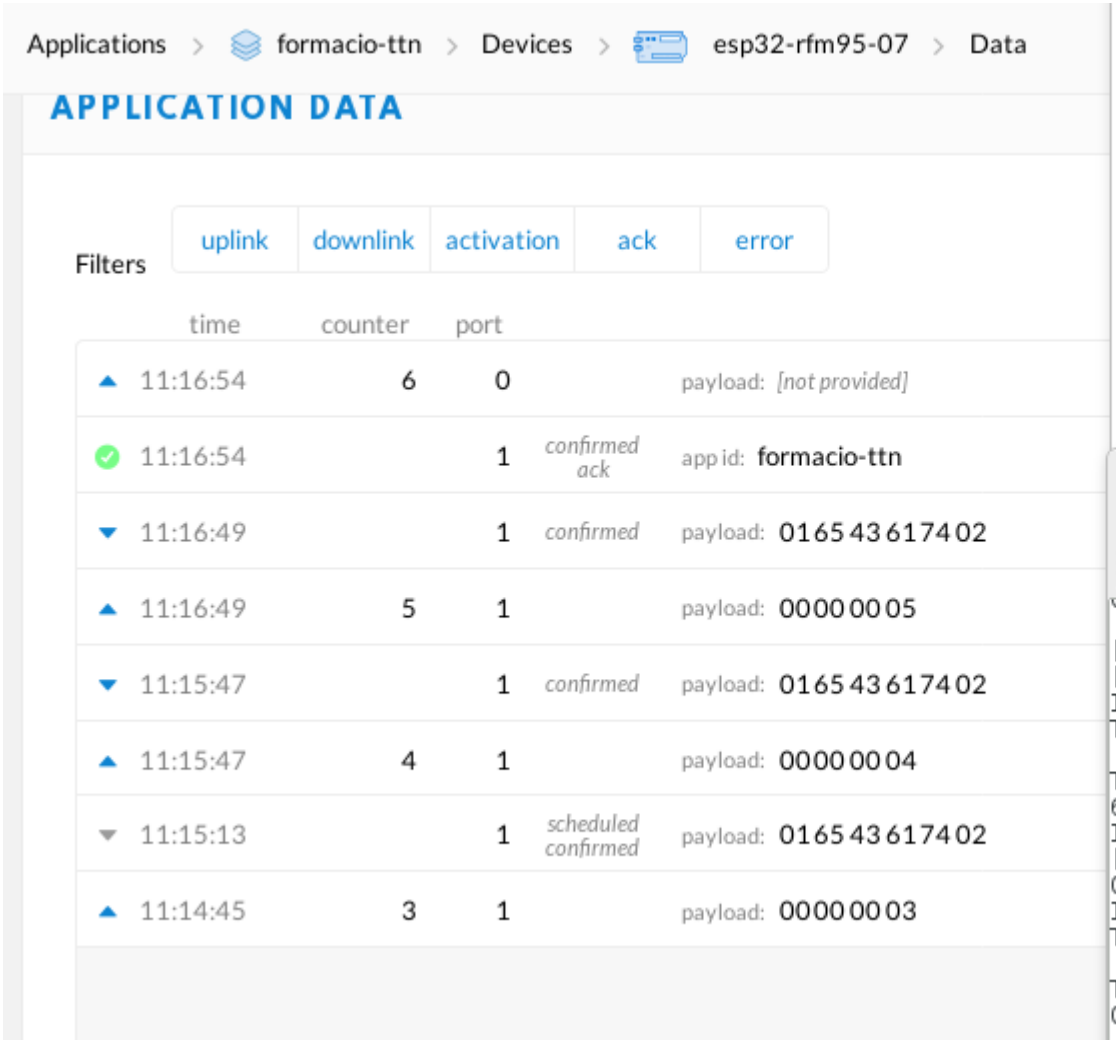
Uplink des del node a l'aplicació a TTN



Downlink des de l'aplicació TTN al node



Downlink des de l'aplicació TTN al node




```
#define LORA_MODE LORA_MODE_ABP

#if LORA_MODE == LORA_MODE_ABP
  static const PROGMEM u1_t NWKSKEY[
  static const u1_t PROGMEM APPSKEY[
  static const u4_t DEVADDR = 0x2601
#endif

#if LORA_MODE == LORA_MODE_OTAA
    // De moment no és operatiu a aq
    const char *appEui = "";
    const char *appKey = "";
#endif
```

```
[RFM95] Packet queued
[RFM95] Pending message
18295111: [RFM95] EV_TXCOMPLETE (incl
TXRX_ACK confirmed UP frame was acked

TX complete ......................
6 1
1654361742
[RFM95] Received 6 bytes of payload
01 65 43 61 74 02
18678004: [RFM95] EV_TXCOMPLETE (incl
TXRX_ACK confirmed UP frame was acked

TX complete ......................
0 0
```

Adaptació del node de multicanal a monocanal

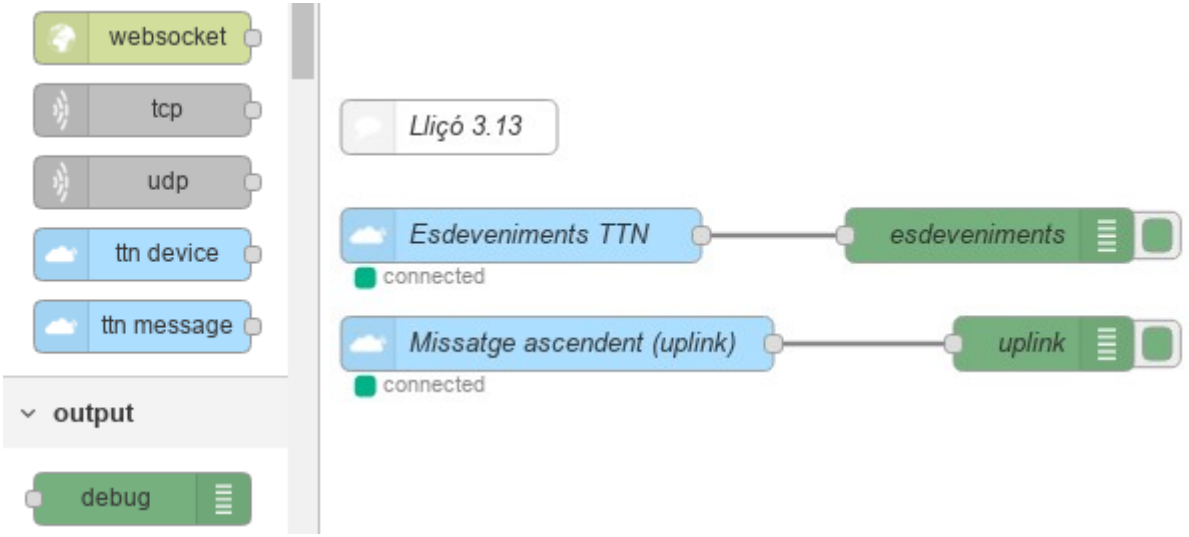
```
  LMIC_setupChannel(0, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
/*
  LMIC_setupChannel(1, 868300000, DR_RANGE_MAP(DR_SF12, DR_SF7B), BAND_CENTI);      // g-band
  LMIC_setupChannel(2, 868500000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
  LMIC_setupChannel(3, 867100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
  LMIC_setupChannel(4, 867300000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
  LMIC_setupChannel(5, 867500000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
  LMIC_setupChannel(6, 867700000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
  LMIC_setupChannel(7, 867900000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
  LMIC_setupChannel(8, 868800000, DR_RANGE_MAP(DR_FSK,  DR_FSK),   BAND_MILLI);      // g2-band
*/
    LMIC_setupChannel(1, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
    LMIC_setupChannel(2, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
    LMIC_setupChannel(3, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
    LMIC_setupChannel(4, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
    LMIC_setupChannel(5, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
    LMIC_setupChannel(6, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
    LMIC_setupChannel(7, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);      // g-band
    LMIC_setupChannel(8, 868100000, DR_RANGE_MAP(DR_SF12, DR_SF7),   BAND_CENTI);
```

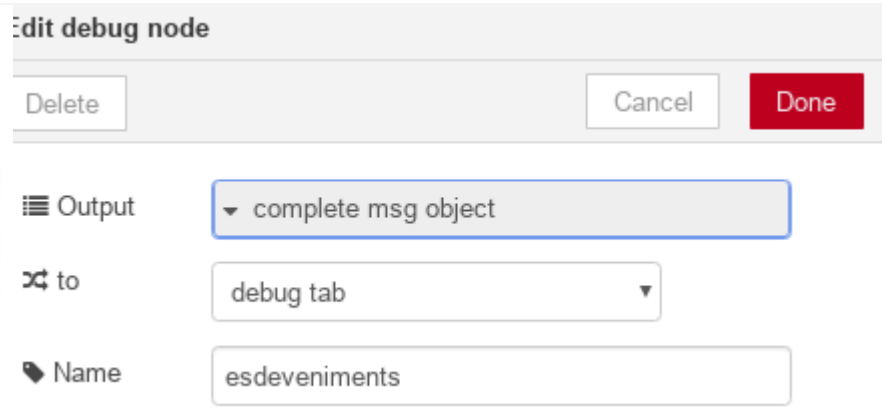
Enllaç al codi multicanal
Enllaç al codi monocanal
Biblioteca arduino-lmic

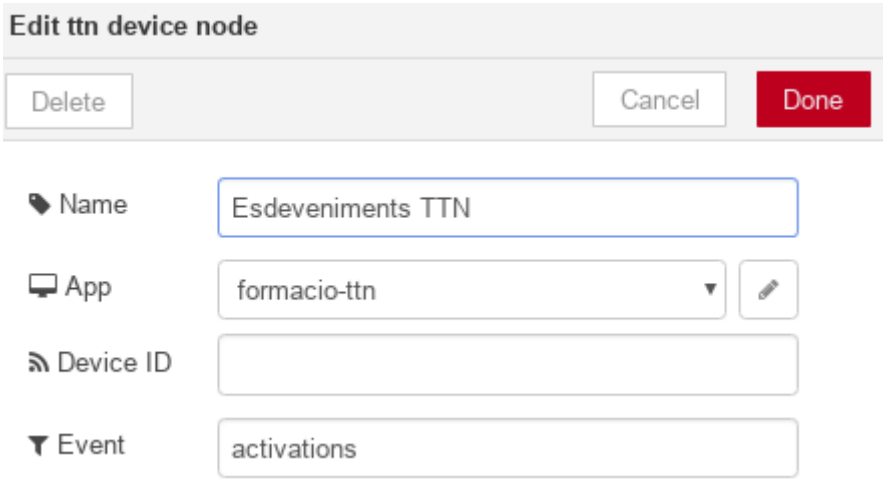
Node-RED

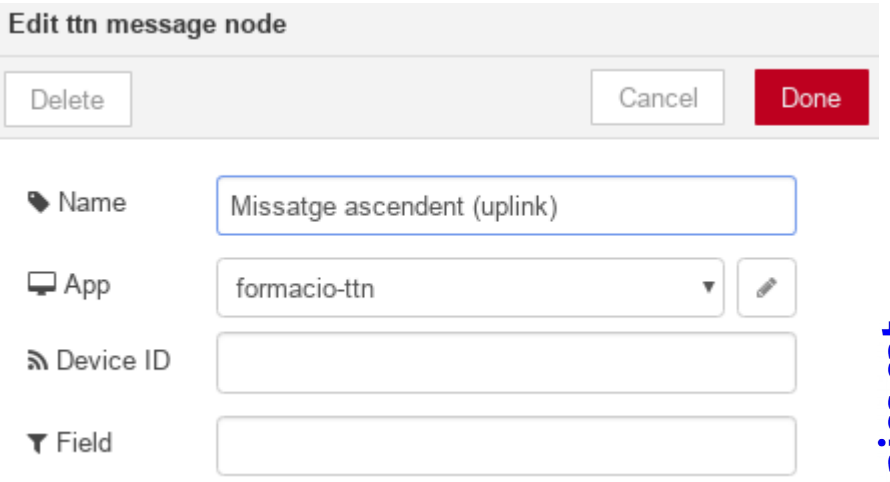
LoRaWAN

Nodes 'ttn device' i 'ttn message'







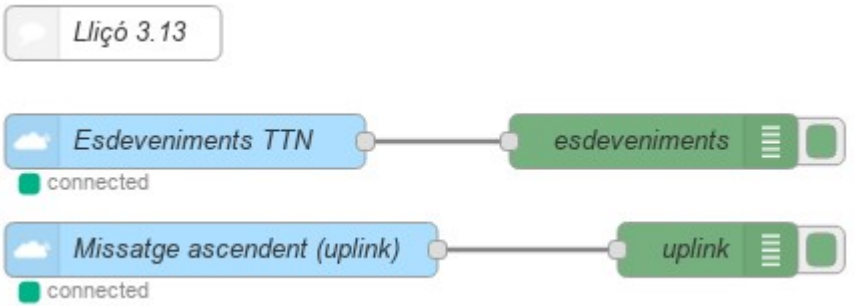


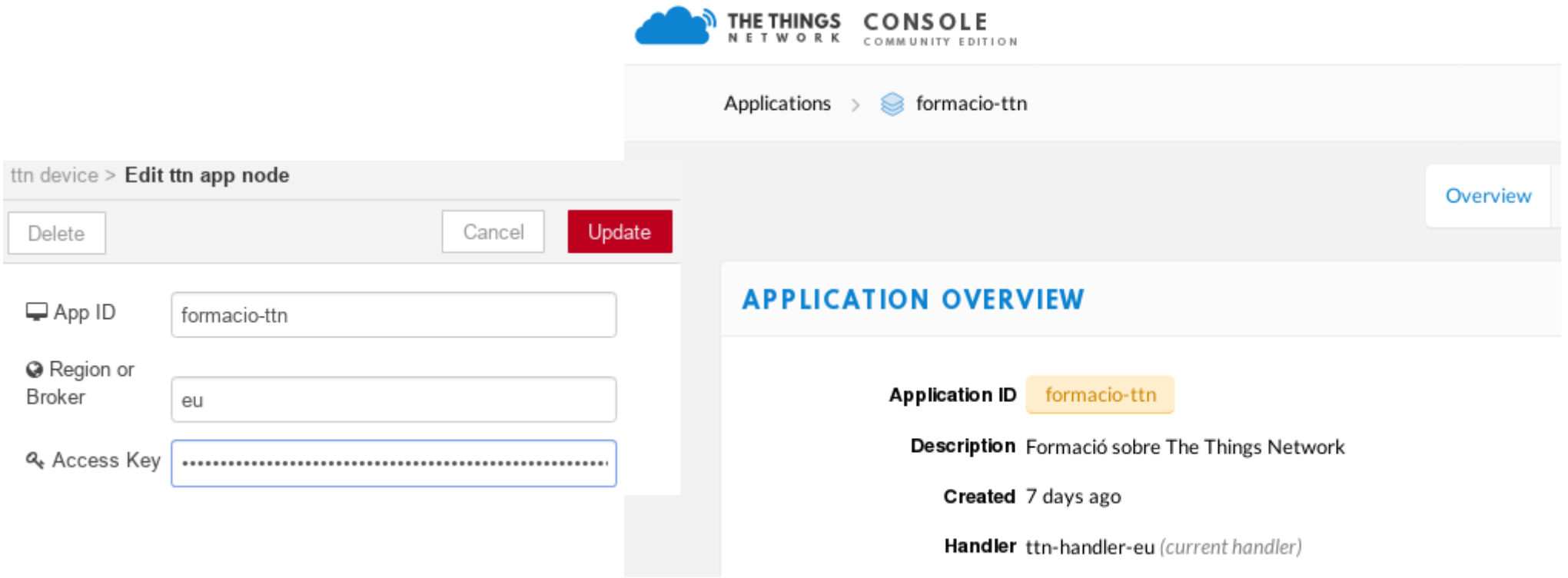
Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_13.txt
Codi d'Arduino IDE per a l'ESP32: https://binefa.cat/IoT/esp32/lorawan_ttnEsp32_rfm95_01_multichannel-llico_3_13.tar.gz

Node-RED

LoRaWAN

App ID



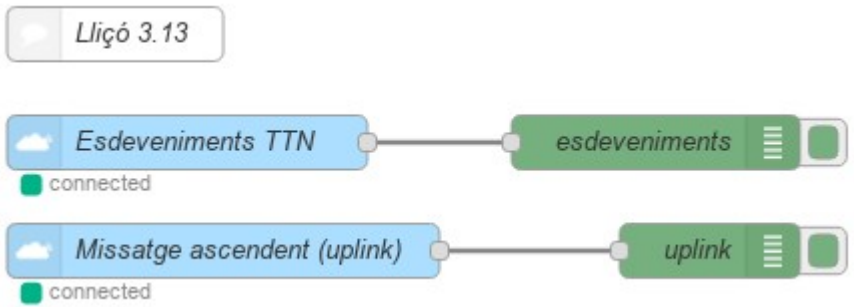


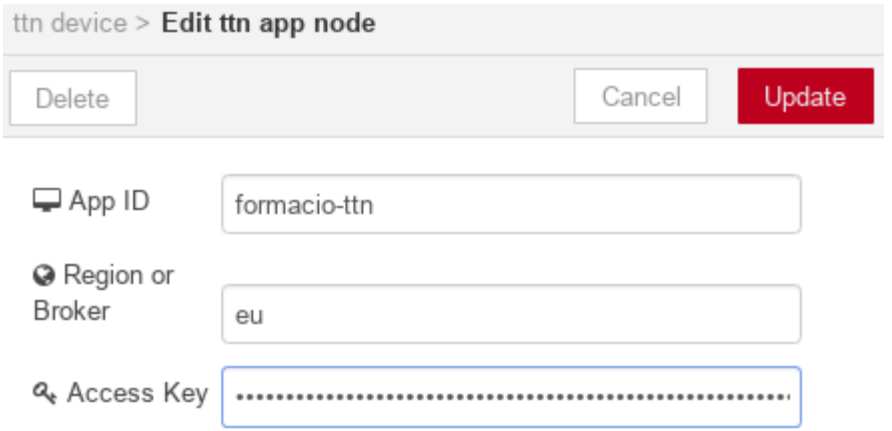
Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_13.txt
Codi d'Arduino IDE per a l'ESP32: https://binefa.cat/IoT/esp32/lorawan_ttnEsp32_rfm95_01_multichannel-llico_3_13.tar.gz

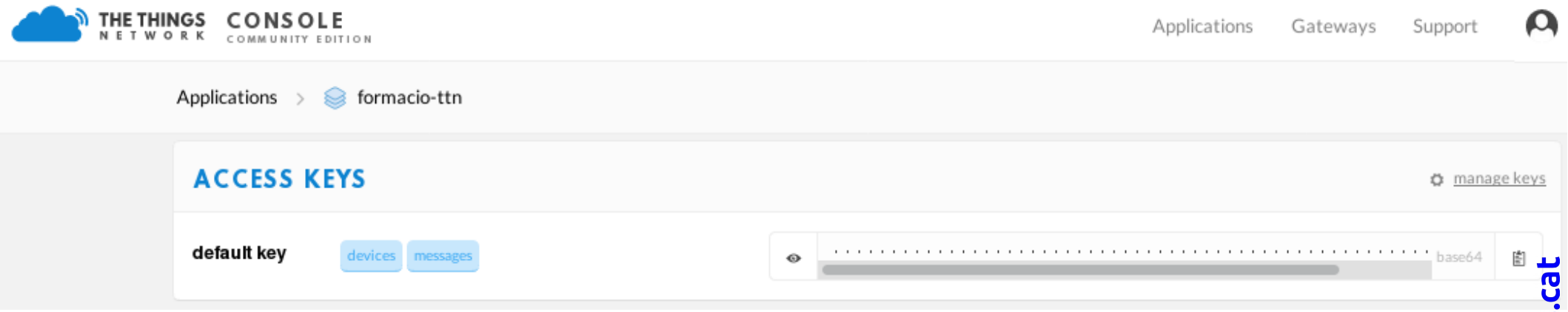
Node-RED

LoRaWAN

Access Key



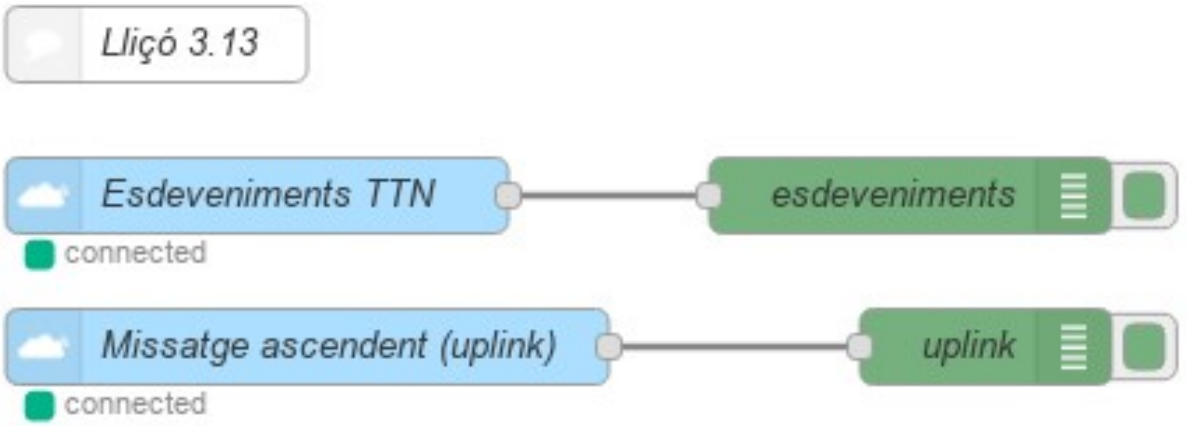


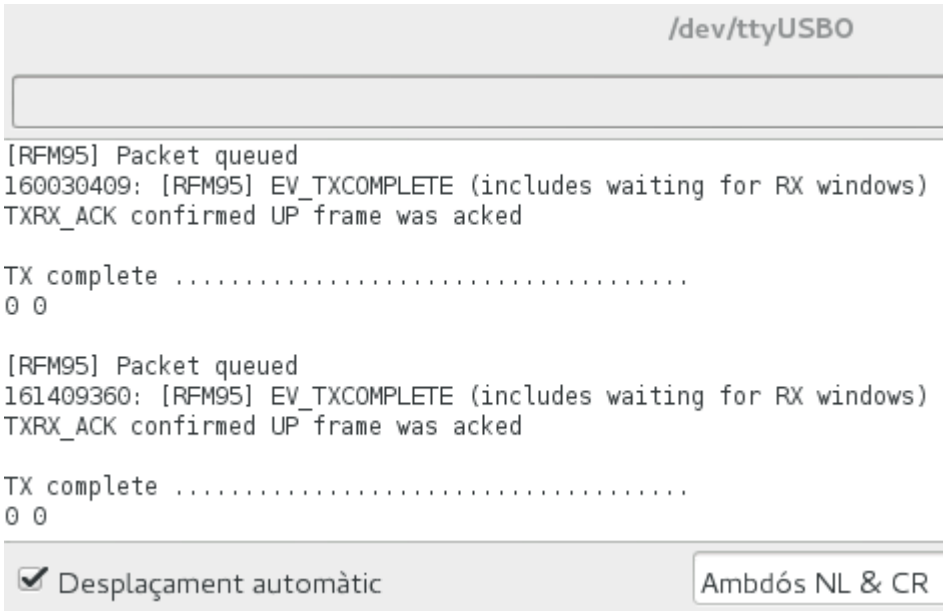


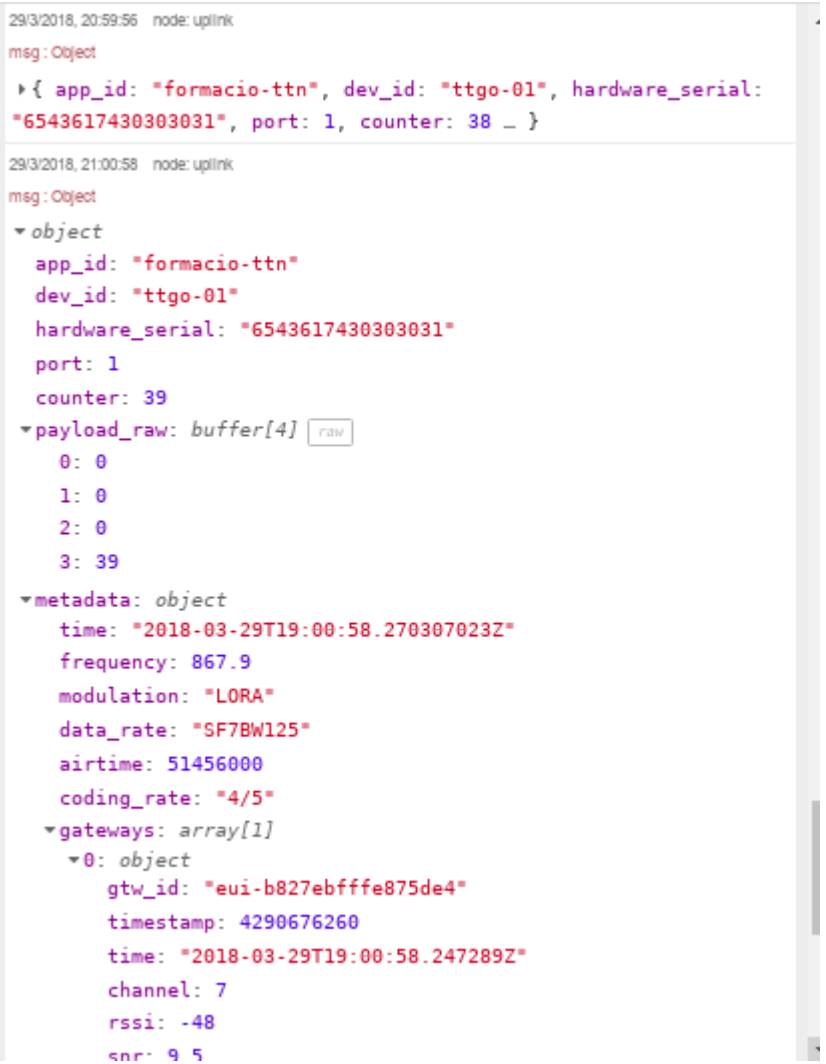
Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_13.txt
Codi d'Arduino IDE per a l'ESP32: https://binefa.cat/IoT/esp32/lorawan_ttnEsp32_rfm95_01_multichannel-llico_3_13.tar.gz

Node-RED

LoRaWAN







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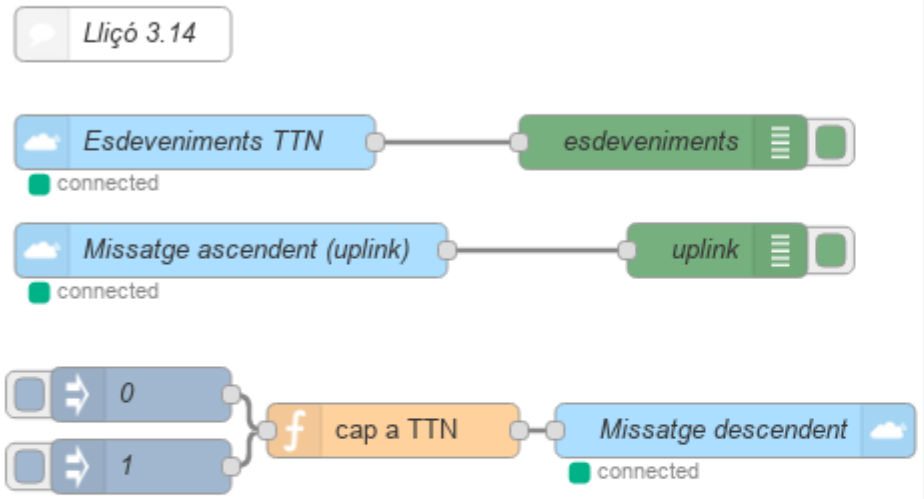
Codi d'Arduino IDE per a l'ESP32: https://binefa.cat/IoT/esp32/lorawan_ttnEsp32_rfm95_01_multichannel-llico_3_13.tar.gz

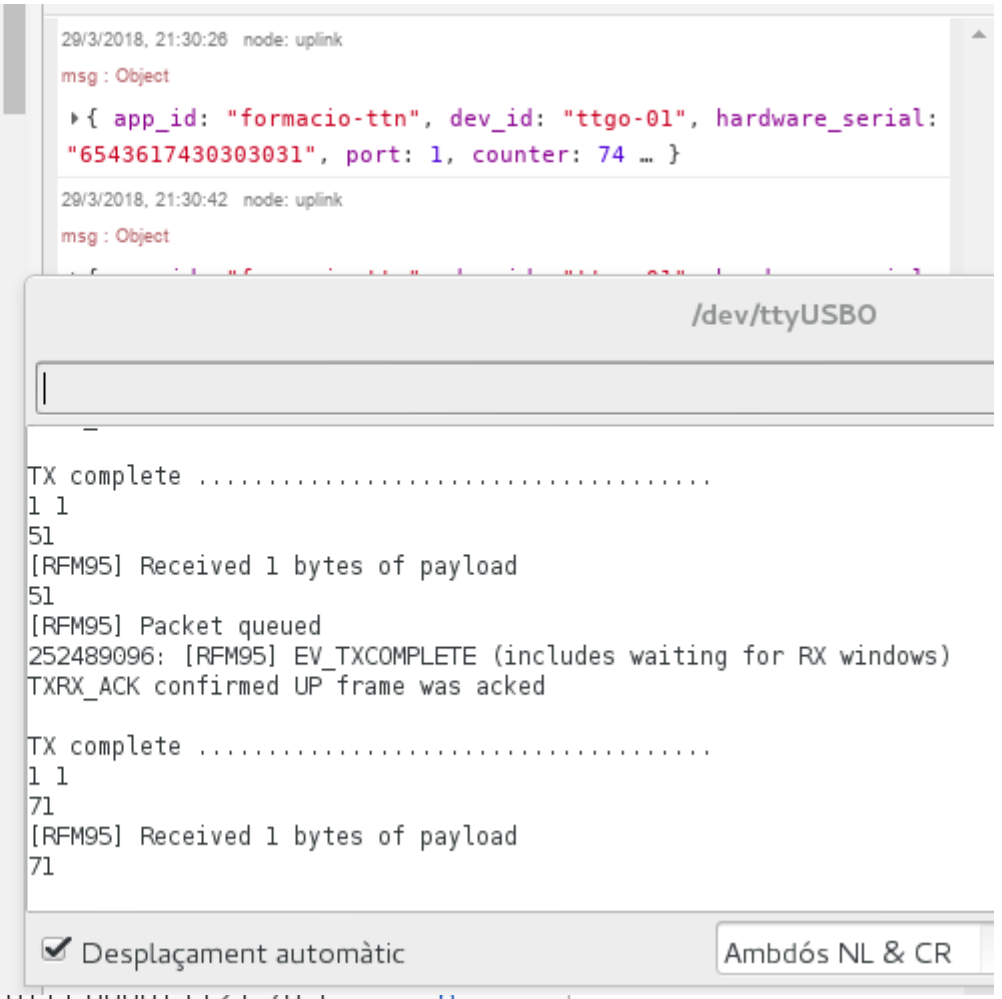
Node-RED

LoRaWAN

Missatge descendent (*downlink*)




```
return {
    dev_id: msg.dev_id,
    port: msg.port,
    schedule: "replace",
    confirmed: false,
    payload: Buffer.from([msg.payload ? 0x71 : 0x51])
}
```

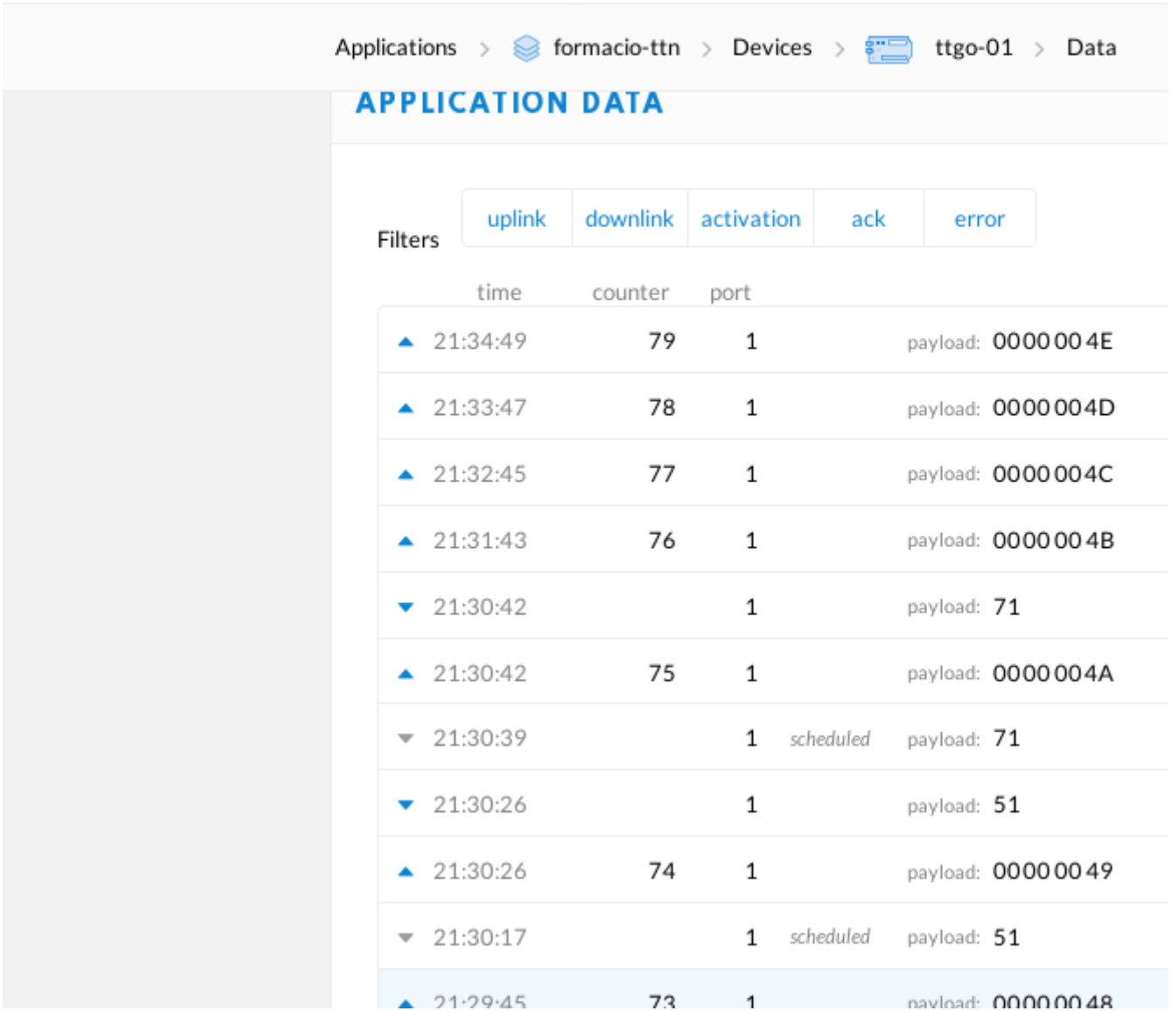


0101 0001	81	51	Q	0111 0001	113	71	q
0101 0010	82	52	R	0111 0010	114	72	r

Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_14.txt
Codi d'Arduino IDE per a l'ESP32: https://binefa.cat/IoT/esp32/lorawan_ttnEsp32_rfm95_01_multichannel-llico_3_13.tar.gz

Node-RED

LoRaWAN / Missatge descendent (*downlink*)



Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_14.txt
Codi d'Arduino IDE per a l'ESP32: https://binefa.cat/IoT/esp32/lorawan_ttnEsp32_rfm95_01_multichannel-llico_3_13.tar.gz

Node-RED

LoRaWAN

Missatge descendent (*downlink*)

Edit function node

Delete | Cancel | Done

Name: cap a TTN

Function

```
return {
    dev_id: msg.dev_id,
    port: msg.port,
    schedule: "replace",
    confirmed: false,
    payload: Buffer.from([msg.payload ? 0x71 : 0x51])
}
```

Edit inject node

Delete | Cancel | Done

Payload: 0

Topic:

Repeat: none

Inject once at start?

Name: 0

0101 0000	80	50	P	0111 0000	112	70	p
0101 0001	81	51	Q	0111 0001	113	71	q
0101 0010	82	52	R	0111 0010	114	72	r

DEVICE OVERVIEW

Application ID: formacio-ttn

Device ID: ttgo-01

Description: Placa TTGO-01

Activation Method: ABP

Edit ttn send node

Delete | Cancel | Done

Name: Missatge descendent

App: formacio-ttn

Device ID: ttgo-01

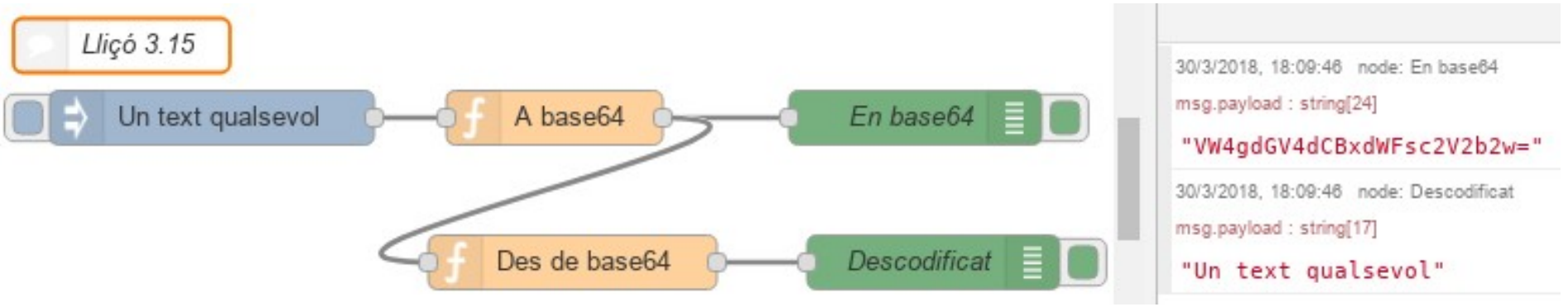
Port: 1

Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_14.txt

Codi d'Arduino IDE per a l'ESP32: https://binefa.cat/IoT/esp32/lorawan_ttnEsp32_rfm95_01_multichannel-llico_3_13.tar.gz

Node-RED

Codificació i descodificació en base64

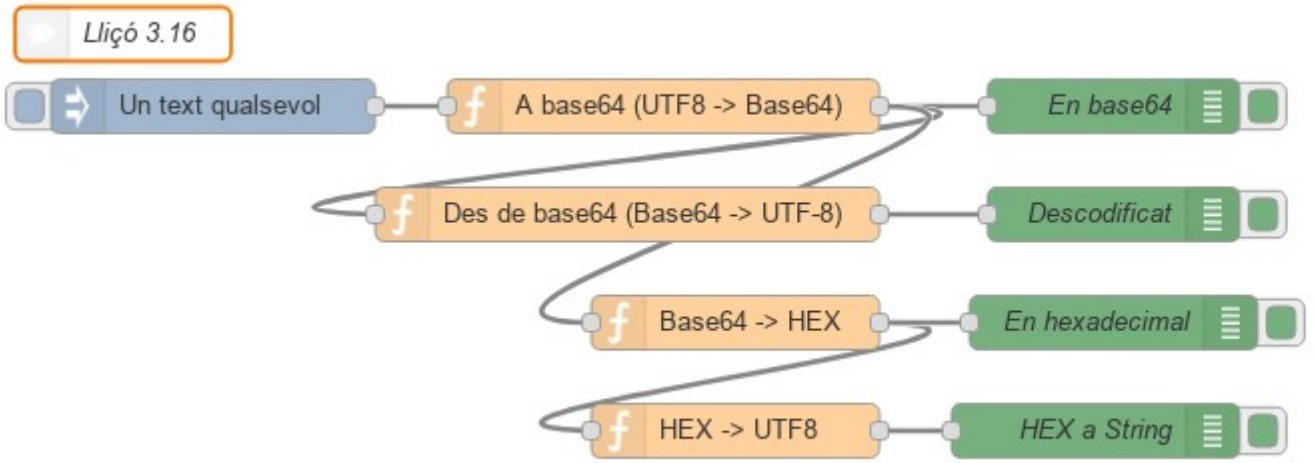


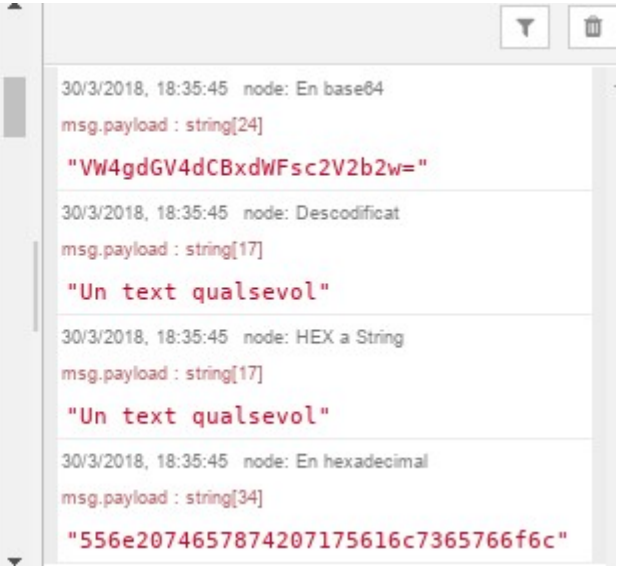
Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_15.txt
Per a codificar i descodificar en línia: https://www.base64encode.org/

Node-RED

Codificació i descodificació en base64

Presentació en hexadecimal



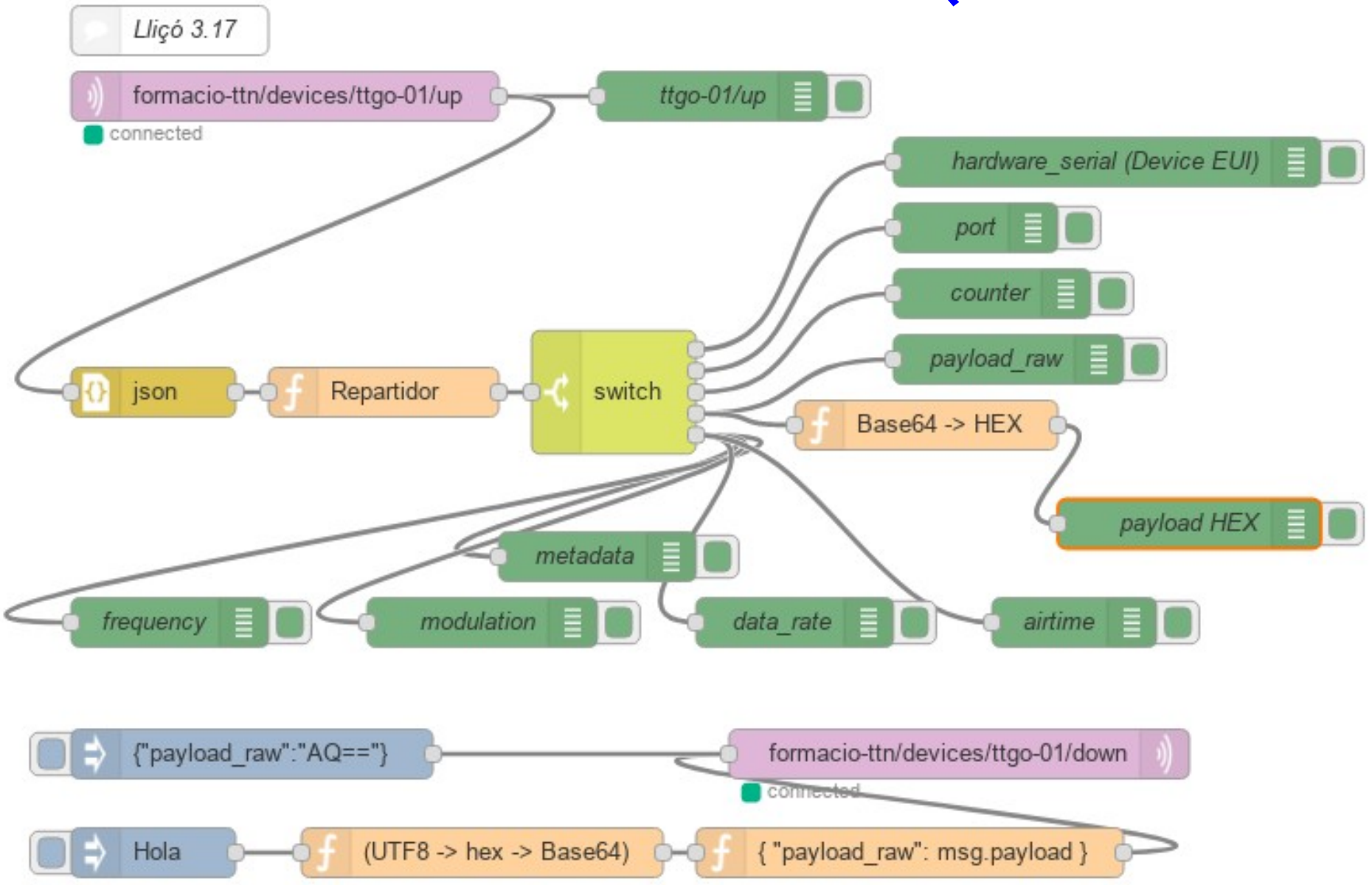


Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_16.txt

Node-RED

LoRaWAN

TTN fent servir MQTT

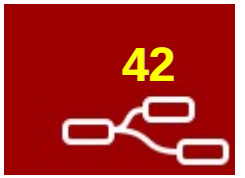


Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_17.txt

Node-RED

LoRaWAN

TTN fent servir MQTT



Edit mqtt in node

Delete | Cancel | Done

Server: eu.thethings.network:1883

Topic: formacio-ttn/devices/ttgo-01/up

QoS: 2

Name: Name

Edit mqtt out node

Delete | Cancel | Done

Server: eu.thethings.network:1883

Topic: formacio-ttn/devices/ttgo-01/down

QoS | Retain

Name: Name

Tip: Leave topic, qos or retain blank if you want to set them via msg properties.

mqtt in > **Edit mqtt-broker node**

Delete | Cancel | Update

Connection | Security | Birth Message | Will Message

Server: eu.thethings.network Port: 1883

Enable secure (SSL/TLS) connection

Client ID: Leave blank for auto generated

Keep alive time (s): 60 Use clean session

Use legacy MQTT 3.1 support

mqtt in > **Edit mqtt-broker node**

Delete | Cancel | Update

Connection | **Security** | Birth Message | Will Message

Username: formacio-ttn

Password: ••••••••

Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_17.txt

Node-RED

LoRaWAN

TTN fent servir MQTT

Edit function node

Delete | Cancel | Done

Name: Repartidor

Function

```
var keys = Object.keys(msg.payload);

var msgs = keys.map(function(key) {
    return { topic: key, payload: msg.payload[key] };
});
return [msgs];
```

Edit switch node

Delete | Cancel | Done

Name: Name

Property: msg. topic

==	hardware_serial	→ 1
==	port	→ 2
==	counter	→ 3
==	payload_raw	→ 4
==	metadata	→ 5

Edit function node

Delete | Cancel | Done

Name: (UTF8 -> hex -> Base64)

Function

```
var b = new Buffer(msg.payload);
msg.payload = b.toString('base64');

return msg;
```

Edit function node

Delete | Cancel | Done

Name: { "payload_raw": msg.payload }

Function

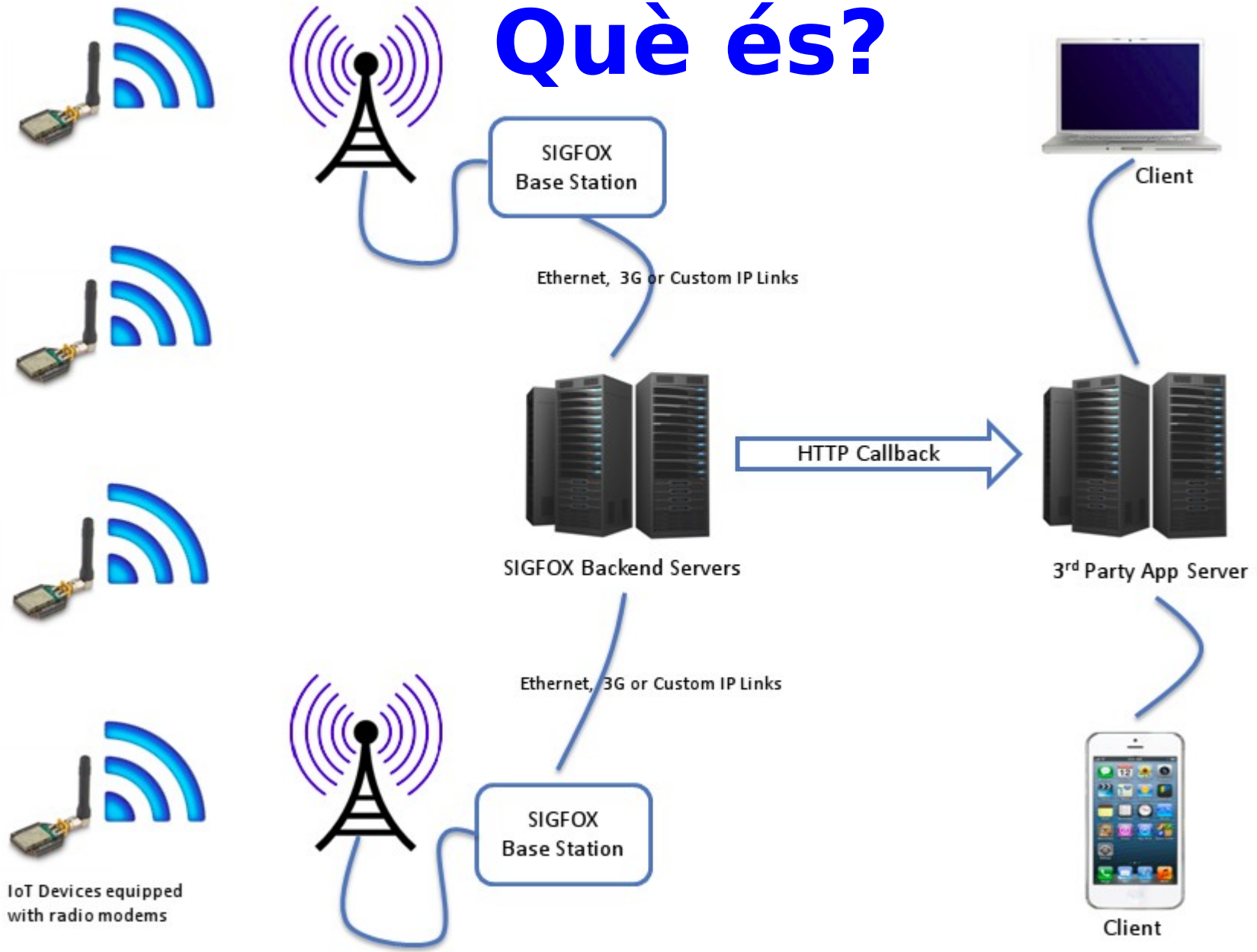
```
msg.payload = { "payload_raw": msg.payload };

return msg;
```

Codi Node-RED: https://binefa.cat/IoT/nodeRed/03_nodeRed_17.txt

sigfox

Què és?



https://aprendiendoarduino.wordpress.com/tag/lorawan/