
# LoRaWAN
# For
# Embedded System Developer

LoRa IoT by CAT

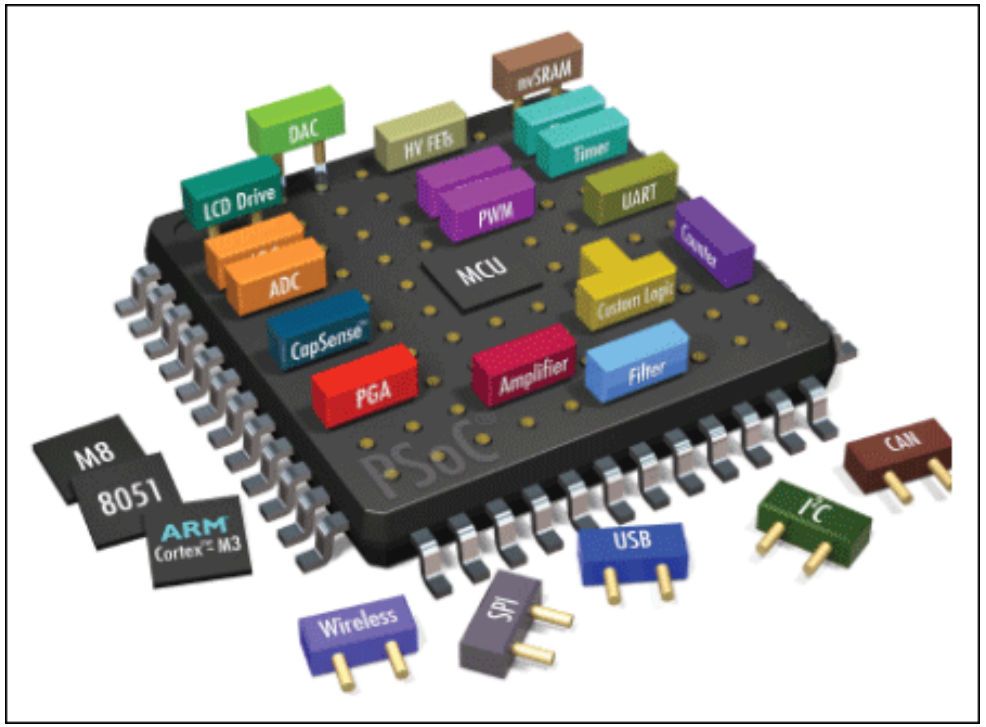
# TOPIC

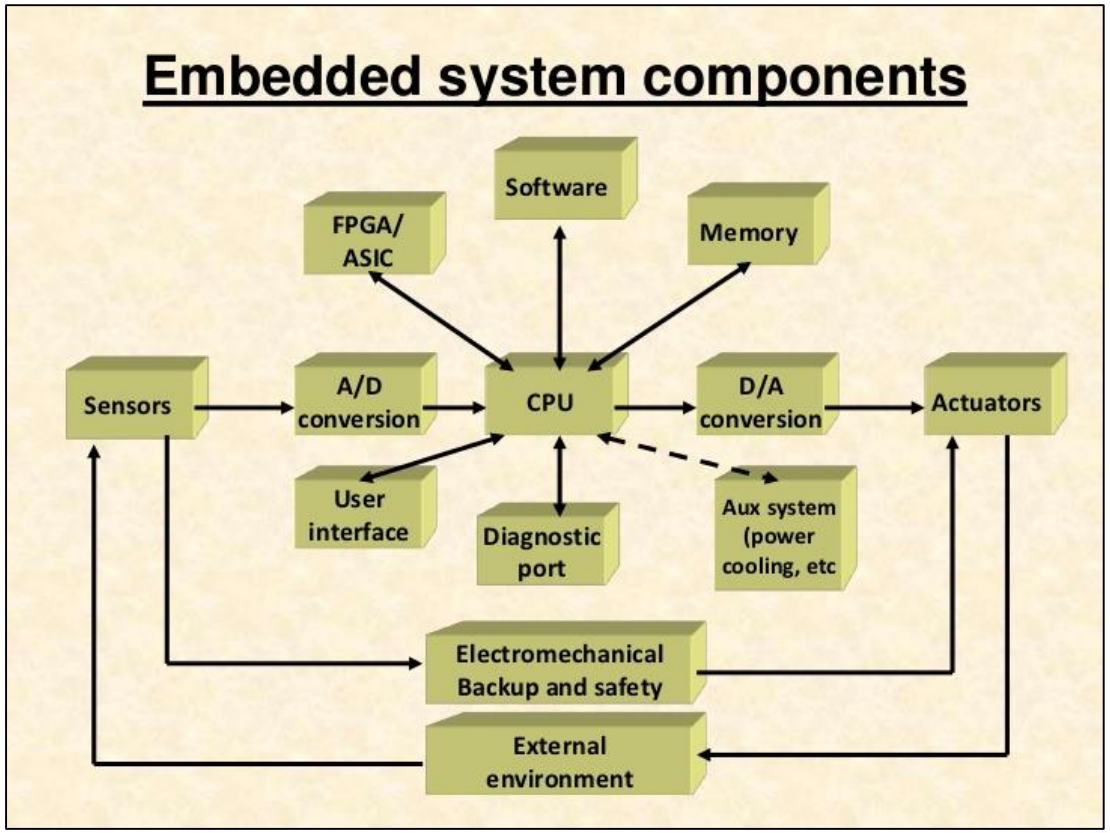
- **IoT Concept**
- **LoRaWAN Concept**
- **LoRaWAN IoT by CAT Telecom**

# TOPIC

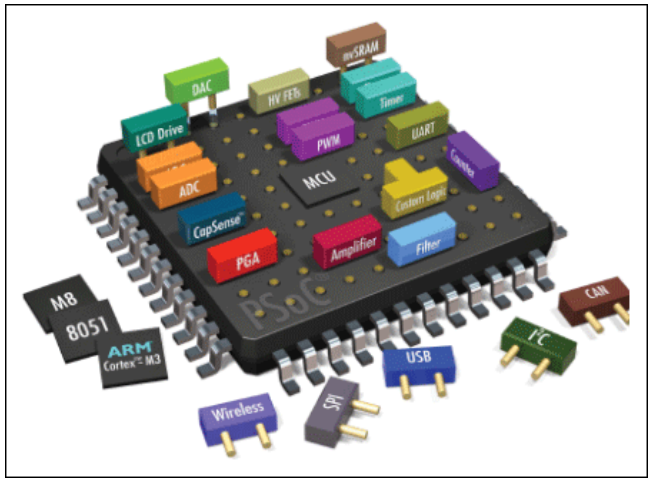
- **IoT Concept**
- LoRaWAN Concept
- LoRaWAN IoT by CAT Telecom

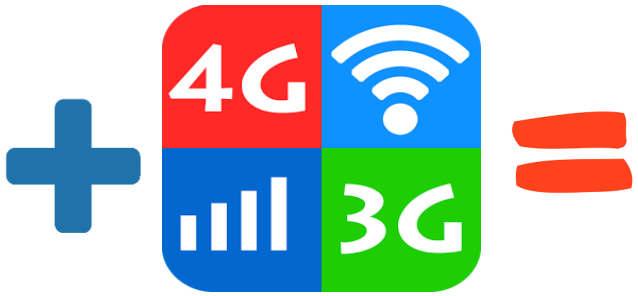
# IoT Concept


DAC
HV FETs
Timers
LCD Drive
PWM
UART
ADC
MCU
CapSense
Custom Logic
PGA
Amplifier
Filter
M8
8051
ARM
Cortex M3
CAN
I²C
USB
Wireless
SPI


Embedded system components
Software
FPGA/
ASIC
Memory
Sensors
A/D
conversion
CPU
D/A
conversion
Actuators
User
interface
Diagnostic
port
Aux system
(power
cooling, etc
Electromechanical
Backup and safety
External
environment

# IoT Concept





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CAT CONTACT CENTER 1322

# Network Concept

## Discussion

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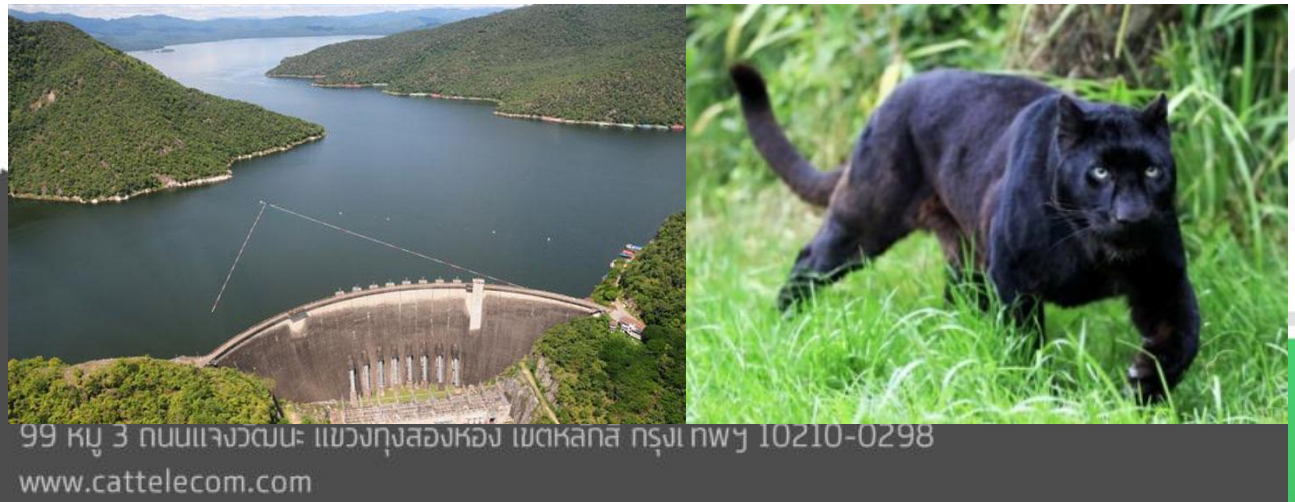


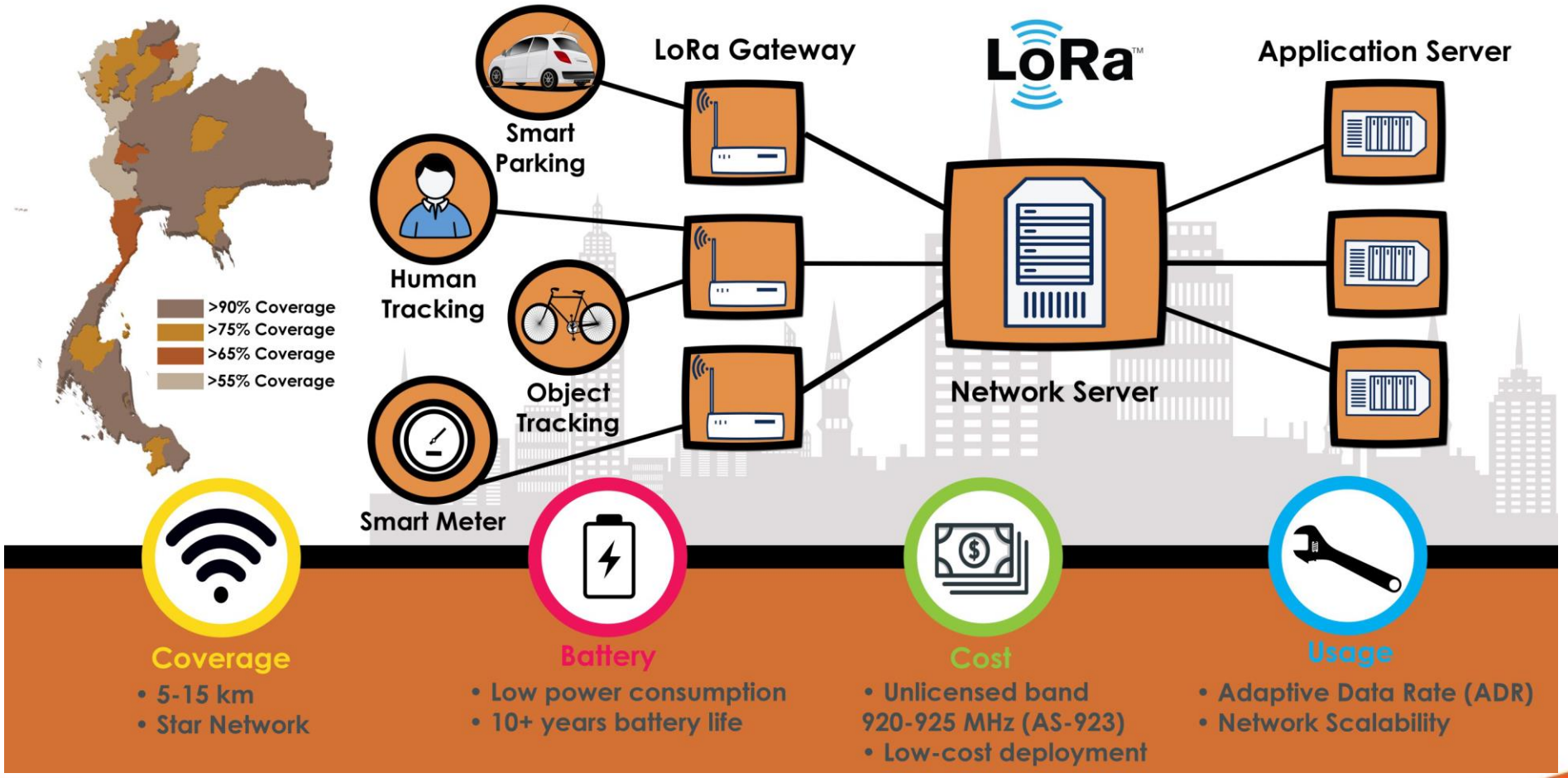

# TOPIC

- IoT Concept
- **LoRaWAN Concept**
- LoRaWAN IoT by CAT Telecom

# LoRaWAN Network Alliance


Ref: LoRa-Aliance.org

# LoRaWAN Network Topology



# IoT Value Chain

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## End Node Device

### Chip Vendor

life.augmented

MICROCHIP

ARDUINO

range pi

Orange Pi Plus2E

RAK

The simplest, the best

pycom GO INVENT

muRata

INNOVATOR IN ELECTRONICS

Acsip

seeed

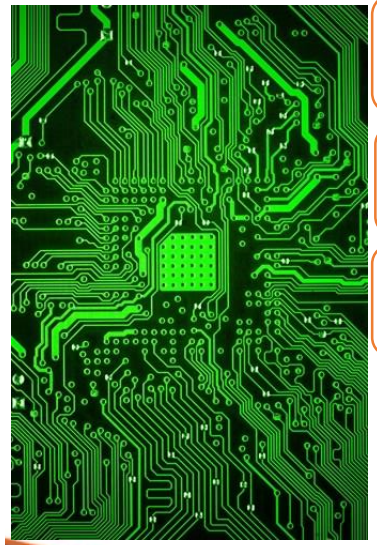
The IoT Hardware Enabler

DRAGINO

M5STACK

### RF Chip Vendor

SEMTECH



### Solution

- Smart Health
- Smart Parking
- Smart Farm
- Smart Environment

## Network

### Infrastructure and Service

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## Application & Service

### Tool

MySQL

php

HTML CSS JS

node JS

Node-RED

docker

Virtual Machines

### Platform

Google Cloud Platform

amazon web services

IBM Bluemix

Microsoft Azure

axiata

### Service

Cayenne myDevices

- Smart Health
- Smart Parking
- Smart Farm
- Smart Environment

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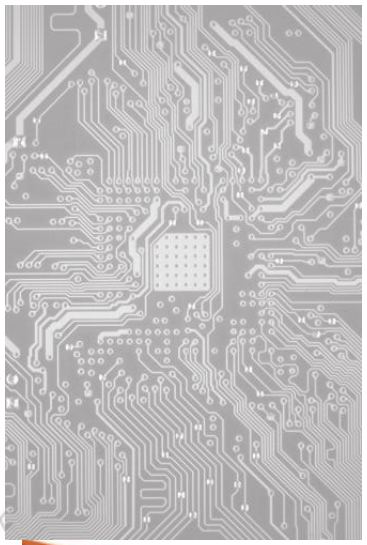

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# LORA BASIC CONCEPT

- **Frequency**
- **Channel**
- **Data Rate**
- **LoRa Class**
- **Activation Mode**
- **Data Message (Flow & Payload)**
- **Configuration**

# LORA BASIC CONCEPT

- **Frequency**
- Channel
- Data Rate
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- Data Message (Flow & Payload)
- Configuration

# Frequency

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LoRa®

## In Thailand

กสทช.

## Regulator

| Frequency Band | 433MHz | 920-925 MHz | 2.4-2.5 GHz |
|---|---|---|---|
| Availability | ✓ now | In process | ✓ now |
| LoRaWAN Regional Parameters | EU 433 MHz ISM Band | AS 923 MHz (APAC Cluster) | International 2.4 GHz ISM Band |
| Transceiver Modules (Examples, not limited to) | Semtech SX1276-1279 Semtech SX1236 | Semtech SX1276-1279 Semtech SX1272-1273 | Semtech SX1280 Semtech SX1281 |
| Frequency Plan | | LoRa Regional Parameters v. 1.0.2 | |
| Operating Range | 10-30 km | 7-15 km | 3-7 km |
| Applications | • Automated Meter Reading<br>• Building Automation<br>• Wireless Alarm and Security Systems<br>• Industrial Monitoring and Control<br>• Long range precision farming | • Automated Meter Reading<br>• Building Automation<br>• Wireless Alarm and Security Systems<br>• Industrial Monitoring and Control<br>• Long range precision farming | • Home automation<br>• Tracking applications<br>• Wearables & sports/fitness sensors<br>• Radio-controlled toys & drones<br>• Smart watches & beacons |

# Frequency

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LoRa

**With AS923 Mhz ISM Band**

กสทช.

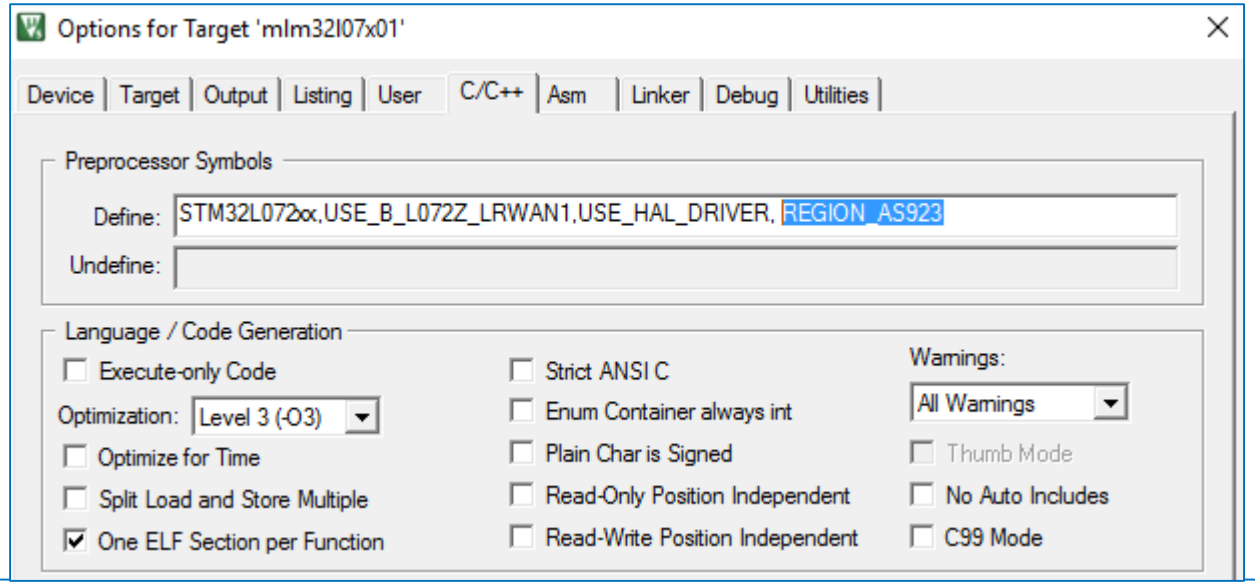
### 2.7.2 AS923 ISM Band channel frequencies

This section applies to regions where the frequencies [923…923.5MHz] are comprised in the ISM band, which is the case for the following countries:

- Brunei [923-925 MHz]
- Cambodia [923-925 MHz]
- Indonesia [923-925 MHz]
- Japan [920-928 MHz]
- Laos [923-925 MHz]
- New Zealand [915-928 MHz]
- Singapore [920-925 MHz]
- Taiwan [922-928 MHz]
- Thailand [920-925 MHz]
- Vietnam [920-925 MHz]

The network channels can be freely attributed by the network operator. However the two following default channels must be implemented in every AS923MHz end-device. Those channels are the minimum set that all network gateways should always be listening on.

# Frequency




```
#define AS923_BAND0                                 { 100, AS923_DEFAULT_TX_POWER, 0,  0 } //  1.0 %

/*!
 * LoRaMac default channel 1
 * Channel = { Frequency [Hz], RX1 Frequency [Hz], { ( ( DrMax << 4 ) | DrMin ) }, Band }
 */
#define AS923_LC1                                   { 923200000, 0, { ( ( DR_5 << 4 ) | DR_0 ) }, 0 }

/*!
 * LoRaMac default channel 2
 * Channel = { Frequency [Hz], RX1 Frequency [Hz], { ( ( DrMax << 4 ) | DrMin ) }, Band }
 */
#define AS923_LC2                                   { 923400000, 0, { ( ( DR_5 << 4 ) | DR_0 ) }, 0 }
```

# LORA BASIC CONCEPT

- Frequency
- **Channel**
- Data Rate
- LoRa Class
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# Channel

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## AS923-925

Used in Brunei, Cambodia, Hong Kong, Indonesia, Laos, Taiwan, Thailand, Vietnam

| Channel | Frequency |
|---|---|
| 1 | 923.2 |
| 2 | 923.4 |
| 3 | 922.0 |
| 4 | 922.2 |
| 5 | 922.4 |
| 6 | 922.6 |
| 7 | 922.8 |
| 8 | 923.0 |

| Channel | Frequency |
|---|---|
| 9 | 920.4 |
| 10 | 920.6 |
| 11 | 920.8 |
| 12 | 921.0 |
| 13 | 921.2 |
| 14 | 921.4 |
| 15 | 921.6 |
| 16 | 921.8 |

# Channel

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*Ref: LoRaWAN Regional Parameters 1_0_2*

The following table gives the list of frequencies that should be used by end-devices to broadcast the JoinReq message.

| Modulation | Bandwidth [kHz] | Channel Frequency [MHz] | FSK Bitrate or LoRa DR / Bitrate | Nb Channels | Duty cycle |
|---|---|---|---|---|---|
| LoRa | 125 | 923.20<br>923.40 | DR2 | 2 | < 1% |

Table 49: AS923 JoinReq Channel List

### 2.7.4 AS923 JoinAccept CFList

The AS923 LoRaWAN implements an optional channel frequency list (CFlist) of 16 octets in the JoinAccept message.

In this case the CFList is a list of five channel frequencies for the channels three to seven whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these channels are usable for DR0 to DR5 125 KHz LoRa modulation.

| Size (bytes) | 3 | 3 | 3 | 3 | 3 | 1 |
|---|---|---|---|---|---|---|
| CFList | Freq Ch3 | Freq Ch4 | Freq Ch5 | Freq Ch6 | Freq Ch7 | RFU |

# LORA BASIC CONCEPT

- Frequency
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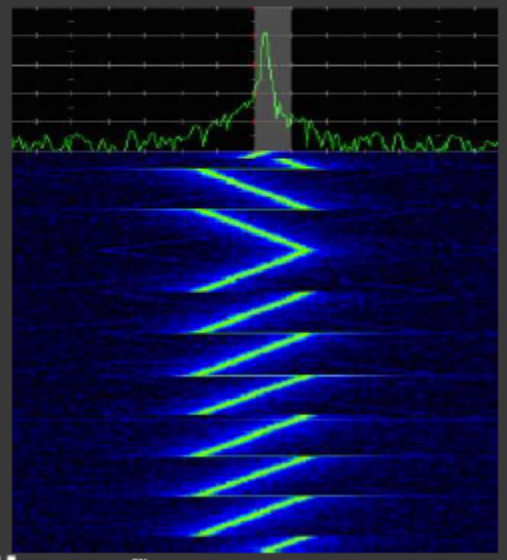
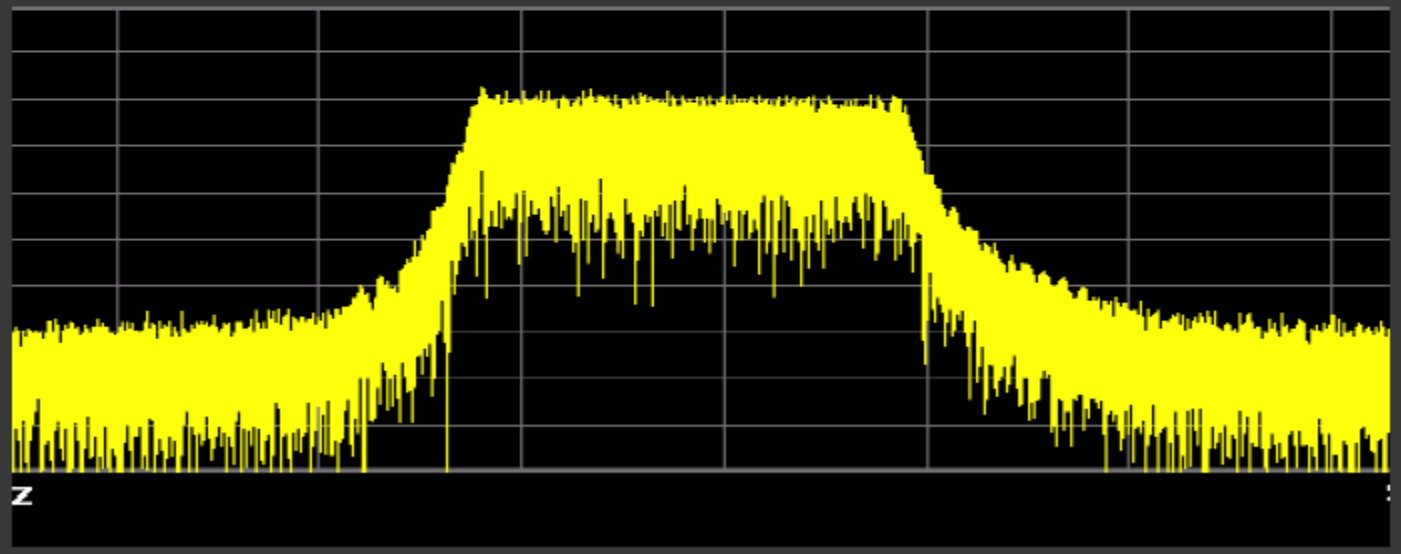
# Data Rate

## Related Parameter

- A Spread Spectrum Technology
  - Developed by Semtech Corporation (http://www.semtech.com/)
  - Chirped-FM modulation, symbols of ramping frequency
  - Processing gain = increased receive sensitivity
  - Enables longer range at expense of lower data rate





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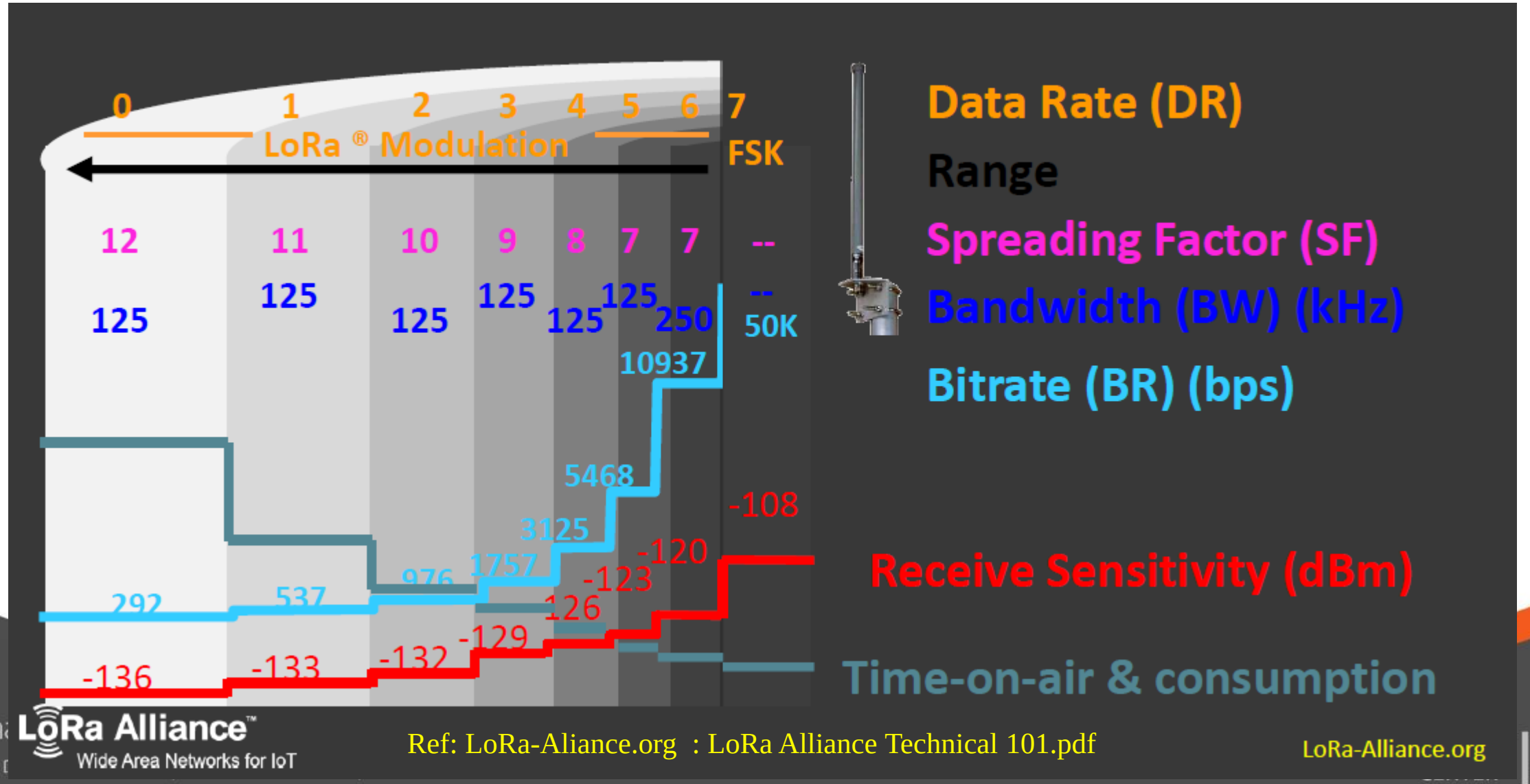
Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

LoRa-Alliance.org

# Data Rate

## Related Parameter

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# Data Rate

| Spreading Factor (at 125 kHz) | Bitrate | Range | Time on Air (ms) |
|---|---|---|---|
| SF7 | 5470 bps | 2 km | 56 ms |
| SF8 | 3125 bps | 4 km | 100 ms |
| SF9 | 1760 bps | 6 km | 200 ms |
| SF10 | 980 bps | 8 km | 370 ms |
| SF11 | 440 bps | 11 km | 740 ms |
| SF12 | 290 bps | 14 km | 1400 ms |

Show the Data Rate as function of the distance and the Spreading Factor (SF).

L**oRaWAN** optimizes the communication by **Adaptative Data Rate** >> The network instructs a node to perform a rate adaptation by using a requested data rate (and a requested TX Power).

# Data Rate

*Ref: LoRaWAN Regional Parameters 1_0_2*

### 2.7.3 AS923 Data Rate and End-point Output Power encoding

The "TxParamSetupReq/Ans" MAC command MUST be implemented by the AS923 devices.

The following encoding is used for Data Rate (DR) in the AS923 band:

| DataRate | Configuration | Indicative physical bit rate [bit/s] |
|---|---|---|
| 0 | LoRa: SF12 / 125 kHz | 250 |
| 1 | LoRa: SF11 / 125 kHz | 440 |
| 2 | LoRa: SF10 / 125 kHz | 980 |
| 3 | LoRa: SF9 / 125 kHz | 1760 |
| 4 | LoRa: SF8 / 125 kHz | 3125 |
| 5 | LoRa: SF7 / 125 kHz | 5470 |
| 6 | LoRa: SF7 / 250 kHz | 11000 |
| 7 | FSK: 50 kbps | 50000 |
| 8..15 | RFU | |

Table 50: Data rate table

# Data Rate

มาตรฐานทางเทคนิคของเครื่องโทรคมนาคมและอุปกรณ์
กสทช. มท. 1033 – 2560
เครื่องวิทยุคมนาคม ที่ไม่ใช่ประเภท Radio Frequency Identification: RFID
ซึ่งใช้คลื่นความถี่ย่าน 920-925 เมกะเฮิรตซ์

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**2.3.2 การส่งข้อมูลผ่านคลื่นความถี่ด้วยการแผ่สเปกตรัม (Frequency Hopping Spread Spectrum : FHSS)**

**นิยาม** การส่งข้อมูลผ่านคลื่นความถี่ด้วยการแผ่สเปกตรัม (Frequency Hopping Spread Spectrum : FHSS) หมายถึง การส่งสัญญาณคลื่นความถี่ที่ตรงกับเวลาที่ช่องความถี่ใช้งานแต่ละช่วงเวลาหนึ่ง เรียกว่า เวลาที่ใช้ช่องสัญญาณ

**ขีดจำกัด** การส่งข้อมูลผ่านคลื่นความถี่ด้วยการแผ่สเปกตรัม (Frequency Hopping Spread Spectrum : FHSS) จะต้องแสดงความเป็นไปตามมาตรฐานใดมาตรฐานหนึ่งดังต่อไปนี้

| ความกว้างแถบความถี่ของช่องสัญญาณที่ 20 dB (20 dB bandwidth of the hopping channel) | จำนวนช่องสัญญาณ (Hopping Number) | เวลาช่องสัญญาณถดค้าง (Dwell Time) | เงื่อนไขการใช้งาน |
|---|---|---|---|
| น้อยกว่า 250 KHz | ≥ 20 | 0.4 วินาทีภายใน 8 วินาที | ไม่เกิน 10 % ช่วงใช้งานใน 1 ชั่วโมง |
| มากกว่าหรือเท่ากับ 250 KHz แต่ไม่เกิน 500 KHz | ≥ 10 | 0.4 วินาทีภายใน 4 วินาที | ไม่เกิน 1 % ช่วงใช้งานใน 1 ชั่วโมง |

***Ref:*** *ราชกิจจานุเบกษา ใช้คลื่นความถี่ย่าน 920 - 925 เมกะเฮิรตซ์*

# Data Rate

*Ref: LoRaWAN Regional Parameters 1_0_2*

### 2.7.6 AS923 Maximum payload size

The maximum **MACPayload** size length (*M*) is given by the following table for both dwell time configurations: No Limit and 400ms. It is derived from the PHY layer limitation depending on the effective modulation rate used taking into account a possible repeater encapsulation layer.

| DataRate | *Uplink MAC Payload Size (M)* | | *Downlink MAC Payload Size (M)* | |
|---|---|---|---|---|
| | UplinkDwellTime = 0 | UplinkDwellTime = 1 | DownlinkDwellTime = 0 | DownlinkDwellTime = 1 |
| 0 | 59 | N/A | 59 | N/A |
| 1 | 59 | N/A | 59 | N/A |
| 2 | 59 | 19 | 59 | 19 |
| 3 | 123 | 61 | 123 | 61 |
| 4 | 230 | 133 | 230 | 133 |
| 5 | 230 | 250 | 230 | 250 |
| 6 | 230 | 250 | 230 | 250 |
| 7 | 230 | 250 | 230 | 250 |
| 8:15 | RFU | | RFU | |

Table 53: AS923 maximum payload size

# LORA BASIC CONCEPT

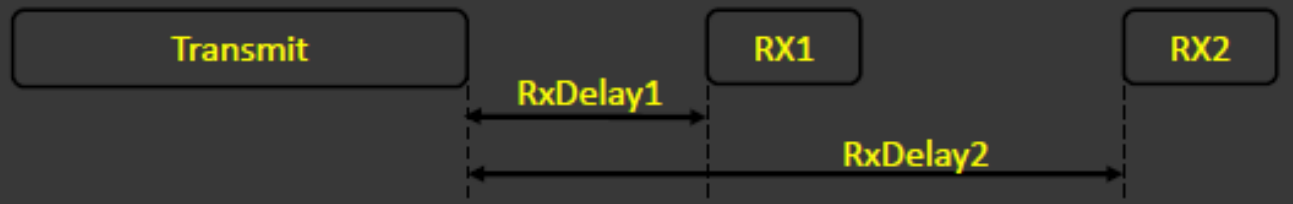
- Frequency
- Channel
- Data Rate
- **LoRa Class**
- Activation Mode
- Data Message (Flow & Payload)
- Configuration

# LoRa Class

| Class Name | Intended Usage |
|---|---|
| A (“all”) | Battery powered sensors (or actuators with no latency constraint)<br>Most energy efficient communication class. Must be supported by all devices. |
| B (“beacon”) | Battery powered actuators<br>Energy efficient communication class for latency controlled downlink. Based on slotted communication synchronized with a network beacon. |
| C (“continuous”) | Main powered actuators<br>Devices witch can afford to listen continuously. No latency for downlink communication. |

# LoRa Class

- Battery Powered – Class A
  - Bidirectional communications
  - Unicast messages
  - Small payloads, long intervals
  - End-device initiates communication (uplink)
  - Server communicates with end-device (downlink) during predetermined response windows:

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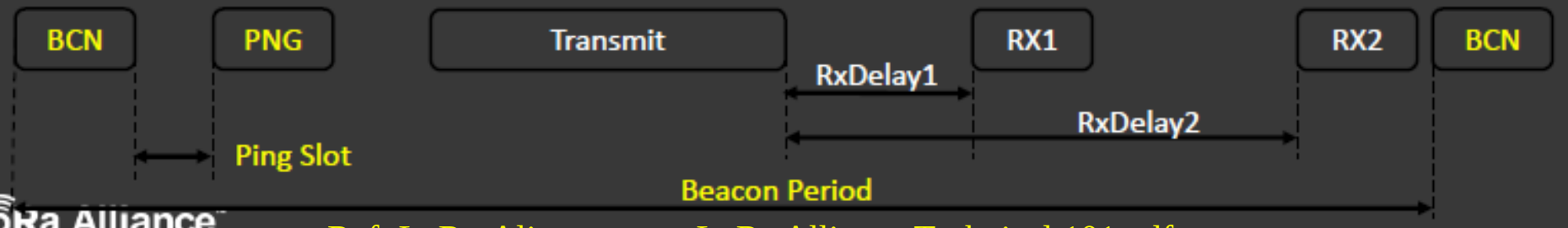
Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

LoRa-Alliance.org

# LoRa Class

- Low Latency – Class B
  - Bidirectional with scheduled receive slots
  - Unicast and Multicast messages
  - Small payloads, long intervals
  - Periodic beacon from gateway
  - Extra receive window (ping slot)
  - Server can initiate transmission at fixed intervals

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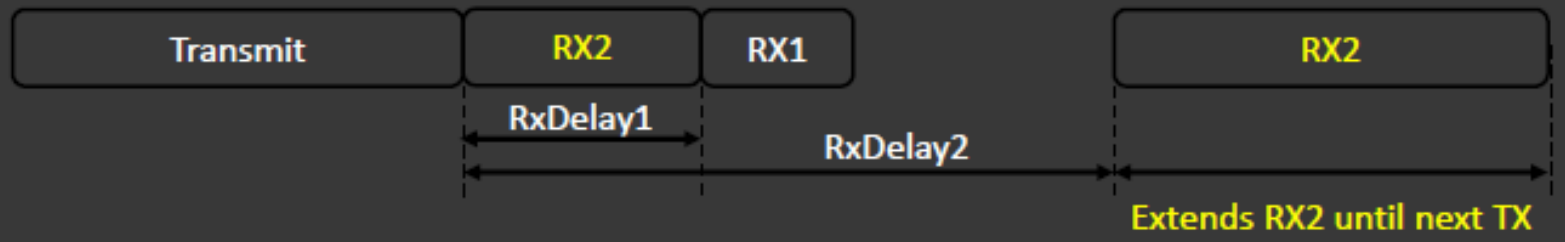
# LoRa Class

- No Latency – Class C
  - Bidirectional communications
  - Unicast and Multicast messages
  - Small payloads
  - Server can initiate transmission at any time
  - End-device is constantly receiving

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- **Activation Mode**
- Data Message (Flow & Payload)
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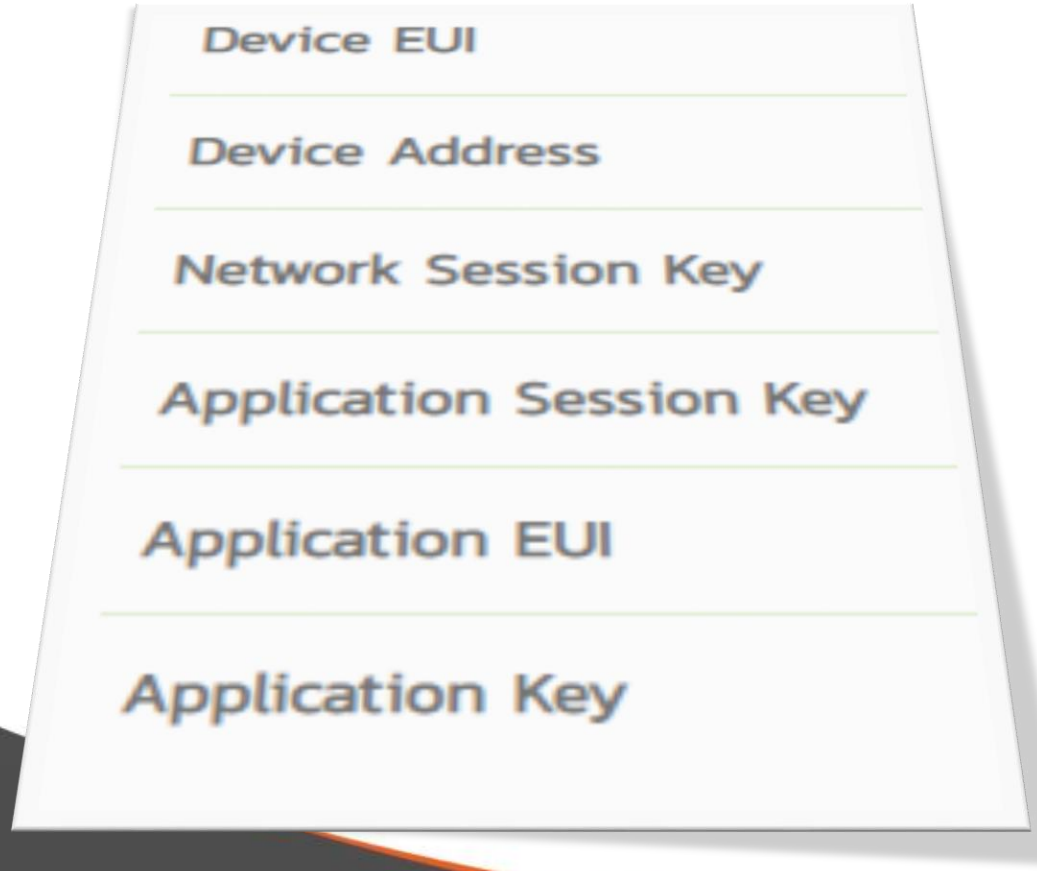
# Activation Mode




## Over-the-Air Activation (OTAA)

- Based on Globally Unique Identifier
- Over the air message handshaking

## Activation By Personalization (ABP)

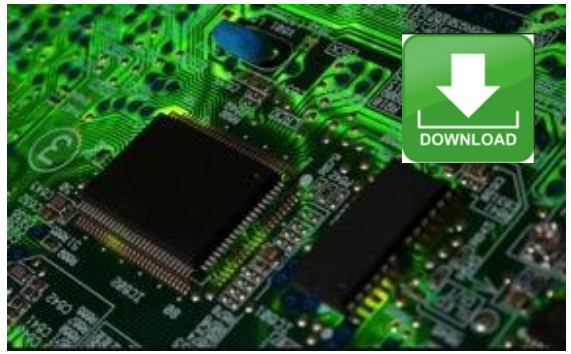
- Shared keys stored at production time
- Locked to a specific network

# Activation Mode：Over-the-Air Activation (OTAA)

- End-device transmits **Join Request** to application server containing:
  - Globally unique end-device identifier (**DevEUI**)
  - Application identifier (**AppEUI**)
  - Authentication with Application key (**AppKey**)
- End-device receives **Join Accept** from application server
- End-device authenticates **Join Accept**
- End-device **decrypts** Join Accept
- End-device extracts and stores Device Address (**DevAddr**)
- End-device **derives**:
  - Network Session Key (**NwkSKey**)
  - Application Session Key (**AppSKey**)

# Activation Mode：Activation By Personalization (ABP)

- The following information is configured at production time:
  - Device Address (**DevAddr**)
  - Network Session Key (**NwkSKey**)
  - Application Session Key (**AppSKey**)
- **No over the air handshaking**
- Device is ready to communicate on the network without any additional procedure.



# Activation Mode

| | OTAA | ABP |
|---|---|---|
| Device EUI | ✓ | ✓ |
| Device Address | ✗ | ✓ |
| Network Session Key | ✗ | ✓ |
| Application Session Key | ✗ | ✓ |
| Application EUI | ✓ | ✗ |
| Application Key | ✓ | ✗ |

# LORA BASIC CONCEPT

- Frequency
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- **Data Message (Flow & Payload)**
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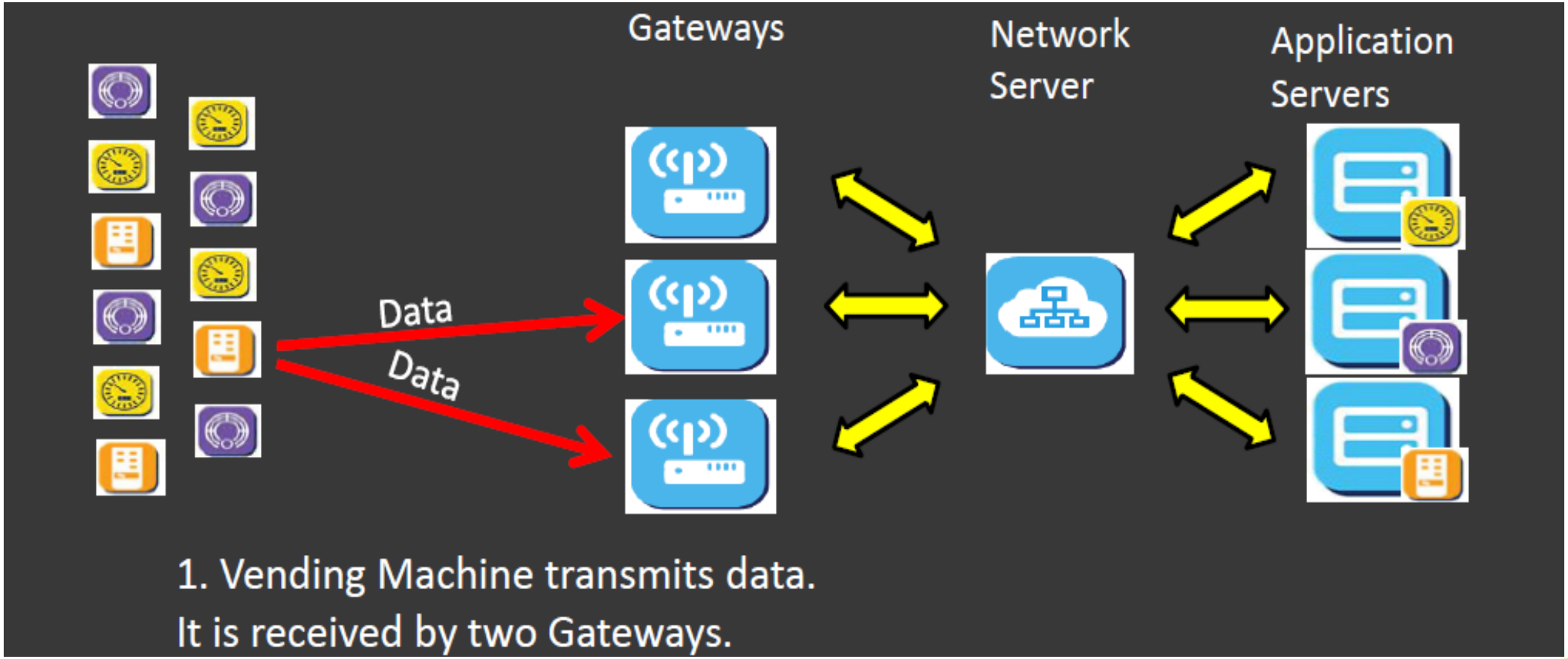
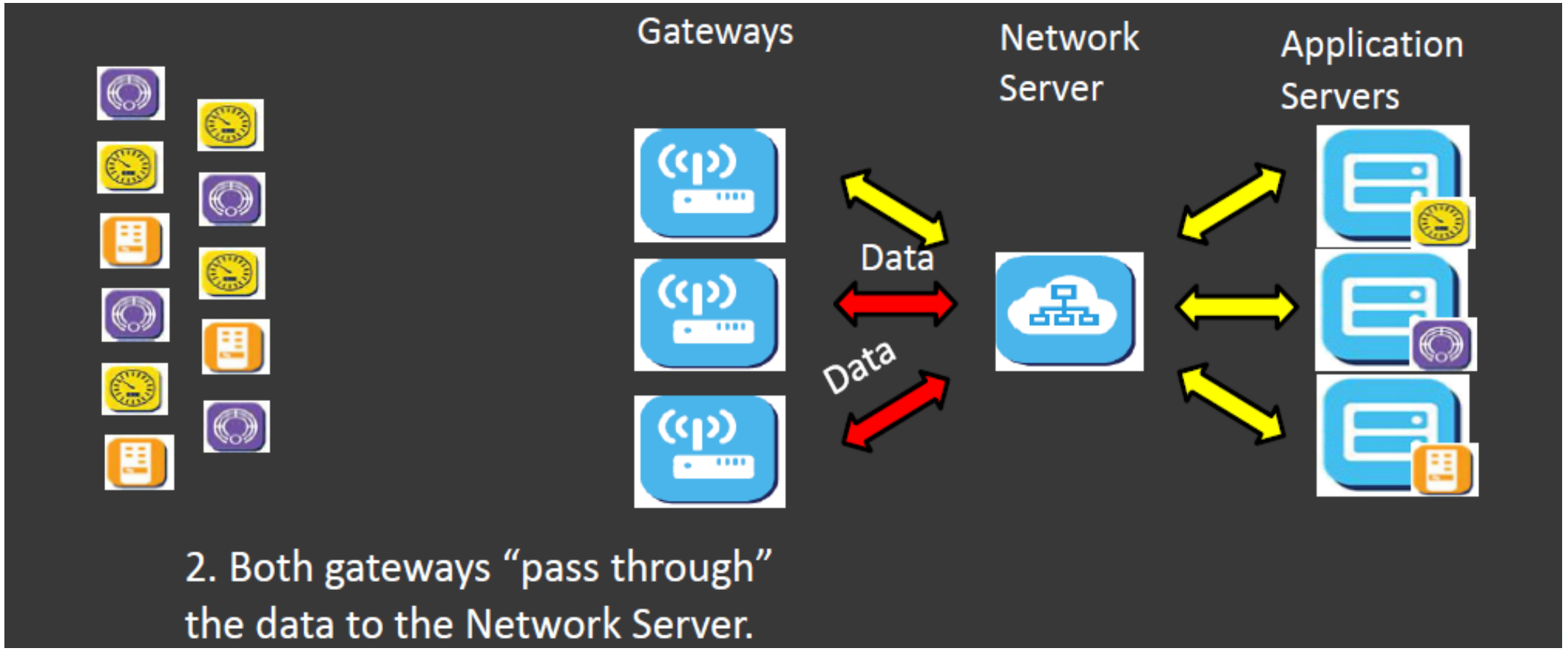
# Data Message (Flow & Payload)



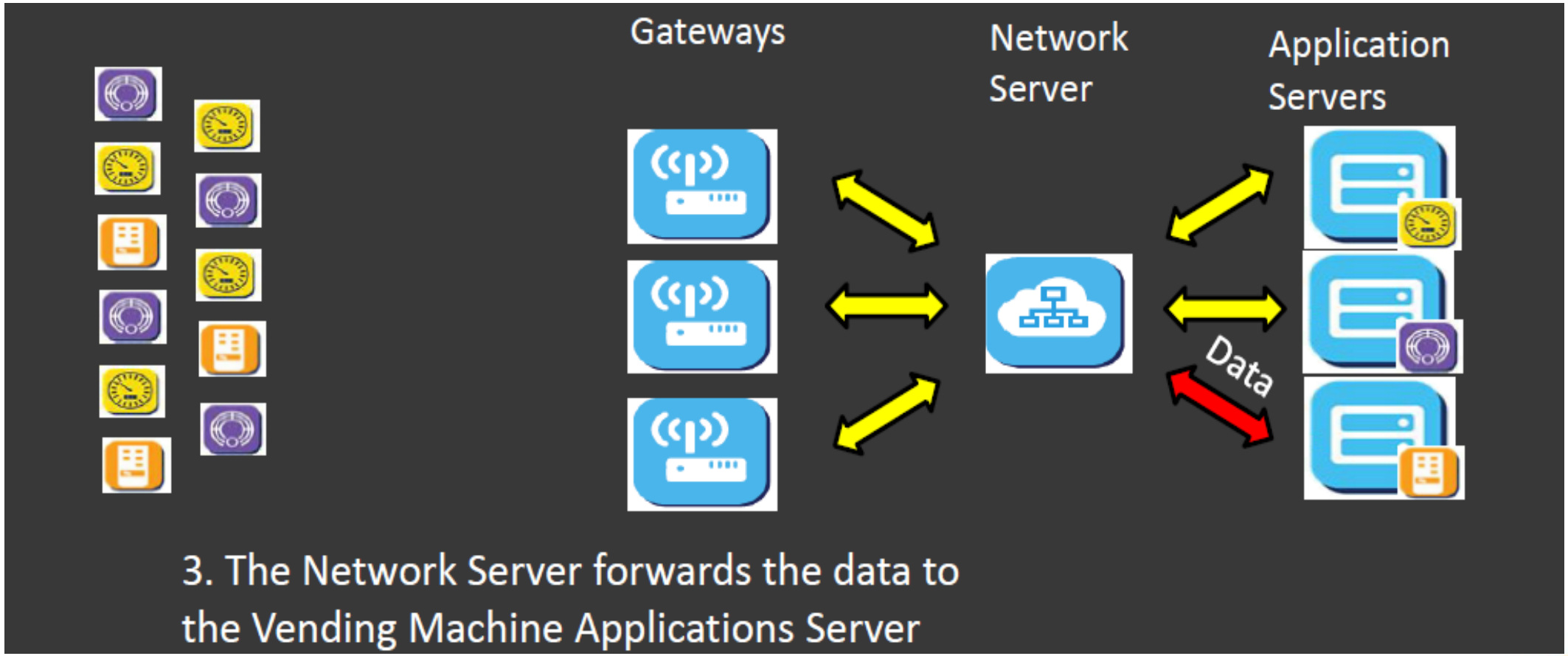

Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Data Message (Flow & Payload)




Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Data Message (Flow & Payload)




Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

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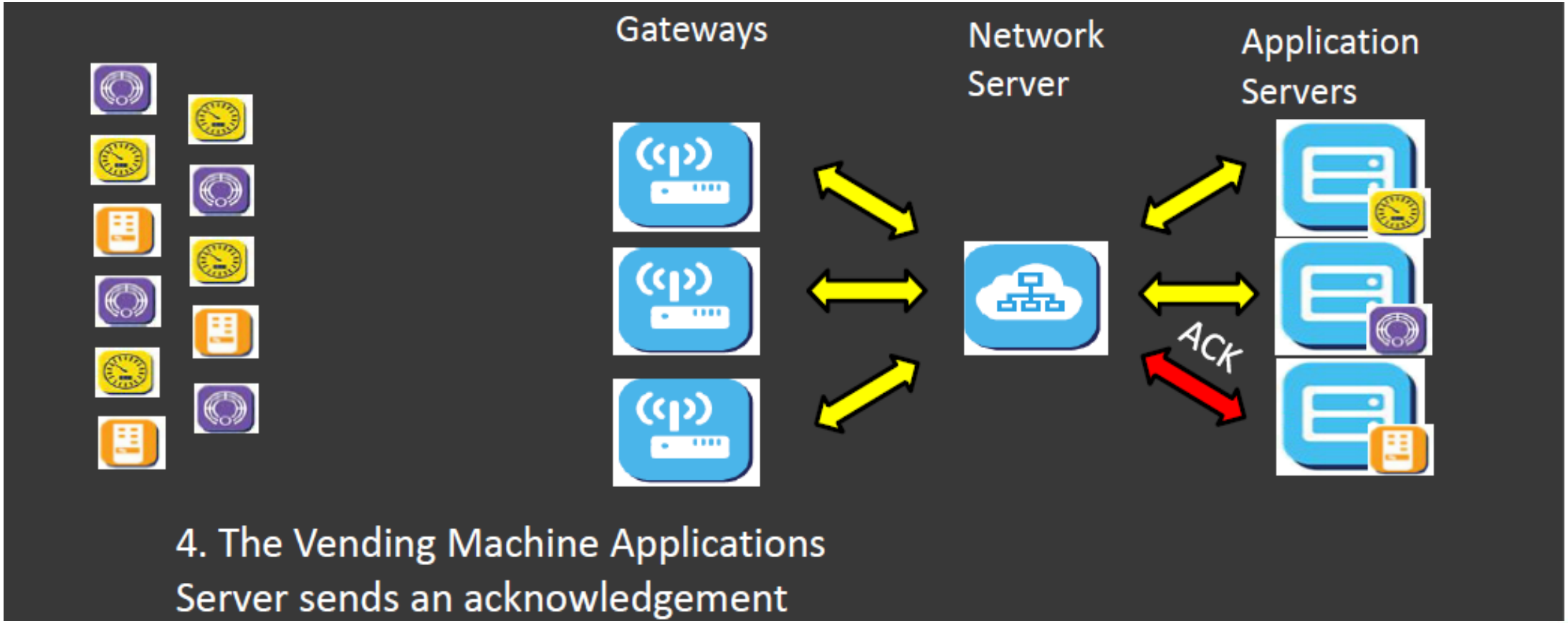


Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

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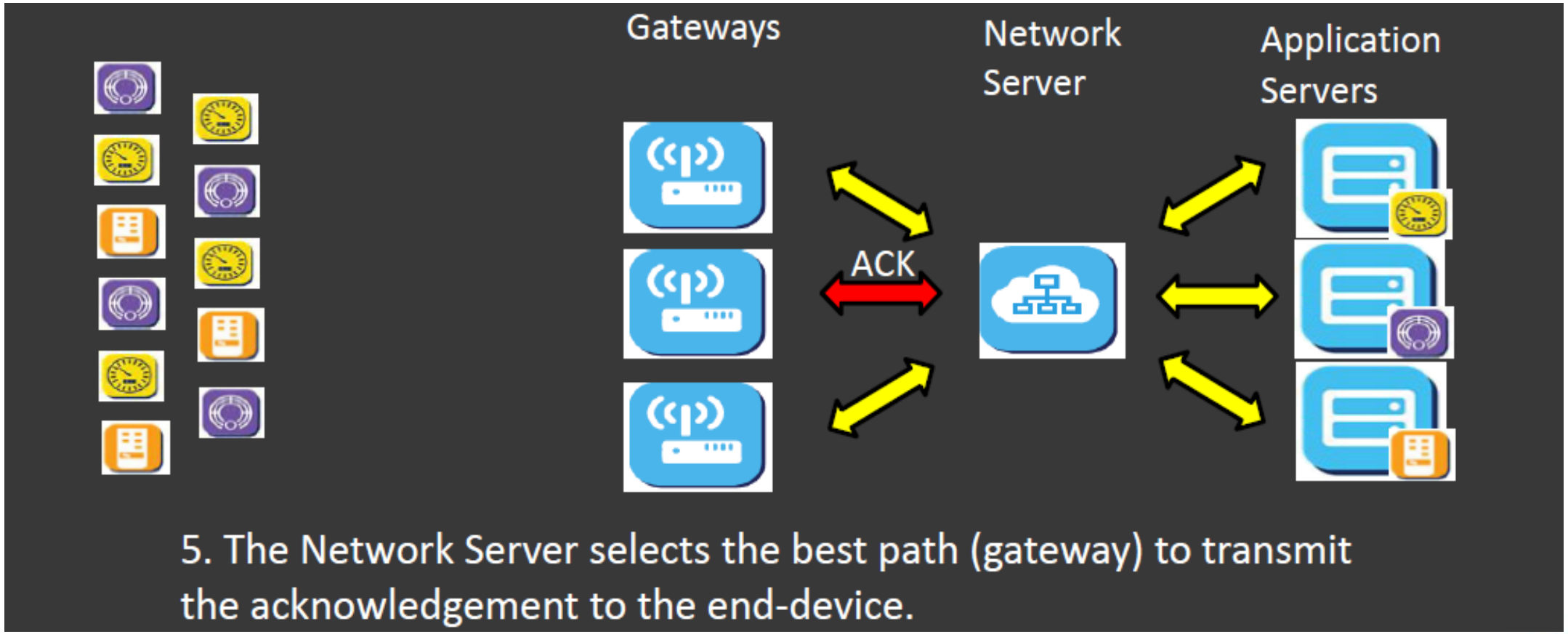


Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

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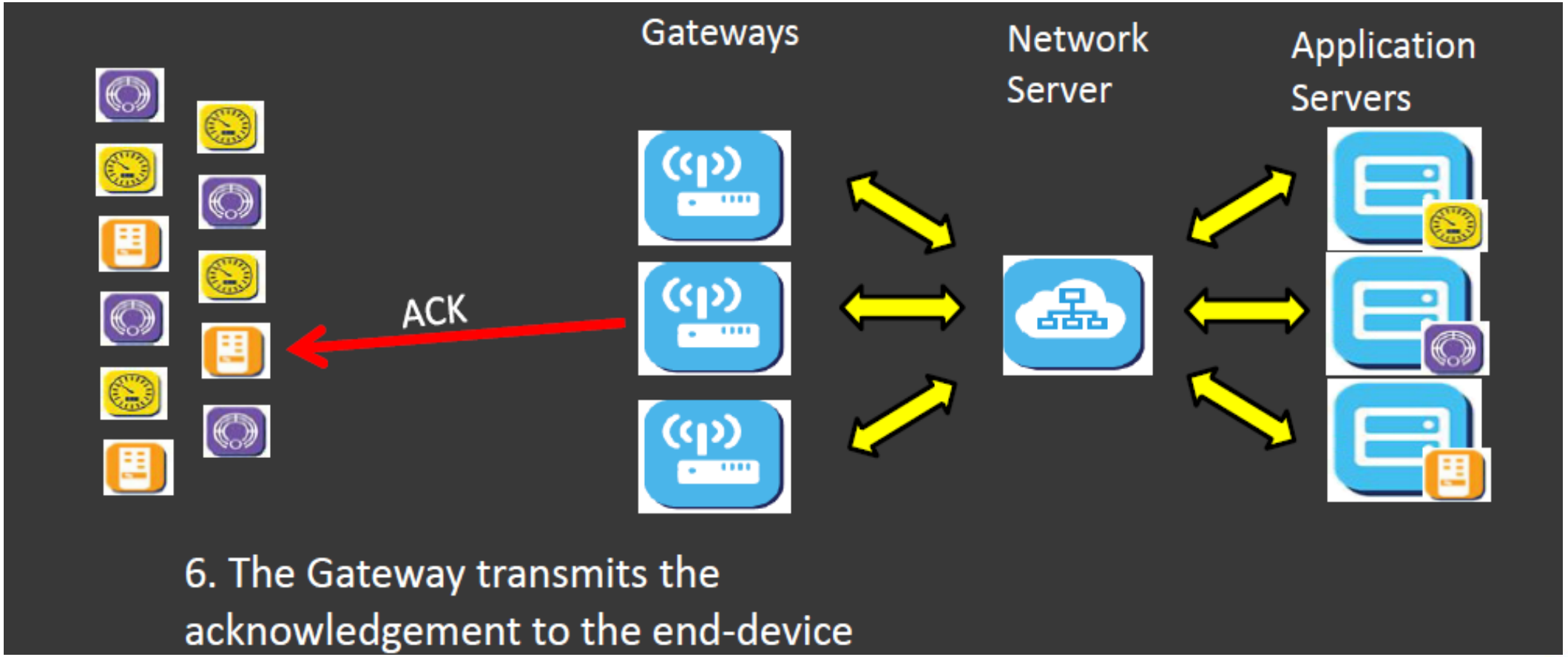


Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Data Message (Flow & Payload)

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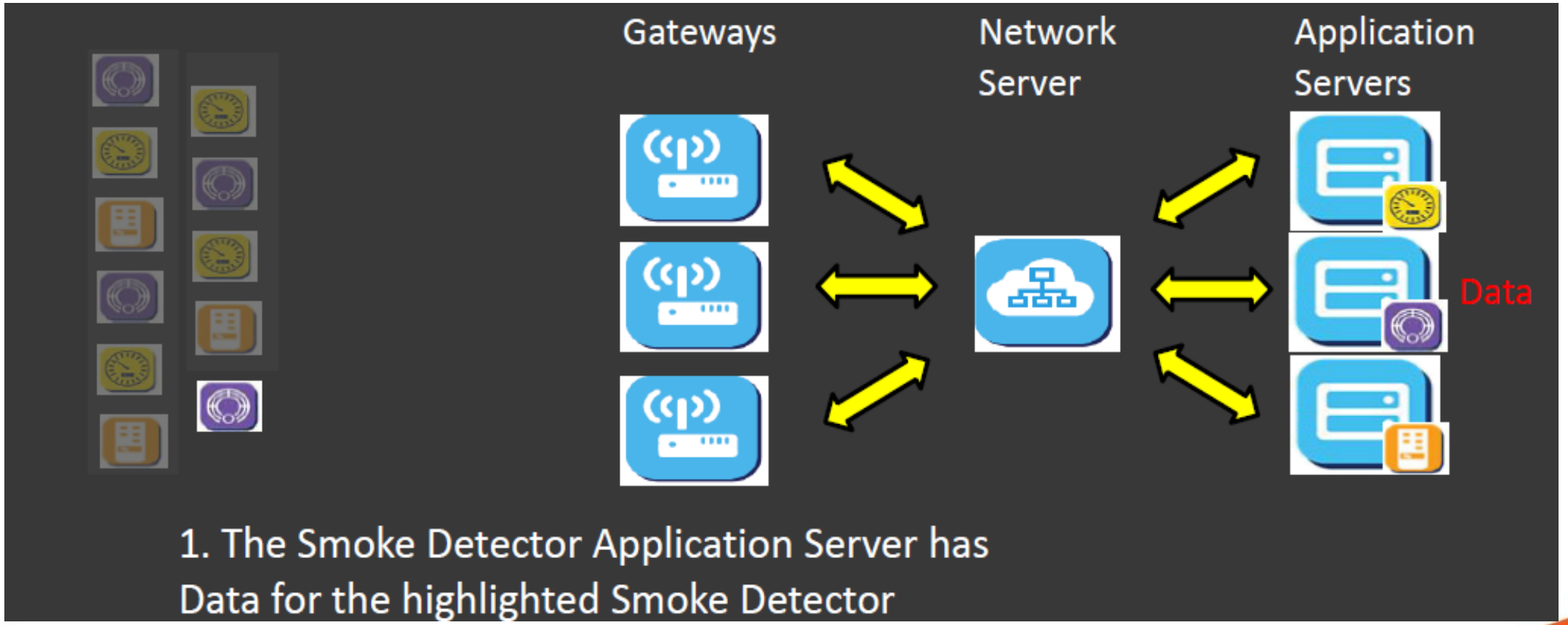
## Download & Upload

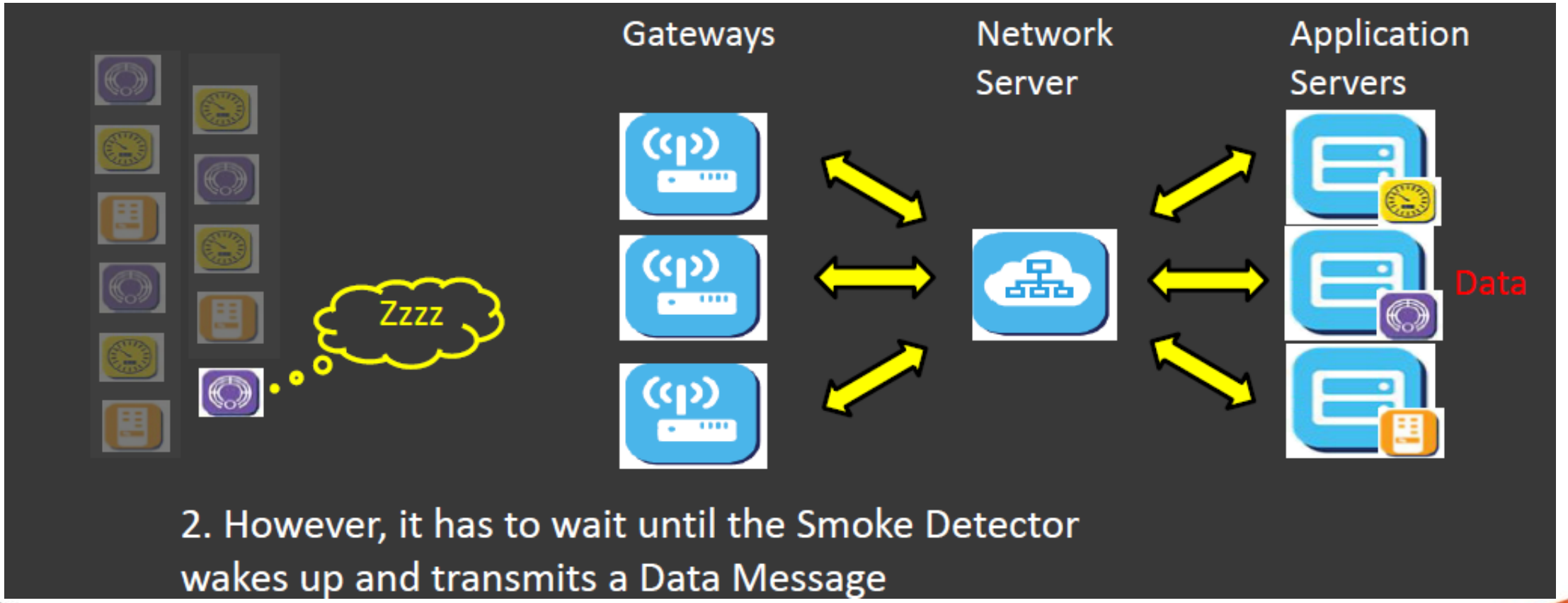



Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Data Message (Flow & Payload)

LoRa IoT by CAT

## Download & Upload

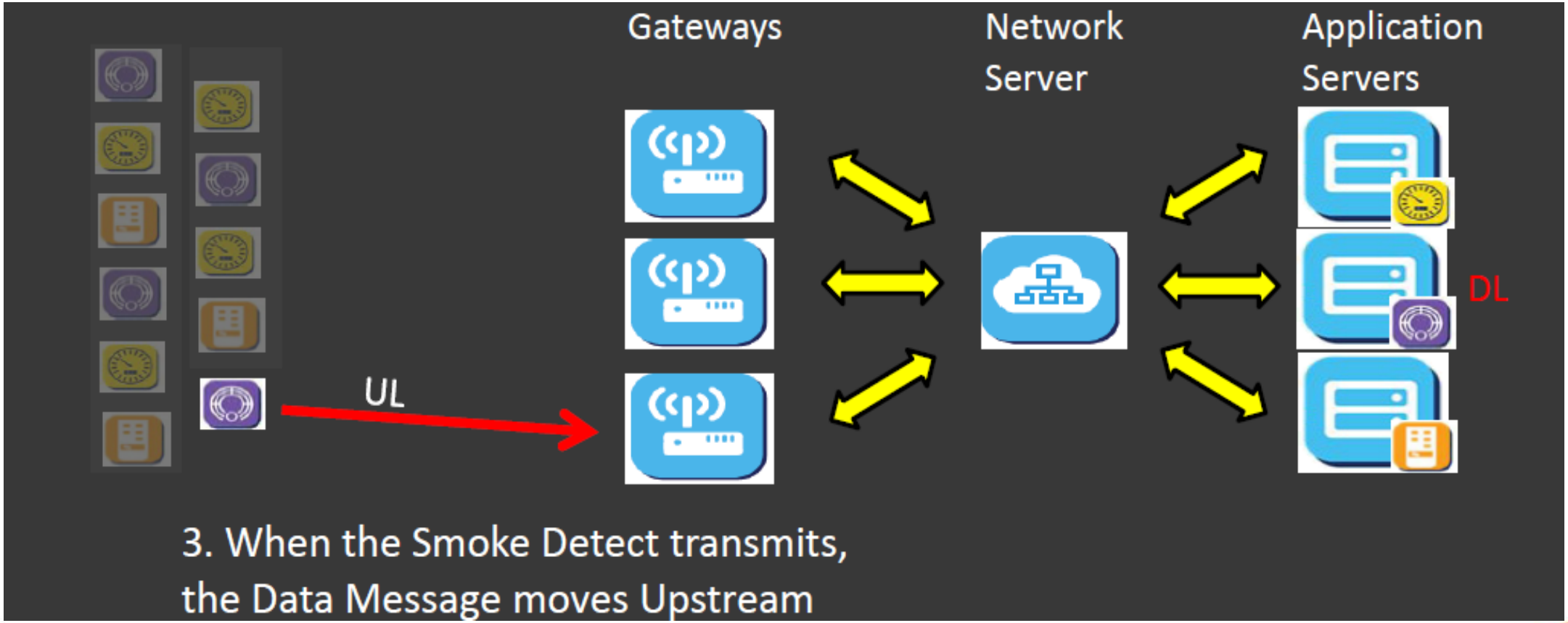



Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Data Message (Flow & Payload)

LoRa IoT by CAT

## Download & Upload

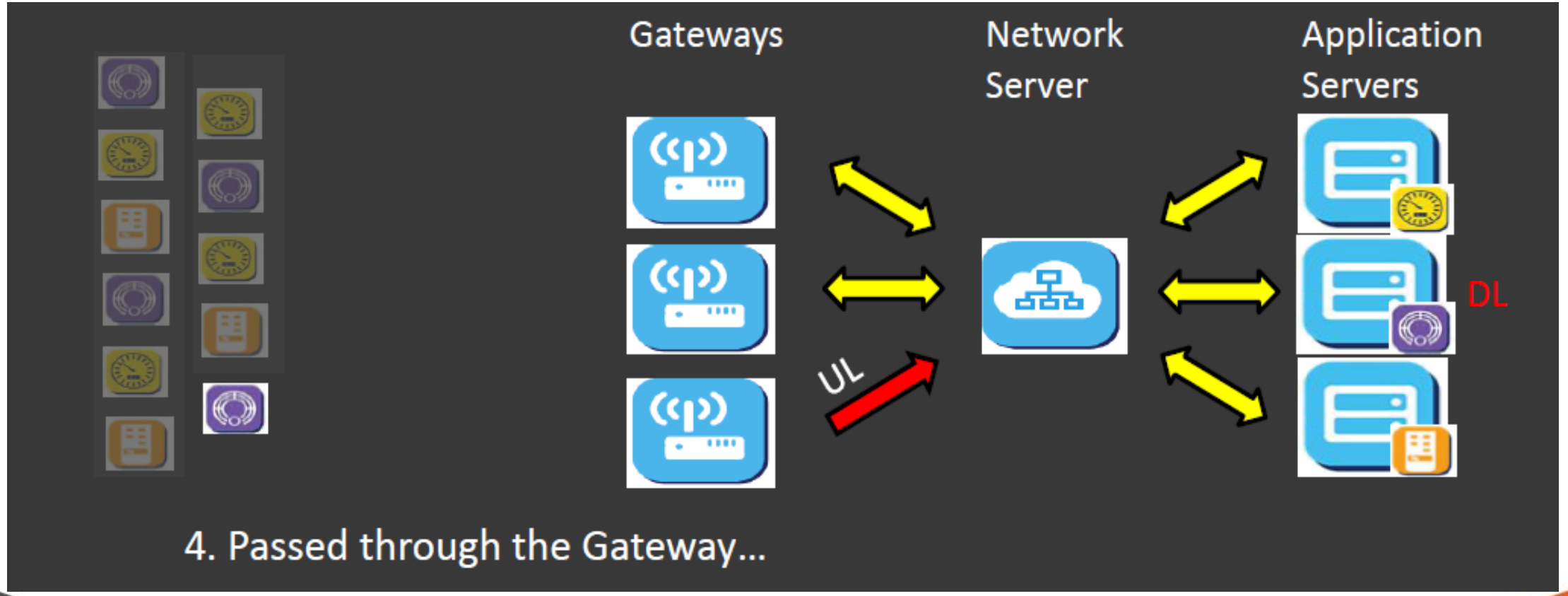



Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Data Message (Flow & Payload)

LoRa IoT by CAT

## Download & Upload




Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Data Message (Flow & Payload)

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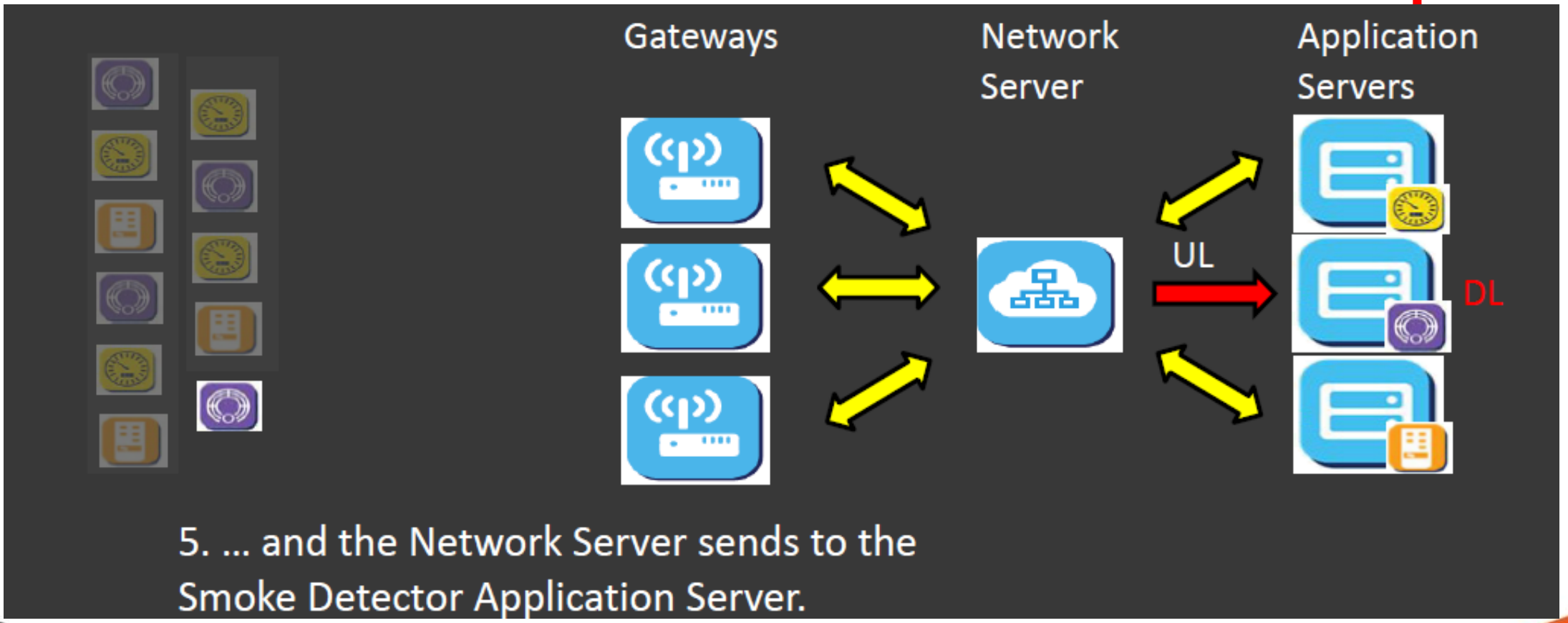


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# Data Message (Flow & Payload)

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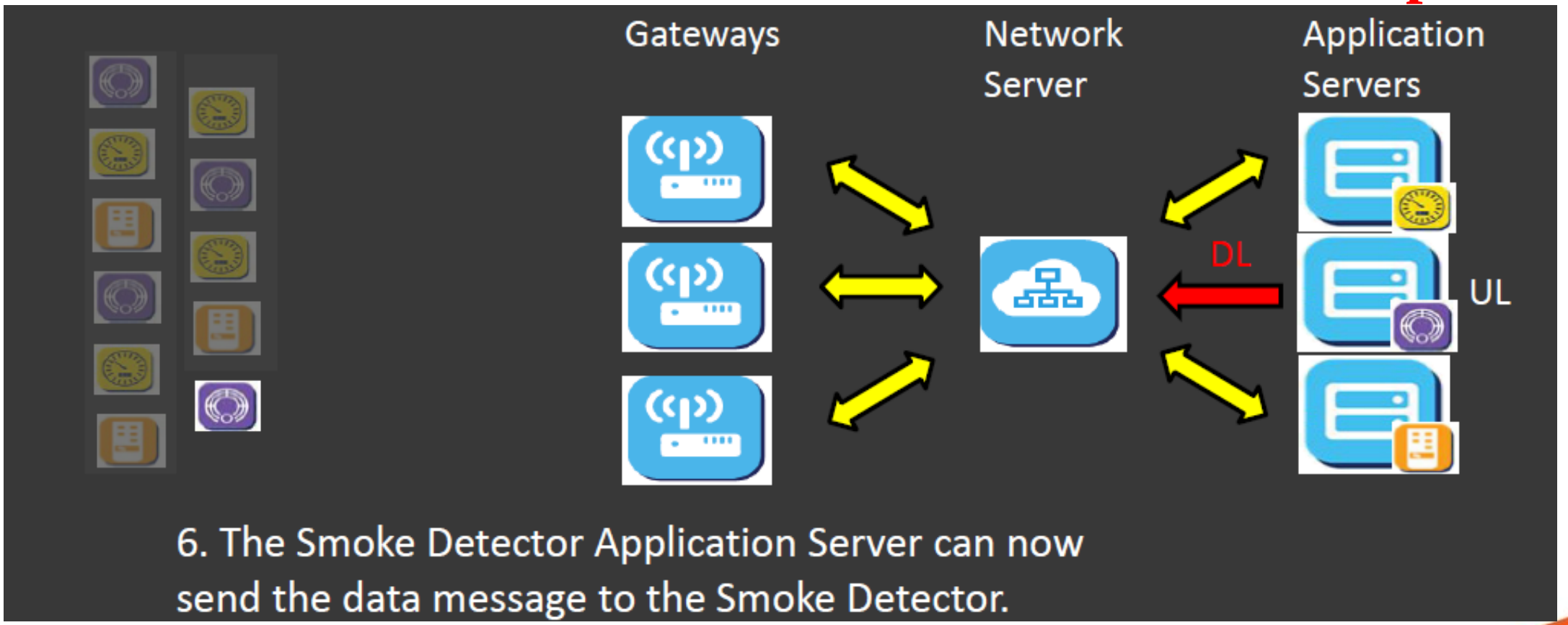


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# Data Message (Flow & Payload)

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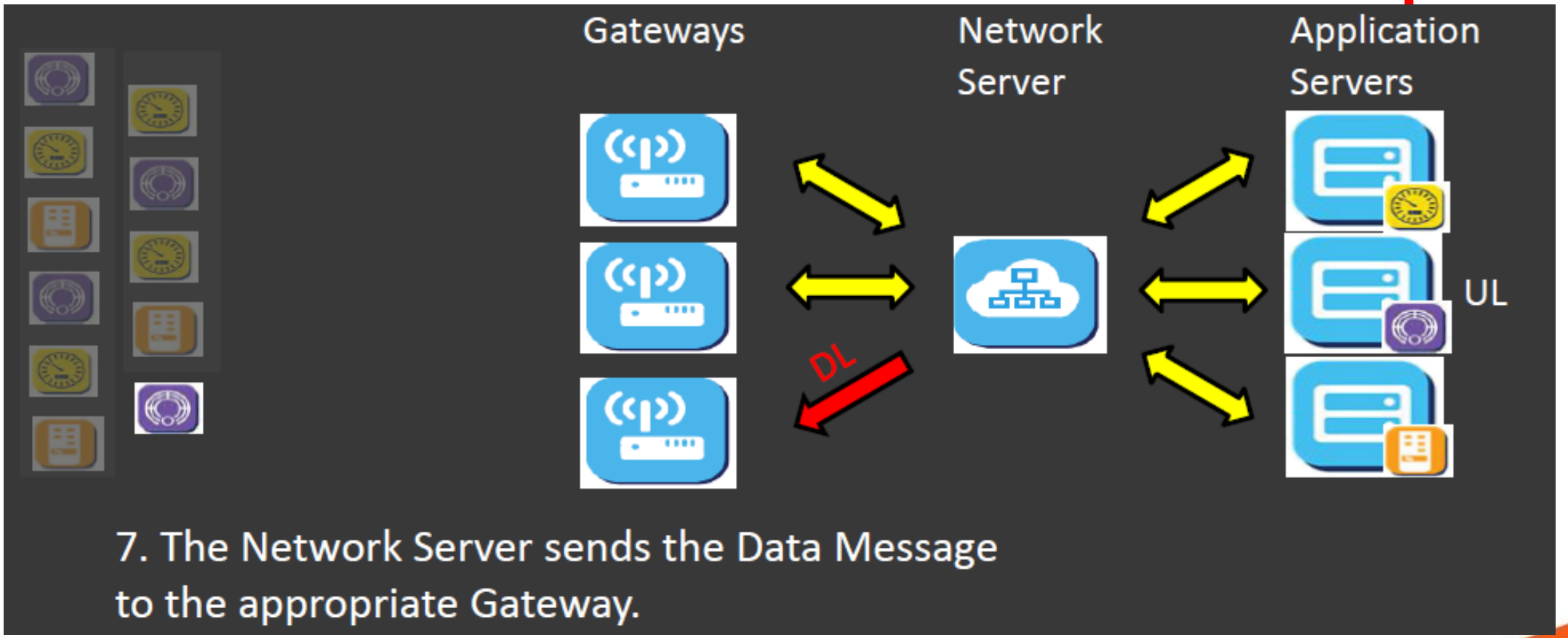


Ref: LoRa-Aliance.org : LoRa Alliance Technical 101.pdf

# Frame Message (MAC Message Format)

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*Ref: LoRaWAN Specification 1_0_2*

*Radio PHY layer:*

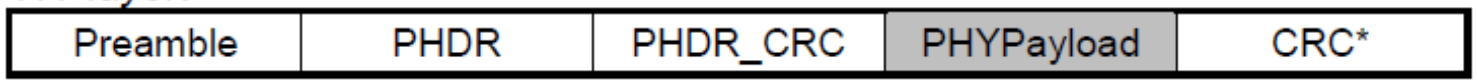


Figure 5: Radio PHY structure (CRC* is only available on uplink messages)

*PHYPayload:*

1

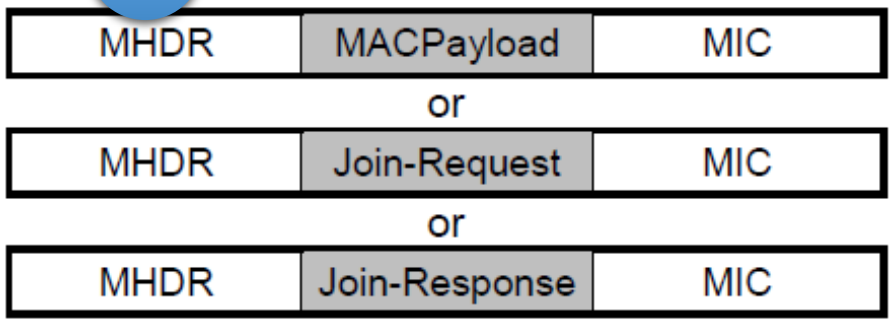


Figure 6: PHY payload structure

*MACPayload:*

2


Figure 7: MAC payload structure

*FHDR:*

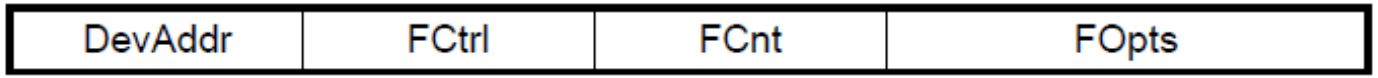


Figure 8: Frame header structure

# Frame Message (MAC Message Format)

LoRa IoT by CAT

*Ref: LoRaWAN Specification 1_0_2*

1

## 4.2 MAC Header (MHDR field)

| Bit# | 7..5 | 4..2 | 1..0 |
|---|---|---|---|
| MHDR bits | MType | RFU | Major |

### 4.2.1 Message type (MType bit field)

The LoRaWAN distinguishes between six different MAC message types: **join request**, **join accept**, **unconfirmed data up/down**, and **confirmed data up/down**.

| MType | Description |
|---|---|
| 000 | Join Request |
| 001 | Join Accept |
| 010 | Unconfirmed Data Up |
| 011 | Unconfirmed Data Down |
| 100 | Confirmed Data Up |
| 101 | Confirmed Data Down |
| 110 | RFU |
| 111 | Proprietary |

Table 1: MAC message types

# Frame Message (MAC Message Format)

LoRa IoT by CAT

*Ref: LoRaWAN Specification 1_0_2*

2

### 4.3.3 MAC Frame Payload Encryption (FRMPayload)

If a data frame carries a payload, **FRMPayload** must be encrypted before the message integrity code (**MIC**) is calculated.

The encryption scheme used is based on the generic algorithm described in IEEE 802.15.4/2006 Annex B [IEEE802154] using AES with a key length of 128 bits.

**OR**

### 5 MAC Commands

For network administration, a set of MAC commands may be exchanged exclusively between the network server and the MAC layer on an end-device. MAC layer commands are never visible to the application or the application server or the application running on the end-device.

# Data Payload

## Example Format: Cayenne Application Server

| Type | IPSO | LPP | Hex | Data Size | Data Resolution per bit |
|---|---|---|---|---|---|
| Digital Input | 3200 | 0 | 0 | 1 | 1 |
| Digital Output | 3201 | 1 | 1 | 1 | 1 |
| Analog Input | 3202 | 2 | 2 | 2 | 0.01 Signed |
| Analog Output | 3203 | 3 | 3 | 2 | 0.01 Signed |
| Illuminance Sensor | 3301 | 101 | 65 | 2 | 1 Lux Unsigned MSB |
| Presence Sensor | 3302 | 102 | 66 | 1 | 1 |
| Temperature Sensor | 3303 | 103 | 67 | 2 | 0.1 °C Signed MSB |
| Humidity Sensor | 3304 | 104 | 68 | 1 | 0.5 % Unsigned |
| Accelerometer | 3313 | 113 | 71 | 6 | 0.001 G Signed MSB per axis |
| Barometer | 3315 | 115 | 73 | 2 | 0.1 hPa Unsigned MSB |
| Gyrometer | 3334 | 134 | 86 | 6 | 0.01 °/s Signed MSB per axis |
| GPS Location | 3336 | 136 | 88 | 9 | Latitude : 0.0001 ° Signed MSB |
| | | | | | Longitude : 0.0001 ° Signed MSB |
| | | | | | Altitude : 0.01 meter Signed MSB |

Ref: https://mydevices.com/cayenne/docs/lora/

# Data Payload

## Example Format: Cayenne Application Server

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### Examples

Device with 2 temperature sensors

| Payload (Hex) | 03 67 01 10 05 67 00 FF | |
|---|---|---|
| Data Channel | Type | Value |
| 03 ⇒ 3 | 67 ⇒ Temperature | 0110 = 272 ⇒ 27.2°C |
| 05 ⇒ 5 | 67 ⇒ Temperature | 00FF = 255 ⇒ 25.5°C |

Device with temperature and acceleration sensors

**Frame N**

| Payload (Hex) | 01 67 FF D7 | |
|---|---|---|
| Data Channel | Type | Value |
| 01 ⇒ 1 | 67 ⇒ Temperature | FFD7 = -41 ⇒ -4.1°C |

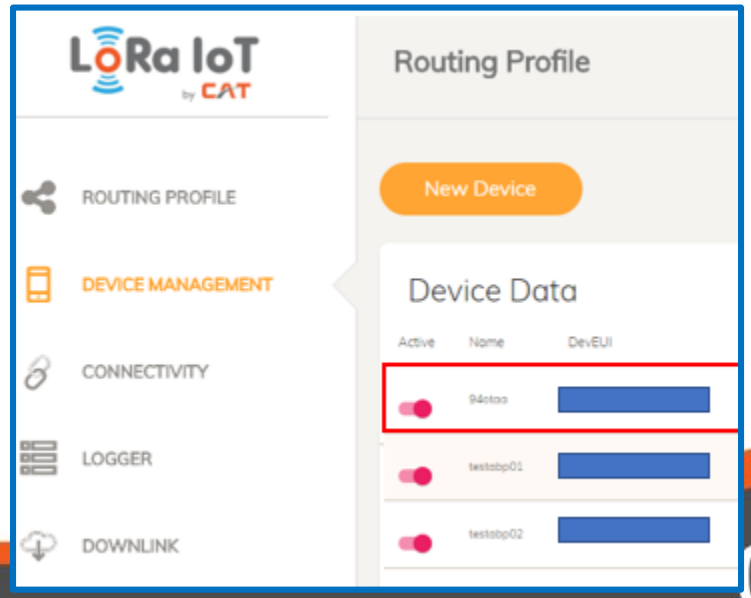
Ref: https://mydevices.com/cayenne/docs/lora/

# LORA BASIC CONCEPT

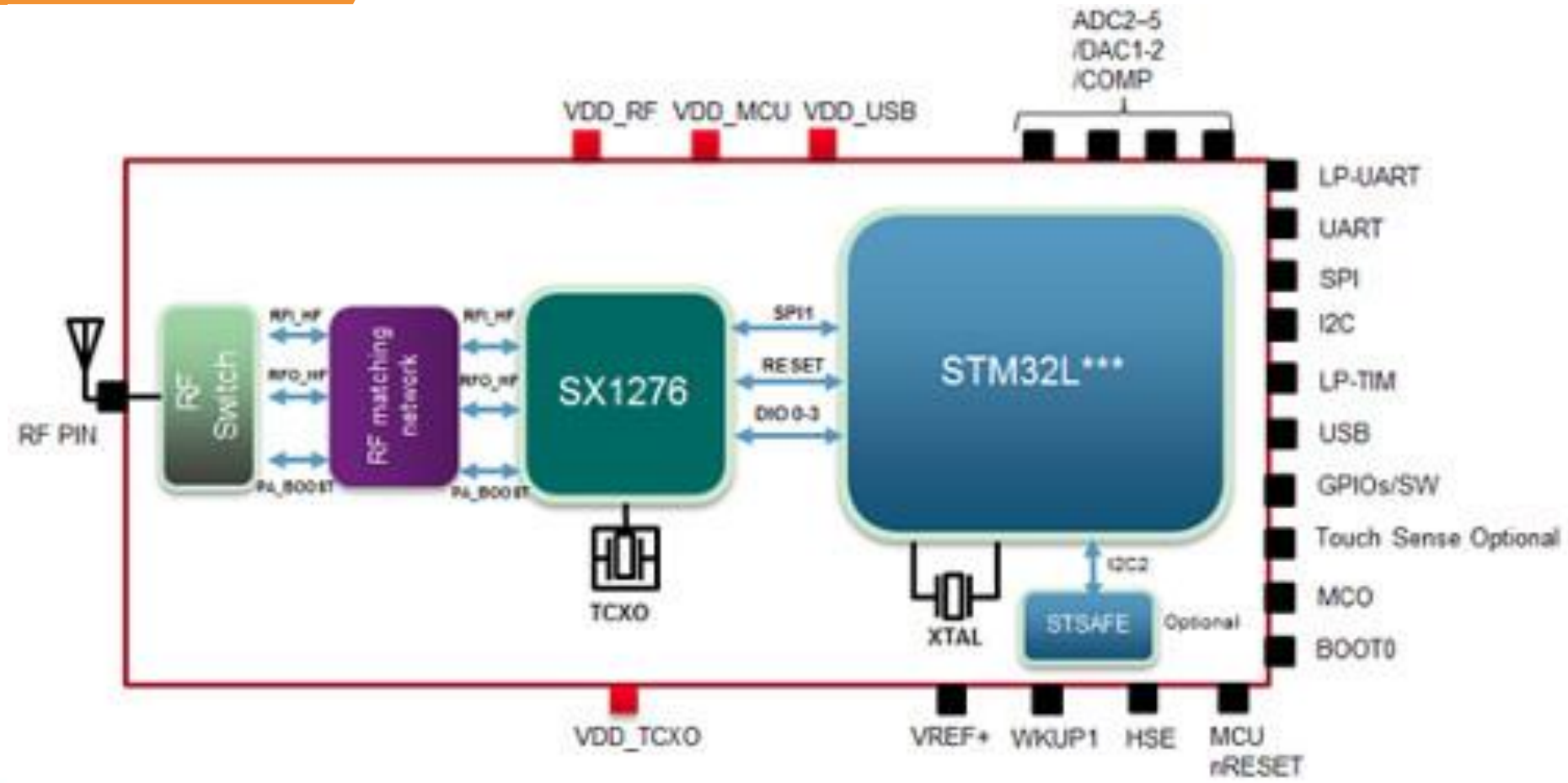
- Frequency
- Channel
- Data Rate
- LoRa Class
- Activation Mode
- Data Message (Flow & Payload)
- **Configuration**

# Configuration

| Key | Description |
|---|---|
| Device EUI (DevEUI) | Unique device ID  64 bit |
| Device Profile | Refer to Device Class, Frequency and version |
| Network Key (NwkSKey) | The optional 128-bit key used to encrypt the payload of the messages. |
| Application Server (AS) Routing Profile | The routing information defining how sensor data is routed to an application back-end connected to the core network platform. |
| Application Key (AppSKey) | The optional 128-bit key used to encrypt the payload of the messages. |



# Configuration



# Configuration

LoRa Alliance™

**CERTIFICATE OF COMPLIANCE**

## LoRaWAN™ Certified Product

The LoRa Alliance™ is pleased to congratulate Murata Electronics Europe on the completion of the LoRaWAN™ Certification Program for the following product:

| | |
|---|---|
| MANUFACTURER | Murata Electronics Europe |
| TYPE OF DEVICE | Module |
| MODEL IDENTIFICATION | CMWX1ZZABZ-078 |
| LoRaWAN REGION | EU868 |
| FIRMWARE VERSION | 1.0.3 |
| HARDWARE VERSION | MP |
| CERTIFICATION DATE | February 2, 2017 |
| LoRaWAN SPECIFICATION | V1.0.1 |
| Class of Operation (A, B or C) | A |

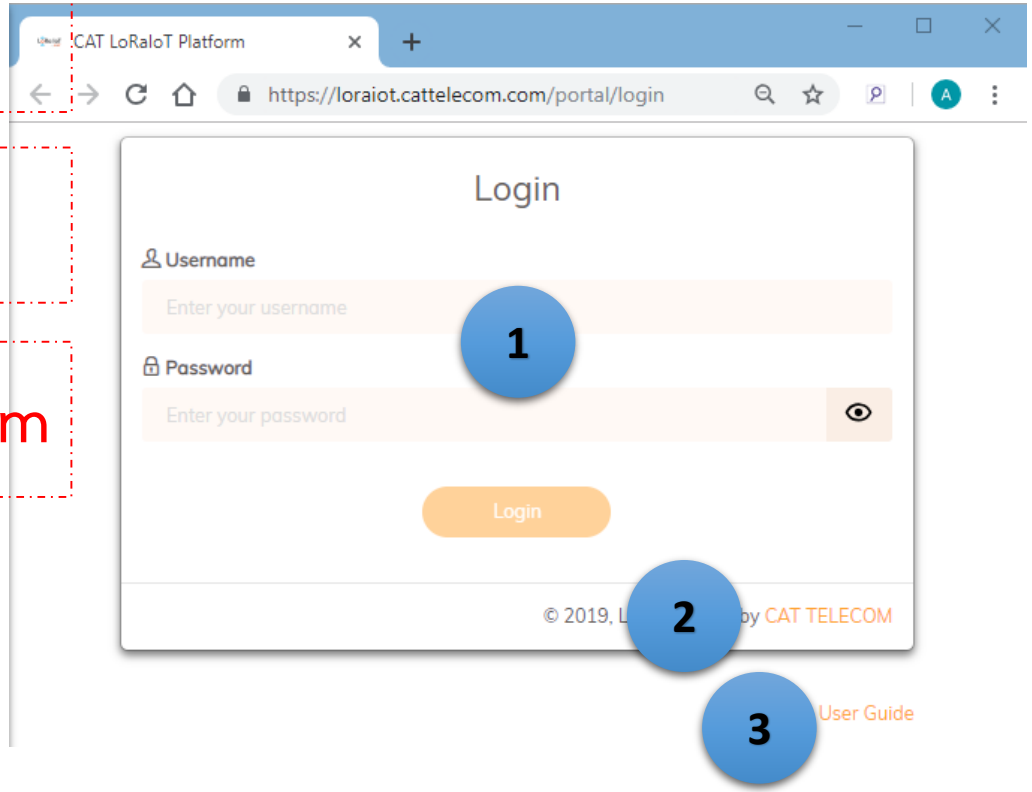
This Certificate serves to confirm that the above mentioned product has passed all relevant tests in conjunction with the LoRaWAN™ Certification Program and is deemed compliant to it. The Manufacturer has been granted the right to use the following term and all associated logos:

# TOPIC

- IoT Concept
- LoRaWAN Concept
- **LoRaWAN IoT by CAT Telecom**

# LoRa Platform

1. เข้าใช้งานระบบ
2. เว็บไซด์ข้อมูล
3. คู่มือใช้งาน Platform



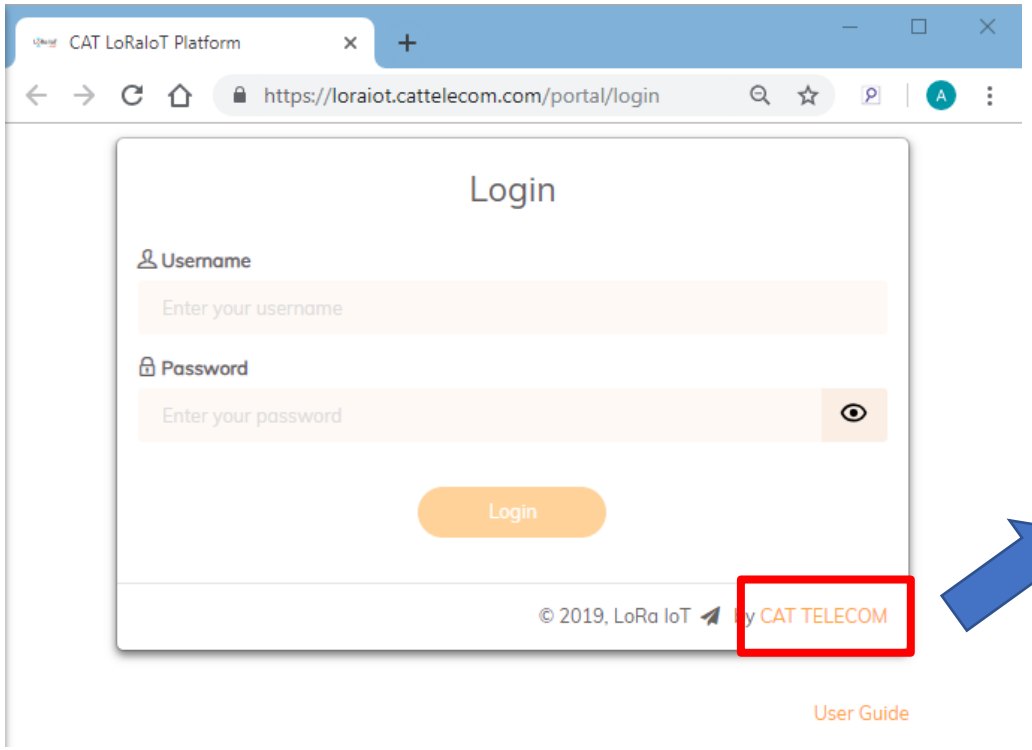

ตามกระดาษของแต่ละทีม

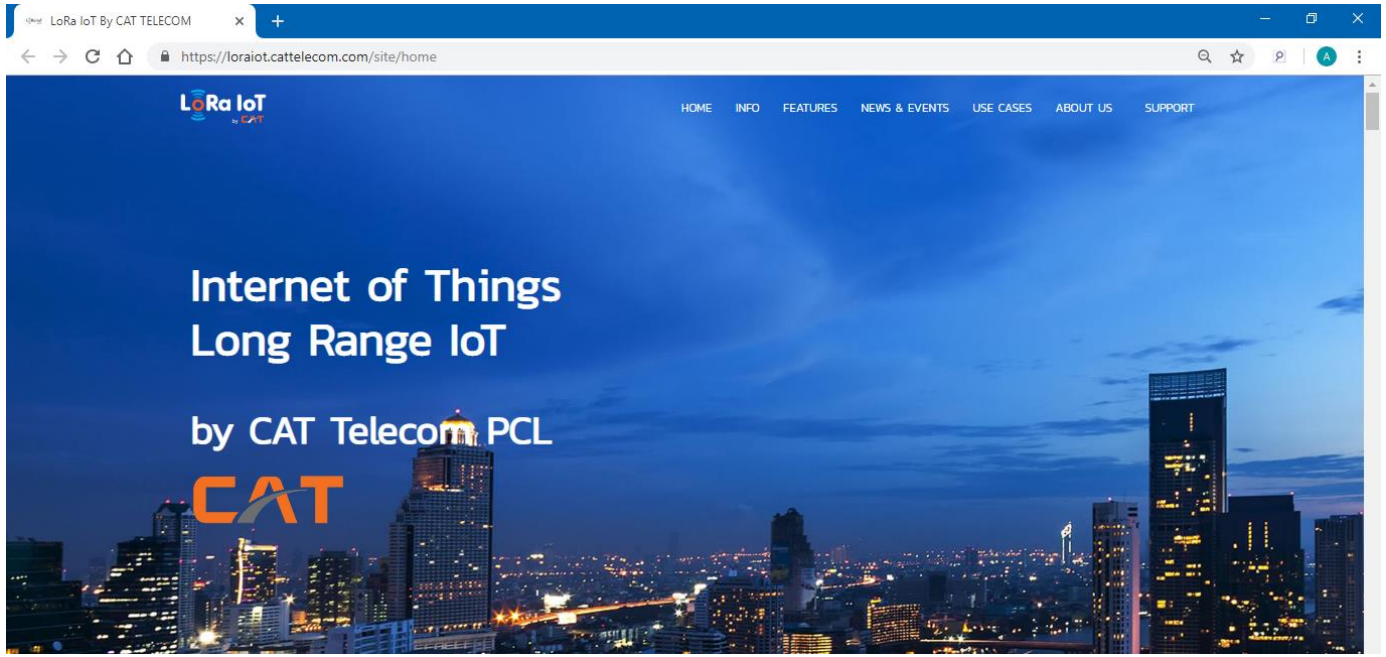
Username

Password

**https://loraiot.cattelecom.com/portal/login**

# LoRa Platform เว็บไซต์ข้อมูล https://loraiot.cattelecom.com

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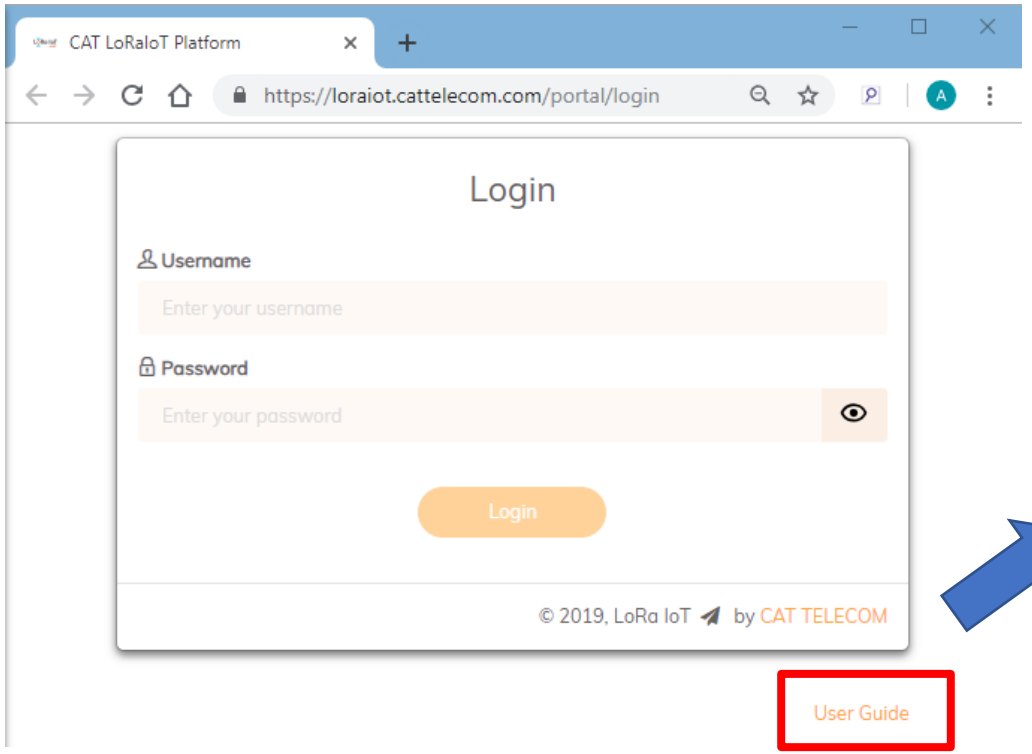
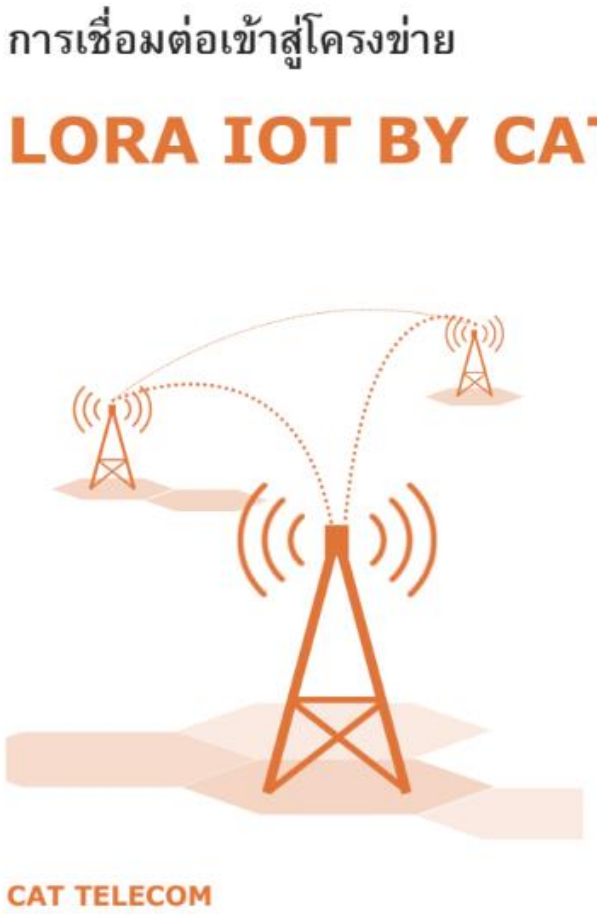
www.cattelecom.com
CAT CONTACT CENTER 1322

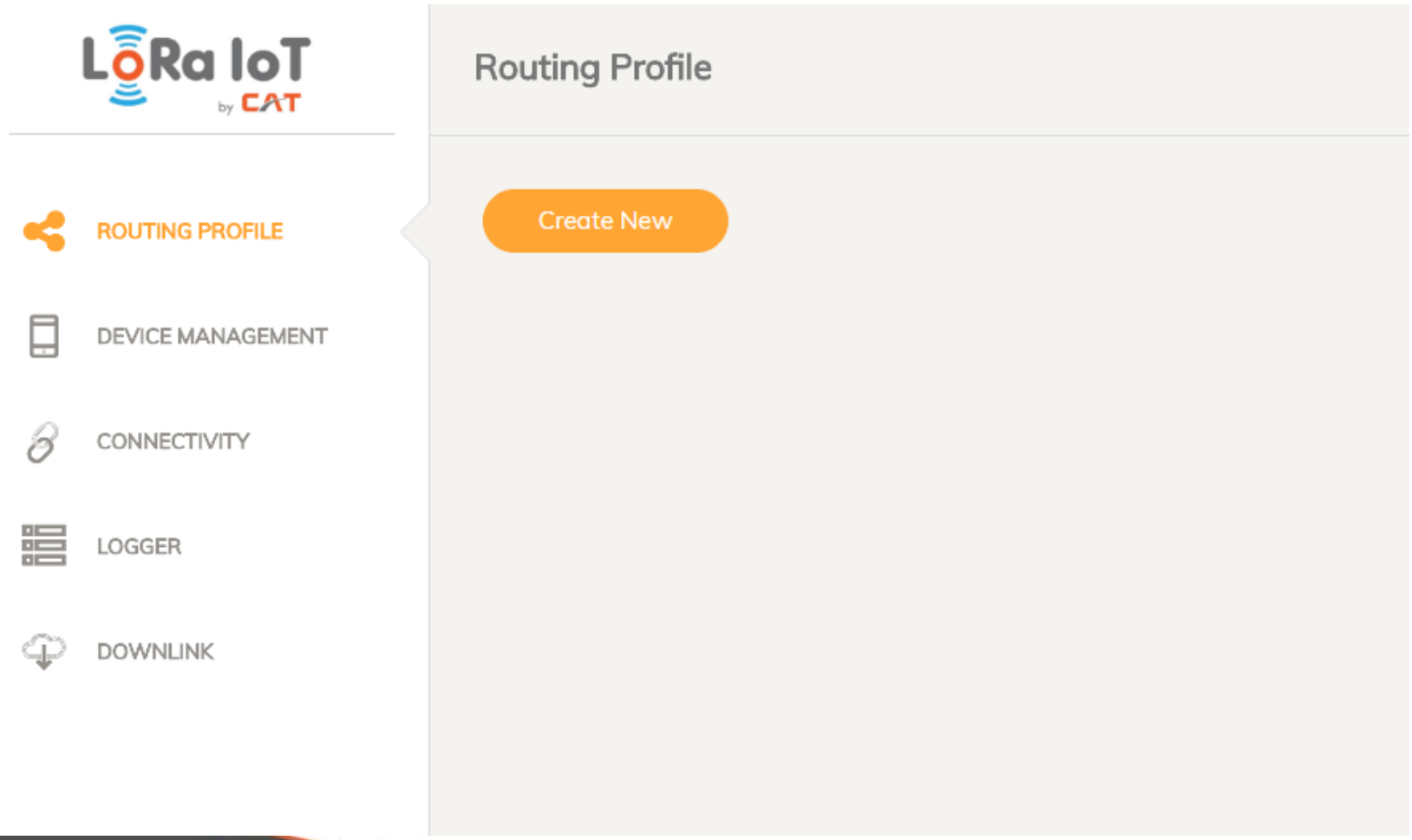
# LoRa Platform คู่มือใช้งาน Platform







# LoRa Platform




- Routing Profile
- Device Management
- Connectivity
- Logger
- Downlink

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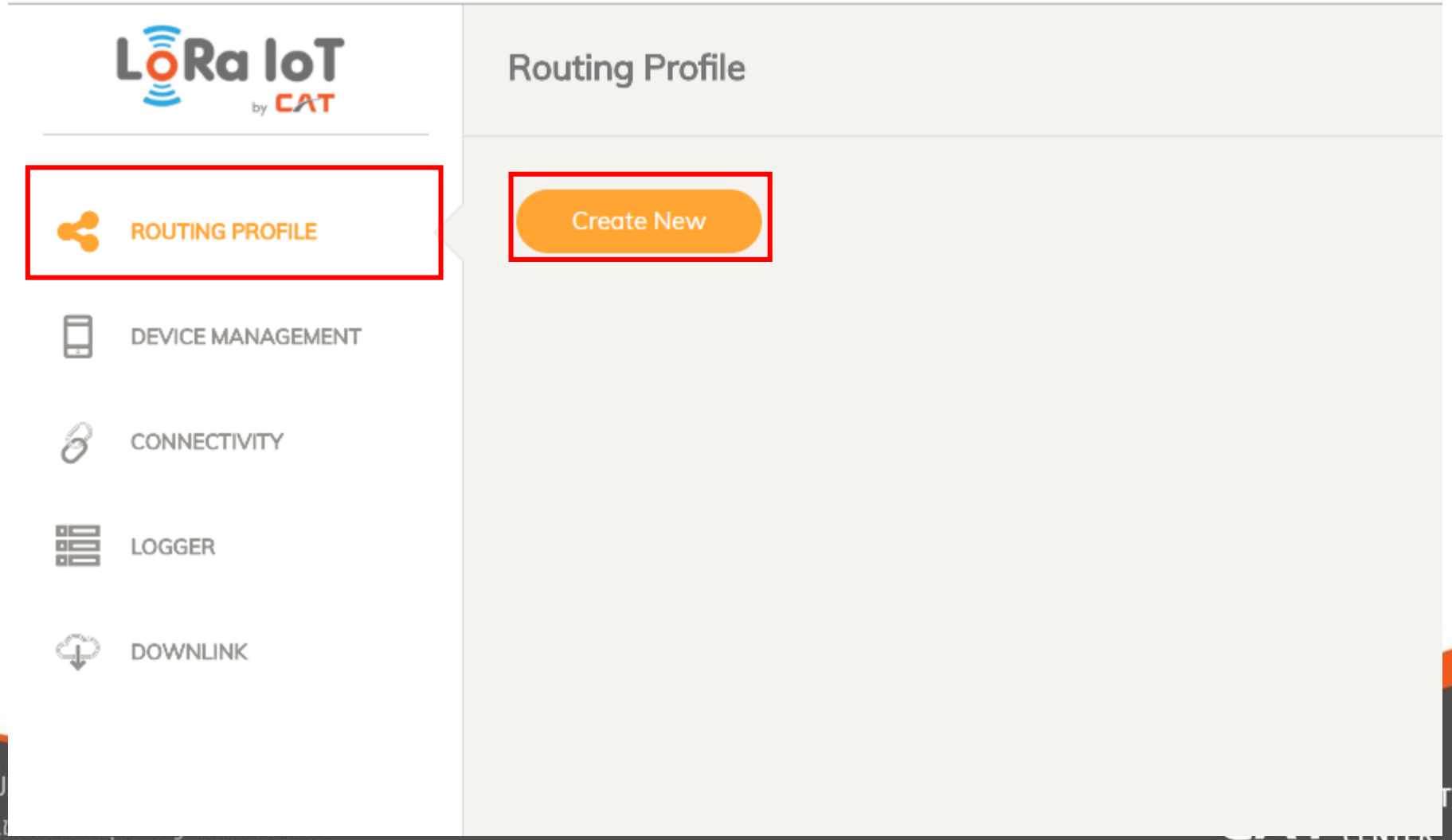
# Routing Profile

# Routing Profile



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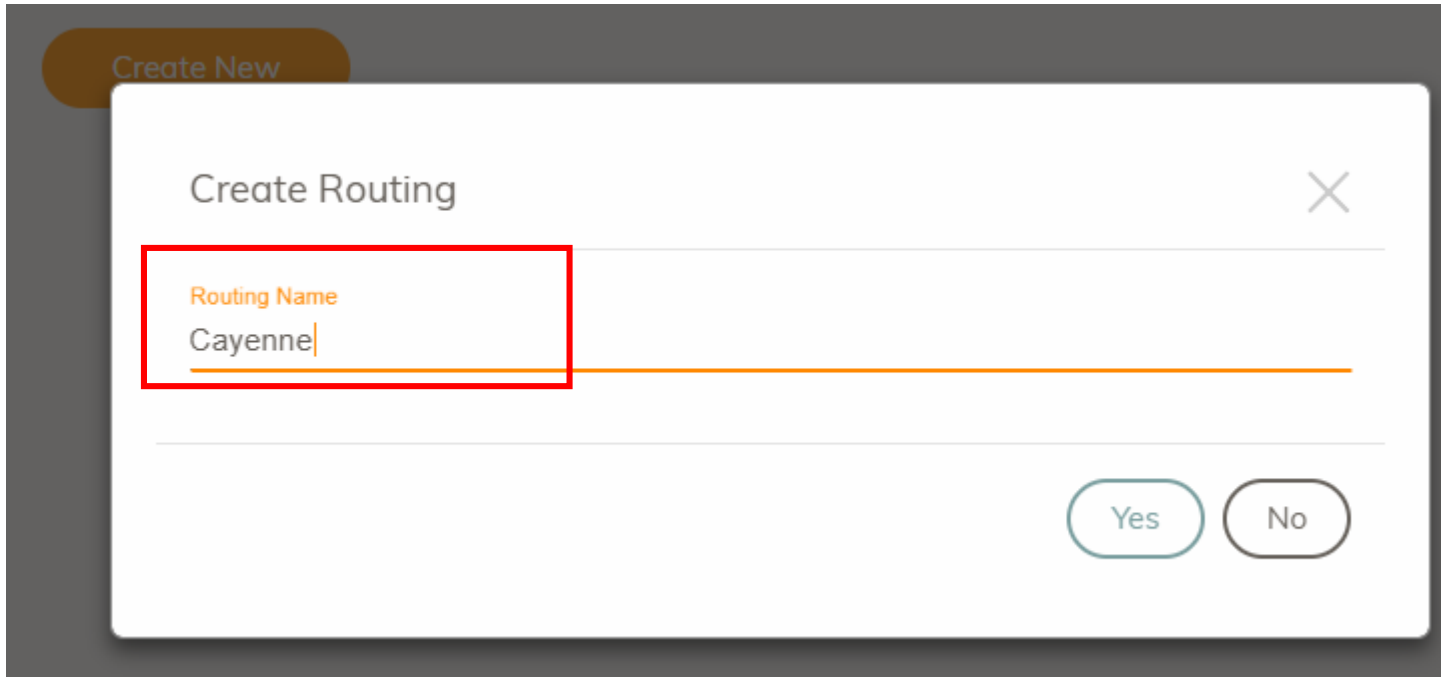

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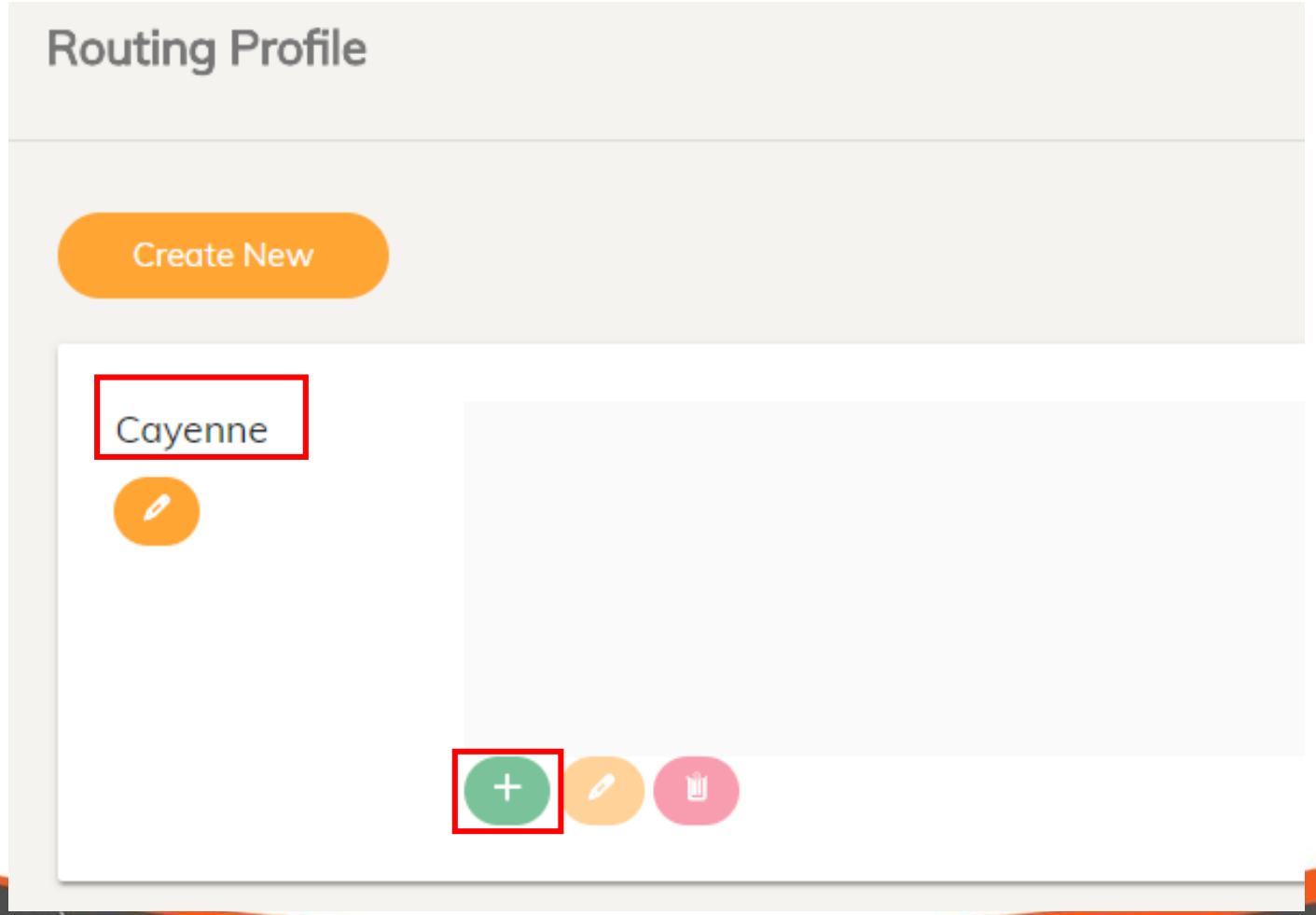

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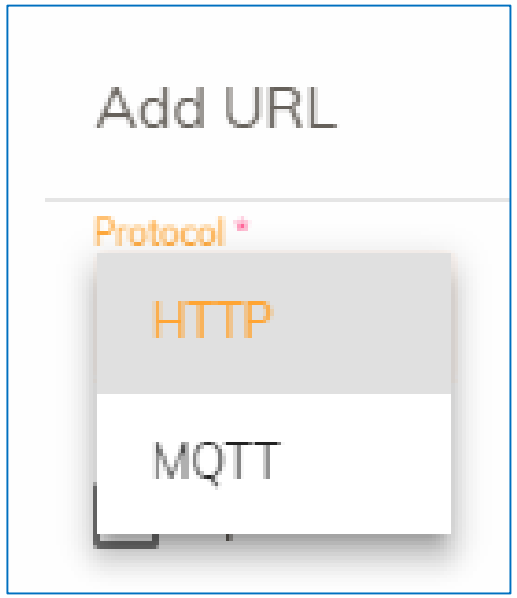
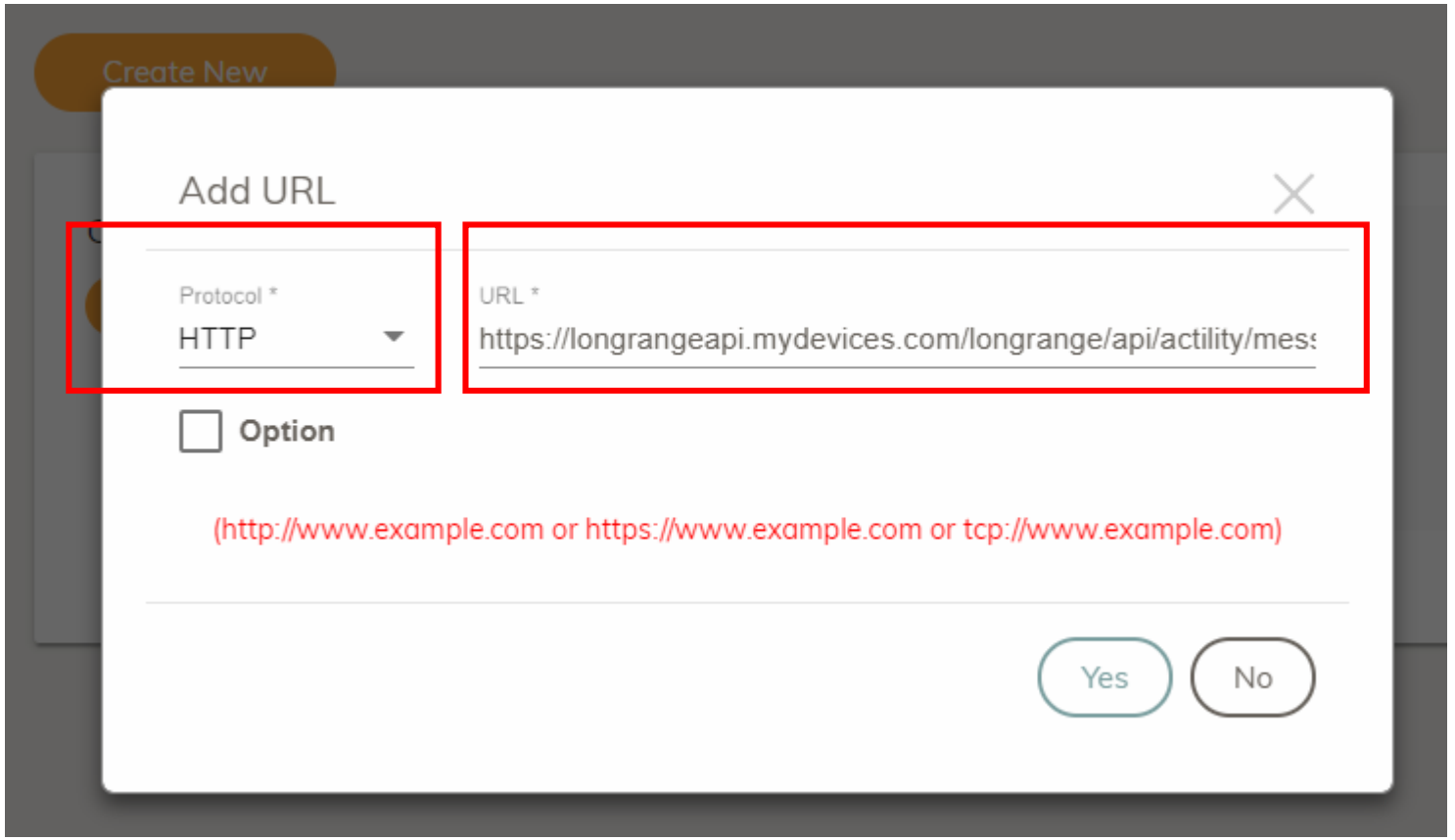
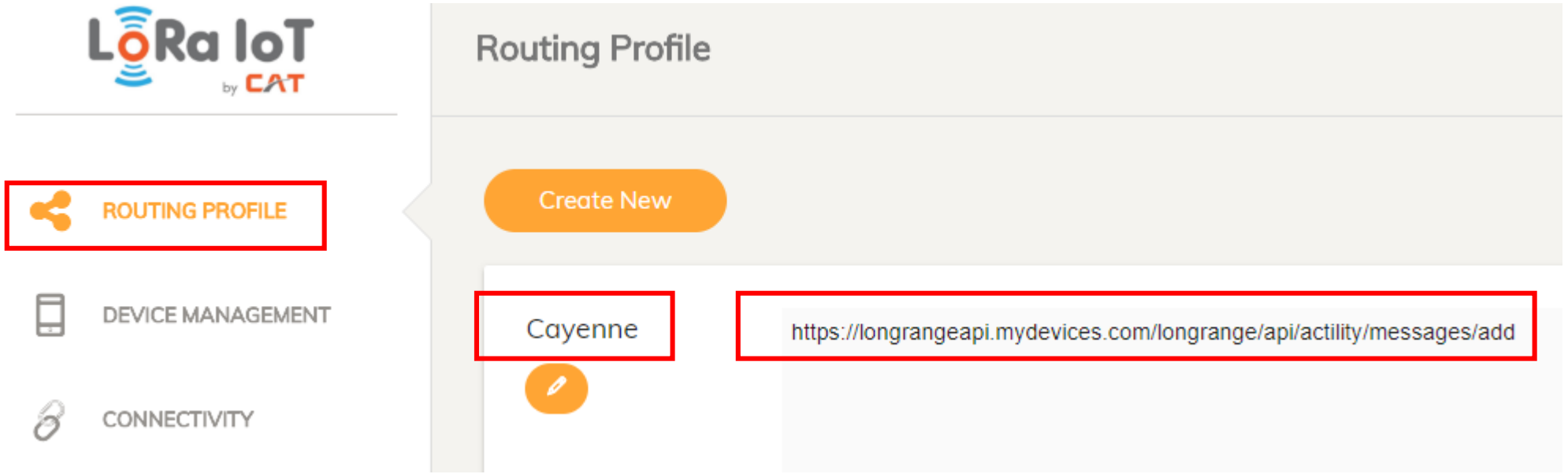



**https://longrangeapi.mydevices.com/longrange/api/actility/messages/add**

# Routing Profile



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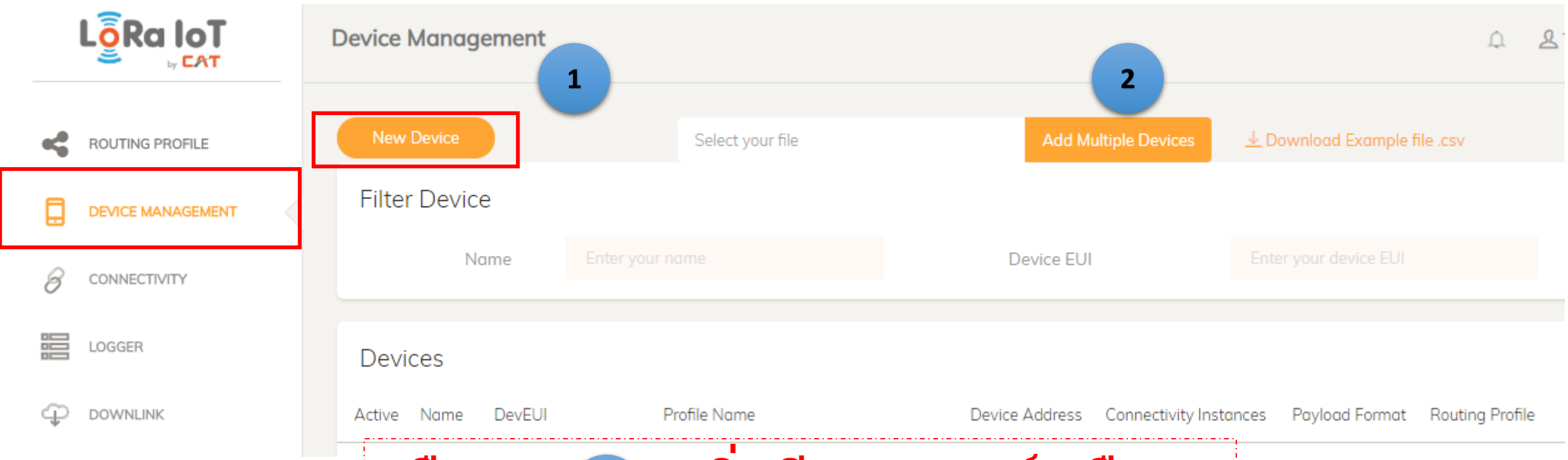
# Device Management

# Device Management




เลือก 1 เพิ่มทีละอุปกรณ์ หรือ

2 เพิ่มทีละหลายอุปกรณ์

# Device Management

1 เพิ่มทีละอุปกรณ์

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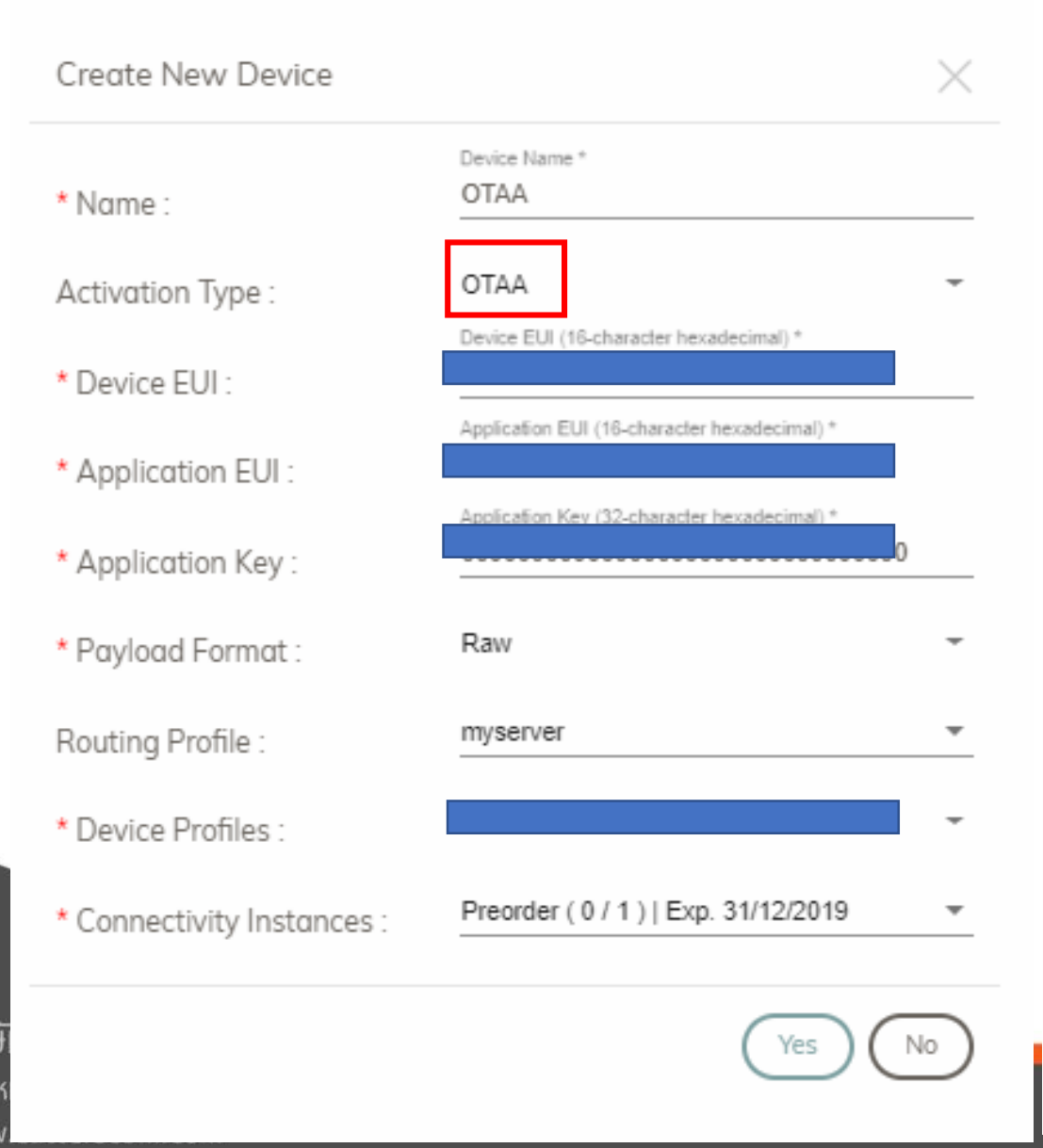
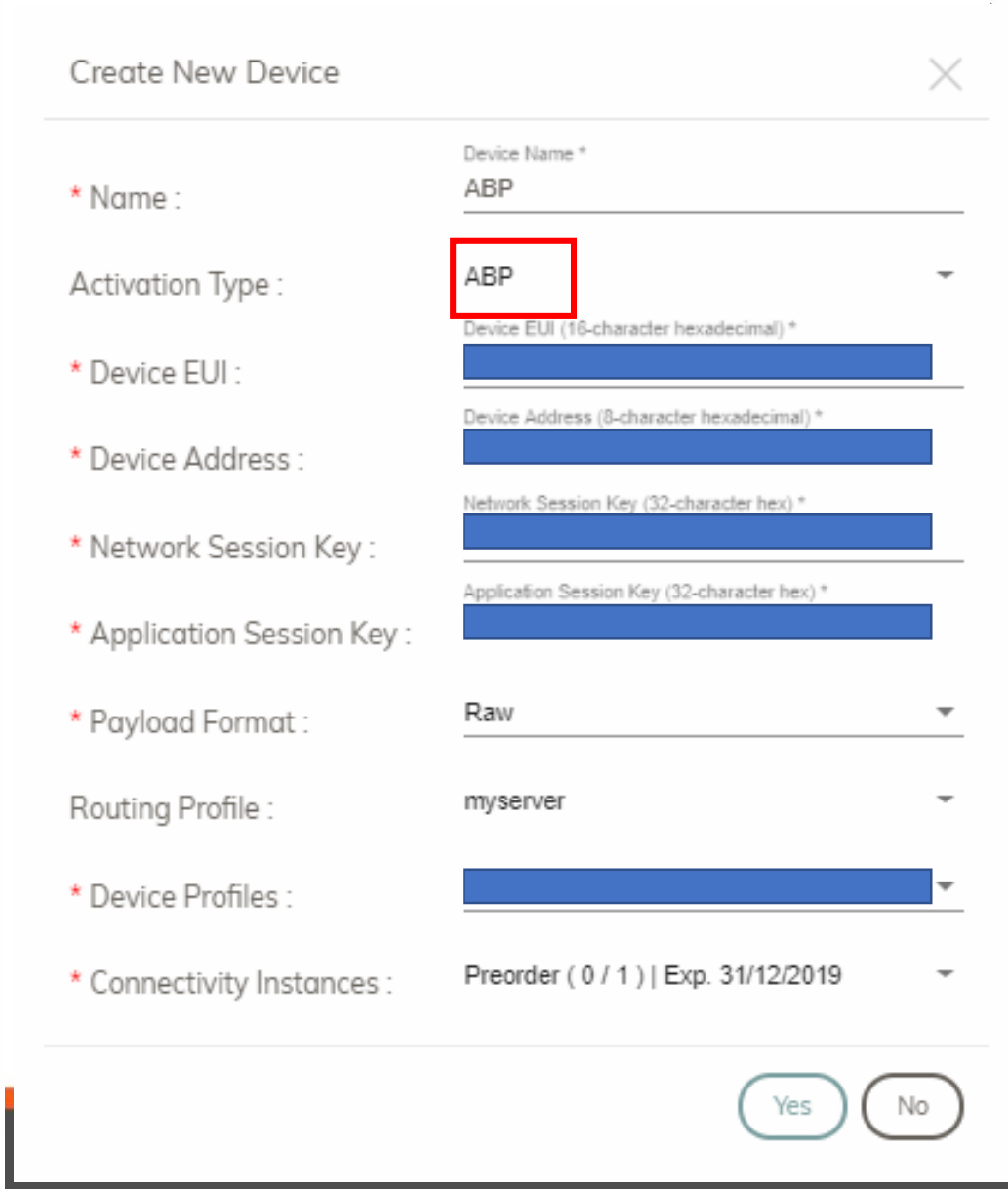


# Device Management

1 เพิ่มทีละอุปกรณ์

ABP

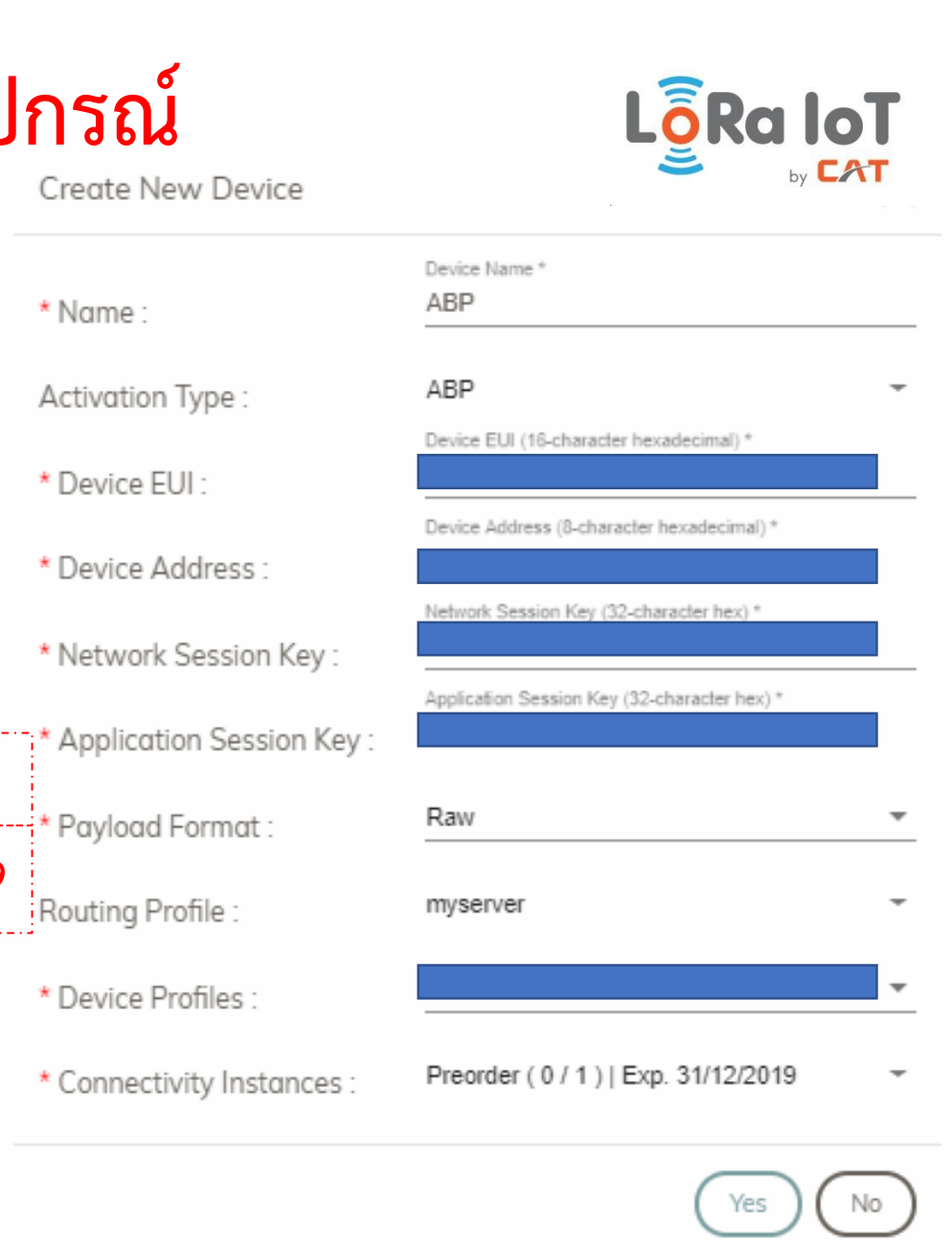
DeviceEUI: AA-00-DB-CA-12-EF-11-XX

DeviceAddr: 12-EF-11-XX

Network Session Key : 28-AE-D2-2B-7E-15-16-A6-09-CF-AB-F7-15-88-4F-3C

Application Session Key: 16-28-AE-2B-7E-15-D2-A6-AB-F7-CF-4F-3C-15-88-09

LoRaWAN 1.0.2 Class A – AS923



# Device Management

1 เพิ่มทีละอุปกรณ์

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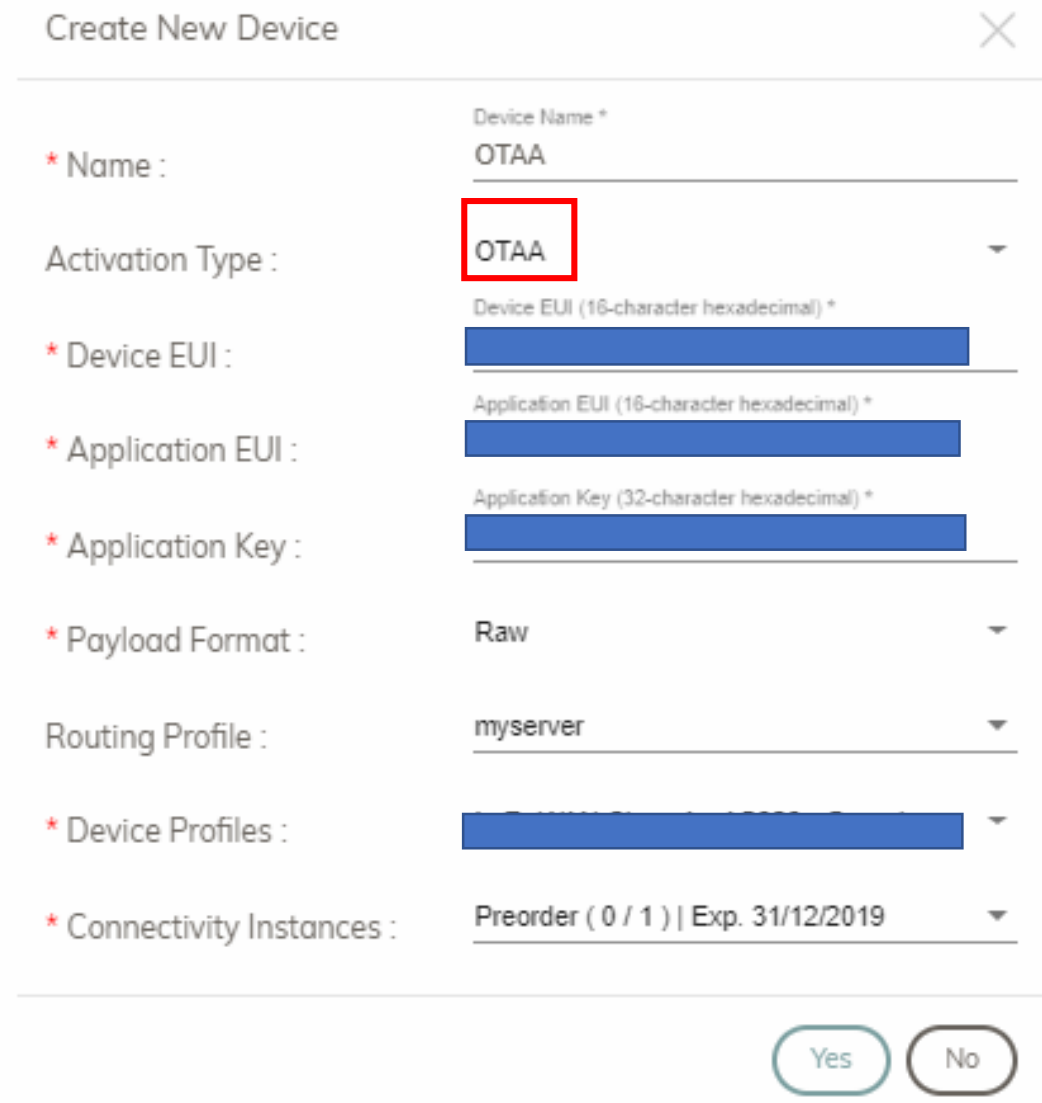
OTAA

DeviceEUI: AA-00-DB-CA-12-EF-11-XX

Application EUI : 16-28-AE-2B-7E-15-D2-A6

Application Key: 16-28-AE-2B-7E-15-D2-A6-AB-F7-CF-4F-3C-15-88-09

LoRaWAN 1.0.2 Class A – AS923

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www.cattelecom.com

# Device Management

1 เพิ่มทีละอุปกรณ์

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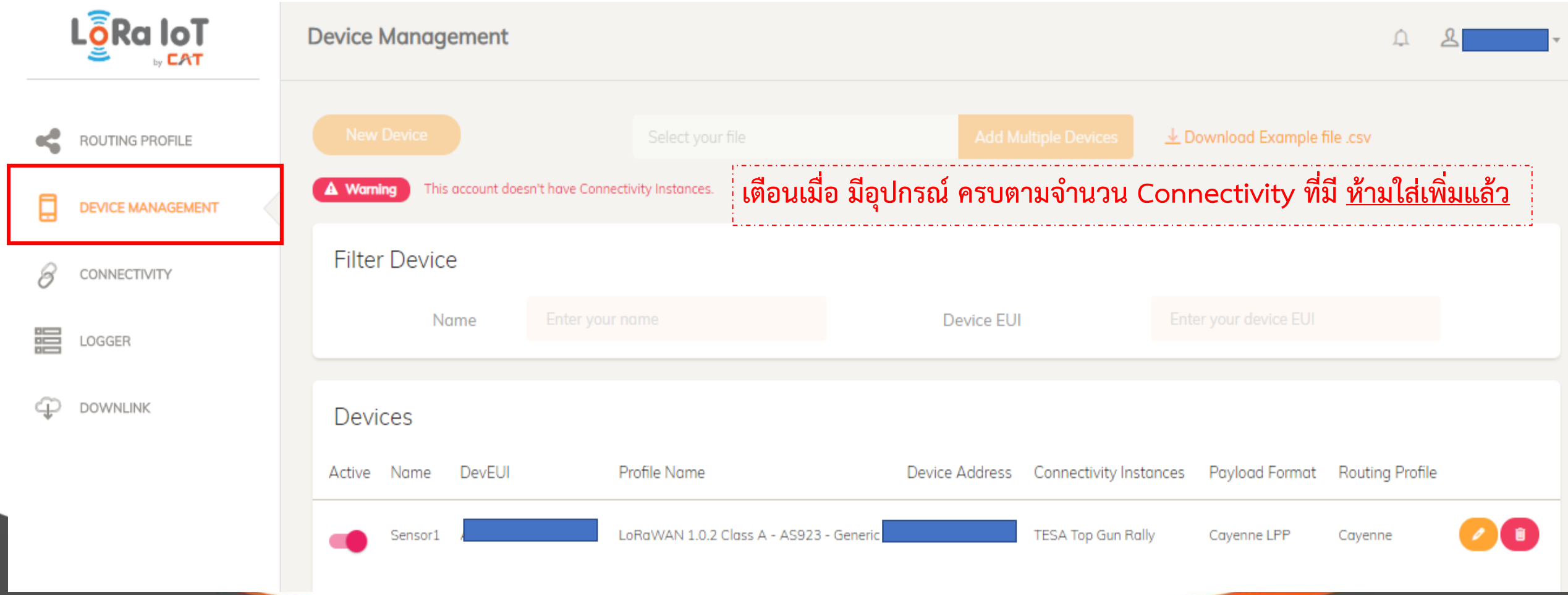

# Device Management

## 2 เพิ่มทีละหลายอุปกรณ์

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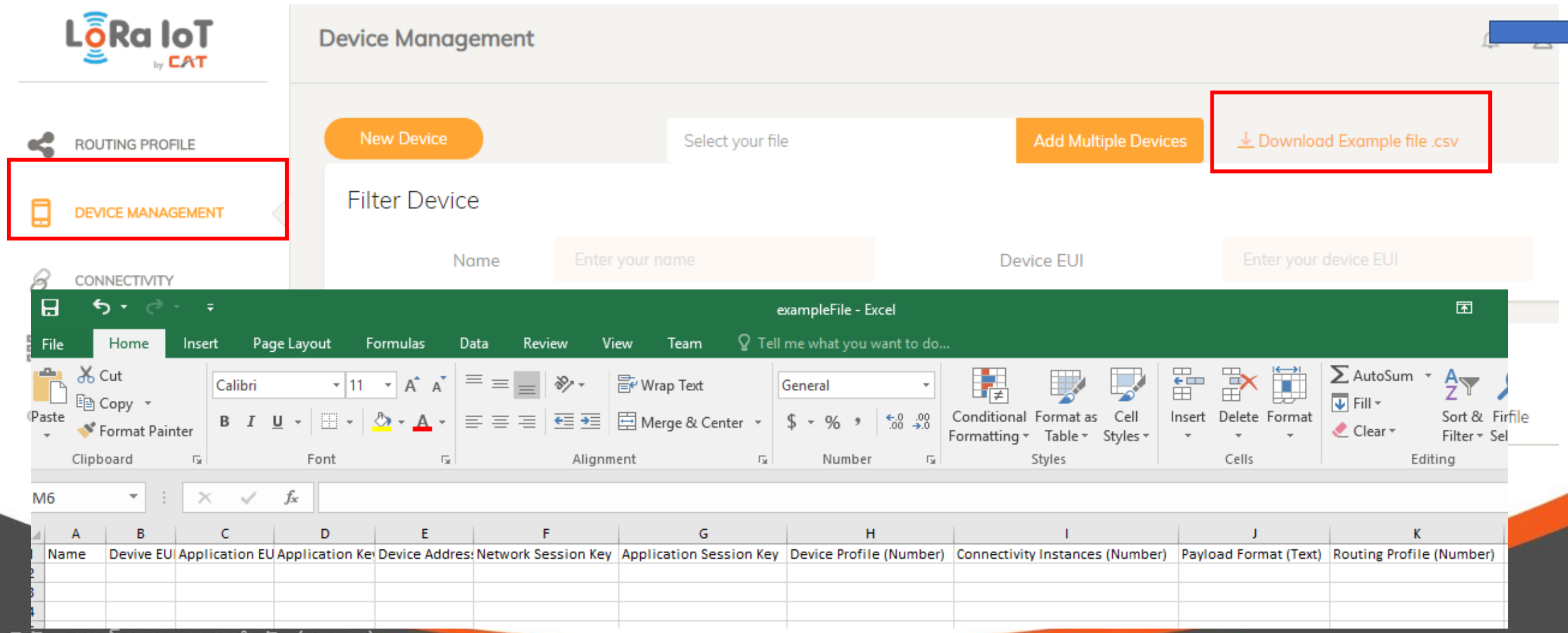

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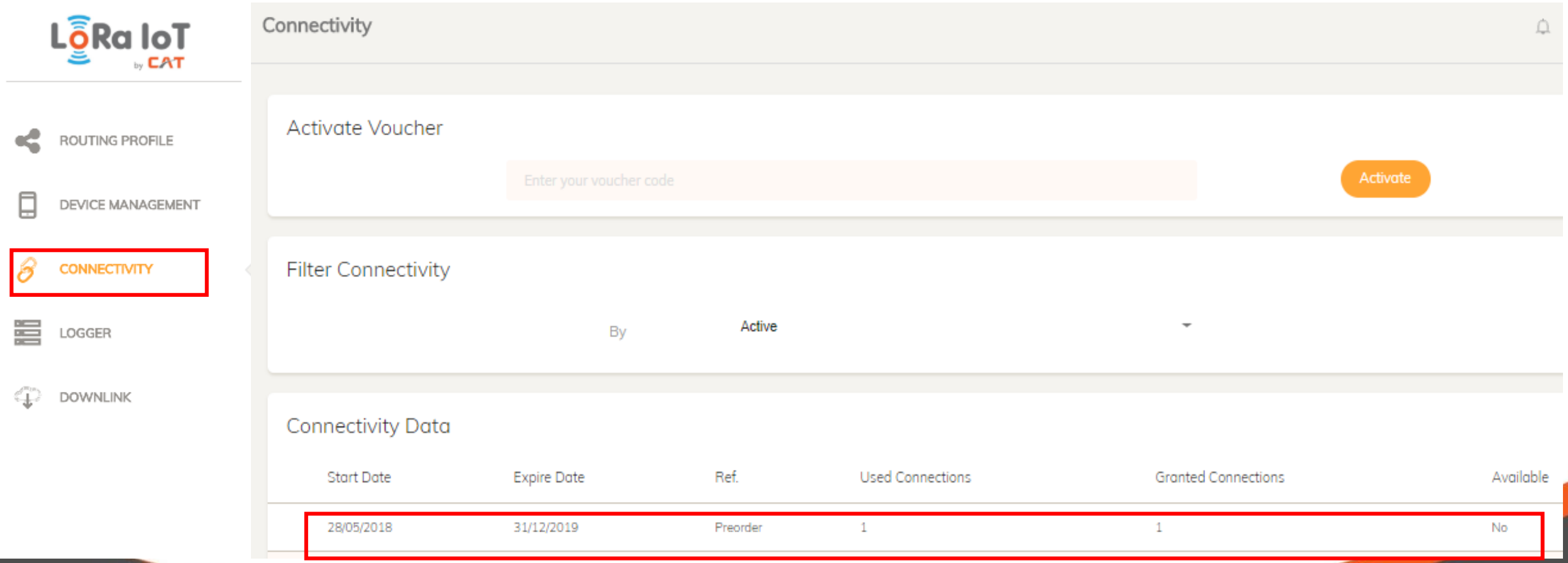
# Connectivity

# Connectivity



# Logger

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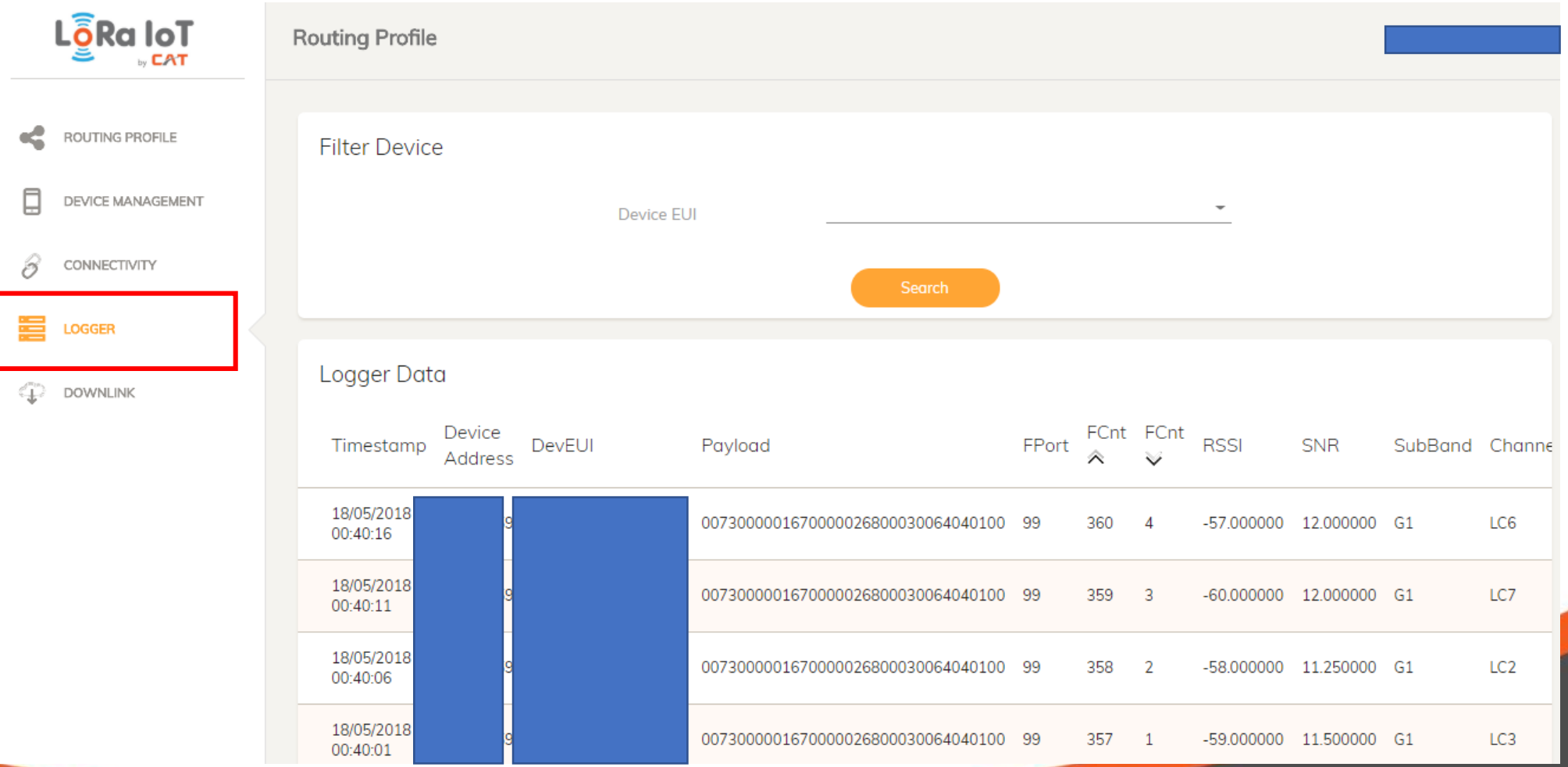
Logger

# Logger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ROUTING PROFILE
DEVICE MANAGEMENT
CONNECTIVITY
LOGGER
DOWNLINK
Routing Profile
Filter Device
Device EUI
Search
Logger Data
Timestamp
Device Address
DevEUI
Payload
FPort
FCnt
FCnt
RSSI
SNR
SubBand
Channe
18/05/2018 00:40:16
00730000016700000268000300640401009900360 4-57.00000012.000000G1LC6
18/05/2018 00:40:11
00730000016700000268000300640401009900359 3-60.00000012.000000G1LC7
18/05/2018 00:40:06
00730000016700000268000300640401009900358 2-58.00000011.250000G1LC2
18/05/2018 00:40:01
00730000016700000268000300640401009900357 1-59.00000011.500000G1LC3

# Logger

LoRa IoT by CAT

- ROUTING PROFILE
- DEVICE MANAGEMENT
- CONNECTIVITY
- LOGGER
- DOWNLINK

Filter Device

Device EUI 0004A30B00235FB2 Refresh

Logger Data

| | Timestamp | Device Address | DevEUI | Payload | FPort | FCnt | FCnt | RSSI | SNR | SubBand | Channel | LRR ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ↑ | 27/11/2018 16:26:58 | [redacted] | [redacted] | 05689f066701f5 | 89 | 127 | 9 | -36.000000 | 9.500000 | G1 | LC6 | C00002D1 |
| ↑ | 27/11/ :26:18 | | | 05689f066701f5 | 89 | 126 | 9 | -35.000000 | 6.500000 | G1 | LC5 | C00002D1 |

แอบคลิกดูอยู่นะจ๊ะ

Payload (parsed) :


```
{
    "frames": [
        {
            "channel": 5,
            "type": 104,
            "typeString": "Humidity Sensor",
            "value": 79.5
        },
        {
            "channel": 6,
            "type": 103,
            "typeString": "Temperature Sensor",
```

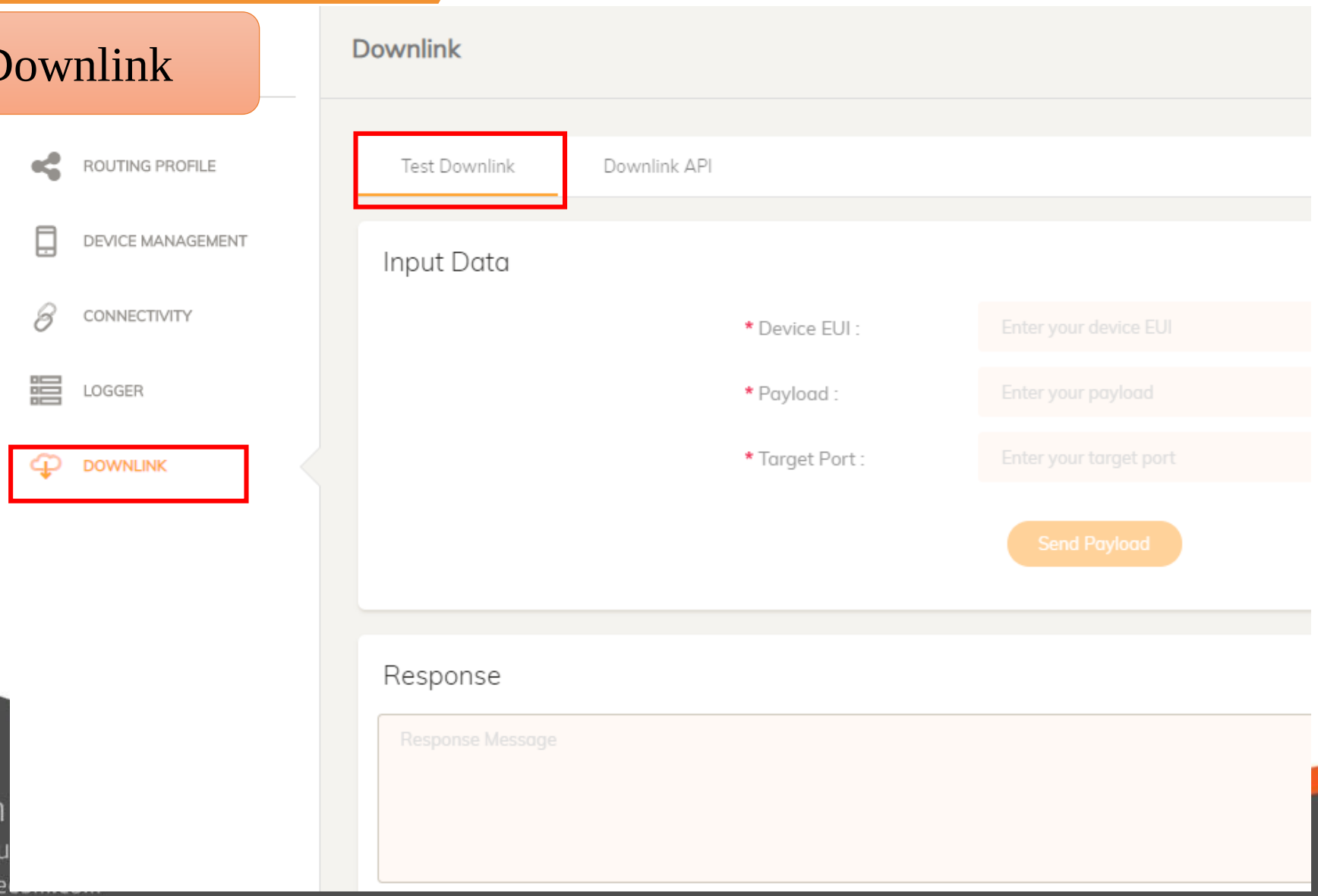
# Downlink

LoRa IoT by CAT

Downlink

# Downlink

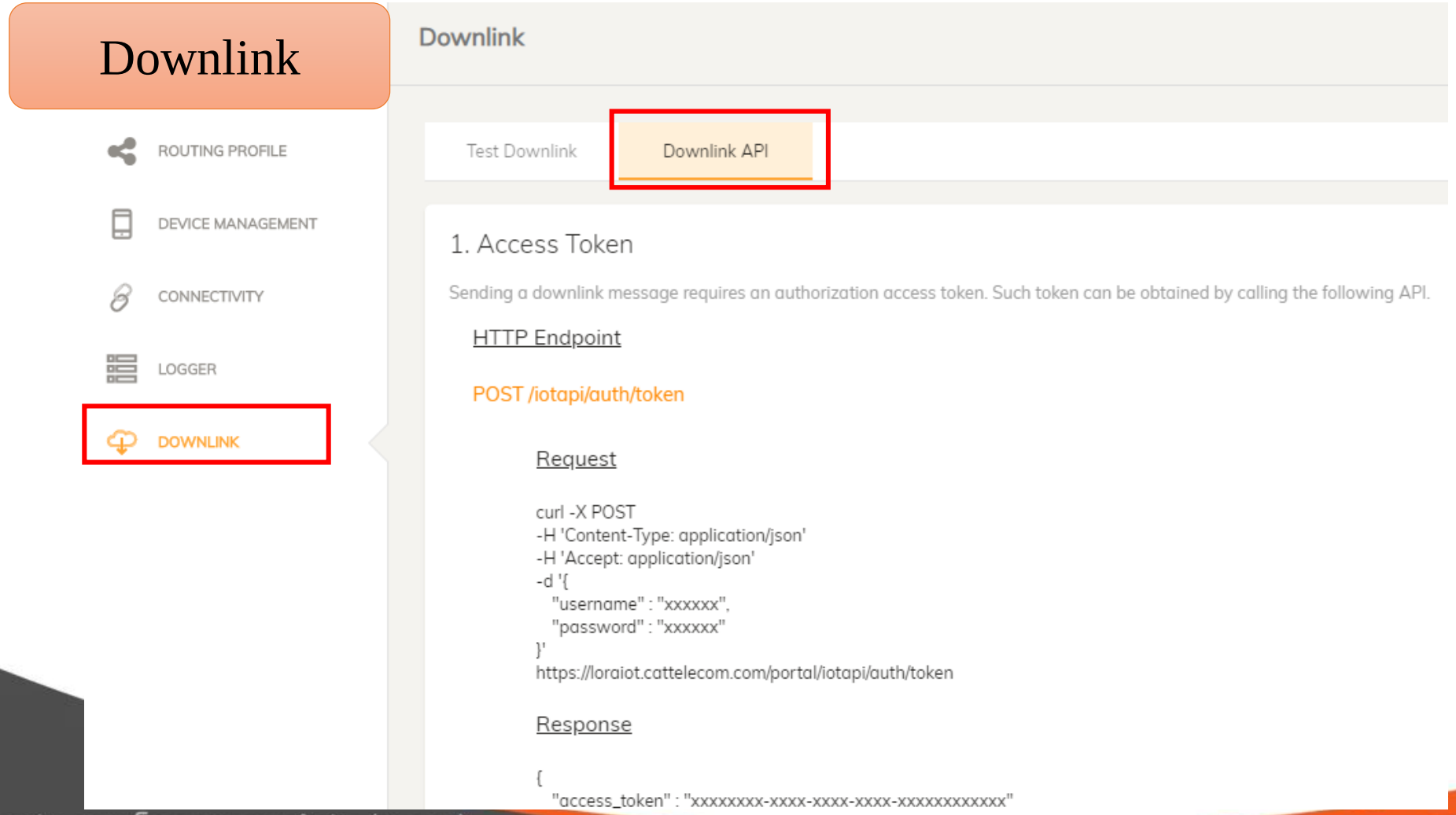
Downlink



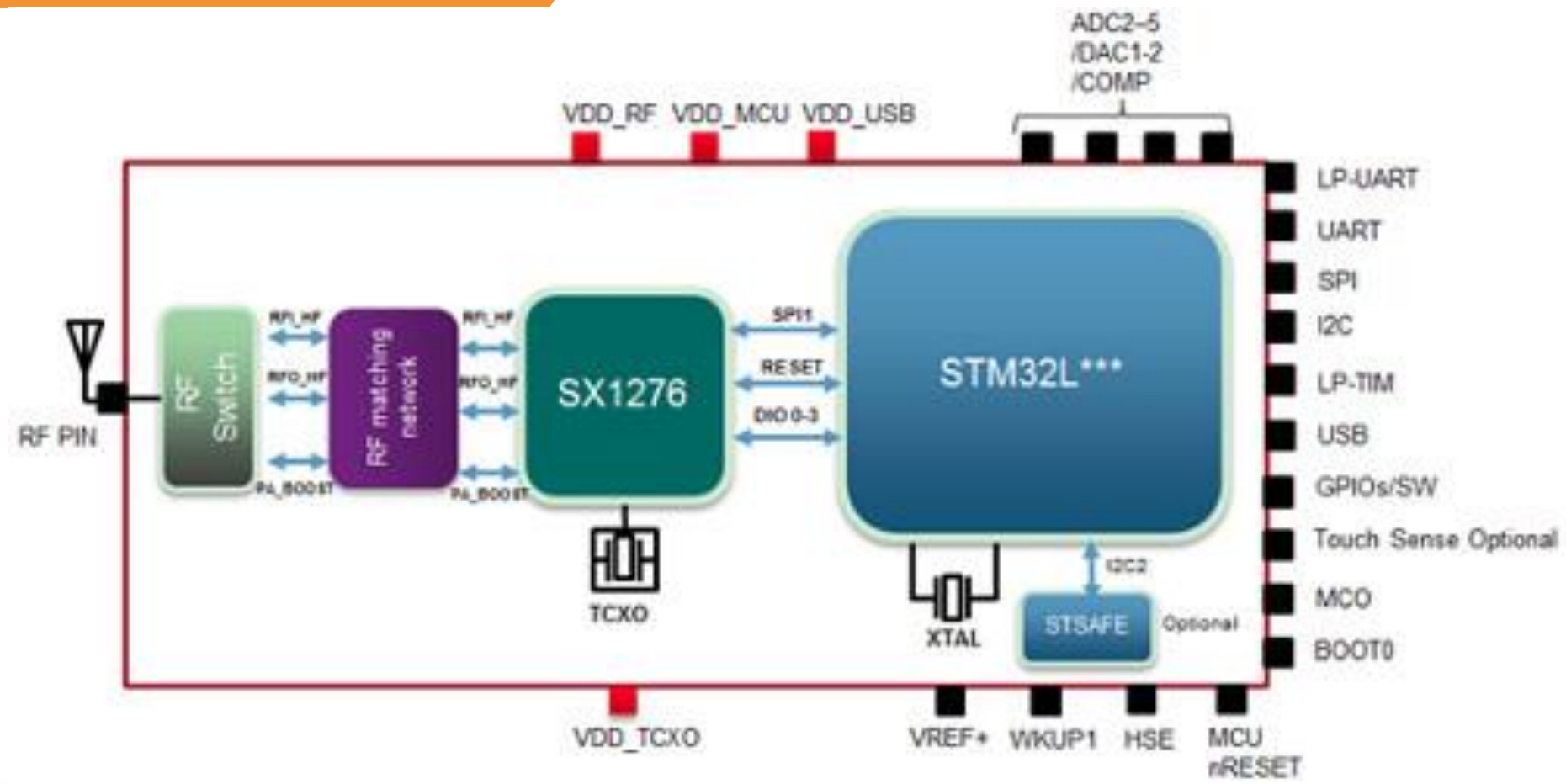
# Downlink

LoRa IoT by CAT

Downlink



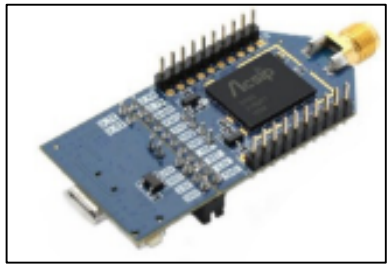
# Device Configuration

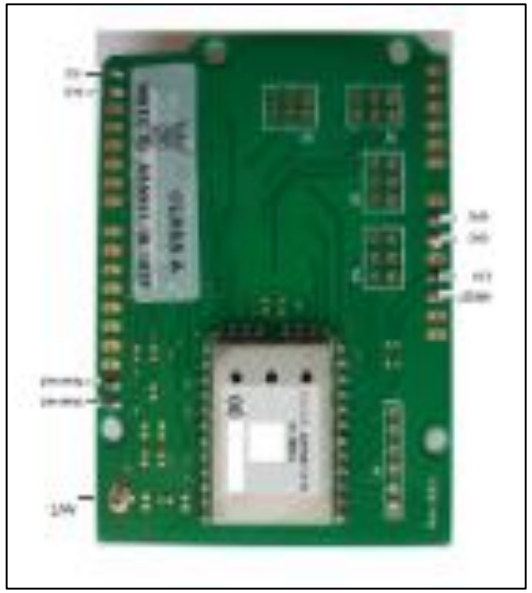


# LoRaWAN for Embedded System

## LoRa Module & Dev Kit





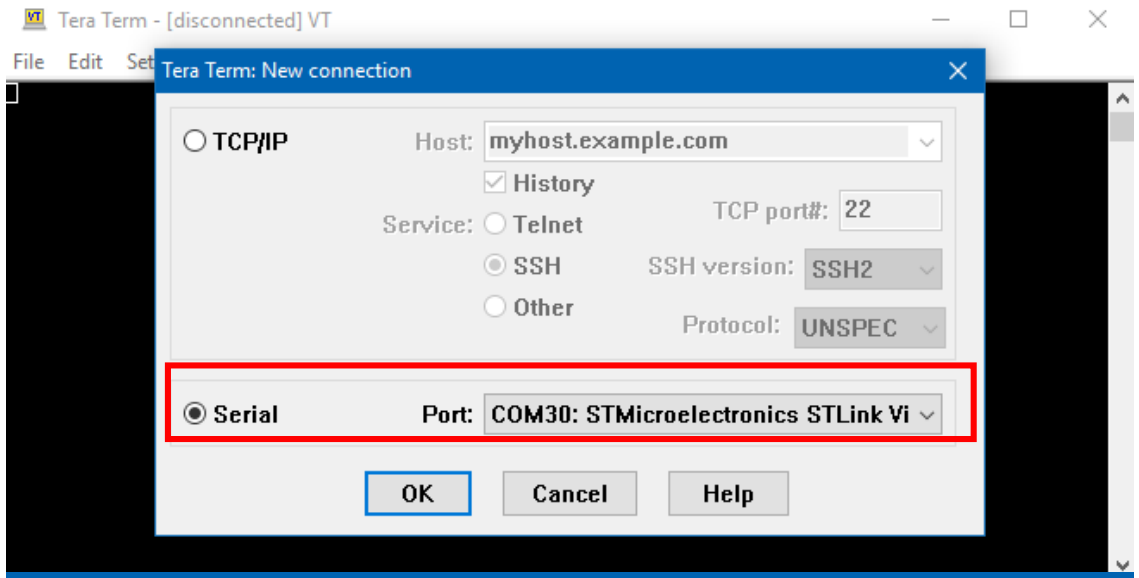



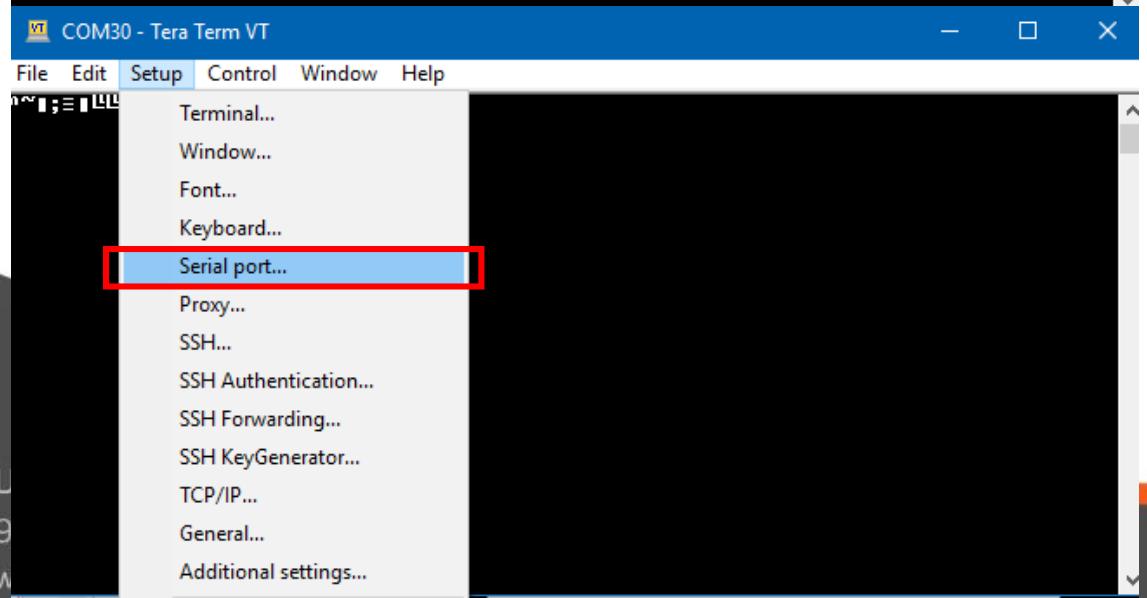
บริษัท กสท โทรคมนาคม จำกัด (มหาชน)
99 หมู่ 3 ถนนแจ้งวัฒนะ แขวงทุ่งสองห้อง เขตหลักสี่ กรุงเทพฯ 10210-0298
www.cattelecom.com

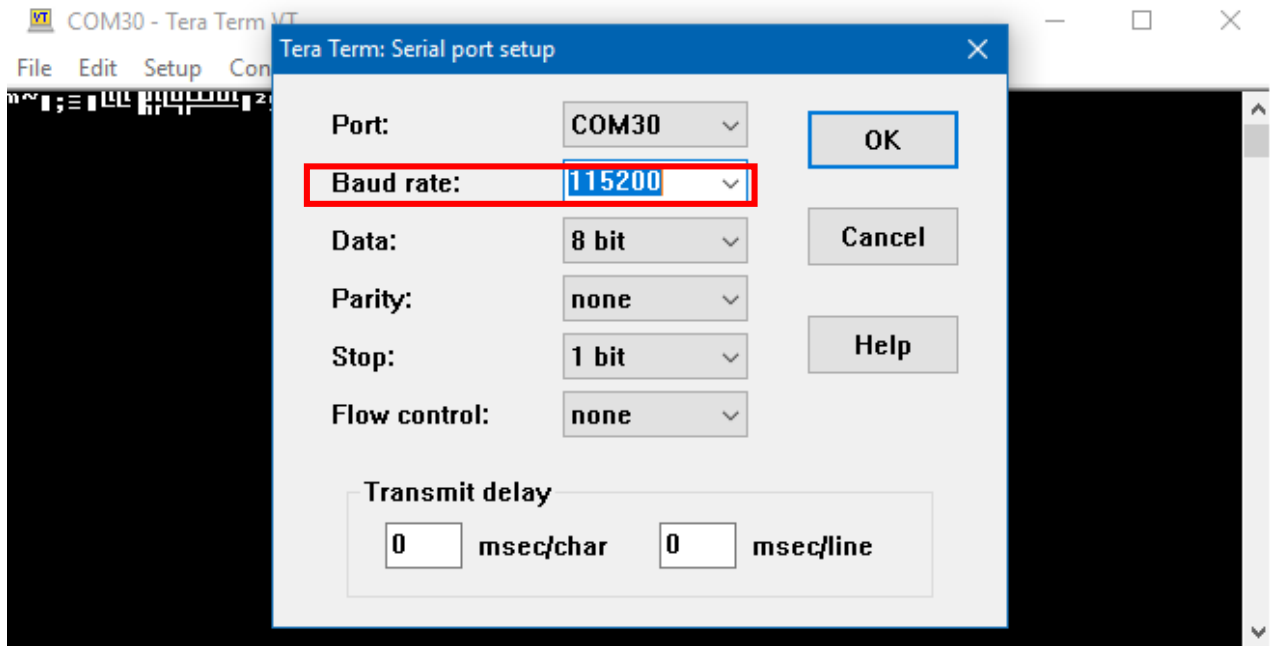
# Device Configuration

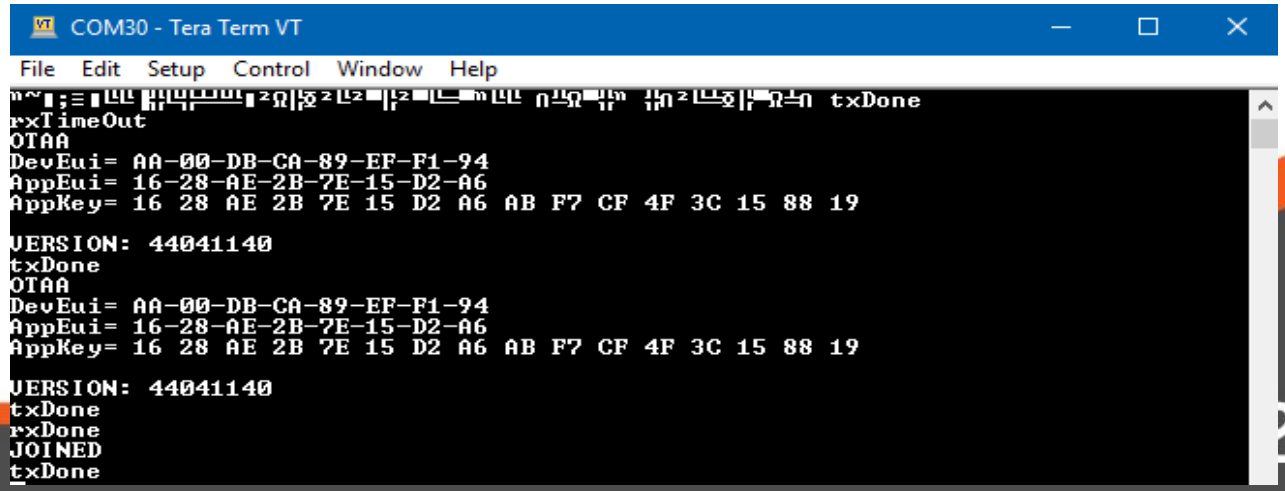
| Brand | | Spec | Download |
|---|---|---|---|
| STMicroelectronics<br>[Starter Kit]<br>✓ Verified |  | STM32 B-L072Z-LRWAN1<br>Operation Mode:<br>• Programmable (Development toolchains, Embedded Platform and Arduino Programming)<br>• LoRa Modem (AT Command)<br>Feature:<br>• Support AS923 Frequency 920-925<br>• CMWX1ZZABZ-091 LoRa® module (Murata)<br>• SMA and U.FL RF interface connectors<br>• Including 50 Ohm SMA RF antenna<br>• On-board ST-LINK/V2-1 supporting USB re-enumeration capability<br>• Board power supply: (USB bus or external VIN 3.3 V or AAA 3 batteries)<br>• 4 general-purpose LEDs<br>• 2 push-buttons (user and reset)<br>• ArduinoTM Uno V3 connectors<br>• ARM® mbedTM (see http://mbed.org) | Manual for STM32 |

# Serial Communication : Check Status

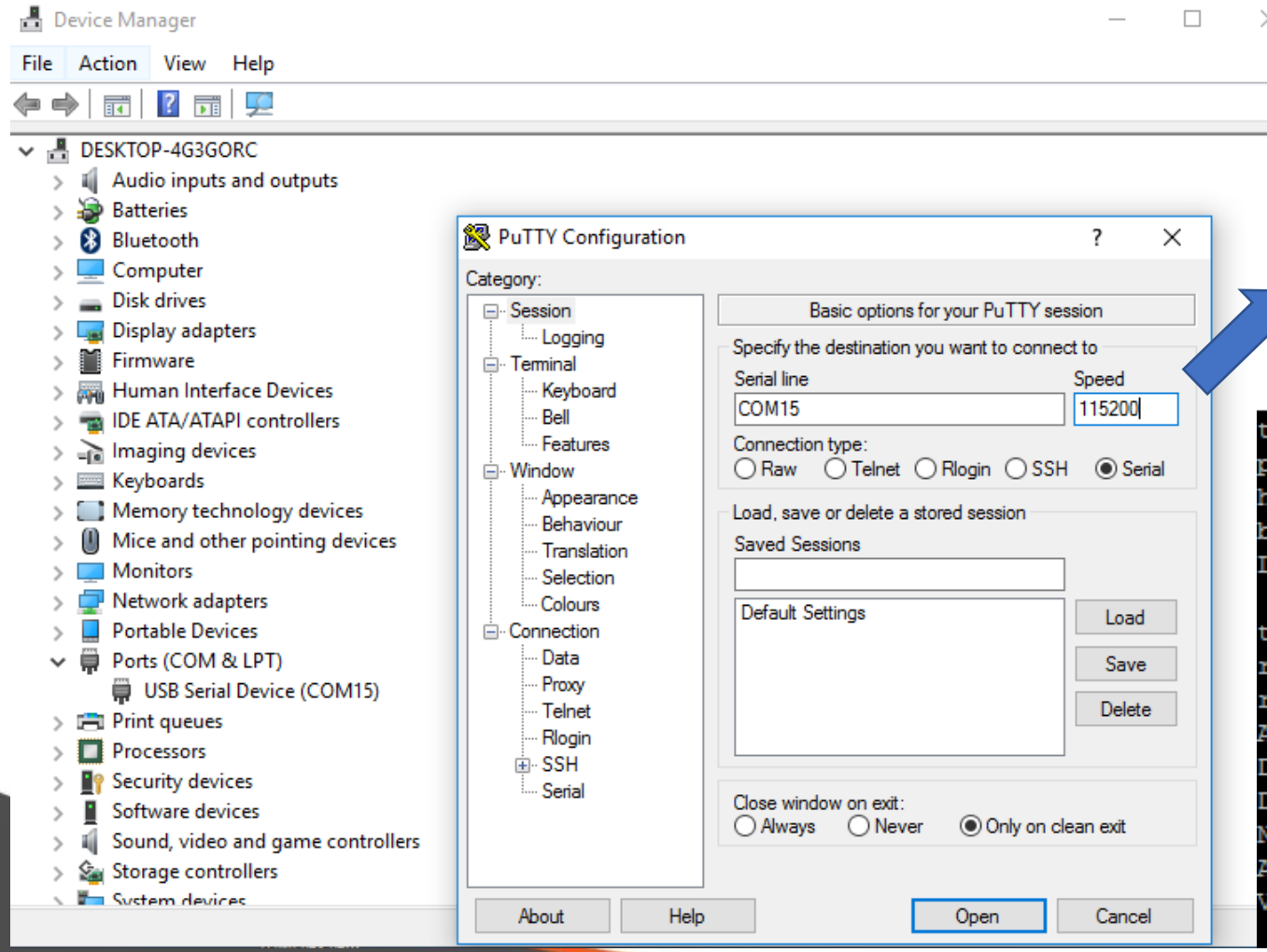


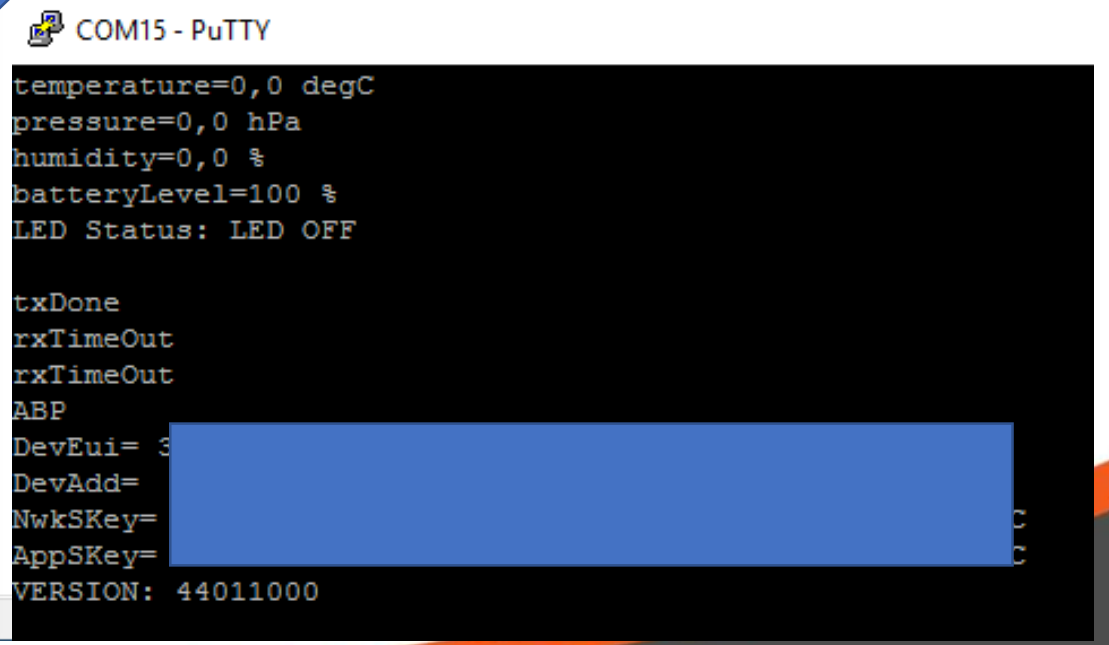
# Serial Communication : Check Status







115200



# Device Configuration

LoRa IoT by CAT

ABP

# Device Configuration

** LoRaWAN Key Setting !!

LoRa IoT by CAT

ABP

```
74   * When set to 1 the application uses the Over-the-Air activation procedure
75   * When set to 0 the application uses the Personalization activation procedure
76   */
77  #define OVER_THE_AIR_ACTIVATION                     0
78
79  /*!
80   * Indicates if the end-device is to be connected to a private or public network
81   */
82  #define LORAWAN_PUBLIC_NETWORK                      true
83
84  /*!
85   * When set to 1 DevEui is LORAWAN_DEVICE_EUI
86   * When set to 0 DevEui is automatically generated by calling
87   *         BoardGetUniqueId function
88   */
89  #define STATIC_DEVICE_EUI                           1
90
91  /*!
92   * Mote device IEEE EUI (big endian)
93   *
94   * \remark see STATIC_DEVICE_EUI comments
95   */
96  #define LORAWAN_DEVICE_EUI                          { 0xAA, 0x00, 0xDB, 0xCA, 0x[redacted], 0xEF, 0x[redacted], 0x[redacted] }
```

Comissioning.h

DeviceEUI: 0xAA, 0x00, 0xDB, 0xCA, 0x12, 0xEF, 0x11, 0xXX

# Device Configuration

## ** LoRaWAN Key Setting !!

LoRa IoT by CAT

ABP

Comissioning.h

DeviceAddr: 0x12EF11XX

```
115 /*!
116  * When set to 1 DevAdd is LORAWAN_DEVICE_ADDRESS
117  * When set to 0 DevAdd is automatically generated using
118  *          a pseudo random generator seeded with a value derived from
119  *          BoardUniqueId value
120  */
121 #define STATIC_DEVICE_ADDRESS                       1
122 /*!
123  * Device address on the network (big endian)
124  *
125  * \remark see STATIC_DEVICE_ADDRESS comments
126  */
127 #define LORAWAN_DEVICE_ADDRESS                      ( uint32_t )0x[redacted]
128
129 /*!
130  * AES encryption/decryption cipher network session key
131  */
132 #define LORAWAN_NWKSKEY                             { 0x28, 0xAE, 0xD2, 0x2B, 0x7E, 0x15, 0x16, 0xA6, 0x09, 0xCF, 0xAB, 0xF7, 0x15, 0x88, 0x4F, 0x3C }
133
134 /*!
135  * AES encryption/decryption cipher application session key
136  */
137 #define LORAWAN_APPSKEY                             { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x09 }
```

{ 0x28, 0xAE, 0xD2, 0x2B, 0x7E, 0x15, 0x16, 0xA6, 0x09, 0xCF, 0xAB, 0xF7, 0x15, 0x88, 0x4F, 0x3C }

{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x09 }

# Device Configuration

LoRa IoT by CAT

OTAA

# Device Configuration

## ** LoRaWAN Key Setting !!

LoRa IoT by CAT

OTAA

```
74   * When set to 1 the application uses the Over-the-Air activation procedure
75   * When set to 0 the application uses the Personalization activation procedure
76   */
77  #define OVER_THE_AIR_ACTIVATION                     1
78
79  /*!
80   * Indicates if the end-device is to be connected to a private or public network
81   */
82  #define LORAWAN_PUBLIC_NETWORK                      true
83
84  /*!
85   * When set to 1 DevEui is LORAWAN_DEVICE_EUI
86   * When set to 0 DevEui is automatically generated by calling
87   *         BoardGetUniqueId function
88   */
89  #define STATIC_DEVICE_EUI                           1
90
91  /*!
92   * Mote device IEEE EUI (big endian)
93   *
94   * \remark see STATIC_DEVICE_EUI comments
95   */
96  #define LORAWAN_DEVICE_EUI                          { 0xAA, 0x00, 0xDB, 0xCA, 0x[redacted], 0xEF, 0x[redacted], 0x[redacted] }
```

Comissioning.h

DeviceEUI: 0xAA, 0x00, 0xDB, 0xCA, 0x12, 0xEF, 0x11, 0xXX

# Device Configuration

** LoRaWAN Key Setting !!

LoRa IoT by CAT

OTAA

Comissioning.h

```
/*!
 * Application IEEE EUI (big endian)
 */
#define LORAWAN_APPLICATION_EUI                     { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6 }
/*!
 * AES encryption/decryption cipher application key
 */
#define LORAWAN_APPLICATION_KEY                     { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x19 }
#if( OVER_THE_AIR_ACTIVATION == 0 )
```

{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6}

{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x09 }

# Device Configuration

** Please check payload format!!

LoRa IoT by CAT

```
60 /*!
61  * CAYENNE_LPP is myDevices Application server.
62  */
63 #define CAYENNE_LPP
```

main.c

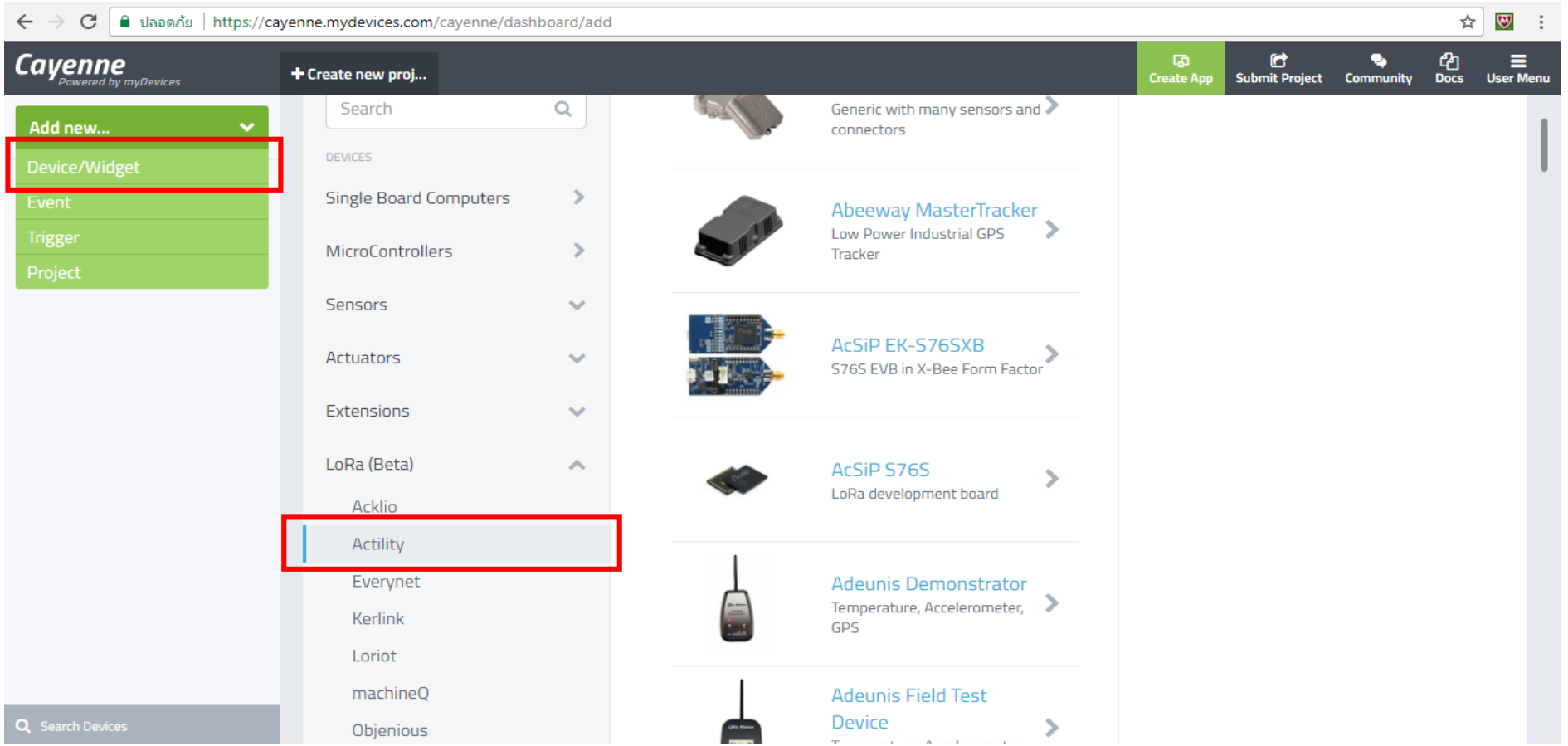
```
#ifdef CAYENNE_LPP
  uint8_t cchannel=0;
  temperature = ( int16_t )( sensor_data.temperature * 10 );     /* in °C * 10 */
  pressure    = ( uint16_t )( sensor_data.pressure * 100 / 10 );  /* in hPa / 10 */
  humidity    = ( uint16_t )( sensor_data.humidity * 2 );        /* in %*2     */
  uint32_t i = 0;
  int16_t Bat_Display;

  batteryLevel = HW_GetBatteryLevel( );                     /* 1 (very low) to 254 (fully charged) */
  Bat_Display = (batteryLevel*10000/254);
  Bat_Display = 9712;
  AppData->Port = LPP_APP_PORT;

  *IsTxConfirmed =  LORAWAN_CONFIRMED_MSG;
  AppData->Buff[i++] = cchannel++;
  AppData->Buff[i++] = LPP_DATATYPE_BAROMETER;
  AppData->Buff[i++] = ( pressure >> 8 ) & 0xFF;
  AppData->Buff[i++] = pressure & 0xFF;
  AppData->Buff[i++] = cchannel++;
  AppData->Buff[i++] = LPP_DATATYPE_TEMPERATURE;
  AppData->Buff[i++] = ( temperature >> 8 ) & 0xFF;
  AppData->Buff[i++] = temperature & 0xFF;
  AppData->Buff[i++] = cchannel++;
  AppData->Buff[i++] = LPP_DATATYPE_HUMIDITY;
  AppData->Buff[i++] = humidity & 0xFF;
#if !defined(REGION_US915) && !defined(REGION_US915_HYBRID)
  AppData->Buff[i++] = cchannel++;
  AppData->Buff[i++] = LPP_DATATYPE_DIGITAL_INPUT;
  AppData->Buff[i++] = Count_SW_up;//batteryLevel*100/254;
  AppData->Buff[i++] = cchannel++;
  AppData->Buff[i++] = LPP_DATATYPE_DIGITAL_OUTPUT;
```

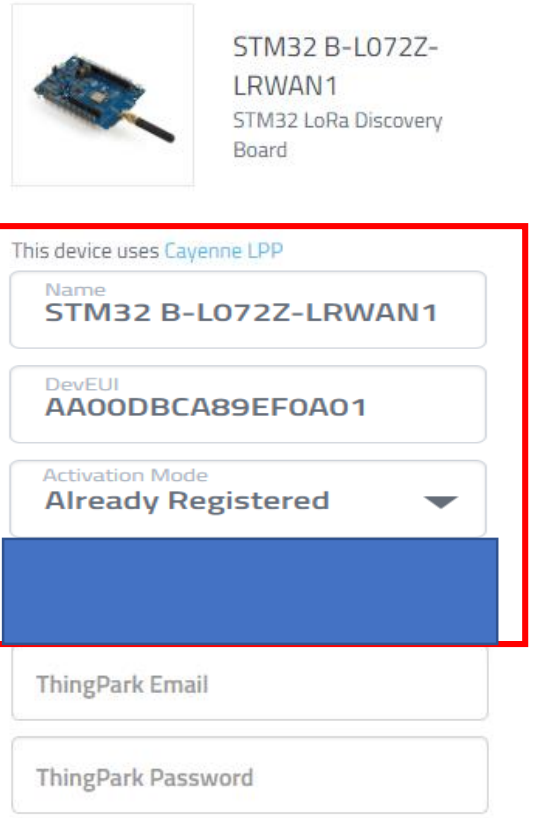
# Application Server

# Example Application



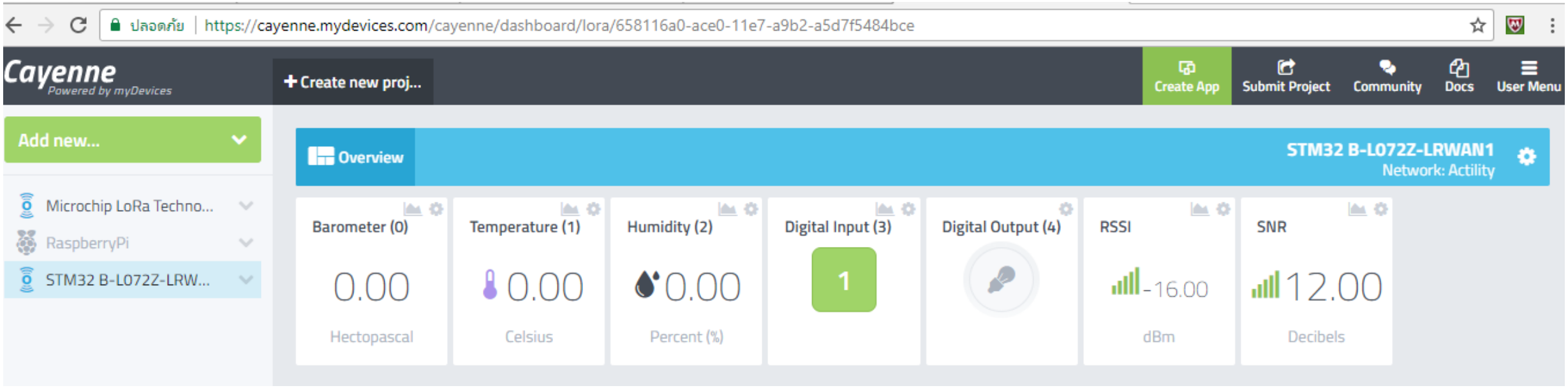

**https://cayenne.mydevices.com/cayenne/dashboard/add**

# Example Application




**https://cayenne.mydevices.com/cayenne/dashboard/add**

# Example Application




**https://cayenne.mydevices.com/cayenne/dashboard/add**

# Summary

## Document

- https://loraiot.cattelecom.com

**Support:** ***LoRa Alliance, NBTC, LoRa IoT Platform Manual***

**Device**

- https://www.st.com

**Application Note: Examples of AT commands on I-CUBE-LRWAN**

- https://mydevices.com/cayenne/docs/lora/

# โจทย์ประชันทักษะ Hardware Programming

LoRa IoT by CAT

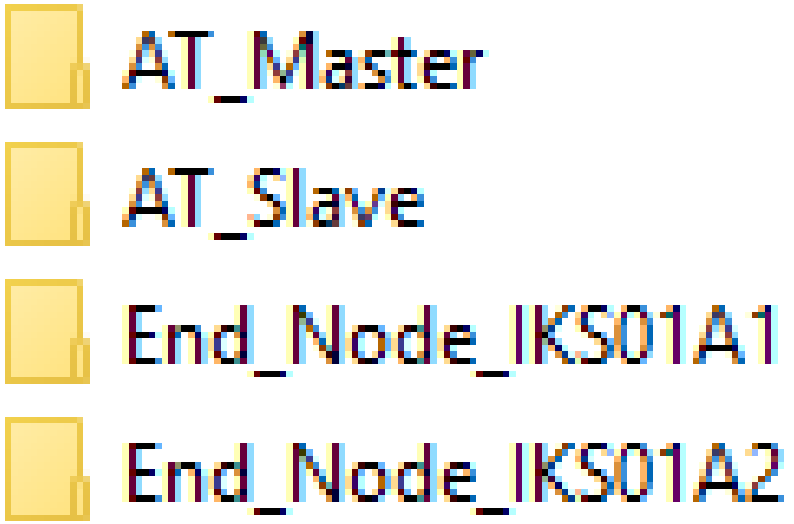
| Brand | Spec | Download |
|---|---|---|
| STMicroelectronics [Starter Kit] ✓ Verified | STM32 B-L072Z-LRWAN1 | Manual for STM32 |

Operation Mode:

- Programmable (Development toolchains, Embedded Platform and Arduino Programming)
- LoRa Modem (AT Command)

Feature:

- Support AS923 Frequency 920-925
- CMWX1ZZABZ-091 LoRa® module (Murata)
- SMA and U.FL RF interface connectors
- Including 50 Ohm SMA RF antenna
- On-board ST-LINK/V2-1 supporting USB re-enumeration capability




**STM32CubeExpansion_LRWAN_V1.1.5\Projects\Multi\Applications\LoRa**

# โจทย์ประชันทักษะ Hardware Programming

LoRa IoT by CAT

## ข้อกำหนด

- **Project: STM32CubeExpansion_LRWAN_V1.1.5\Projects\Multi\Applications\LoRa**
- **Operation: AT_Slave**
- **Activation Mode: OTAA**
- **LoRa : Class A**
- **Account: TGR13_XX**

DeviceEUI: AA-00-DB-CA-12-EF-11-XX

Application EUI : 16-28-AE-2B-7E-15-D2-A6

Application Key: 16-28-AE-2B-7E-15-D2-A6-AB-F7-CF-4F-3C-15-88-09

# โจทย์ประชันทักษะ Hardware Programming

| หัวข้อการประชันทักษะ | รายการตัดสิน | คะแนน | หมายเหตุ |
|---|---|---|---|
| เชื่อมต่อ เข้าสู่ระบบได้<br>Operation Mode: AT Command<br>Activation Mode: OTAA | แสดงสถานะการเชื่อมต่อด้วยคำสั่ง AT Command | 1 – เชื่อมต่อได้<br>0 – เชื่อมต่อไม่ได้ | |
| | แสดง Log การส่งข้อมูลบน Portal LoRa IoT CAT | 1 – เชื่อมต่อได้<br>0 – เชื่อมต่อไม่ได้ | |
| สื่อสารส่งข้อมูลขา Uplink | ส่งค่า **เลขทีม** ไปยัง<br>Application Server Cayenne ได้ | 1 – ส่งค่าเลขทีม ได้<br>0 – ส่งค่าเลขทีม ไม่ได้ | |
| | ส่งค่า **อุณหภูมิที่กำหนดให้** ไปยัง<br>Application Server Cayenne ได้ | 1 – ส่งค่า Temp ได้<br>0 – ส่งค่า Temp ไม่ได้ | |
| สื่อสารรับข้อมูลขา Downlink | ส่งค่า Downlink จาก Portal LoRa IoT CAT<br>มายัง อุปกรณ์ได้ | 1 – รับค่า ได้<br>0 – รับค่า ไม่ได้ | คอม 2 เครื่อง<br>(เครื่องส่ง, เครื่องต่ออุปกรณ์) |

# Q&A