



การจัดฝึกอบรมเชิงปฏิบัติการหลักสูตร：  
**LoRaWAN Workshop**  
**For Developer**

บริษัท กสท โทรคมนาคม จำกัด (มหาชน)  
99 หมู่ 3 ถนนแจ้งวัฒนะ แขวงกุ้งส่องห้อง เมืองกาญจนบุรี กาญจนบุรี 10210-0298  
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# TOPIC

- IoT Concept
- Network Concept
- LoRa Network and Basic Concept
- Workshop : LoRa Account and Device Management
- Workshop : LoRa Example Application



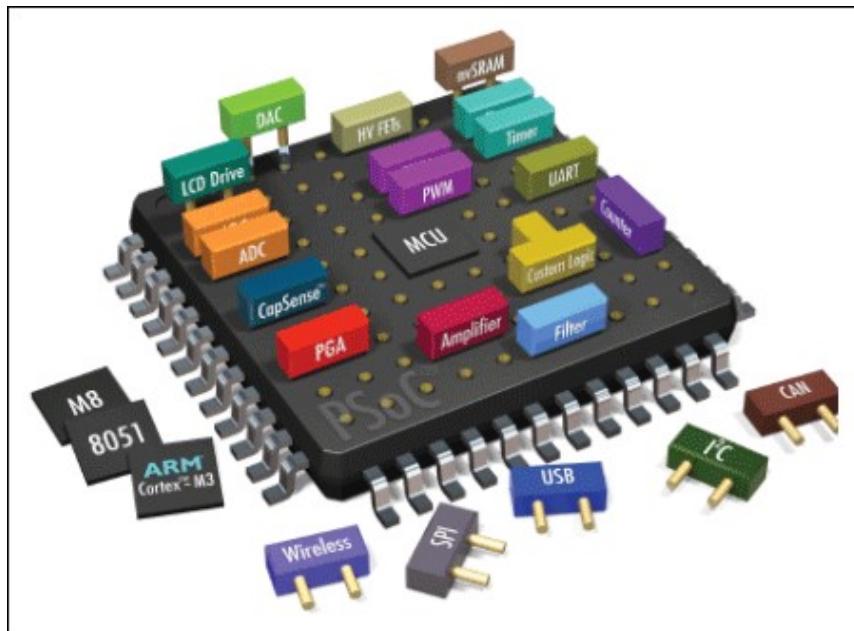
# TOPIC

- Embedded System គីអូ ឧប្បរ
  - ភាគវិទ្យា និងការងារ
  - ភាគវិទ្យា និងការងារ

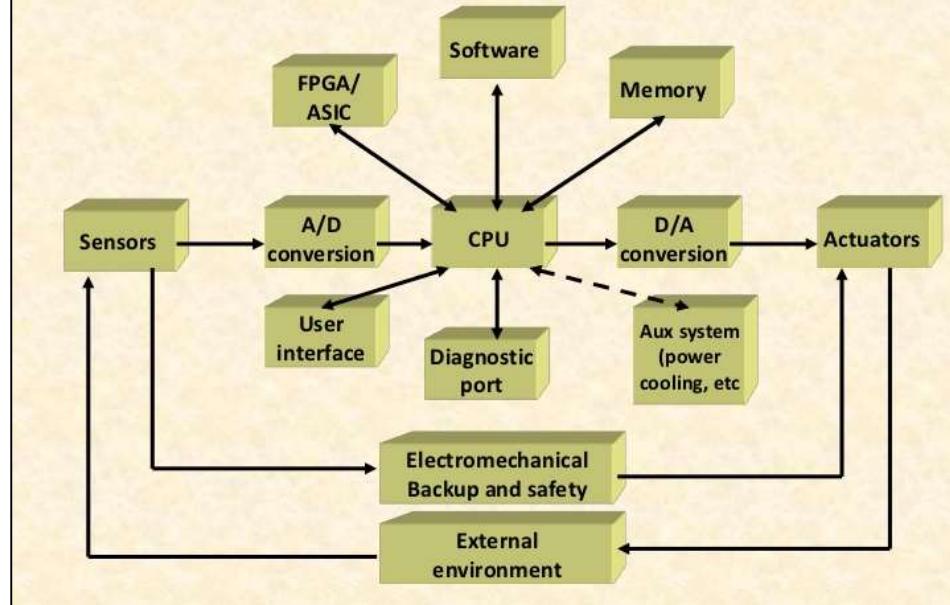
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# IoT Concept

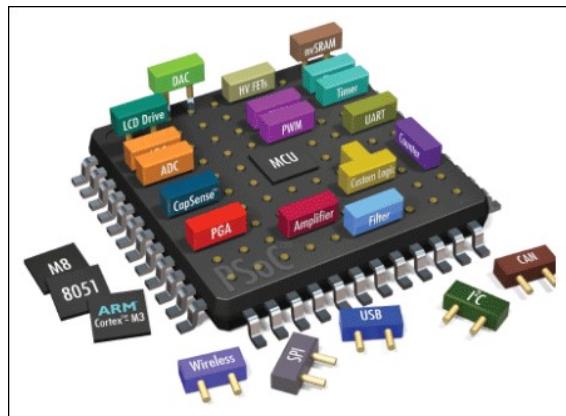


## Embedded system components



# IoT Concept

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# Network Concept

Hello, Thai Embedded System Association



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# Network Concept

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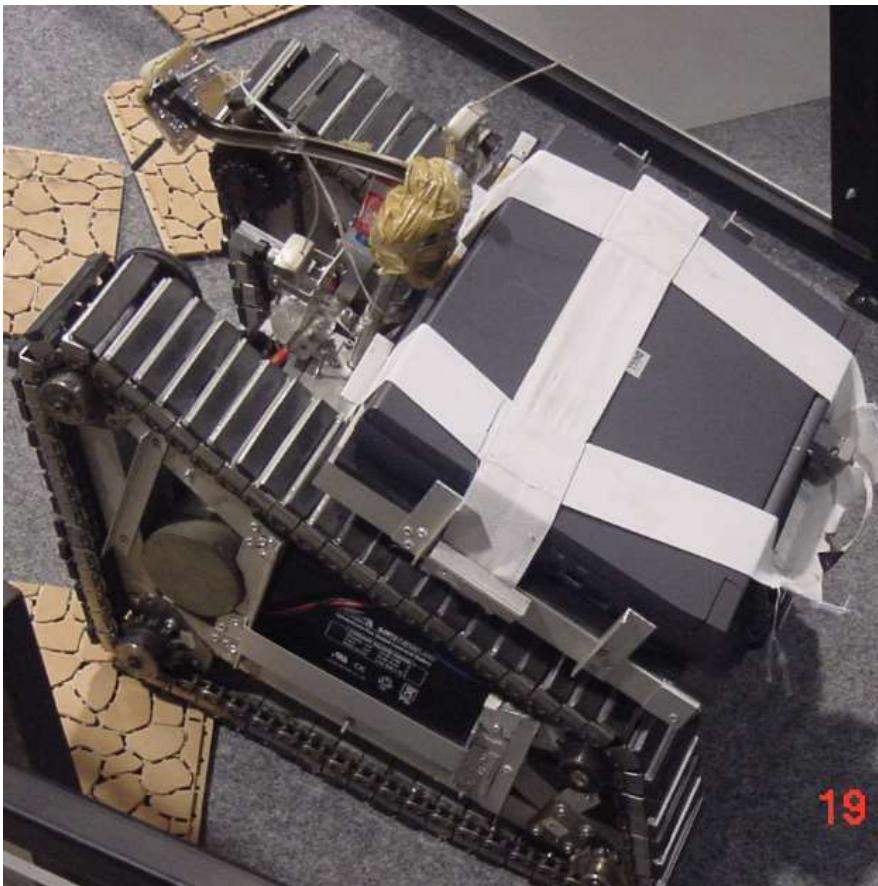


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# Network Concept

Hello, Thai Embedded System Association



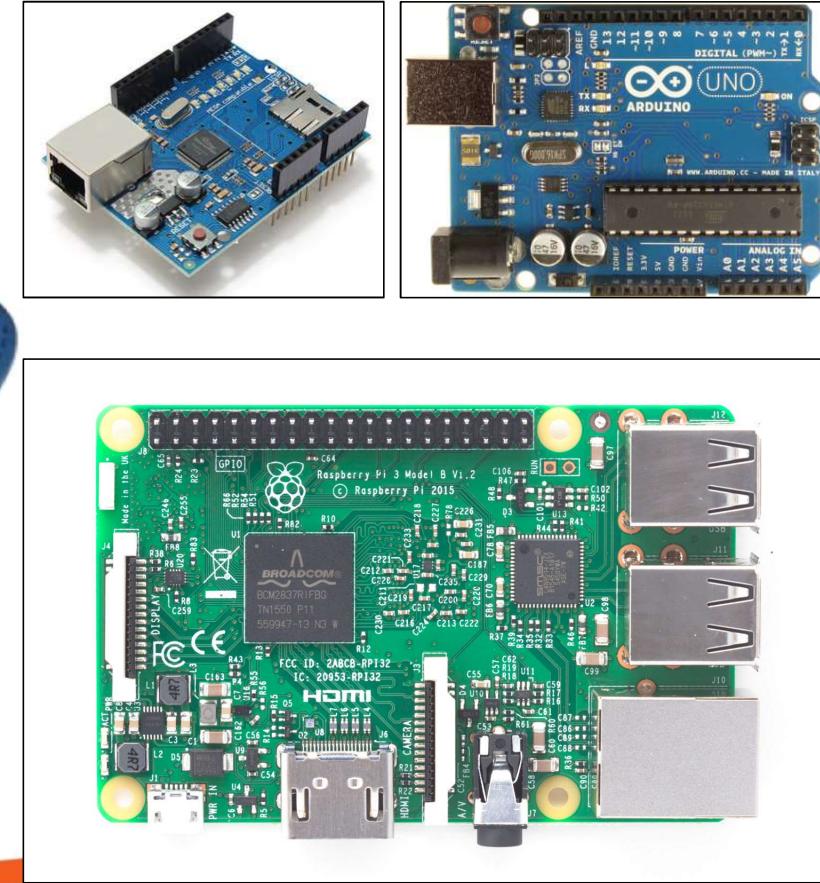
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# Network Concept

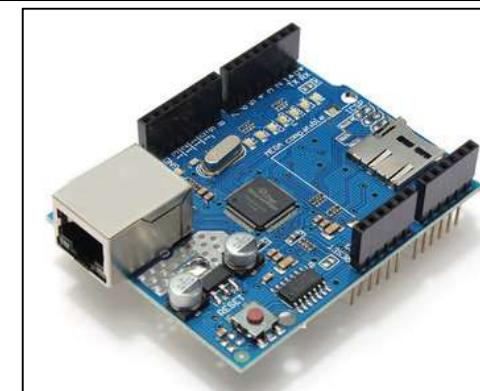
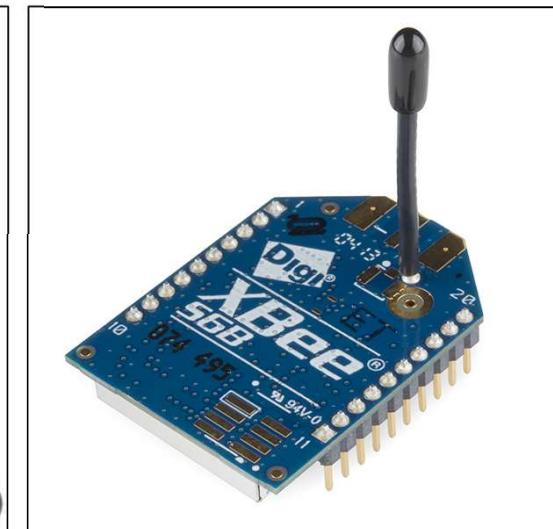
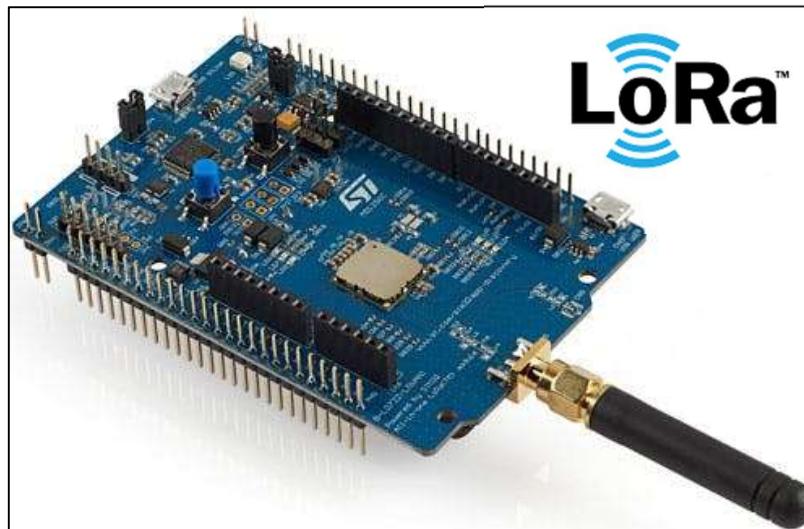
## Discussion

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# Network Concept

Hello, Thai Embedded System Association



# Network Concept



# Network Concept



**Setup      Wireless      Security      Storage      Access Restrictions**

**Basic Wireless Settings** | **Wireless Security**

Manual     Wi-Fi Protected Setup™

Network Mode: **Mixed**

Network Name (SSID): **Linksys00037**

Channel Width: **20 MHz Only**

Channel: **Auto (DFS)**

SSID Broadcast:  **Enabled**     **Disabled**

**Settings      Wi-Fi**

Wi-Fi **ON**

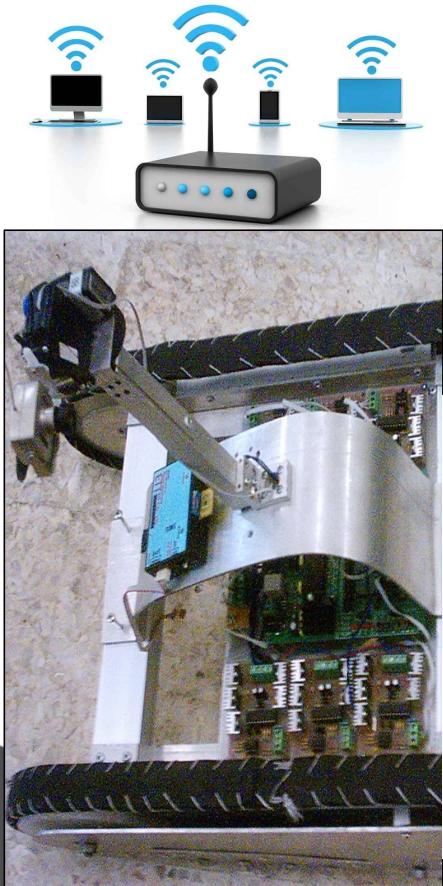
CHOOSE A NETWORK...

network_name	Wi-Fi	<b>i</b>
Wi-Fi_network	Wi-Fi	<b>i</b>
Wi-Fi_secure	Wi-Fi	<b>i</b>
Other...		

Ask to Join Networks **OFF**

Known networks will be joined automatically.  
If no known networks are available, you will have to manually select a network.

# Network Concept



**Notebook B**

SSID:	WiFly-GSX-XX
Channel:	1
DHCP:	OFF
IP address:	169.254.1.1
Netmask:	255.255.0.0
Port:	2000

set wlan join 4	<Enter>	ให้ในคูลเข้าสู่ Adhoc mode
AOK		
set wlan ssid My_Adhoc	<Enter>	ตั้งชื่อ SSID ของในคูล
AOK		
set wlan chan 1	<Enter>	เลือกช่องสัญญาณ
AOK		
set ip address 169.254.1.1	<Enter>	ตั้งค่า ip address
AOK		
set ip netmask 255.255.0.0	<Enter>	ตั้งค่า subnet mask
AOK		
set ip dhcp 0	<Enter>	ปิดการทำงาน dhcp
AOK		
save	<Enter>	บันทึกค่า
Storing in config		
reboot	<Enter>	เริ่มการทำงานใหม่

# Network Concept

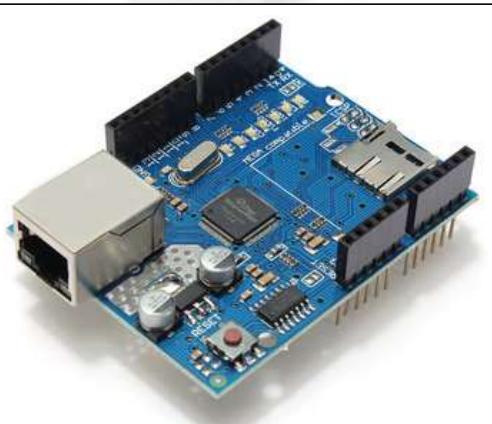


```

1  #include <ESP8266WiFi.h>
2
3  WiFiServer server(88); // ประกาศสร้าง TCP Server ที่พอร์ต 88
4
5  int pin = 2;
6  String line;
7
8  void setup() {
9    pinMode(pin, OUTPUT);
10
11  Serial.begin(115200); // เปิดใช้การ Debug ผ่าน Serial
12  WiFi.mode(WIFI_AP); // ไฟฟ้า WiFi ในโหมด AP
13  WiFi.softAP("ESP_IOXhop"); // ตั้งให้ชื่อ WiFi เป็น ESP_IOXhop
14
15  server.begin(); // เริ่มต้นใช้ TCP Server
16 }
17
18 void loop() {
19  WiFiClient client = server.available();
20  if (!client) // ถ้าไม่มีการเชื่อมต่อมาใหม่
21    return; // ส่งสิ่งด่วนๆ ท่าให้ลืมปืนถูกยกເຖິງ
22
23  Serial.println("New client"); // ส่งข้อความว่า New client ไปที่ Serial
24  while (client.connected()) { // วนรอบไปเรื่อยๆ หากรึໆມีการเชื่อมต่ออยู่
25    if (client.available()) { // ถ้ามีการส่งข้อมูลเข้ามา
26      char c = client.read(); // อ่านข้อมูลอ กນา 1 ไบต์
27
28      if (c == '\r') { // ถ้าเป็น \r (return)
29        Serial.println(line); // แสดงศิวແປຣ line ไปที่ Serial Monitor
30
31        if (line == "LEDON") { // ถ้าส่งข้อความเข้ามาว่า LEDON
32          digitalWrite(pin, HIGH); // ให้ LED ติด
33        } else { // ถ้าไม่ใช่
34          digitalWrite(pin, LOW); // ให้ LED ดับ
35        }
36
37        line = ""; // ล้างค่าศิวແປຣ line
38        break; // ออกจากลูป
39
40      } else if (c == '\n') { // ถ้าเป็น \n (new line)
41        // Pass {new line}
42
43      } else { // ถ้าไม่ใช่
44        line += c; // เพิ่มຂ່ອງລູ 1 ໃນຕໍ່ ໄປຕ້ອທ້າຍໃນສົວແປຣ line
45
46      }
47    }
48
49    delay(1);
50
51    client.stop(); // ปิดการเชื่อมต่อกับ Client
52
53    Serial.println("Client disconnect"); // ส่งข้อความว่า Client disconnect
54  }
55
56 }

```

# Network Concept



```
#include "SPI.h"
#include "Ethernet.h"

byte mac[] = { 0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED };
byte server[] = { 173,194,126,119 }; // www.google.co.th

EthernetClient client;

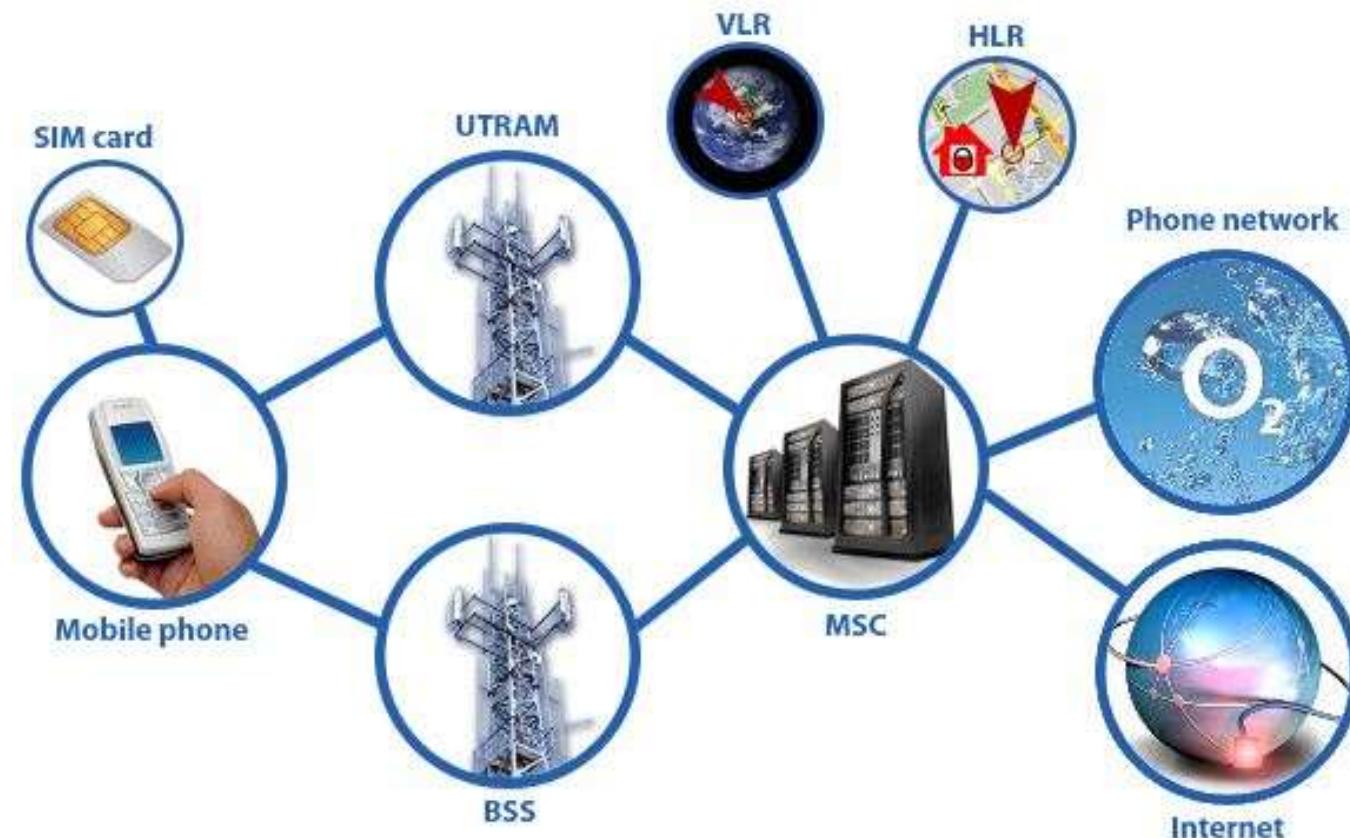
void setup()
{
  Serial.begin(9600);
  if(Ethernet.begin(mac) == 0) { // start ethernet using mac & DHCP
    Serial.println("Failed to configure Ethernet using DHCP");
    while(true) // no point in carrying on, so stay in endless loop:
  }
  delay(1000); // give the Ethernet shield a second to initialize

  Serial.print("This IP address: ");
  IPAddress myIPAddress = Ethernet.localIP();
  Serial.print(myIPAddress);
  if(client.connect(server, 80)>0) {
    Serial.println(" connected");
    client.println("GET /search?q=arduino HTTP/1.0");
    client.println();
  } else {
    Serial.println("connection failed");
  }
}
```

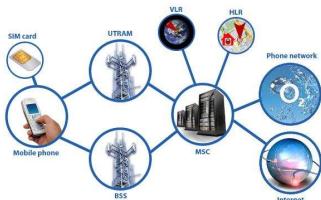
```
void loop()
{
  if (client.available()) {
    char c = client.read();
    // uncomment the next line to show all the received characters
    // Serial.print(c);
  }

  if (!client.connected()) {
    Serial.println();
    Serial.println("disconnecting.");
    client.stop();
    for(;;)
  }
}
```

# Network Concept



# Network Concept



SIM 800 GSM Module



```
#include "SIM900.h"
#include "SoftwareSerial.h"
//#include "inetGSM.h"
//#include "sms.h"
//#include "call.h"

//To change pins for Software Serial, use the two lines in GSM.cpp.

//GSM Shield for Arduino
//www.open-electronics.org
//this code is based on the example of Arduino Labs.

//Simple sketch to communicate with SIM900 through AT commands.

//InetGSM inet;
//CallGSM call;
//SMSGSM sms;

int numdata;
char inSerial[40];
int i=0;
```

```
void serialhwread()
{
    i=0;
    if (Serial.available() > 0) {
        while (Serial.available() > 0) {
            inSerial[i]=(Serial.read());
            delay(10);
            i++;
        }
    }

    inSerial[i]='\0';
    if(!strcmp(inSerial,"/END")) {
        Serial.println(" _");
        inSerial[0]=0x1a;
        inSerial[1]='\0';
        gsm.SimpleWriteLn(inSerial);
    }

    //Send a saved AT command using serial port
    if(!strcmp(inSerial,"TEST")) {
        Serial.println("SIGNAL QUALITY");
        gsm.SimpleWriteLn("AT+CSQ");
    } else {
        Serial.println(inSerial);
        gsm.SimpleWriteLn(inSerial);
    }
    inSerial[0]='\0';
}
```

ATT: SHUT OK
RIC:
SHUT OK
status=READY
OK
RING
+CLIP: "0815930607",129,"","","",0
RING
+CLIP: "0815930607",129,"","","",0
RING
+CLIP: "0815930607",129,"","","",0
NO CARRIER

# Network Concept



TESA ร่วมกับ มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าพระนครเหนือ กรมอุทยานแห่งชาติ สัดว้า และพัฒร์พิช และ กสท โทรคมนาคม



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ระบบวัจจربิยะสำหรับอุทยานแห่งชาติ 4.0

วันที่ 7 - 13 มกราคม 2561



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## Discussion



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Art & Cultural Conservation & Tourism Information System

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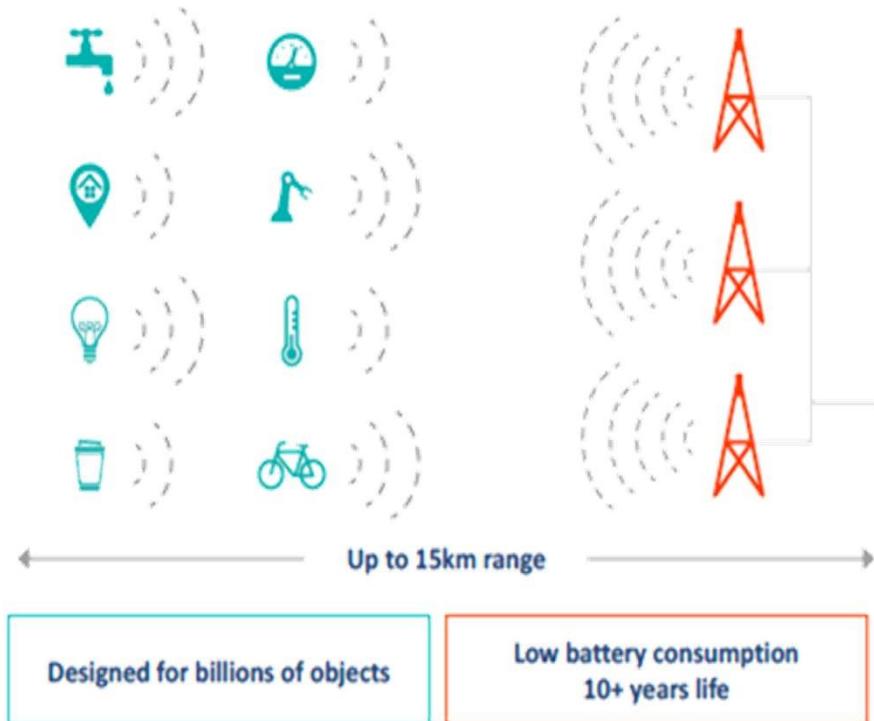
ตามรอย 'อ้อเจ้า' ย่ากันและ  
กำ 'วัดไชยฯ' ทรายหนัก



# TOPIC

- IoT Concept
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- **LoRa Network and Basic Concept**
- Workshop : LoRa Account and Device Management
- Workshop : LoRa Example Application

# LoRa Network and Basic Concept



STM32 hardware tools  
boost LoRa® technology



## LoRa Technology Evaluation Kit

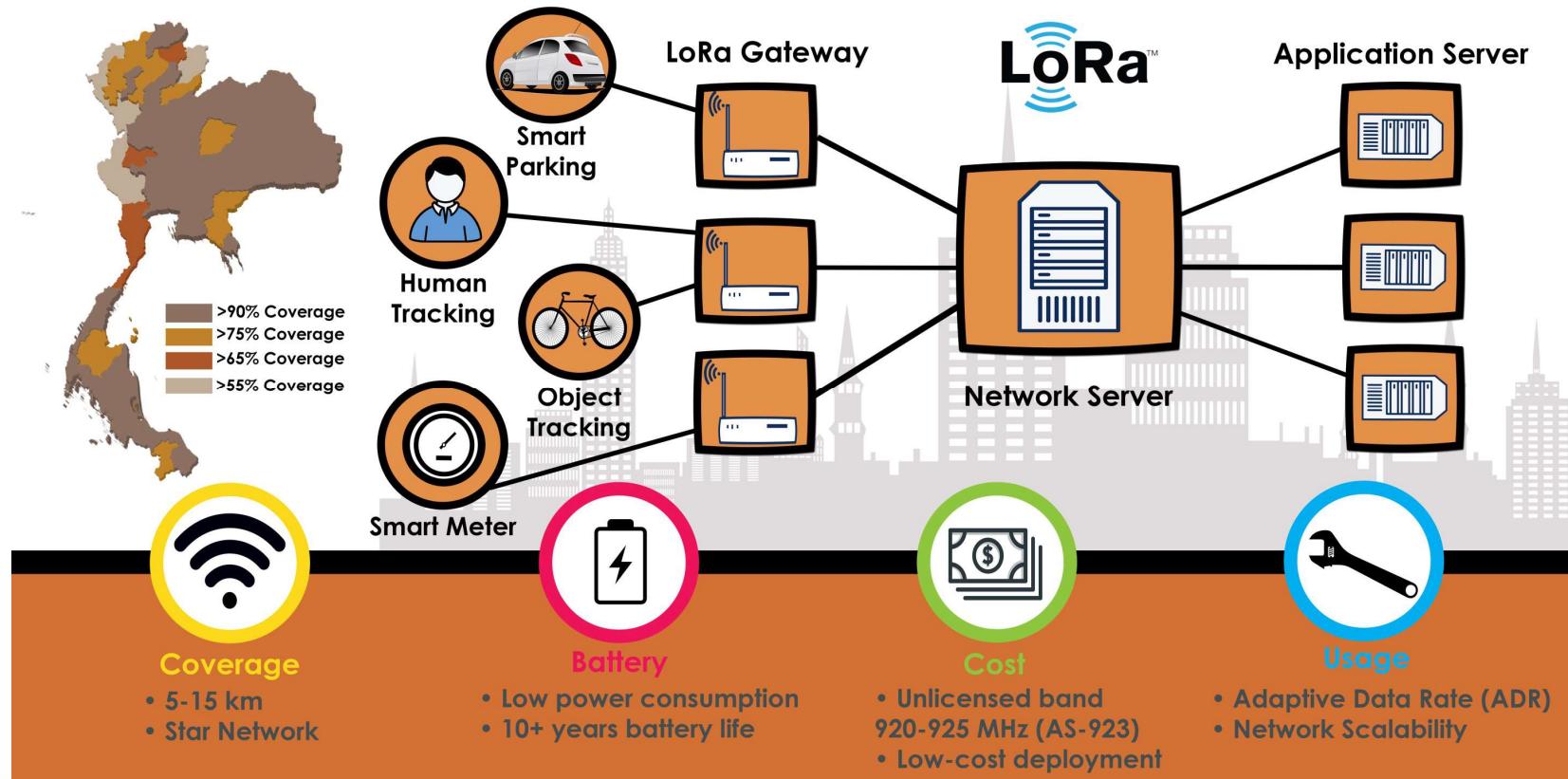
- Everything needed to develop a LoRaWAN™ Network
- 868MHz and 915MHz kits available
- Includes an 8 channel\* gateway and 2 motes
- Local LoRaWAN Network/Application server (docker image)
- GUI for Config & Testing (Windows, Linux and MAC OS)
- DV164140-1 (868 MHz); \$499
- DV146140-2 (915 MHz); \$499
- [www.microchip.com/LoRa](http://www.microchip.com/LoRa)



\* 6 channel for the DV164140-1



# LoRaWAN Network



# LoRaWAN Network

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# LORA BASIC CONCEPT

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

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- Frequency
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# Frequency



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

# 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]
- ❖ Hong Kong [920-925 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]

End-point max power := 14 dBm ERP = 25mW ERP= 41 mW e.i.r.p.

Channel plan and configuration please see: "LoRaWAN Regional Parameters 1.0.2"

[https://portal.lora-alliance.org/DesktopModules/Inventures\\_Document/FileDownload.aspx?ContentID=1397](https://portal.lora-alliance.org/DesktopModules/Inventures_Document/FileDownload.aspx?ContentID=1397)

# Frequency



Options for Target 'mlm32l07x01'

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

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by **CAT**

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

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# LORA BASIC CONCEPT

- Frequency
- Channel
- **Data Rate**
- LoRa Class
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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).

**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

## 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 E2 - AS923 maximum payload sizes

# LORA BASIC CONCEPT

- Frequency
- Channel
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- 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 BASIC CONCEPT

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

# 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)

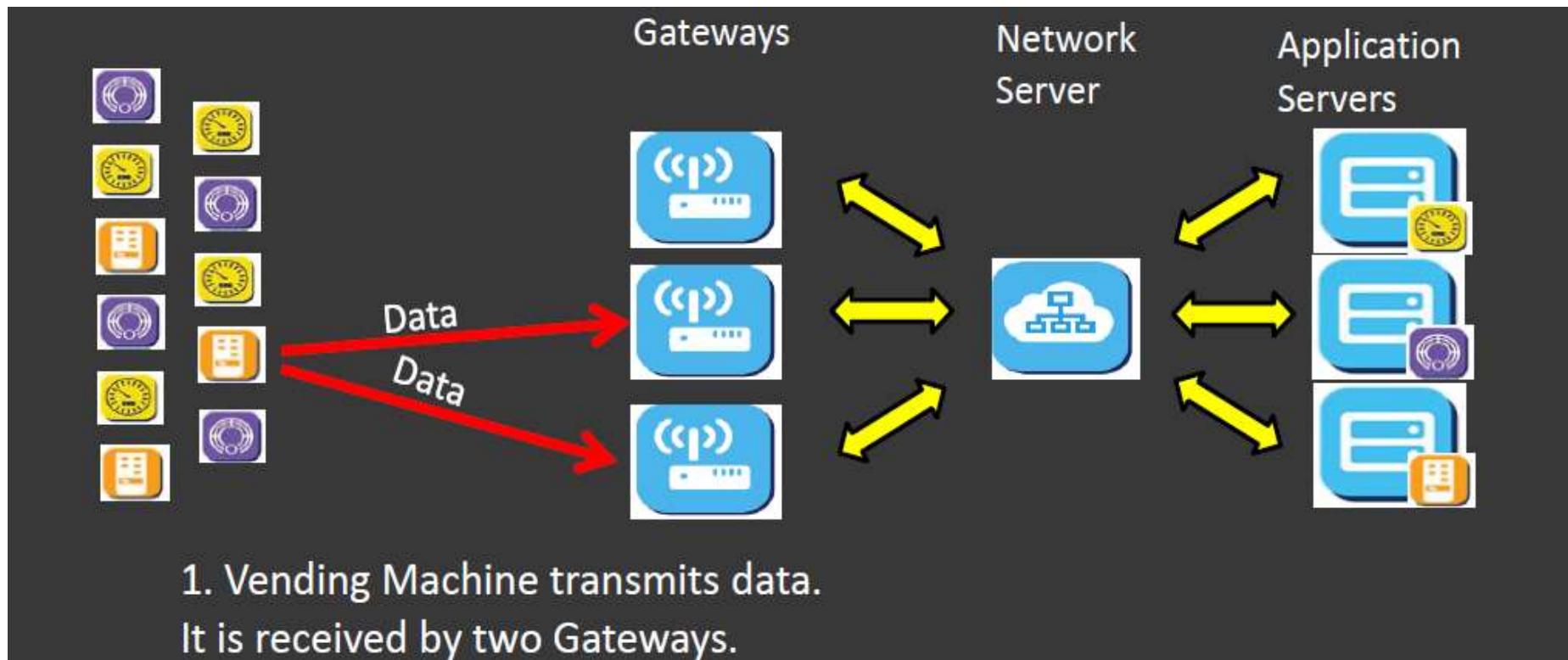
- The following information is configured at production time:
  - Device Address (**DevAddr**)
  - Network Session Key (**NwkSKey**)
  - Application Session Key (**AppSKey**)
- **No over the air handshaking**
- Device is ready to communicate on the network without any additional procedure.



# LORA BASIC CONCEPT

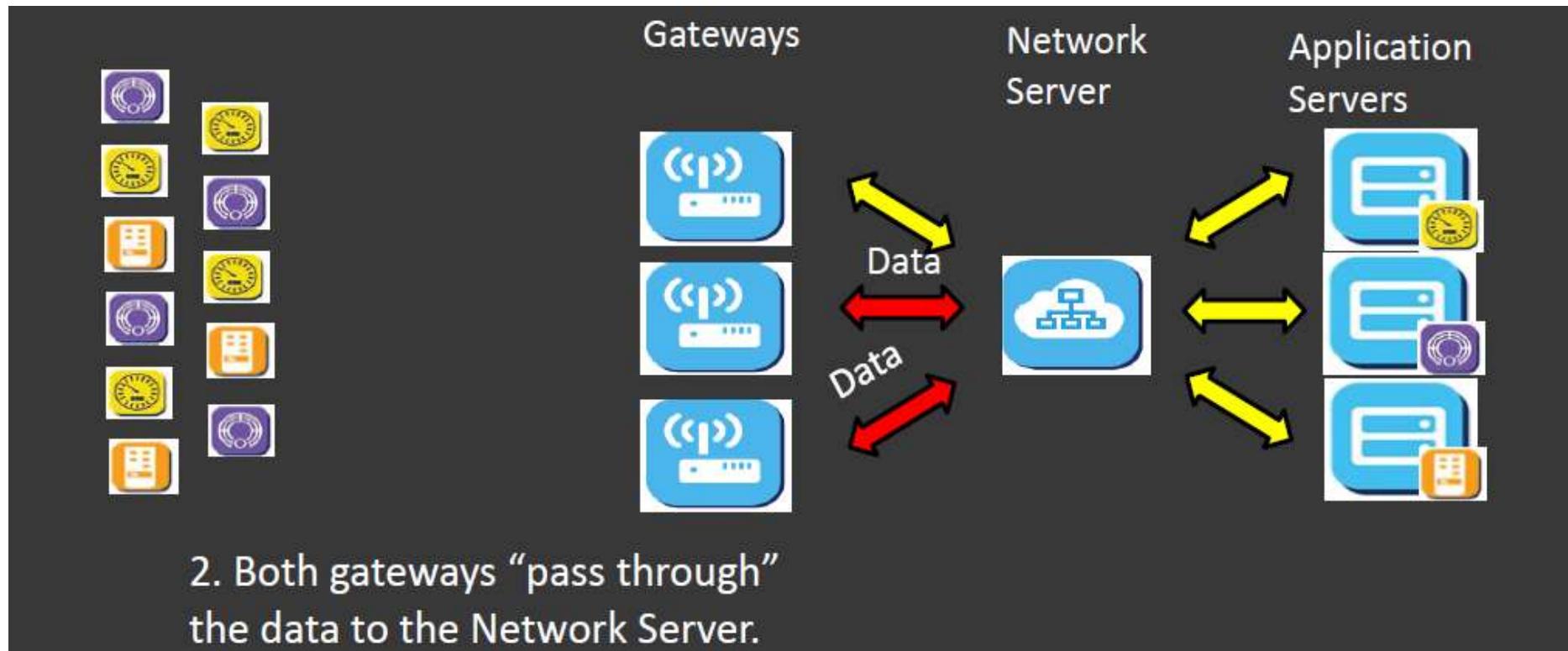
- Frequency
- Channel
- Data Rate
- LoRa Class
- Activation Mode
- **Data Message (Flow & Payload)**
- Configuration

# Data Message (Flow & Payload)



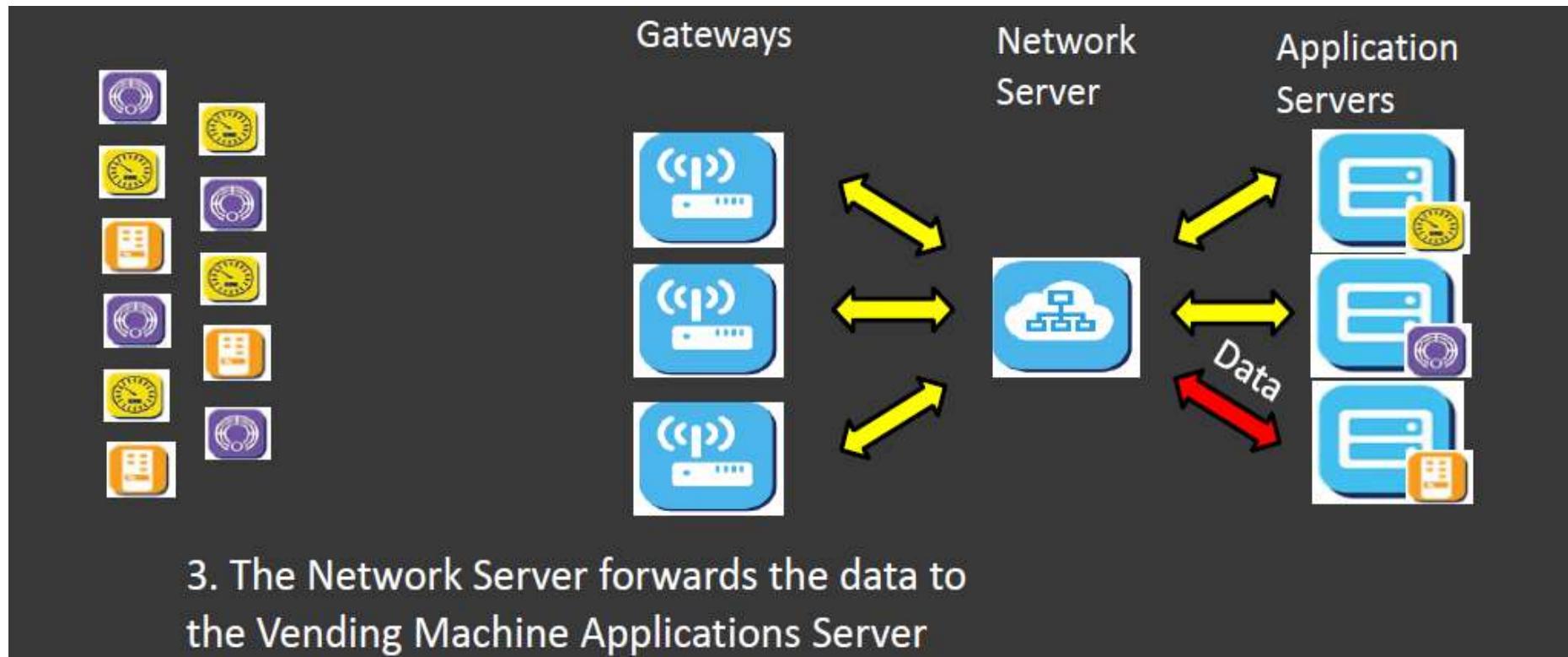
Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)



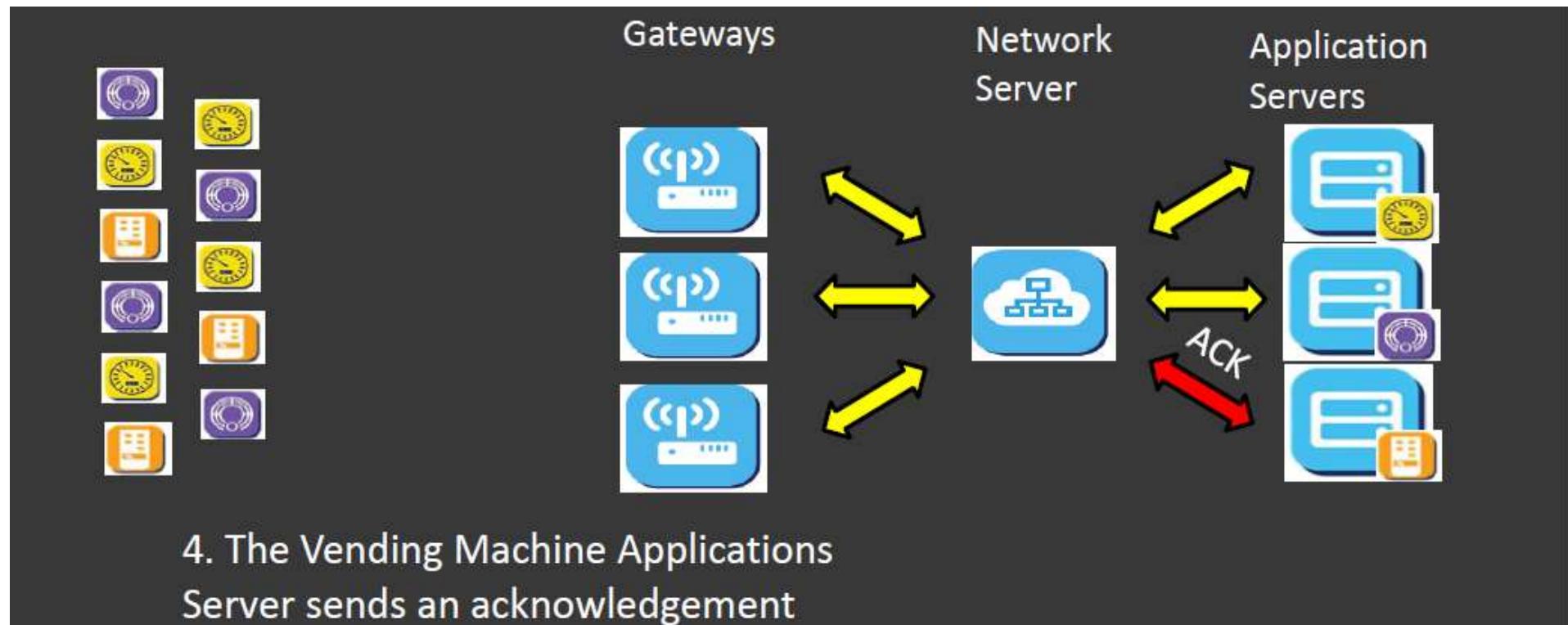
Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)



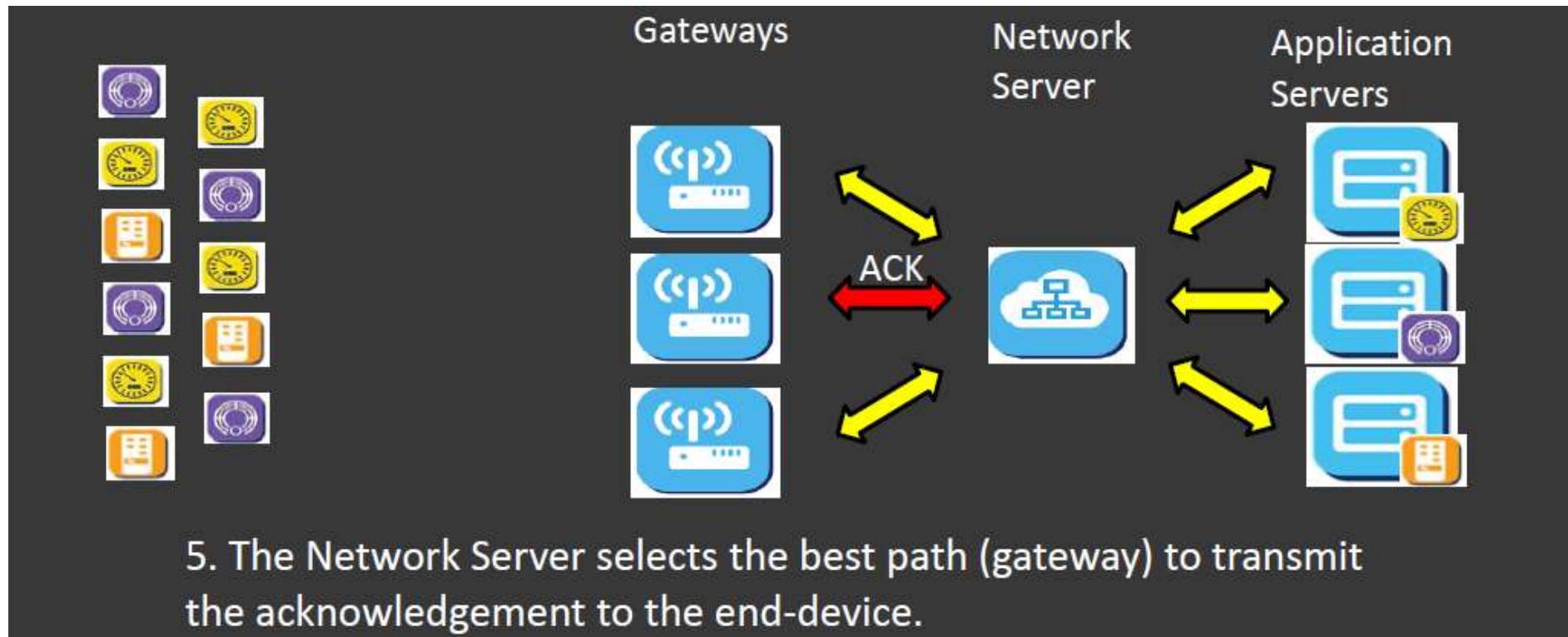
Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)



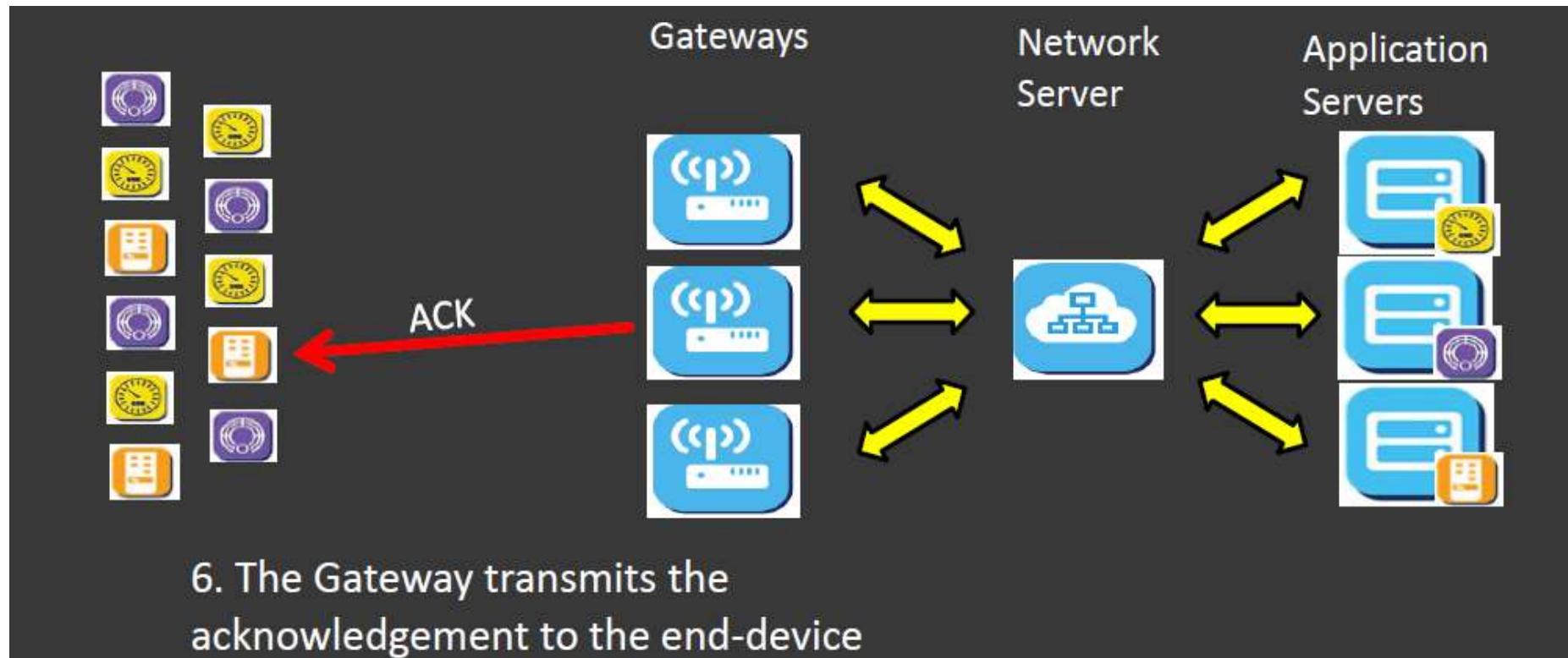
Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)



Ref: LoRa-Aliance.org

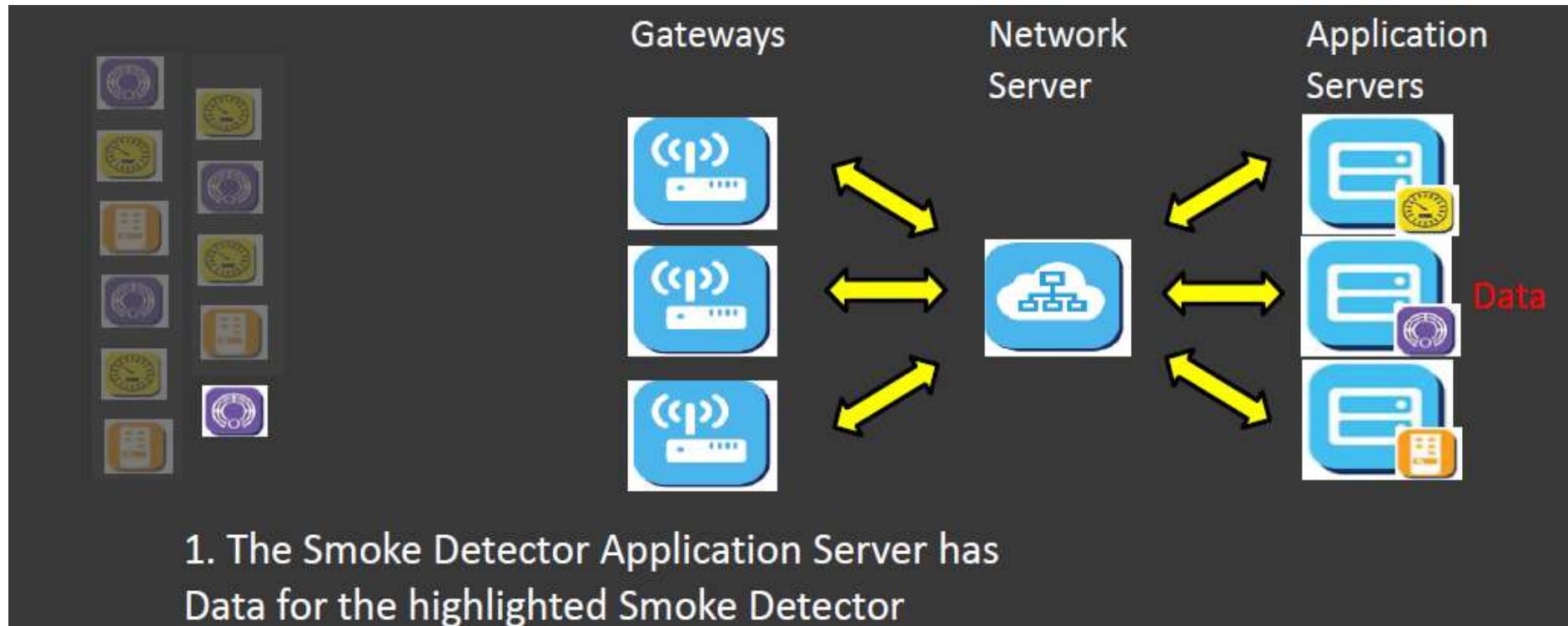
# Data Message (Flow & Payload)



Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)

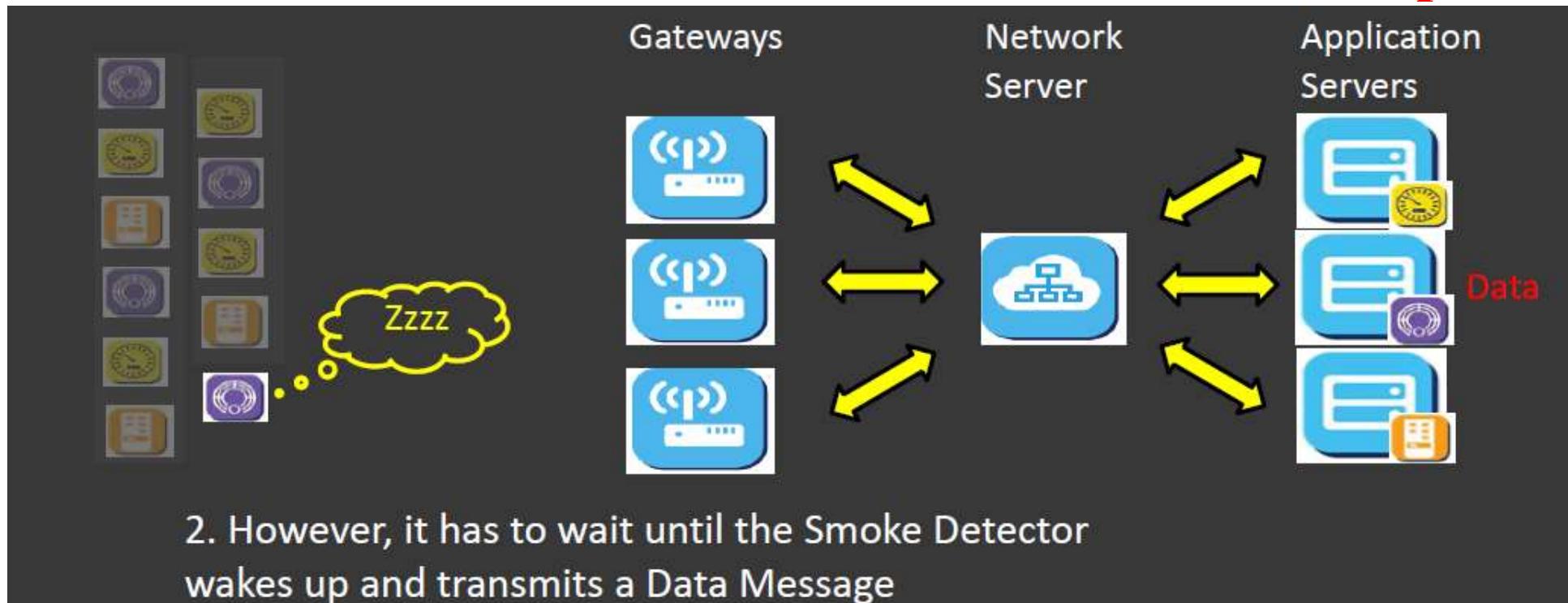
## Download & Upload



Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)

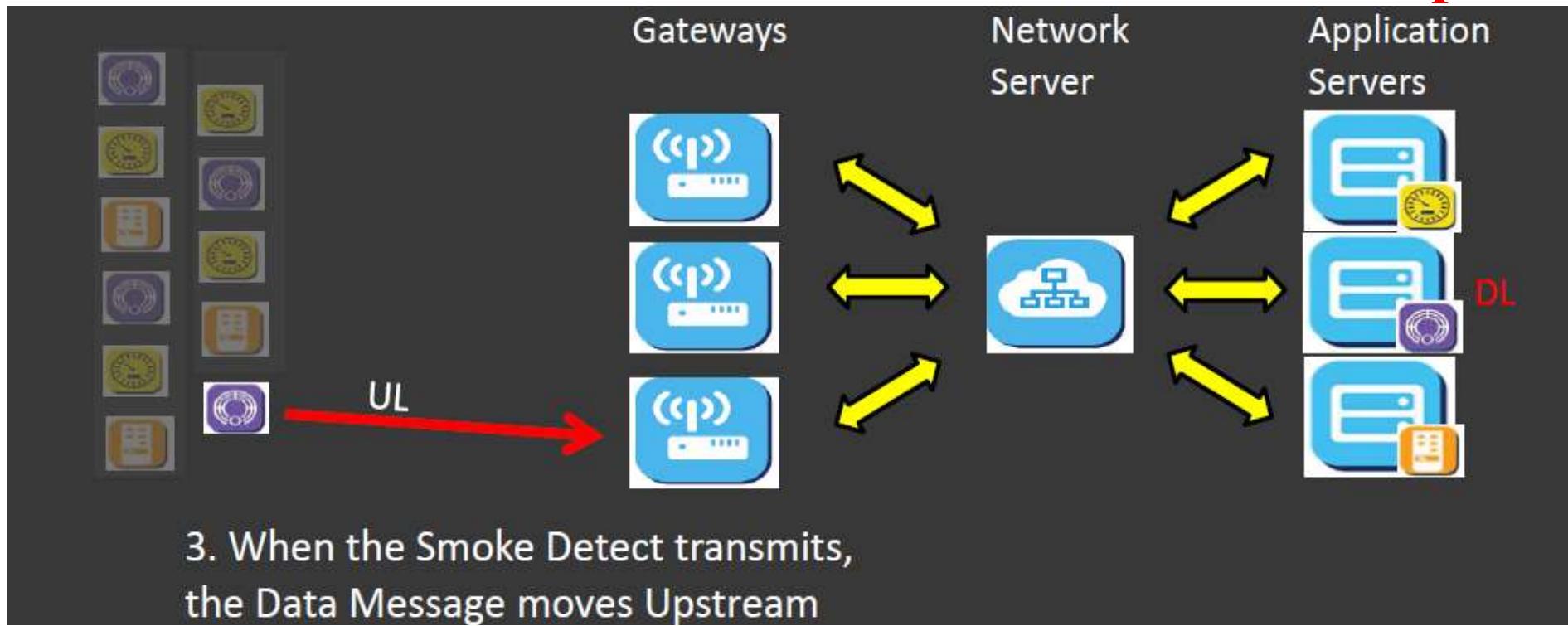
## Download & Upload



Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)

## Download & Upload

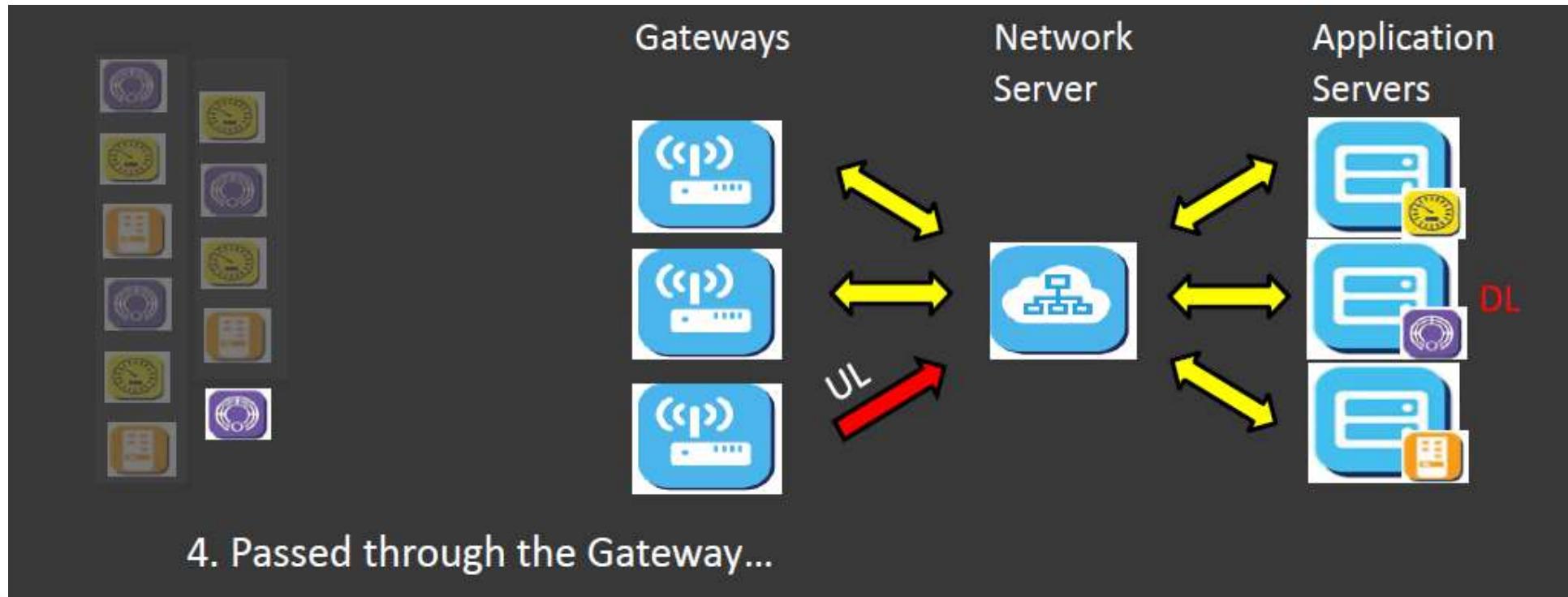


3. When the Smoke Detect transmits,  
the Data Message moves Upstream

Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)

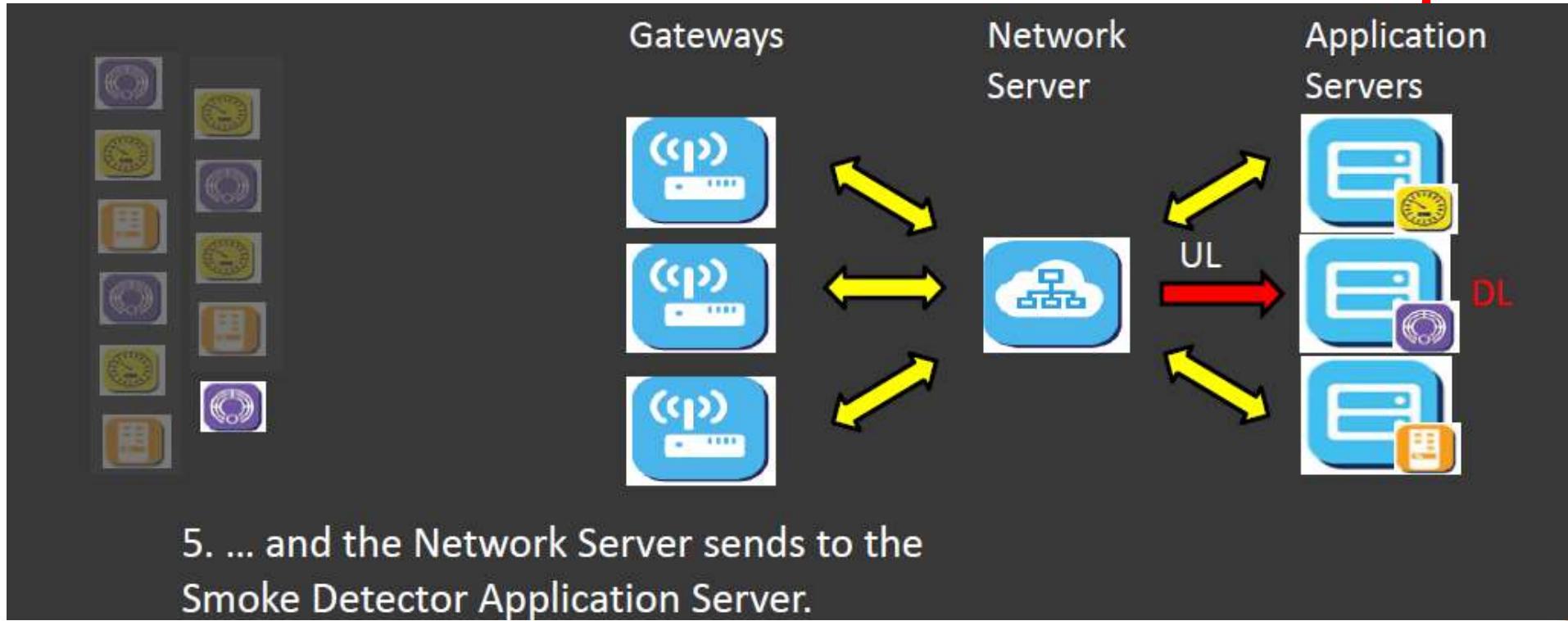
## Download & Upload



Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)

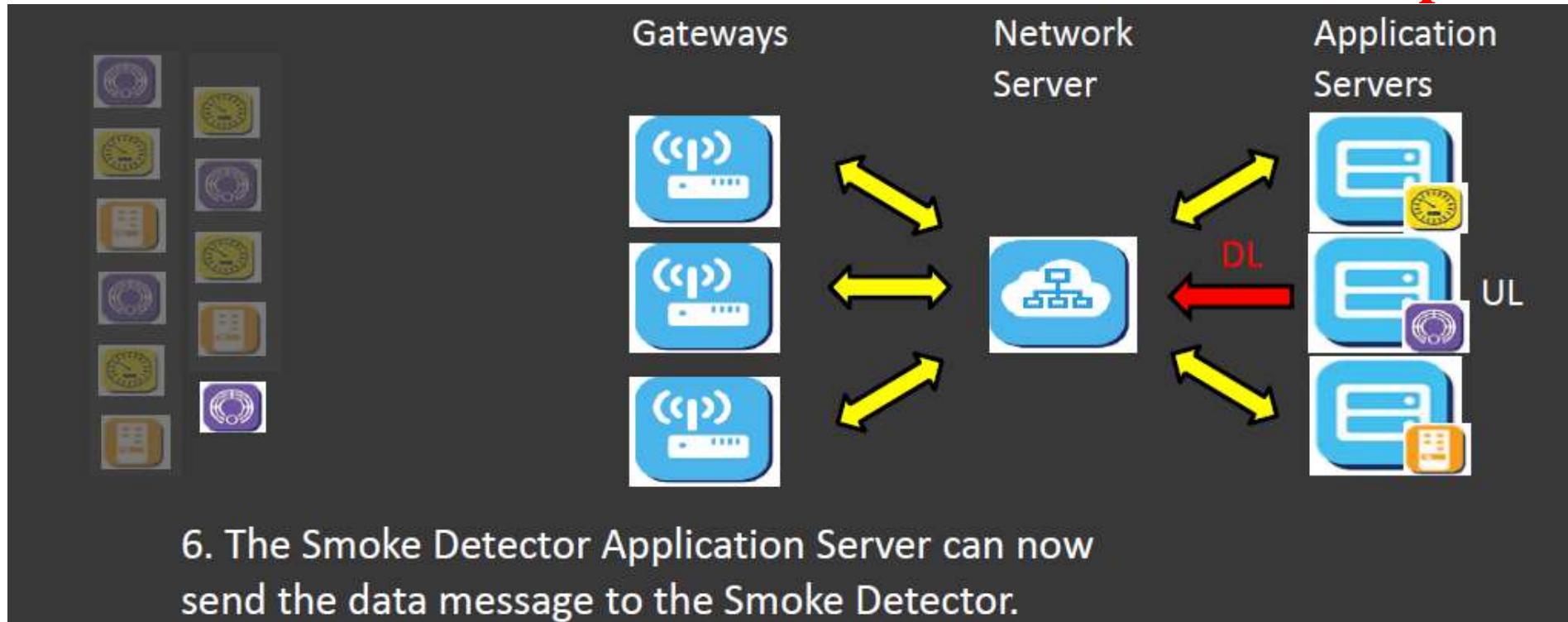
## Download & Upload



Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)

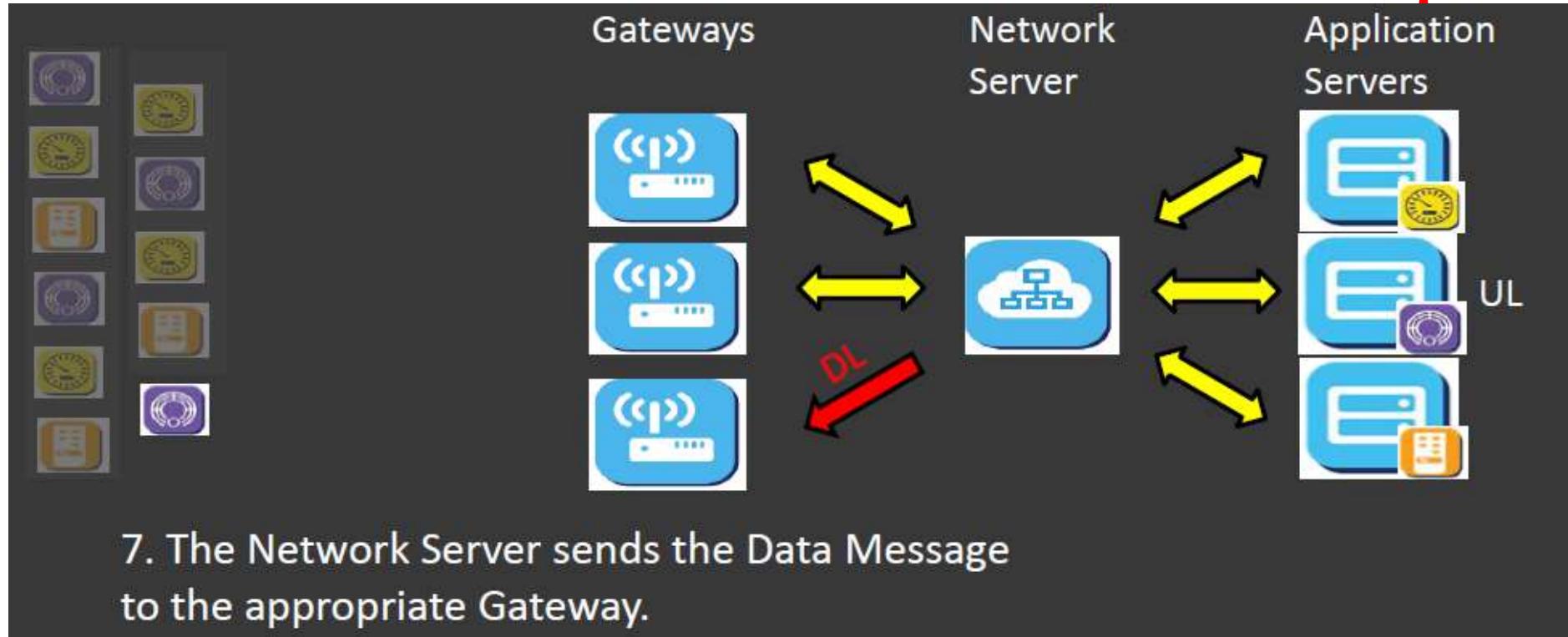
## Download & Upload



Ref: LoRa-Aliance.org

# Data Message (Flow & Payload)

## Download & Upload



Ref: LoRa-Aliance.org



# 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/>

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# 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/>

# TESA Application Server

## Payload Structure

1 Byte	N Byte	1 Byte	M Byte	1 Byte	O Byte	...
Data1 Type	Data1	Data2 Type	Data2	Data3 Type	Data3	...

## Data Type

Type	Data Type	Data Type (HEX)	Data Size (Byte)	Data Resolution
<b>Pressure</b>	1	01	2	0.1 hPa Unsigned MSB
<b>Temperature</b>	2	02	2	0.1 °C Signed MSB
<b>Humidity</b>	3	03	2	0.1 % Unsigned
<b>Gyroscope</b>	4	04	6	0.01 °/s Signed MSB per axis
<b>Accelerometer</b>	5	05	6	0.001 G Signed MSB per axis
<b>Magnetometer</b>	6	06	6	1 mGauss Signed MSB per axis
<b>LEDs</b>	7	07	1	1 for each bit
<b>Digital Input 1</b>	8	08	1	1
<b>Digital Input 2</b>	9	09	1	1
<b>Digital Input 3</b>	10	0A	1	1
<b>Digital Input 4</b>	11	0B	1	1
<b>Digital Input 5</b>	12	0C	1	1
<b>Digital Output</b>	160	A0	1	1

# TESA Application Server

## Examples

Device with temperature and acceleration sensors

Payload (HEX)	02 01 00 05 00 ED 06 07 FE 0C
---------------	-------------------------------

Data Type	Data
02 => 2 => Temperature	0100 => 256 => 25.6 °C
05 => 5 => Accelerometer	X: 00ED => 237 => 0.231 G
	Y: 0607 => 1543 => 1.543 G
	Z: FEOC => -500 => -0.5 G

# LORA BASIC CONCEPT

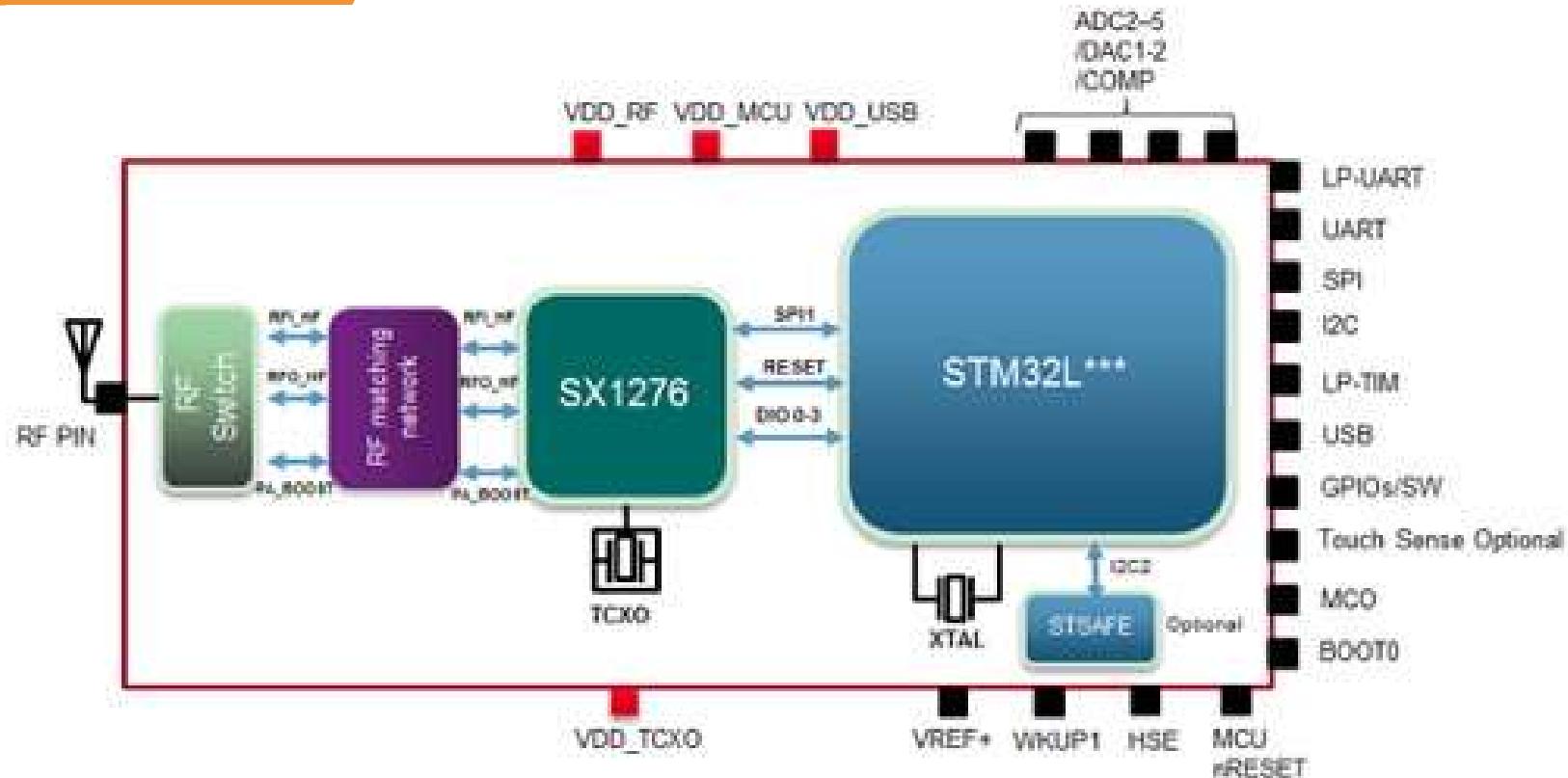
- Frequency
- Channel
- Data Rate
- LoRa Class
- Activation Mode
- Data Message (Flow & Payload)
- Configuration

# 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:

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[www.cattelecom.com](http://www.cattelecom.com)

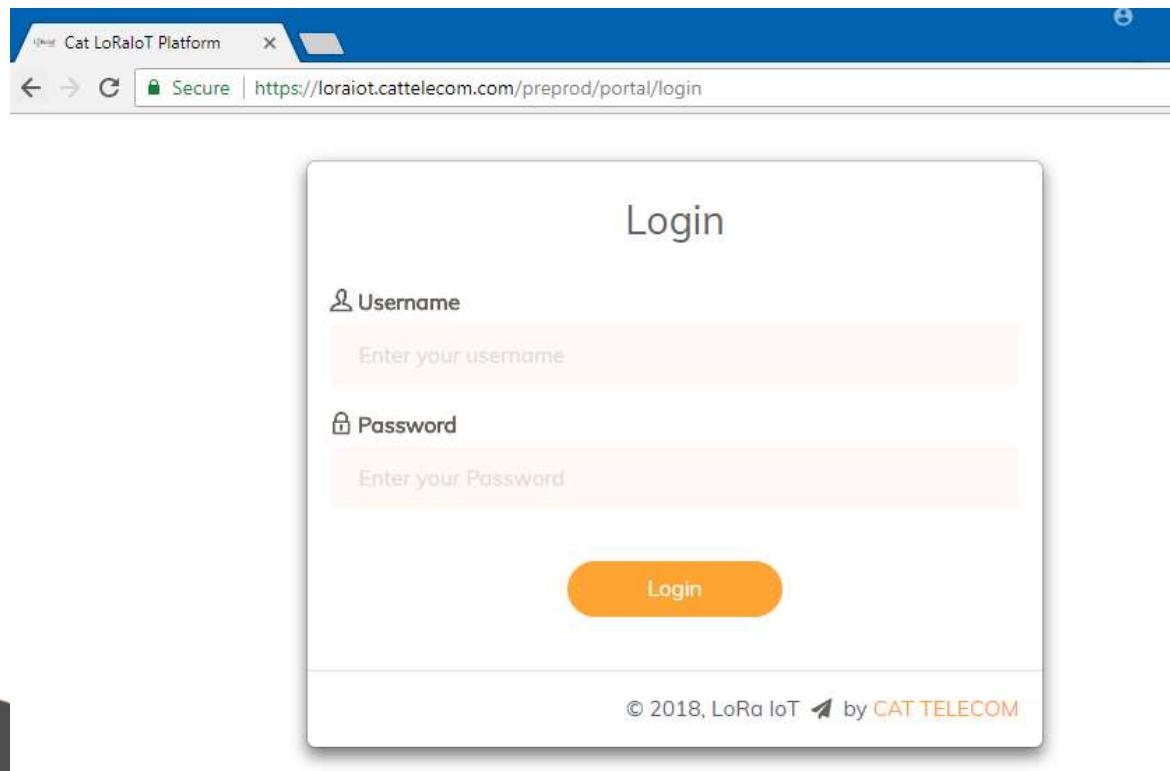
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# TOPIC

- IoT Concept
- Network Concept
- LoRa Network
- LoRa Basic Concept
- LoRa Account
- Device Manager
- Example Application

# LoRa Account

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



The screenshot shows a web browser window titled "Cat LoRaIoT Platform". The address bar indicates a secure connection to "https://loraiot.cattelecom.com/preprod/portal/login". The main content is a "Login" form. It features two input fields: "Username" and "Password", both with placeholder text "Enter your username" and "Enter your Password" respectively. Below these fields is a yellow "Login" button. At the bottom of the form, there is a copyright notice: "© 2018, LoRa IoT by CAT TELECOM".

ตามกระดาษ

Username

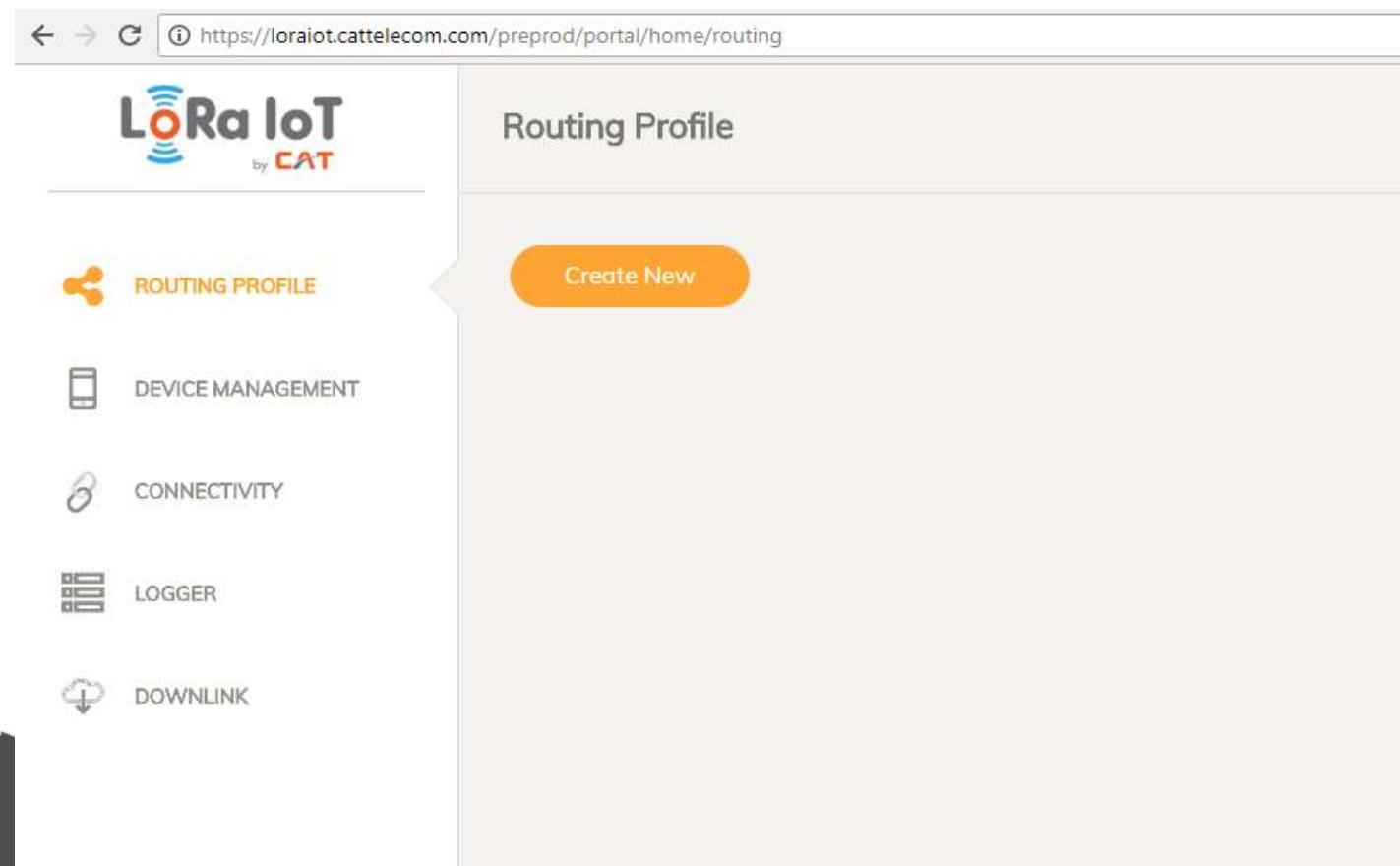
Password

ของแต่ละทีม

# TOPIC

- IoT Concept
- Network Concept
- LoRa Network and Basic Concept
- **Workshop : LoRa Account and Device Management**
- Workshop : LoRa Example Application

# Device Manager



The screenshot shows the LoRa IoT Device Manager portal. The URL in the address bar is <https://loraiot.cattelecom.com/preprod/portal/home/routing>. The left sidebar has icons for ROUTING PROFILE, DEVICE MANAGEMENT, CONNECTIVITY, LOGGER, and DOWNLINK. The main content area is titled "Routing Profile" and contains a "Create New" button.

Routing Profile

Device Management

Connectivity

Logger

Downlink



# Device Manager

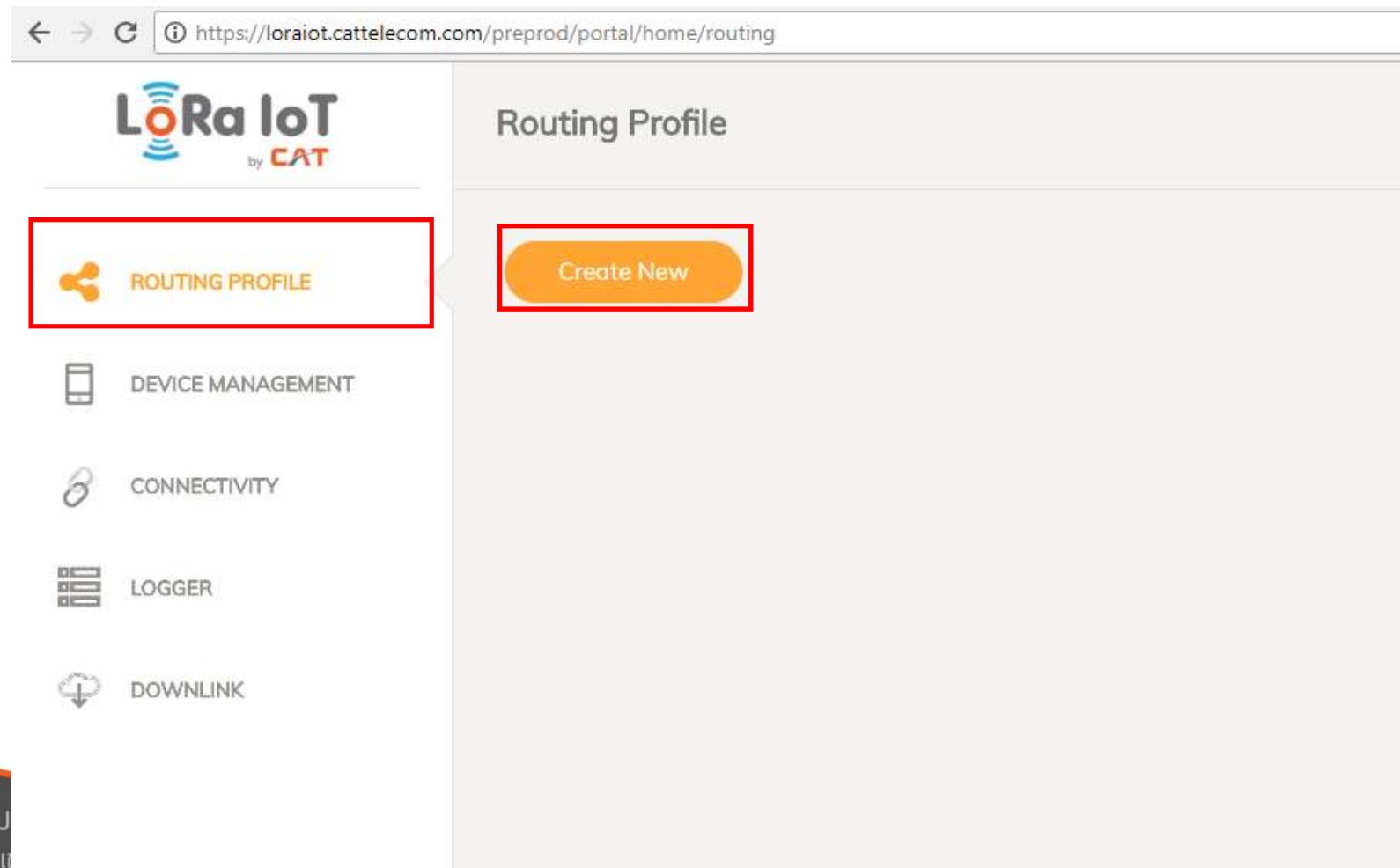
## Routing Profile

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# Device Manager

## Routing Profile



https://loraiot.cattelecom.com/preprod/portal/home/routing

Lora IoT by CAT

ROUTING PROFILE

Create New

DEVICE MANAGEMENT

CONNECTIVITY

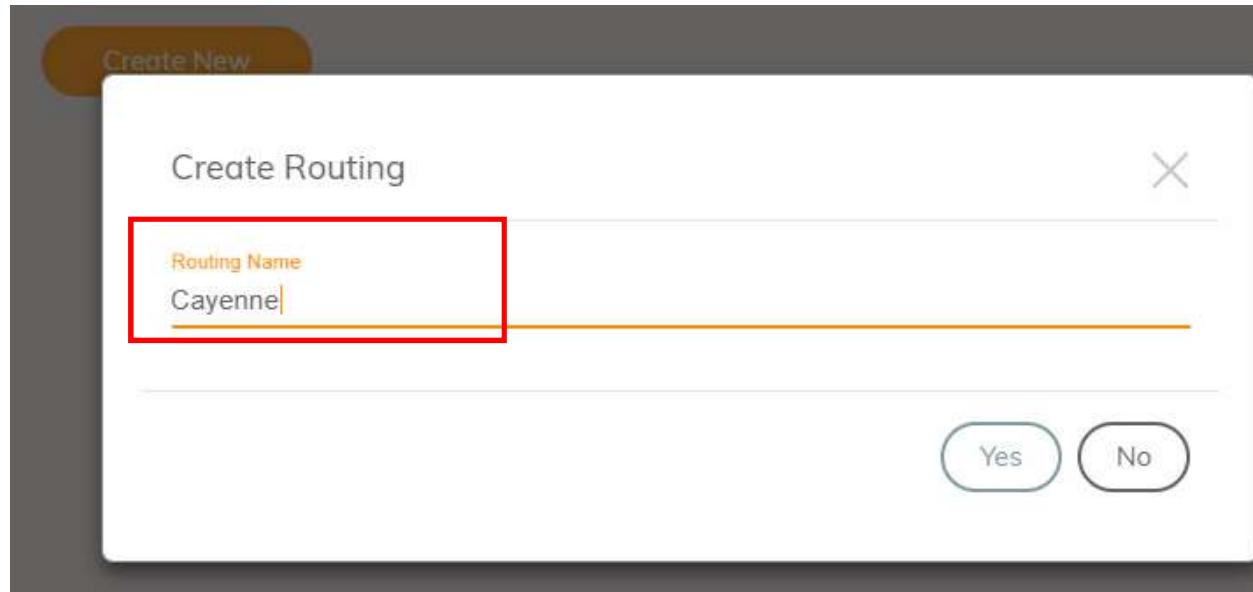
LOGGER

DOWNLINK

Routing Profile

# Device Manager

## Routing Profile



# Device Manager

Routing Profile

Routing Profile

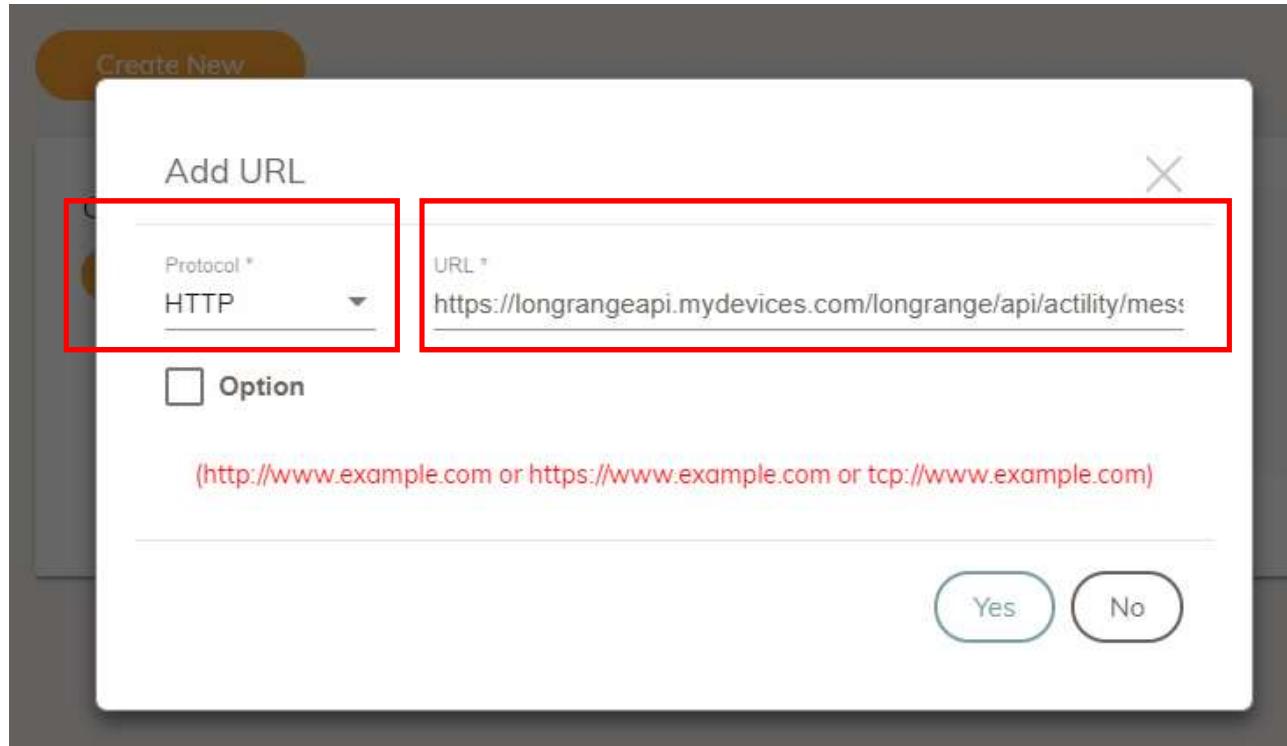
Create New

Cayenne



# Device Manager

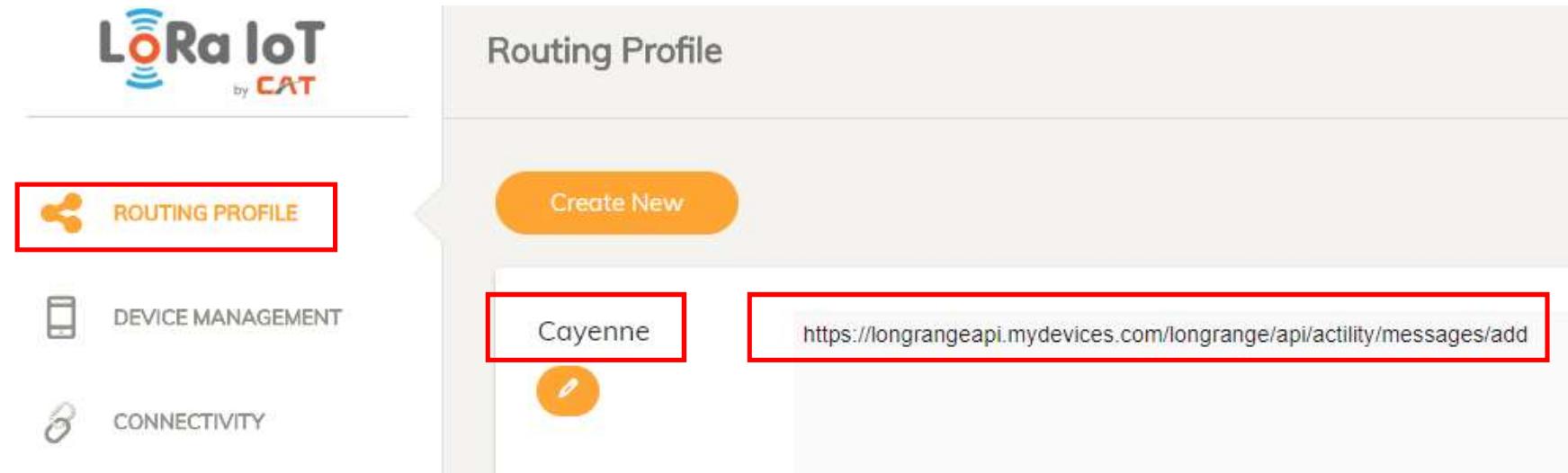
## Routing Profile



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

# Device Manager

## Routing Profile



The screenshot shows the LoRa IoT Device Manager interface. On the left, there's a sidebar with three options: 'ROUTING PROFILE' (highlighted with a red box), '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 small edit icon next to it. A URL is displayed in a box: <https://longrangeapi.mydevices.com/longrange/api/actility/messages/add>.



# Device Manager

## Device Management

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# Device Manager



The screenshot shows the Lora IoT Device Manager interface. On the left, there's a sidebar with the Lora IoT logo and four main navigation items: ROUTING PROFILE, DEVICE MANAGEMENT (which is highlighted with a red box), and CONNECTIVITY. Below these are two additional items. The main content area is titled "Routing Profile" and contains a "New Device" button, also highlighted with a red box. Below this is a section titled "Device Data" with columns for Name, DevEUI, Profile Name, Device Address, and Connectivity Inst.

# Device Manager



## Create New Device

\* Name : OTAA

Activation Type : **OTAA**

\* Device EUI :

\* Application EUI :

\* Application Key :

\* Payload Format : Raw

Routing Profile : myserver

\* Device Profiles : LoRaWAN Class A - AS923 - Generic

\* 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 : LoRaWAN Class A - AS923 - Generic

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

Yes No

# Device Manager

## Device Management

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 – AS933

ABP

### Create New Device

\* Name :

Device Name \*  
ABP

Activation Type :

ABP

\* Device EUI :

Device EUI (16-character hexadecimal) \*

\* Device Address :

Device Address (8-character hexadecimal) \*

\* Network Session Key :

Network Session Key (32-character hex) \*

\* Application Session Key :

Application Session Key (32-character hex) \*

\* Payload Format :

Raw

Routing Profile :

myserver

\* Device Profiles :

LoRaWAN Class A - AS923 - Generic

\* Connectivity Instances :

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

Yes

No





# Device Manager

## Device Management

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 – AS933

OTAA

### 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

LoRaWAN Class A - AS923 - Generic

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

Yes

No

# Device Manager

## Device Management



 ROUTING PROFILE

 DEVICE MANAGEMENT

 CONNECTIVITY

 LOGGER

 DOWNLINK

### Routing Profile

 testworkshop02 

New Device

### Device Data

Active	Name	DevEUI	Profile Name	Device Address	Connectivity Instances	Payload Format	Routing Profile	
	940taa		LoRaWAN Class A - AS923 - Generic		Preorder	Raw	myserver	 
	testabp01		LoRaWAN Class A - AS923 - Generic		Preorder	Raw	myserver	 
	testabp02		LoRaWAN Class A - AS923 - Generic		Preorder	Raw	myserver	 

# Device Manager



## Connectivity

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# Device Manager



ROUTING PROFILE

DEVICE MANAGEMENT

**CONNECTIVITY**

LOGGER

DOWNLINK

Connectivity

Activate Voucher

Enter your voucher code

Activate Activate

Filter Connectivity

By Active

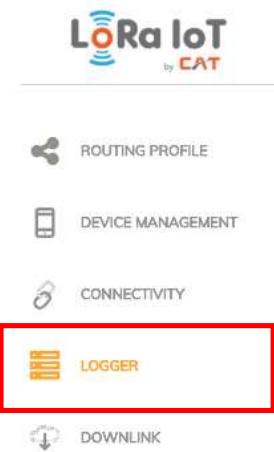
Connectivity Data

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

## Logger

# Device Manager

## Logger



**Routing Profile**

Filter Device

Device EUI:

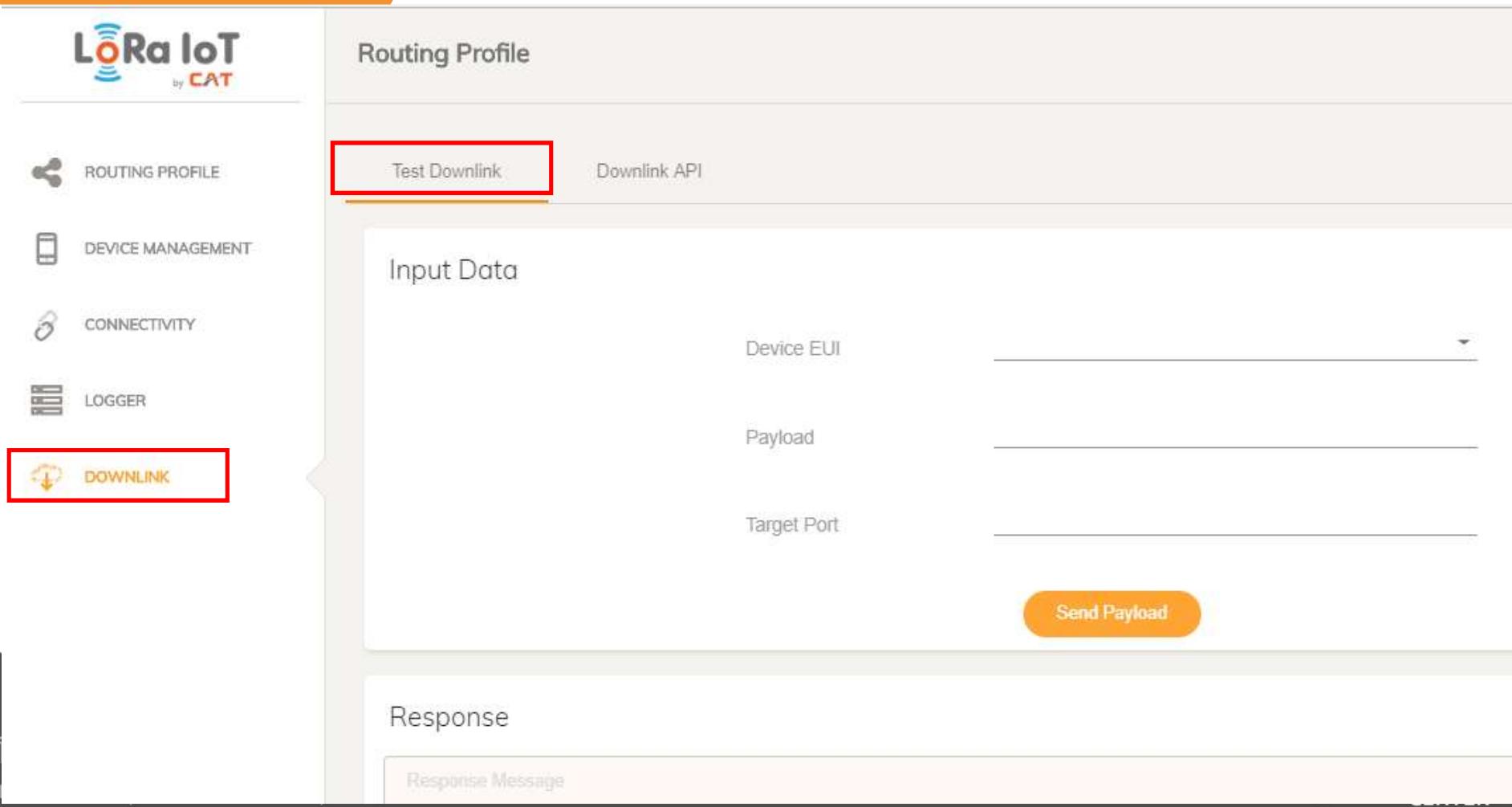
Search:

**Logger Data**

Timestamp	Device Address	DevEUI	Payload	FPort	FCnt 	FCnt 	RSSI	SNR	SubBand	Channel
18/05/2018 00:40:16	9		007300000167000026800030064040100	99	360	4	-57.000000	12.000000	G1	LC6
18/05/2018 00:40:11	9		007300000167000026800030064040100	99	359	3	-60.000000	12.000000	G1	LC7
18/05/2018 00:40:06	9		007300000167000026800030064040100	99	358	2	-58.000000	11.250000	G1	LC2
18/05/2018 00:40:01	9		007300000167000026800030064040100	99	357	1	-59.000000	11.500000	G1	LC3

## Downlink

# Device Manager



The screenshot shows the LoRa IoT Device Manager interface. On the left, there's a sidebar with icons for Routing Profile, Device Management, Connectivity, Logger, and Downlink. The Downlink icon is highlighted with a red box. The main area is titled "Routing Profile" and contains tabs for "Test Downlink" (which is highlighted with a red box) and "Downlink API". Below these tabs is a section titled "Input Data" with fields for "Device EUI", "Payload", and "Target Port", each with a corresponding input field. At the bottom right of this section is a yellow "Send Payload" button. Below the input fields is a section titled "Response" with a "Response Message" input field.

ROUTING PROFILE

DEVICE MANAGEMENT

CONNECTIVITY

LOGGER

DOWNLINK

Test Downlink

Downlink API

Input Data

Device EUI

Payload

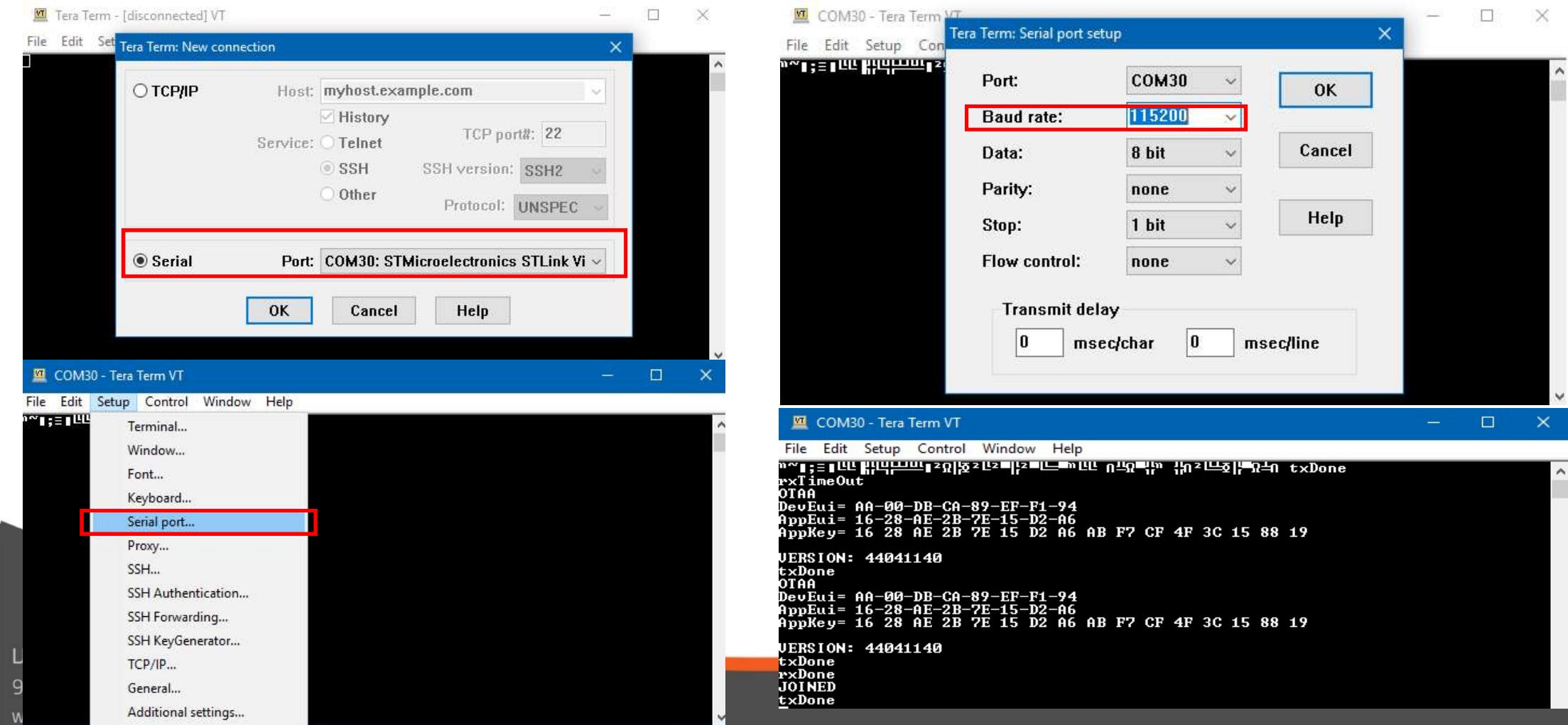
Target Port

Send Payload

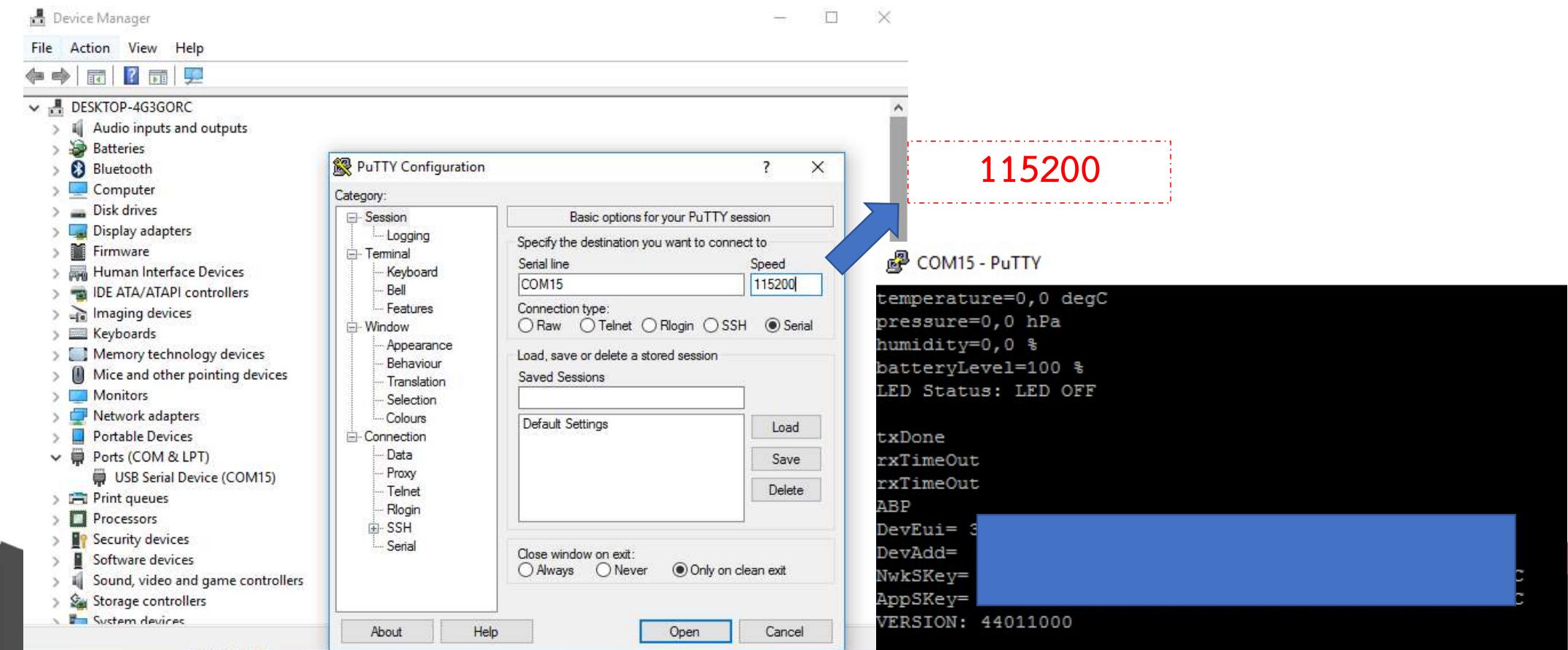
Response

Response Message

# Get Device EUI and Address From Node



# Get Device EUI and Address From Node



# Device Manager

COM15 - PuTTY

```
batteryLevel=100 %
LED Status: LED OFF

ABP
DevEui= 34:5A:69:32:2B:7E:15:16
DevAdd= 00:00:00:00:00:00:00:00
NwkSKey= 28 AE D2 2B 7E 15 16 A6 09 CF AB F7 15 88 4F 3C
AppSKey= 16 28 AE 2B 7E 15 D2 A6 AB F7 CF 4F 3C 15 88 09
VERSION: 44011000

temperature=0,0 degC
pressure=0,0 hPa
humidity=0,0 %
batteryLevel=100 %
LED Status: LED OFF
```

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

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



Commissioning.h  
 Change LORAWAN\_NWKSKEY  
 Change LORAWAN\_APPSKY

# Device Manager



# ABP

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# Device Manager

\*\* Please check payload format  
and 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 Manager

\*\* Please check payload format  
and 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 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_APPSKY { 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x09 }
```

# Device Manager



# OTAA

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# Device Manager

\*\* Please check payload format  
and 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 Manager

\*\* Please check payload format  
and 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 )  
  
{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6}  
{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6 }  
  
{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x19 }  
{ 0x16, 0x28, 0xAE, 0x2B, 0x7E, 0x15, 0xD2, 0xA6, 0xAB, 0xF7, 0xCF, 0x4F, 0x3C, 0x15, 0x88, 0x09 }
```

# Device Manager

main.c

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

\*\* Please check payload format  
and LoRaWAN Key Setting !!

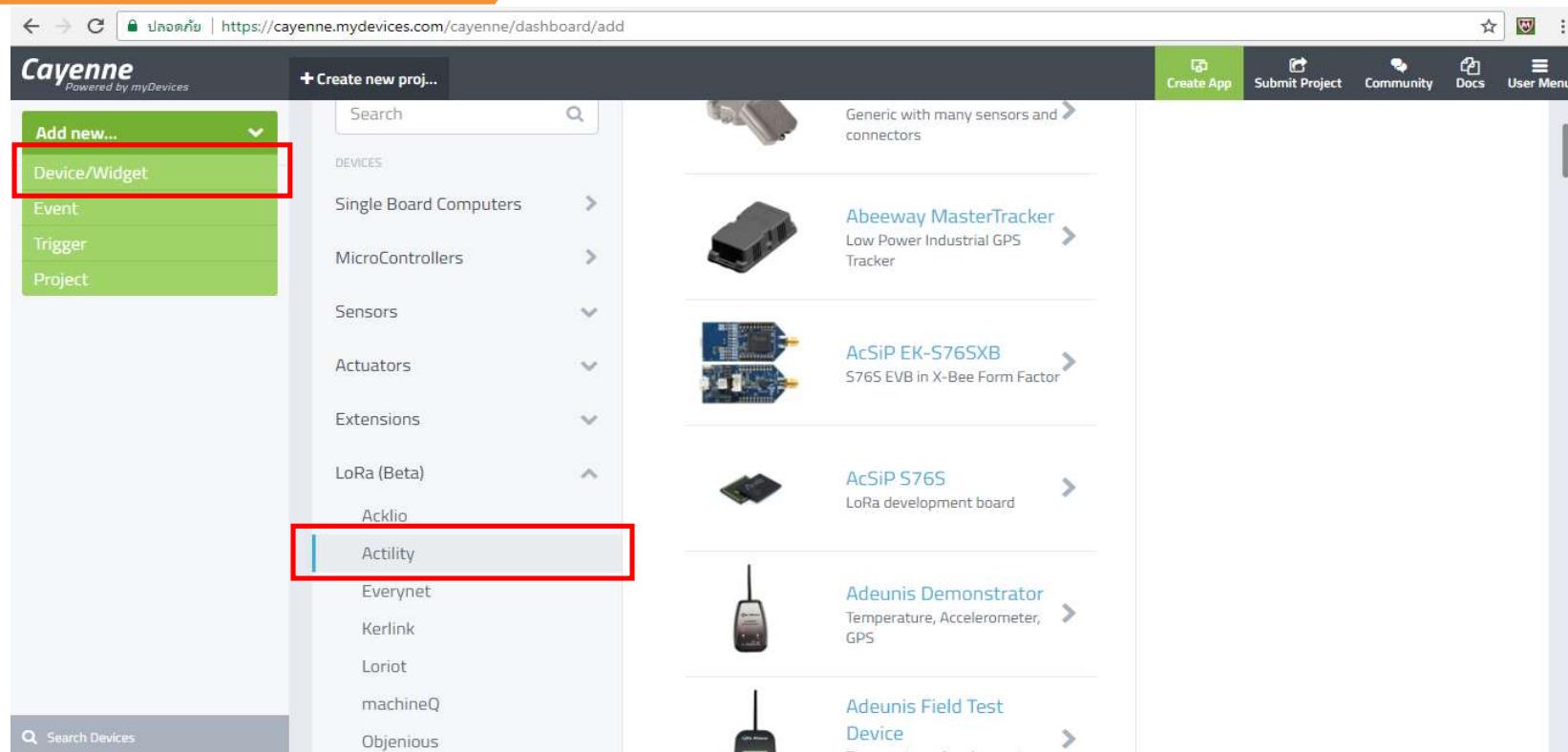


```
#ifdef CAYENNE_LPP  
    uint8_t cchannel=0;  
    temperature = ( int16_t )( sensor_data.temperature * 10 ); /* in °C * 10 */  
    pressure = ( uint16_t )( sensor_data.pressure * 100 / 10 ); /* in hPa / 10 */  
    humidity = ( uint16_t )( sensor_data.humidity * 2 ); /* in %*2 */  
    uint32_t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

# TOPIC

- IoT Concept
- Network Concept
- LoRa Network and Basic Concept
- Workshop : LoRa Account and Device Management
- **Workshop : LoRa Example Application**

# Example Application



The screenshot shows the Cayenne dashboard interface. On the left, there's a sidebar with a 'Devices' section containing various categories like Single Board Computers, MicroControllers, Sensors, Actuators, Extensions, LoRa (Beta), Acklio, and a highlighted 'Actility'. A red box highlights the 'Device/Widget' option in the 'Add new...' dropdown menu. Below the sidebar, there's a main area showing several device cards with images and names.

- 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



STM32 B-L072Z-LRWAN1  
STM32 LoRa Discovery Board

This device uses Cayenne LPP

Name: STM32 B-L072Z-LRWAN1

DevEUI: AA00DBCA89EF0A01

Activation Mode: Already Registered

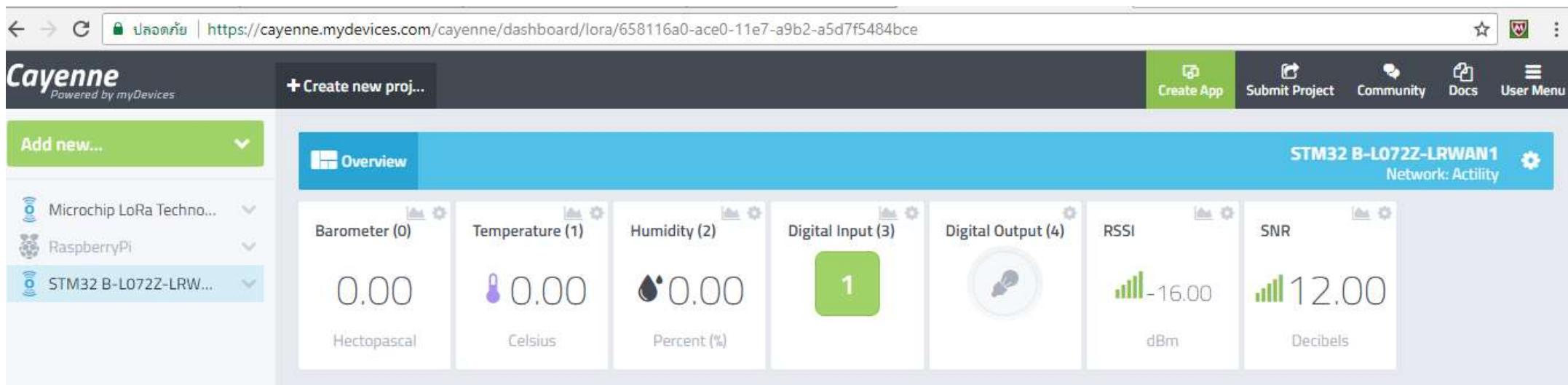
ThingPark Server: dev1.thingpark.com

ThingPark Email

ThingPark Password

<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'. The main area is titled 'Overview' and displays real-time data from a device named 'STM32 B-L072Z-LRWAN1' connected via 'Actility'. The data is presented in six cards:

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

On the left sidebar, under 'Add new...', the device 'STM32 B-L072Z-LRWAN1' is selected.

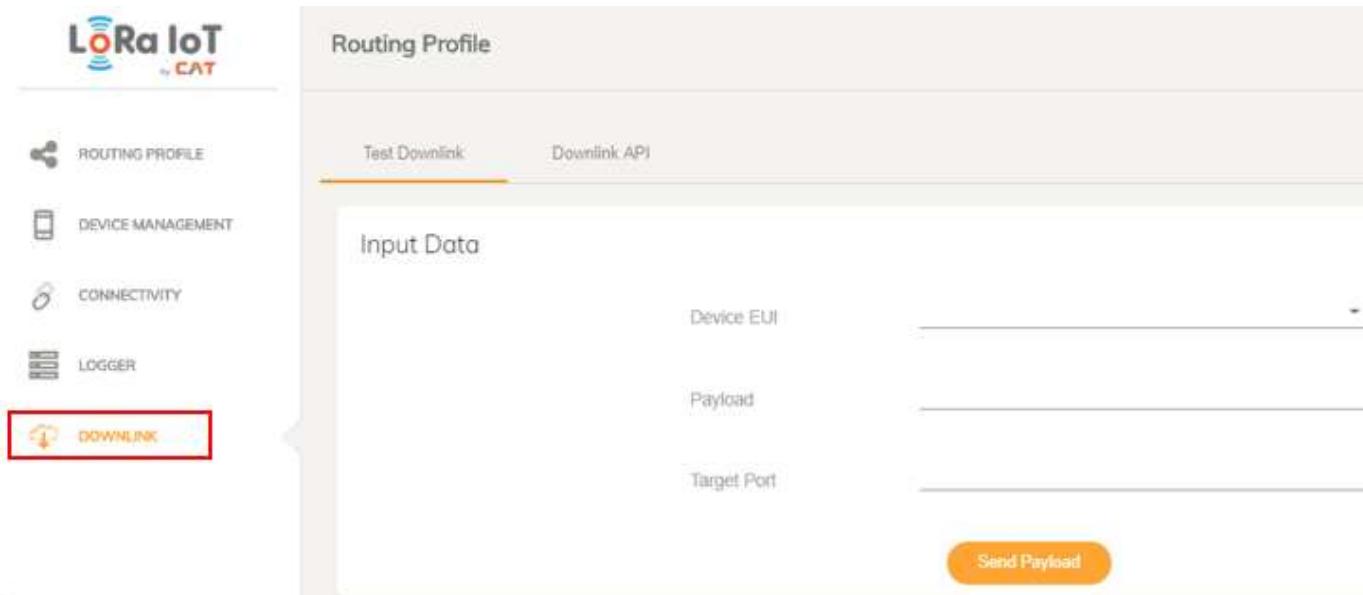
<https://cayenne.mydevices.com/cayenne/dashboard/add>

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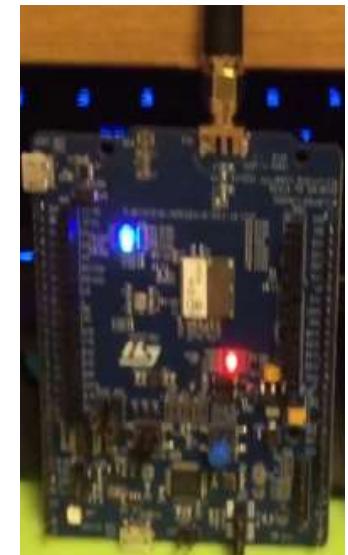
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# Extra Challenge

## Lab1: Turn on and Turn off LED status

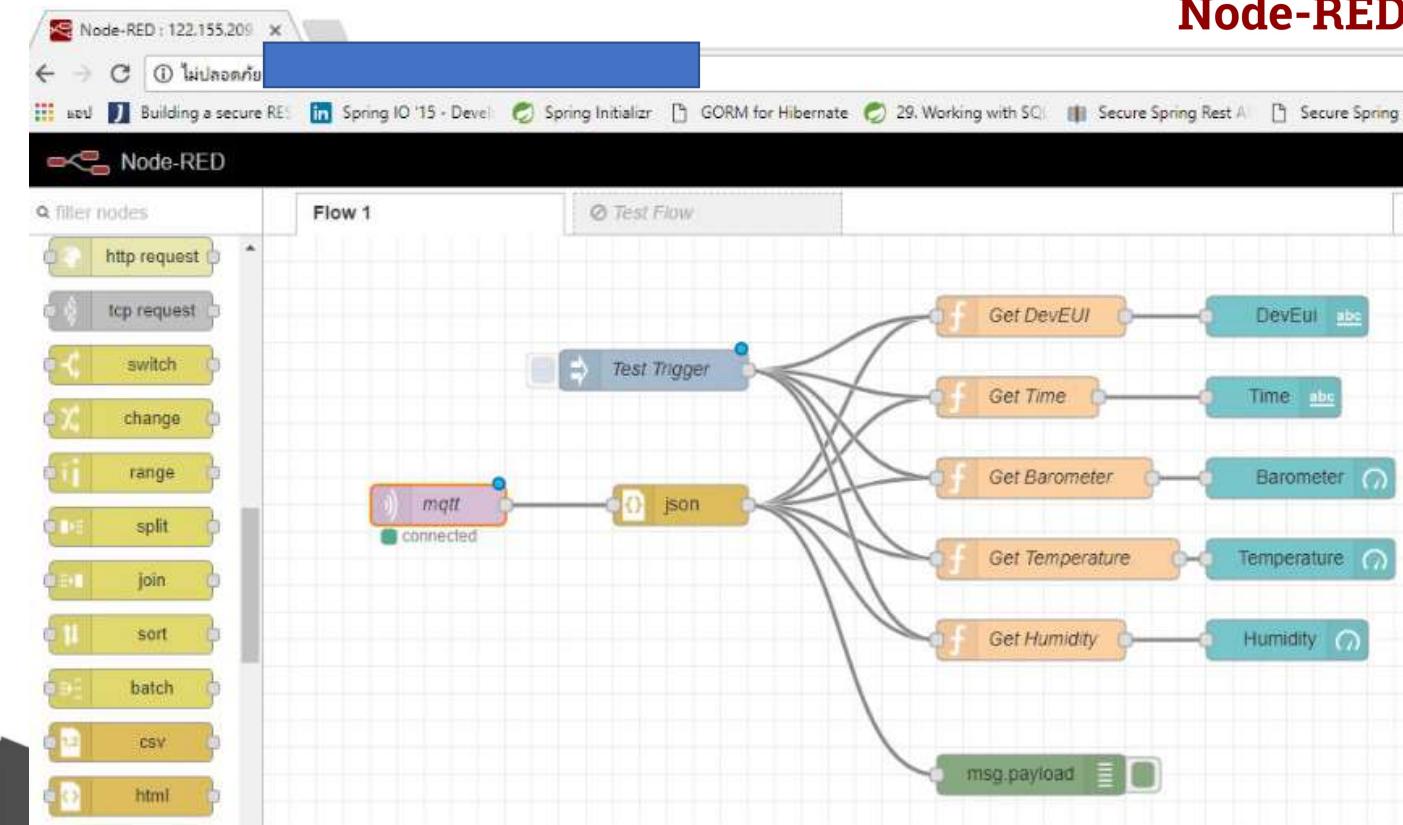
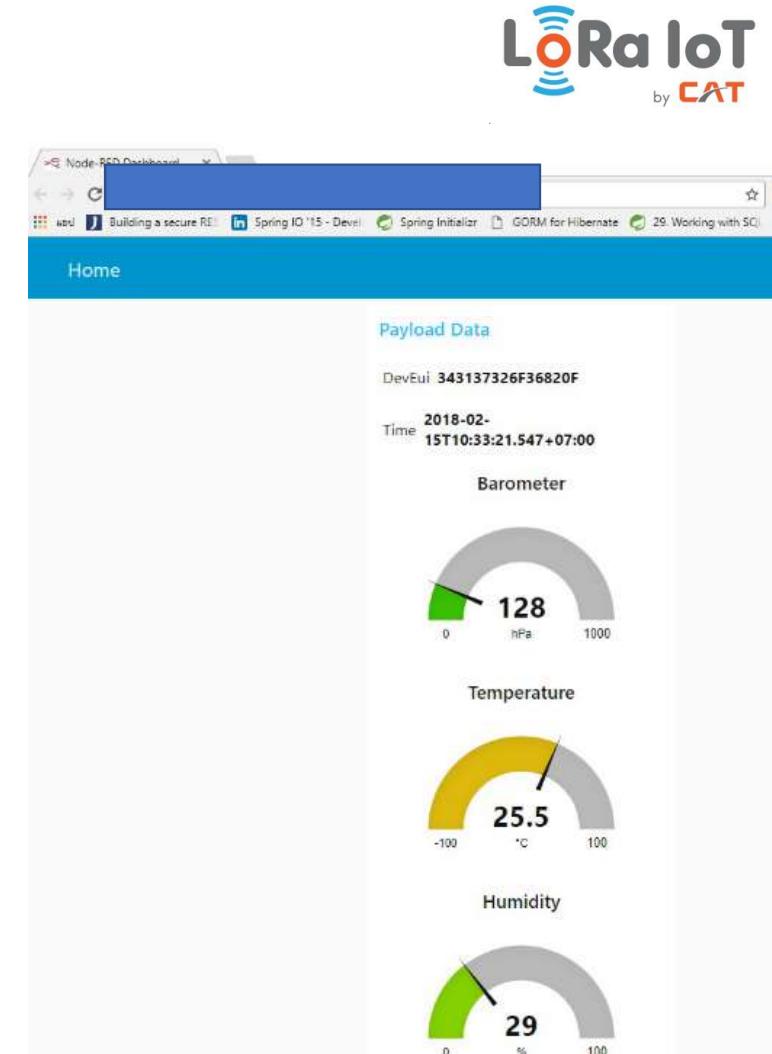
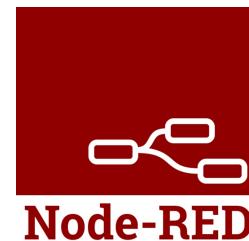


The screenshot shows the LoRa IoT platform's Routing Profile section. The 'Downlink' tab is active. The 'Input Data' area contains fields for 'Device EUI', 'Payload', and 'Target Port'. A prominent orange 'Send Payload' button is at the bottom.



## Lab2: Compare response from Class\_A and Class\_C

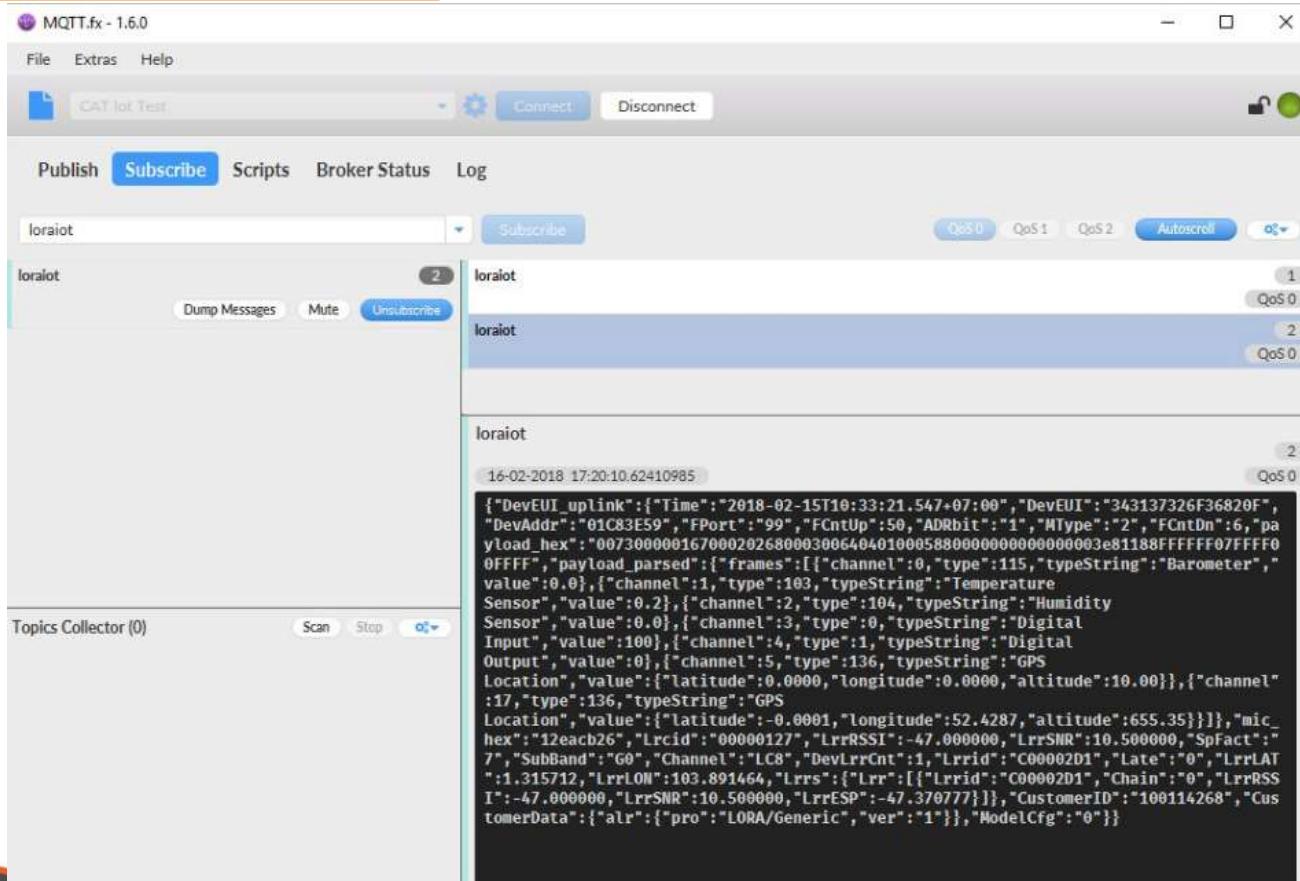
# Example Application



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# Example Application





## Q&A