EMB-Fem2GW-O

DOCUMENTATION

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Embit s.r.l.

Document information

Versions & Revisions

Revision	Date	Author	Comments
1.0	2020-02-20	Embit-AM	Initial release
1.1	2020-04-21	Embit-AM	SIM Size changed
1.2	2020-08-24	Embit-AM	Password updated
1.3	2021-02-04	Embit-AM	Picture updated
1.4	2021-02-09	Embit-AM	Feature updated

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1 Introduction

The **EMB-Fem2GW-O** uses LoRa® technology and complies with the LoRaWAN® specifications defined by LoRa Alliance. It enables IoT (Internet of Things) implementations mandating low data rates and battery-powered end devices over long-distance connectivity. The gateway is an IP67-grade outdoor product, with a plastic case.

This guide explains how to start using the **EMB-Fem2GW-O**. The **EMB-Fem2GW-O** gateway is a multi service up-gradable platform, designed to meet IoT (Internet of Things) and M2M (Machine-2-Machine) scenarios. It enables LoRaWAN® connectivity, having the role of fully compliant LoRaWAN® Gateway v1.5. It provides the LoRaWAN® packet forwarder functionality: it has an independent Semtech SX130x radio transceivers which support up to 8 LoRaWAN® independent channels allowing to 8 data packets to arrive exactly at the same time and being captured without issues. The radio section is based on the EMBIT MiniPCI-express board, EMB-LR130x-mPCIe. It starts to operate as a LoRaWAN® base station, receiving radio packets and forwarding them to a LoRaWAN® network server. It supports end device types Class A, B, and C, GPS clock timing synchronization, channel diversity, spreading factors, and adaptive data rate (ADR). It also supports the regional frequency profile defined for LoRa Alliance for EU 863-870 MHz, US 902-928 MHz, AU915-928 MHz, AS920-923 MHz, AS923-925 MHz, KR920-923 MHz, IN865-867 MHz. It has a TCP/IP connection through Ethernet, or via 4G connection, available through SIM card and 4G mini PCI express module. In the latter case, high latency could lead to the LoRaWAN® network performance decrease. Its functionalities will be described in details in the following paragraphs. It includes GPS connectivity to locate the device.

Thanks to the Semtech SX1301 performances and the efficient Embit RF design, the possible radio ranges are up to 15 km in the country side and up to 3 km in urban areas.

The OS system is Linux based, and the customer can configure it according to his needs, with a complete root access. The **EMB-Fem2GW-O** provides a web interface to manage and configure the connectivity with the different network protocols.

The gateway must be powered from +9 to +28 VDC. With a different voltage, its functionalities may stop irretrievably. It has a peak of consumption less than 20 Watt.

2 Hardware Specification

- Processor: Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.2GHz

- RAM Memory: 1 GB, LPDDR2 SDRAM

- Flash Memory: 8 GB, EMMC Flash Memory

- LAN Connection: Ethernet RJ45 10/100 Base-T

- LoRaWAN® Connectivity: Semtech SX1301 +20/+27 dBm @ 868 MHz

- Receiver Sensitivity: up to -139 dBm

- Connectivity: GPS Module U-Blox NEO-M8-Q

- Cellular Connectivity: 4G LTE / 3G UMTS / 2G GPRS through Mini Size SIM embedded inside

- Cellular Module: Quectel EC21-E Mini PCIe

- Power Source: from +9 to +28 VDC

- Ports: Ethernet 10/100/1000 RJ 45 / 1 N-Type Antenna Connector for 868/915 MHz / Air Port

- Power Consumption: 20 W

- Operating System: Linux 9.8 Stretch

- Dimensions: L: 165 mm W: 165 mm H: 45 mm

- Weight: 1.0 kg

- Certifications: WIP

Figure 1 EMB-Fem2GW-O

3 Power Supply

The gateway must be powered from +9 to +28 VDC. It has a 2 poles male connector.

The female part is represented in the Figure below.

Figure 2 Power Connector Scheme

Pole 1 is **Vin** and Pole 2 is **GND**. A higher voltage than +28 VDC may stop its functionalities irretrievably.

4 Operating System

EMB-Fem2GW-O Operating System is Linux 9.8 Stretch.

It is allowed full SSH root access to the final user, using as username and password:

Username: root

Password: raspberry

The final user can install, unistall, upgrade every single program.

Pay attention, each action may stop irretrievably the functionalities of the system.

5 Antenna Configuration

EMB-Fem2GW-O has 1 N-Type Antenna Connector. In the same side of the Ethernet connector, SMA connector is placed.

Antenna has to be screwed on the connector.
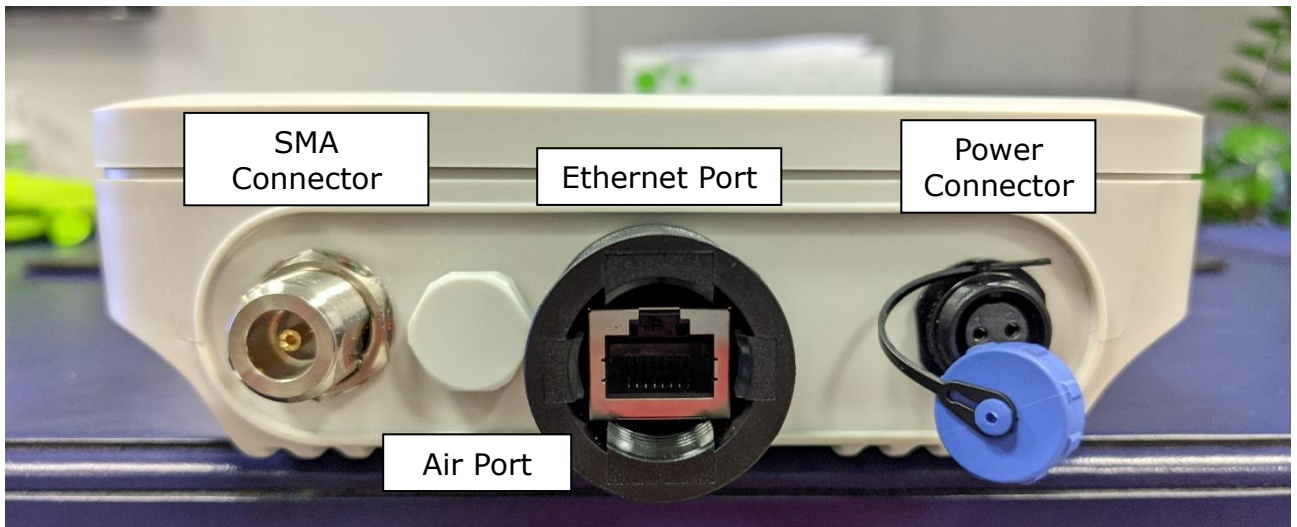
Figure 3 Side View of the EMB-Fem2GW-O

6 LoRaWAN® Feature

LoRa® is the physical layer utilized to create the long-range communication link. It is based on Chirp Spread Spectrum (CSS) modulation, which combines low power characteristics and increases the communication range.

LoRaWAN® is the MAC (Media Access Control) protocol specification defined by the LoRa Alliance, put on top the LoRa® physical layer. It is supported by an established ecosystem of LoRaWAN® compliant devices that are available from multiple vendors, and which can be certified for interoperability by the LoRa Alliance.

In this network Architecture, three main roles are defined:

- **End-Device**: endpoints with sensors embedded;

- **Gateways**: they provide LoRaWAN® wireless connectivity to the devices. They are the connection between the devices and the IP backhaul network to the Network Server;

- **Network Server**: the intelligence of the network. It is centralized radio controller, which performs radio management, the provisioning and authentication of devices, and the delivery of the data to one or multiple application servers through a set of Application Programming Interfaces (APIs).

Another role is the **Application Server**. It is managed by the final customer and it is put on top of the Network Server. Full Network Image follows.
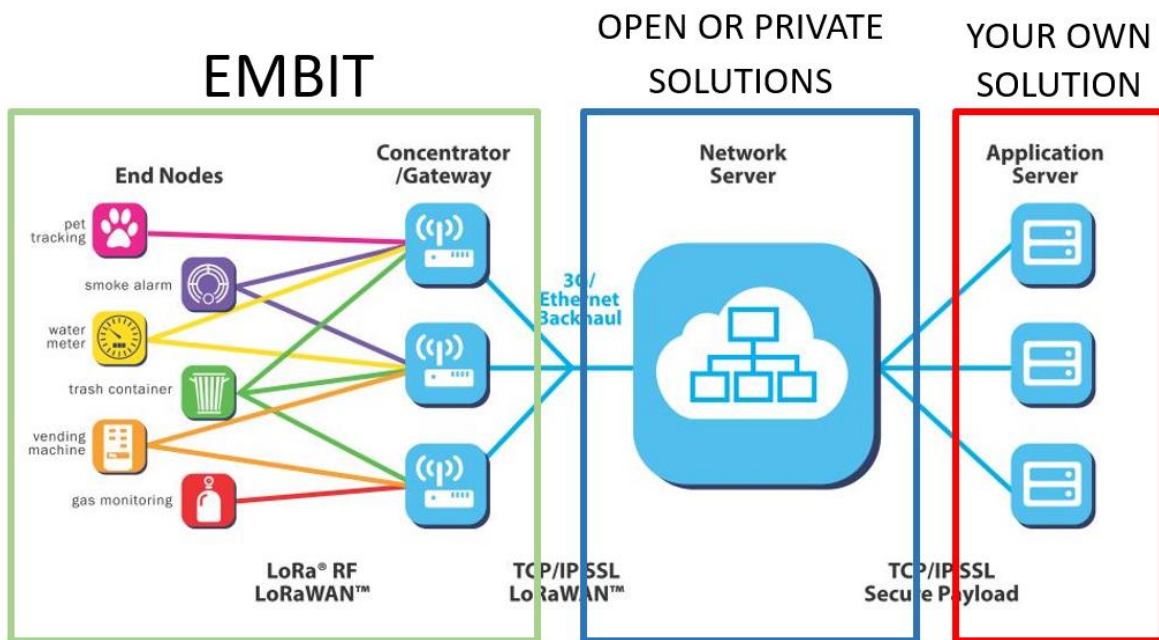
Figure 4 LoRaWAN® Network Architecture

Each communication is fully encrypted with three keys, each one with a length of 128 bits. The algorithm used for it is AES-128. These algorithms have been analysed by the cryptographic community for many years, are NIST approved and widely adopted as a best security practice for constrained nodes and networks.

EMB-Fem2GW-O supports LoRaWAN® specifications 1.0.1, 1.0.2, and 1.1 and supports class A, class B, and C endpoints. It provides Long-Range LoRaWAN® connectivity up to 2-3 km in urban area and up to 15 km in rural environment.

Radio Frequency path supports EU868 MHz frequency bands, and it can transmit power up to +27 dBm, being fully compliant with the current RF regulations in Europe, ERC-REC-70-3E.

The RF path is fully compliant to Semtech specifications and it is able to achieve a Receiver Sensitivity up to -139 dBm.

This architecture supports also Listen-Before-Talk (LBT) functionalities.

7 LoRaWAN® Gateway Configuration Web Interface

Emb-Fem2GW-O provides a web interface, which allows to select and configure the desired LoRaWAN® packet forwarder.

It is reachable at *https://[gateway_IP_address]:10000*. The default data access is:

username: root

password: raspberry
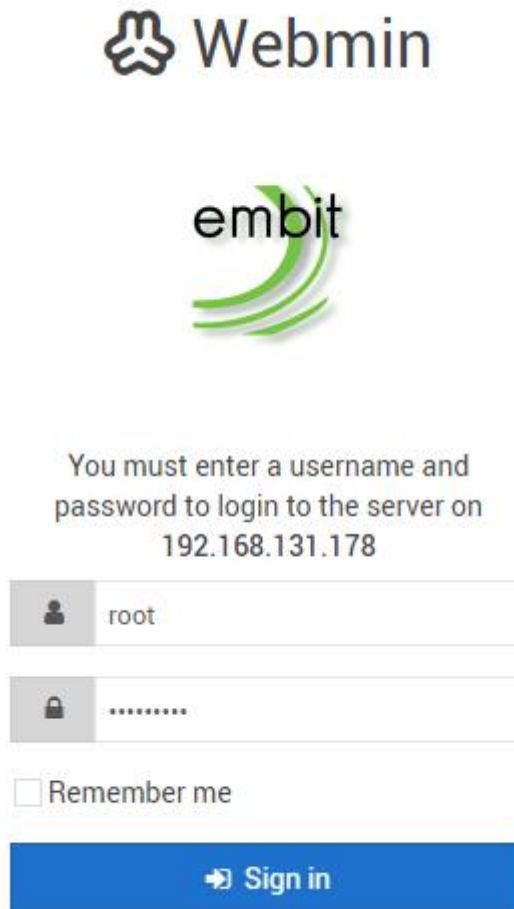
Figure 5 Log In Page

"Embit Gateway Configuration" is located in the left menu, in the category Networking.
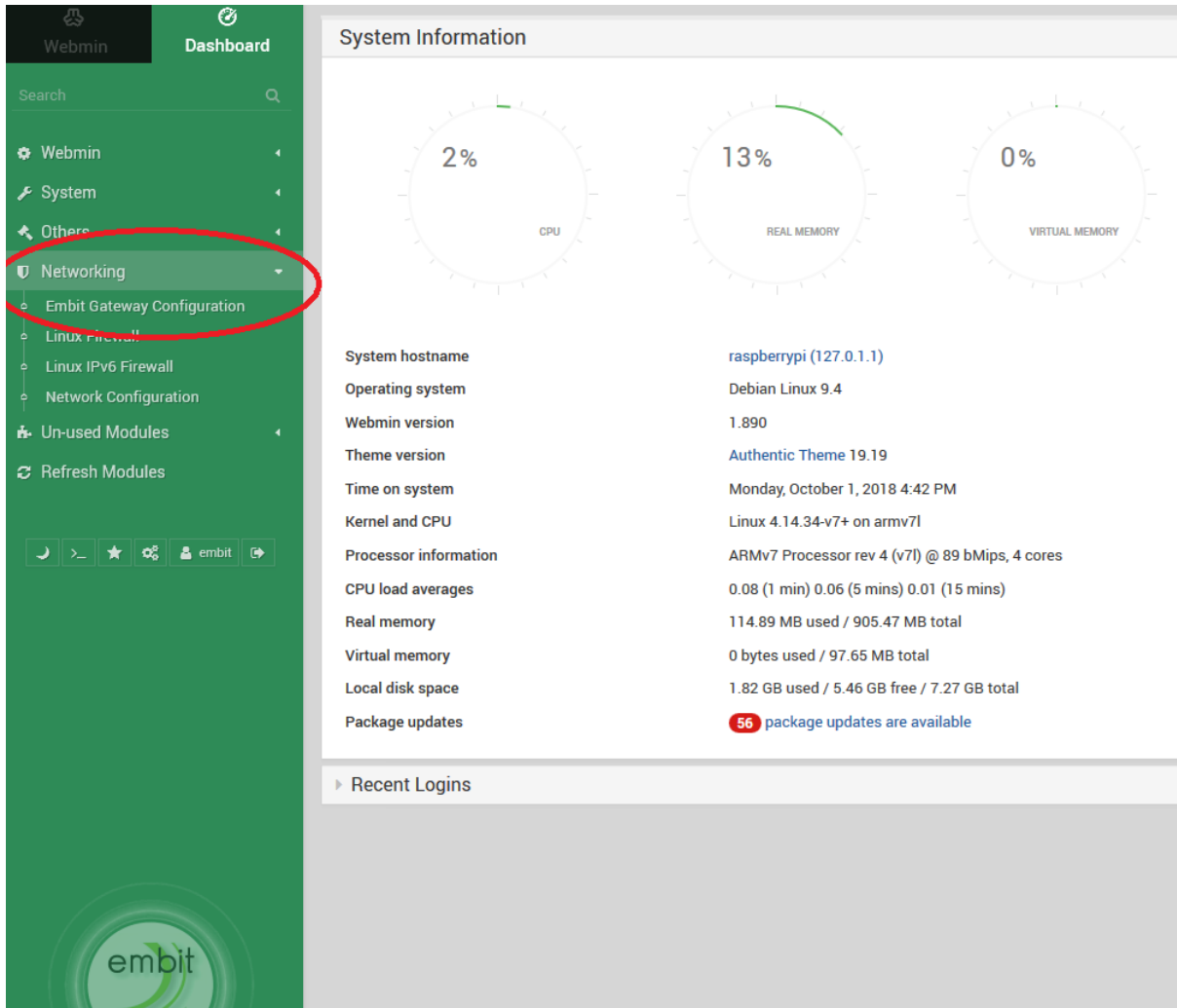
Figure 6 Main Page

In the "*Packet Forwarder*" tab, the system state information is reported. In this page is possible to select the LoRaWAN® packet forwarder among the installed ones, from the drop-down menu. Once selected, the chosen LoRaWAN® packet forwarder starts running.

Figure 7 Embit Gateway Configuration Main Tab

In the configuration tab, it is possible to customize the network parameter of the LoRaWAN® packet forwarders.
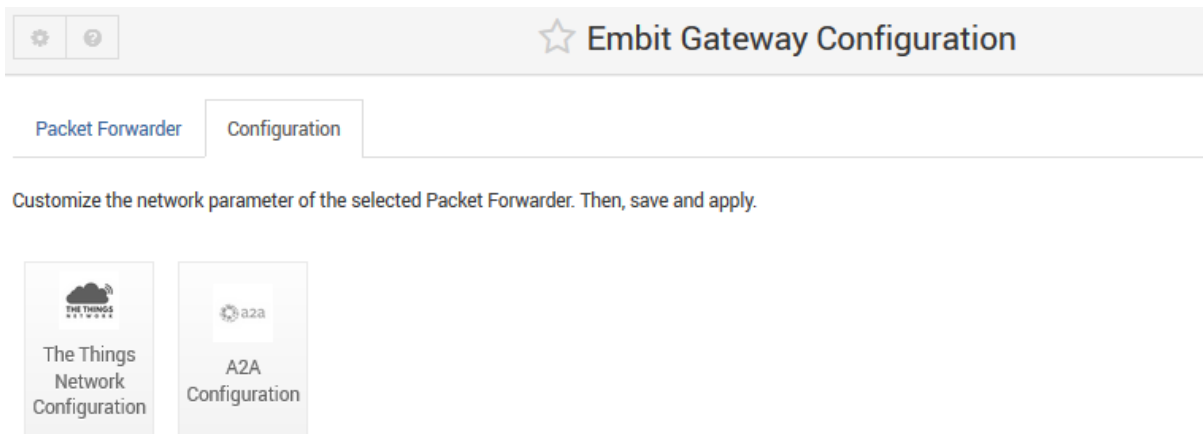
Figure 8 Embit Gateway Configuration Tab

The following parameters can be changed in the **The Things Network** packet forwarder.
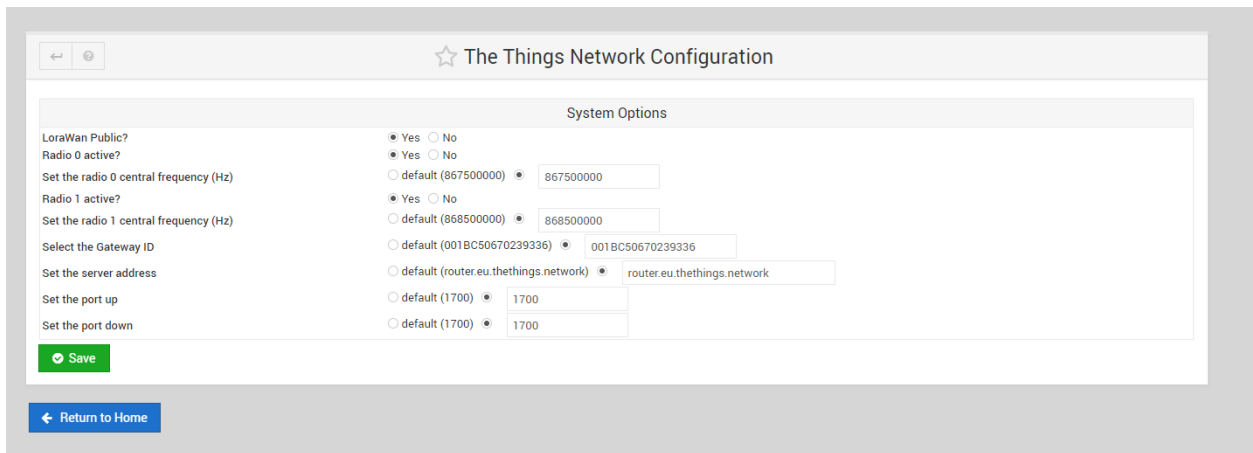

Figure 9 Embit Gateway Configuration Page

The changes are applied through the "*Apply*" button in the main tab.

8 LoRaWAN® Gateway EUI

EMB-Fem2GW-O connects to the LoRaWAN® network with a Gateway EUI (Extended Unique Identifier) written in the label. Gateway EUI can be changed using the the LoRaWAN® Gateway Configuration Web Interface.

9 Example: A2A Smart City LoRaWAN® Network Server

In this section, it is explained how to register a gateway in a LoRaWAN® Network Server. The LoRaWAN® Network Server taken into account for this example is A2A Smart City Network Server.

It is important to know that the **EMB-Fem2GW-O** can support different packet forwarders.

Step 1: Take your Unique Gateway EUI

The Unique Gateway EUI is a number which allows the Network Server to identify your gateway. This parameter is written in the label of the **EMB-Fem2GW-O** Gateway. It can be changed, according to your preferences, through Embit Gateway Configuration Web Interface, under the "Configuration Tab". Once pressed the button related to the Network Server you would like to use, the field "Select the Gateway ID" can be filled with a 8-bytes (hex) value. Be sure your **EMB-Fem2GW-O** is running A2A Smart City packet forwarder, checking on Embit Gateway Configuration Web Interface. In case it is not running the wanted packet forwarder, select it from the drop-down menu and press "Apply".

Figure 10 A2A Configuration Parameters Page

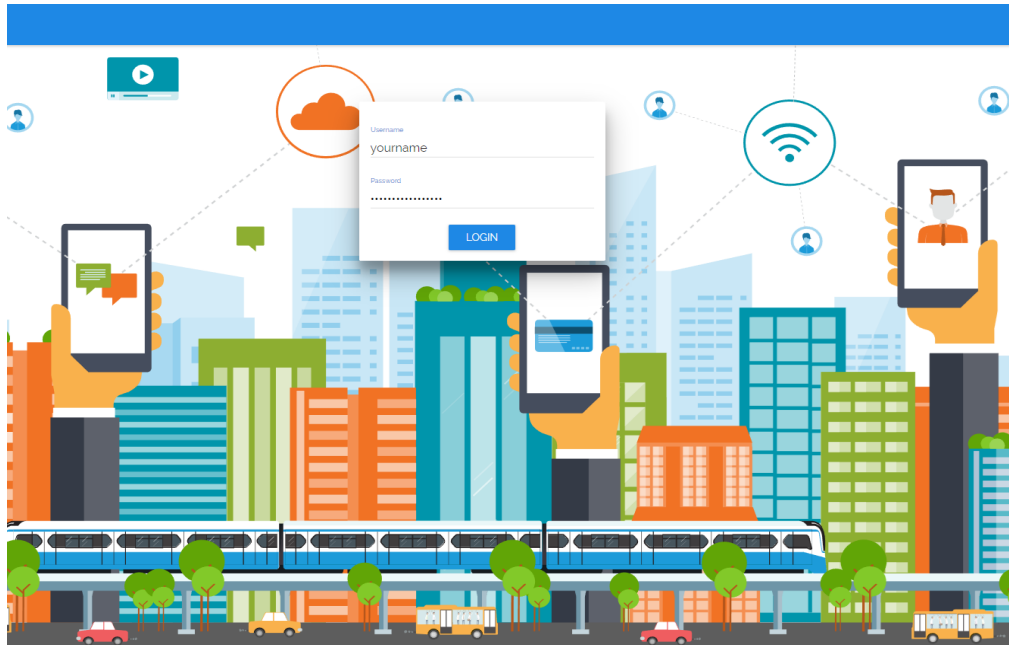## Step 2: Sign Up with your A2A Smart City Account

Figure 11 A2A Log In Page

Step 3: Create a Gateway

In "Gateway" Tab, press "+ INSERT" to add your gateway to the Gateway List (Figure 15).
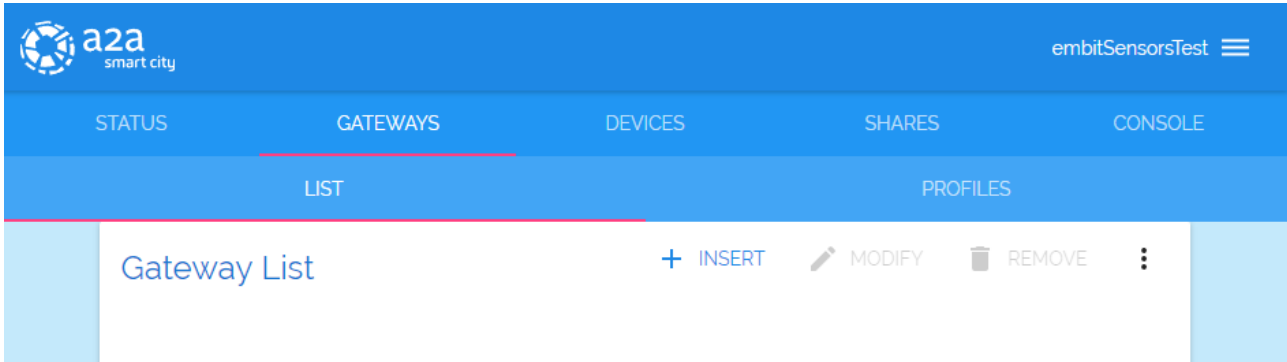

Figure 12 Gateway List Web page

Step 4: Register your Gateway Data

Add your Gateway EUI to the Address field and select the Profile among the available ones.

Note: if there are no profiles available, you can create your own profile, under "Profiles" tab, pressing "+ INSERT". At the end of each registration, pay attention to press "SAVE".
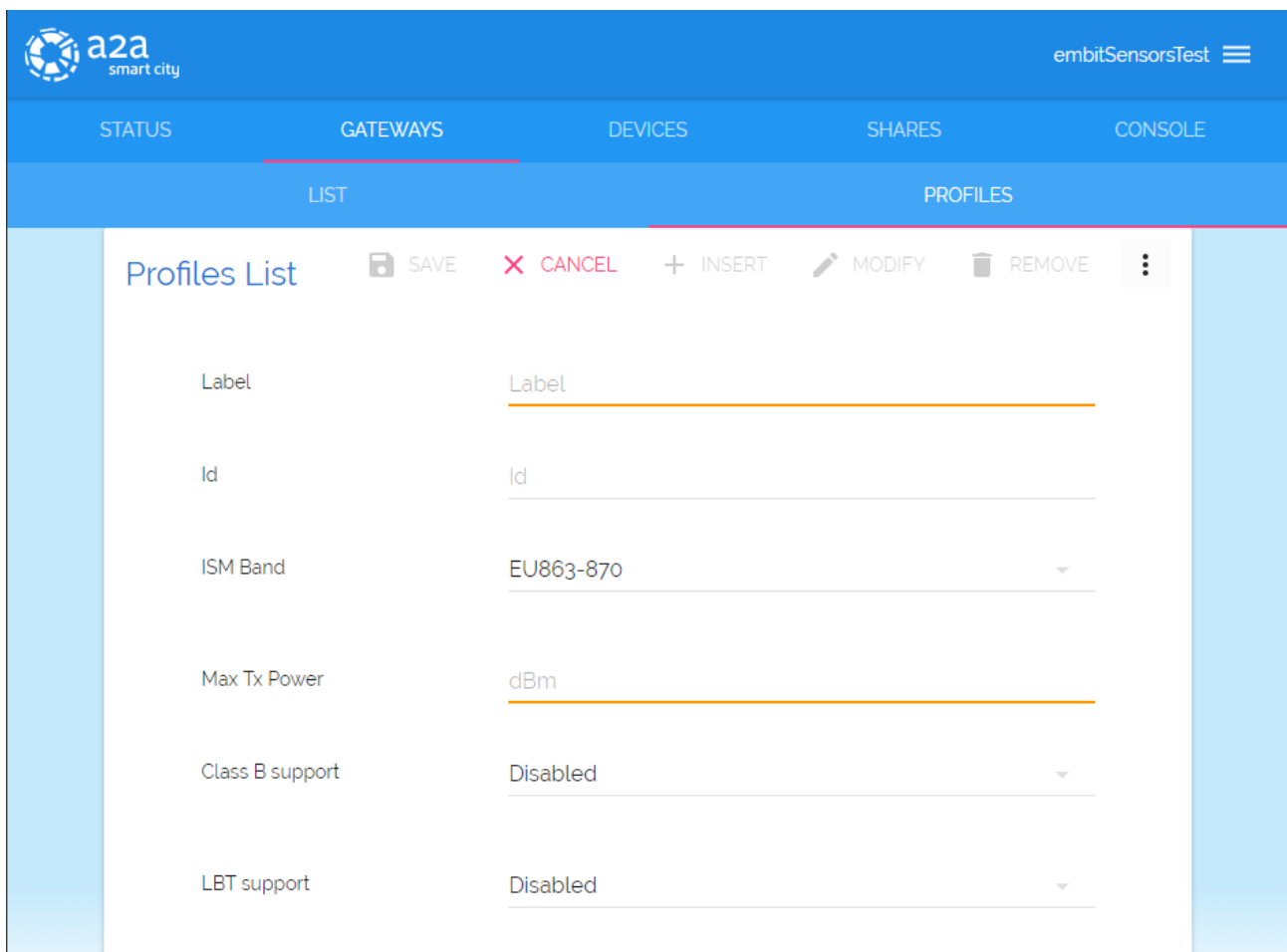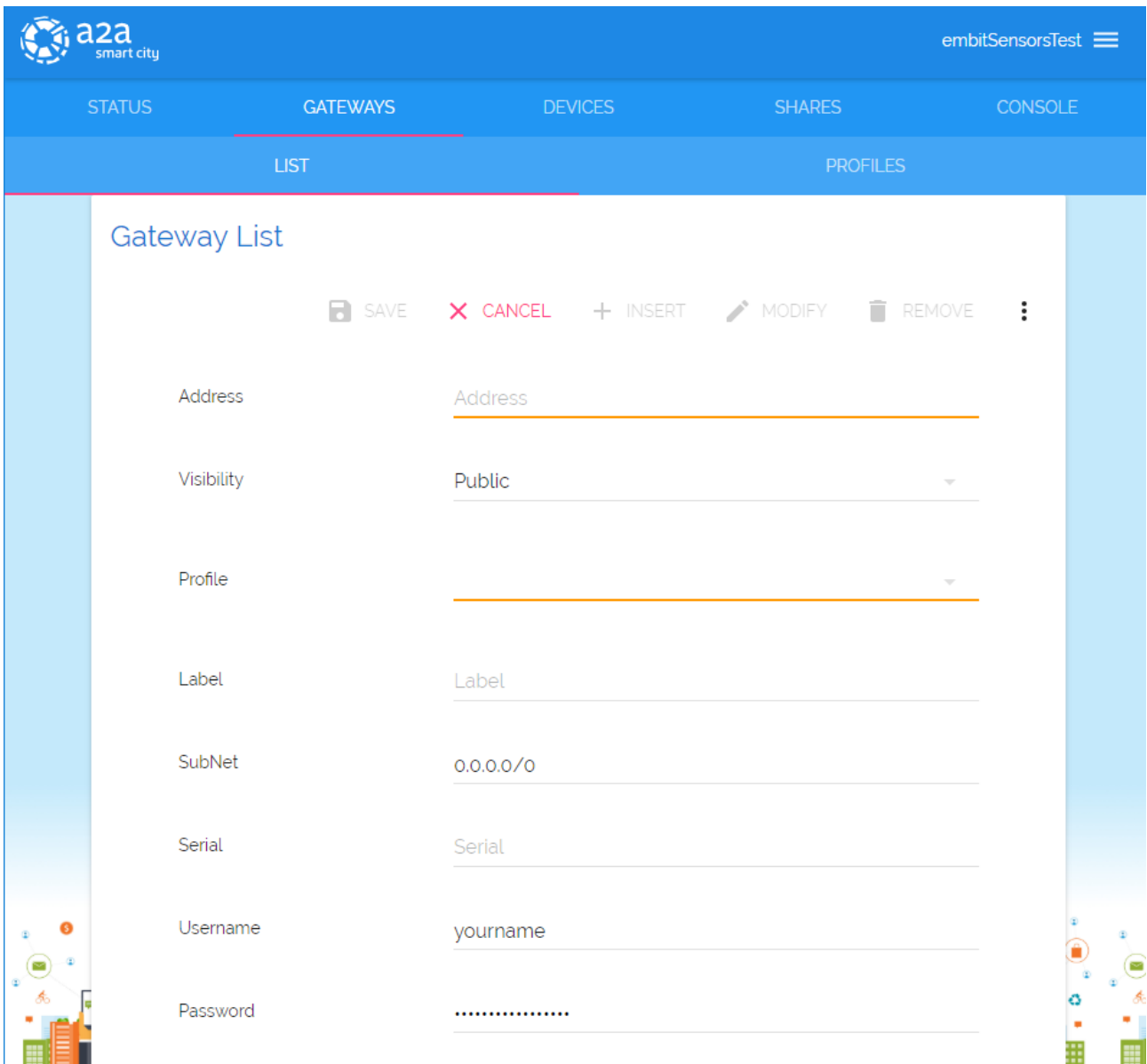
Figure 13 Gateway List - Profile

Figure 14 Gateway List - Add Gateway

Step 5: Look at the Data

At this point, your gateway is on the Gateway List page. Pressing on "Info", and then on "EVENTS" tab it is possible to look at the data which your gateway is transmitting and receiving (Figure 18). The payload is encrypted, to guarantee privacy and security.

Figure 15 Gateway Events

Step 6: Create your own Application

To connect your devices to your gateway, you need to create your application in "Devices" tab (Figure 19). In the Application List, press "+ INSERT" and a configuration pop up will appear (Figure 20). In the ID and Label fields you can put values and text human readable. Join EUI field represents the App EUI, and it has to be set with a 8-bytes (hex) value.

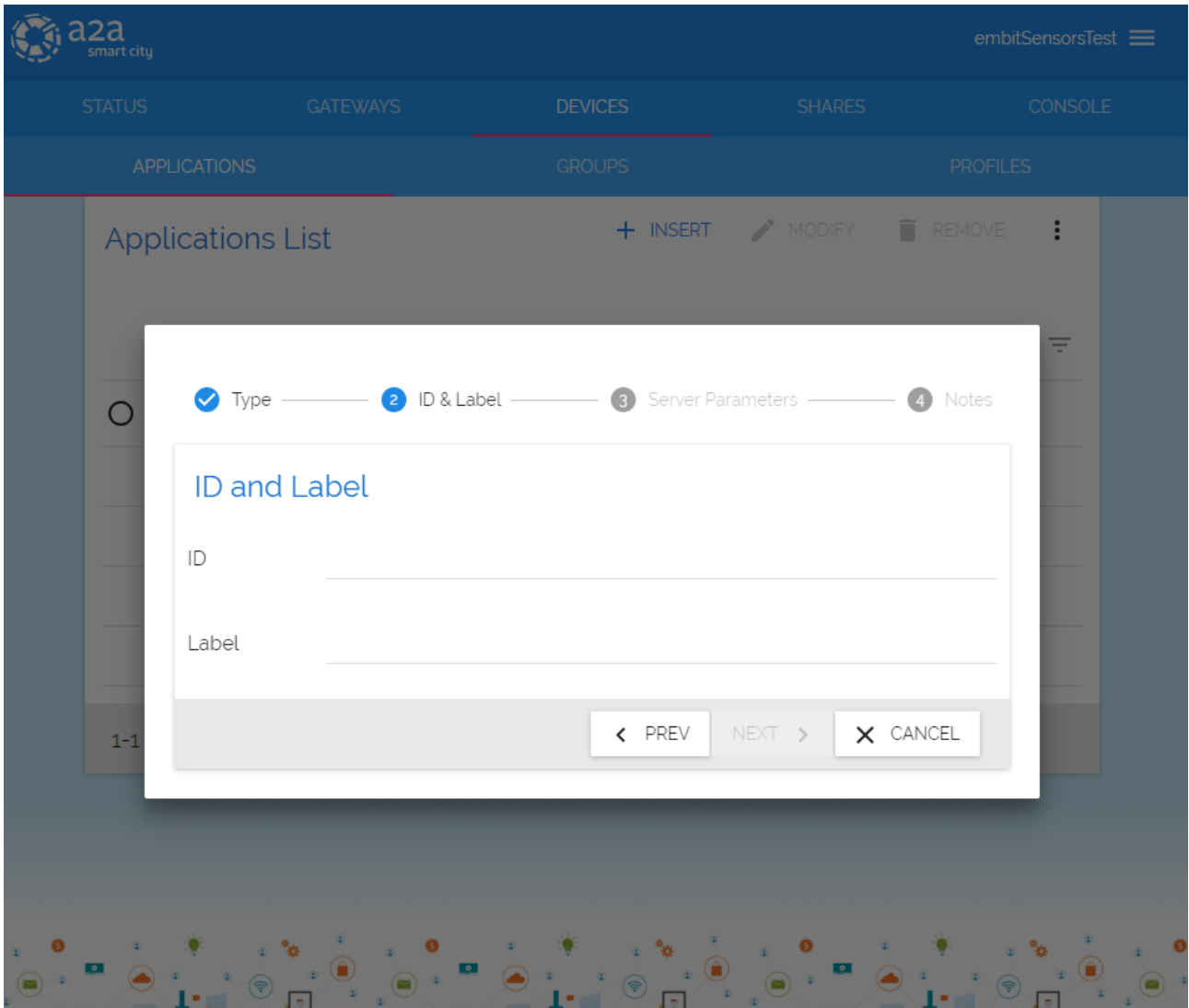*Figure 16 A2A Application List*

Figure 17 Device Configuration

Step 7: Register your Device

Selecting your new Application, "Applications Devices" menu appears (Figure 21), just below the Application List. Press "+ INSERT" and register your Device. In case of choosing OTAA activation, the Device EUI field has to be filled with a 8-bytes (hex) value and the App Key field with a 16-bytes (hex) value.

If ABP activation is chosen, DevEUI, DevAddr, Network Session Key and Application Session Key has to be set with 8-bytes (hex) value, 8-bytes (hex) value, 16-bytes (hex) value and 16-bytes (hex) value respectively.

Application Devices   + INSERT   ✏ MODIFY   🗑 REMOVE   ⋮
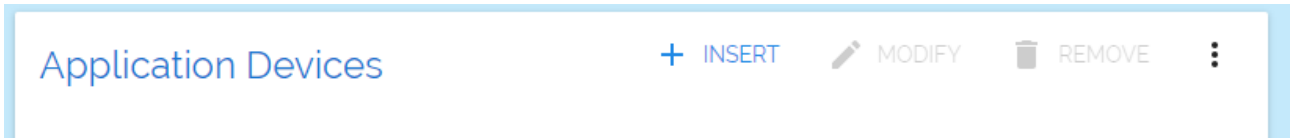
Figure 18 Application Devices Web Page

Step 8: Let's Network Start

If OTAA activation mode is selected, your end-device has to be set with Device EUI, App EUI and App Key. These parameters must be the same configured in the Network Server Application. Then, the end-device has to send a Join Request. When a Join Accept message is received by the end-device, the network is started.
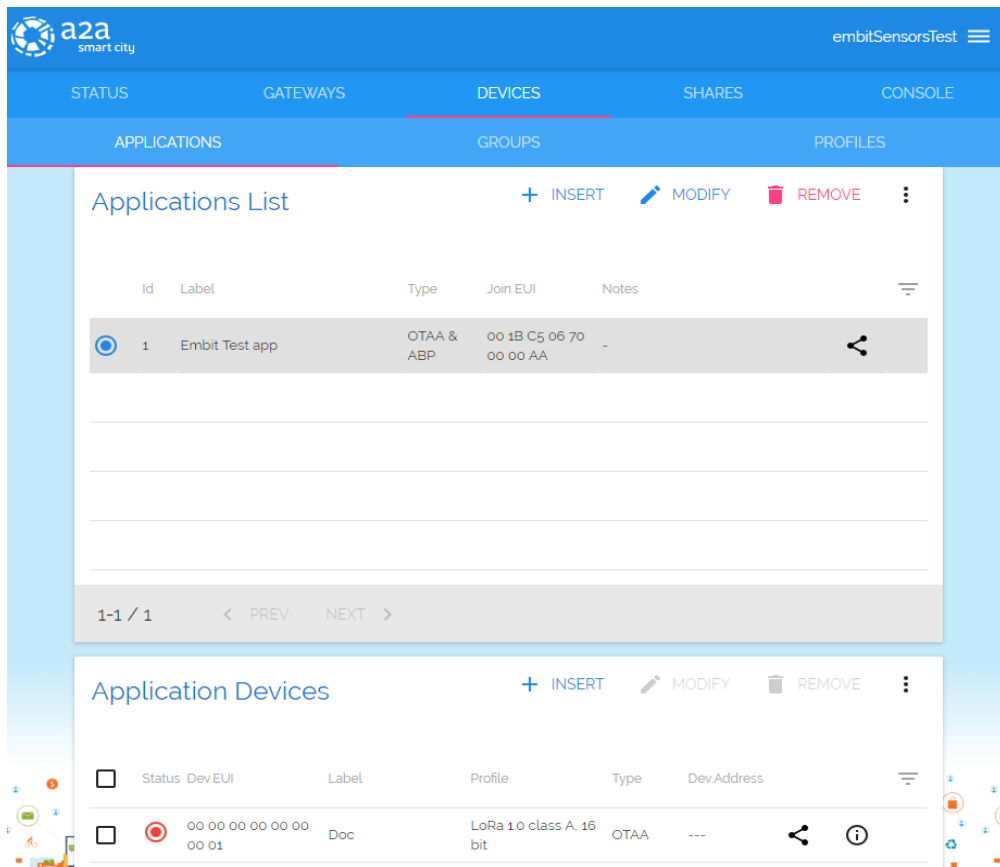
Figure 19 Applications List Web Page

The packets are visible under the Gateway Info Page, as described in Step 5, or pressing on the "Info" icon related to your Dev EUI in the Application Devices List.

In the "Console" tab of your device, it is possible to look at the data transmitted and to set downlink message which are to be sent by the Gateway to your device during the Rx windows. In "Logs" table data are showed without encryption, because only the account and application owner can access to this page.
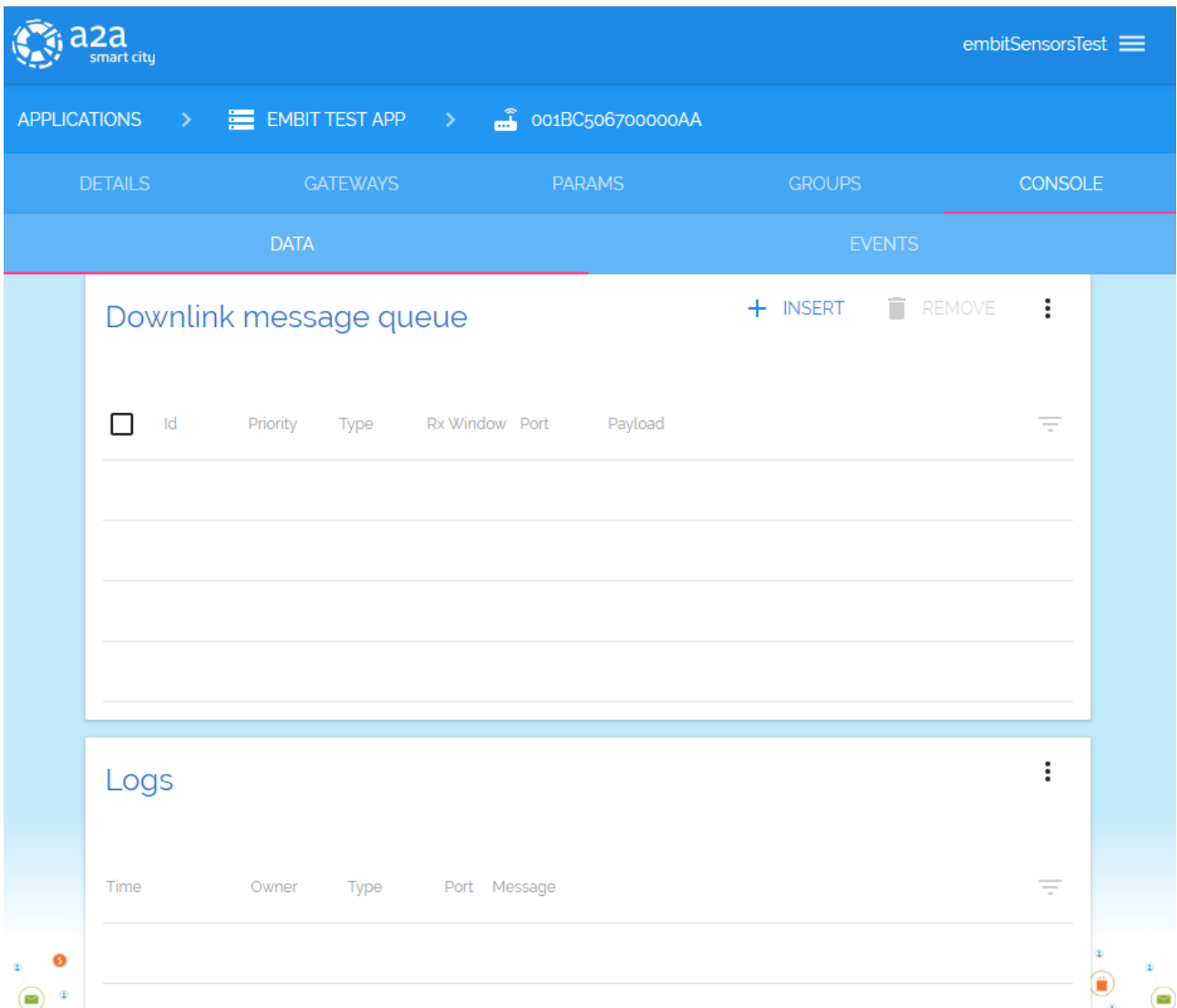
Figure 20 Device Data Web Page

If ABP activation mode is chosen, your end-device needs to be set with DevEUI, DevAddr, Network Session Key and Application Session Key. These parameters must be the same configured previously in the Network Server. In this case, the network starts when a packet with all these valid fields is received.

10 Example: The Things Network LoRaWAN® Network Server

In this section, it is explained how to register a gateway in an open LoRaWAN® Network Server. The LoRaWAN® Network Server taken into account is The Things Network.

Step 1: Take your Unique Gateway EUI

The Unique Gateway EUI is a number which allows the Network Server to identify your gateway. This parameter is written in the label of the **EMB-Fem2GW-O** Gateway. It can be changed, according to your preferences, through Embit Gateway Configuration Web Interface, under the "Configuration Tab". Once pressed the button related to the Network Server you would like to use, the field "Select the Gateway ID" can be filled with a-8 bytes (hex) value (Figure 24). Be sure your **EMB-Fem2GW-O** is running The Things Network packet forwarder, checking on Embit Gateway Configuration Web Interface. In case it is not running the wanted packet forwarder, select it from the drop-down menu and press "Apply".
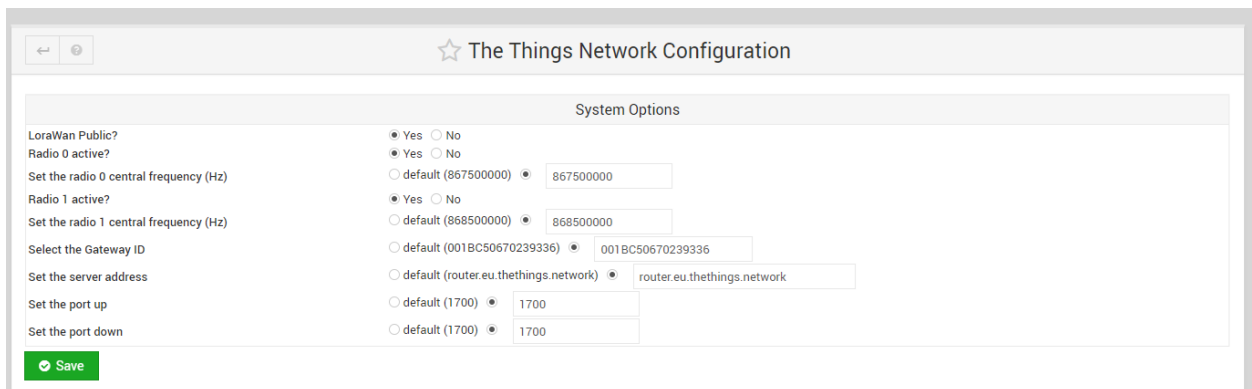

Figure 21 The Things Network Gateway Configuration Web Interface

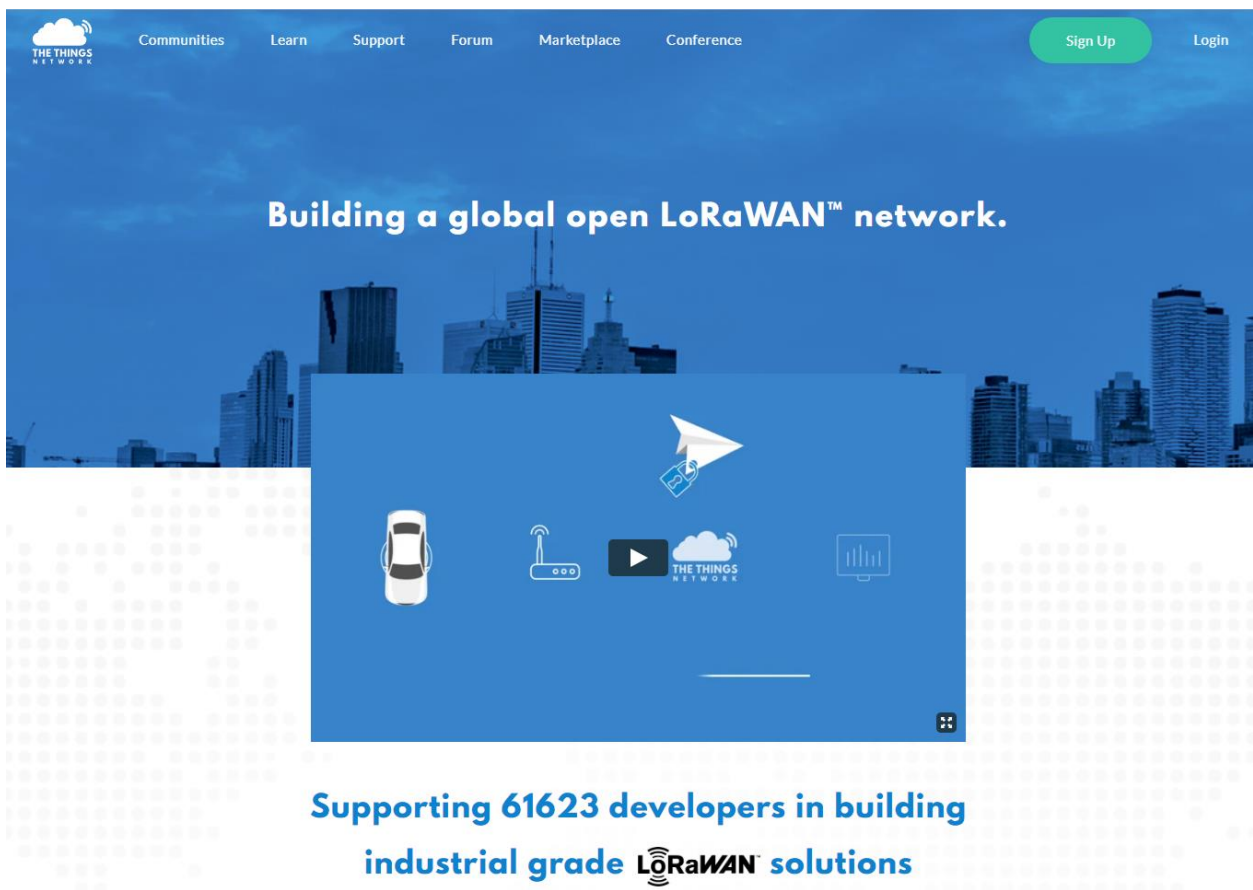**Step 2: Sign Up with your The Things Network Account**

Figure 22 The Things Network Log In Page

Step 3: Go to Gateway page

From your account, open "Console" section and then press on "Gateways" button. (Figure 26)
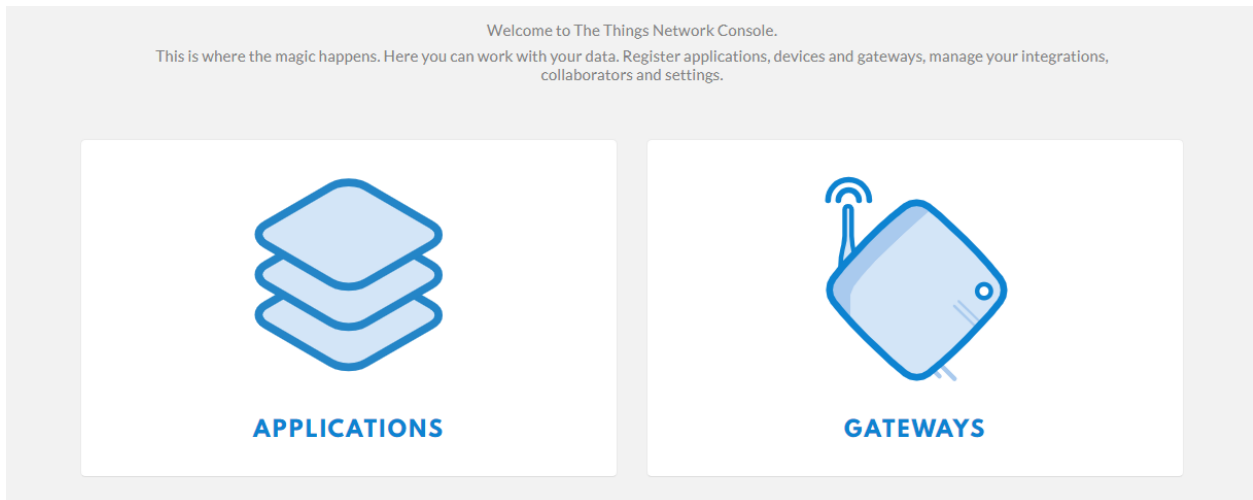

Figure 23 The Things Network Console

Step 4: Register your Gateway

Press "Register Gateway" button and a configuration page will open (Figure 27). Pay attention to the flag "I'm using the legacy packet forwarder". Fill Gateway EUI field with a 8-bytes (hex) value. Select "Frequency Plan" and "Router" according to your region. Then press "Register Gateway".

Figure 24 Register Gateway Page

Step 5: Check Gateway Connection

Go to your Gateway page, select the one you have just created and "General Information" will appear.
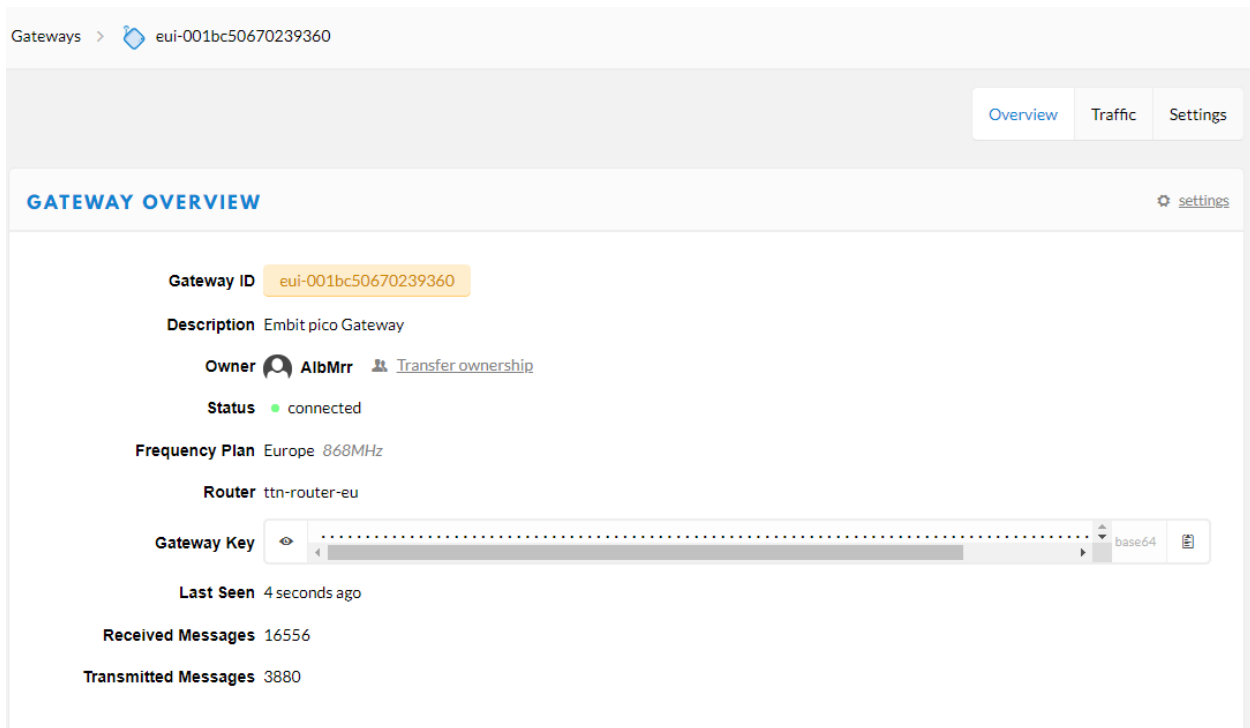
Figure 25 Gateway Overview Page

When your Gateway is connected, a green dot is showed near the "Status" string.

Step 6: Traffic Monitoring

Pressing "Traffic" tab, up to the right corner in Gateway Overview page, the user can look at the transmitted and received data by the Gateway. In this case, data are encrypted due to safety reason.

Figure 26 Gateway Traffic Monitoring Page

Step 7: Go to Application

From your account, open "Console" section and then press "Applications" button.
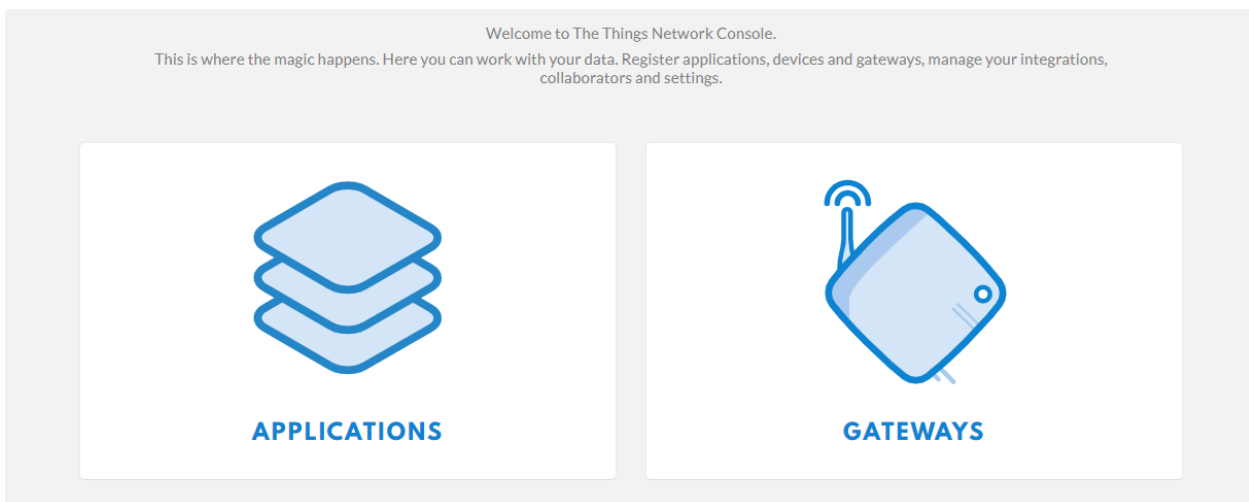
Figure 27 The Things Network Console

Step 8: Register your Application

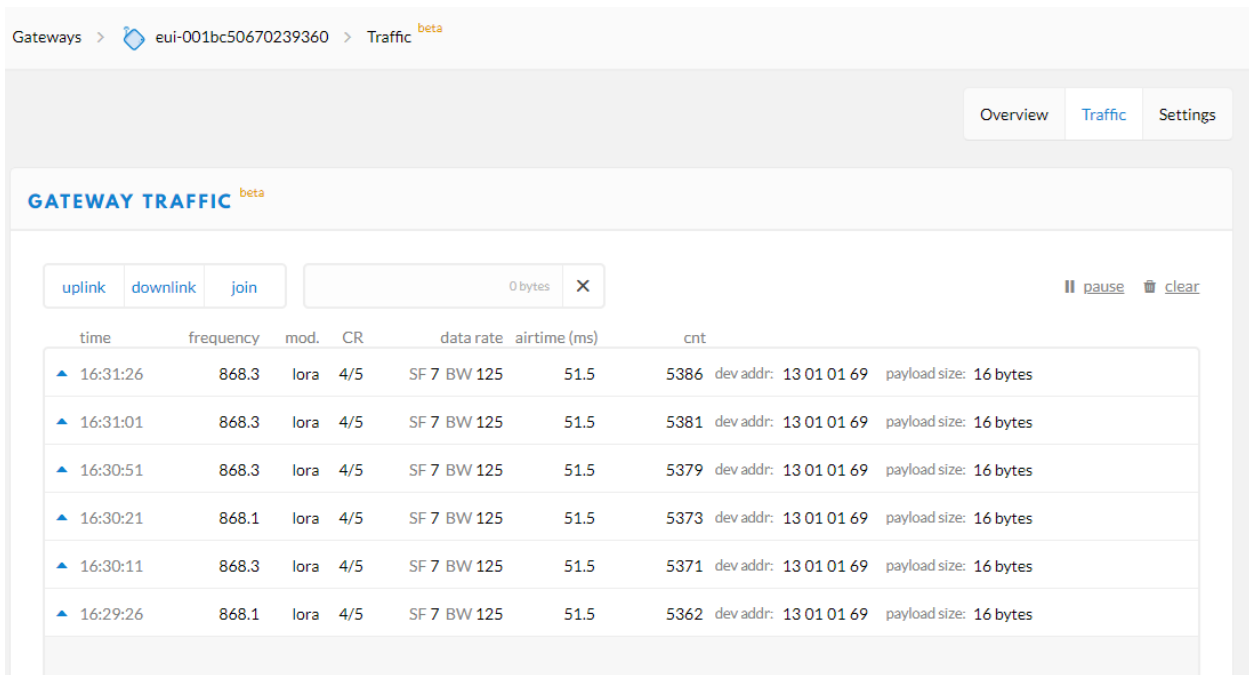Press "Add Application" and a configuration page will open. Application ID and Description are human-readable string, Application EUI is automatically assigned by The Things Network Server and select "Handler Registration" according to your region (Figure 31).

Figure 28 The Things Network - Add Application

Step 9: Register your Device

Go to the "Application Overview" page and press "Register Device".
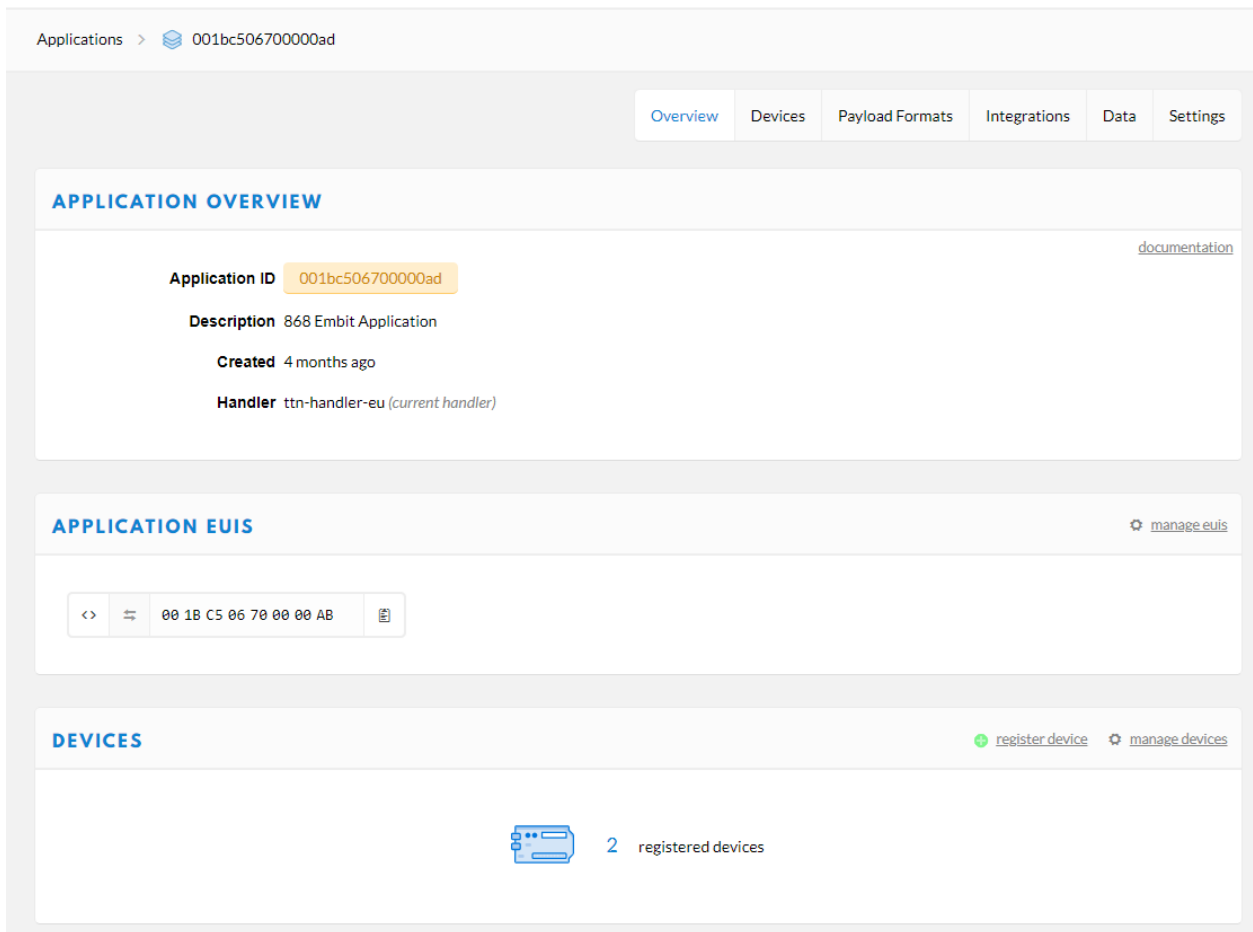
Figure 29 Application Overview Page

"Registration Device" page will open. Device ID field can be filled with a human-readable string, Dev EUI must be filled with a 8-bytes (hex) value, AppKey is automatically generated by The Things Network Server, and App EUI is related to your Application. Pressing "Register" button, the device is registered.
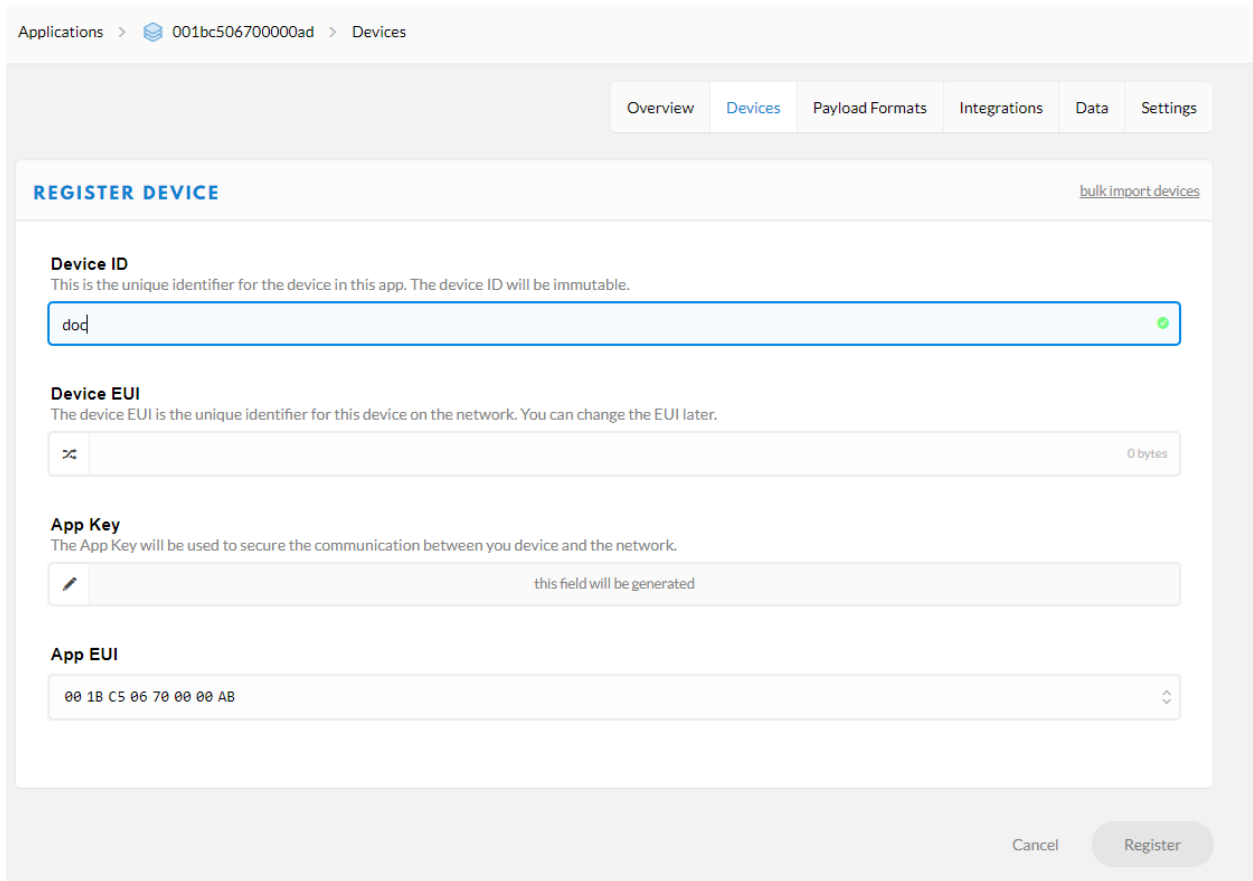
Figure 30 Register Device Page

Step 10: Let's Network Start

If OTAA activation mode is selected, your device has to send Device EUI, App EUI and App Key to the Gateway. These values must be the same configured in the Network Server Application. Then, the device has to send a Join Request. When a Join Accept message is received, the network is started. The packets are visible in the "Gateway Overview" page, as in Step 6, or in "Application Overview" page in "Data" tab.
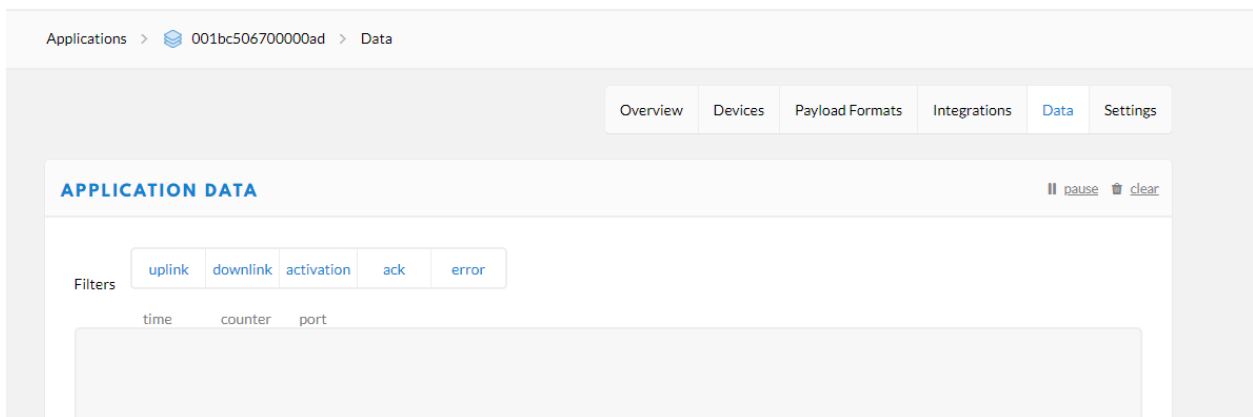
Figure 31 Application Data

If ABP activation mode is chosen, you have to change the Device Settings. In the "Devices Overview" page, in the "Setting" tab, you must select ABP as activation method. All the keys are automatically generated.
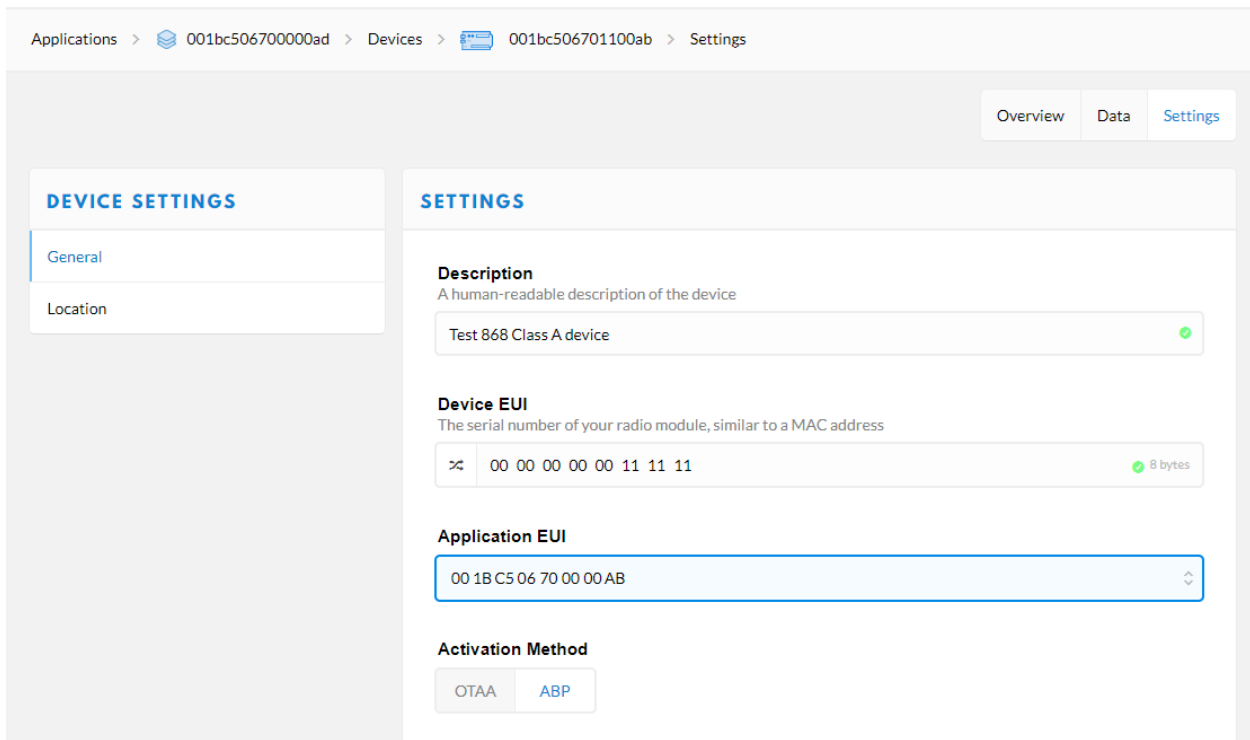
Figure 32 Application Settings

Your Device needs to be set with DevEUI, DevAddr, Network Session Key and Application Session Key. These parameters must be the same configured previously in the Network Server. In this case, the network starts when a packet with all these valid fields is received.

11   IP Backhaul Connection

EMB-Fem2GW-O supports two kinds of backhaul IP connection:

- Ethernet IP connectivity;
- Cellular connectivity.

The system is connected to the Ethernet Network through Ethernet Cable. IP address is assigned through DHCP.

Cellular connectivity is achieved using Quectel LTE Module. **EMB-Fem2GW-O** supports mini SIM Size, with a Push-Push connector. It automatically guarantees LTE

connectivity, and without it switches to 3G/UMTS or to GPRS connection according to the cellular coverage.

12   LTE Connection

In this section is described how **EMB-Fem2GW-O** manages the LTE pheripheral.

How to set up a LTE Network is explained. In Linux OS, LTE interface is called ppp0. We setup the OS to start the LTE module at boot time, according to the lte configuration file stored in /etc/ppp/peers.

This file is composed as follows:

#connect is the command to manage the script to launch LTE connection. The last name, in this case tre.it, is the APN server name.

connect "/usr/sbin/chat -v -f /etc/chatscripts/gprs -T tre.it"

#serial port adopted by the LTE Module

/dev/ttyUSB3

#With this option, the peer will have to supply the local IP address during IPCP negotiation (unless it specified explicitly on the command line or in an options file)

Noipdefault

#Add a default route to the system routing tables, using the peer as the gateway, when IPCP negotiation is successfully completed

defaultroute

replacedefaultroute

#Do not require the peer to authenticate itself

Noauth

Do not exit after a connection is terminated; instead try to reopen the connection

persist

Ask the peer for up to 2 DNS server addresses. The addresses supplied by the peer (if any) are passed to the /etc/ppp/ip-up script in the environment variables DNS1 and DNS2, and the environment variable USEPEERDNS will be set to 1. In addition, pppd will create an /etc/ppp/resolv.conf file containing one or two nameserver lines with the address(es) supplied by the peer.

Usepeerdns

Steps to modify this file follows:

1. Enter through SSH Connection in the Gateway using as username root and password raspberry

2. Move to the proper folder using the command cd /etc/ppp/peers

3. Open a Linux File editor to modify the file using the command nano lte
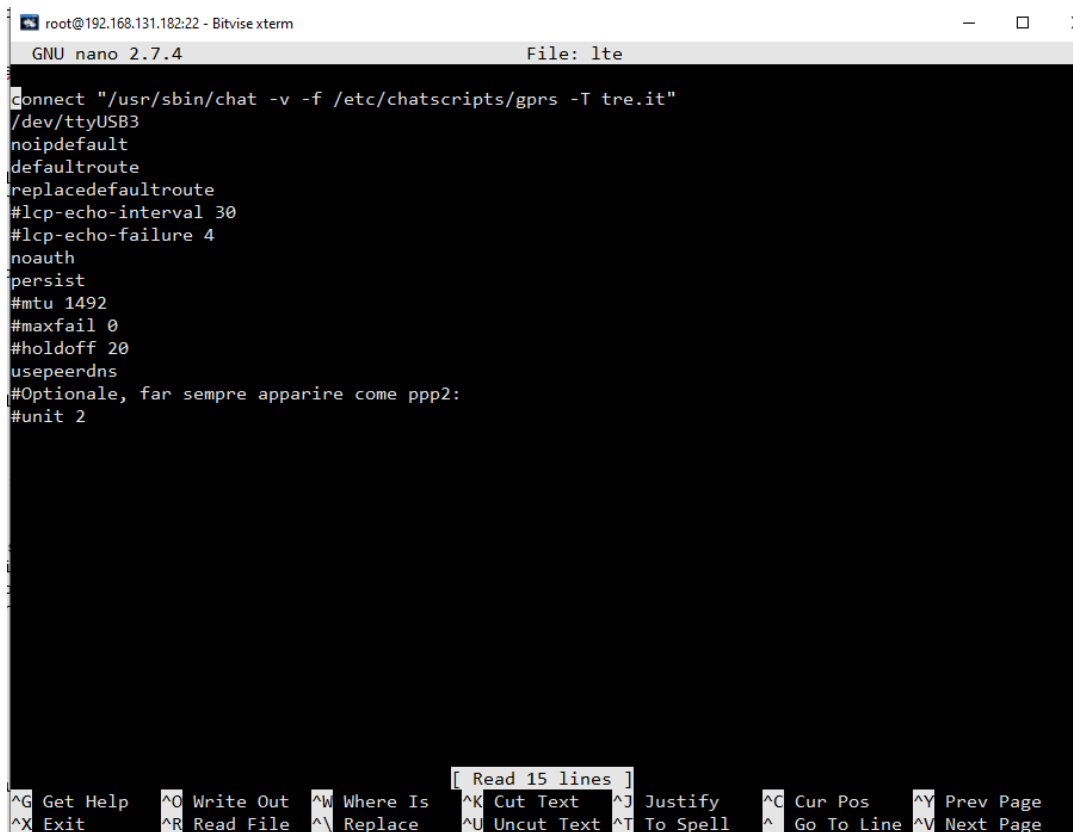
    The following screen appears

Figure 33 /etc/lte file view

4. Change tre.it with your APN address

5. Press Ctrl+O to save, confirming the name of the file pressing ENTER

6. Restart the LTE network using the commands

    ifdown lte

    ifup lte

13   Assembly

In this section, it is described how to mount the **EMB-Fem2GW-O** on a pole. It has to be in a position sufficiently high to guarantee a good communication range.

EMB-Fem2GW-O is provided with the mounting bracket, shown in the following picture.

Figure 34 Mounting Bracket with Gateway

The mounting bracket has to be attached to the back of the **EMB-Fem2GW-O** using screws and washer and attached on the pole as the image below.

Figure 35 EMB-Fem2GW-O on the pole

14　Disclaimer of liability

The information provided in this and other documents associated to the product might contain technical inaccuracies as well as typing errors. Regulations might also vary in time. Updates to these documents are performed periodically and the information provided in these manuals might change without notice. The user is required to

ensure that the documentation is updated and the information contained is valid. Embit reserves the right to change any of the technical/functional specifications as well as to discontinue manufacture or support of any of its products without any written announcement.

14.1   Disclaimer of liability

The user must read carefully all the documentation available before using the product. In particular, care must be taken in order to comply with the regulations (e.g., power limits, duty cycle limits, etc.).

14.2   Handling Precautions

This product is an ESD sensitive device. Handling precautions should be carefully observed.

14.3   Limitations

Every operation involving a modification on the internal components of the module will void the warranty.

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