



LoRaWAN
For
Embedded System Developer

บริษัท กสท โทรคมนาคม จำกัด (มหาชน)
99 หมู่ 3 ถนนแจ้งวัฒนะ แขวงทุ่งสองห้อง เมืองพะเยา 10210-0298
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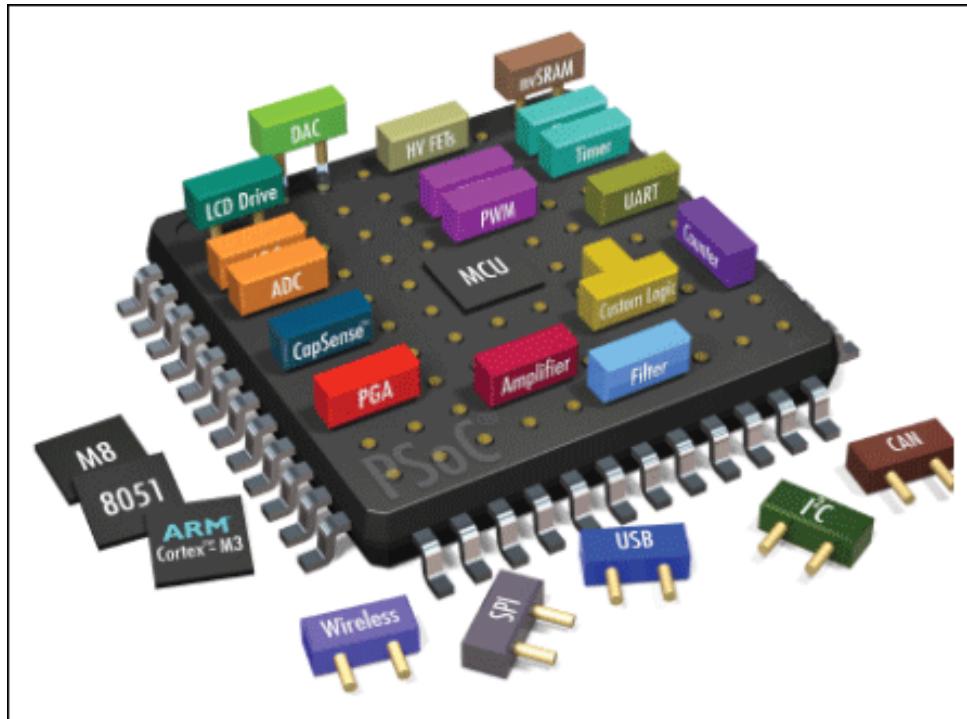
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- LoRaWAN Concept
- LoRaWAN IoT by CAT Telecom

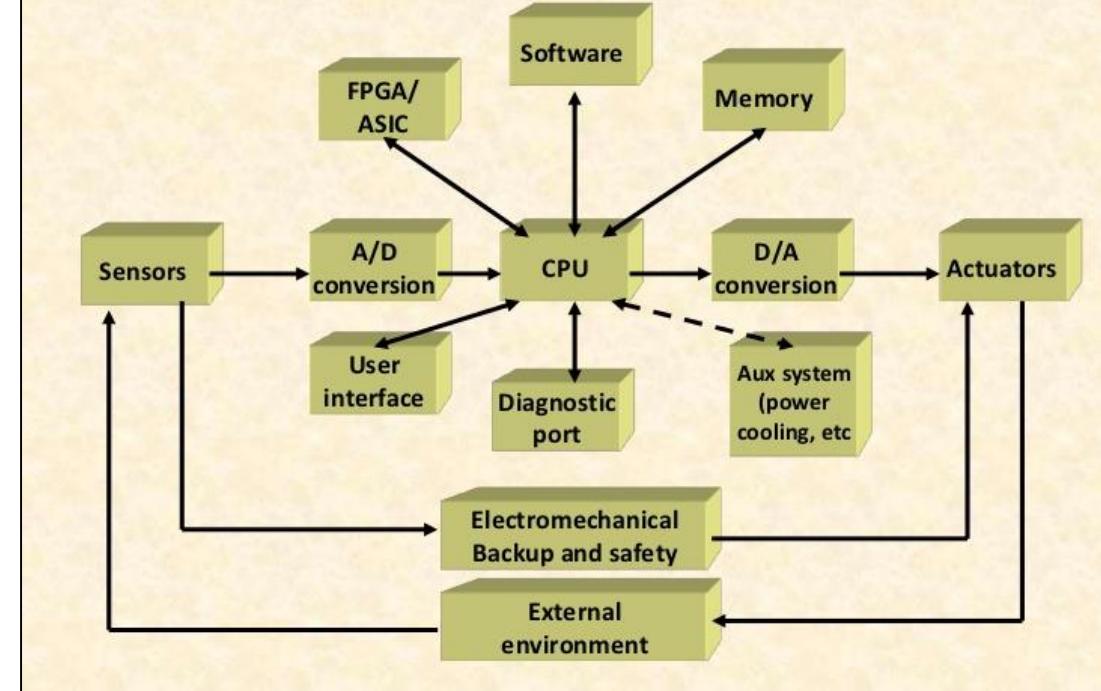
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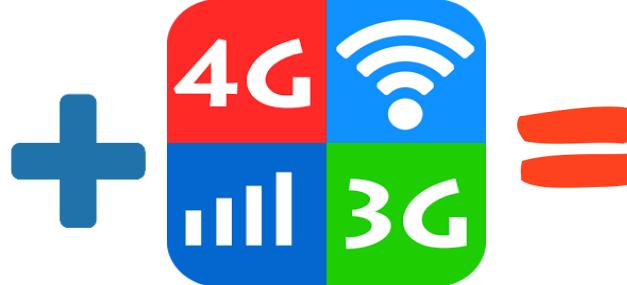
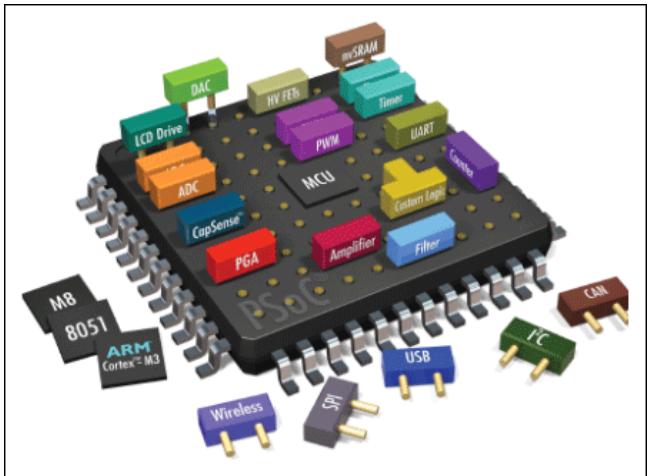
IoT Concept



Embedded system components



IoT Concept



Network Concept



Discussion



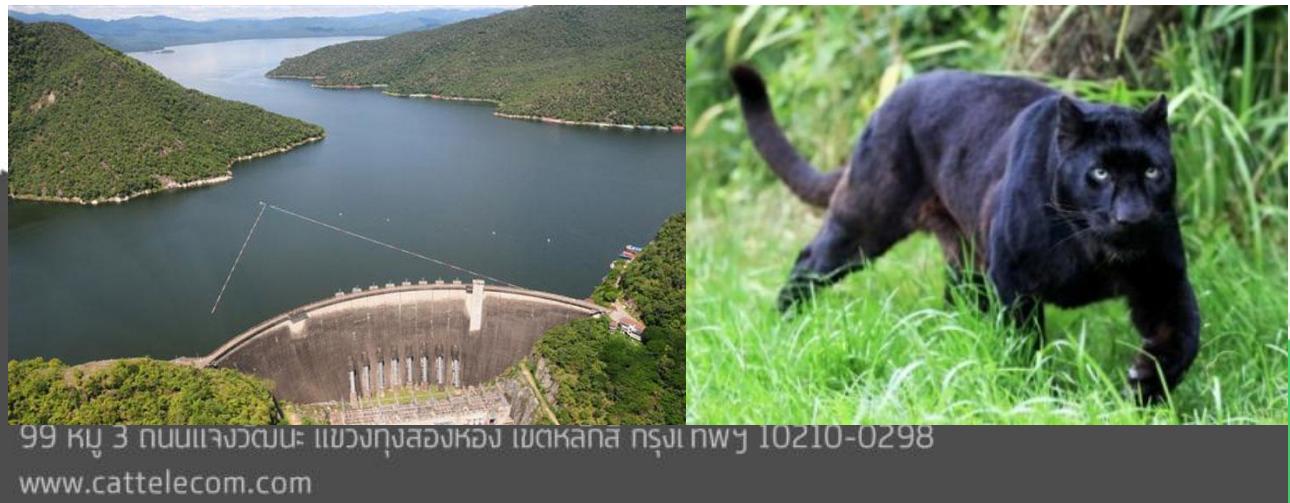
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TOPIC

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LoRaWAN Network

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Network Operators

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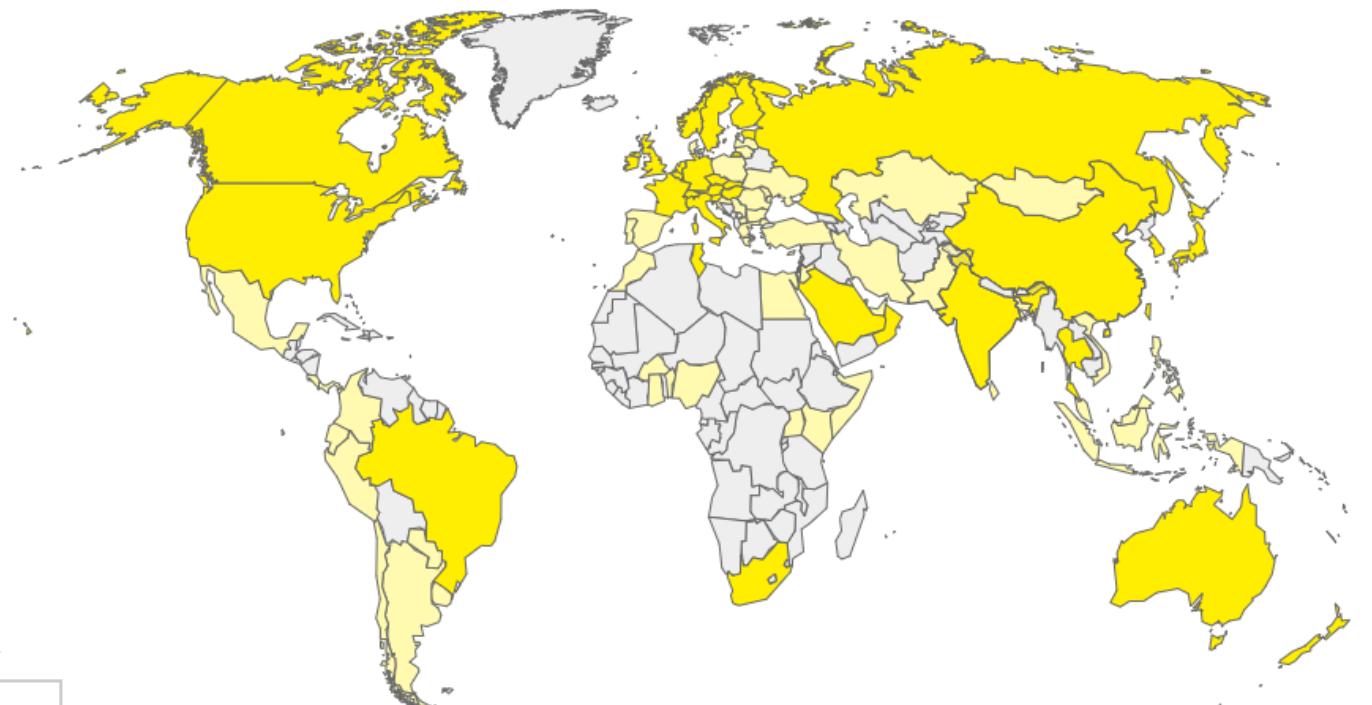
Alliance Member Operators

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Countries operating in

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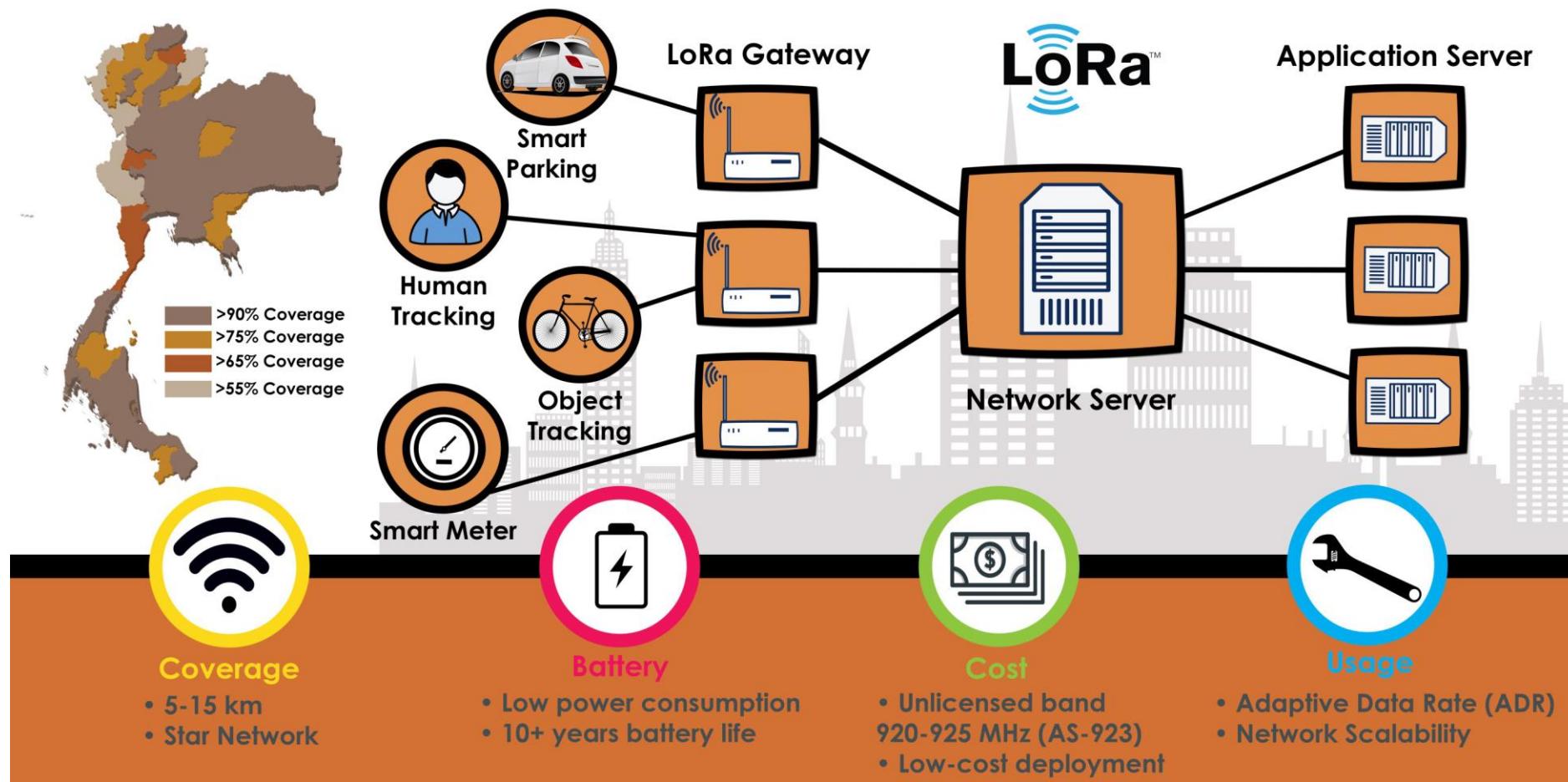
Countries with LoRaWAN Deployments



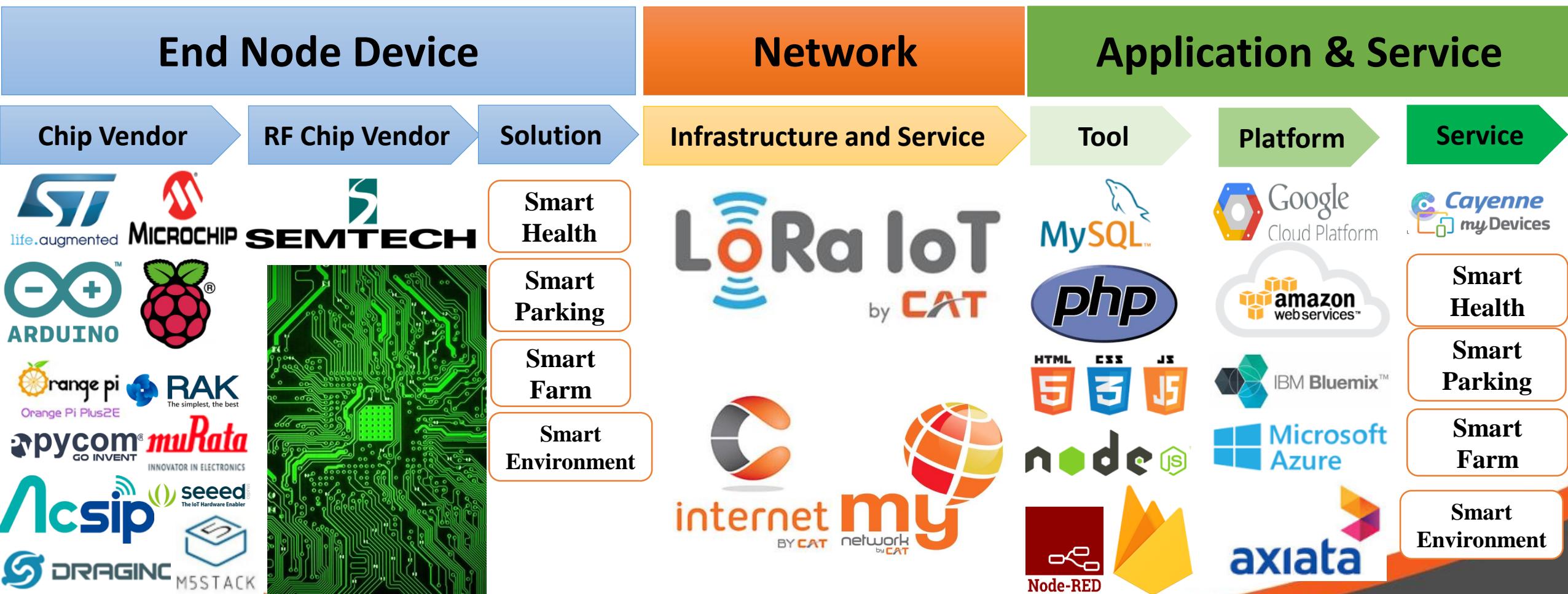
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LoRaWAN Network

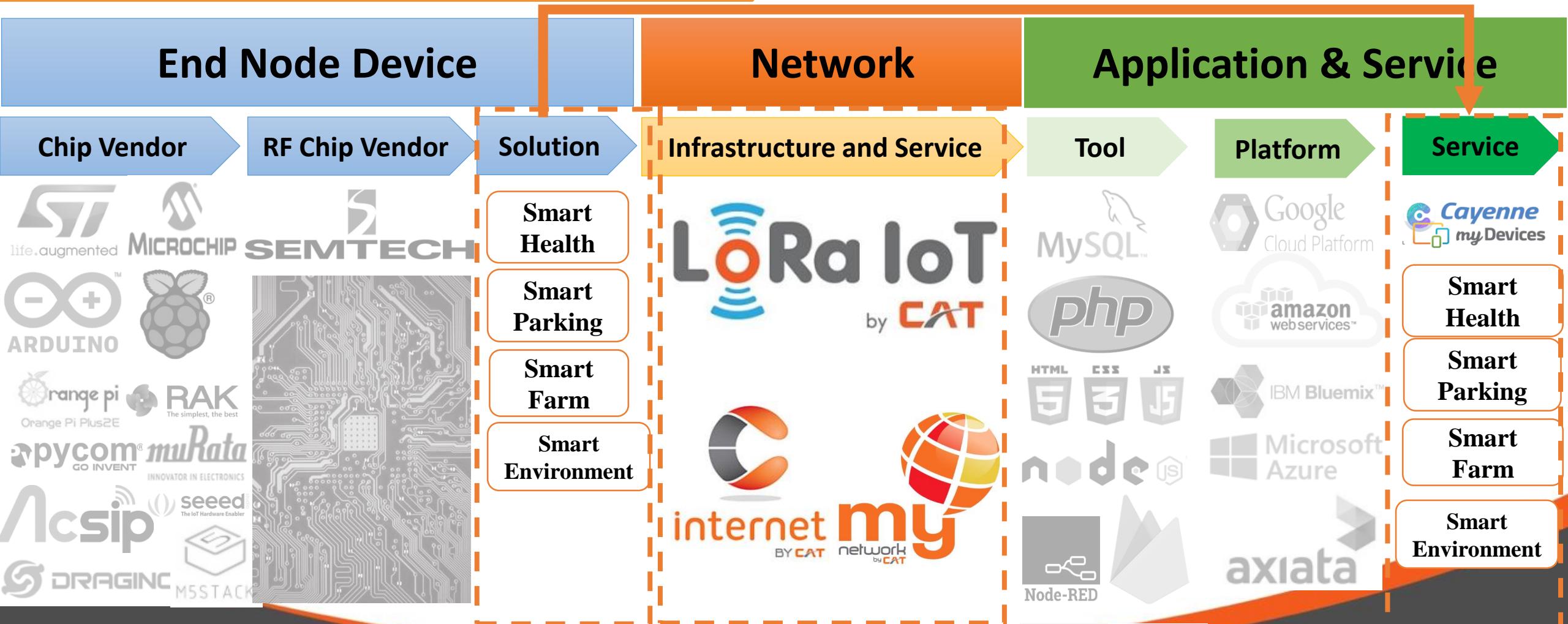
Topology



IoT Value Chain



IoT Value Chain



LORA BASIC CONCEPT

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

LORA BASIC CONCEPT

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Frequency

Regulator



In Thailand



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	<ul style="list-style-type: none"> • Automated Meter Reading • Building Automation • Wireless Alarm and Security Systems • Industrial Monitoring and Control • Long range precision farming 	<ul style="list-style-type: none"> • Automated Meter Reading • Building Automation • Wireless Alarm and Security Systems • Industrial Monitoring and Control • Long range precision farming 	<ul style="list-style-type: none"> • Home automation • Tracking applications • Wearables & sports/fitness sensors • Radio-controlled toys & drones • Smart watches & beacons

Frequency



With AS923 Mhz ISM Band



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

Options for Target 'mlm32I07x01'

Device | Target | Output | Listing | User | C/C++ | Asm | Linker | Debug | Utilities

Preprocessor Symbols

Define: STM32L072xx,USE_B_L072Z_LRWAN1,USE_HAL_DRIVER,REGION_AS923

Undefine:

Language / Code Generation

Execute-only Code Strict ANSI C Warnings: All Warnings

Optimization: Level 3 (-O3) Enum Container always int

Optimize for Time Plain Char is Signed

Split Load and Store Multiple Read-Only Position Independent

One ELF Section per Function Read-Write Position Independent Thumb Mode

No Auto Includes C99 Mode

```

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

Channel

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

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	923.20 923.40	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

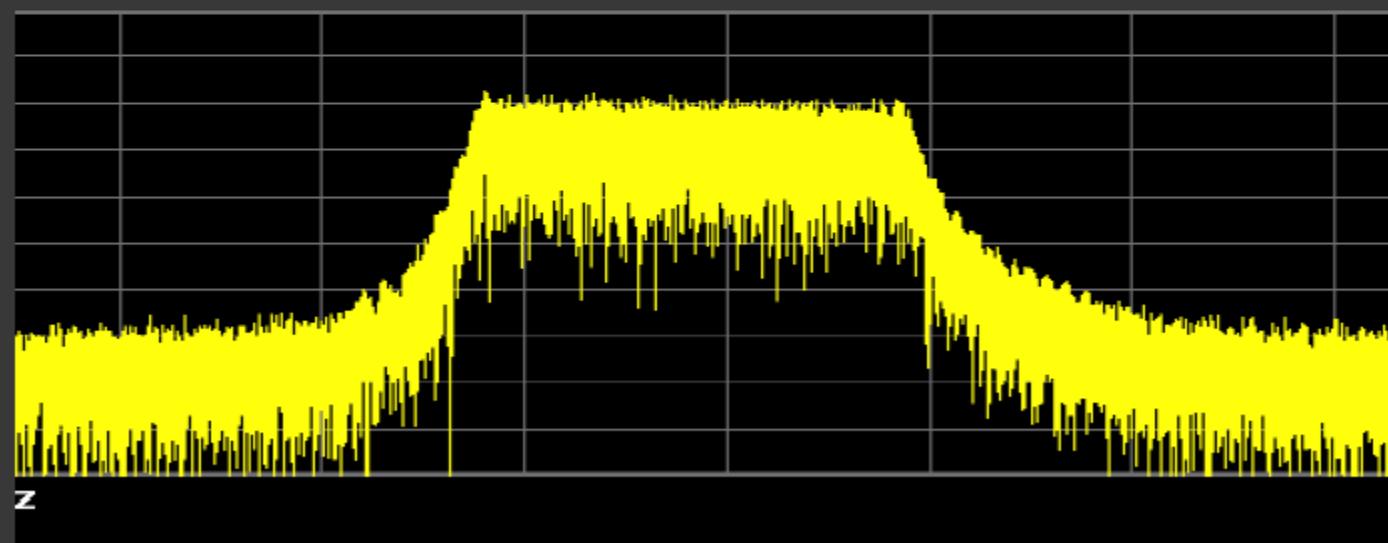
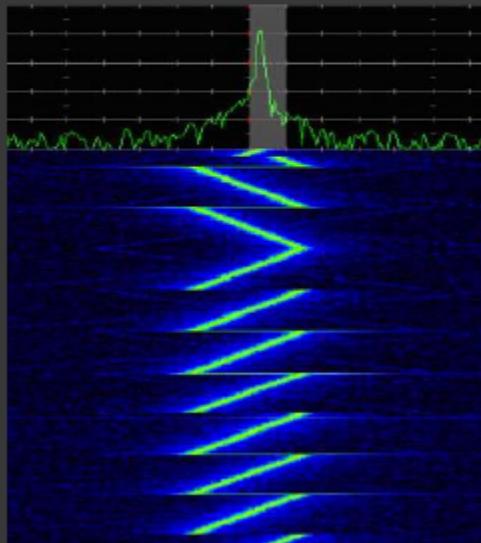
LORA BASIC CONCEPT

- Frequency
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Data Rate

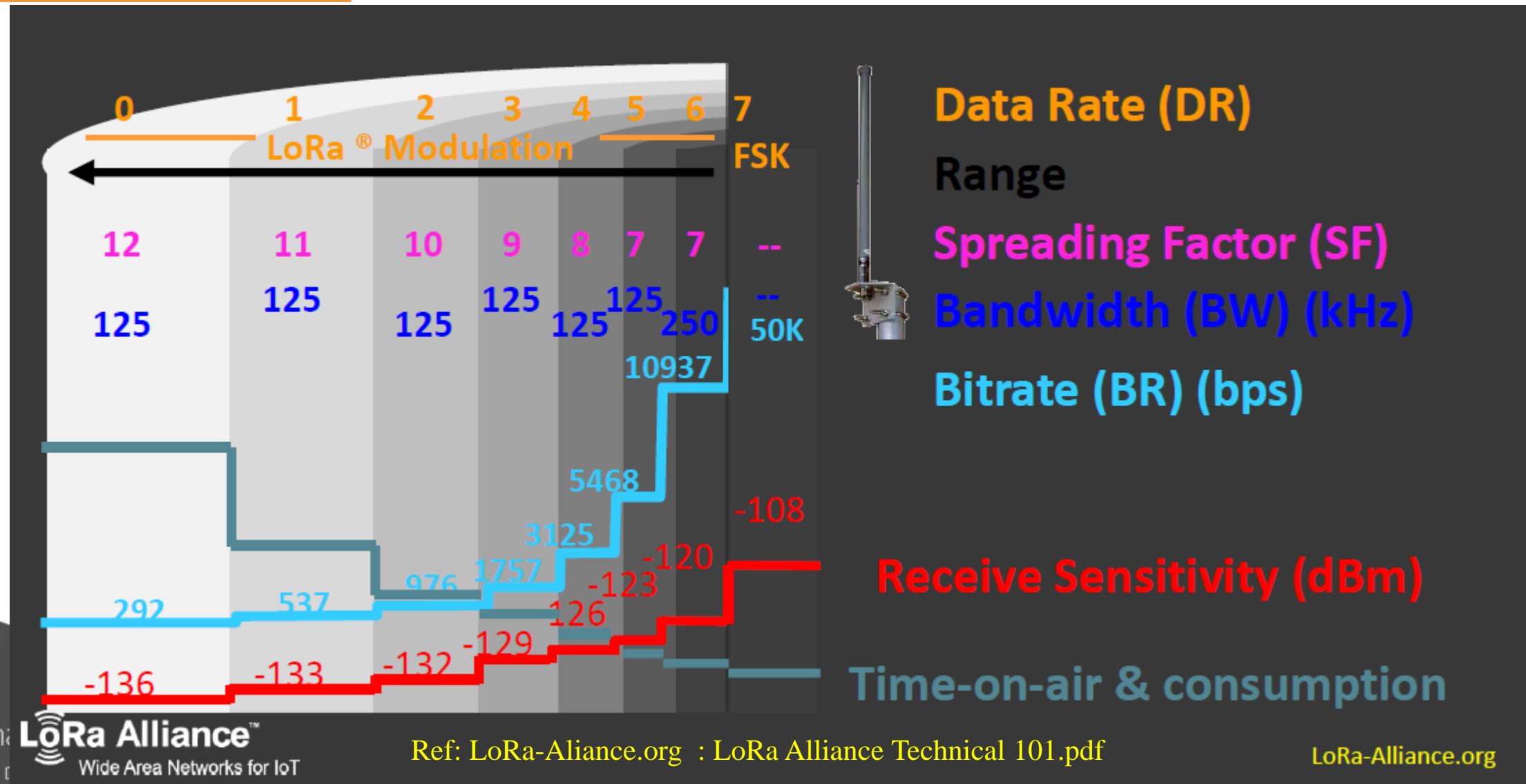
Related Parameter

- 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



Data Rate

Related Parameter



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).

LoRaWAN 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

เครื่องวิทยุคมนาคม ที่ไม่ใช้ประเทา Radio Frequency Identification: RFID
ซึ่งใช้คลื่นความถี่ย่าน 920-925 เมกะเฮิรตซ์

2.3.2 การส่งข้อมูลผ่านคลื่นความถี่ด้วยการแฟลสเปกตรัม (Frequency Hopping Spread Spectrum : FHSS)

นิยาม การส่งข้อมูลผ่านคลื่นความถี่ด้วยการแฟลสเปกตรัม (Frequency Hopping Spread Spectrum : FHSS) หมายถึง การส่งสัญญาณคลื่นความถี่ที่ตรงกับเวลาที่ซ่องความถี่ใช้งานแต่ละช่วงเวลาหนึ่ง เรียกว่า เวลาที่ใช้ซ่องสัญญาณ

ข้อจำกัด การส่งข้อมูลผ่านคลื่นความถี่ด้วยการแฟลสเปกตรัม (Frequency Hopping Spread Spectrum : FHSS) จะต้องแสดงความเป็นไปตามมาตรฐานให้มาตรฐานหนึ่งดังต่อไปนี้

ความกว้างแบบความถี่ของช่องสัญญาณที่ 20 dB (20 dB bandwidth of the hopping channel)	จำนวนช่องสัญญาณ (Hopping Number)	เวลาซ่องสัญญาณคงค้าง (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

2.7.6 AS923 Maximum payload size

Ref: LoRaWAN Regional Parameters 1_0_2

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 (<i>M</i>)		Downlink MAC Payload Size (<i>M</i>)	
	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 E2 - 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) Most energy efficient communication class. Must be supported by all devices.
B ("beacon")	Battery powered actuators Energy efficient communication class for latency controlled downlink. Based on slotted communication synchronized with a network beacon.
C ("continuous")	Main powered actuators Devices which can afford to listen continuously. No latency for downlink communication.

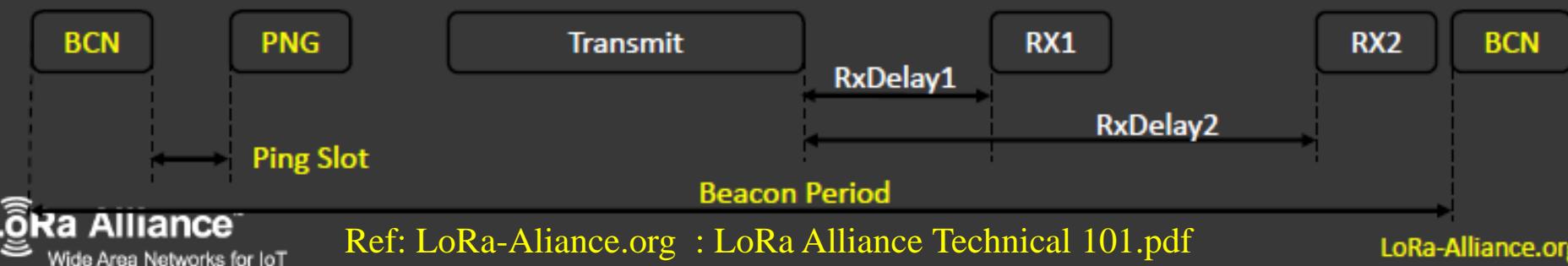
LoRa Class

- 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:



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



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



LORA BASIC CONCEPT

- Frequency
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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

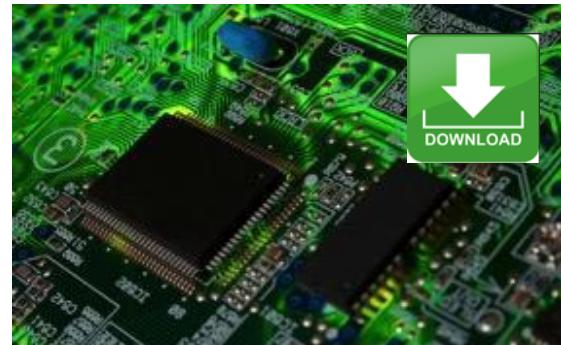
Activation Mode : Over-the-Air Activation (OTAA)

- 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.



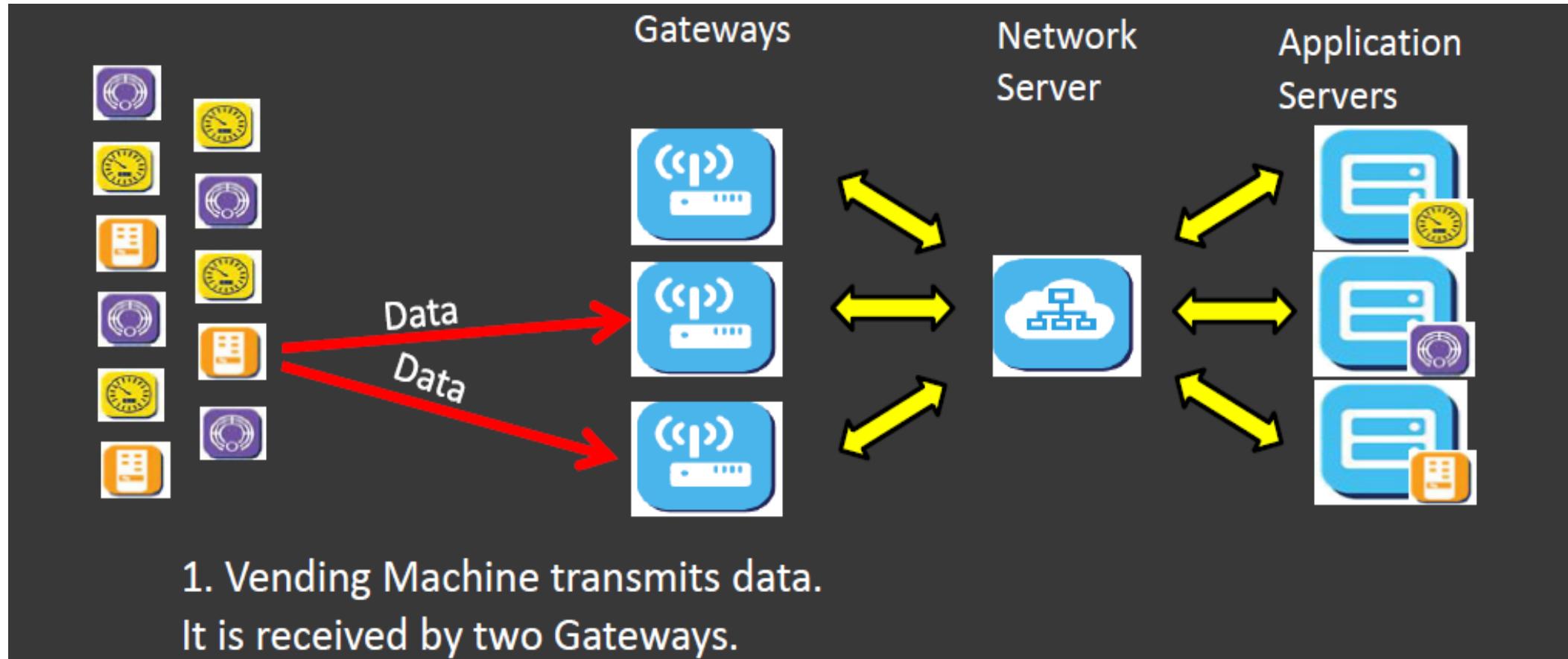
Activation Mode

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

LORA BASIC CONCEPT

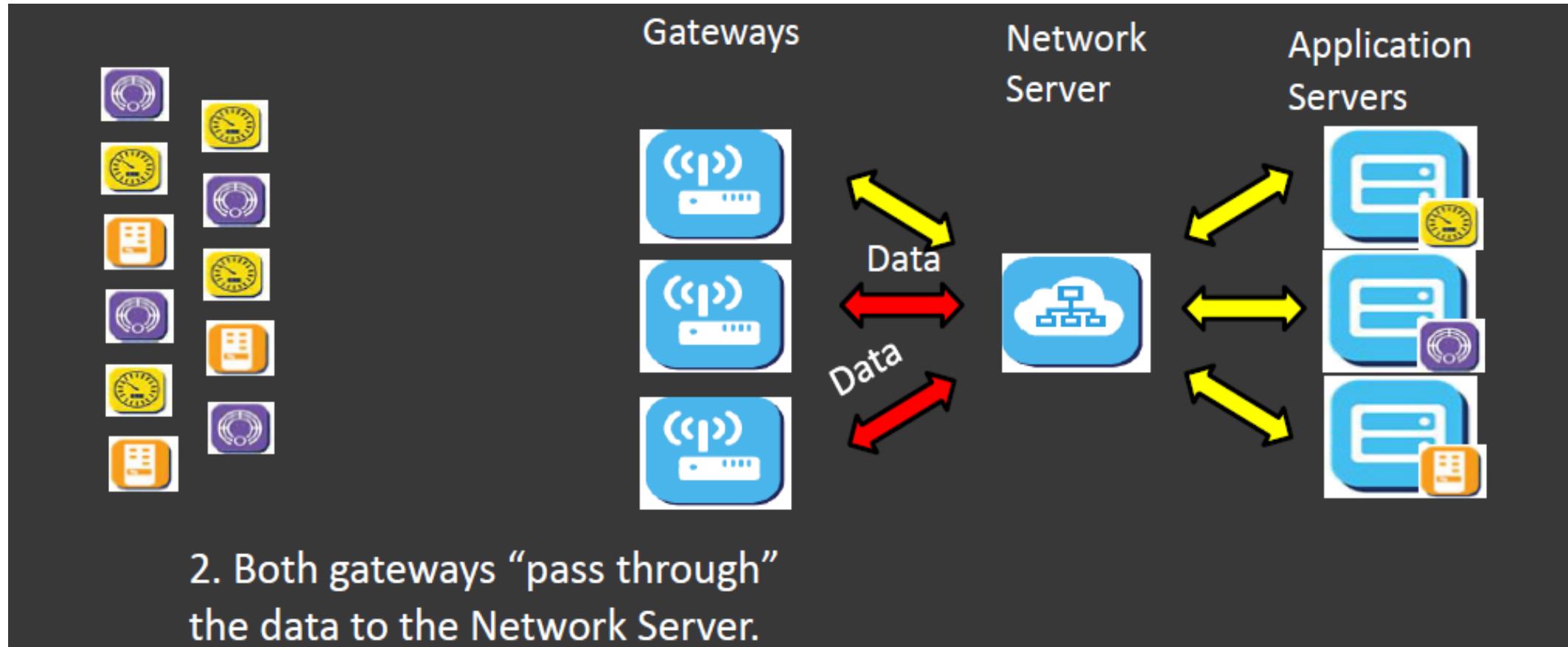
- Frequency
- Channel
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- Configuration

Data Message (Flow & Payload)



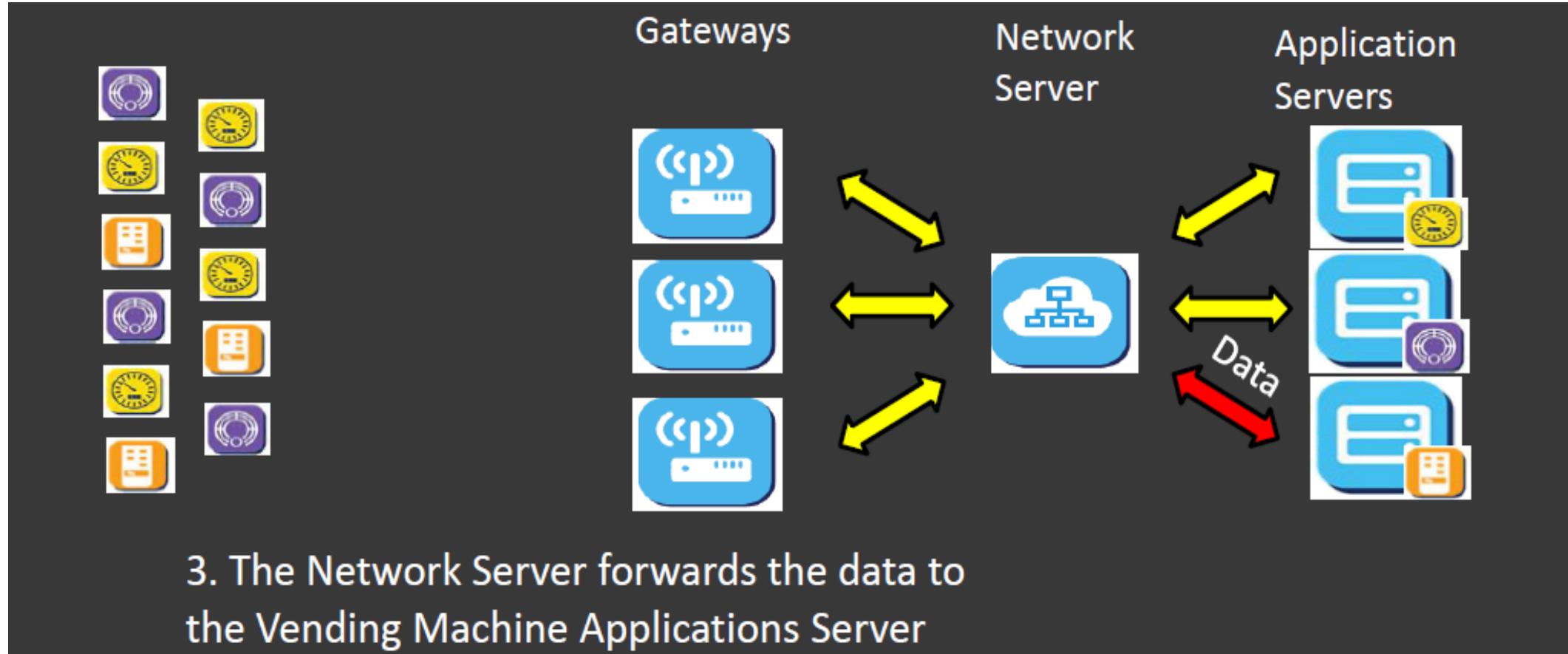
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Data Message (Flow & Payload)



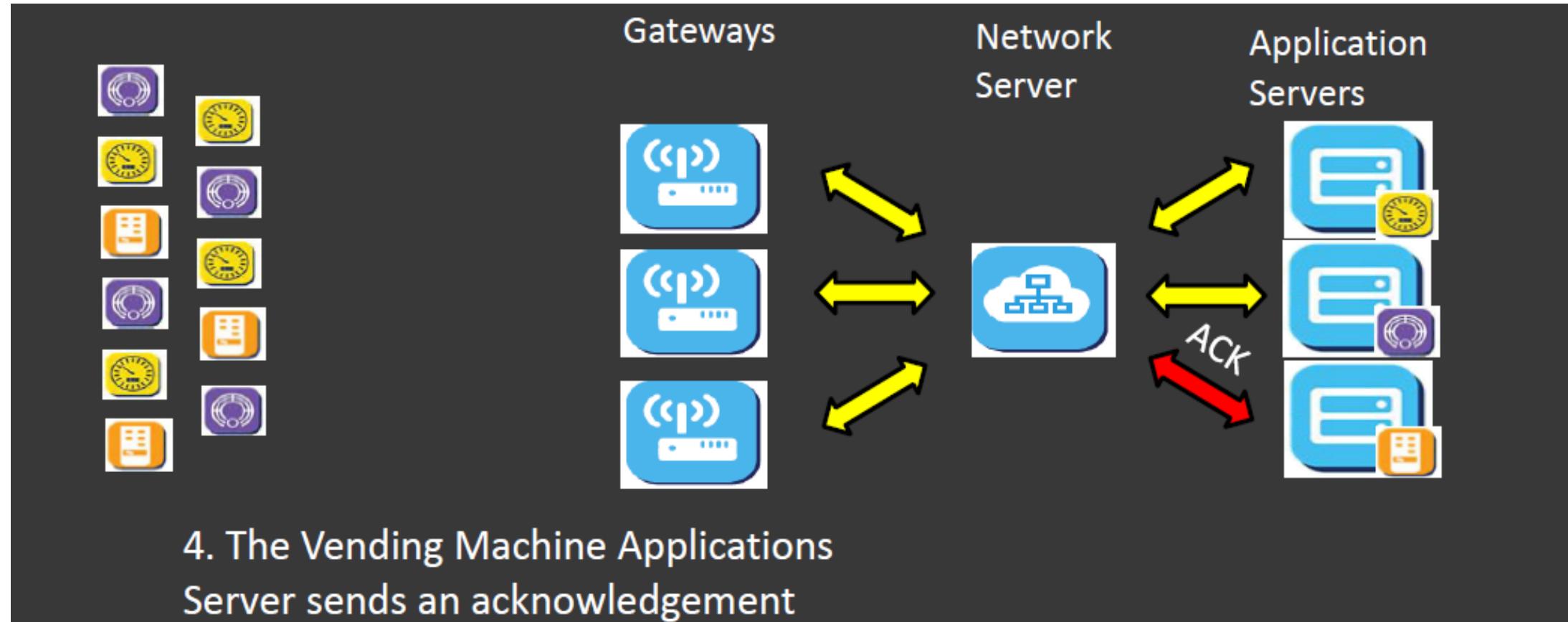
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Data Message (Flow & Payload)



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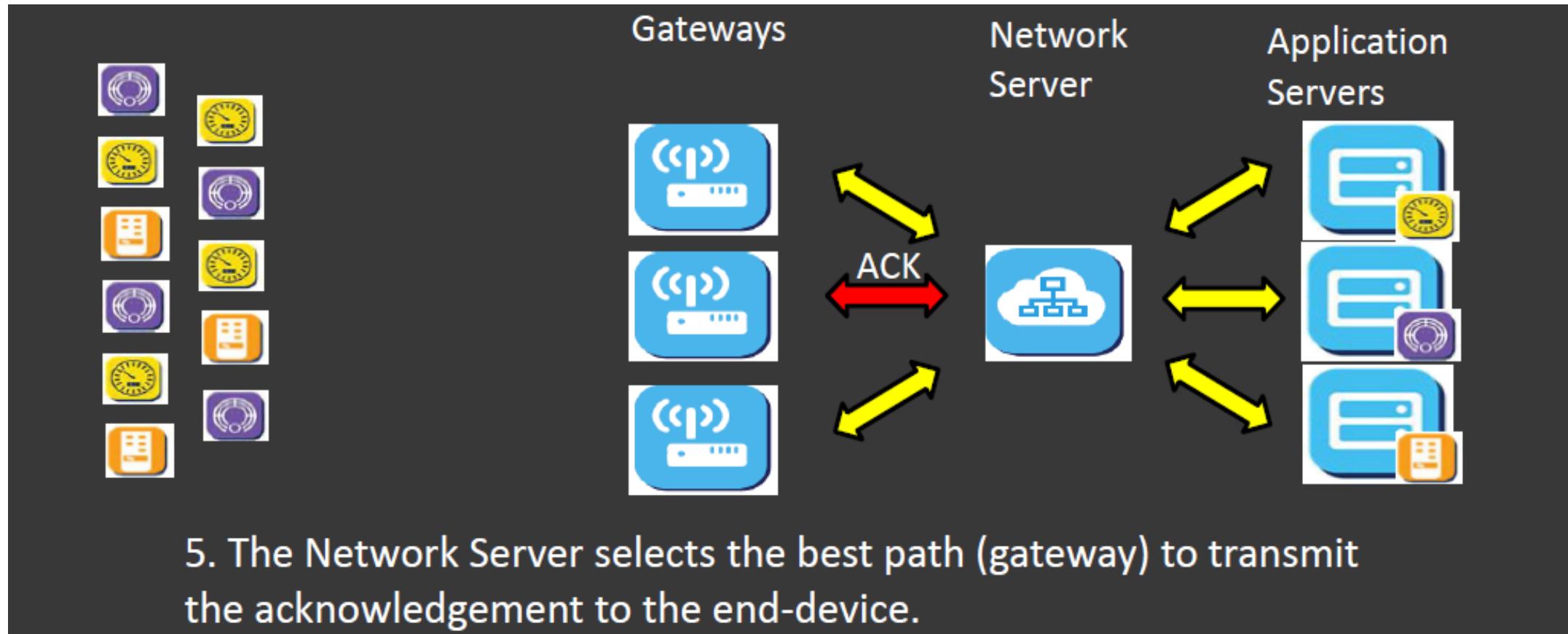
Data Message (Flow & Payload)



4. The Vending Machine Applications
Server sends an acknowledgement

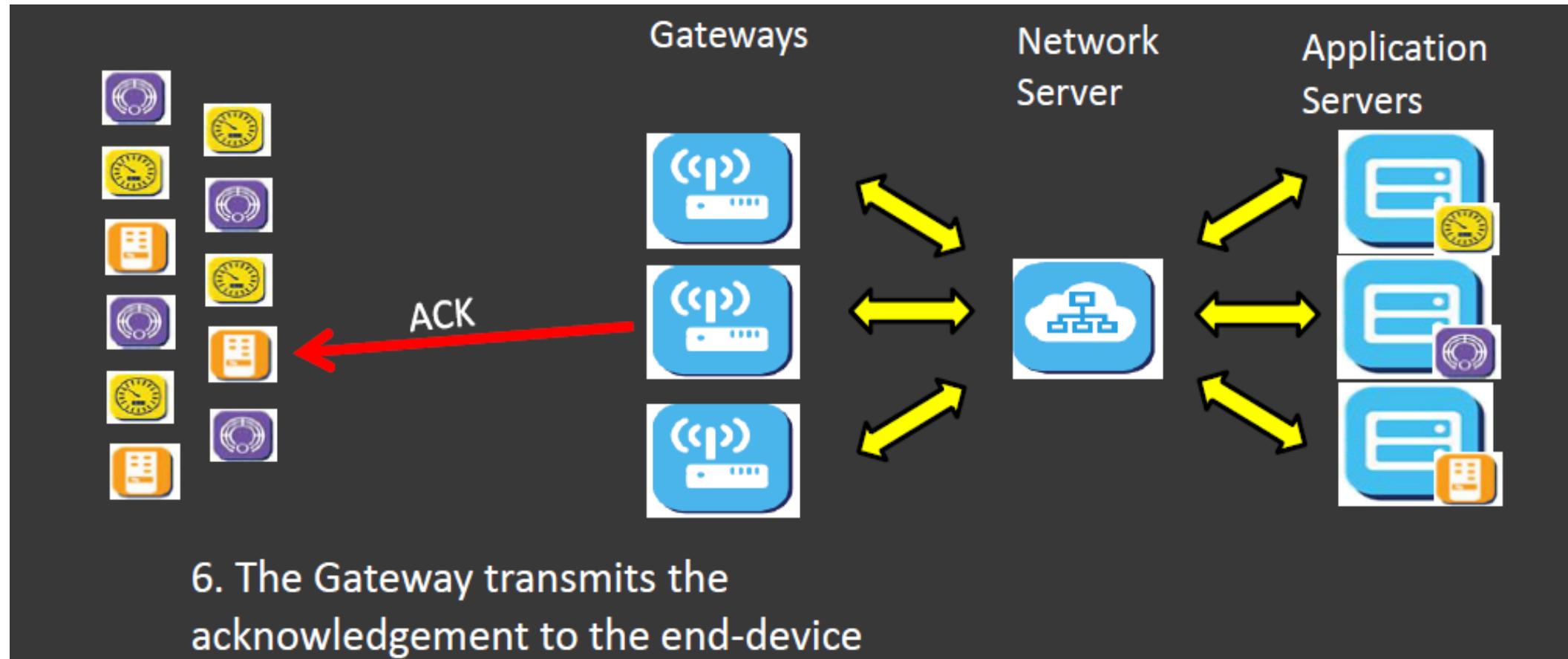
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Data Message (Flow & Payload)



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

Data Message (Flow & Payload)

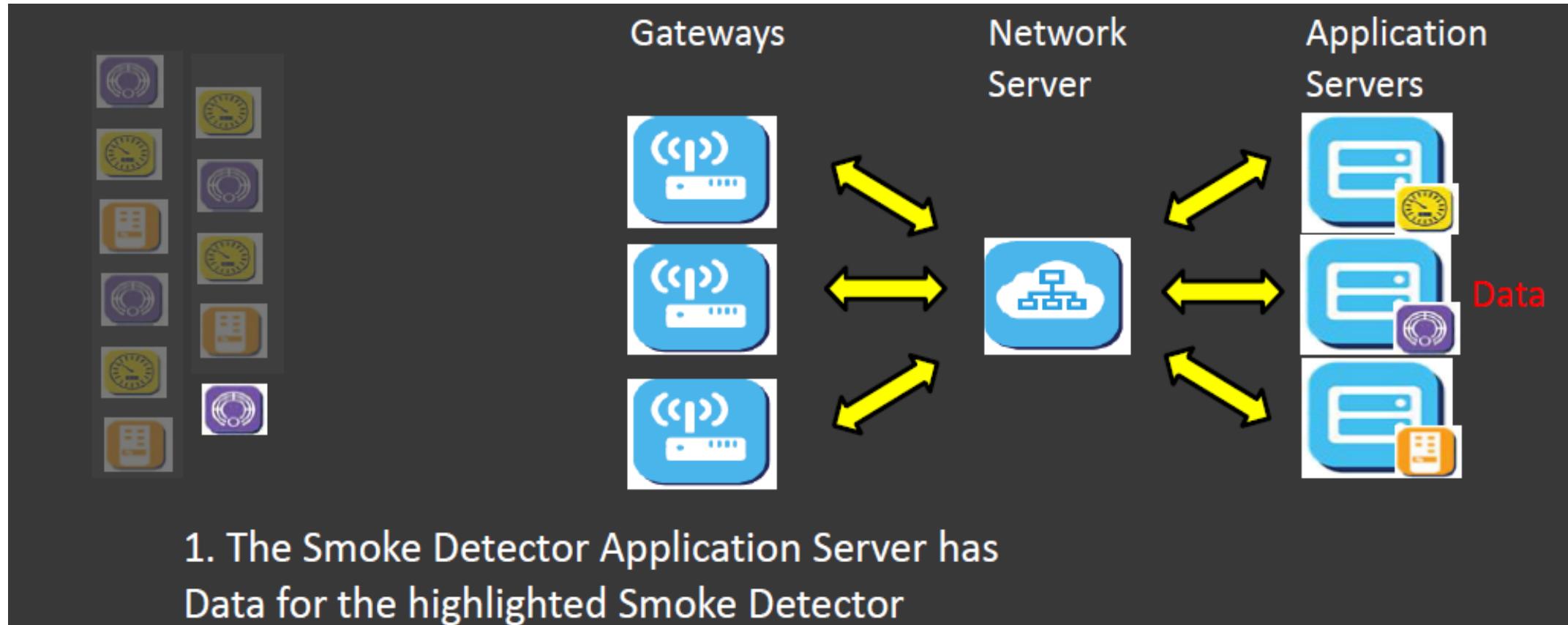


6. The Gateway transmits the acknowledgement to the end-device

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Data Message (Flow & Payload)

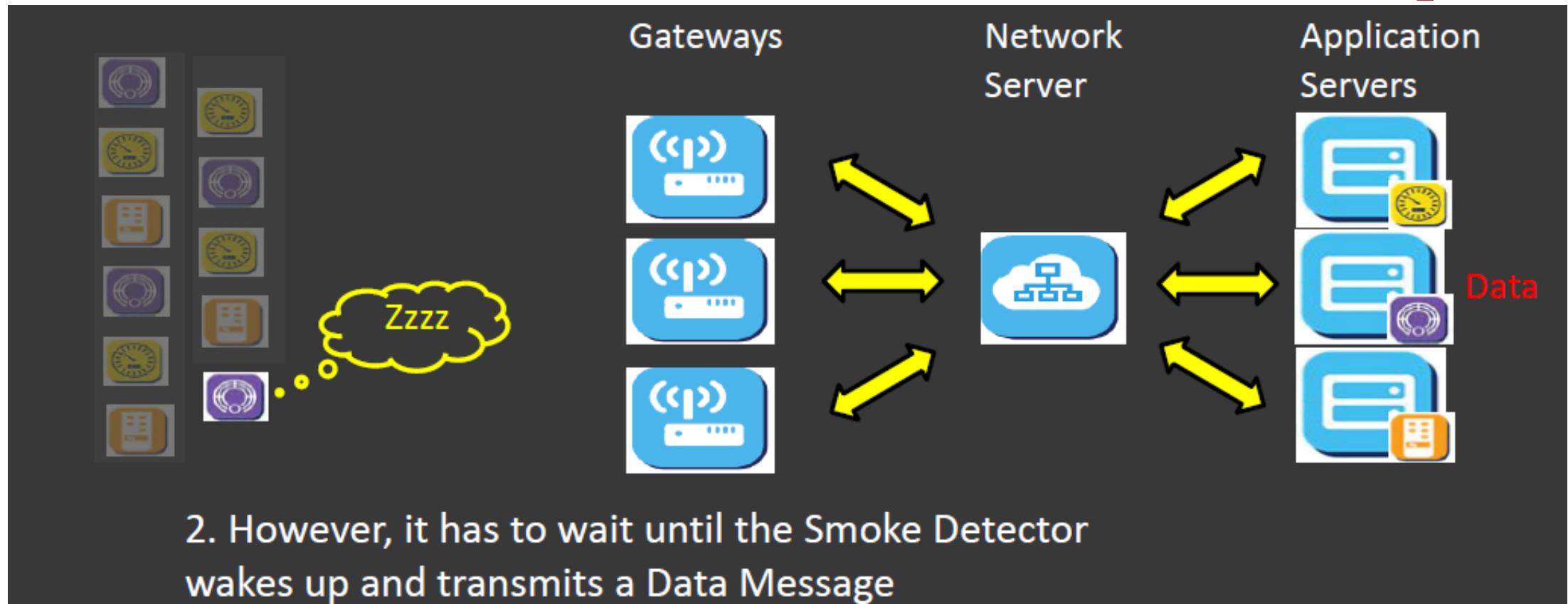
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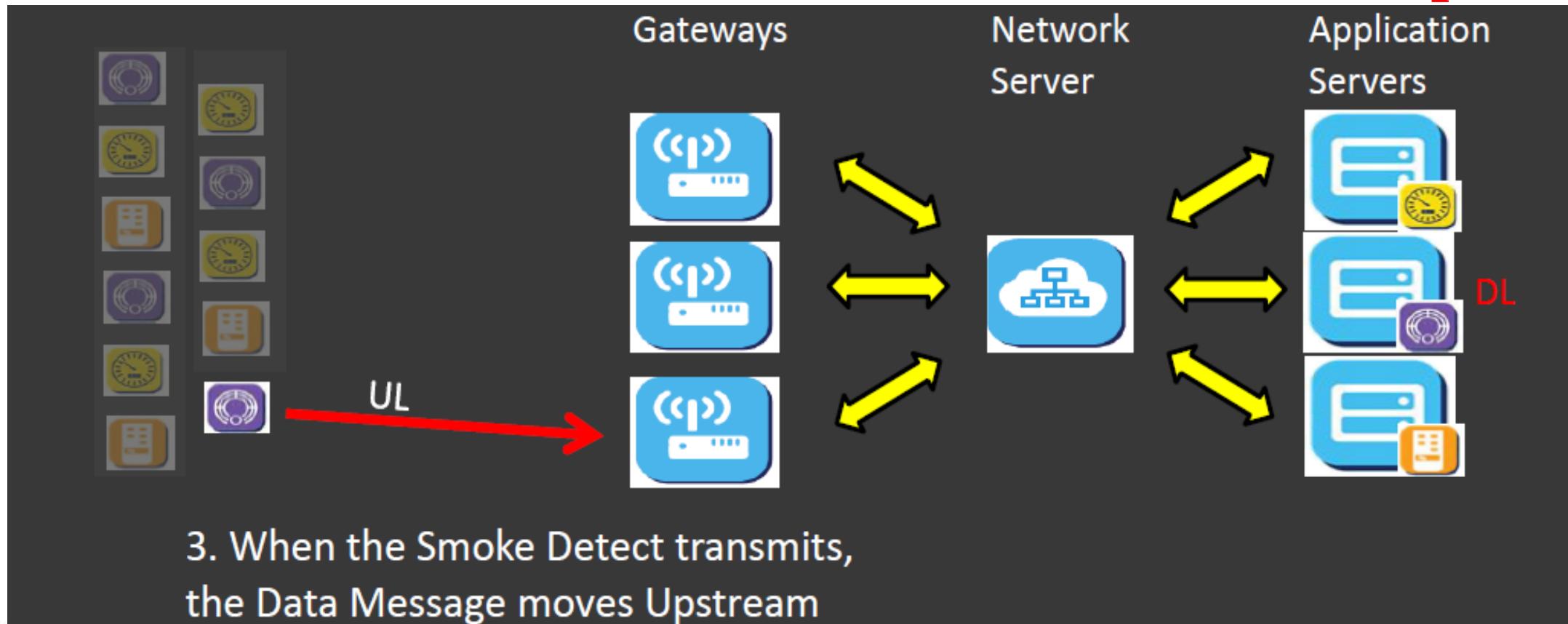
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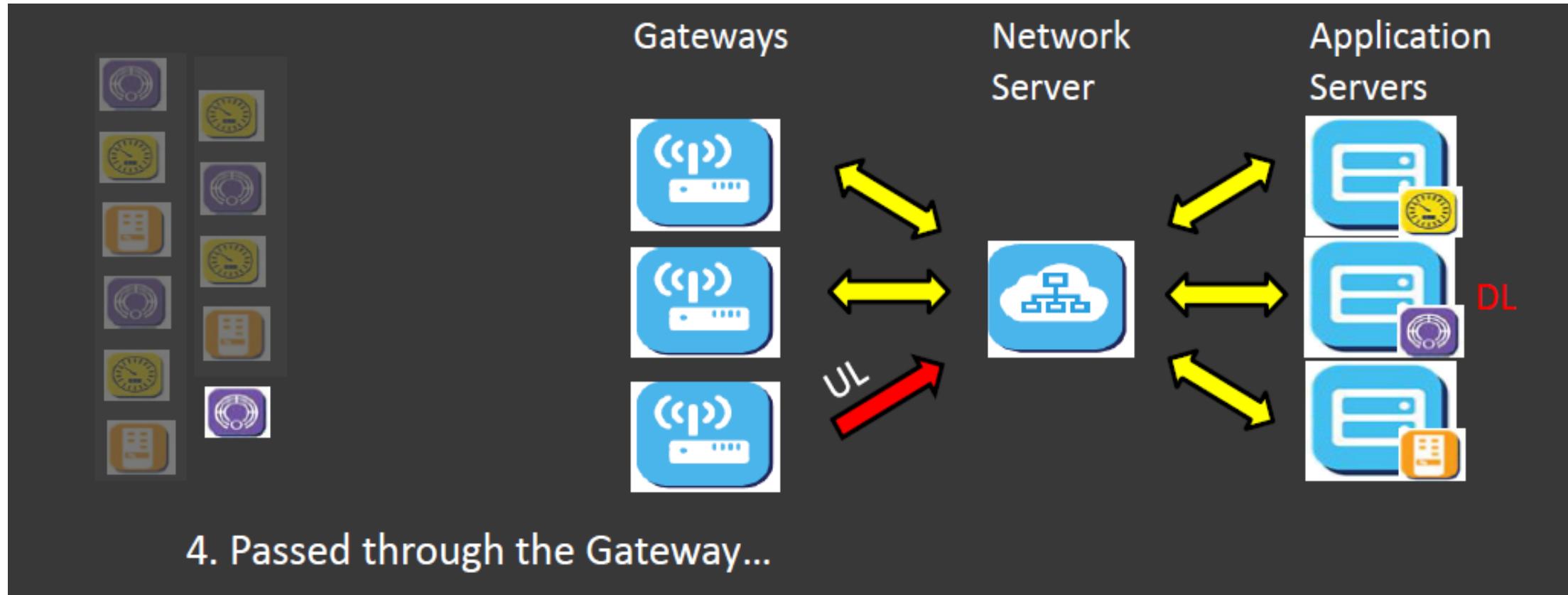
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Data Message (Flow & Payload)

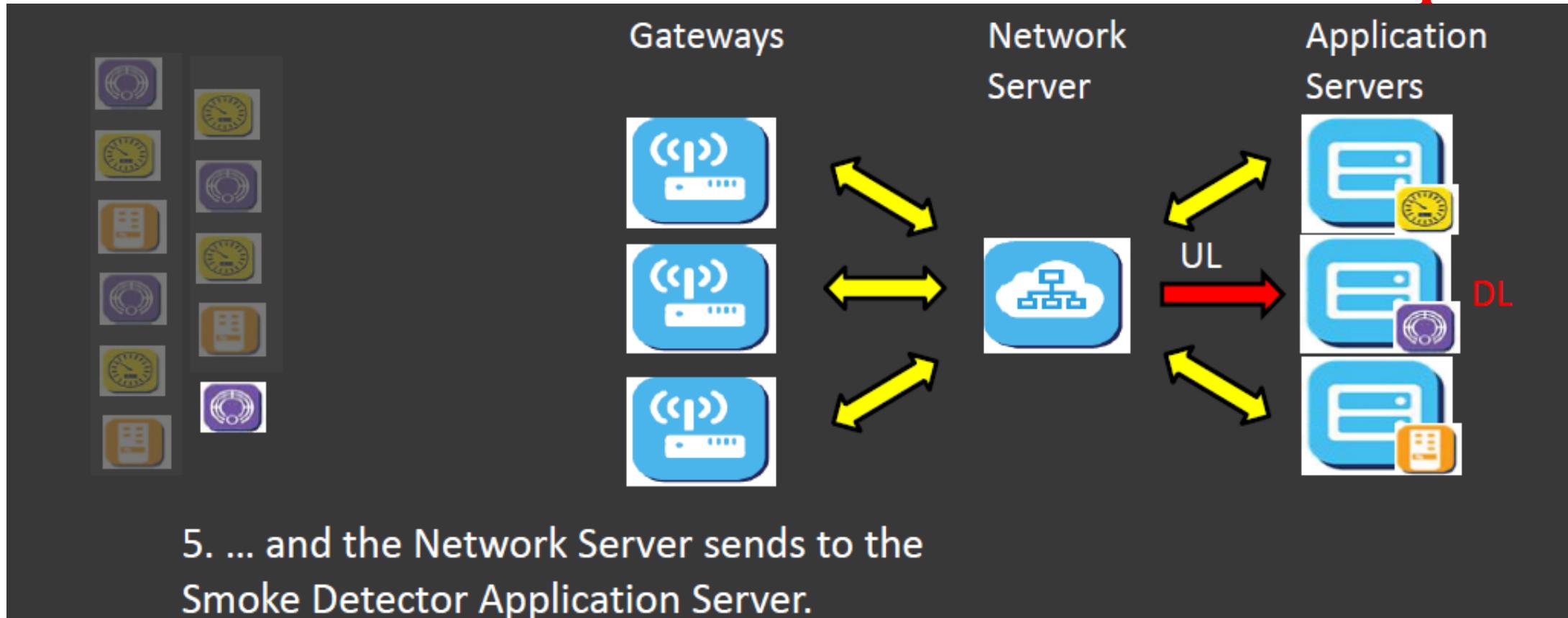
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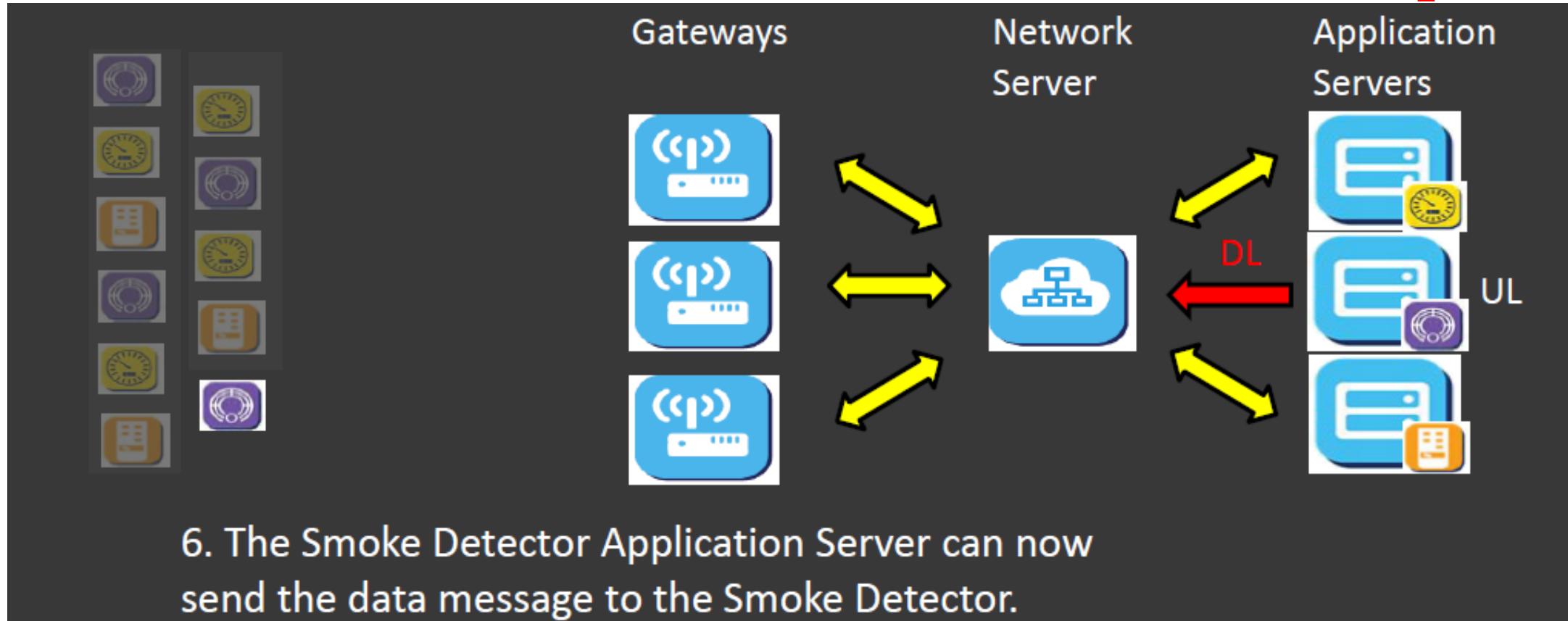
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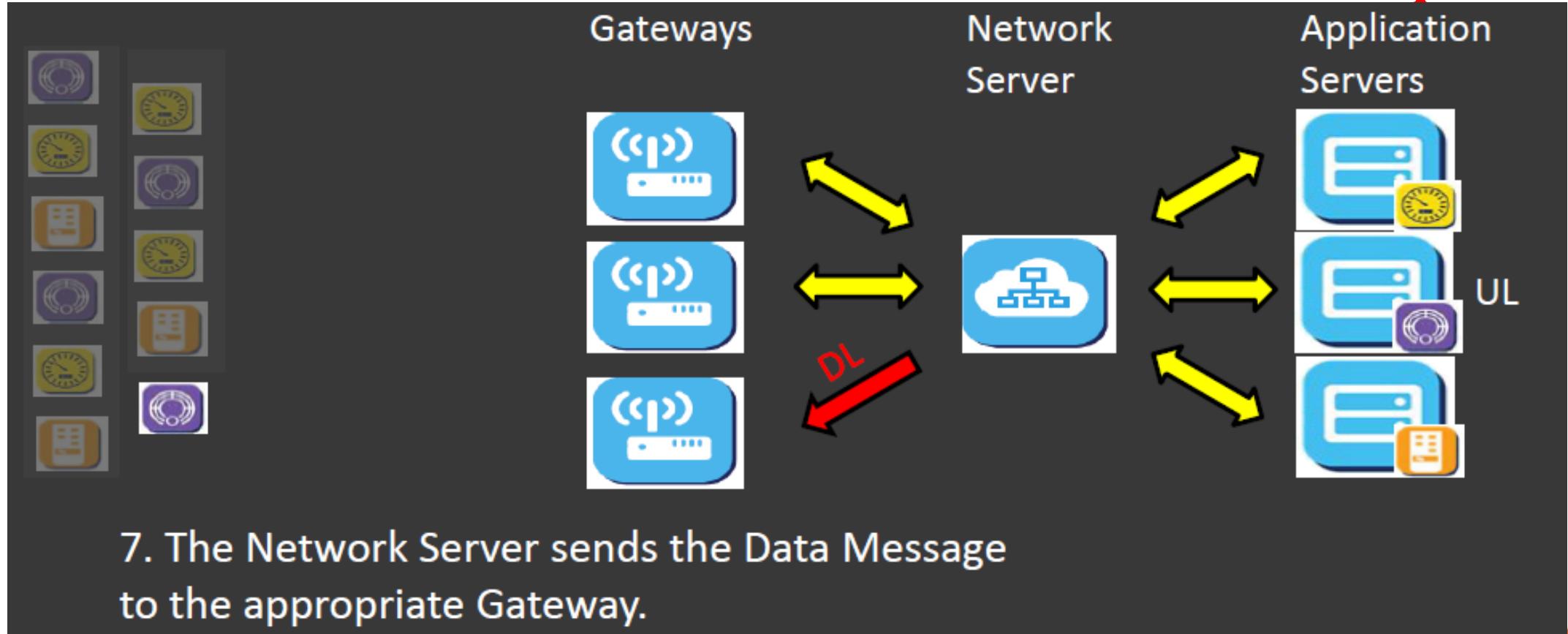
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Data Message (Flow & Payload)

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Frame Message (MAC Message Format)

Ref: LoRaWAN Specification 1_0_2

Radio PHY layer:

Preamble	PHDR	PHDR_CRC	PHYPayload	CRC*
----------	------	----------	------------	------

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

PHYPayload:

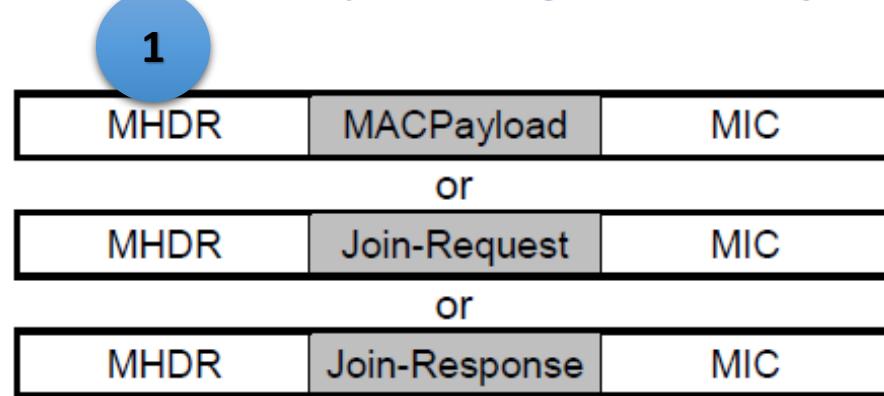


Figure 6: PHY payload structure

MACPayload:



Figure 7: MAC payload structure

FHDR:

DevAddr	FCtrl	FCnt	FOpts
---------	-------	------	-------

Figure 8: Frame header structure

Frame Message (MAC Message Format)

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)

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

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

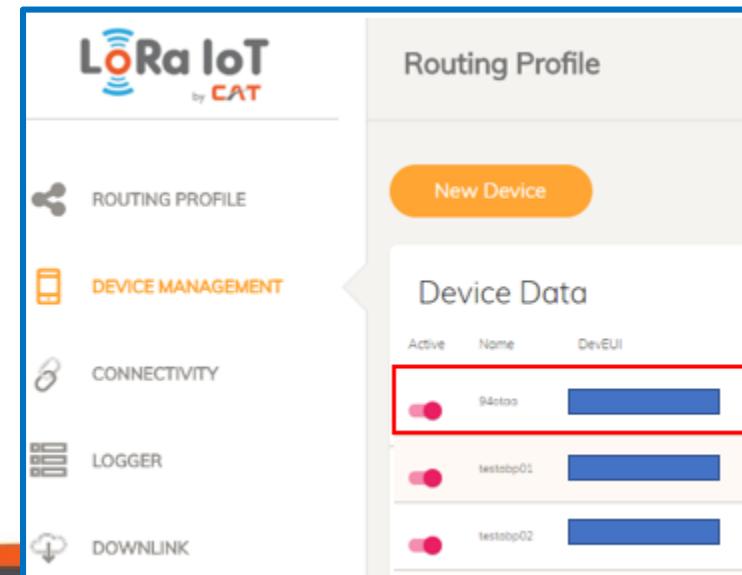
Ref: <https://mydevices.com/cayenne/docs/lora/>

LORA BASIC CONCEPT

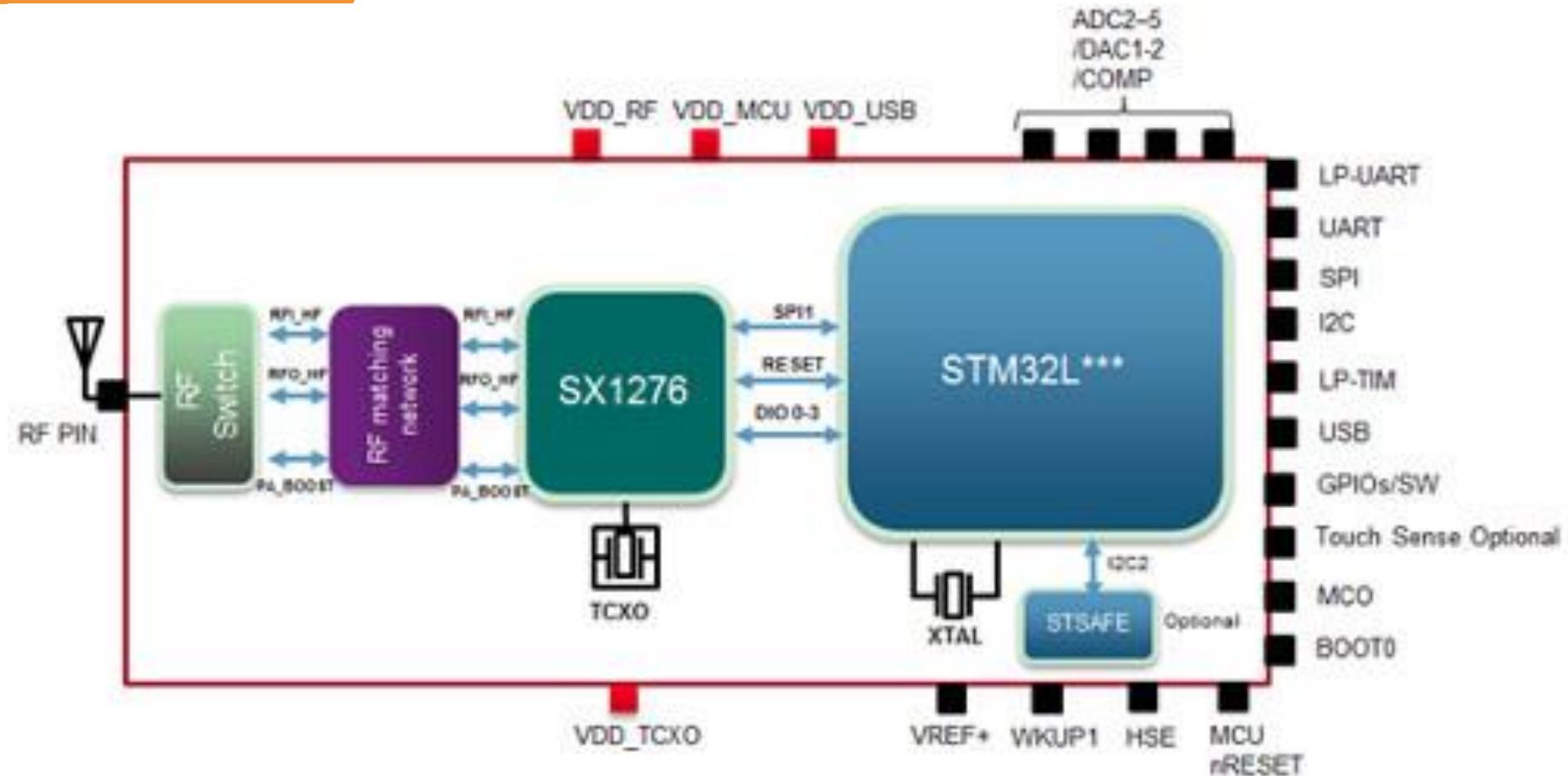
- Frequency
- Channel
- Data Rate
- LoRa Class
- Activation Mode
- Data Message (Flow & Payload)
- Configuration

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



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

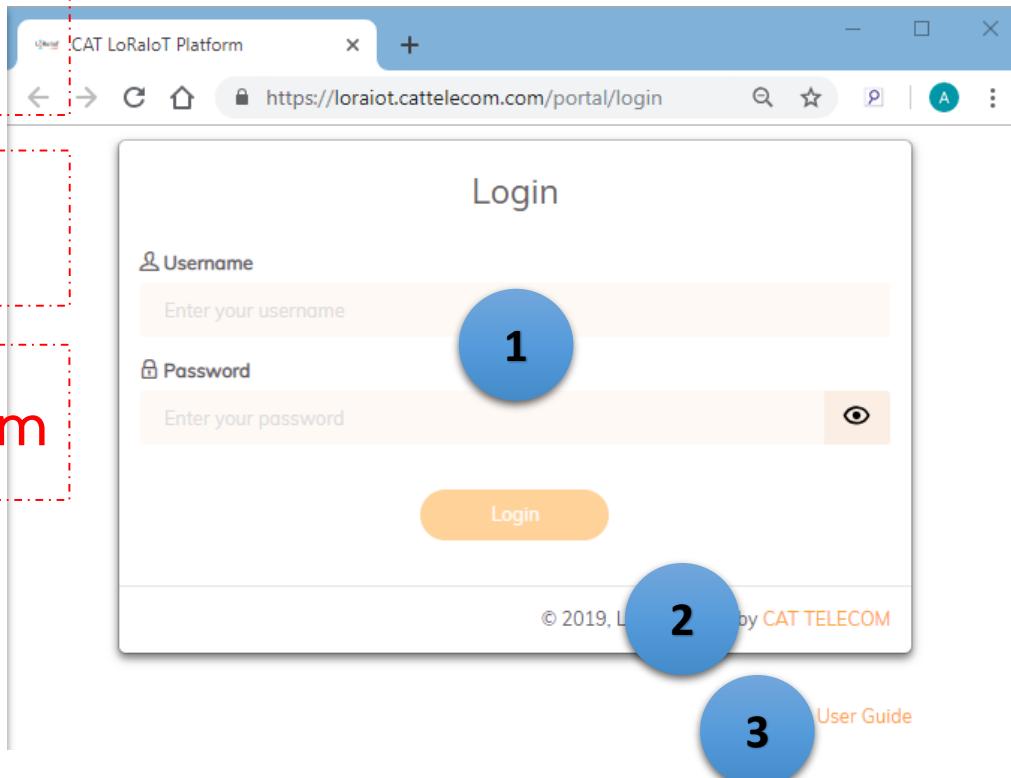
เข้าใช้งานระบบ

2

เว็บไซต์ข้อมูล

3

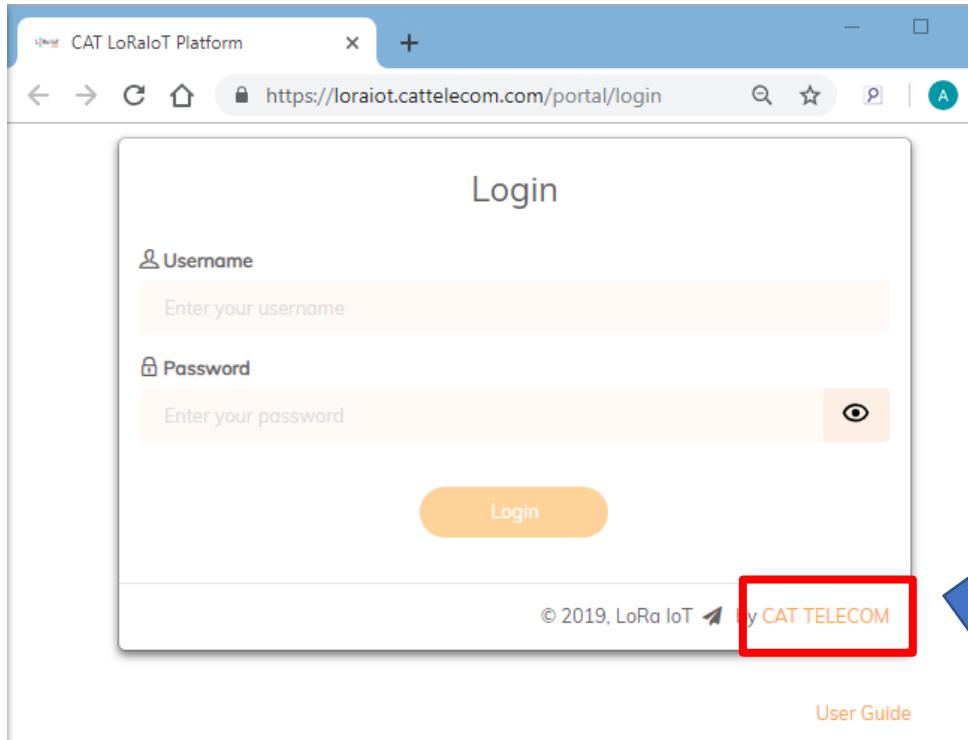
คู่มือใช้งาน Platform



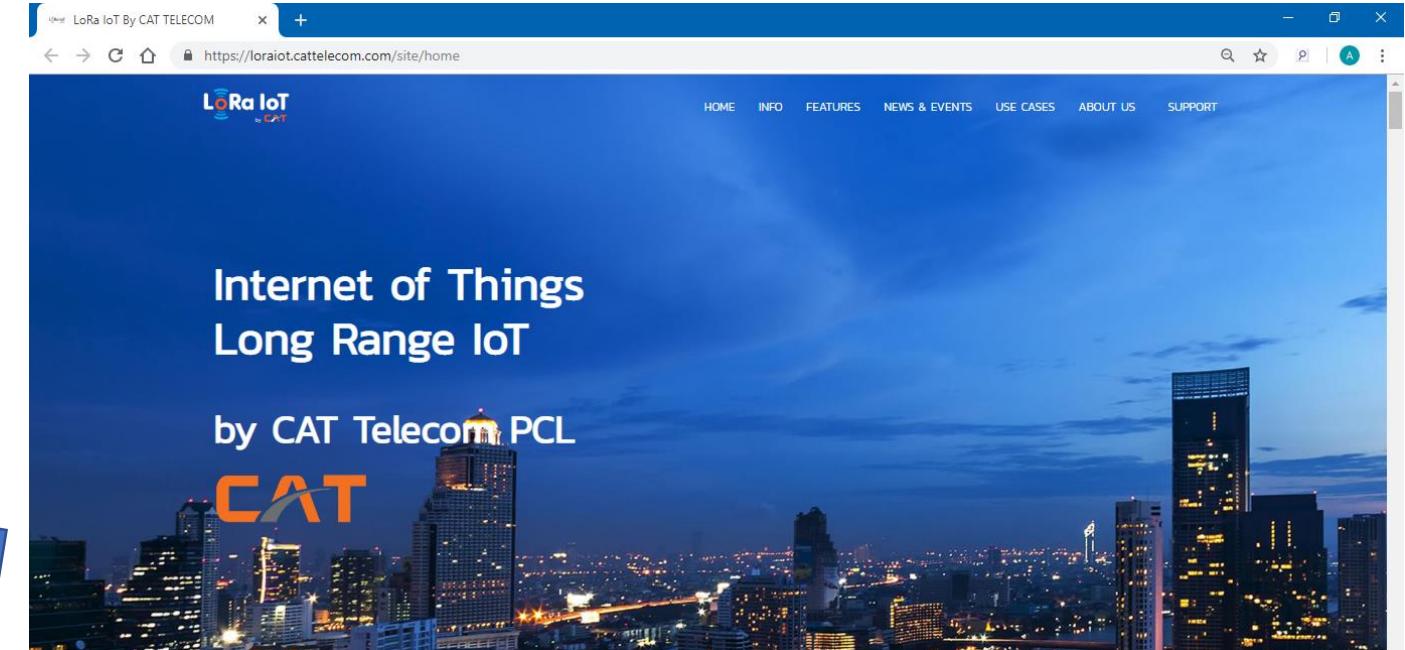
<https://loraiot.cattelecom.com/portal/login>

LoRa Platform

เว็บไซด์ข้อมูล <https://loraiot.cattelecom.com>

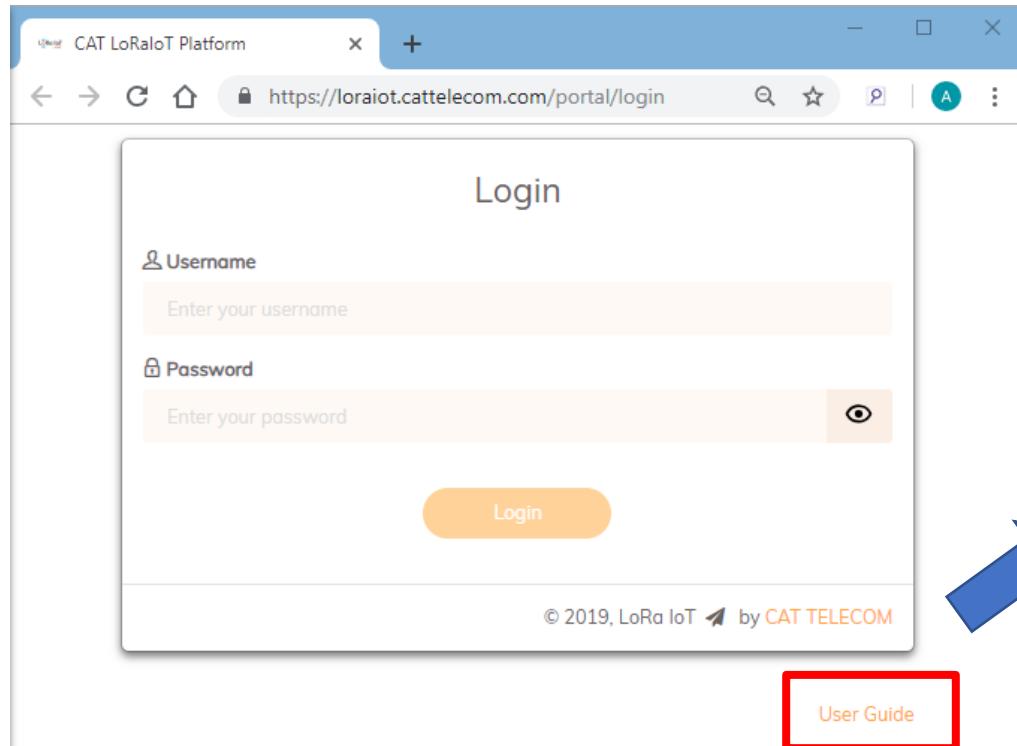


A screenshot of a web browser showing the "CAT LoRaIoT Platform" login page at <https://loraiot.cattelecom.com/portal/login>. The page has a light gray header and a white main area. It contains fields for "Username" and "Password", both with placeholder text "Enter your username" and "Enter your password". Below these is an orange "Login" button. At the bottom left, there is a copyright notice "© 2019, LoRa IoT by CAT TELECOM" followed by a small logo of two people shaking hands. A red rectangular box highlights this text. To the right of the box is a large blue arrow pointing towards the right side of the image. At the bottom center, there is a link "User Guide".



LoRa Platform

คู่มือใช้งาน Platform



การเชื่อมต่อเข้าสู่โครงข่าย

LORA IOT BY CAT



LoRa Platform



Routing Profile

Create New



DEVICE MANAGEMENT

CONNECTIVITY

LOGGER

DLINK

Routing Profile

Device Management

Connectivity

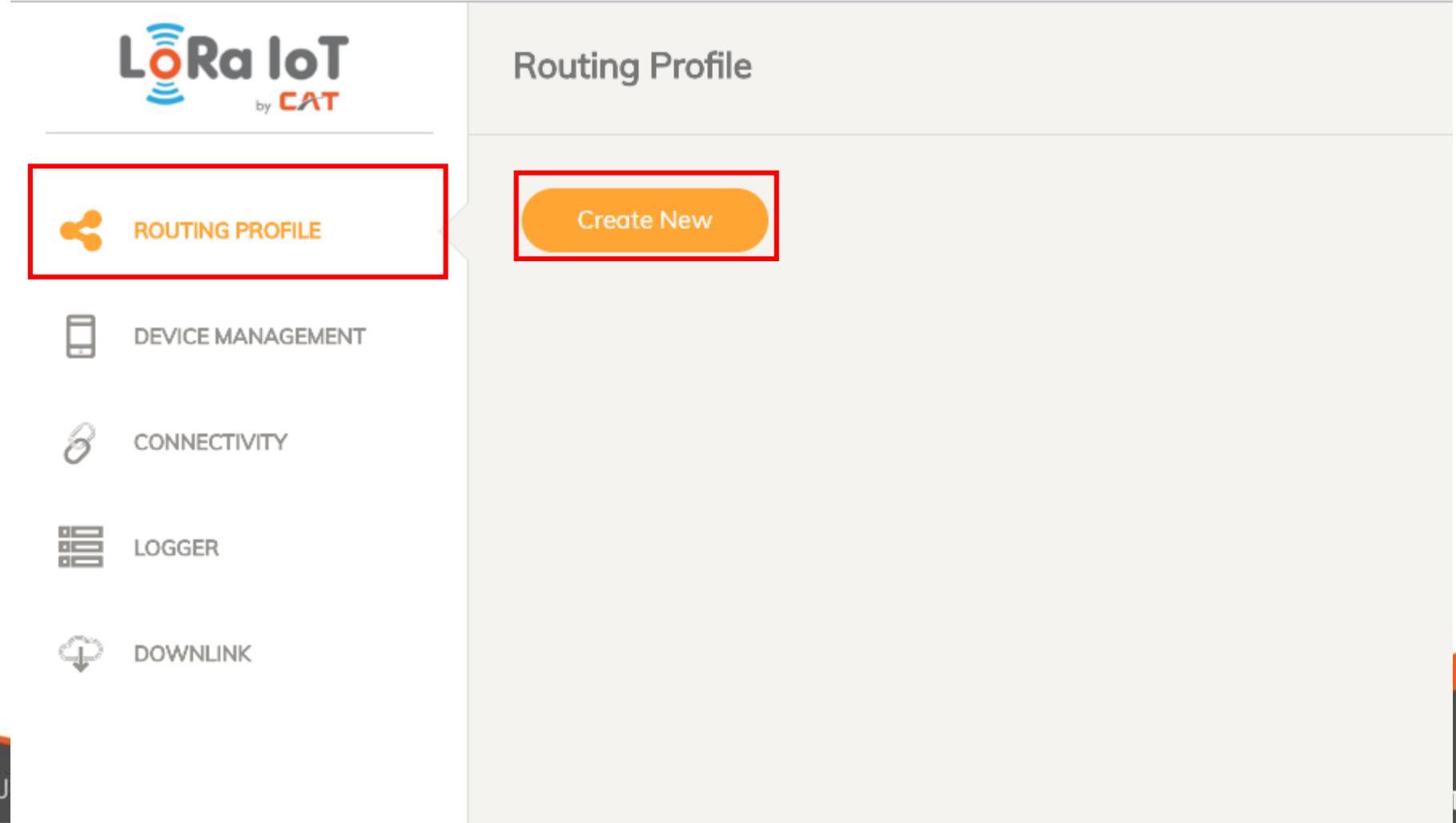
Logger

Downlink

Routing Profile

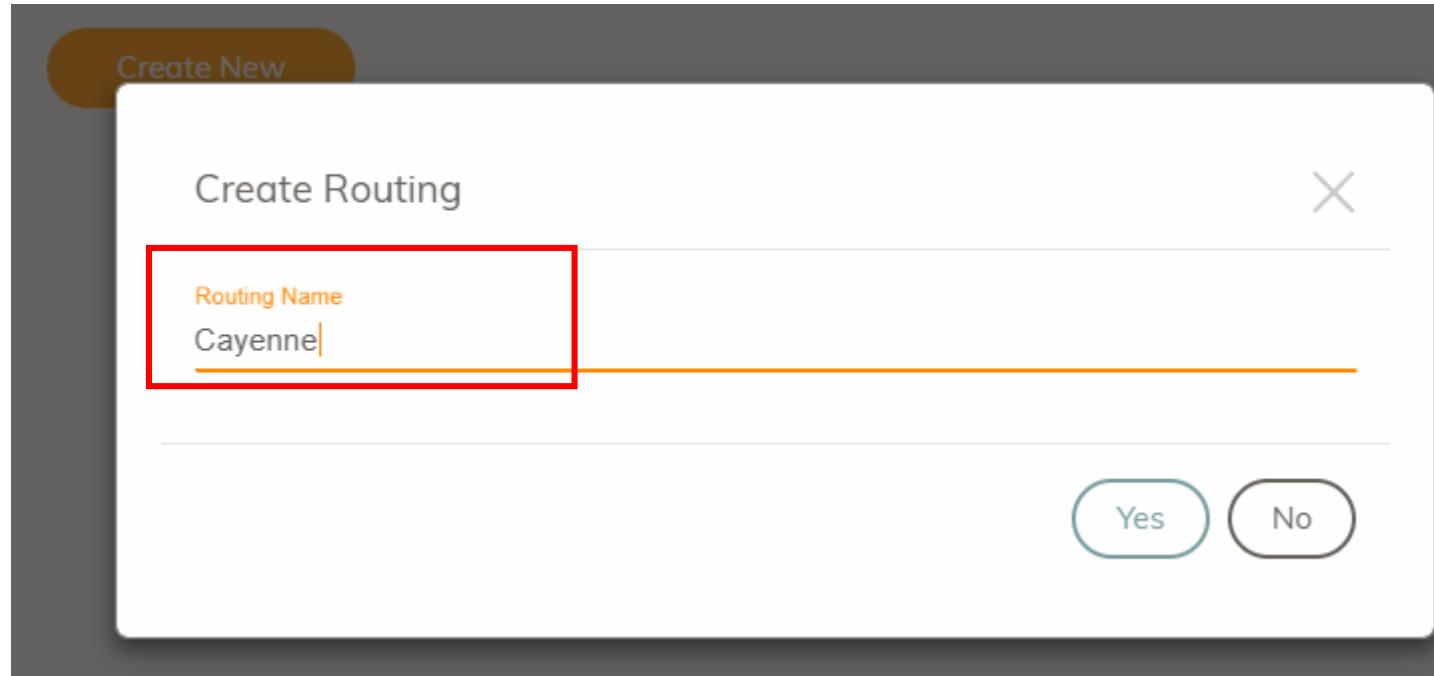
Routing Profile

Routing Profile



The screenshot shows the LoRa IoT by CAT web interface. On the left, there's a sidebar with the LoRa IoT logo at the top. Below it are five menu items: 'ROUTING PROFILE' (highlighted with a red box), 'DEVICE MANAGEMENT', 'CONNECTIVITY', 'LOGGER', and 'DOWNLINK'. On the right, the main content area is titled 'Routing Profile'. Inside this area, there's a large orange button with the text 'Create New'.

Routing Profile



Routing Profile

Routing Profile

Create New

Cayenne



Routing Profile

Add URL

Protocol *

HTTP

MQTT

Create New

Add URL

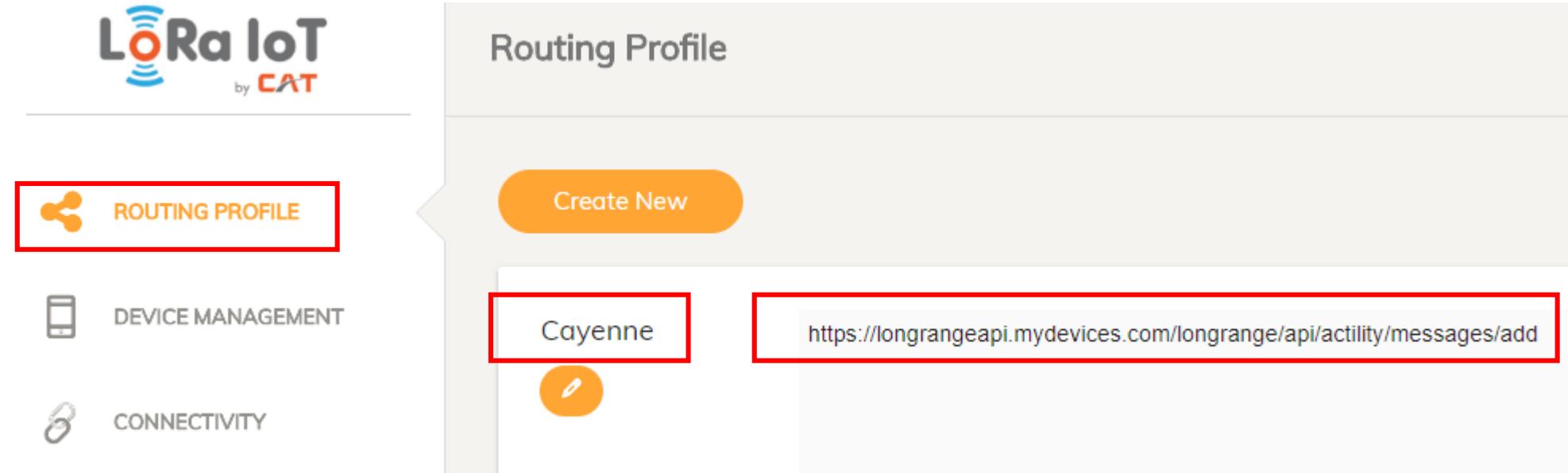
HTTP

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

Option
(http://www.example.com or https://www.example.com or tcp://www.example.com)

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

Routing Profile

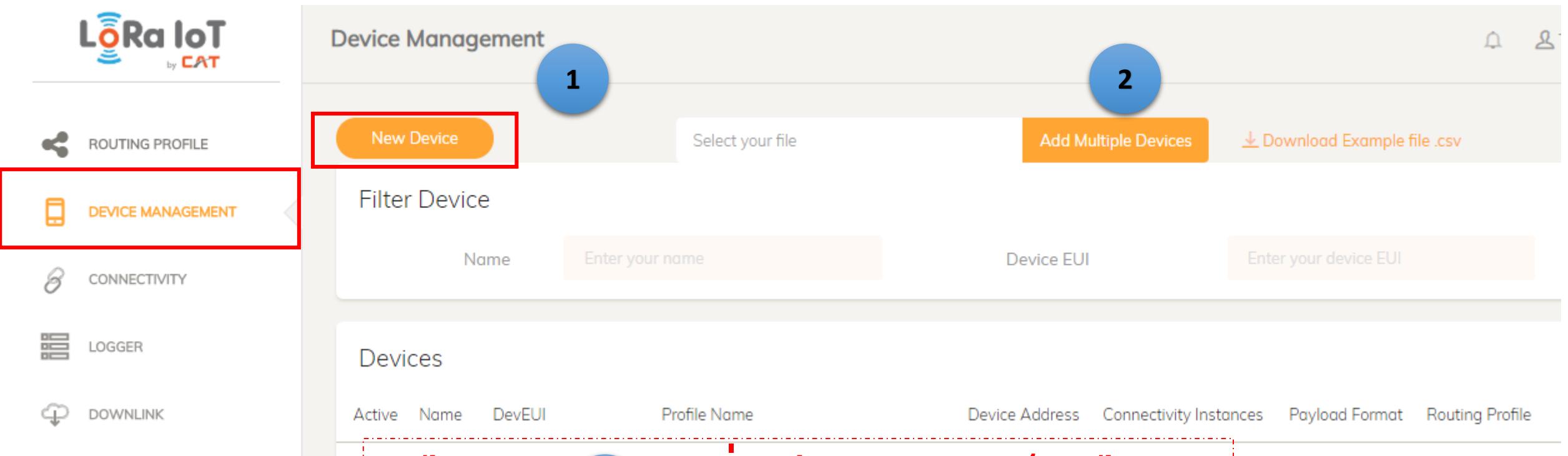


The screenshot shows the LoRa IoT platform interface. On the left, there's a navigation bar with three items: 'ROUTING PROFILE' (highlighted with a red border), 'DEVICE MANAGEMENT', and 'CONNECTIVITY'. The main area is titled 'Routing Profile' and contains a 'Create New' button. Below it, there's a list item for 'Cayenne' with a URL: <https://longrangeapi.mydevices.com/longrange/api/actility/messages/add>. A small orange edit icon is positioned next to the Cayenne entry.

Device Management

Device Management

Device Management



Device Management

1 New Device **2** Add Multiple Devices

Select your file Download Example file .csv

Filter Device

Name Enter your name Device EUI Enter your device EUI

Active	Name	DevEUI	Profile Name	Device Address	Connectivity Instances	Payload Format	Routing Profile

เลือก

1

เพิ่มทีละอุปกรณ์ หรือ

2

เพิ่มทีละหลายอุปกรณ์

Device Management

1

เพิ่มที่ละอุปกรณ์



Create New Device

* Name : OTAA

Activation Type : **OTAA**

* Device EUI :

* Application EUI :

* Application Key : 0

* Payload Format : Raw

Routing Profile : myserver

* Device Profiles :

* Connectivity Instances : Preorder (0 / 1) | Exp. 31/12/2019

Yes No

Create New Device

* Name : ABP

Activation Type : **ABP**

* Device EUI :

* Device Address :

* Network Session Key :

* Application Session Key :

* Payload Format : Raw

Routing Profile : myserver

* Device Profiles :

* Connectivity Instances : Preorder (0 / 1) | Exp. 31/12/2019

Yes No

Device Management

1

เพิ่มทีละอุปกรณ์



Create New Device

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

* Name :

Activation Type :

* Device EUI :

* Device Address :

* Network Session Key :

* Application Session Key :

* Payload Format :

Routing Profile :

* Device Profiles :

* Connectivity Instances :

Device Name *

ABP

ABP

Device EUI (16-character hexadecimal) *

Device Address (8-character hexadecimal) *

Network Session Key (32-character hex) *

Application Session Key (32-character hex) *

Raw

myserver

Preorder (0 / 1) | Exp. 31/12/2019

Yes

No

Device Management

1

เพิ่มทีละอุปกรณ์



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

Create New Device

* Name :

Activation Type :

* Device EUI :

* Application EUI :

* Application Key :

* Payload Format :

Routing Profile :

* Device Profiles :

* Connectivity Instances :

Device Name *
OTAA

OTAA

Device EUI (16-character hexadecimal) *

Application EUI (16-character hexadecimal) *

Application Key (32-character hexadecimal) *

Raw

myserver

Preorder (0 / 1) | Exp. 31/12/2019

Yes

No

Device Management



1

เพิ่มทีละอุปกรณ์



Device Management

New Device Select your file Add Multiple Devices Download Example file .csv

เตือนเมื่อ มีอุปกรณ์ ครบตามจำนวน Connectivity ที่มี ห้ามใส่เพิ่มแล้ว

Warning This account doesn't have Connectivity Instances.

Filter Device

Name Enter your name Device EUI Enter your device EUI

Devices

Active	Name	DevEUI	Profile Name	Device Address	Connectivity Instances	Payload Format	Routing Profile
<input checked="" type="checkbox"/>	Sensor1		LoRaWAN 1.0.2 Class A - AS923 - Generic		TESA Top Gun Rally	Cayenne LPP	Cayenne

Device Management

2

เพิ่มทีละหลายอุปกรณ์



Lora IoT by CAT

ROUTING PROFILE

DEVICE MANAGEMENT

New Device Select your file Add Multiple Devices Download Example file .csv

Filter Device Name Enter your name Device EUI Enter your device EUI

exampleFile - Excel

Tell me what you want to do...

File Home Insert Page Layout Formulas Data Review View Team Conditional Formatting Table Cell Styles Insert Delete Format AutoSum Fill Clear Sort & Filter Filter Sel

Clipboard Font Alignment Number Styles Cells Editing

M6

Name	Devive EU	Application EU	Application Key	Device Address	Network Session Key	Application Session Key	Device Profile (Number)	Connectivity Instances (Number)	Payload Format (Text)	Routing Profile (Number)
1										
2										
3										
4										

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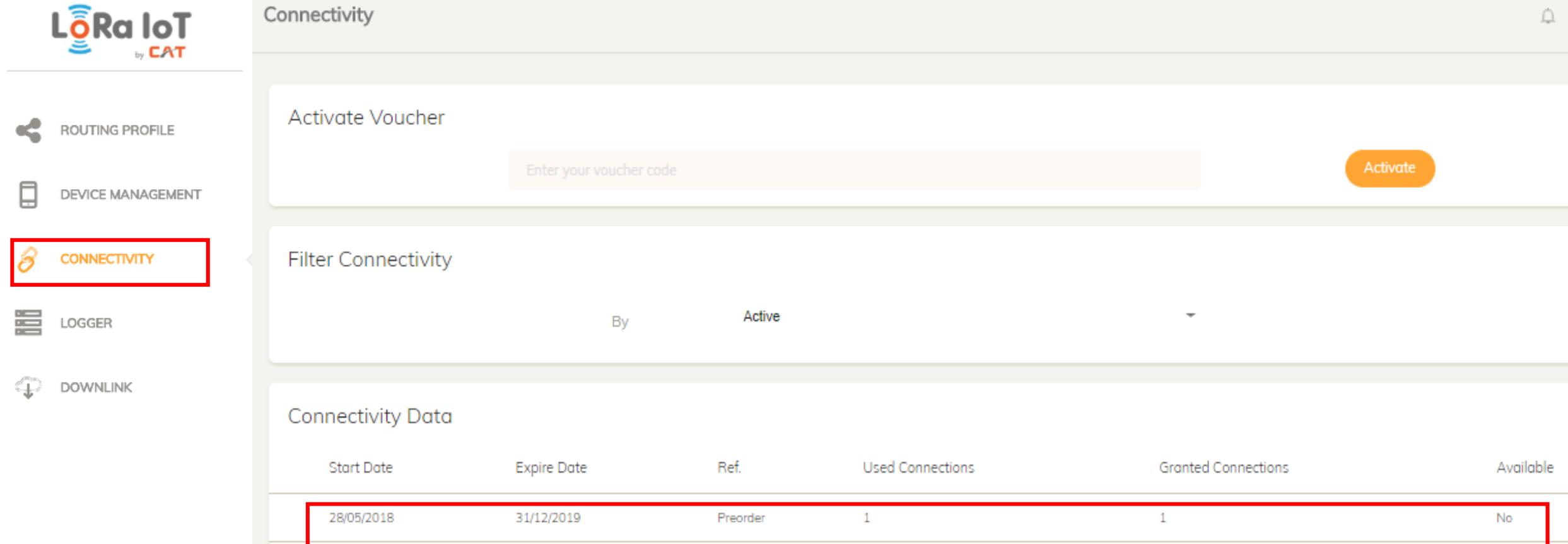
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Connectivity

Connectivity

Connectivity



The screenshot shows the LoRa IoT by CAT web interface with the following details:

- Left Sidebar:**
 - ROUTING PROFILE**
 - DEVICE MANAGEMENT**
 - CONNECTIVITY** (highlighted with a red border)
 - LOGGER**
 - DOWNLINK**
- Header:** Connectivity
- Activate Voucher:** Enter your voucher code **Activate** button
- Filter Connectivity:** By Active
- Connectivity Data:**

Start Date	Expire Date	Ref.	Used Connections	Granted Connections	Available
28/05/2018	31/12/2019	Preorder	1	1	No

Logger

Logger

Logger



-  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	9		0073000001670000026800030064040100	99	360	4	-57.000000	12.000000	G1	LC6
18/05/2018 00:40:11	9		0073000001670000026800030064040100	99	359	3	-60.000000	12.000000	G1	LC7
18/05/2018 00:40:06	9		0073000001670000026800030064040100	99	358	2	-58.000000	11.250000	G1	LC2
18/05/2018 00:40:01	9		0073000001670000026800030064040100	99	357	1	-59.000000	11.500000	G1	LC3

Logger



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
↑ 27/11/2018 16:26:18	[REDACTED]	[REDACTED]	05689f066701f5	89	126	9	-35.000000	6.500000	G1	LC5	C00002D1



ແອບຄລິກດູອຍ່ານະຈັກ

Payload (parsed) :

```
{
  "frames": [
    {
      "channel": 5,
      "type": 104,
      "typeString": "Humidity Sensor",
      "value": 79.5
    },
    {
      "channel": 6,
      "type": 103,
      "typeString": "Temperature Sensor",
      "value": 25.5
    }
  ]
}
```

Downlink

Downlink

Downlink

Downlink

 ROUTING PROFILE

 DEVICE MANAGEMENT

 CONNECTIVITY

 LOGGER

 DOWNLINK

Downlink

[Test Downlink](#)

[Downlink API](#)

Input Data

* Device EUI :

Enter your device EUI

* Payload :

Enter your payload

* Target Port :

Enter your target port

[Send Payload](#)

Response

Response Message

Downlink

Downlink

 ROUTING PROFILE

 DEVICE MANAGEMENT

 CONNECTIVITY

 LOGGER

 DOWNLINK

Downlink

Test Downlink

Downlink API

1. Access Token

Sending a downlink message requires an authorization access token. Such token can be obtained by calling the following API.

HTTP Endpoint

POST /iotapi/auth/token

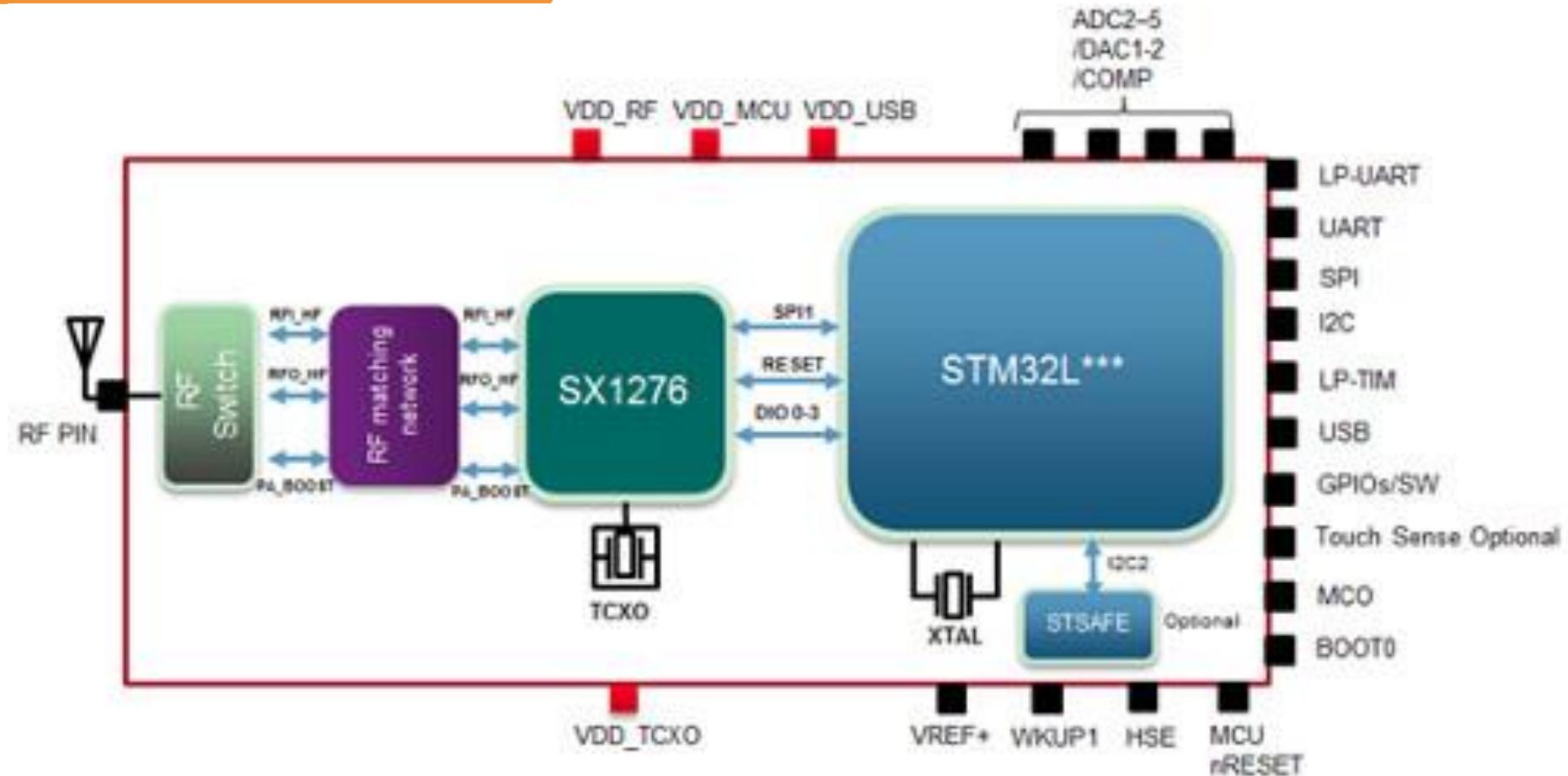
Request

```
curl -X POST
-H 'Content-Type: application/json'
-H 'Accept: application/json'
-d '{
    "username" : "xxxxxx",
    "password" : "xxxxxx"
}'
https://loraiot.cattelecom.com/portal/iotapi/auth/token
```

Response

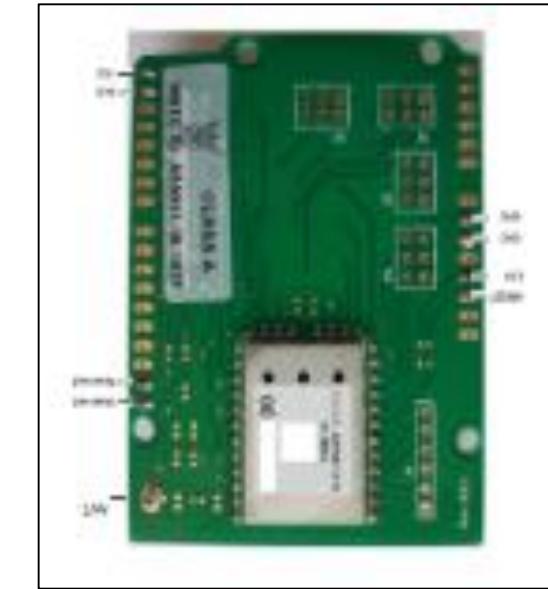
```
{
    "access_token" : "xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx"
```

Device Configuration



LoRaWAN for Embedded System

LoRa Module & Dev Kit



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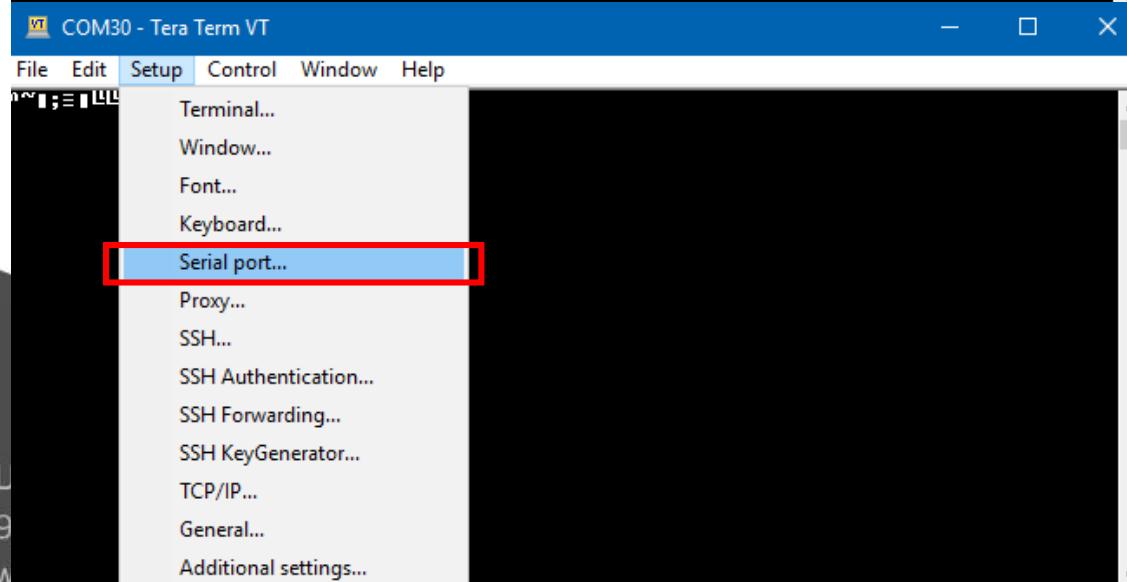
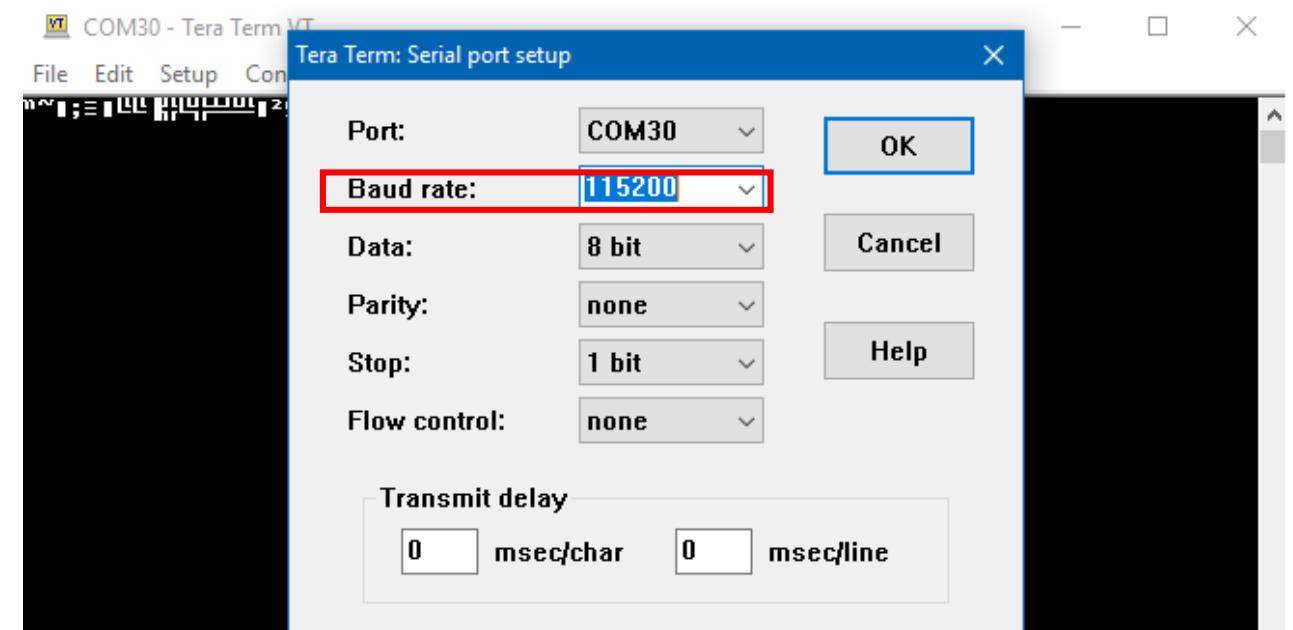
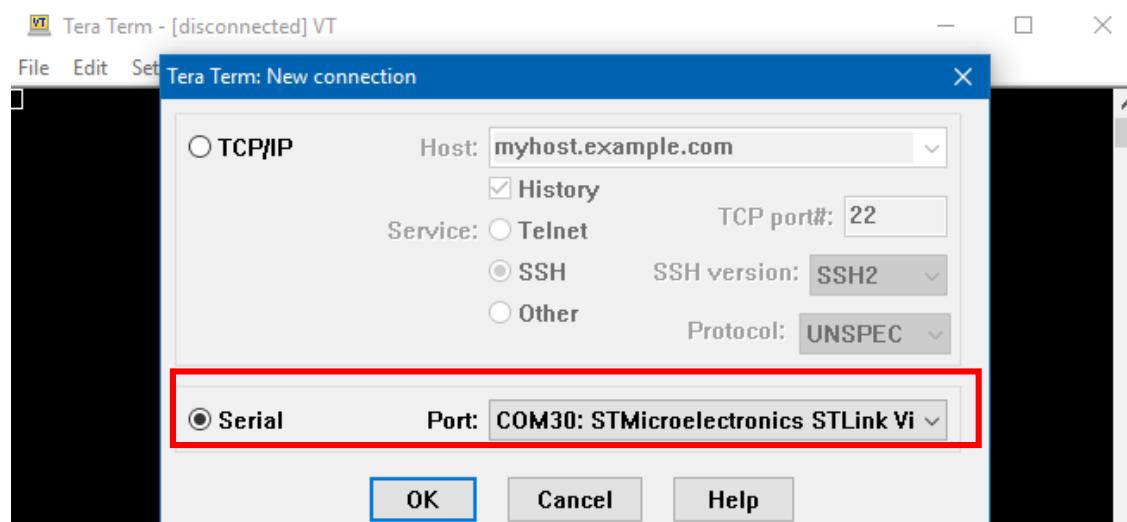
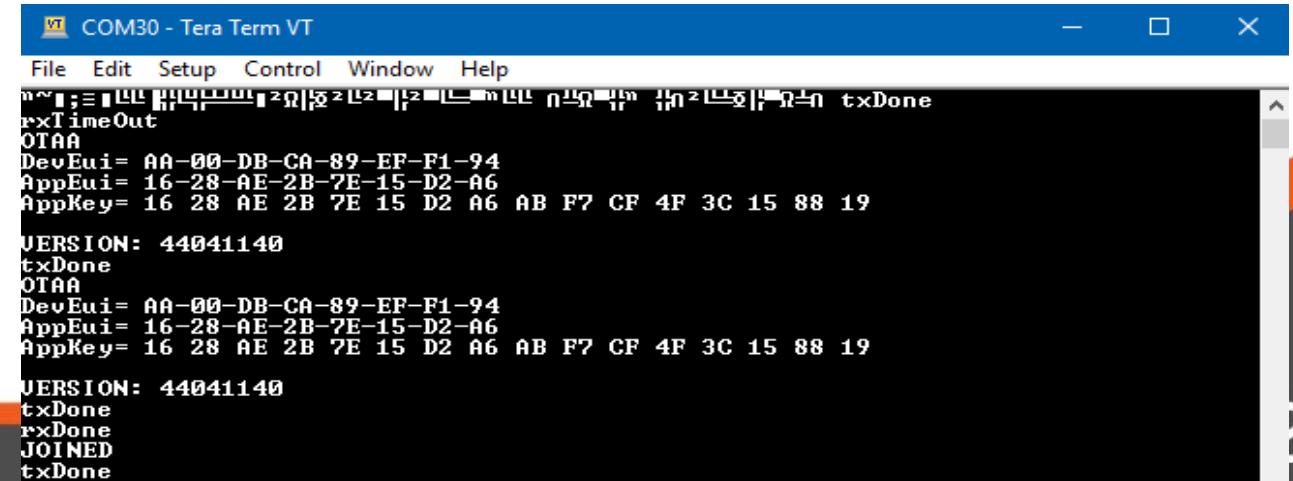
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Device Configuration

Brand	Spec	Download
STMicroelectronics [Starter Kit] <div style="display: flex; align-items: center;"> ✓ Verified </div>	<p>STM32 B-L072Z-LRWAN1</p> <div style="border: 2px solid red; padding: 5px; margin-bottom: 10px;"> <p>Operation Mode:</p> <ul style="list-style-type: none"> • Programmable (Development toolchains, Embedded Platform and Arduino Programming) • LoRa Modem (AT Command) </div> <p>Feature:</p> <ul style="list-style-type: none"> • 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 • Board power supply: (USB bus or external VIN 3.3 V or AAA 3 batteries) • 4 general-purpose LEDs • 2 push-buttons (user and reset) • ArduinoTM Uno V3 connectors • ARM® mbedTM (see http://mbed.org) 	 Manual for STM32

Serial Communication : Check Status

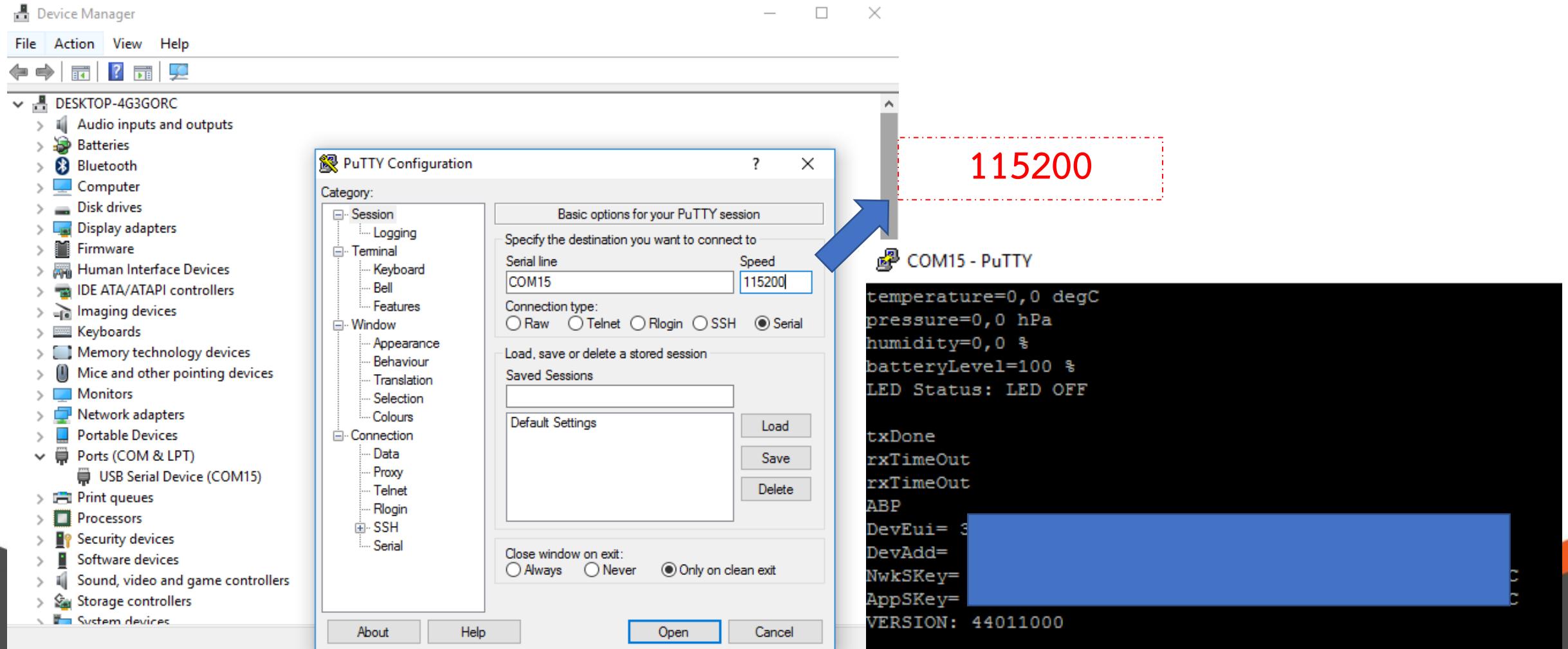



```

txDone
rxTimeOut
OTAA
DevEui= AA-00-DB-CA-89-EF-F1-94
AppEui= 16-28-AE-2B-7E-15-D2-A6
AppKey= 16 28 AE 2B 7E 15 D2 A6 AB F7 CF 4F 3C 15 88 19
VERSION: 44041140
txDone
rxDone
JOINED
txDone

```

Serial Communication : Check Status



Device Configuration

ABP

Device Configuration

** LoRaWAN Key Setting !!

```

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, 0x12, 0xEF, 0x11, 0xXX }

```

ABP

Comissioning.h

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

Device Configuration

** LoRaWAN Key Setting !!

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_NWKSKY                { 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_APPSKY                { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x09 }
138

```

Device Configuration

OTAA

Device Configuration

** LoRaWAN Key Setting !!

```

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, 0x12, 0xEF, 0x11, 0xXX }

```

OTAA

Comissioning.h

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

Device Configuration

** LoRaWAN Key Setting !!

OTAA

Comissioning.h

```

102 /*!
103  * Application IEEE EUI (big endian)
104  */
105 #define LORAWAN_APPLICATION_EUI
106 /*!
107  * AES encryption/decryption cipher application key
108  */
109 #define LORAWAN_APPLICATION_KEY
110 #if( OVER_THE_AIR_ACTIVATION == 0 )
111     { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6}
112     { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6 }
113     { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x19 }
114 #endif

```

{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x19 }

Device Configuration

**** Please check payload format!!**

main.c

```

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

```

```

#ifndef 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( );
    Bat_Display = (batteryLevel*10000/254);
    Bat_Display = 9712;
    AppData->Port = LPP_APP_PORT;

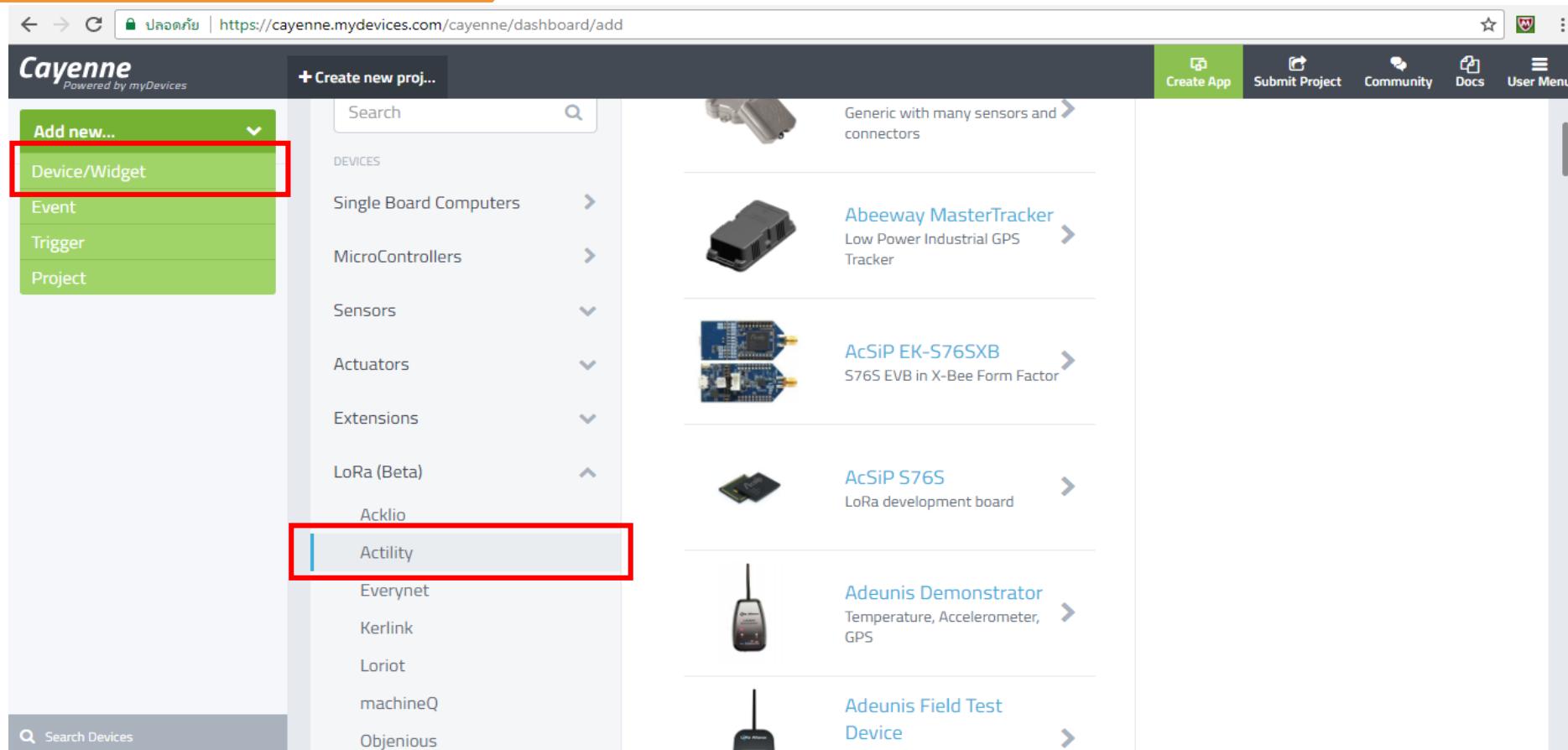
    *IsTxConfirmed = LORAWAN_CONFIRMED_MSG;
    AppData->Buff[i++] = cchannel++;
    AppData->Buff[i++] = LPP_DATATYPE_BAROMETER;
    AppData->Buff[i++] = ( pressure >> 8 ) & 0xFF;
    AppData->Buff[i++] = pressure & 0xFF;
    AppData->Buff[i++] = cchannel++;
    AppData->Buff[i++] = LPP_DATATYPE_TEMPERATURE;
    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

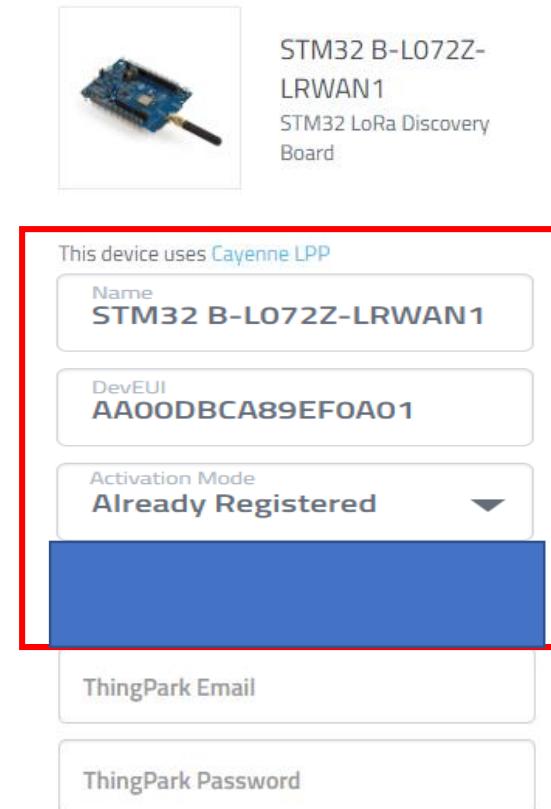


The screenshot shows the Cayenne dashboard creation interface. On the left, a sidebar has a dropdown menu with options: 'Add new...', 'Device/Widget' (highlighted with a red box), 'Event', 'Trigger', and 'Project'. Below this, under 'Acklio', the 'Acklio' option is also highlighted with a red box. The main area lists various device categories and specific device models with their descriptions and images.

- Generic with many sensors and connectors
- Abeeway MasterTracker
Low Power Industrial GPS Tracker
- AcSiP EK-S76SXB
S76S EVB in X-Bee Form Factor
- AcSiP S76S
LoRa development board
- Adeunis Demonstrator
Temperature, Accelerometer, GPS
- Adeunis Field Test Device

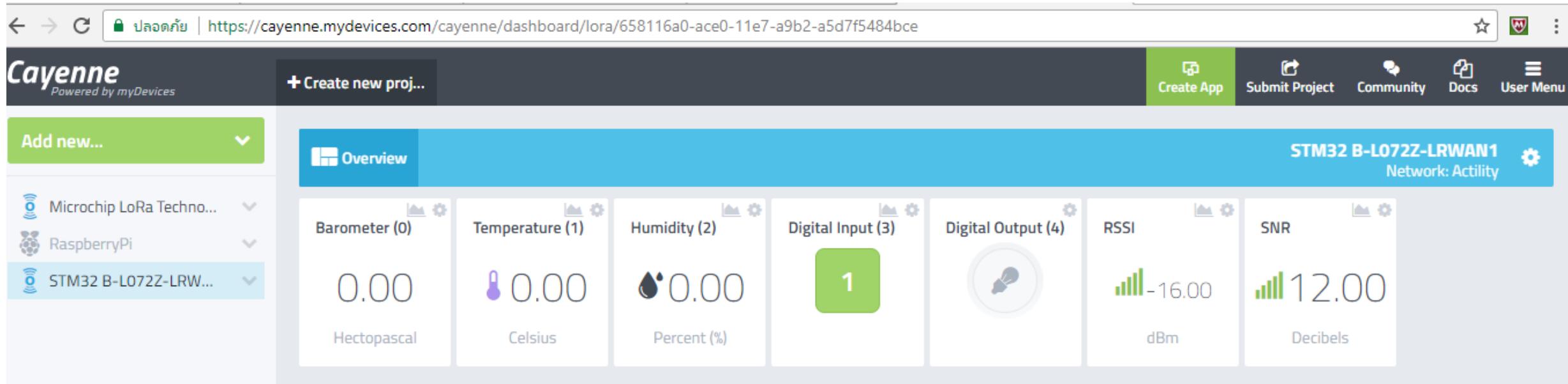
<https://cayenne.mydevices.com/cayenne/dashboard/add>

Example Application



<https://cayenne.mydevices.com/cayenne/dashboard/add>

Example Application



The screenshot shows the Cayenne IoT dashboard interface. At the top, there's a navigation bar with links for 'Create new proj...', 'Create App', 'Submit Project', 'Community', 'Docs', and 'User Menu'. On the left, a sidebar lists connected devices: 'Microchip LoRa Techno...', 'RaspberryPi', and 'STM32 B-L072Z-LRW...'. The main area is titled 'Overview' and displays real-time data for various sensors. The data is presented in cards:

- Barometer (0)**: 0.00 Hectopascal
- Temperature (1)**: 0.00 Celsius
- Humidity (2)**: 0.00 Percent (%)
- Digital Input (3)**: 1 (represented by a green button)
- Digital Output (4)**: (represented by a lightbulb icon)
- RSSI**: -16.00 dBm
- SNR**: 12.00 Decibels

The device name 'STM32 B-L072Z-LRWAN1' and its network 'Actility' are visible at the top right.

<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/>

ໂຈຍ່ປະສົງທັກຍະ Hardware Programming

Brand

STMicroelectronics
[Starter Kit]

✓ Verified



Spec

STM32 B-L072Z-LRWAN1

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 UFL RF interface connectors
- Including 50 Ohm SMA RF antenna
- On-board ST-LINK/V2-1 supporting USB re-enumeration capability

Download

 Manual for STM32



AT_Master



AT_Slave



End_Node_IKS01A1



End_Node_IKS01A2

STM32CubeExpansion_LRWAN_V1.1.5\Projects\Multi\Applications\LoRa

ໂຈຍ່ປະສົງທັກຍະ Hardware Programming

ຂໍ້ກໍານົດ

- Project: STM32CubeExpansion_LRWAN_V1.1.5\Projects\Multi\Applications\LoRa
- Operation: AT_Slave DeviceEUI: AA-00-DB-CA-12-EF-11-**XX**
- Activation Mode: OTAA Application EUI : 16-28-AE-2B-7E-15-D2-A6
- LoRa : Class A Application Key: 16-28-AE-2B-7E-15-D2-A6-AB-F7-CF-4F-3C-15-88-09
- Account: TGR13_**XX**

ໂຄຍ່ປະຊຳທັກຂະໜາດ Hardware Programming



หัวข้อการประชันທັກຂະໜາດ	รายการตัดสิน	คะแนน	หมายเหตุ
ເຊື່ອມຕ່ອງ ເຂົ້າສູ່ວະບັບໄດ້ Operation Mode: AT Command Activation Mode: OTAA	ແສດງສະຖານະການເຊື່ອມຕ່ອງດ້ວຍຄຳສັ່ງ AT Command	1 – ເຊື່ອມຕ່ອງໄດ້ 0 – ເຊື່ອມຕ່ອງໄໝ໌ໄດ້	
	ແສດງ Log ການສົ່ງຂໍ້ມູນບັນ Portal LoRa IoT CAT	1 – ເຊື່ອມຕ່ອງໄດ້ 0 – ເຊື່ອມຕ່ອງໄໝ໌ໄດ້	
ສື່ອສາວສົ່ງຂໍ້ມູນຂາ Uplink	ສົ່ງຄ່າ ເລຂ່າທີມ ໄປຍັງ Application Server Cayenne ໄດ້	1 – ສົ່ງຄ່າເລຂ່າທີມ ໄດ້ 0 – ສົ່ງຄ່າເລຂ່າທີມ ໄໝ໌ໄດ້	
	ສົ່ງຄ່າ ອຸນຫກຸມທີ່ກໍານົດໃຫ້ ໄປຍັງ Application Server Cayenne ໄດ້	1 – ສົ່ງຄ່າ Temp ໄດ້ 0 – ສົ່ງຄ່າ Temp ໄໝ໌ໄດ້	
ສື່ອສາວຮັບຂໍ້ມູນຂາ Downlink	ສົ່ງຄ່າ Downlink ຈາກ Portal LoRa IoT CAT ມາຍັງ ອຸປກຣນີໄດ້	1 – ຮັບຄ່າ ໄດ້ 0 – ຮັບຄ່າ ໄໝ໌ໄດ້	ຄອນ 2 ເຄື່ອງ (ເຄື່ອງສັ່ງ, ເຄື່ອງຕ່ອອຸປກຣນີ)



Q&A