

Proyecto Integrado: Redes LoRaWAN

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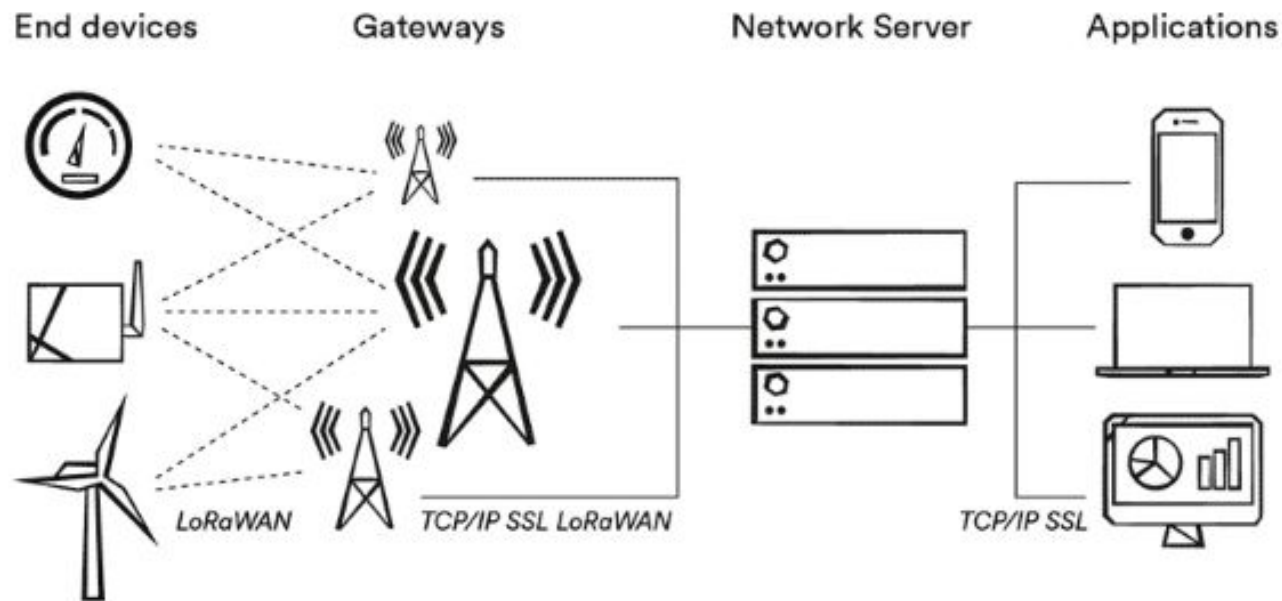


¿Qué es Lorawan y cuáles son sus características?

- Protocolo de red para Redes de baja potencia y largo alcance.
- Mensajes entre sensores y Gateways por radiofrecuencia.
- Mensajes TCP-UDP/IP con Cifrado AES.
- Conexión punto a punto y bajo consumo energético.



Arquitectura de la red de LoRaWAN




OTA (Over the air activation)

Lora es un protocolo basado en MAC.

Se trata de una activación basada sobre la MAC del dispositivo y una contraseña de dispositivo (DEVICE EUI & DEVICE KEY)

Por un lado está el filtrado de la MAC del dispositivo o identificador de dispositivo (DEVICE EUI) y luego el servidor tiene que tener la clave del dispositivo para poder recibir el payload/mensaje de los datos cifrados del dispositivo.



The screenshot shows a web-based configuration interface titled "Edit End-Device Key". It contains several input fields and dropdown menus for configuring device parameters. The fields are as follows:

Field	Value
Dev EUI	01-01-01-01-01-01-01
App EUI	01-01-01-01-01-01-01
App Key	2B7E151628AED2A6ABF7158809CF
Class	A
Device Profile	LW102-OTA-US915
Network Profile	DEFAULT-CLASS-A

A blue "Finish" button is located in the bottom right corner of the form.

Regulación de Lorawan

Lora hace uso de radiofrecuencias para conectar los dispositivos y/o sensores con los puntos de acceso de los mismos para poder llevar los datos a distancias muy lejanas.

El espectro radiofónico es un tema muy delicado en todos los países del mundo, ya que las propias compañías de telefonía se pelean por el propio uso del espectro radiofónico para evitar interferencias y mejorar la cobertura de los dispositivos.

Lora Alliance fue una organización que se creó para regular el uso de la red Lora en todo el mundo.



Usos de la red Lorawan

- Control del Ciclo del agua.
- Control Medioambiental.
- Agricultura Sostenible /
Optimización de recursos hídricos.
- Control de infraestructuras.
- Gestión de variables en edificios
(sensores de movimiento, luz,
temperatura, humedad...)



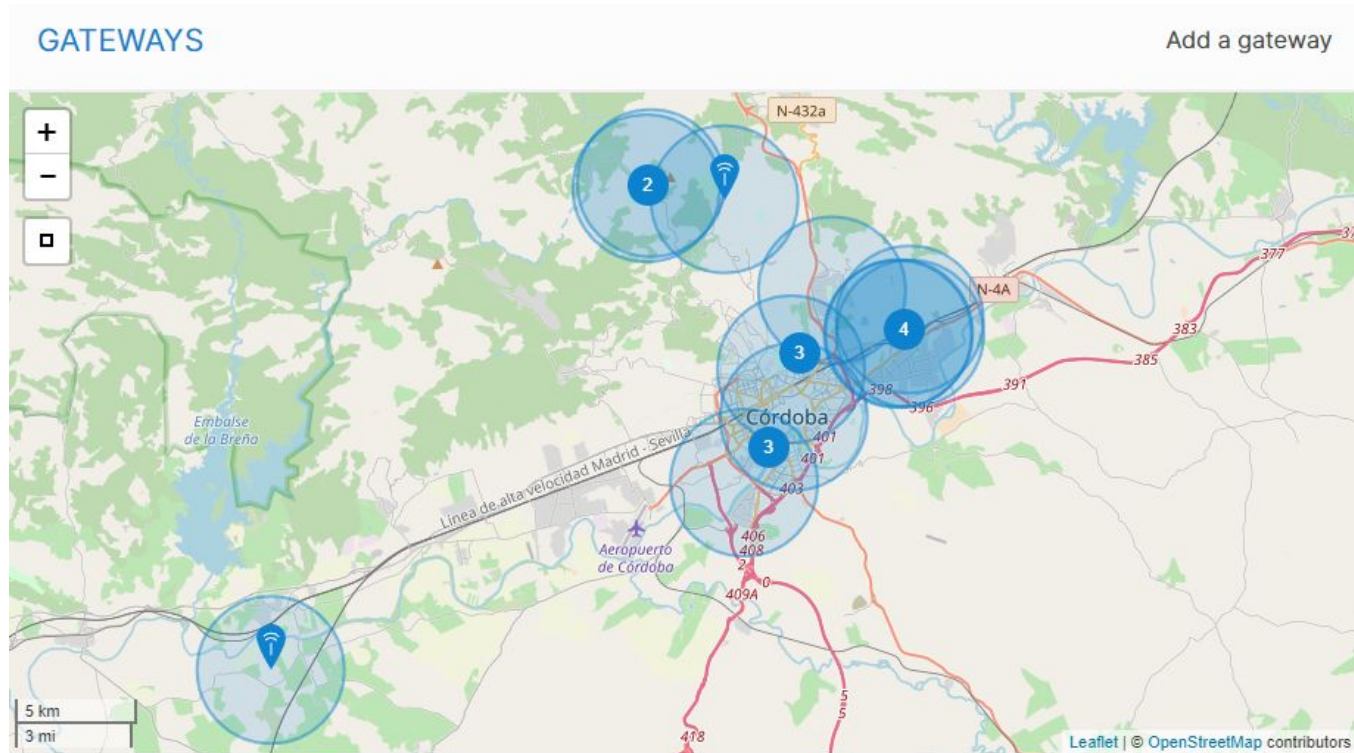
Proyectos Lorawan

Red BlockChain para compartir acceso a internet de manera cifrada y privada.

La propia Universidad de Córdoba tiene un proyecto para IoT basado en Lorawan y dispositivos desplegados por toda la ciudad.

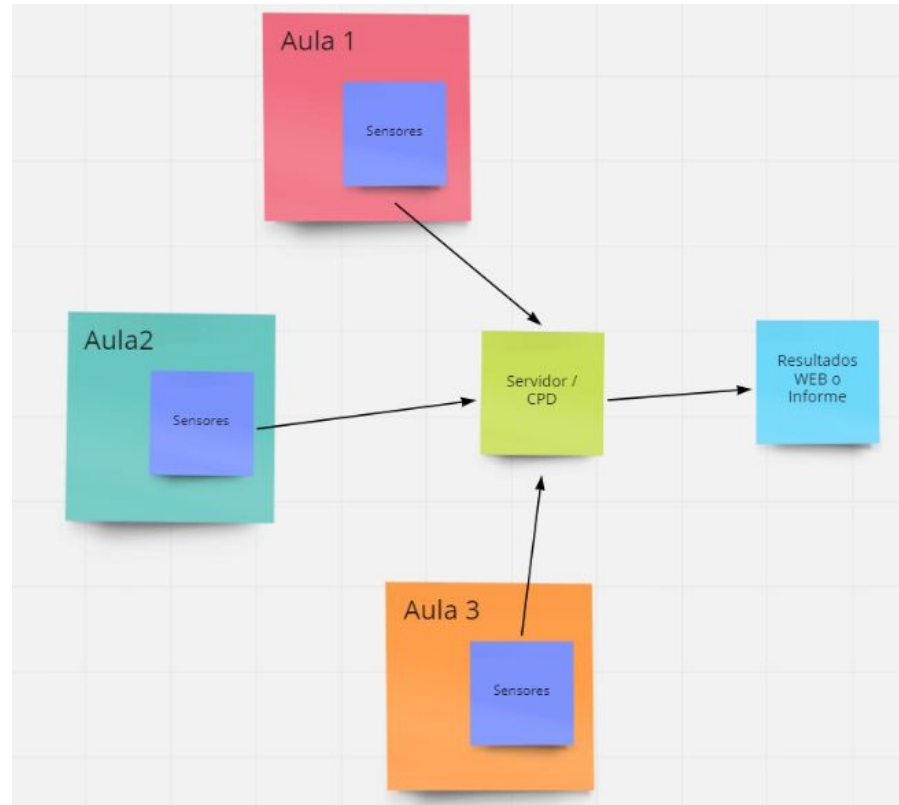


Distancia de funcionamiento de los dispositivos

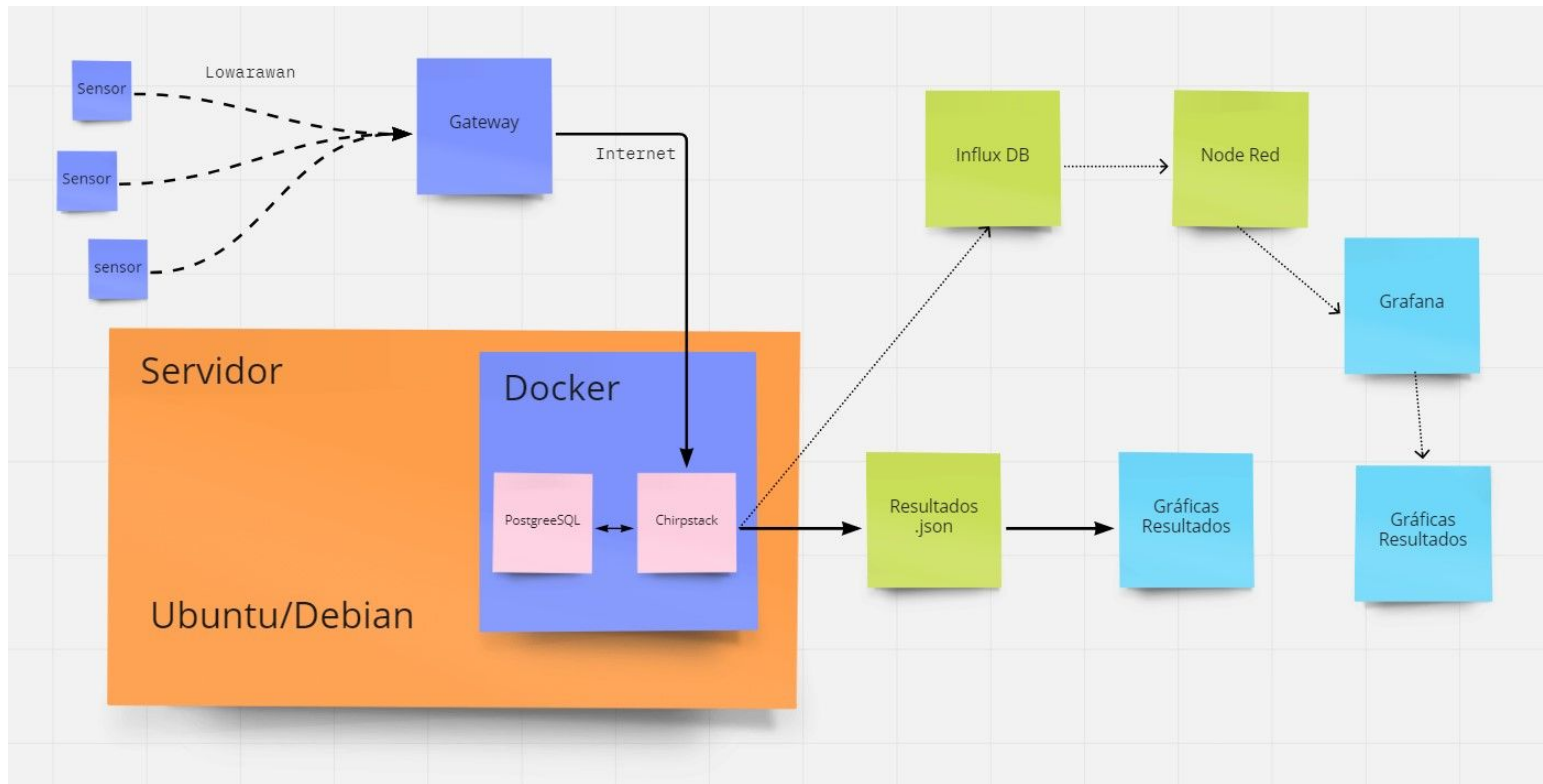


Proyecto IoT Lorawan IES Gran Capitán

LA IDEA:



EL ESQUEMA FINAL DEL PROYECTO



Montaje Docker y lanzamos el contenedor

```
lorawan@lorawan: ~/chirpstack-docker
GNU nano 4.8 docker-compose.yml
- postgresql
- mosquitto

chirpstack-application-server:
  image: chirpstack/chirpstack-application-server:3
  ports:
    - 8080:8080
  volumes:
    - ./configuration/chirpstack-application-server:/etc/chirpstack-application-server
  depends_on:
    - chirpstack-network-server

chirpstack-gateway-bridge:
  image: chirpstack/chirpstack-gateway-bridge:3
  ports:
    - 1700:1700/udp
  volumes:
    - ./configuration/chirpstack-gateway-bridge:/etc/chirpstack-gateway-bridge
  depends_on:
    - mosquitto

postgresql:
  image: postgres:9.6-alpine
  environment:
    - POSTGRES_PASSWORD=root
  volumes:
    - ./configuration/postgresql/initdb:/docker-entrypoint-initdb.d
    - postgresqldata:/var/lib/postgresql/data

redis:
  image: redis:5-alpine
  volumes:
    - redisdata:/data

mosquitto:
  image: eclipse-mosquitto:2
  ports:
    - 1883:1883
  volumes:
    - ./configuration/eclipse-mosquitto/mosquitto.conf:/mosquitto/config/mosquitto.conf

volumes:
  postgresqldata:
  redisdata:
```

```
lorawan@lorawan: ~/chirpstack-docker
Pulling chirpstack-application-server (chirpstack/chirpstack-application-server:3)...
3: Pulling from chirpstack/chirpstack-application-server
59bf1c3509f3: Already exists
0bfa78039fc8: Pull complete
868a2d72a83b: Pull complete
Digest: sha256:e0b23dfd24d6da76fd5a792c5025bfcfff20414222eab0c3779d84a3b98b71b
Status: Downloaded newer image for chirpstack/chirpstack-application-server:3
Creating chirpstack-docker_postgresql_1 ... done
Creating chirpstack-docker_mosquitto_1 ... done
Creating chirpstack-docker_redis_1 ... done
Creating chirpstack-docker_chirpstack-network-server_1 ... done
Creating chirpstack-docker_chirpstack-gateway-bridge_1 ... done
Creating chirpstack-docker_chirpstack-application-server_1 ... done
Attaching to chirpstack-docker_postgresql_1, chirpstack-docker_mosquitto_1, chirpstack-docker_redis_1, c
chirpstack-docker_chirpstack-network-server_1, chirpstack-docker_chirpstack-gateway-bridge_1, chirpstack-
docker_chirpstack-application-server_1
chirpstack-application-server_1 | time="2022-06-13T09:06:46.808376275Z" level=info msg="starting ChirpS
tack Application Server" docs="https://www.chirpstack.io/" version=
chirpstack-application-server_1 | time="2022-06-13T09:06:46.808476535Z" level=info msg="storage: settin
g up storage package"
chirpstack-application-server_1 | time="2022-06-13T09:06:46.808625642Z" level=info msg="storage: setup m
etrics"
chirpstack-application-server_1 | time="2022-06-13T09:06:46.808701603Z" level=info msg="storage: settin
g up Redis client"
chirpstack-application-server_1 | time="2022-06-13T09:06:46.808815454Z" level=info msg="storage: connec
ting to PostgreSQL database"
chirpstack-application-server_1 | time="2022-06-13T09:06:46.814839832Z" level=warning msg="storage: pin
g PostgreSQL database error, will retry in 2s" error="dial tcp 172.18.0.2:5432: connect: connection refu
sed"
chirpstack-gateway-bridge_1 | time="2022-06-13T09:06:46.253401327Z" level=info msg="starting ChirpS
tack Gateway Bridge" docs="https://www.chirpstack.io/gateway-bridge/" version=
chirpstack-gateway-bridge_1 | time="2022-06-13T09:06:46.253436907Z" level=info msg="backend/seamtech
udp: starting gateway udp listener" addr="0.0.0.0:1700"
chirpstack-gateway-bridge_1 | time="2022-06-13T09:06:46.303155198Z" level=info msg="integration/mqt
t: connected to mqtt broker"
chirpstack-gateway-bridge_1 | time="2022-06-13T09:06:46.303161023Z" level=warning msg="[store] m
emorystore wiped" module=mqtt
mosquitto_1 | 1655111205: mosquitto version 2.0.14 starting
mosquitto_1 | 1655111205: Config loaded from /mosquitto/config/mosquitto.conf.
mosquitto_1 | 1655111205: Opening ipv4 listen socket on port 1883.
mosquitto_1 | 1655111205: Opening ipv6 listen socket on port 1883.
mosquitto_1 | 1655111205: mosquitto version 2.0.14 running
mosquitto_1 | 1655111206: New connection from 172.18.0.5:33822 on port 1883.
mosquitto_1 | 1655111206: New client connected from 172.18.0.5:33822 as auto-808300
AQ-0BC5-5F10-0BB8-EC3832066AE8 (p2, c1, k30).
chirpstack-network-server_1 | time="2022-06-13T09:06:46.151394211Z" level=info msg="starting ChirpS
tack Network Server" band=EU868 docs="https://www.chirpstack.io/" net_id=000000 version=
chirpstack-network-server_1 | time="2022-06-13T09:06:46.180947561Z" level=info msg="storage: settin
g up storage module"
```

Comprobación Servidor IoT

The screenshot shows a web browser window with the ChirpStack application. The address bar shows the URL `192.168.12.158:8080/#/organizations/1/users/create`. The ChirpStack logo and a search bar are in the top navigation bar. A left sidebar contains a menu with items: Dashboard, Network-servers, Gateway-profiles, Organizations, All users, API keys, and a dropdown for 'chirpstack' which includes Org. dashboard, Org. users, Org. API keys, Service-profiles, Device-profiles, and Gateways. The main content area is titled 'Organization users / Add' and contains a form for adding a new user. The form has an 'Email *' input field, a text block explaining user permissions, and three checkboxes for different roles: 'User is organization admin', 'User is device admin', and 'User is gateway admin'. Each role checkbox is accompanied by a brief description of its permissions. An 'ADD USER' button is located at the bottom right of the form.

ChirpStack Application Ser x +

No es seguro 192.168.12.158:8080/#/organizations/1/users/create

Google Hangouts

ChirpStack

Search organization, application, gateway or device

admin

Dashboard

Network-servers

Gateway-profiles

Organizations

All users

API keys

chirpstack

Org. dashboard

Org. users

Org. API keys

Service-profiles

Device-profiles

Gateways

Organization users / Add

Email *

An user without additional permissions will be able to see all resources under this organization and will be able to send and receive device payloads.

☐ User is organization admin

An organization admin user is able to add and modify resources part of the organization.

☐ User is device admin

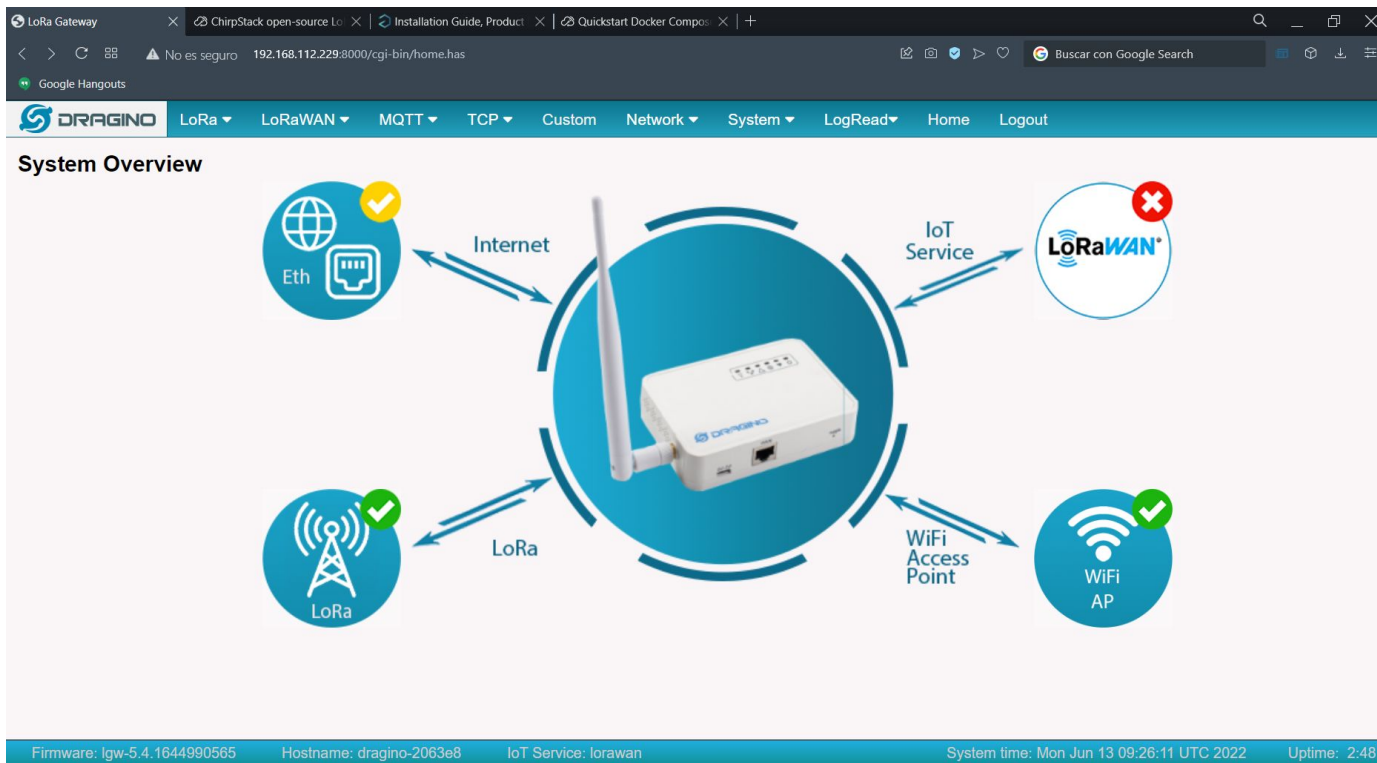
A device admin user is able to add and modify resources part of the organization that are related to devices.

☐ User is gateway admin

A gateway admin user is able to add and modify gateways part of the organization.

ADD USER

Conectamos el gateway



Configuración Gateway Red Lora

The screenshot shows a web browser window with the URL `192.168.112.229:8000/cgi-bin/lora-lora.has`. The page title is "LoRa Gateway" and the breadcrumb trail is "ChirpStack open-source LoRaWAN Gateway". The navigation menu includes "LoRa", "LoRaWAN", "MQTT", "TCP", "Custom", "Network", "System", "LogRead", "Home", and "Logout".

LoRa Configuration

Debug Level:

Radio Settings

Keep Alive Period (sec):
Frequency Plan:

Static GPS coordinates ?

Enable Static GPS	<input type="checkbox"/>	Altitude (m)	<input type="text" value="450"/>
Latitude	<input type="text" value="22.700000"/>	Longitude	<input type="text" value="114.240000"/>

Current Mode: **LoRaWAN Semtech UDP**

Configuración server IoT Gateway

LoRa Gateway

ChirpStack open-source LoRaWAN Stack | Installation Guide, Product | Quickstart Docker Compose

192.168.112.229:3000/cgi-bin/lorawan.has

Google Hangouts

DRAGINO

LoRa | LoRaWAN | MQTT | TCP | Custom | Network | System | LogRead | Home | Logout

LoRaWAN Configuration

General Settings

Email

Gateway EUI

Primary LoRaWAN Server

Service Provider Server Address

Uplink Port Downlink Port

Primary Packet Filter

Fport Filter ? DevAddr Filter ?

Secondary LoRaWAN Server

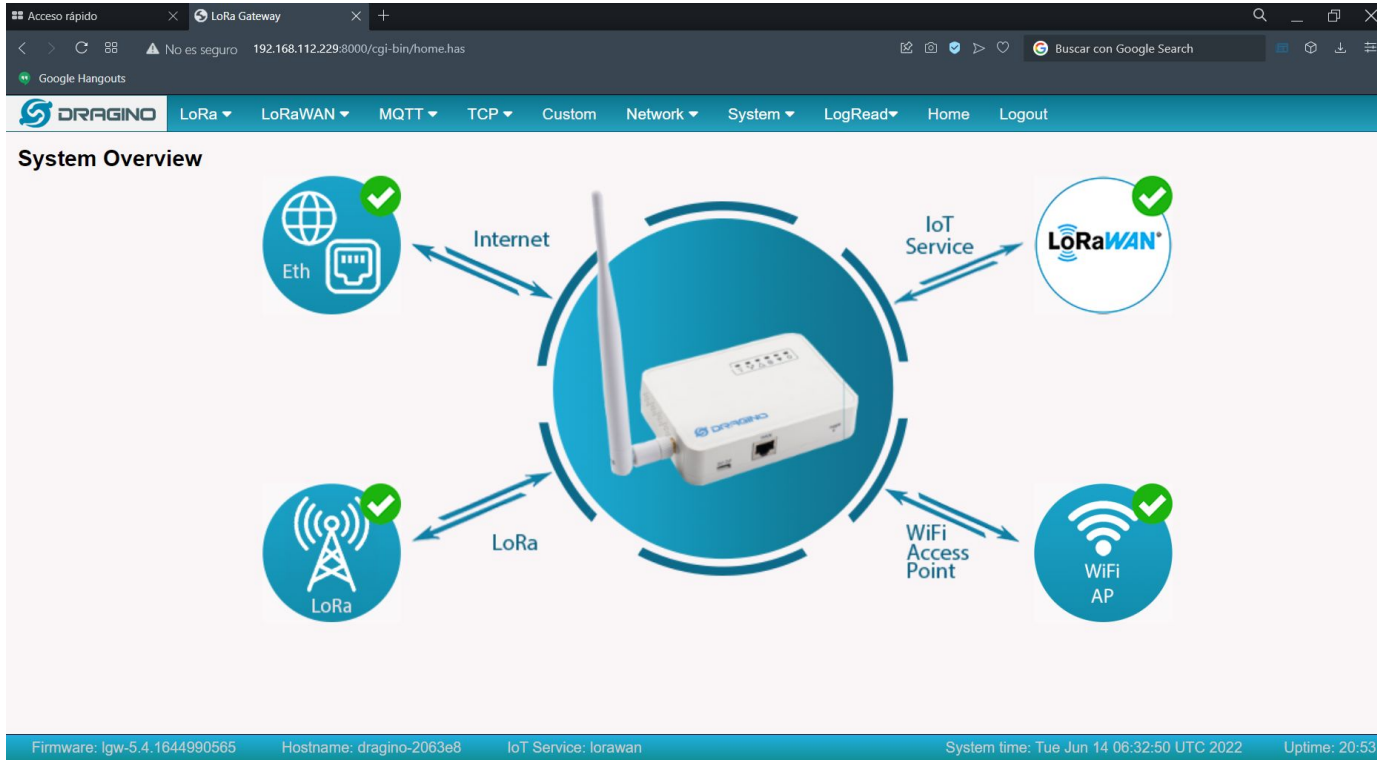
Service Provider

Secondary Packet Filter

Fport Filter ? DevAddr Filter ?

Current Mode: LoRaWAN Semtech UDP

Dragino Configurado



Configuración de los perfiles de los dispositivos

The screenshot shows the ChirpStack web application interface. The browser address bar indicates the URL: `192.168.12.158:8080/#/organizations/34/device-profiles/create`. The ChirpStack logo and a search bar are at the top. A left sidebar contains navigation links: Network-servers, Gateway-profiles, Organizations, All users, API keys, and a dropdown menu for 'IES-Gran-Capitan'. The main content area is the 'CREATE DEVICE-PROFILE' form for the 'Network-server *' 'lesGranCapitan01'. The form includes the following fields:

- Network-server ***: lesGranCapitan01 (The network-server on which this device-profile will be provisioned. After creating the device-profile, this value can't be changed.)
- LoRaWAN MAC version ***: 1.0.3 (The LoRaWAN MAC version supported by the device.)
- LoRaWAN Regional Parameters revision ***: RP002-1.0.3 (Revision of the Regional Parameters specification supported by the device.)
- ADR algorithm ***: Default ADR algorithm (LoRa only) (The ADR algorithm that will be used for controlling the device data-rate.)
- Max EIRP ***: 0 (Maximum EIRP supported by the device.)
- Uplink interval (seconds) ***: 600 (The expected interval in seconds in which the device sends uplink messages. This is used to determine if a device is active or inactive.)

A 'CREATE DEVICE-PROFILE' button is located at the bottom right of the form.

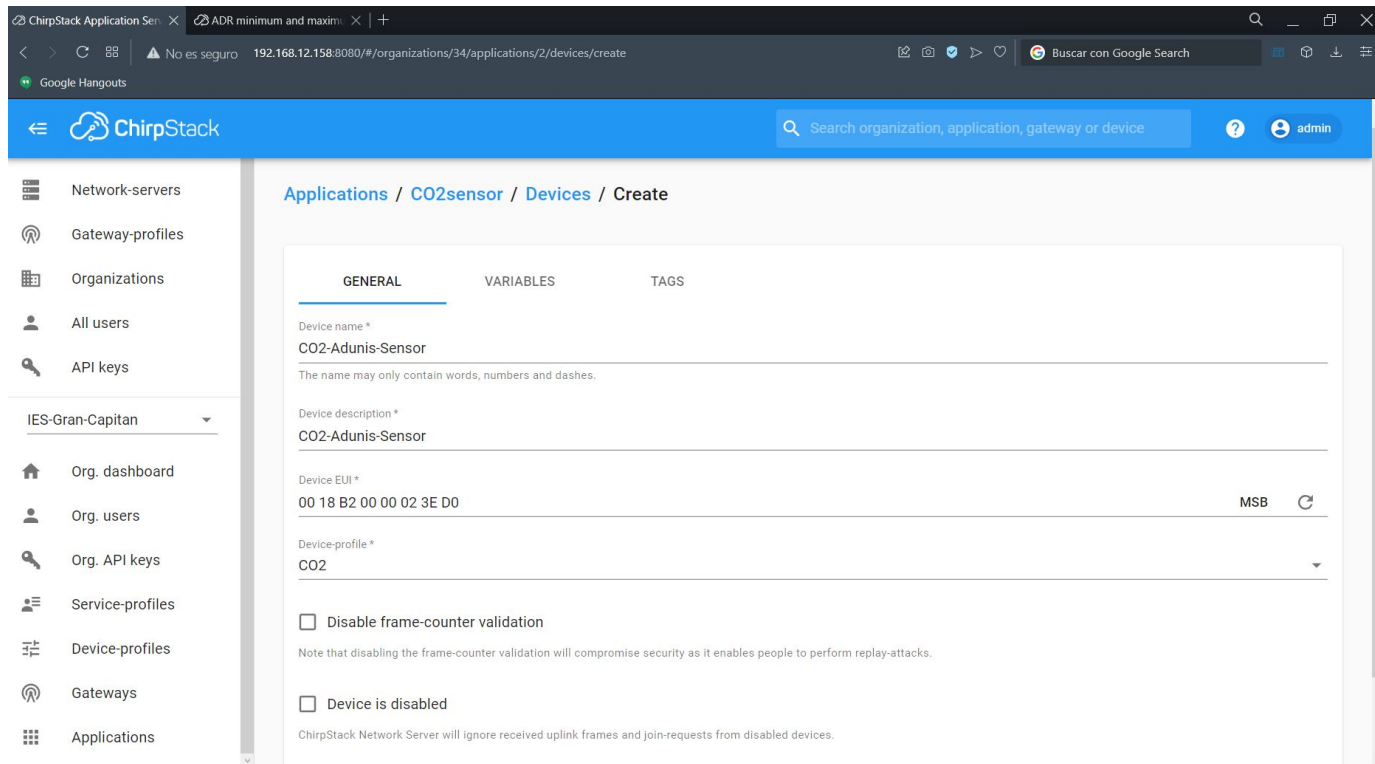
Configuración Decoder de los sensores

The screenshot shows the ChirpStack Application Server web interface. The browser address bar displays the URL `192.168.12.158:8080/#/organizations/34/device-profiles/47119881-2a70-45f9-89a7-7efa0cb42c57`. The interface has a blue header with the ChirpStack logo and a search bar. A left sidebar contains navigation links: Network-servers, Gateway-profiles, Organizations, All users, API keys, IES-Gran-Capitan (selected), Org. dashboard, Org. users, Org. API keys, Service-profiles, Device-profiles, Gateways, and Applications. The main content area is titled "Device-profiles / CO2" and includes a "DELETE" button. Below this is a tabbed interface with tabs for GENERAL, JOIN (OTAA / ABP), CLASS-B, CLASS-C, CODEC (selected), and TAGS. The CODEC tab shows a section for "Payload codec" with the option to use "Custom JavaScript codec functions". A text area contains the following JavaScript code:

```
6667 // * 'pulse3' => 'Pulse 3 device'
6668 // * 'pulse4' => 'Pulse 4 device'
6669 // * 'pulse4nbiot' => 'Pulse 4 NB-IoT device'
6670 // * 'repeater' => 'Repeater device'
6671 // * 'temp' => 'Temp device'
6672 // * 'temp3' => 'Temp 3 device'
6673 // * 'temp4' => 'Temp 4 device'
6674 // * 'ticcbeLinkyMono' => 'TIC CBE/LINKY MONO device'
6675 // * 'ticcbeLinkyTri' => 'TIC CBE/LINKY TRI device'
6676 // * 'ticPmePmi' => 'TIC PME-PMI device'
6677 decoder.setDeviceType("comfortCo2");
6678
6679 return decoder.decode(base64tohex(bytes));
6680 }
```

Below the code area, a note states: "The function must have the signature `function Decode(fPort, bytes)` and must return an object. ChirpStack Application Server will convert this object to JSON." At the bottom, a comment reads: `1 // Encode encodes the given object into an array of bytes.`

Conexión sensores al servidor IoT



The screenshot shows the ChirpStack web application interface. The browser address bar indicates the URL: `192.168.12.158:8080/#/organizations/34/applications/2/devices/create`. The ChirpStack logo and a search bar are at the top. A left sidebar contains navigation links: Network-servers, Gateway-profiles, Organizations, All users, API keys, IES-Gran-Capitan (selected), Org. dashboard, Org. users, Org. API keys, Service-profiles, Device-profiles, Gateways, and Applications. The main content area is titled 'Applications / CO2sensor / Devices / Create' and features three tabs: GENERAL (active), VARIABLES, and TAGS. The 'GENERAL' tab contains the following fields and options:

- Device name ***: CO2-Adunis-Sensor. A note below states: 'The name may only contain words, numbers and dashes.'
- Device description ***: CO2-Adunis-Sensor.
- Device EUI ***: 00 18 B2 00 00 02 3E D0. To the right are 'MSB' and '↻' icons.
- Device-profile ***: CO2 (selected from a dropdown menu).
- ☐ **Disable frame-counter validation**. A note below reads: 'Note that disabling the frame-counter validation will compromise security as it enables people to perform replay-attacks.'
- ☐ **Device is disabled**. A note below reads: 'ChirpStack Network Server will ignore received uplink frames and join-requests from disabled devices.'

Sensores conectados

The screenshot shows the ChirpStack web application interface. The browser address bar displays the URL: 192.168.12.158:8080/#/organizations/34/gateways/a84041ffff2063e8/frames. The ChirpStack logo and navigation menu are visible on the left. The main content area shows the 'Gateway01' page with tabs for 'GATEWAY DETAILS', 'GATEWAY CONFIGURATION', 'CERTIFICATE', 'GATEWAY DISCOVERY', and 'LIVE LORAWAN FRAMES'. The 'LIVE LORAWAN FRAMES' tab is active, displaying a table of live frames. The table has columns for timestamp, frame type, frequency, bandwidth, and other parameters. The frames are listed in descending order of timestamp.

Timestamp	Frame Type	Frequency	Bandwidth	Other Parameters
Jun 13 11:35:35 AM	ConfirmedDataUp	868.3 MHz	SF12	BW125 FPort: 1 FCnt: 3029 DevAddr: 0063aea4
Jun 13 11:35:35 AM	ConfirmedDataUp	867.3 MHz	SF12	BW125 FPort: 1 FCnt: 3029 DevAddr: 0063aea4
Jun 13 11:35:31 AM	JoinRequest	868.1 MHz	SF12	BW125 DevEUI: 0018b2100000679f
Jun 13 11:35:28 AM	ConfirmedDataUp	867.9 MHz	SF12	BW125 FPort: 1 FCnt: 3029 DevAddr: 0063aea4
Jun 13 11:34:35 AM	JoinRequest	868.3 MHz	SF12	BW125 DevEUI: 0018b2100000679f

Resultados dispositivos

The screenshot displays the ChirpStack web application interface. The browser's address bar shows the URL: `192.168.12.158:8080/#/organizations/34/applications/2/devices/0018b20000023ed0/data`. The ChirpStack logo and a search bar are at the top. A left sidebar contains navigation links: Network-servers, Gateway-profiles, Organizations, All users, API keys, IES-Gran-Capitan (selected), Org. dashboard, Org. users, Org. API keys, Service-profiles, Device-profiles, Gateways, and Applications. The main content area shows the configuration for a device with the following details:

- frequency: 868100000
- modulation: "LORA"
- ioRaModulationInfo: {} 4 keys
 - bandwidth: 125
 - spreadingFactor: 7
 - codeRate: "4/5"
 - polarizationInversion: false
- adr: true
- dr: 5
- fCnt: 4
- fPort: 1
- data: "a2QBAQ8kA4gRx0jk"
- objectJSON: {} 6 keys
 - alarmCo2: {} 2 keys
 - alarmStatus: "inactive"
 - co2: {} 2 keys
 - unit: "ppm"
 - value: 904
 - alarmHumidity: {} 2 keys
 - alarmStatus: "active"
 - humidity: {} 2 keys
 - unit: "%"
 - value: 36
 - alarmTemperature: {} 2 keys
 - alarmStatus: "inactive"
 - temperature: {} 2 keys
 - unit: "°C"
 - value: 27.1
- status: {} 6 keys
 - configurationDone: false
 - configurationInconsistency: false

Protocolo Mosquito y Resultados

lorawan@lorawan: ~

Last login: Mon Jun 13 10:32:58 2022 from 192.168.12.4

lorawan@lorawan:~\$ mosquitto_sub -v -t '#'

gateway/a84041ffff2063e8/state/conn

@A c

gateway/e35cf791a9bf73e6/state/conn

\0000s

gateway/0babbba5c5e404c5/state/conn

0000

gateway/0babbba5c5e404c5/event/stats

00000 (00080000)192.168.12.4Z000JtNch200a00a000r0

0}0004/5 000z0

00 }0004/50000

00K00

gateway/0babbba5c5e404c5/event/up

00000]0;U%\$000 }0004/50>

00(01'@8000z0[000 00IC 10 00

```
application/3/device/0018b2100000679f/event/up {"applicationID":"3","applicationName":"HumedadYTemperatura","deviceName":
:"Humedad-Y-temp-Adeunis","deviceProfileName":"Humedad","deviceProfileID":"9f5e76d8-24bb-4cd9-aad3-f1f43497a788","devEUI
":"0018b2100000679f","rxInfo":[{"gatewayID":"0babbba5c5e404c5","uplinkID":"601d8bdf-fc1e-4943-a0bd-60a0ec31187c","name":
"Gateway01","rssi":-56,"loRaSNR":11.8,"location":{"latitude":0,"longitude":0,"altitude":0}],{"txInfo":{"frequency":86850
0000,"dr":5},"adr":{"dr":5},"adr":{"dr":5},"fCnt":1950,"fPort":1,"data":"TQQRAS4cDoWJGA==","object":{"alarmHumidity":{"alarmStatus":"active
","humidity":{"unit":"%","value":28}},"alarmTemperature":{"alarmStatus":"active","temperature":{"unit":"°C","value":30.2
}},"status":{"configurationDone":false,"configurationInconsistency":false,"frameCounter":0,"hardwareError":false,"lowBat
tery":false},"type":"0x4d Comfort alarm"}}
gateway/0babbba5c5e404c5/command/down
```

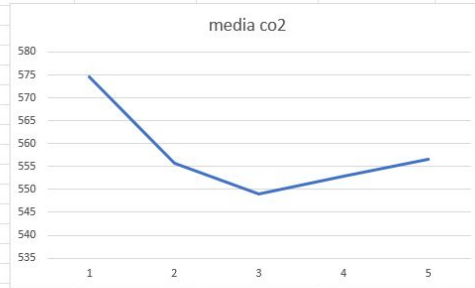
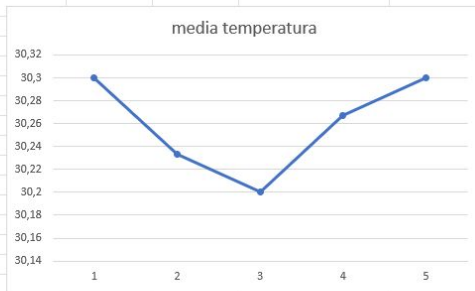
0 00(D00.

00(000 000[00]0004/5 0r0

```
28 sudo apt install mosquitto-clients
29 mosquitto_sub -v -t '#'
```

Mostrando resultados en Excel

co2/unit	co2/values/0	co2/values/1	co2/values/2	decodingInfo	humidity/unit	humidity/values/0	humidity/values/1	humidity/values/2	temperature/unit	temperature/values/0	temperature/values/1	temperature/values/2	media temperatura	media co2
ppm	574	580	570	values: [t=0, t-1, t-2, ...]	%	32	32	32	°C	30,3	30,3	30,3	30,3	574,666667
ppm	570	559	538	values: [t=0, t-1, t-2, ...]	%	32	32	32	°C	30,3	30,2	30,2	30,23333333	555,666667
ppm	538	552	557	values: [t=0, t-1, t-2, ...]	%	32	32	32	°C	30,2	30,2	30,2	30,2	549
ppm	557	550	552	values: [t=0, t-1, t-2, ...]	%	32	32	32	°C	30,2	30,3	30,3	30,26666667	553
ppm	552	561	557	values: [t=0, t-1, t-2, ...]	%	32	32	32	°C	30,3	30,3	30,3	30,3	556,666667



DEMO TIME



¿Preguntas / Dudas?

