LORA – LONG RANGE

What's LoRa ?

- LoRa stands for Long Range
- A low-power and long-range wireless communication protocol (LPWAN)
- A new modulation type
- A client-server communication protocol (LoRaWAN)

Specification :

- Modulations : LoRa Spread Spectrum (spreading of the spectrum) and Frequency Shifting
- Frequencies : 433, 868, 915(US) MHz
- Output power <= 20dBm
- Sensibility : -148 dBm
- Range <= 20Km
- Power: Rx = 12mA , Tx = 120mA à 20dBm, 30mA à 13dBm
- Topology LoRaWAN : star Node ⇔ Gateway
- Topology point to point : Node ⇔ Node

- Manufacturer : Semtech (Neuchâtel)

Modules :

- Microchip, IMST, Libelium, ST, PyCom, …

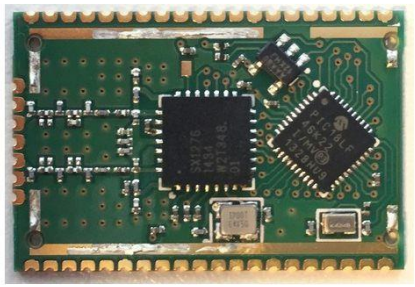
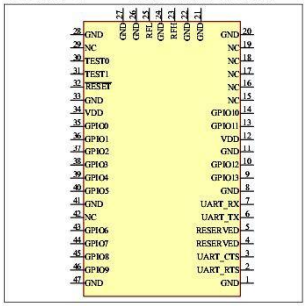
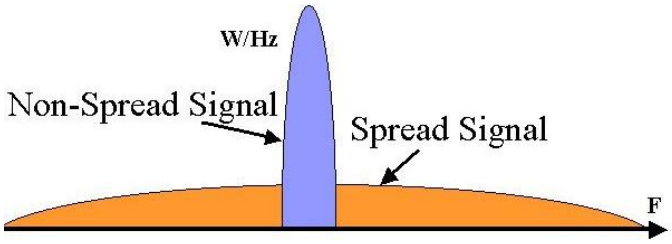


FIGURE 1-2: RN2483 PIN DIAGRAM



Modulation :

Spread Spectrum

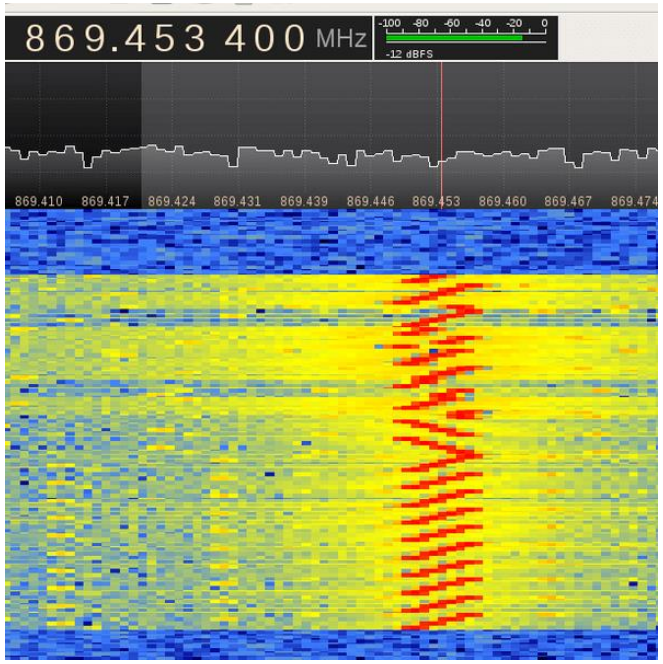


Spreading factor : 7 -12

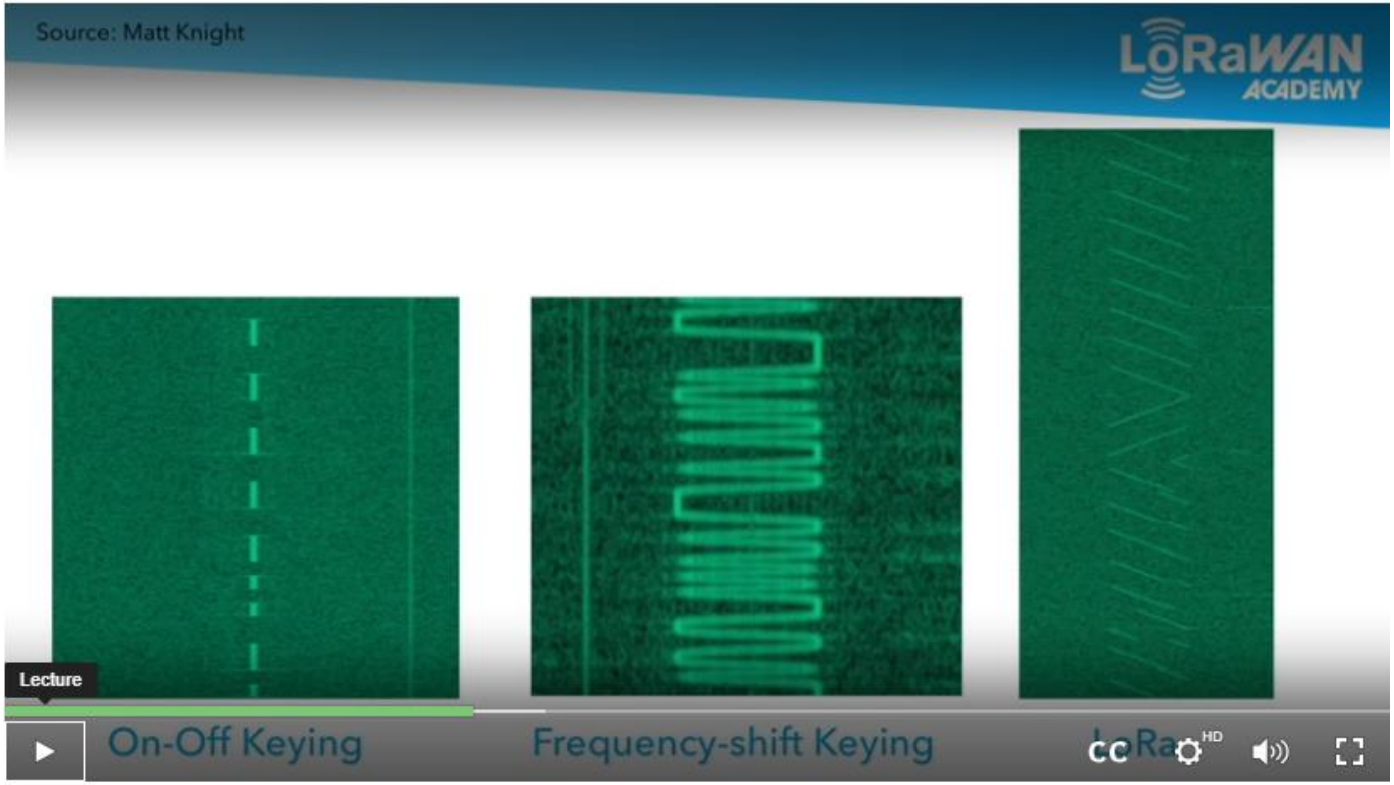
Bandwidth: 125 à 500 KHz

Coding Rate : 4/8 à 4/5

Frequency Shifting



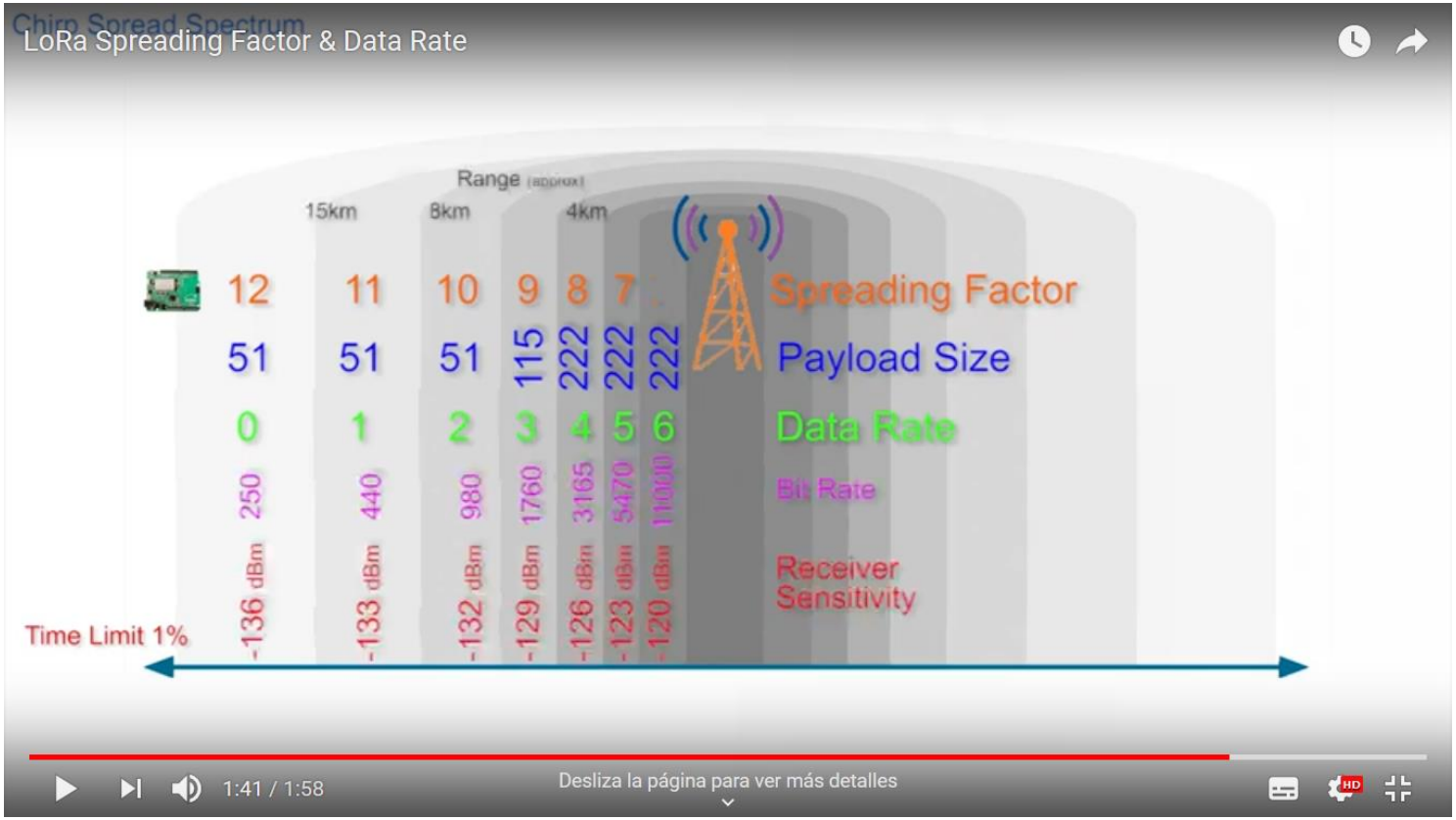
LoRa CHIRP



https://lora-developers.semtech.com/learning-center/lorawan-academy/courses/lora-radio-modulation

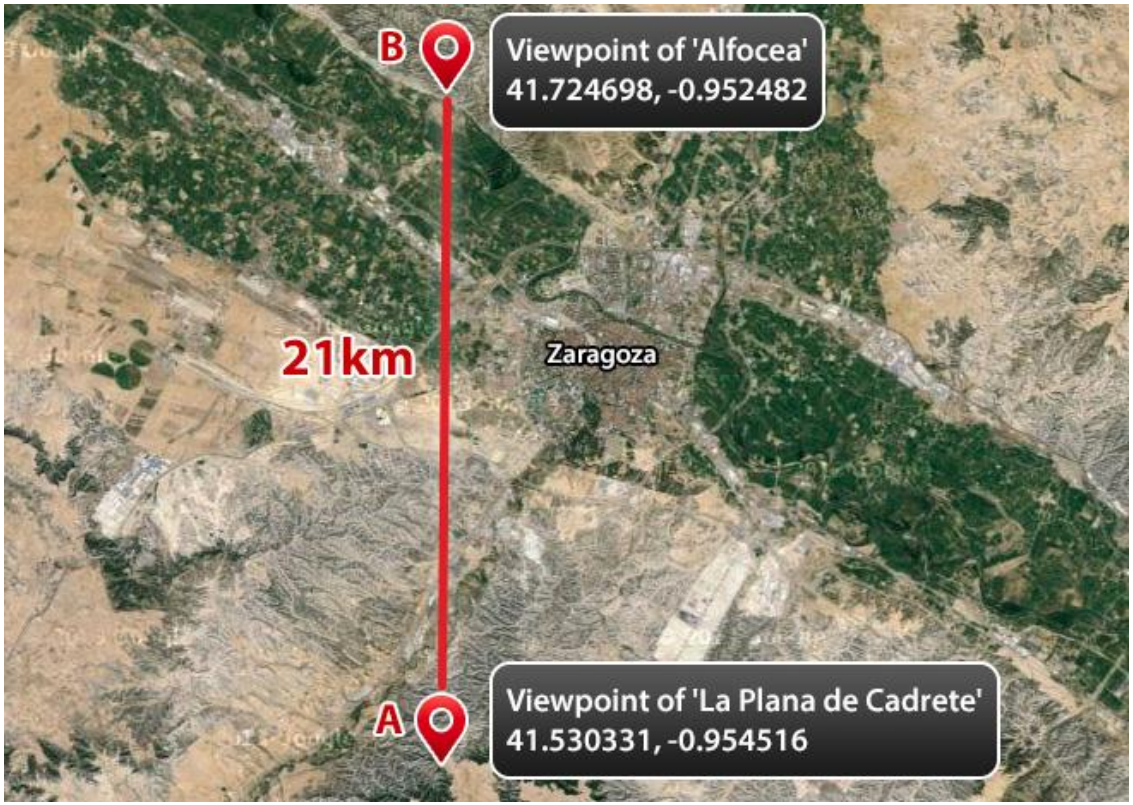
Mode	BW	CR	SF	Sensitivity (dB)	Transmission time (ms) for a 100-byte packet sent	Transmission time (ms) for a 100-byte packet sent and ACK received	Comments
1	125	4/5	12	-134	4245	5781	max range, slow data rate
2	250	4/5	12	-131	2193	3287	-
3	125	4/5	10	-129	1208	2120	-
4	500	4/5	12	-128	1167	2040	-
5	250	4/5	10	-126	674	1457	-
6	500	4/5	11	-125,5	715	1499	-
7	250	4/5	9	-123	428	1145	-
8	500	4/5	9	-120	284	970	-
9	500	4/5	8	-117	220	890	-
10	500	4/5	7	-114	186	848	min range, fast data rate, minimum battery impact

LoRa SF & Data Rate



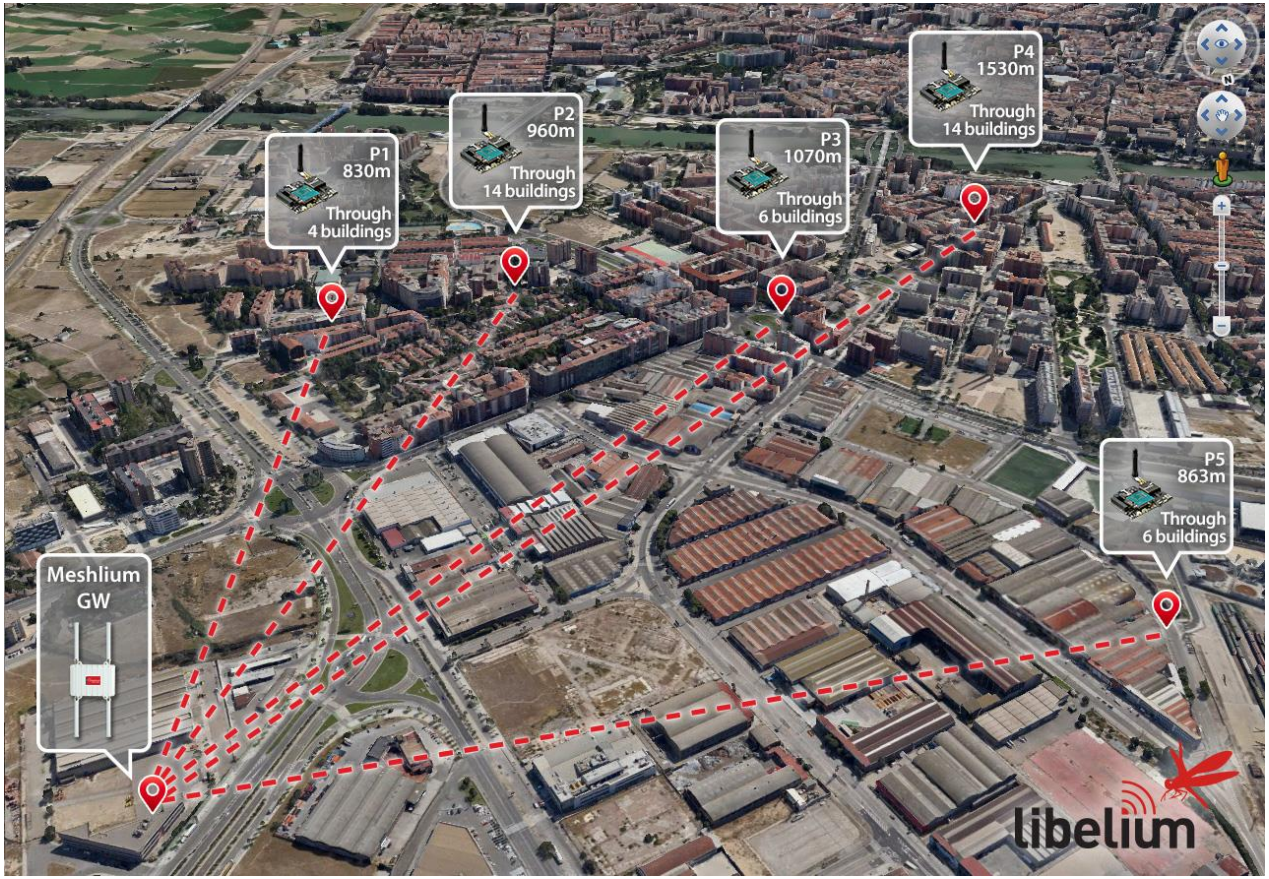
https://www.youtube.com/watch?v=B580NvdXtjs

Range :



Source: Libelium

Range :

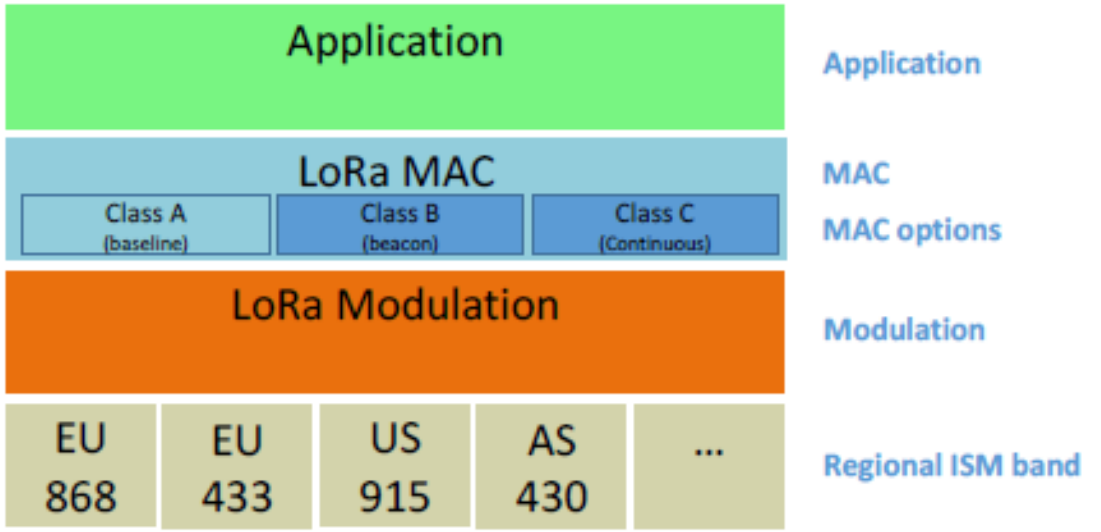


Source: Libelium

LoRaWAN

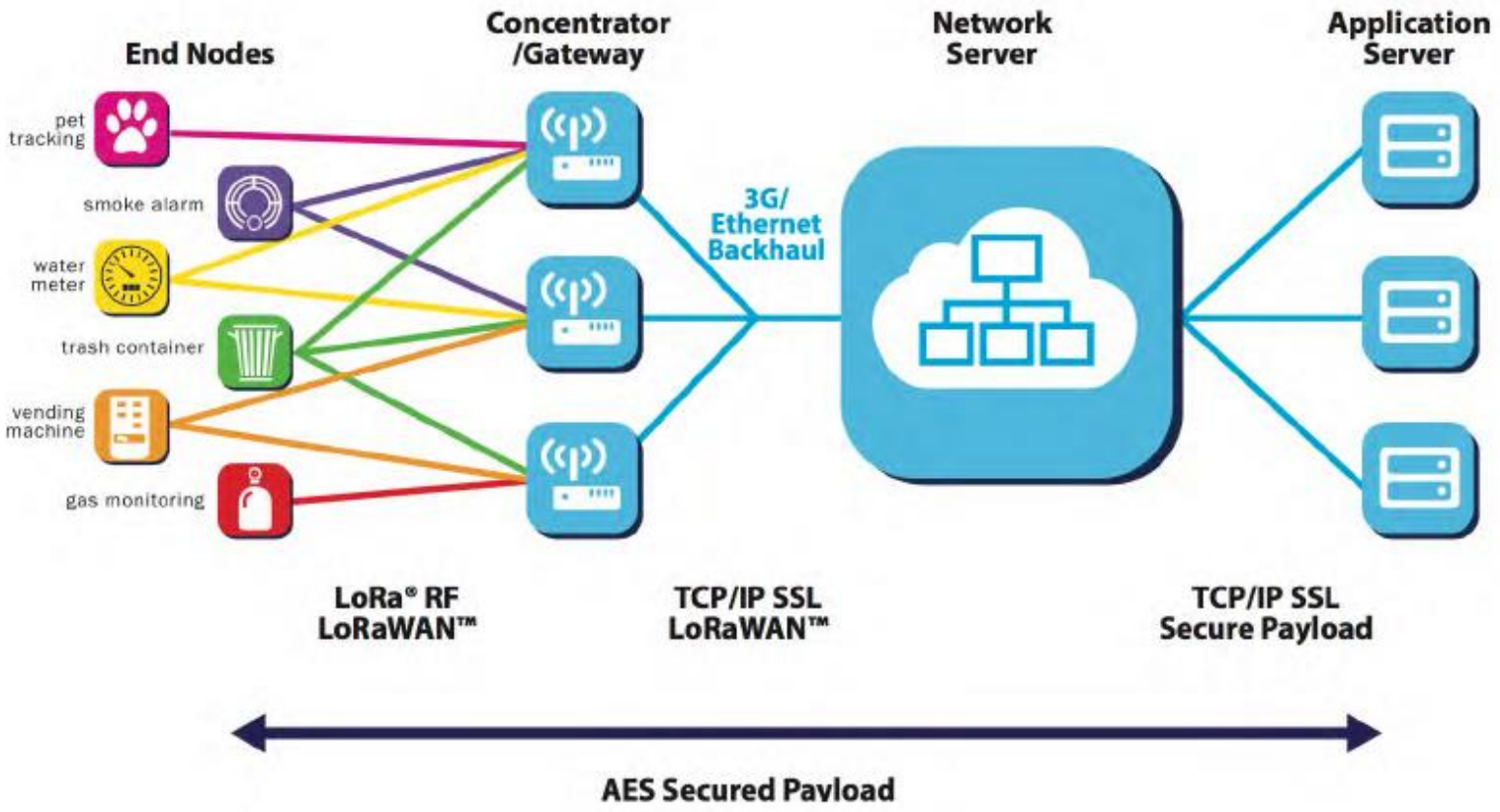
Defines the communication protocol and system architecture for the network.

The protocol and network architecture have the most influence in determining the battery lifetime of a node, the network capacity, the quality of service, the security, and the variety of applications served by the network.



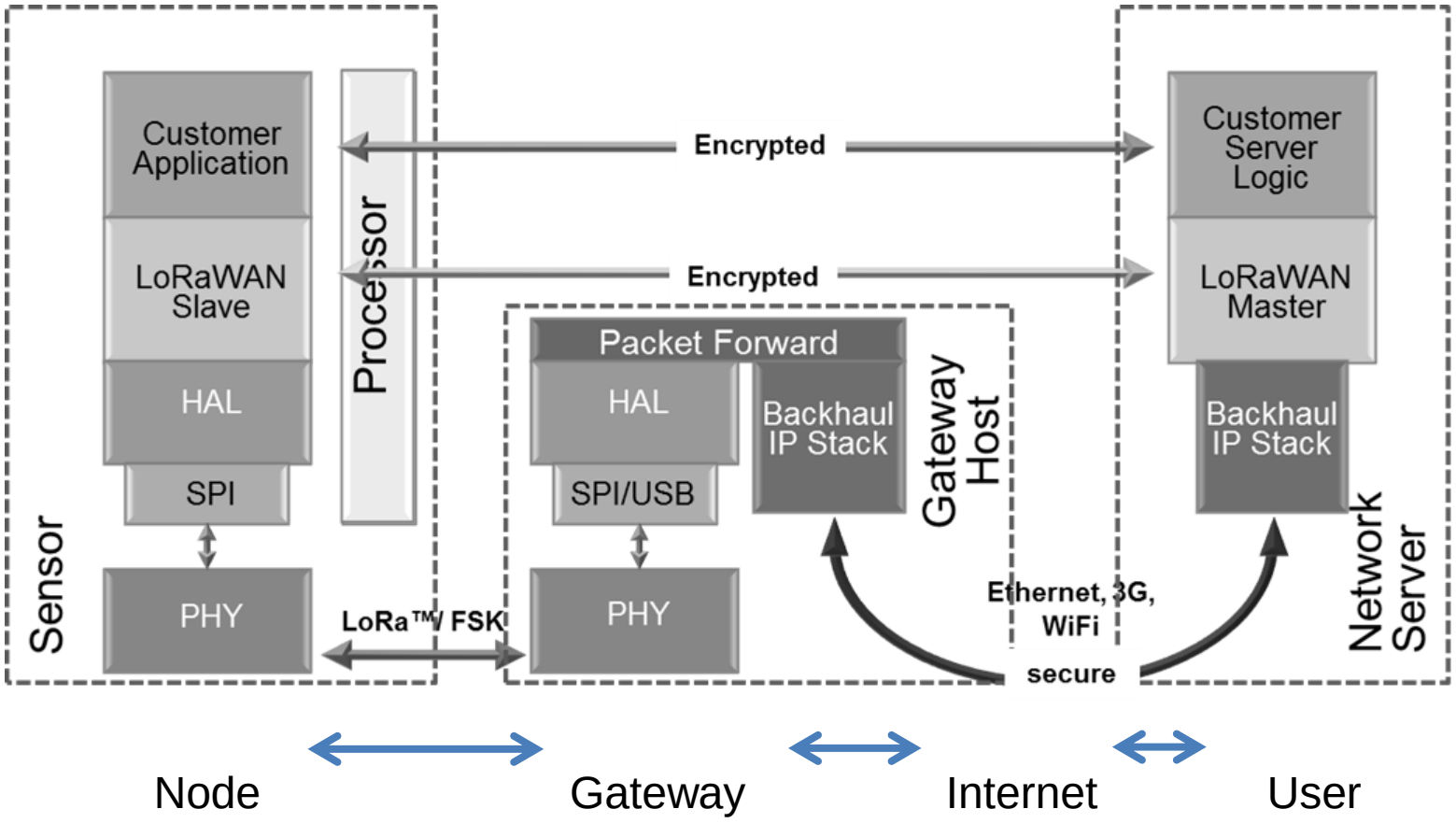
Source: LoRa Alliance

LoRaWAN – Network Architecture

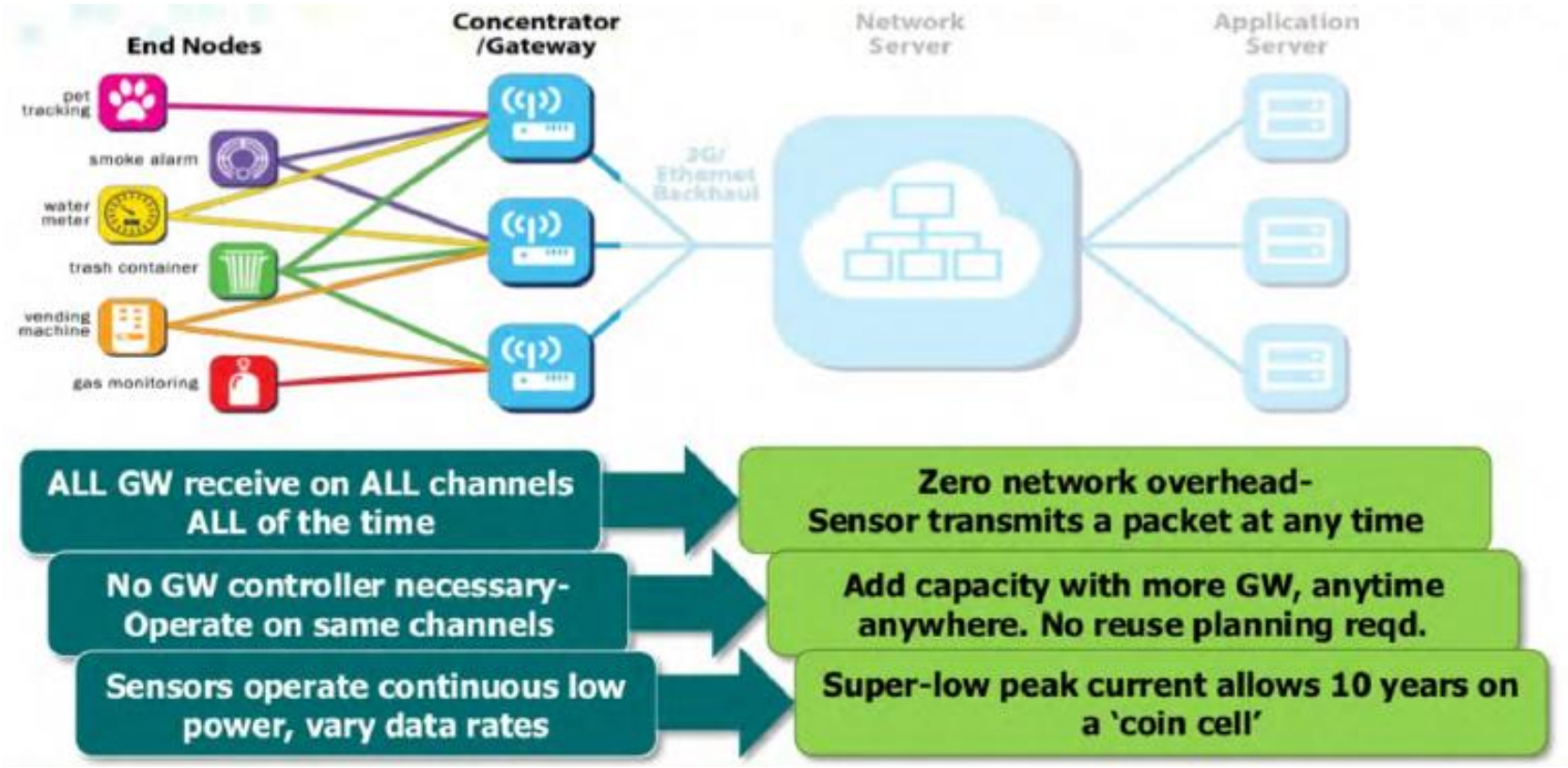


Source: LoRa Alliance

LoRaWAN – Network Architecture

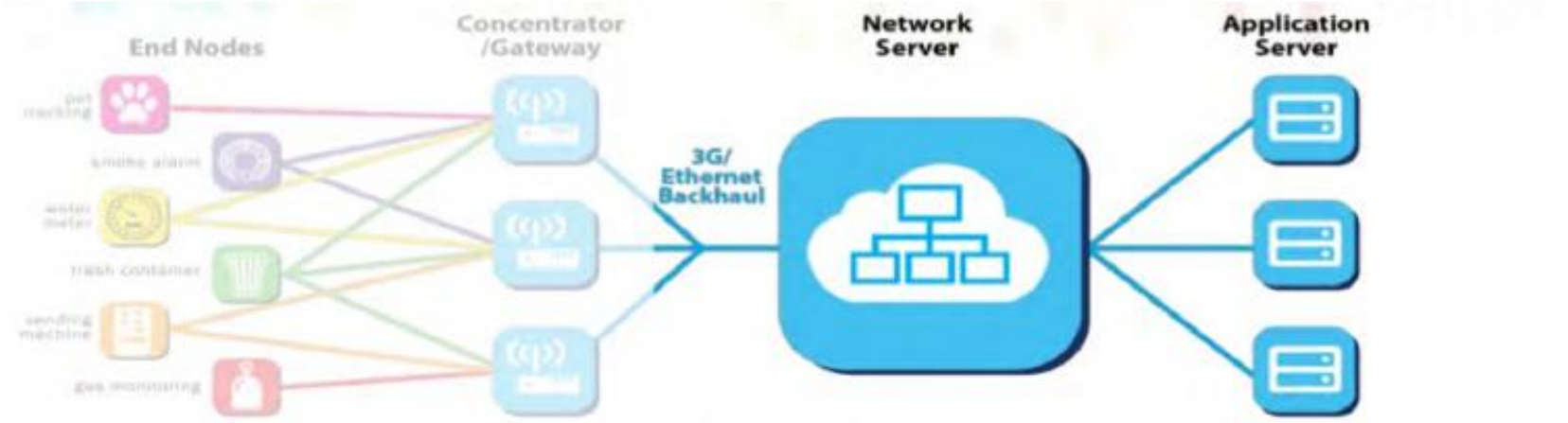


LoRaWAN – Sensor-GW



Source: Semtech

LoRaWAN – Network solution



Network Server removes redundancy where required	A single packet received on many antennas can be processed if reqd.
GW are dumb & perform no data validation uplink or downlink	Network behaviour is determined by the server per application, low cost GW
Separation of data by application or user in server	Single or multiple providers per network allow choice by application

Source: Semtech

LoRaWAN - Security

The network security ensures authenticity of the node in the network while the application layer of security ensures the network operator does not have access to the end user's application data.

AES encryption is used with the key exchange utilizing an IEEE EUI64 identifier.

LoRaWAN – Main characteristics

- Device can send up to 250 Bytes/packet (depends on selected DataRate)
- Fixed DataRate or adaptive DataRate
- Confirmed or Unconfirmed messages
- Port communication (1 to 223)
- Uplink and Downlink communications
- Each end device should have a unique ID (EUI64)
- 2 modes for end device activation
  - **OTAA** (Over-The-Air Activation)
  - **ABP** (Activation By Personalization)
- 32 bits End-device address
- Several security keys (AES-128): Application Key, Network Session Key and Application Session Key

LoRaWAN (Europe)

- Frequencies : 867-869 MHz
- Channel bandwidth Uplinks (from Device to Gateway) : 125/250 kHz
- Channel bandwidth Downlink (from Gateway to Device) : 125 kHz
- Spread-Spectrum : SF7 to SF12
- Data Rate : 250bps to 50kbps
- Tx Power : +14dBm

- In EU863-870 ISM Band the 3 channels (868.1, 868.3 & 868.5) of 125 kHz must be supported by all end-devices.
- LoRa specification implements pseudo-random channel hopping for TX/RX.

LoRaWAN (EU863-870 - TheThingsNetwork)

- Uplink:
  - **868.1** - SF7BW125 to SF12BW125
  - **868.3** - SF7BW125 to SF12BW125 and SF7BW250
  - **868.5** - SF7BW125 to SF12BW125
  - **867.1** - SF7BW125 to SF12BW125
  - **867.3** - SF7BW125 to SF12BW125
  - **867.5** - SF7BW125 to SF12BW125
  - **867.7** - SF7BW125 to SF12BW125
  - **867.9** - SF7BW125 to SF12BW125
  - **868.8** – FSK

- Downlink:
  - Uplink channels 1-9 (RX1)
  - **869.525** - SF9BW125 (RX2 downlink only)

LoRaWAN - packet

- Uplink (from Device to GW)

Uplink PHY:

Preamble	PHDR	PHDR_CRC	PHYPayload	CRC

- Downlink (from GW to Device)

Downlink PHY:

Preamble	PHDR	PHDR_CRC	PHYPayload

LoRaWAN - packet

Radio PHY layer:

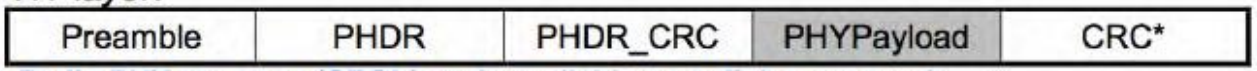


Figure 5: Radio PHY structure (CRC* is only available on uplink messages)

PHYPayload:

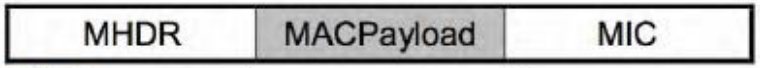


Figure 6: PHY payload structure

MACPayload:

Figure 7: MAC payload structure

Encrypted payload

FHDR:

Figure 8: Frame header structure

LoRaWAN - packet

- MAC Layer (PHYPayload)

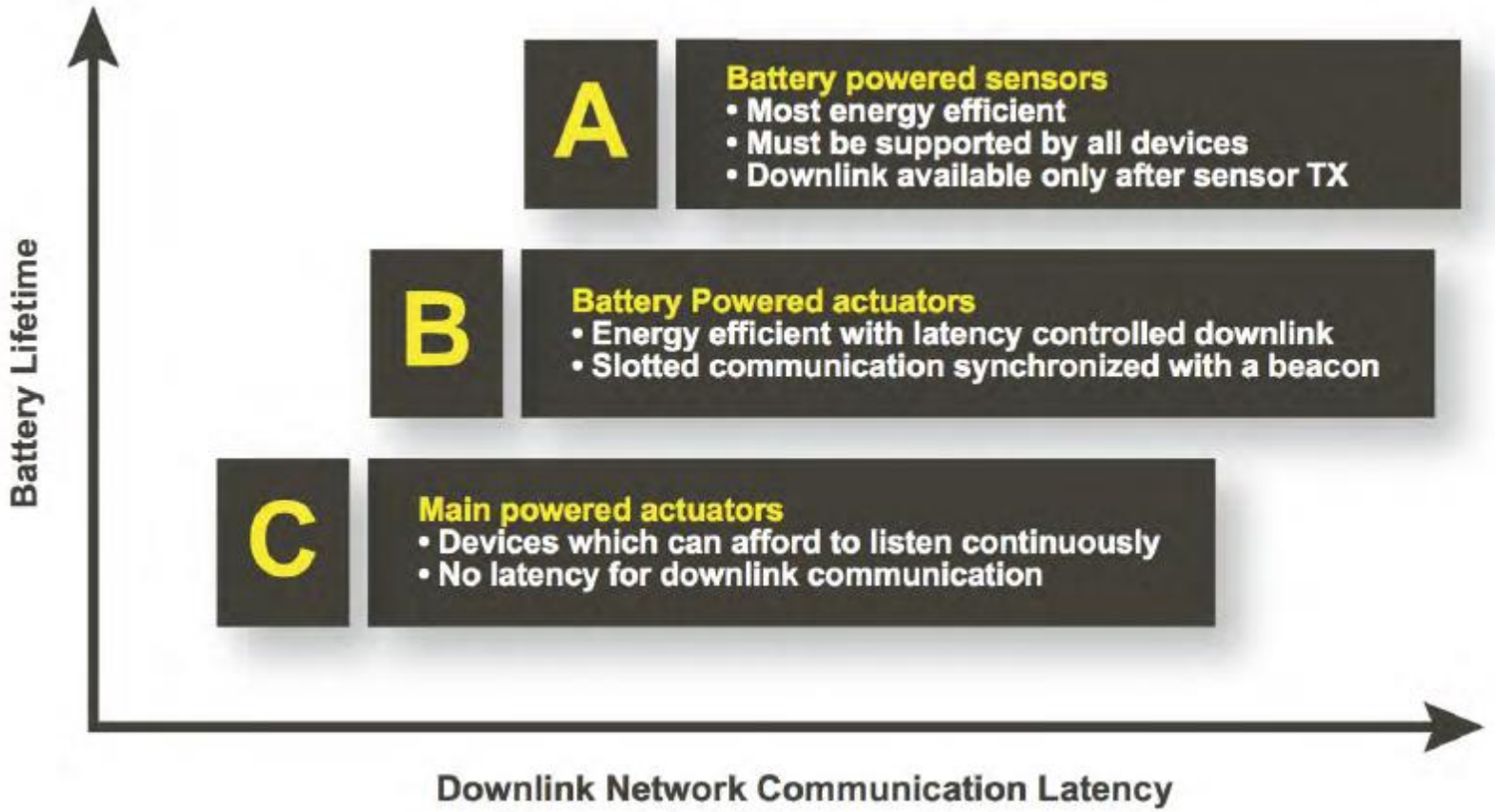
Size (bytes)	1	1..*M*	4
PHYPayload	MHDR	MACPayload	MIC

- MAC Header (MHDR field)

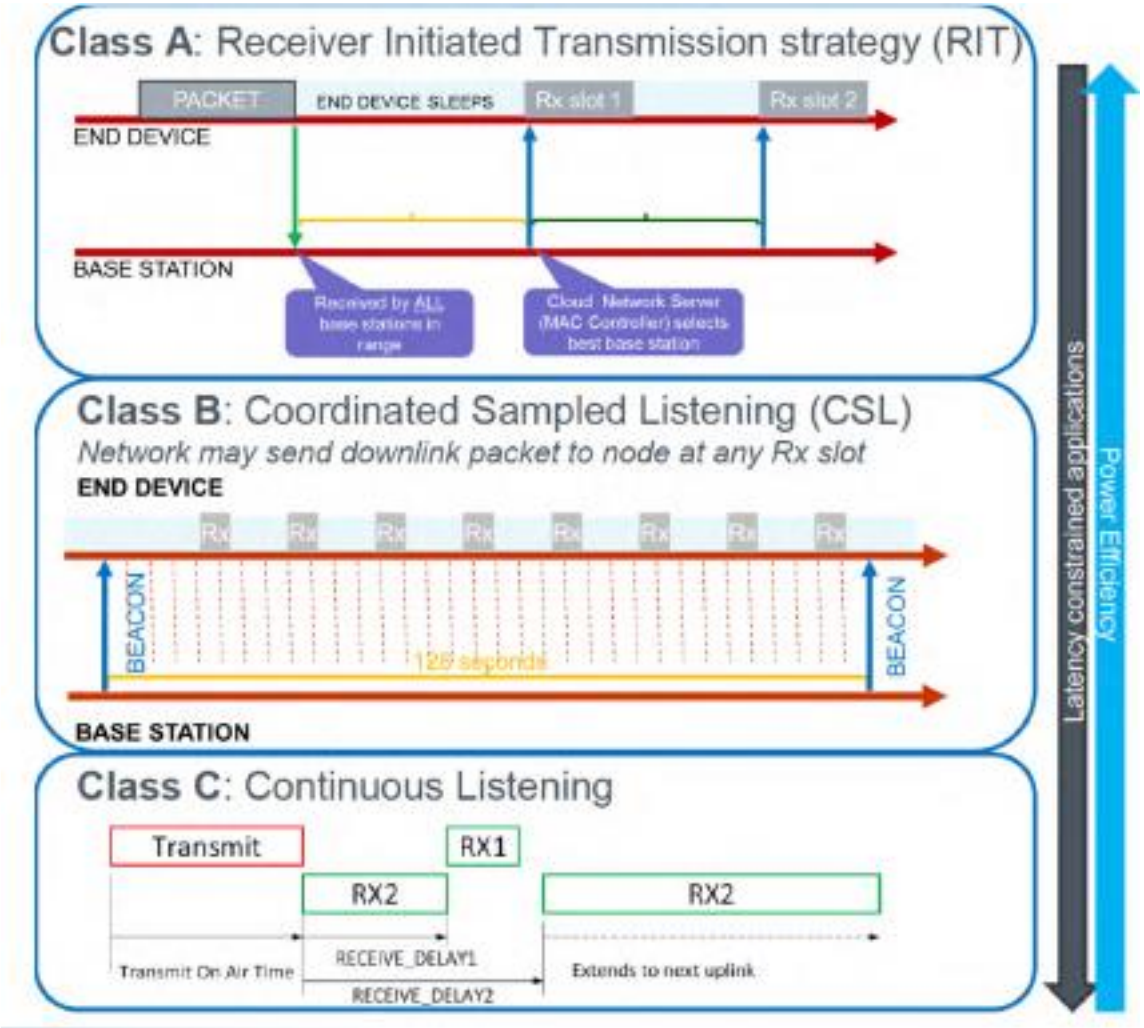
Bit#	7..5	4..2	1..0
MHDR bits	MType	RFU	Major

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

Communication Classes



Source: LoRa Alliance



Source: nickhunn.com

LoRaWAN Limitations

TheThingsNetwork Fair Access Policy: Practice

- Golden rule: 30 seconds air-time per device per day
- For 10 bytes of payload, this translates in (approx.):
  - 20 messages per day at SF12
  - 500 messages per day at SF7
  - more for SF7BW250 and FSK (local-area)
- If your application requires more bandwidth, think of another solution
- This allows for >1000 nodes per gateway
- Downlink bandwidth is even more restricted
  - you can't send all messages as 'confirmed uplink'

https://www.thethingsnetwork.org/docs/lorawan/limitations.html

LoRaWAN airtime calculator: https://www.thethingsnetwork.org/airtime-calculator

LoRaWAN Open Network Operators Coverage Maps

LoRaWAN Public Network Availability

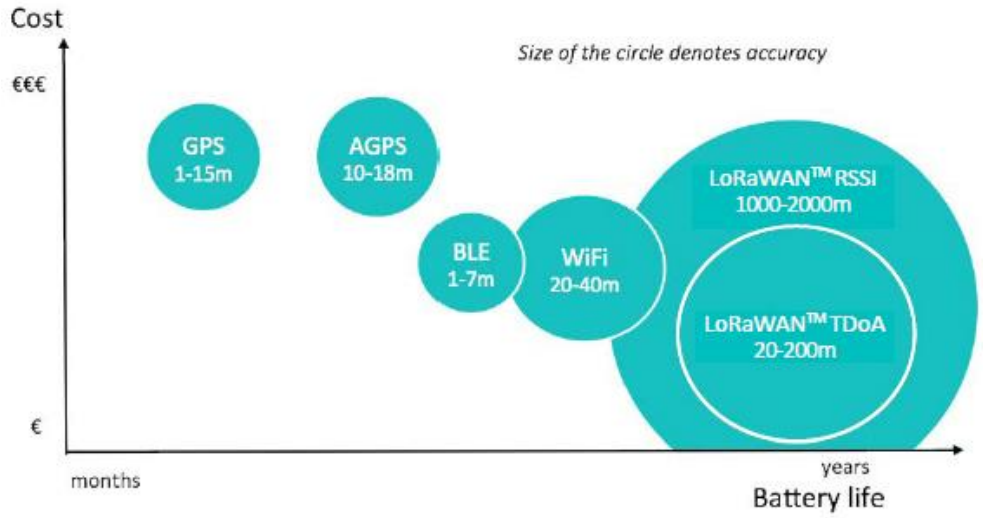
SEMTECH

LoRaWAN – an open global LPWAN standard for IoT driven by the industry

Source: Semtech

LoRa Geolocation

LoRaWAN™ infrastructure provides a geolocation solution for low-power wide-area networks (LPWANs), enabling a wide range of applications requiring location determination for battery powered endpoints.



LoRaWAN TDOA/RSSI
- Lowest cost solution. Works natively with any LoRaWAN sensor
- LoRaWAN enables long battery life use cases
- TDOA: 20-200m accuracy range depending on conditions
- RSSI: 1000-2000m accuracy

WIFI Location
- Cost efficient solution for outdoor and indoor solution
- Accuracy increases with hotspot density

BLE

Requires a BLE beaconing system
Indoor solution

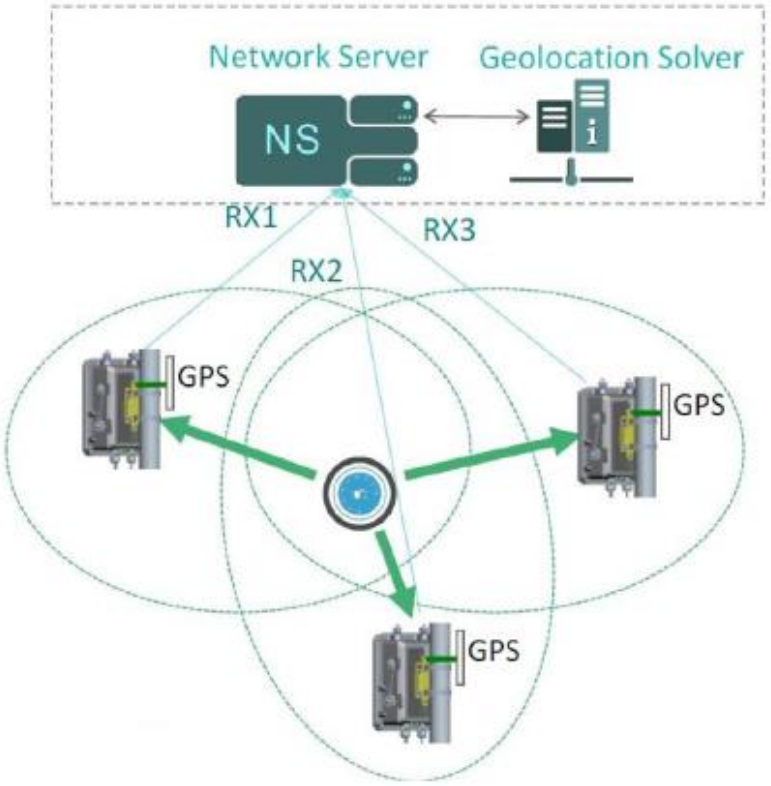
GPS/AGPS
- 1 GPS adds $5-$10 to the BOM
- Most accurate but power consuming solution
- AGPS brings battery consumption improvement

Source: LoRaWAN Academy

LoRa Geolocation Architecture

The geolocation functionality is supported by any existing LoRaWAN end-devices, eliminating additional cost and requiring no additional processing power.

Several gateways simultaneously receive the same uplink message, and the end-device location is determined using multilateration techniques.



Source: LoRaWAN Academy

Power Consumption of LoRa End Devices

Exercise:

A device sends a LoRa data packet of 11 bytes every 15 minutes. Calculate the battery life of a 1000mAh battery.

The following steps indicate what happens when a packet is sent:

1. The device wakes up and reads the sensors (180 ms)
2. Data is sent from the device:
    1. If SF7 is used, it takes 60 ms
    2. If SF12 is used, it takes 1480 ms
3. After sending the data, the device listens for incoming messages (2100 ms)
4. After this cycle, the device goes back to sleep, to be woken up ~15 minutes later.

Device Mode	Total energy consumed
Sleep Mode	0,04mA
Active Mode	8mA
Send Mode	50mA
Active Radio Mode	11mA