EMB-GW1301-O
QUICK START GUIDE

Rev 1.0

Embit s.r.l.

Document information

Versions & Revisions

Revision	Date	Author	Comments
0.1	2019-02-07	Embit-AM	Initial release
0.5	2019-02-12	Embit-MDD	Version Edited
0.6	2019-02-14	Embit-AM	TTN example added
1.0	2019-02-15	Embit	Revision 1.0

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1 Introduction

This guide explains how to start using the **EMB-GW1301-O**.

The **EMB-GW1301-O** gateway is a multi service up-gradable platform, designed to meet IoT (Internet Of Things) and M2M (Machine-2-Machine) scenario. It enables LoRaWAN^{TM} connectivity, having the role of fully compliant LoRaWAN^{TM} Gateway. It provides the LoRaWAN^{TM} packet forwarder functionality: the **SX1301** radio will start to operate as a LoRaWAN^{TM} base station, receiving radio packets and forwarding them to a LoRaWAN^{TM} network server. It can be connected to the network through a PoE connection and / or via a SIM card. In the latter case, high latency could lead to the LoRaWAN^{TM} network performance decrease. Using the **Embit Gateway Configuration web interface** it is possible to set up and launch several LoRaWAN^{TM} packet forwarders with custom parameter. It will be described in the following paragraphs with details.

EMB-GW1301-O manages **8 LoRa channels** in order to handle **thousand of end-devices.**

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 gateway must be powered with a **PoE IEEE 802.3at**, and it has a power consumption less than 20 Watt. Whit a different power supplier, its functionalities may stop irretrievably.
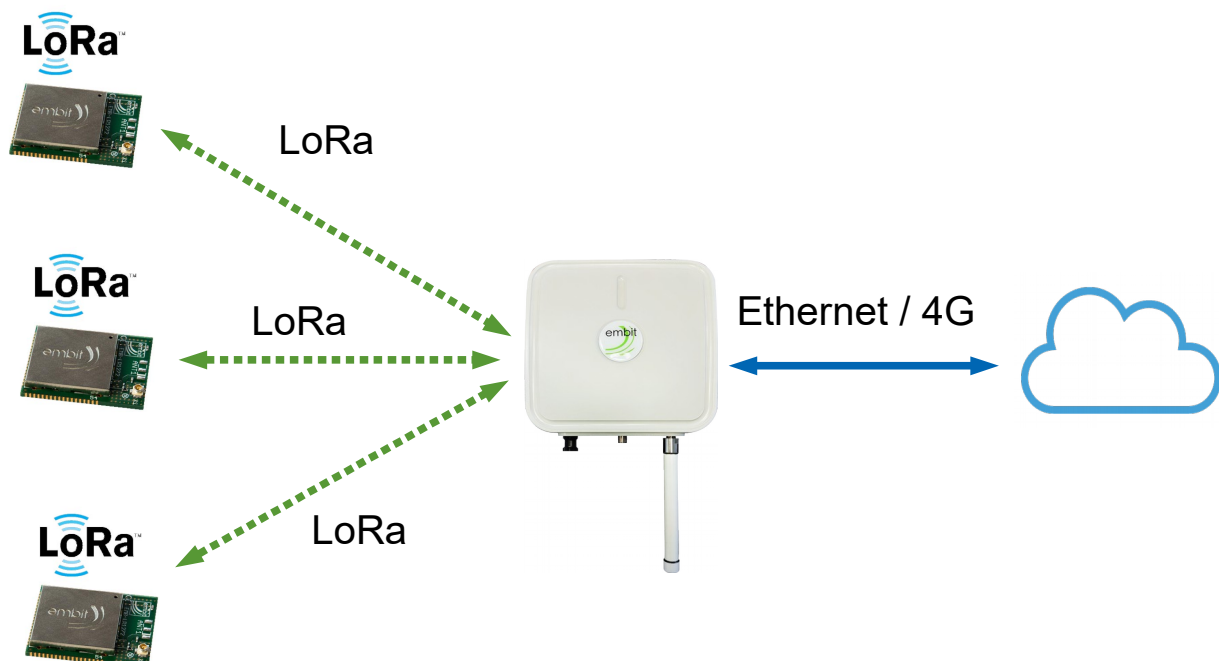

Figure 1: LoRaWAN Network Scenario

2 Hardware Specification

- Processor: Quad-Core ARM Cortex – A7 (1,2 GHz)
- RAM Memory: 1 GB, DDR3
- Flash Memory: 4 GB, EMMC
- LAN Connection: Ethernet RJ45 10/100/1000 Base-T
- LoRaWAN™ Connectivity: Semtech SX1301 +20/+27 dBm @ 868 MHz
- Connectivity: GPS
- Cellular Connectivity: 4G LTE
- Optional Connectivity: 802.15.4 / ZigBee / Wireless M-Bus
- Power Source: PoE IEEE 802.3at
- Ports: Ethernet 10/100/1000 RJ 45 / N-Type Antenna Connector
- Power Consumption: 20 W
- Operating System: Embedded Linux
- Dimensions: L: 276 mm W: 272 mm H: 96 mm
- Weight: 1,9 kg
- Certifications: CE according to RED

3 Main Features

- Full Compliance with LoRaWAN™ network protocol;
- Rapid deployment with existing LoRaWAN™ compliant Network Server or your own LoRaWAN™ Network Server;
- Powerful Semtech SX 1301 8 channels handles thousands of end-devices;
- Supports LoRaWAN™ version 1.0.1 and proprietary LoRa;
- Optional wireless interfaces compliant to IEEE 802.1504, ZigBee, Wireless M-BUS, WiFi IEEE 802,11 b/g/n or proprietary products;
- Easy, proactive monitoring of processes.

4 Power Supply

The power supply is provided by the **PoE connection**. PoE cable must be connected to the Ethernet port is present on the side of the gateway as indicated in the figures below. The PoE injector has to provide at least 20 W.

Figure 2: PoE Connection

Figure 3: PoE Connection, Side view

5 Antenna Configuration

In the same side of the Ethernet connector, SMA connectors are placed (see Figure 4). There should be several connectors in the same side, according to the Gateway model you ordered. On top of each SMA, a label shows what kind of antenna has to be connected.
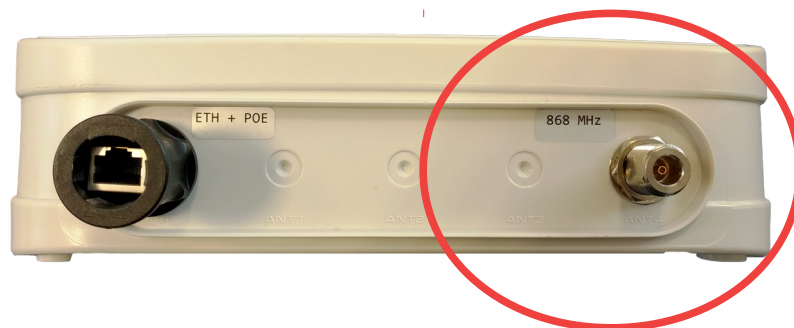

Figure 4: Antenna SMA Connector

Antenna has to be screwed on the connector. The result is showed in the figure below.

Figure 5: Antenna View

6 Quick Start

Since you have connected the power supplier, the Gateway starts working and providing LoRaWAN™ connectivity as well as Internet connectivity, so it can be reached from any kind of web browser. Using the provided web UI, it is possible to set different networks and LoRaWAN™ parameters from the browser.

7 LoRaWAN™ Gateway Configuration Web Interface

Emb-1301GW-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 are:

username: embit

password: password

Figure 6: Embit Web Interface - Log In Page

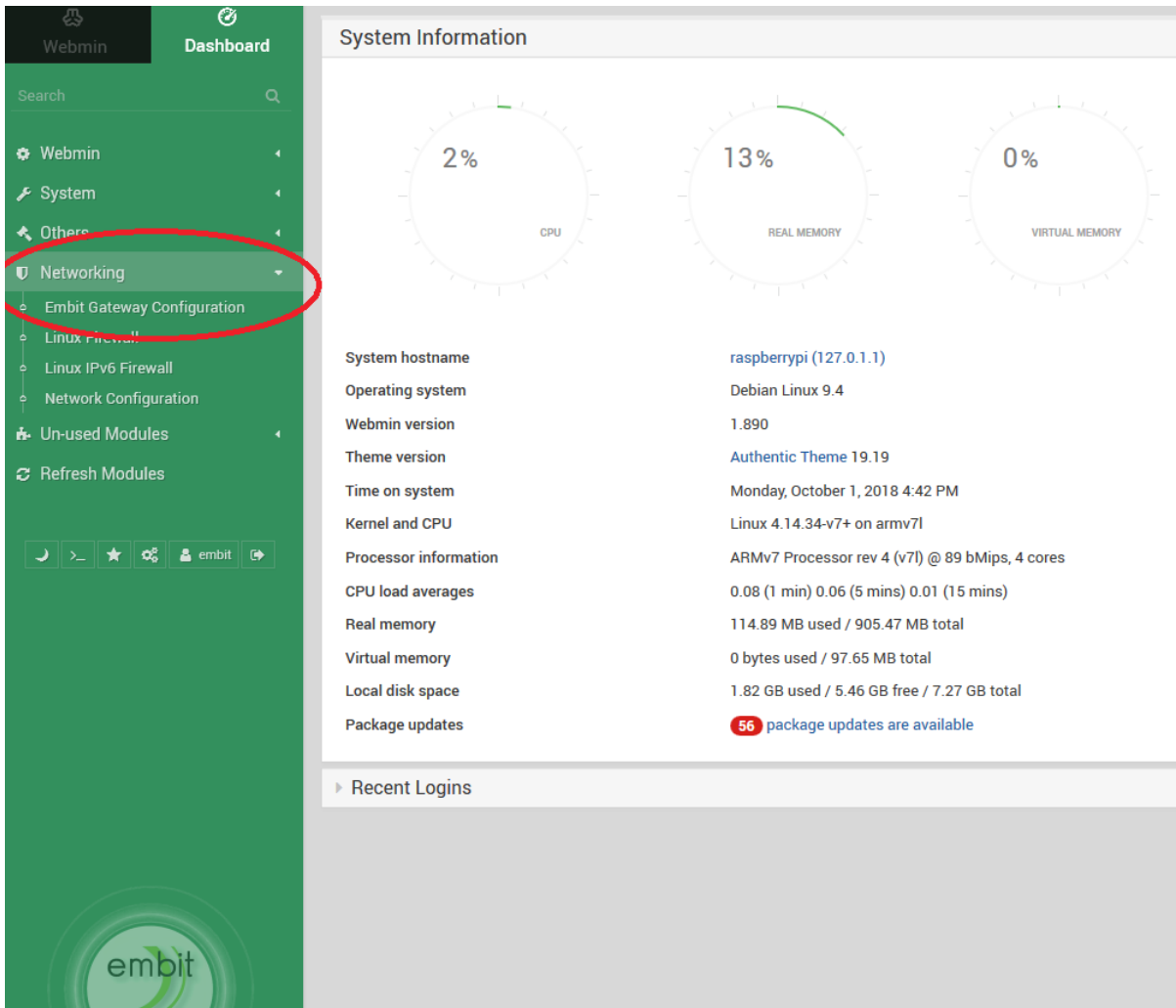"*Embit Gateway Configuration*" is located in the left menu, in the category Networking (Figure 7).

Figure 7: Embit Web Interface - Dashboard

In the "*Packet Forwarder*" tab, the system state information are reported (Figure 8). 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.
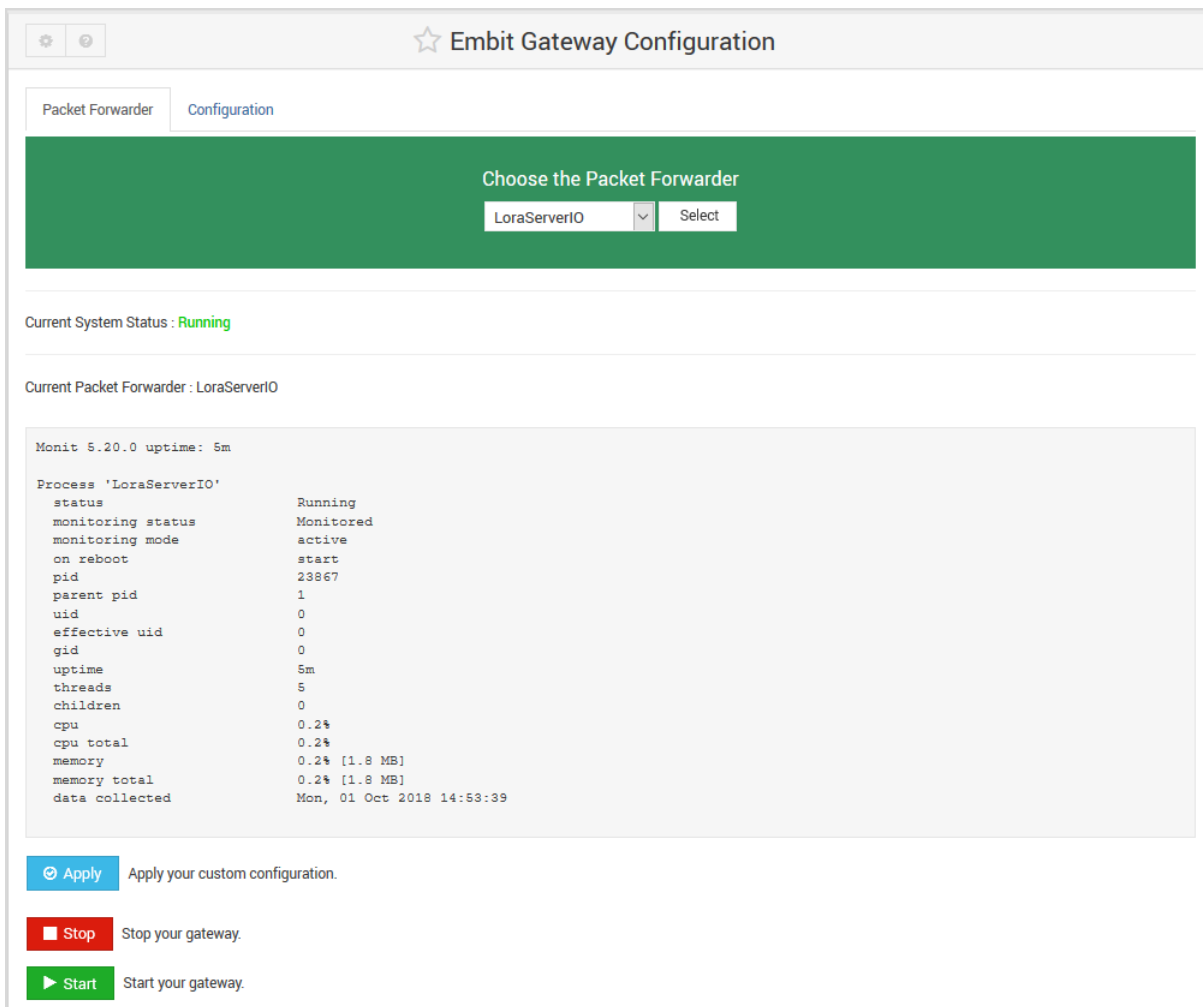
Figure 8: Embit Gateway Configuration - Packet Forwarder Tab

In the configuration tab, it is possible to customize the network parameter of the LoRaWAN™ packet forwarders (Figure 9).
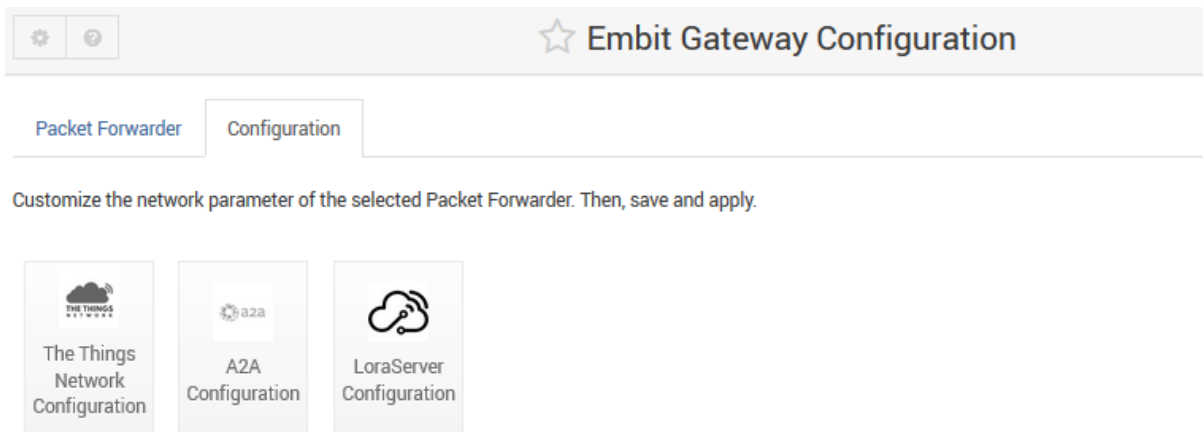

Figure 9: Embit Gateway Configuration - Configuration Tab

The following parameters can be changed in the **The Things Network** packet forwarder (Figure 10).
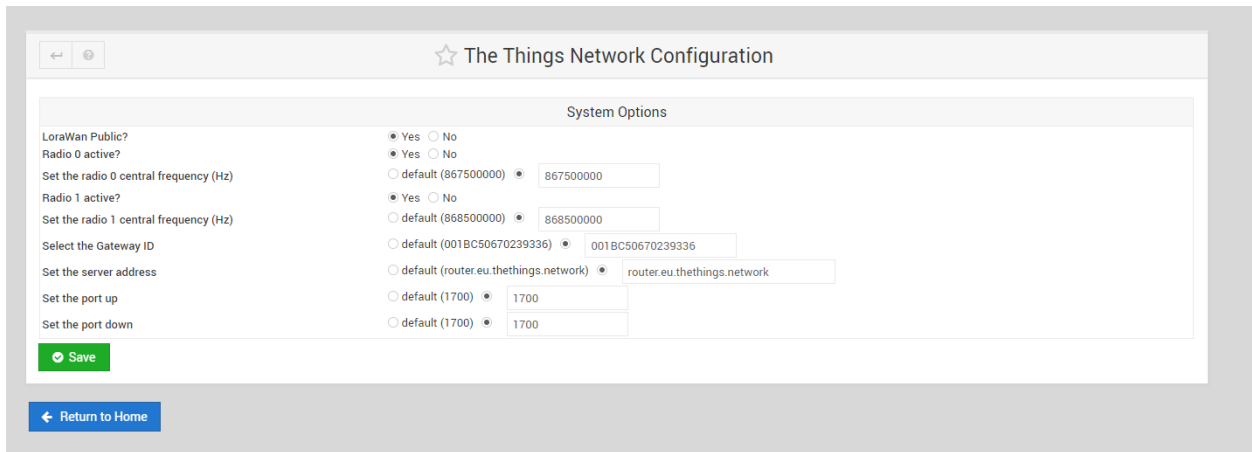

Figure 10: Embit Gateway Configuration - The Things Network Configuration Page

The changes are applied through the "*Apply*" button in the main tab (Figure 8).

8 Network Configuration Web Interface

In the provided Web Interface, **EMB-GW1301-O** network configuration can be managed.

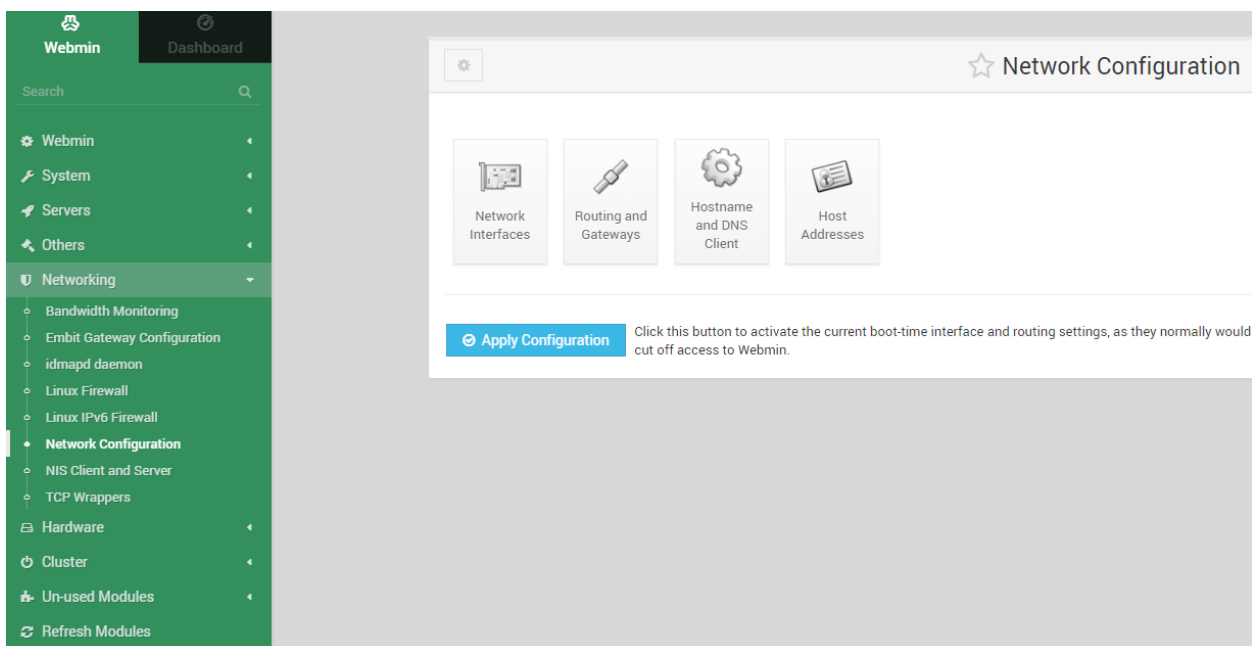"*Network Configuration*" is located in the left menu, in the category "*Networking*" (Figure 11).

Figure 11: Embit Web Interface - Webmin

Selecting "*Network Interfaces*", all the network interface are reported. They are grouped in two tabs (Figure 12):

- Active Now
- Active at Boot

"*Active now*" tab enables to de-activate the selected network interfaces among the available one.
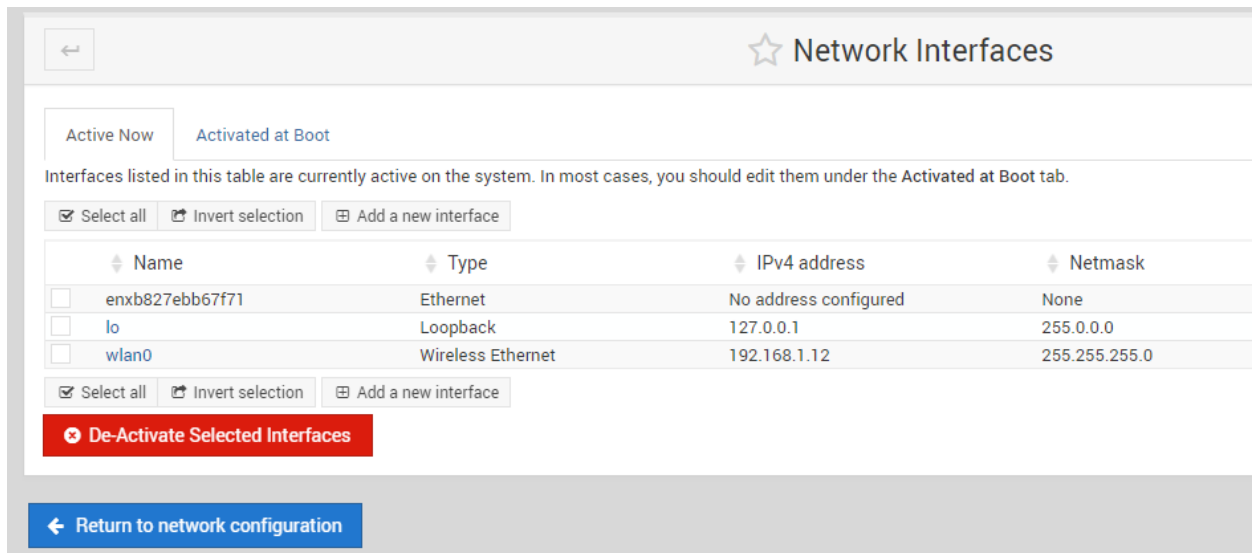

Figure 12: Embit Web Interface - Network Interfaces

To apply the selected preferences, press "*Apply Configuration*" button in the main "*Network Interfaces*" page (Figure 12).

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-GW1301-O** can support different packet forwarders.

Step 1: Take your Unique Gateway ID

The **Unique Gateway ID** is a number which allows the Network Server to identify your gateway. This parameter is written in the label of the **EMB-GW1301-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 13). Be

sure your EMB-GW1301-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 13: A2A Gateway Configuration Web Interface

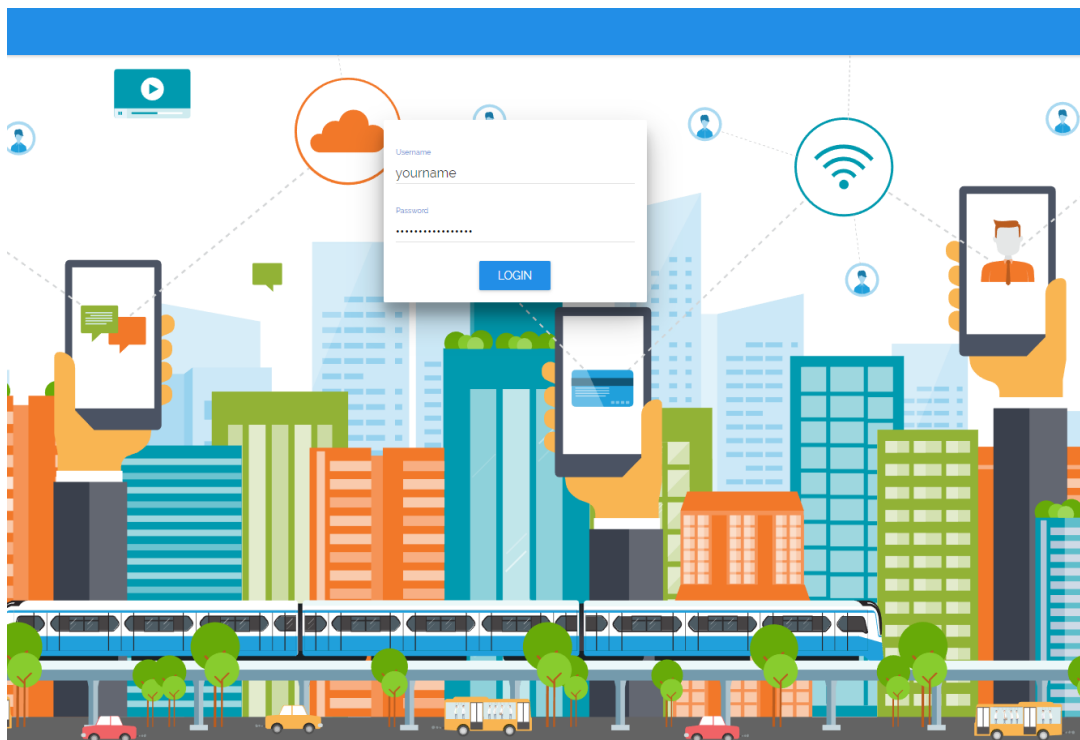## Step 2: Sign Up with your A2A Smart City Account

Figure 14: A2A Smart City Log In Web Page

Step 3: Create a Gateway

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

Figure 15: Gateway List Web Page
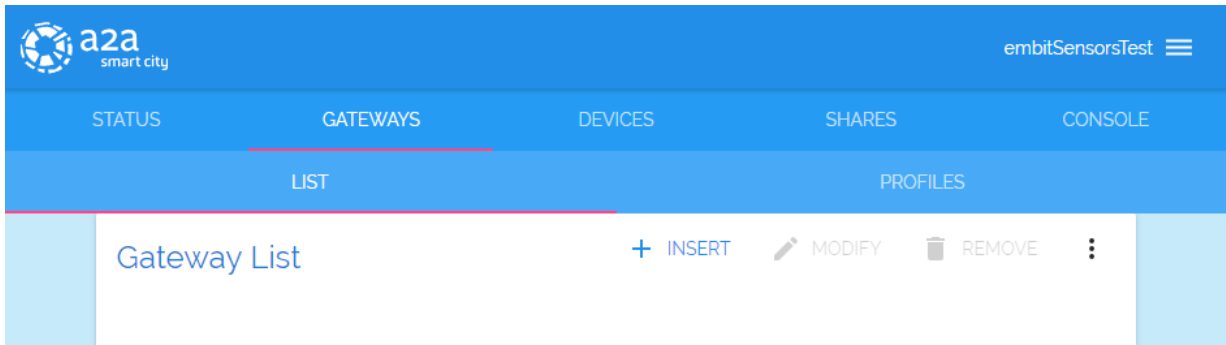
Step 4: Register your Gateway Data

Add your **Gateway Unique ID** 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 16).
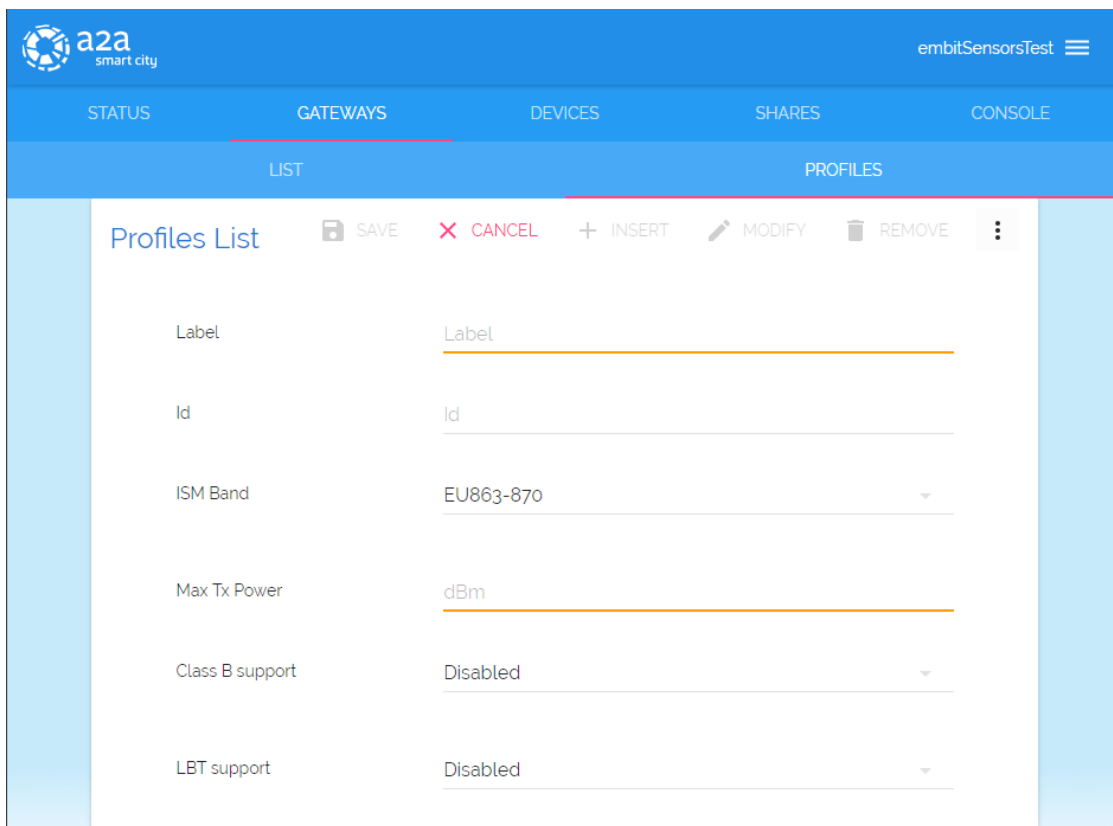

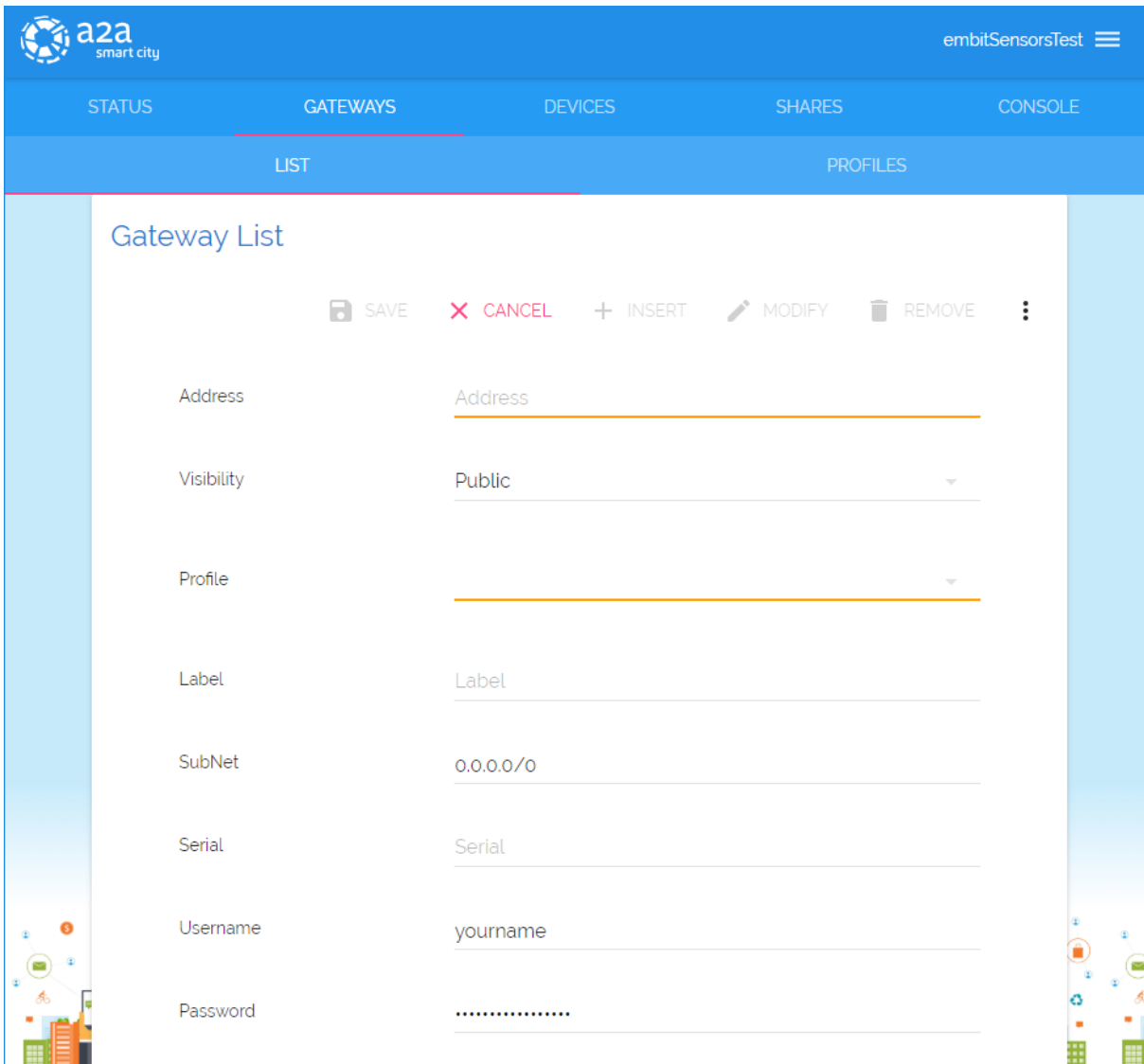*Figure 16: Gateway List - Parameters*

Figure 17: 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 18: Gateways 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 19: Application List Web Page
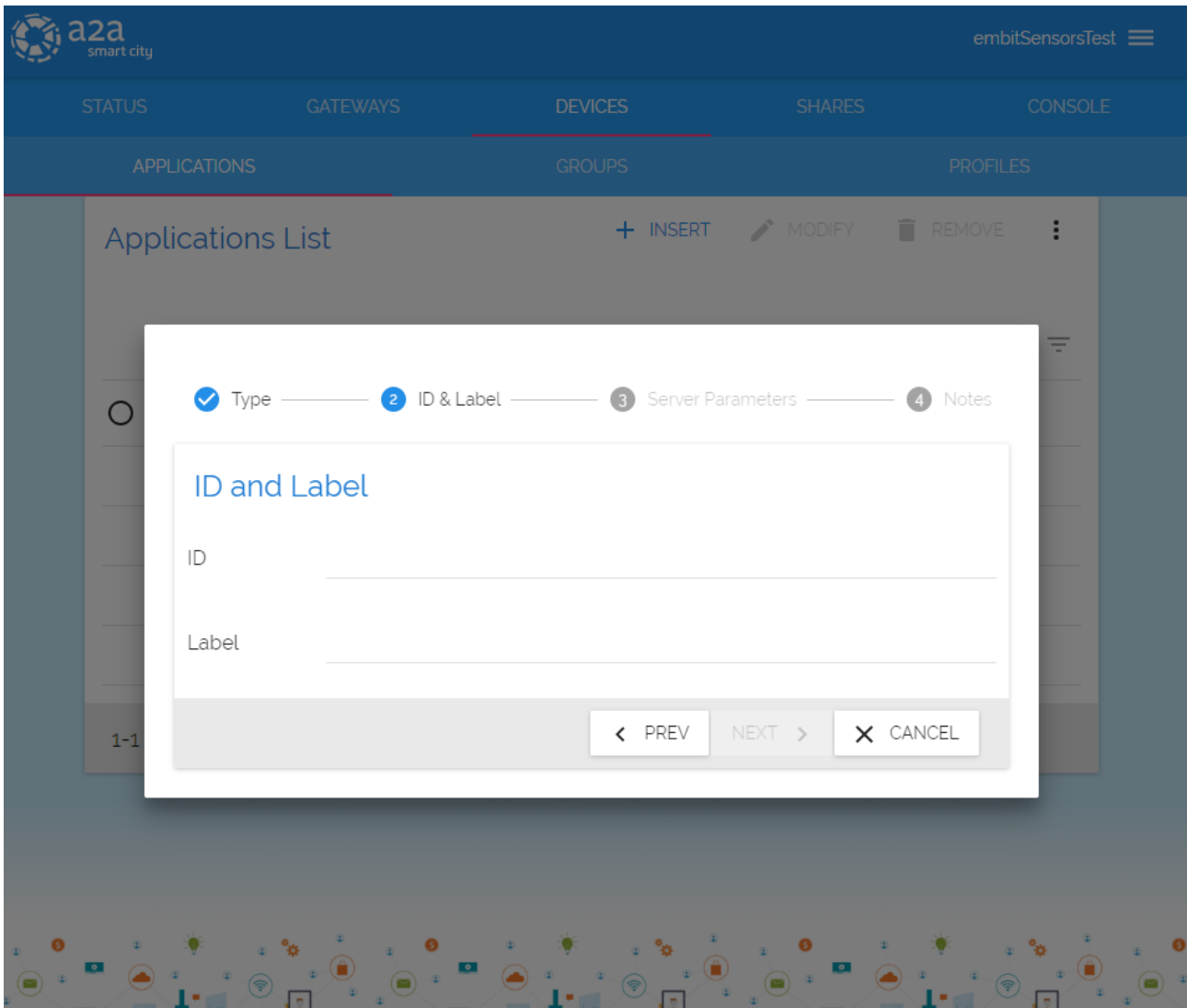
Figure 20: Device Configuration

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.

Figure 21: Application Device 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-devic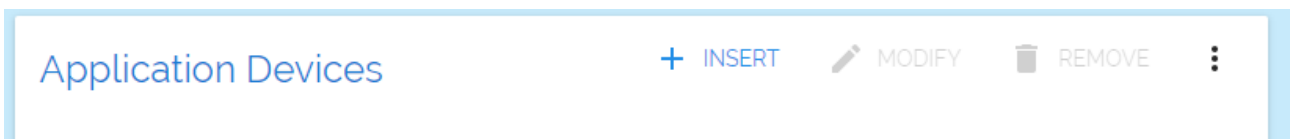e has to send a *Join Request*. When a *Join Accept* message is received by the end-device, the network is started. The packets are visible under the **Gateway Info Page**, as described in *Step 5*, or pressing on the "*Info*" icon related to your *Dev Eui* in the *Application Devices List*.
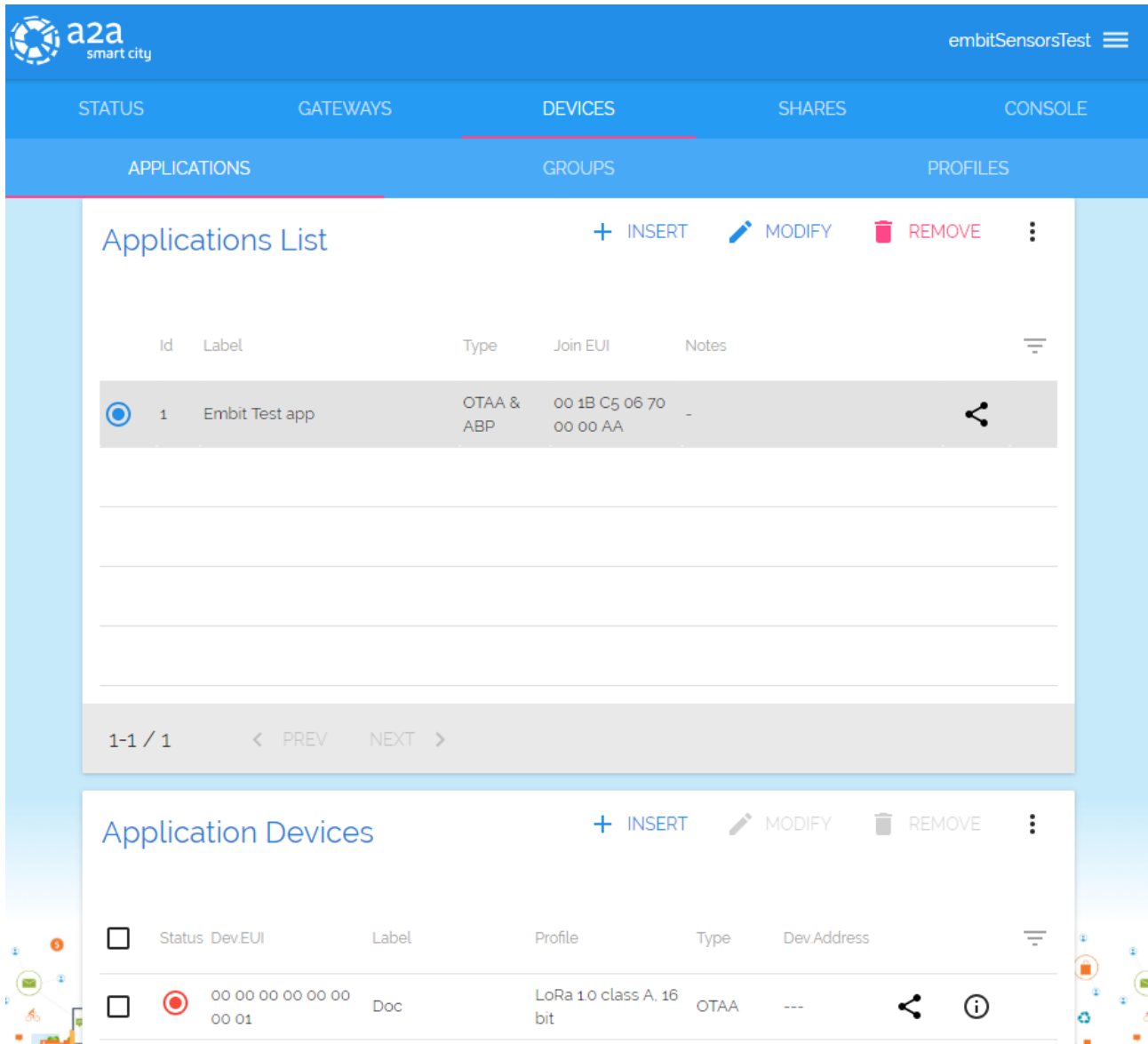
Figure 22: Device Web page

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 23).

Figure 23: 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

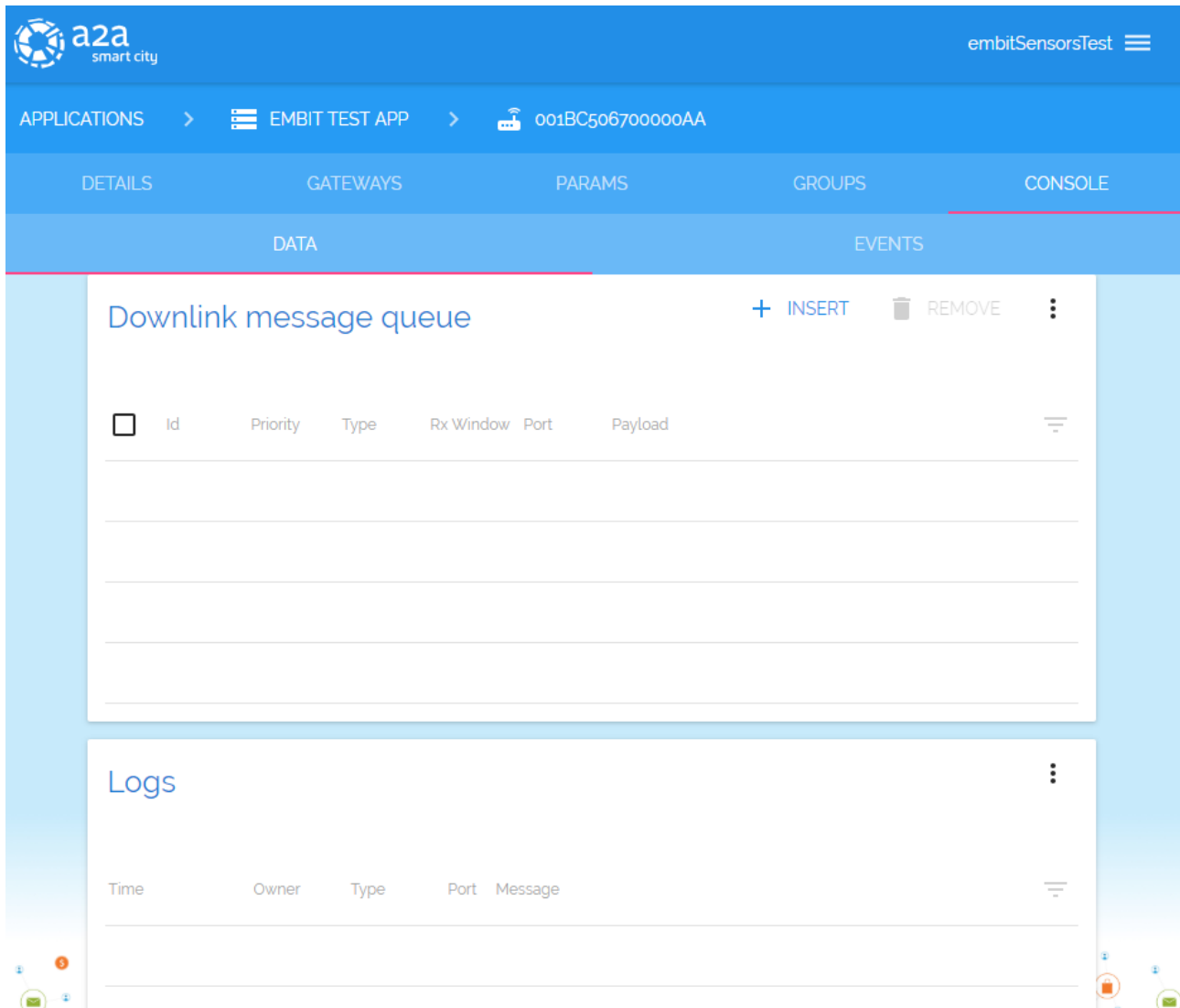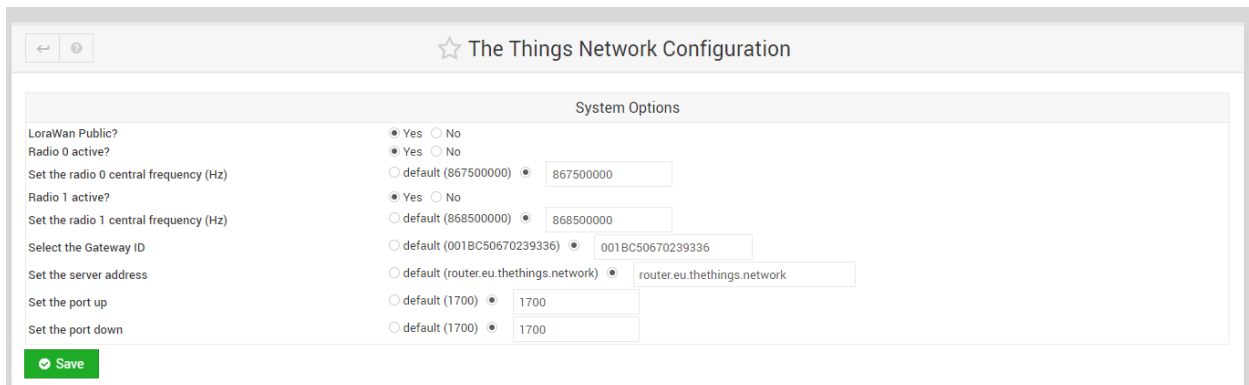In this section, it is explained how to register a gateway in an open LoRaWAN™ Network Server. The LoRaWAN™ Network Server taken into account is **The Things Network**.

Step 1: Take your Unique Gateway ID

The **Unique Gateway ID** is a number which allows the Network Server to identify your gateway. This parameter is written in the label of the **EMB-GW1301-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-GW1301-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 24: The Things Network Gateway Configuration Web Interface

Step 2: Sign Up with your The Things Network Account
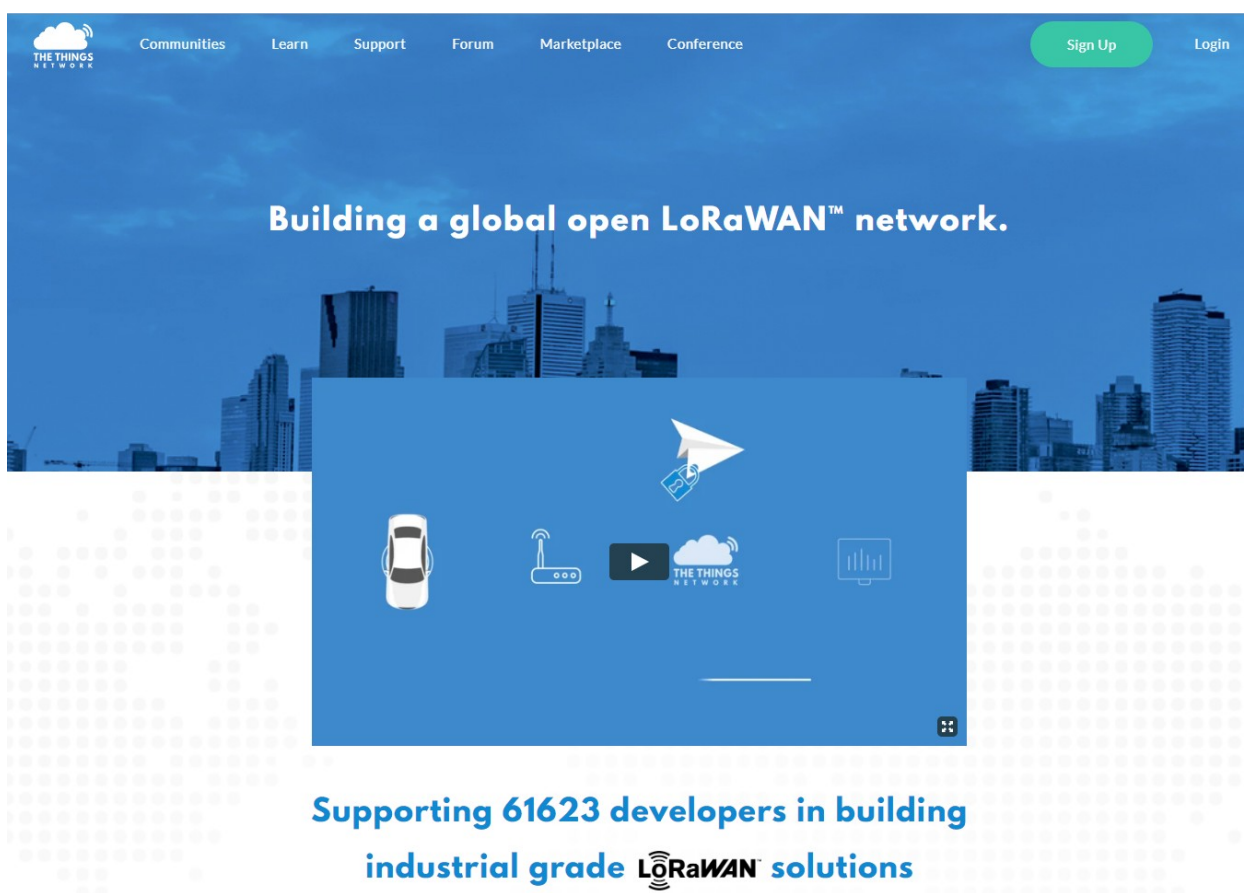
Figure 25: The Thing Network Log In Page

Step 3: Go to Gateway page

From your account, open "*Console"* section and then press on "*Gateways"* button. (Figure 26)
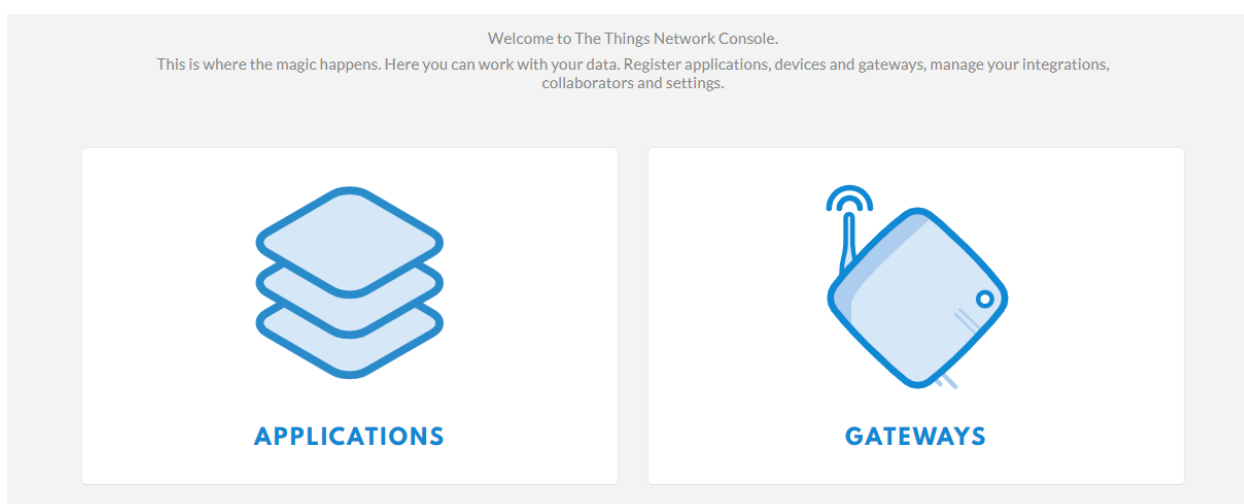
Figure 26: The Things Network Console

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 27: 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.

When your Gateway is connected, a green dot is showed near the *"Status"* string (Figure 28).
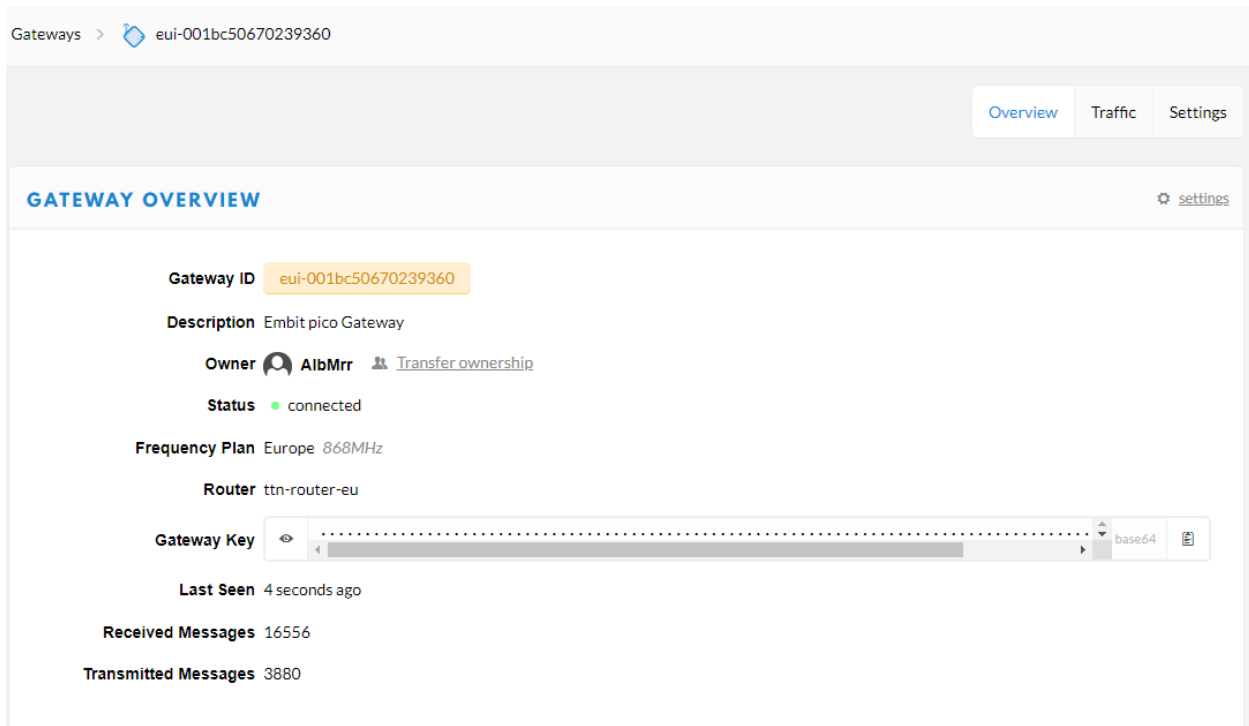
Figure 28: Gateway Overview Page

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 (Figure 29). In this case, data are encrypted due to safety reason.
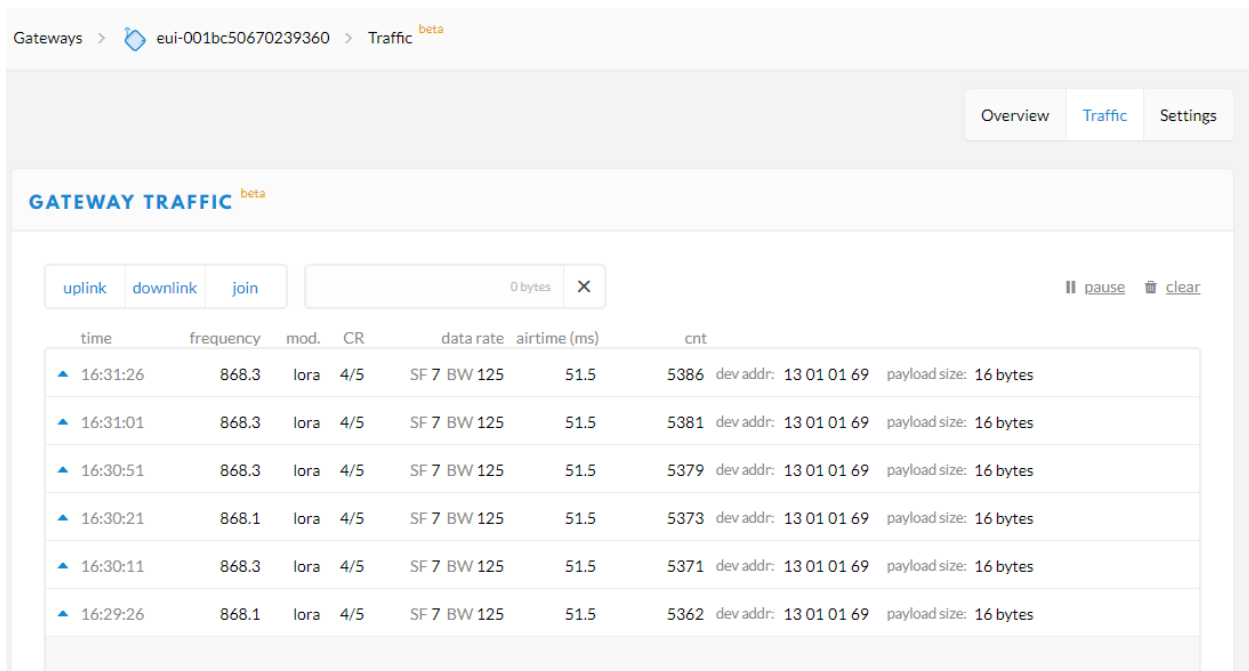
Figure 29: Gateway Traffic Monitoring Page

Step 7: Go to Application

From your account, open "*Console*" section and then press "*Applications*" button.
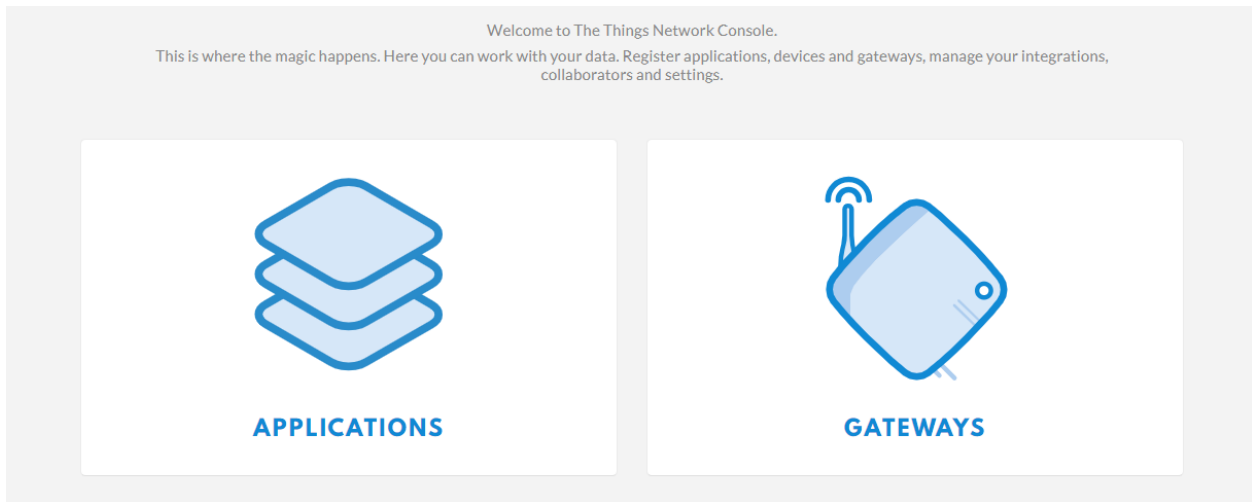
Figure 30: The Things Network Console

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 31: Add Application Page

Step 9: Register your Device

Go to the "*Application Overview*" page and press "*Register Device*" (Figure 32).
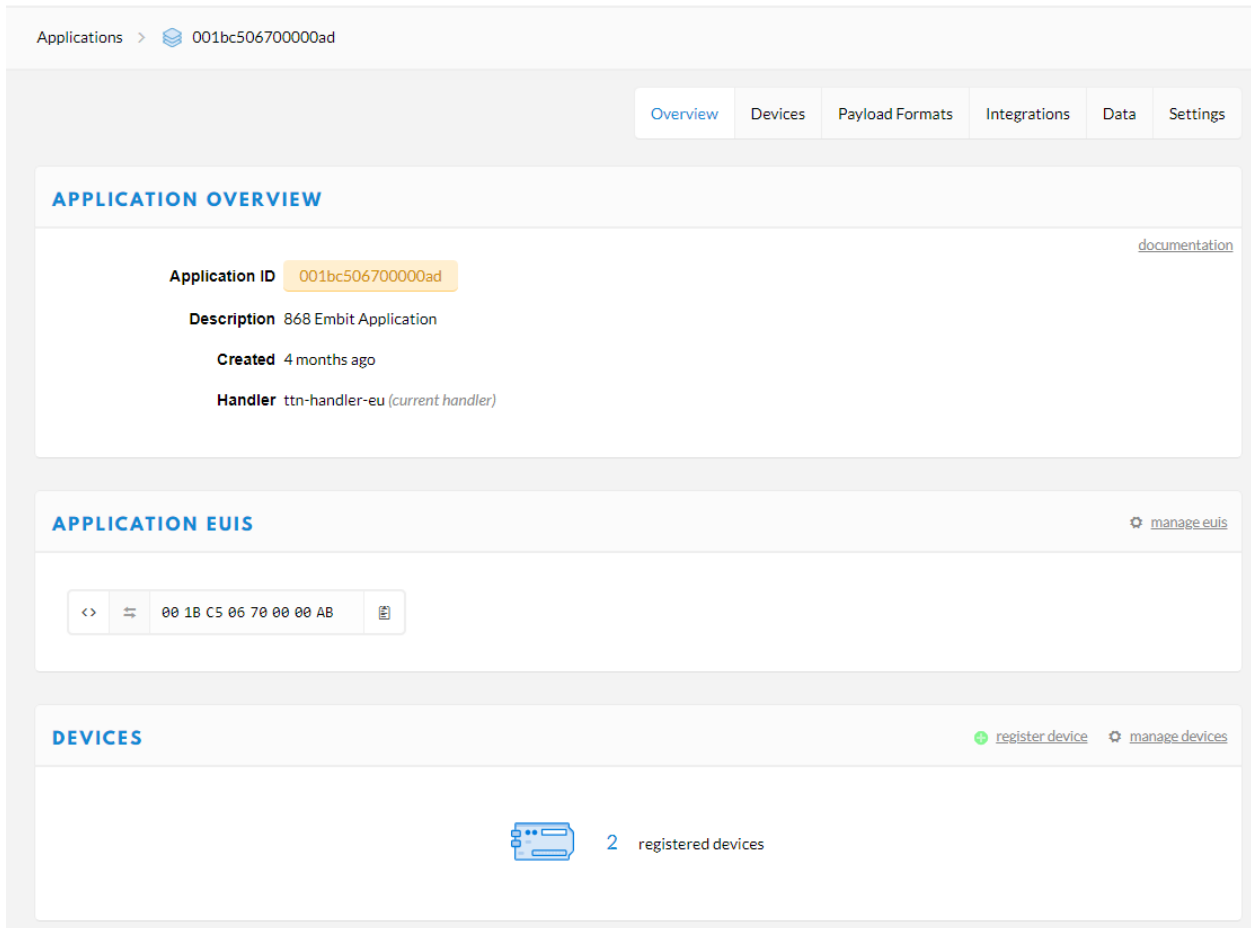
Figure 32: Application Overview Page

"*Registration Device*" page will open (Figure 33). *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 33: 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 34).
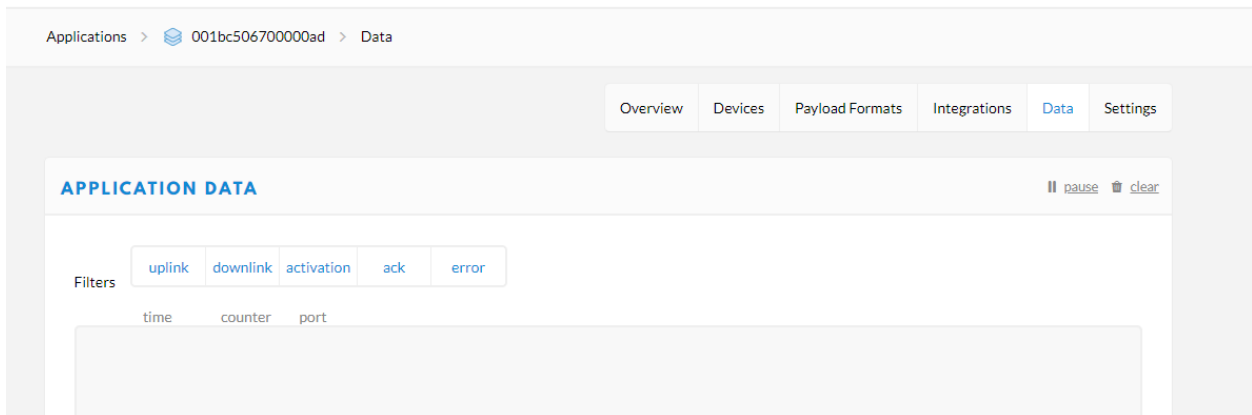
Figure 34: Application Data Monitoring Page

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 35).
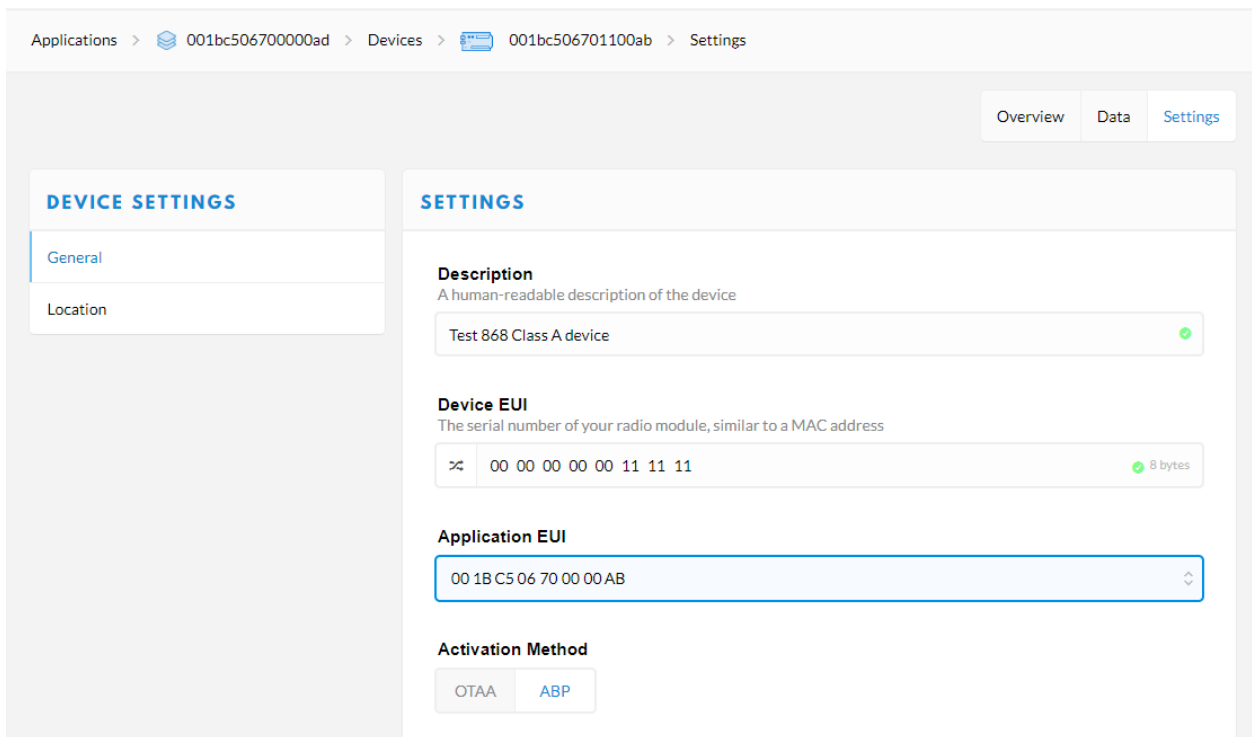
Figure 35: Device Settings Page

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 Annex: EMB-LR1301mPCIe Datasheet

11.1 Introduction

EMB-LR1301-mPCIe provides long range connectivity using ultra-long range spread spectrum communication and high interference immunity on the 868/915 MHz radio bands. It increases operational capacity keeping the gateway cost low.

EMB-LR1301-mPCIe offers up to 8 LoRa Channels in the 868Mhz (or 915MHz) frequency allowing it to receive up to 8 LoRa packets simultaneously and it is able to achieve a sensitivity of **-137dBm** and a RF output power of **+27dBm** making it the ideal device to use in LoRaWAN gateways applications.

It is designed around the Semtech SX1301 [1] digital baseband chip with the RF front-end that consists of two of SX1257, high performance digital

Figure 36. EMB-LR1301-mPCIe.

I and Q modulator/demodulator transceiver chip, terminated with a standard U.FL connector.

It has also the **Listen Before Talk (LBT)** capability giving to the user the possibility to share the same channel. When enabled, the device monitors channels continuously and transmits only if the channel is free. It includes as well a GPS module.

11.1.1 Specifications

- Operating Voltage: +5V
- Current Consumption: 815mA (Tx@+27dBm); 600mA (Rx)
- Modulation: LoRa® Spread Spectrum, FSK, GFSK
- Operating Frequency: 868MHz (EU) / 915MHz (US)
- Frequency Range: 860MHz to 1020MHz
- Operating Temperature: -40°C to +85°C
- RF Output Power: Up to +27dBm
- Interfaces: mPCIe (SPI / I2C / UART / GPIOs)
- Sensitivity: Up to -137dBm
- Dimensions: 71 x 40 x 1 mm

- Features: Listen Before Talk (LBT) Capability, GPS (optional), On-board uFL antenna connector, 8 LoRa Channels,   FPGA supports LoRa Spectral Scan

- Part Numbers: EMB-LR1301-mPCIe-G (GPS included) / EMB-LR1301-mPCIe (without GPS)

11.2 Description

11.2.1 Block Diagram

The **EMB-LR1301-mPCIe** block diagram:
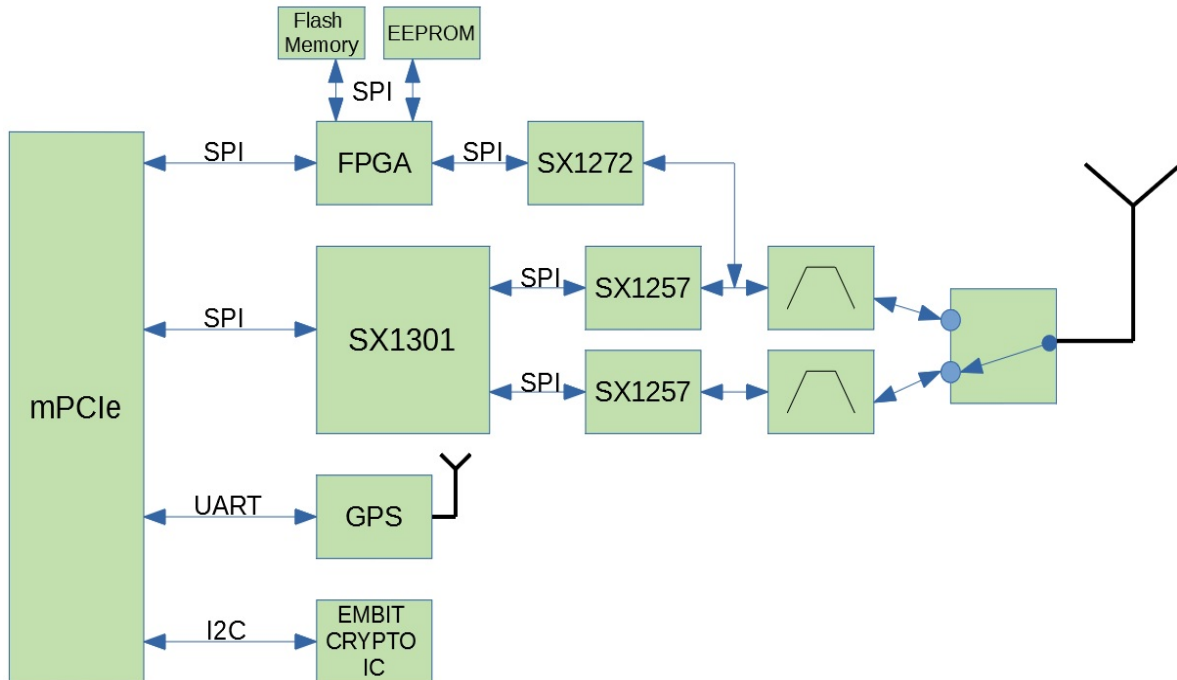
Figure 37: EMB-LR1301-mPCIe block diagram.

11.2.2 SX1301 Module

The **SX1301** digital baseband chip is a massive digital signal processing engine specifically designed to offer breakthrough gateway capabilities in the ISM bands worldwide. It integrates the LORA concentrator IP. The SPI interface gives access to the configuration register via a synchronous full-duplex protocol. Only the slave side is implemented.

Main features:

- **SPI** link with the CPU
- **RF standard supported**: LoraWAN™
- **Frequency band**: 868 / 915 MHz
- **libloragw** is the driver of the SX1301, that provides API for LoRa packet exchange using the SX1301 (developed by Semtech, customized and ported by Embit to this specific platform)
- **packet_forwarder** is the application that allows the exchange of LoRaWAN packet with a LoRaWAN server
- **Sample Projects**:
  - Semtech source code available https://github.com/Lora-net/lora_gateway

- ○ **libloragw core library**
- ○ **helper programs**: util_pkt_logger, util_spi_stress, util_tx_test, util_tx_continuous
- ○ **packet_forwarder**: the basic packet forwarder is a program running on the host of a Lora Gateway that forwards RF packets received by the concentrator to a server through a IP/UDP link, and emits RF packets that are sent by the server.

11.2.3 SX1257 Module

The two **SX1257** [2] are a highly integrated RF front-end to digital I and Q modulator and demodulator Multi-PHY mode transceiver capable of supporting multiple constant and non-constant envelope modulation schemes.

The SX1257 has a maximum signal bandwidth of 500 kHz in both transmission and reception and is intended as a high performance, low-cost RF-to-digital converter and provides a generic RF front-end that allows several constant and non-constant envelope modulation schemes to be handled.

The two transceiver are used instead of one to be able to simultaneously receive 8 LoRa 200 kHz channels.

11.2.4 SX1272 Module and FPGA

The **SX1272** [3] transceivers feature the LoRaTM long range modem that provides ultra-long range spread spectrum communication and high interference immunity whilst minimising current consumption.

It is driven by an **FPGA** providing to the EMB-LR1301-mPCIe the Listen-Before-Talk (LBT) and the spectral scan capabilities. Moreover, the FPGA acts also as 200Khz Notch filter for TX (not programmable).

11.2.5 GPS (ZOE-M8Q)

The **ZOE-M8Q** [4] is a highly integrated GNSS SiPs (System in Package) based on the high performing u-blox M8 concurrent positioning engine. It includes a SAW filter, LNA and TCXO.

UART interface is used for communication to a host and supports configurable baud rates.

11.2.6 External Antenna Connection

The **EMB-LR1301-mPCIe** has two uFL connectors, one for 868MHz antenna (or 915MHz for US market) and one for GPS antenna.

11.3 Connections

11.3.1 Pin Out Description

The table below gives the description of the pin out of the mPCIe interface.

Number	Pin Name	Type	Description
1	SCK_FPGA_HOST	Input	FPGA SPI Clock
2	VBIAS3	Power	+5V
3	CSN_FPGA_HOST	Input	FPGA SPI Chip Select
4	GND9	Power (GND)	Ground
5	MOSI_FPGA_HOST	Input	FPGA SPI MOSI
6	V1-1V5	NC	Not Connected
7	MISO_FPGA_HOST	Output	FPGA SPI MISO
8	SPI-MOSI	Input	SX1301 SPI MOSI
9	GND1	Power (GND)	Ground
10	SPI-MISO	Output	SX1301 SPI MISO
11	PPS_IN	Input	GPS PPS Input
12	SPI-SCLK	Input	SX1301 SPI Clock
13	RES5-REFCLK+	NC	Not Connected
14	SPI-CS	Input	SX1301 SPI Chip Select
15	GND2	Power (GND)	Ground
16	RES3	NC	Not Connected
17	$\overline{\text{CRESET\_N}}$	Input	FPGA Configuration Reset, active low
18	GND10	Power (GND)	Ground
19	C_DONE	Output	FPGA Configuration Done
20	RES14**W_DISABLE#	NC	Not Connected
21	GND3	Power (GND)	Ground
22	PERST#	Input	SX1301 Reset Pin, active low
23	RES6-PERN0	NC	Not Connected
24	VBIAS4	Power	+5V
25	RES7-PERP0	NC	Not Connected
26	GND11	Power (GND)	Ground
27	GND4	Power (GND)	Ground
28	V2-1V5	NC	Not Connected
29	GND5	Power (GND)	Ground
30	I2C_SCL	Input	Crypto Serial Clock
31	RES8-PETN0	NC	Not Connected

32	I2C_SDA	Input/Output	Crypto Serial data
33	RES9-PETP0	NC	Not Connected
34	GND12	Power (GND)	Ground
35	GND6	Power (GND)	Ground
36	USB_D-	NC	Not Connected
37	GND7	Power (GND)	Ground
38	USB_D+	NC	Not Connected
39	VBIAS1	Power	+5V
40	GND13	Power (GND)	Ground
41	VBIAS2	Power	+5V
42	RES	NC	Not Connected
43	GND8	Power (GND)	Ground
44	RES1	NC	Not Connected
45	RES10*	NC	Not Connected
46	RES2	NC	Not Connected
47	GPS_RESET_N	Input	GPS Reset Pin, active low
48	V3-1V5	NC	Not Connected
49	GPS_UART_RXD	Input	Serial Interface (RX)
50	GND14	Power (GND)	Ground
51	GPS_UART_TXD	Output	Serial Interface (TX)
52	VBIAS5	Power	+5V

Table 1: mPCIe Interface Pin Out.

11.4 Electrical Characteristics

11.4.1 Absolute Maximum Ratings

Parameter	Value	Unit
Power Supply Voltage	+5.5	Vdc
Storage Temp. Range	-50 to +150	ºC

Table 2: Absolute maximum ratings.

11.4.2 Operating Conditions

Parameter	Min	Max	Unit
Power Supply Voltage (Vcc)	+5	+5.5	V
Operating Temperature range	-40	+85	°C
Logic Low Input threshold	Vss	Vss+0.4	V
Logic High Input threshold	Vcc-0.4	Vcc	V
Logic Low Output Level	Vss	Vss+0.4	V
Logic High Output Level	Vcc-0.4	Vcc	V

Table 3: Operating Conditions.

11.4.3 Power Consumption

Mode	Typ. value	Unit
Transmission @ +27dBm	815	mA
Transmission @ +20dBm	525	mA
Transmission @ +14dBm	415	mA
Reception	600	mA

Table 4: Power Consumption.

11.4.4 RF Characteristic

Condition	Min	Typ.	Max	Unit
Output Power			+27	dBm
Receiver sensitivity SF12; BW=125KHz		-135		dBm
Receiver sensitivity SF11; BW=125KHz		-133		dBm
Receiver sensitivity SF11; BW=125KHz		-131		dBm
Receiver sensitivity SF11; BW=125KHz		-128		dBm
Receiver sensitivity SF11; BW=125KHz		-125		dBm
Receiver sensitivity SF11; BW=125KHz		-122		dBm
Receiver sensitivity SF12; BW=250KHz		-132		dBm
Receiver sensitivity SF7; BW=250KHz		-119		dBm

Table 5: RF Characteristic.

11.5 References

[1] Semtech, SX1301 Datasheet from www.semtech.com
[2] Semtech, SX1257 Datasheet from www.semtech.com
[3] Semtech, SX1272 Datasheet from www.semtech.com
[4] U-blox, ZOE-M8Q Datasheet from www.u-blox.com

12 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.

12.1 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.).

12.2 Handling Precautions

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

12.3 Limitations

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

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