

# LoRaWAN & The Things Network (TTN)

A Global IoT Community Network

IETF 106 GAIA



These materials, originally developed by Jonathan Brewer for nsr.org, are licensed under the Creative Commons Attribution-NonCommercial 4.0 International license (<http://creativecommons.org/licenses/by-nc/4.0/>)



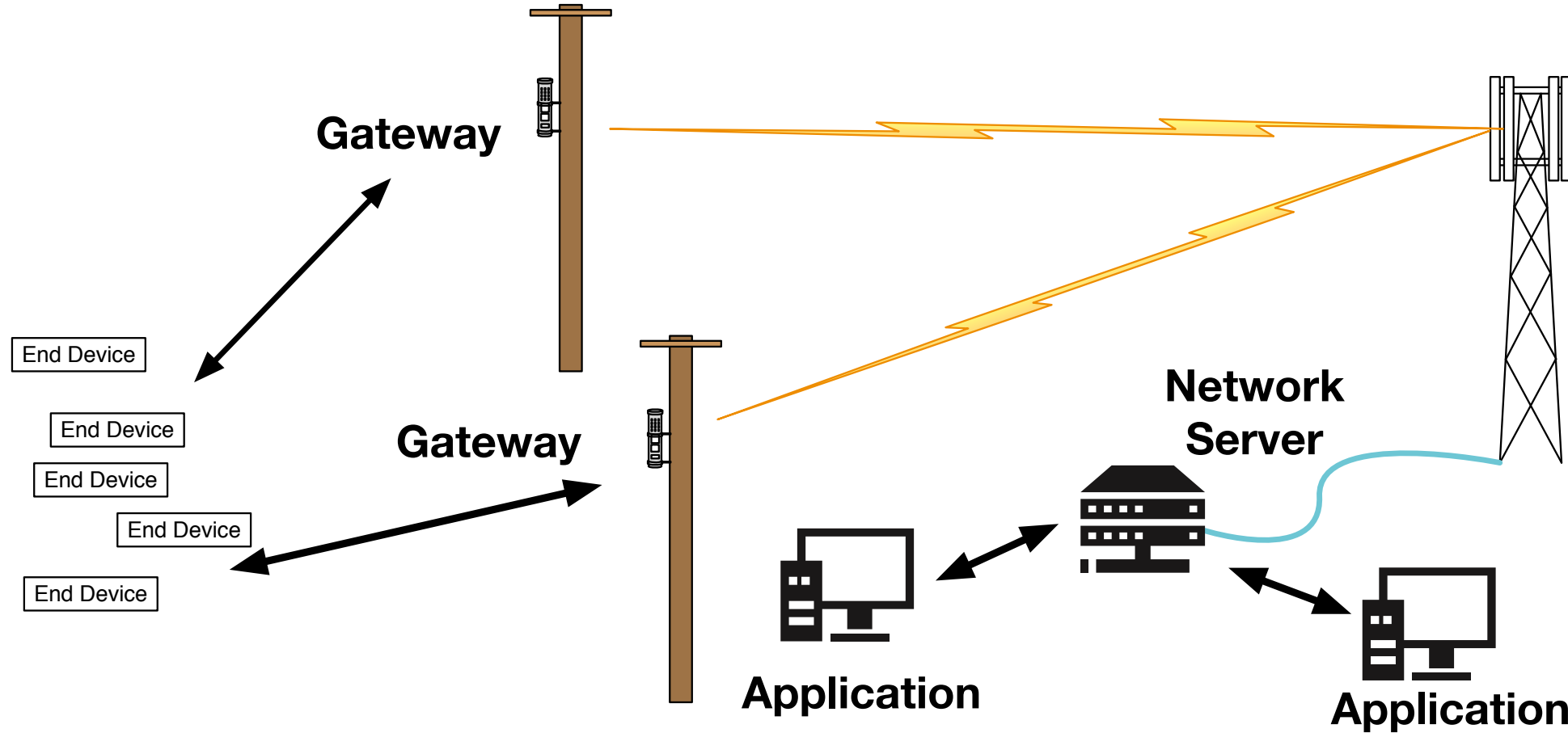
# What is LoRa?

- PHY Radio Protocol for the Internet of Things
- Operates in sub-GHz ISM bands worldwide
  - 433, 470-510, 779-787, 863-870, 902-928 MHz
- Derivative of Chirp Spread Spectrum
- Proprietary to Semtech
- Designed for long range, low power, low data rate
- Star topology (not mesh or p2p)
- 250 bits per second to 22 kilobits per second
  - depending on channel width & modulation

# What is LoRaWAN?

- Wireless Network for the Internet of Things
  - Open, non-proprietary standard
- Adds addressing, mobility & localisation to LoRa
- Multiple base stations can receive & process packets
- Adaptive data rate scheme to improve performance
- Multiple levels of encryption (Network & Application)
- Supports time slot scheduling of device transmission

# LoRaWAN Entities



# LoRaWAN Architecture Overview

- Based on RFC 8376 (Ed. Stephen Farrell)
  - <https://datatracker.ietf.org/doc/rfc8376/>
- *Verbatim text is italicised*
- **Important terms are bolded**
- RFC8376 detail ends with OTA join process

# LoRaWAN: End Device

- *a LoRa client device, sometimes called a mote*
  - Also sometimes called a node
- *Communicates with gateways*
  - And never with other motes or nodes
- Has a globally unique identifier called **DevEUI**
  - In the format of an IEEE EUI64 (64 bit)
- Has a network unique identifier called **DevAddr**
  - Only network unique 32 bit

# LoRaWAN: End Device

Size: 55mm x 20mm x 3.5mm

Operating temperature:  
-40 to 85 degrees celsius

ESP32 Dual Core  
Microcontroller and  
WiFi/Bluetooth 4.2  
radio

3V3 Ultra-Low  
-Noise switching  
regulator

LoRa transceiver

32Mbit flash memory

WS2812 RGB  
multi-colour  
LED



External LoRa antenna  
connector

Reset switch

RF switch

U.FL connector

Internal WiFi and  
Bluetooth Antenna

# LoRaWAN: Device Classes

Class A (lowest power)	ALOHA based, with comms always initiated by end device. After transmit, device listens for replies or network control for a short time period.
Class B (deterministic downlink)	Supports Class A transmissions, plus periodically listens for network messages on a schedule. Still suitable for battery use, but less efficient than Class A.
Class C (lowest latency)	Supports Class A transmissions, plus actively listens for network messages. Not suitable for battery use.



# LoRaWAN: Gateway

- *A radio on the infrastructure side*
- *Sometimes called a concentrator or base-station*
- *Communicates with end devices via LoRaWAN*
- *Communicates with a network server via TCP/IP*
- Can co-exist on multi-protocol base stations
- Typically runs a software instance per gateway radio

# LoRaWAN: Gateway



# LoRaWAN: Network Server (NS)

- *The Network Server terminates LoRaWAN MAC layer*
- *for End-Devices connected to the network*
- *It is the centre of the star topology*
- The Network Server decides:
  - which Gateway will talk to which End Device
  - what data rates will be used by End Devices

# LoRaWAN: Network Server (NS)



**THE THINGS**  
N E T W O R K



**LOR I O T**



# LoRaWAN: Join Server (JS)

- *Server on the Internet Side of a Network Server*
- *Processes join requests from end-devices*
- End devices cannot be used without joining a network
- Often combined with the Network Server

# LoRaWAN: Uplink Message

- *Communications from end devices to the network server or application*
- *Received via one or more gateways*
- Uplink Messages received by more than one gateways are de-duplicated by the Network Server

# LoRaWAN: Downlink Message

- *Communications from network server or application*
- *via one gateway*
- *to a single end-device*
- *or a group of end devices*
- Network Server decides which gateway is in the best place to send a downlink message to a particular device.

# LoRaWAN: Application

- *Application layer code running on the end device*
- *Application code running “behind” the network server*
- *Most end devices will run only one application*
- Identified by a registered IEEE EUI64 value (**AppEUI**)
- “Applications” typically run on Network Servers
  - Provide for device management
  - Route data to external applications
- Misleading name: Could be called application router



# LoRaWAN: Encryption

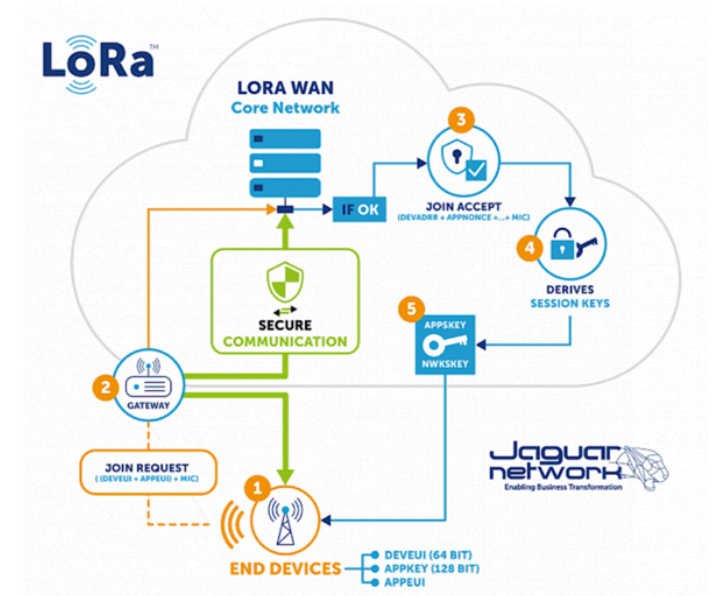
- *All payloads are encrypted*
  - No possibility for attackers to read payloads
  - No possibility for network operator to read payloads
- *and have data integrity*
  - No possibility for changing data in flight
  - No possibility for intercepting & replaying data
- *MAC commands are protected (except frame options)*
  - No possibility for attackers to read metadata

# LoRaWAN: Pre-Joined Devices (ABP)

- *End devices must have two symmetric session keys*
- Devices are personalised with AES 128-bit keys
- Network Session Key (**NwkSKey**)
  - Known only by the network operator
  - Protects network metadata
- Application Session Key (**AppSKey**)
  - Common to all End Devices using an Application
  - Known only to the Application Operator

# LoRaWAN: Over the Air Join (OTAA)

- *End devices must have two symmetric keys*
- Network Session Key (**NwkSKey**)
- Application Key (**AppKey**)
  - Different from the **AppSKey**
  - Unique to every End Device
- Device sends **DevEUI**, **AppEUI**, and **AppKey**
- Network sends data allowing Dev to derive **AppSKey** and **NwkSKey** (then proceed as a pre-joined device)



# What is The Things Network (TTN)?

- TTN is a free, distributed, LoRaWAN platform
- It provides a Network Server, Join Server, and Application Servers
- Web platform allows gateway owners to create coverage
- And application owners to register devices
- All gateways process all traffic!
- TTN helps communities organise & communicate too.

# Where is The Things Network (TTN)?



# TTN Console Views

APPLICATION OVERVIEW

Application ID

sanog32

documentation

Description

IoT Workshop at SANOG32

Created

last year

Handler

ttn-handler-asia-se

APPLICATION EUIs

manage euis

<>

70 B3 D5 7E D0 01 13 A2

DEVICES

register device

manage devices

10

registered devices

COLLABORATORS

manage collaborators

kiwibrew

collaborators

delete

devices

settings

ACCESS KEYS

manage keys

default key

devices

messages

base64

GATEWAY OVERVIEW

settings

Gateway ID

eui-58a0cbffe801433

Description

Cairnhill Rise

Owner

kiwibrew

Transfer ownership

Status

connected

Frequency Plan

Asia 923-925MHz

Router

ttn-router-asia-se

Gateway Key

base64

Last Seen

38 seconds ago

Received Messages

0

Transmitted Messages

0

INFORMATION

edit info

Brand

The Things Network

Model

TTIG 915

Antenna

LOCATION

edit location

Antenna Placement

Altitude

10

registered devices

Google

Map data ©2019 Google

Terms of Use

Report a map error

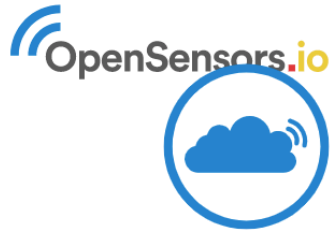
Mapping data provided by TTN Mapper



# TTN Integrations



**MyDevices**  
v2.6.0  
myDevices



**OpenSensors**  
v2.6.0  
The Things Industries B.V.



**TTN Mapper**  
v2.7.1  
JP Meijers



**AllThingsTalk Maker**  
v2.6.0  
AllThingsTalk



**Collos**  
v2.7.10  
Semtech Corporation



**Data Storage**  
v2.0.1  
The Things Industries B.V.



**TagoIO**  
v2.7.5  
TagoIO



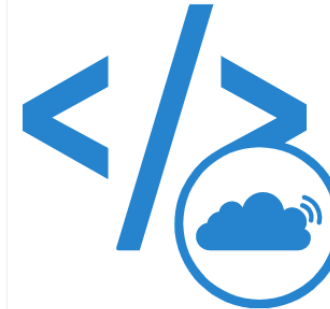
**ThingSpeak**  
v2.7.14  
MathWorks®



**Ubidots**  
v2.7.10  
Ubidots



**EVERYTHING**  
v2.6.0  
EVERYTHING

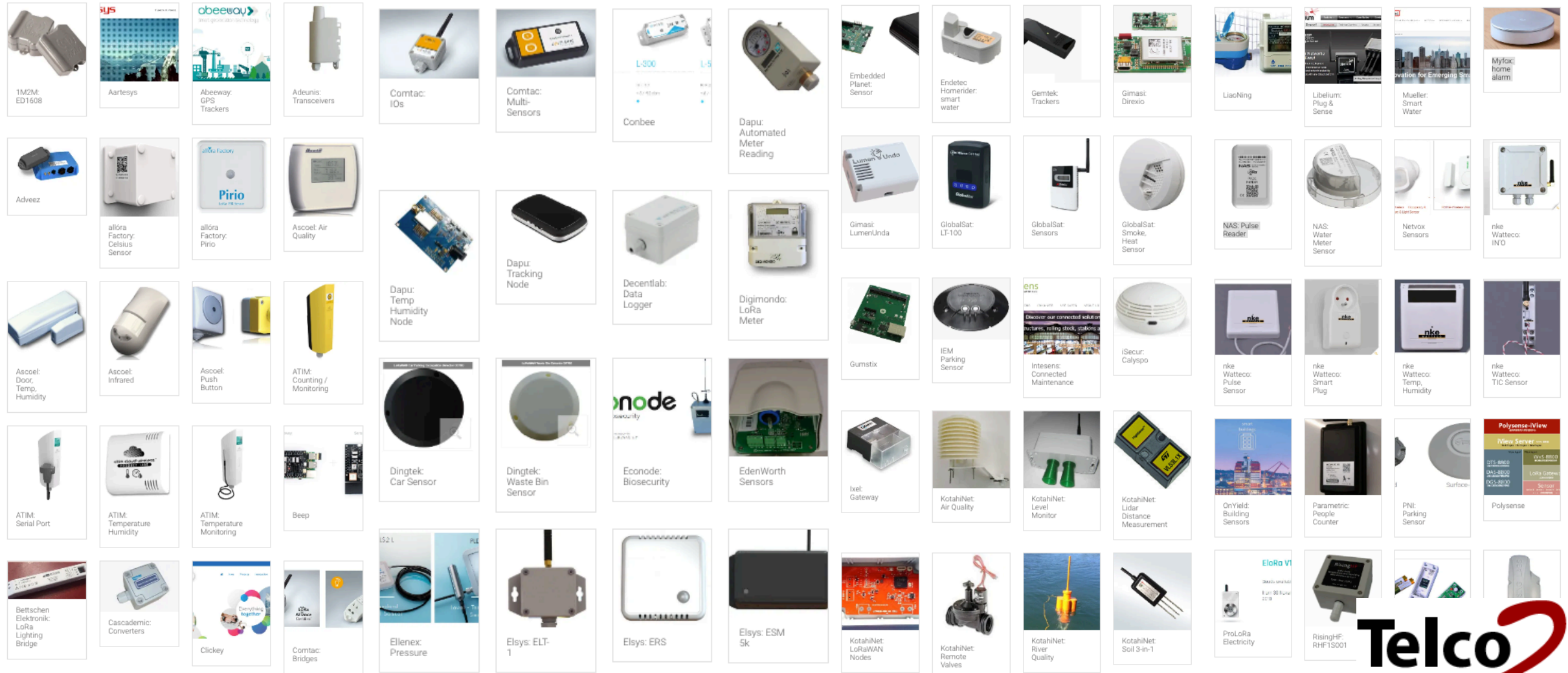


**HTTP Integration**  
v2.6.0  
The Things Industries B.V.



**IFTTT Maker**  
v2.6.0  
The Things Industries B.V.

# LoRaWAN & TTN Device Ecosystem



Devices from <https://lpwanmarket.com/>

