

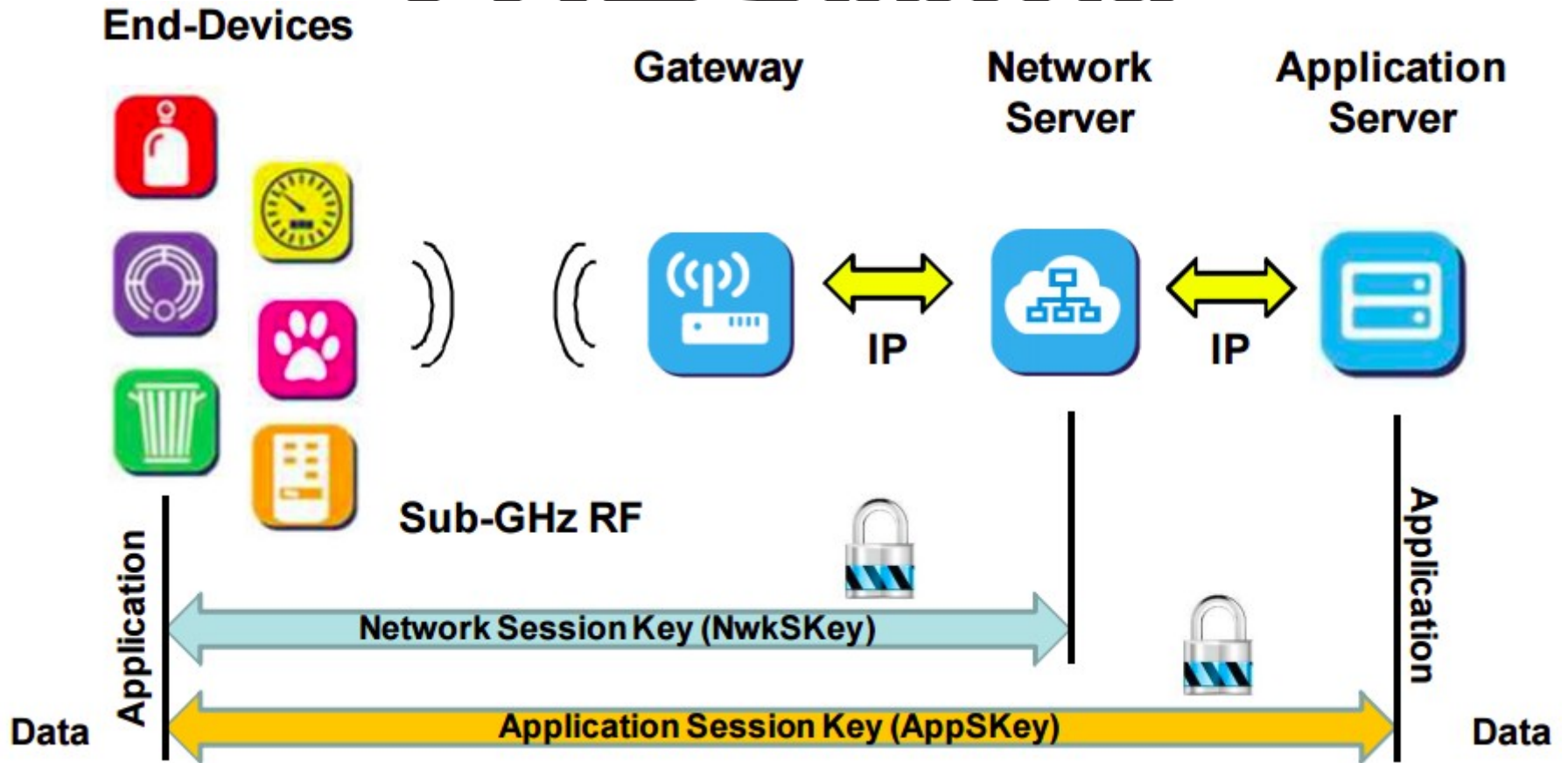
# LoRaWAN™



**M09UF3**  
**M15UF1**



# IoT D2WAN™



<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.

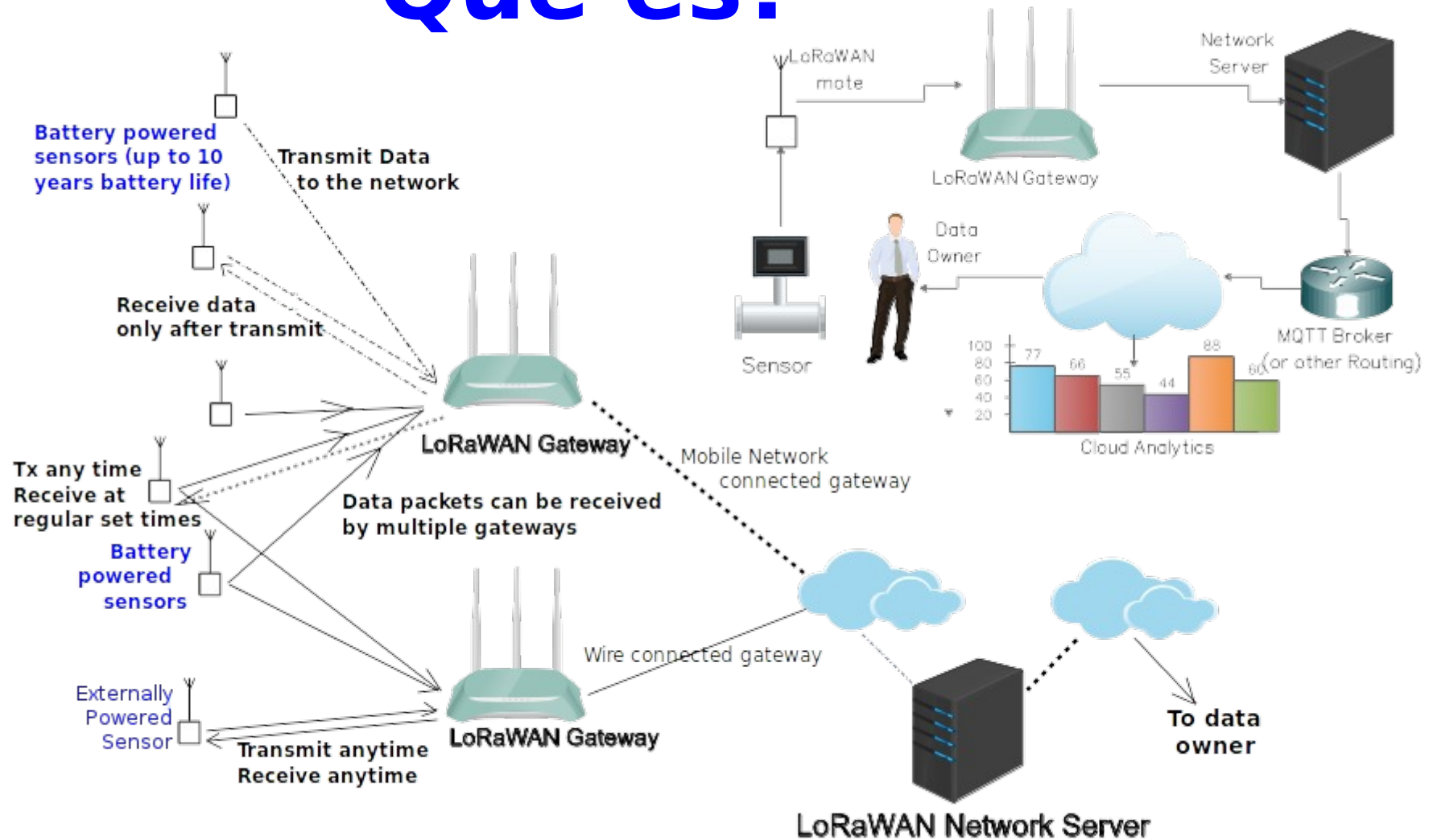
## Què és?

**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.

# LoRaWAN™

## Què és?



# 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

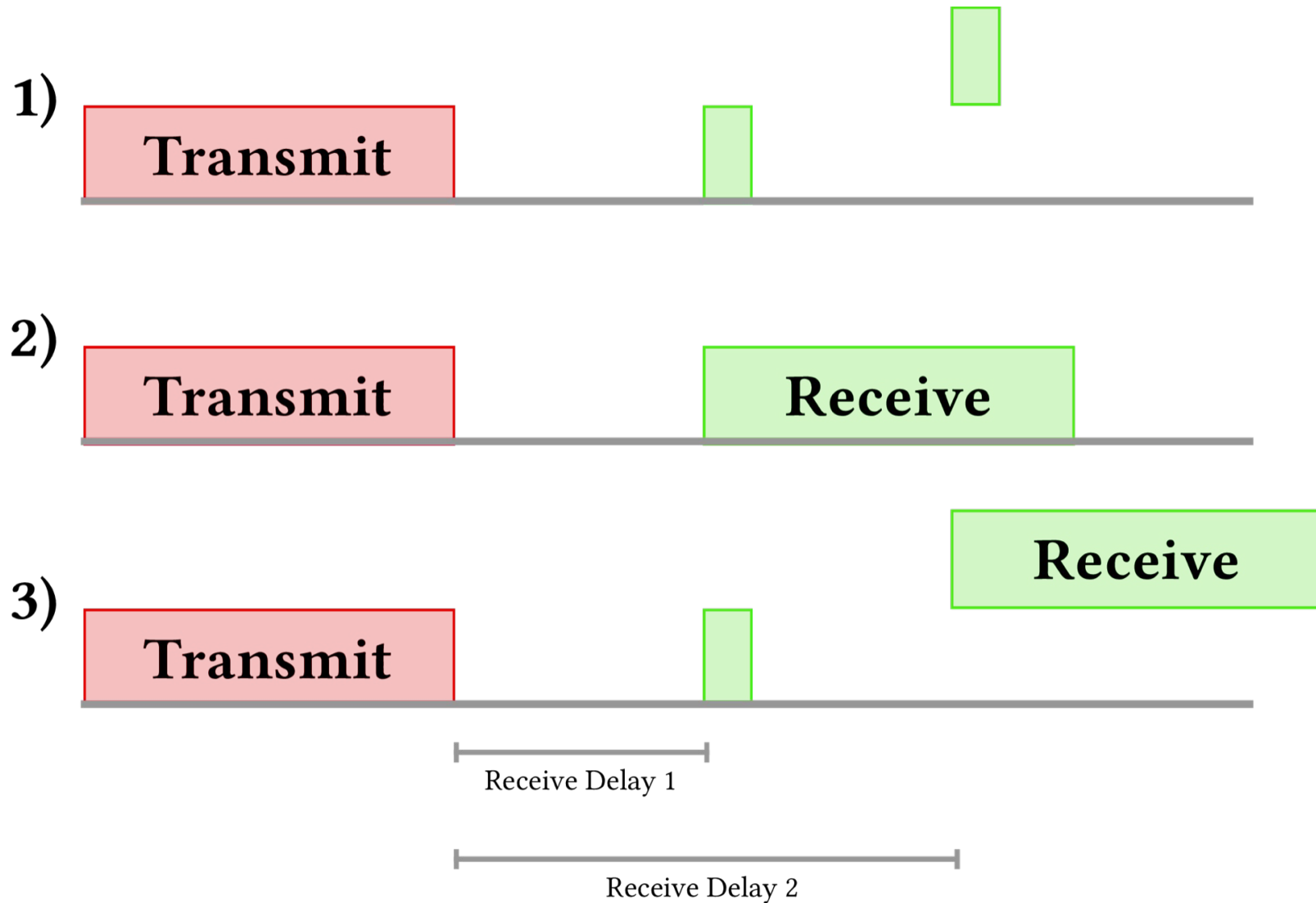
### LoRaWAN endpoint classes

Accordingly the LoRaWAN supports three classes of endpoints:





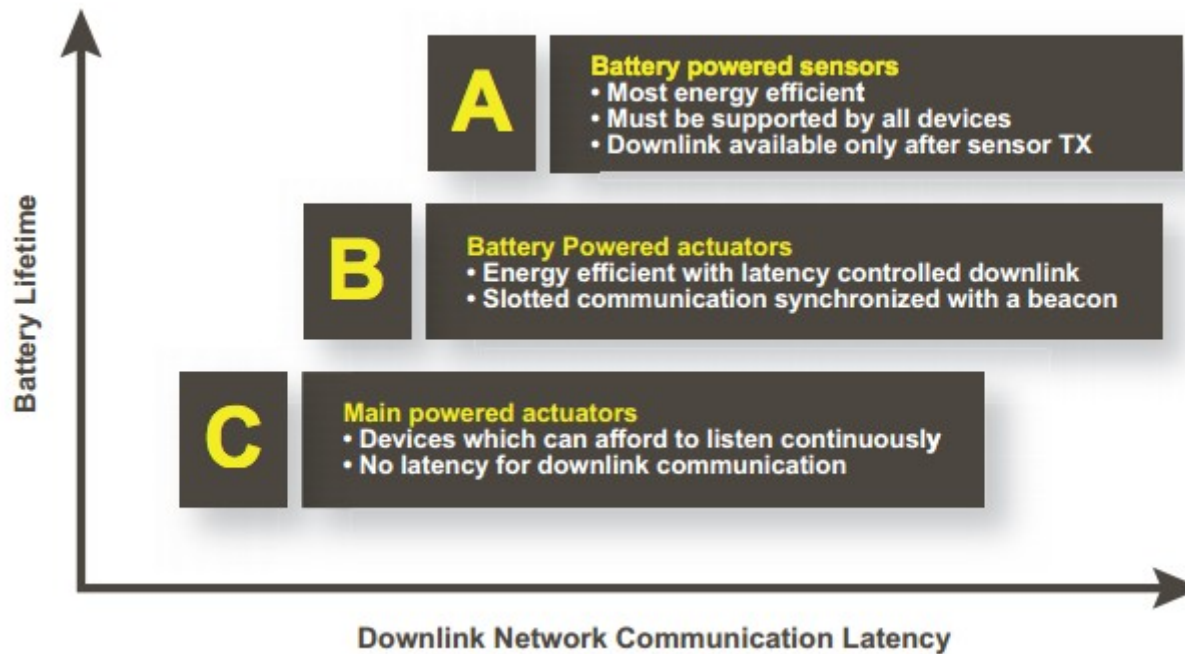
# Classe A de dispositius finals



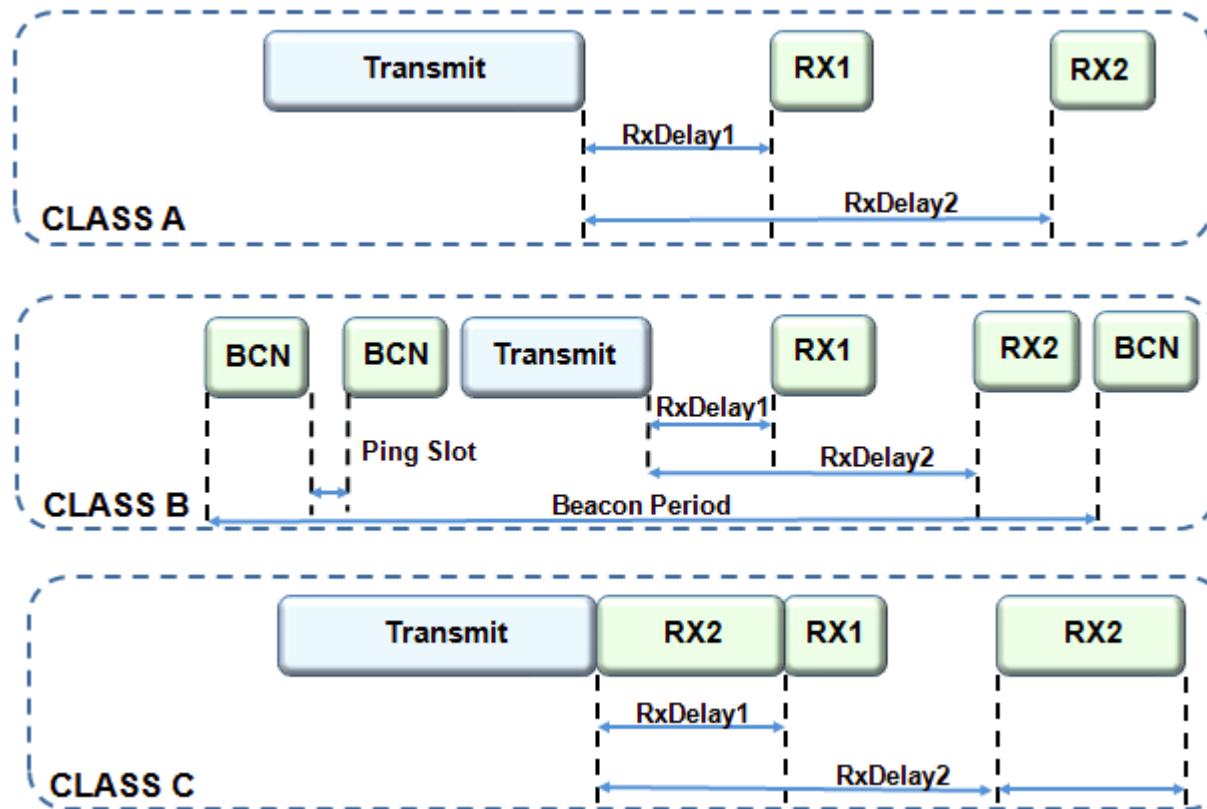
# Classes de dispositius finals

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

## Classes de dispositius finals



## Classes de dispositius finals



## Modulació CHIRP

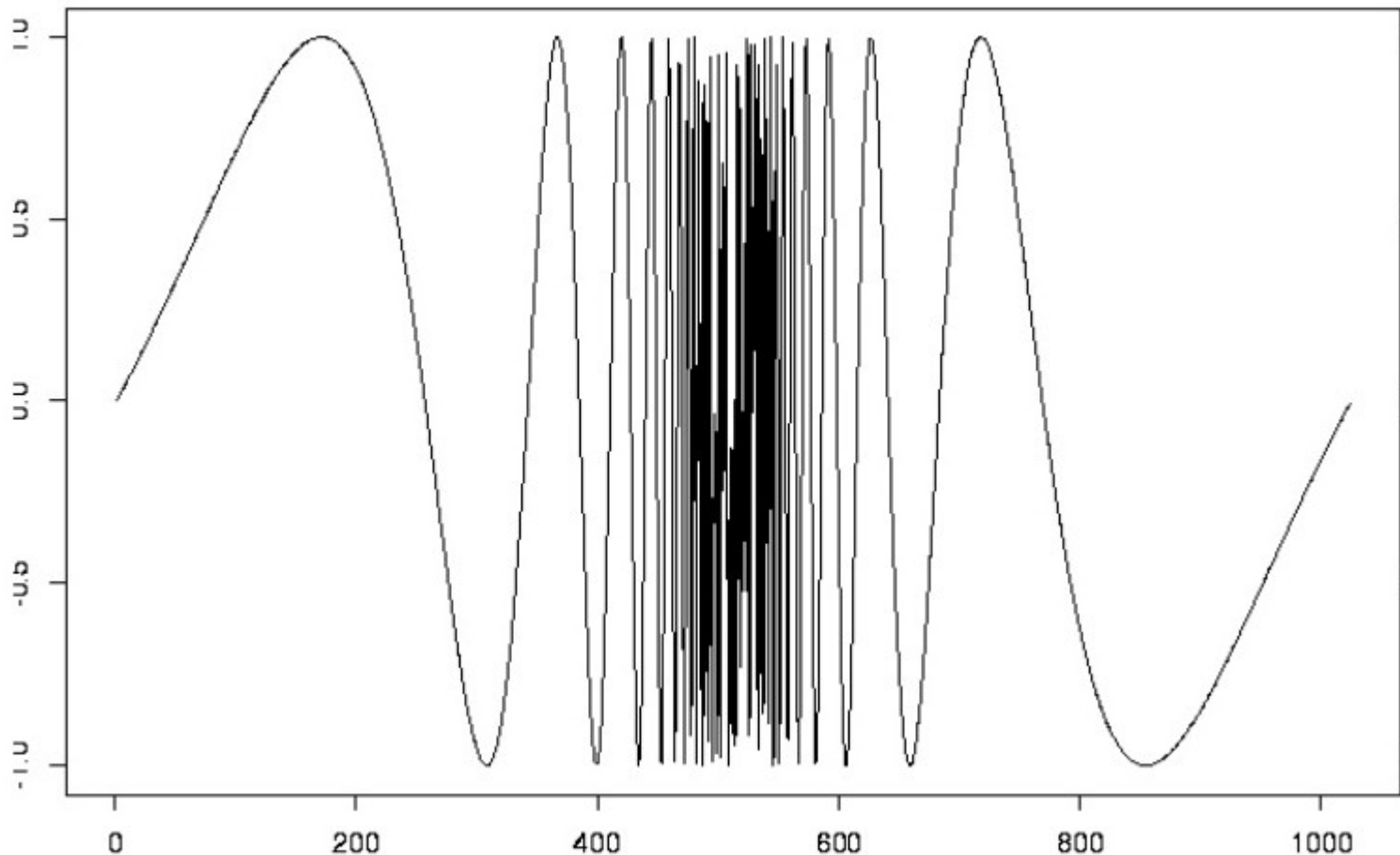
### Chirp

- 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>

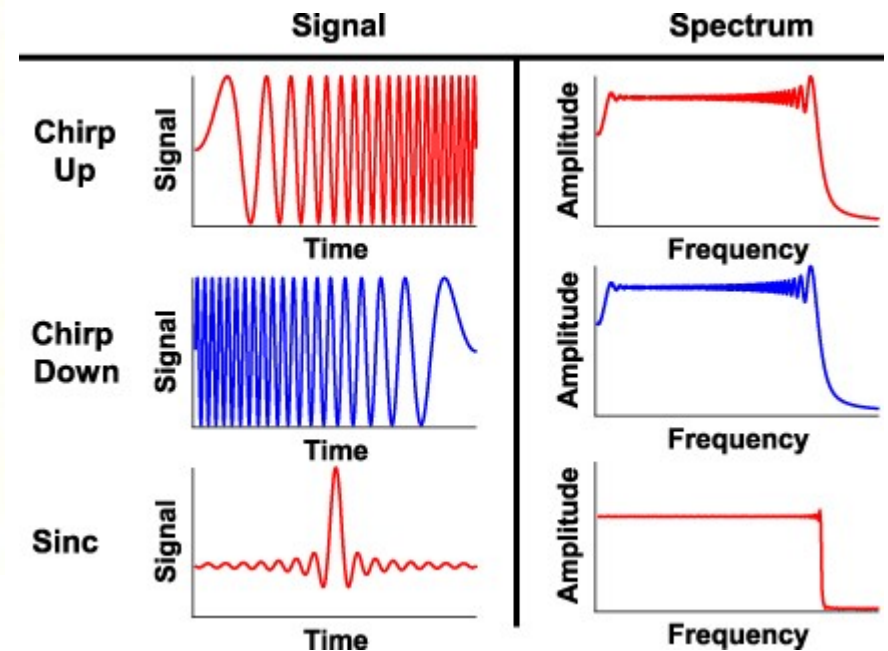
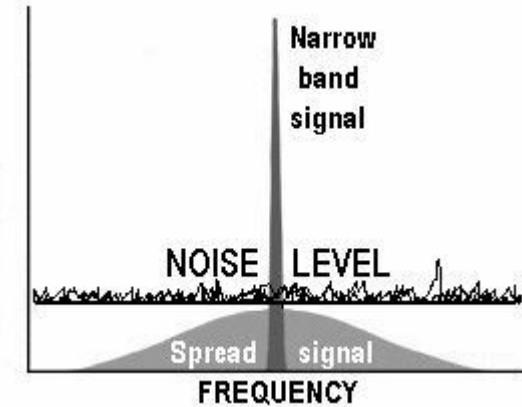
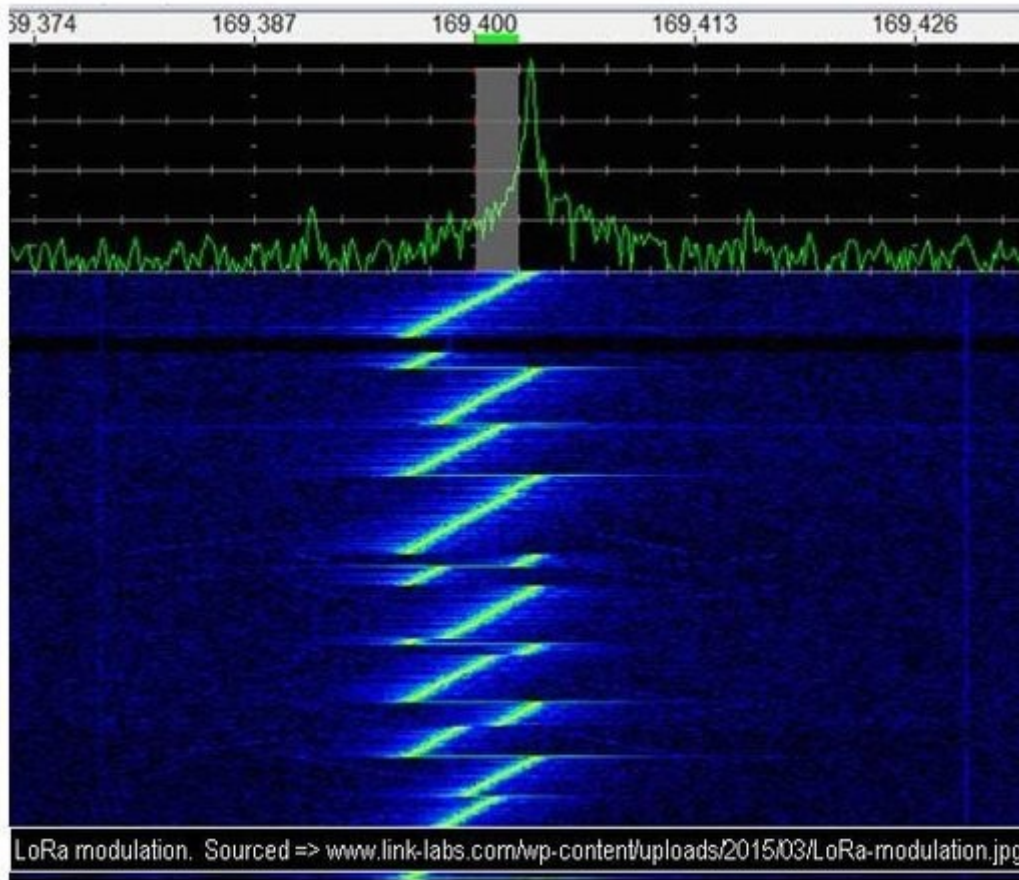
# Modulació CHIRP

Simulated chirp signal





## 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

70%

Cerca



COMMUNITIES LABS LEARN SUPPORT FORUM SHOP

SIGN UP LOGIN



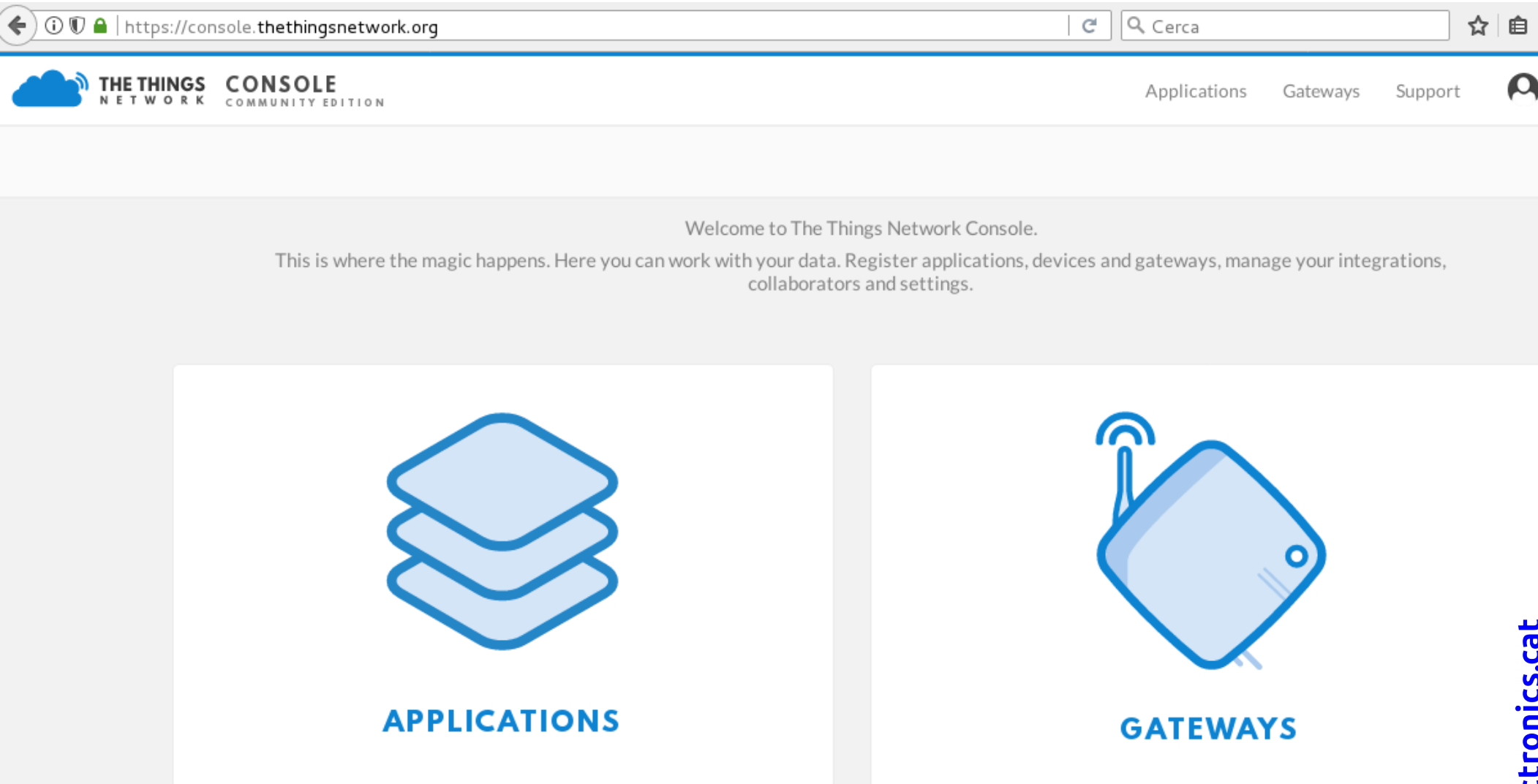
BUILDING A GLOBAL INTERNET OF THINGS NETWORK TOGETHER.

Learn More →

BUILDING A FULLY DISTRIBUTED INTERNET OF THINGS DATA INFRASTRUCTURE.

<https://www.thethingsnetwork.org/>

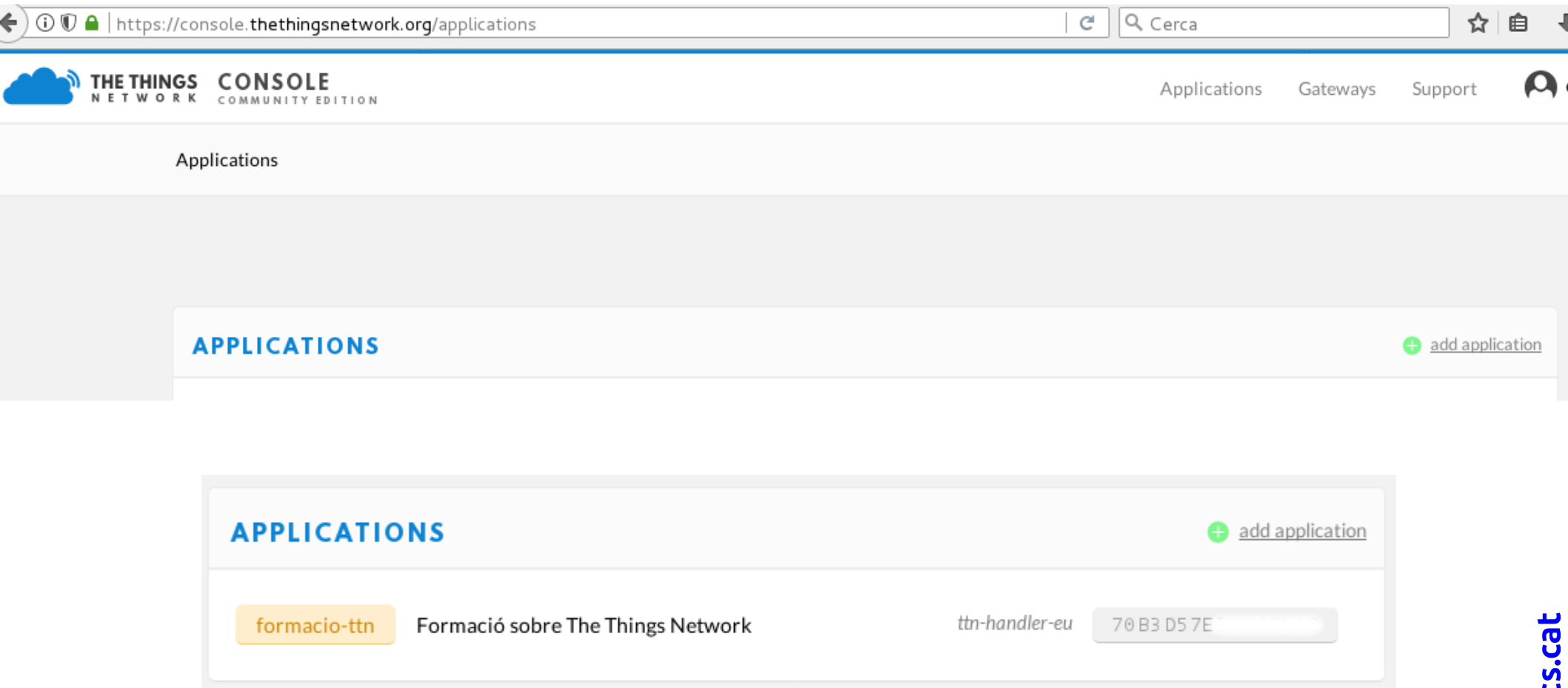
## La consola de The Things Network



The screenshot shows the web interface of the The Things Network Console. At the top, there is a browser address bar with the URL `https://console.thethingsnetwork.org` and a search bar containing the text "Cerca". Below the address bar is the site's header, which includes the "THE THINGS NETWORK" logo, the text "CONSOLE COMMUNITY EDITION", and navigation links for "Applications", "Gateways", and "Support". A user profile icon is also visible in the top right corner.

The main content area features a welcome message: "Welcome to The Things Network Console. This is where the magic happens. Here you can work with your data. Register applications, devices and gateways, manage your integrations, collaborators and settings." Below this message are two large, light blue buttons. The left button is labeled "APPLICATIONS" and features an icon of three stacked, rounded rectangular shapes. The right button is labeled "GATEWAYS" and features an icon of a square device with a radio antenna on top.

## Nova aplicació a The Things Network



The screenshot shows the 'Applications' page in the The Things Network Console. The browser address bar displays 'https://console.thethingsnetwork.org/applications'. The page header includes 'THE THINGS NETWORK CONSOLE COMMUNITY EDITION' and navigation links for 'Applications', 'Gateways', and 'Support'. The main content area is titled 'APPLICATIONS' and features a '+ add application' button. A list of applications is shown, with one application highlighted: 'formacio-ttn' with the description 'Formació sobre The Things Network', the identifier 'ttn-handler-eu', and the EUI '70 B3 D5 7E'.

Applications

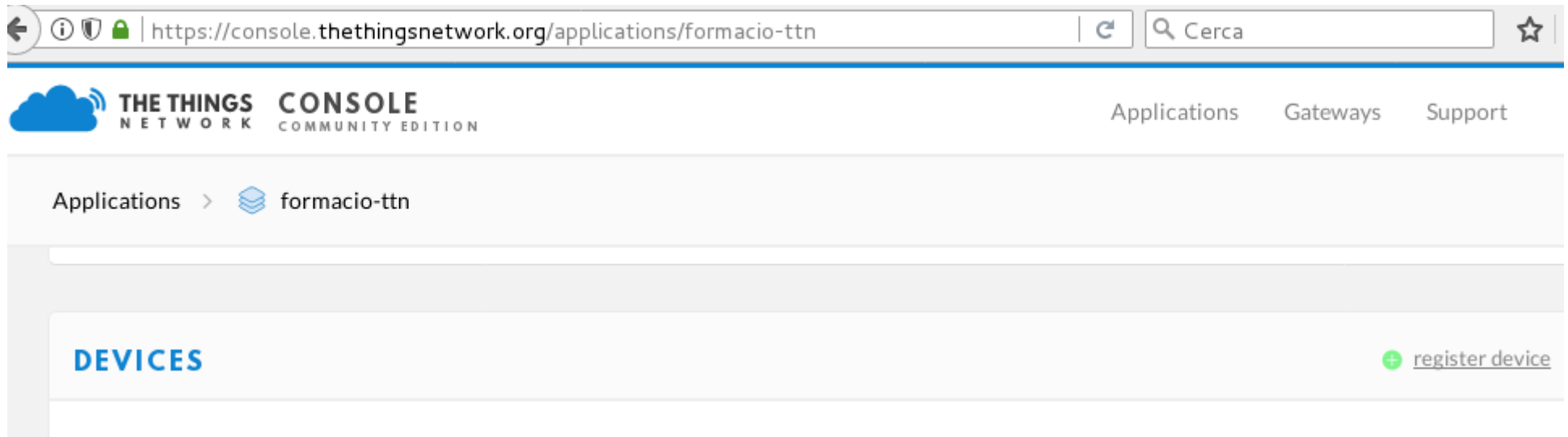
THE THINGS NETWORK CONSOLE COMMUNITY EDITION

Applications Gateways Support

APPLICATIONS + add application

formacio-ttn Formació sobre The Things Network ttn-handler-eu 70 B3 D5 7E

## Registre de dispositiu a l'aplicació a The Things Network



The screenshot shows the web interface of The Things Network Console. The browser address bar displays the URL `https://console.thethingsnetwork.org/applications/formacio-ttn`. The page header includes the logo for 'THE THINGS NETWORK CONSOLE COMMUNITY EDITION' and navigation links for 'Applications', 'Gateways', and 'Support'. The main content area shows the breadcrumb 'Applications > formacio-ttn' and a section titled 'DEVICES' with a '+ register device' button.



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

https://console.thethingsnetwork.org/applications/formacio-ttn/devices/register



Applications Gateways Support

Applications > formacio-ttn > Devices

Overview **Devices** Payload Formats Integrations Data Settings

## REGISTER DEVICE

[bulk import devices](#)

### Device ID

This is the unique identifier for the device in this app. The device ID will be immutable.

esp32-rfm95-07

### Device EUI

The device EUI is the unique identifier for this device on the network. You can change the EUI later.

65 43 61 74 30 30 30 37

### App Key

The App Key will be used to secure the communication between you device and the network.



this field will be generated

Cancel

Register

## Registre de dispositiu a l'aplicació a TTN

Applications > formacio-ttn > Devices > esp32-rfm95-07

### DEVICE OVERVIEW

**Application ID** formacio-ttn

**Device ID** esp32-rfm95-07

**Activation Method** OTAA

**Device EUI** <> ⇄ 65 43 61 74 B 00 00 00 00

**Application EUI** <> ⇄ 70 B3 D5 7E D0 00 00 00

**App Key** <> ⇄ 👁️ .....

**Status** ● never seen

**Frames up** 0 [reset frame counters](#)



**Frames down** 0

## 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

Applications >  formacio-ttn > Devices >  esp32-rfm95-07 > Settings

### DEVICE SETTINGS

- General
- Location

### SETTINGS

**Description**  
A human-readable description of the device

Placa ESP32-LoRa-07 (ESP32 i placa RFM95) ✓

**Device EUI**  
The serial number of your radio module, similar to a MAC address

⌵ 65 43 61 74 30 30 30 37 ✓ 8 bytes

**Application EUI**

70B3D57ED000B108 ⌵

**Activation Method**

OTAA ABP

**Device Address**



## Registre de dispositiu a l'aplicació a TTN

Applications > formacio-ttn > Devices > esp32-rfm95-07 > Settings

**Activation Method**

OTAA  ABP

**Device Address**

The device address will be assigned by the network server

**Network Session Key**

Network Session Key will be generated

**App Session Key**

App Session Key will be generated

**Frame Counter Width**

16 bit  32 bit

**Frame Counter Checks**

Disabling frame counter checks drastically reduces security and should only be used for development purposes

Delete Device Cancel Save

## Registre de dispositiu a l'aplicació a TTN

Applications > formacio-ttn > Devices > esp32-rfm95-07

### DEVICE OVERVIEW

**Application ID** formacio-ttn

**Device ID** esp32-rfm95-07

**Description** Placa ESP32-LoRa-07 (ESP32 i placa RFM95)

**Activation Method** ABP

**Device EUI** <> ⇄ 65 43 61 74 3 00000000 ☒

**Application EUI** <> ⇄ 70 B3 D5 7E D 00000003 ☒

**Device Address** <> ⇄ 26 01 0000 ☒

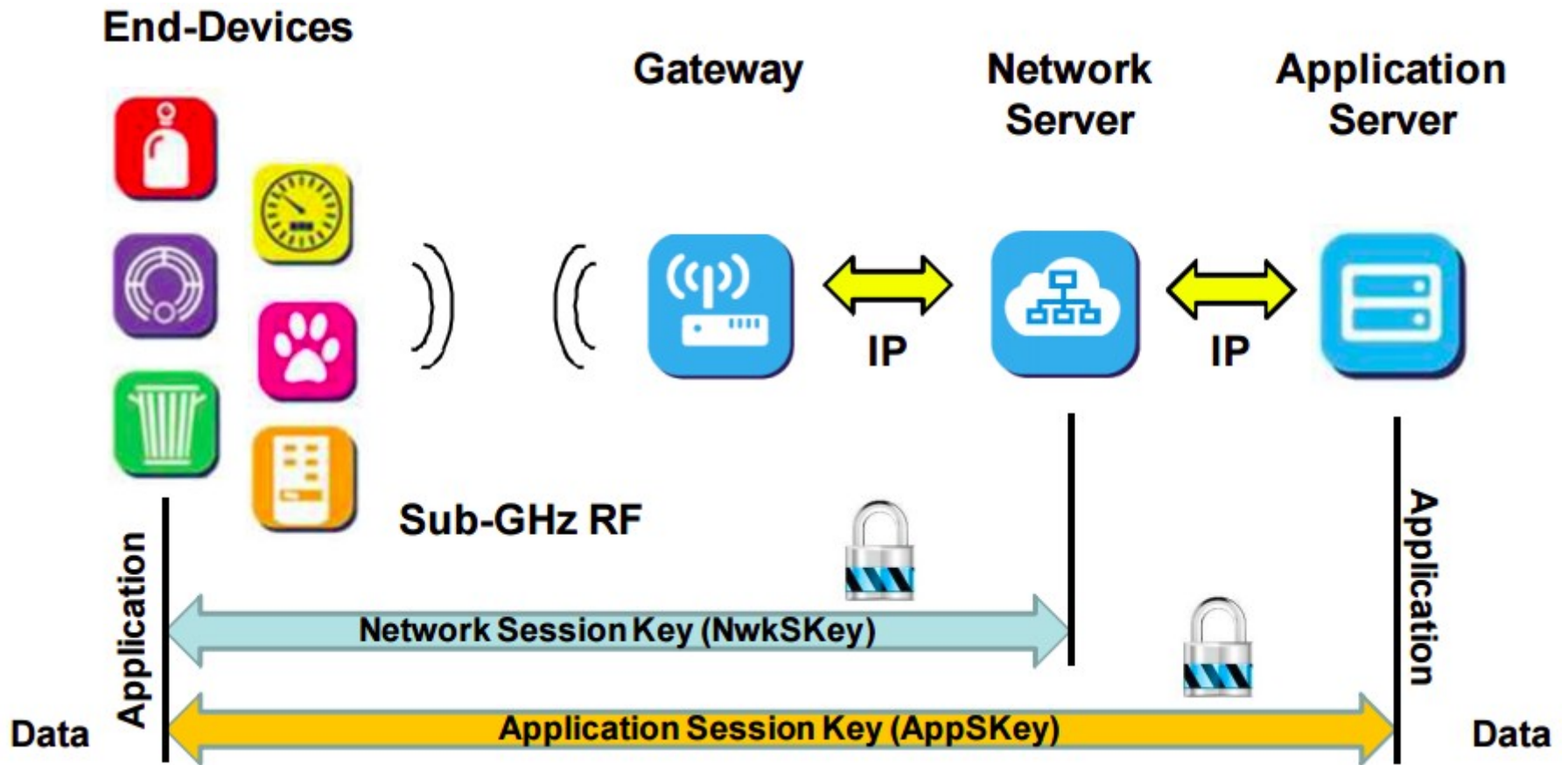
**Network Session Key** <> ⇄ 👁 ..... ☒

**App Session Key** <> ⇄ 👁 ..... ☒

**Status** ● never seen

**Frames up** 0 [reset frame counters](#)

**Frames down** 0



## Registre de dispositiu a l'aplicació a TTN

Applications > formacio-ttn > Devices > esp32-rfm95-07

### DEVICE OVERVIEW

**Application ID** formacio-ttn

**Device ID** esp32-rfm95-07

**Description** Placa ESP32-LoRa-07 (ESP32 i placa RFM95)

**Activation Method** ABP

**Device EUI** <> 65 43 61 74 3 00 00 00 00 00 00 00 00 00 00 00

**Application EUI** <> 70 B3 D5 7E 00 00 00 00 00 00 00 00 00 00 00 00

**Device Address** <> 26 01 1 0 0 0 0 0

**Network Session Key** <> msb { 0xB7, 0x30, 0xAF, 0x7B, 0xEE, 0x7A, 0x20, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00 }

**App Session Key** <> msb { 0x12, 0x5C, 0x41, 0x0C, 0x7E, 0x30, 0x8F, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00 }

**Status** ● never seen

**Frames up** 0 [reset frame counters](#)

**Frames down** 0

## 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, 0x00, 0x11, 0x1F, 0x53, 0x54, 0x15, 0x43 };
  static const PROGMEM u1_t APPSKEY[16] = { 0x12, 0x5C, 0x41, 0x0C, 0x7E, 0x30, 0x8F, 0x11, 0x00, 0x07, 0x95, 0xD1, 0xE1, 0x51, 0x17, 0x51 };
  static const u4_t DEVADDR = 0x26011002 ;
#elseif
#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

Applications > formacio-ttn > Devices > esp32-rfm95-07 > Data

Fitxer Edita Esbós Eines Ajuda

lorawan\_ttnEsp32\_rfm95\_01\_multichar

```
#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 NWSKEY[]
  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 = "";
```

**APPLICATION DATA**

Filters:

	time	counter	port	
▲	11:12:40	1	1	payload: 00 00 00 01
▲	11:11:57	0	1	retry payload: 00 00 00 00

```
[MAIN] Startup
[RFM95] Packet queued
135590: [RFM95] EV_TXCOMPLETE (includes waiting for RX windows)
TXRX_ACK confirmed UP frame was acked

TX complete .....
0 0

[RFM95] Packet queued
2839919: [RFM95] EV_TXCOMPLETE (includes waiting for RX windows)
TXRX_ACK confirmed UP frame was acked

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

## Downlink des de l'aplicació TTN al node

Applications > formacio-ttn > Devices > esp32-rfm95-07

### DOWNLINK

**Scheduling**

[replace](#) [first](#) [last](#)

**FPort**

1

**Confirmed**

**Payload**

[bytes](#) [fields](#)

01 65 43 61 74 02 6 bytes

[Send](#)

## Downlink des de l'aplicació TTN al node

Applications > formacio-ttn > Devices > esp32-rfm95-07 > Data

### APPLICATION DATA

Filters:

	time	counter	port	
▲	11:16:54	6	0	payload: [not provided]
✓	11:16:54		1	confirmed ack app id: formacio-ttn
▼	11:16:49		1	confirmed payload: 016543617402
▲	11:16:49	5	1	payload: 00000005
▼	11:15:47		1	confirmed payload: 016543617402
▲	11:15:47	4	1	payload: 00000004
▼	11:15:13		1	scheduled confirmed payload: 016543617402
▲	11:14:45	3	1	payload: 00000003

```

#define LORA_MODE LORA_MODE_OTAA
#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
  
```





# sigfox

## Què és?



IoT Devices equipped with radio modems



SIGFOX Base Station

Ethernet, 3G or Custom IP Links



SIGFOX Backend Servers

HTTP Callback



Client



3rd Party App Server



SIGFOX Base Station

Ethernet, 3G or Custom IP Links



Client