

# A low power LoRa-LoRaWan relay function with a single input, single output device

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MaDeLoRa 17 February 2020



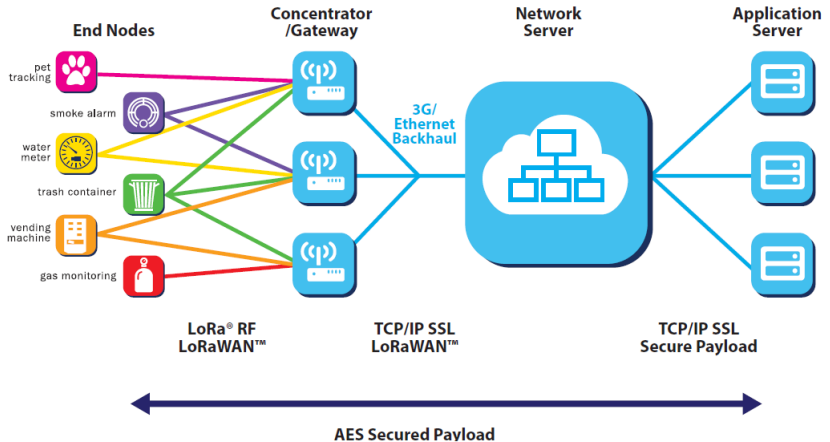
- 1 Context
- 2 LLWURP: LoRa/LoRaWAN Uniform Relay Protocol
- 3 Conclusion

# Overview

- 1 Context
- 2 LLWURP: LoRa/LoRaWAN Uniform Relay Protocol
- 3 Conclusion

- Ad-hoc Wireless Sensors Network
  - Point to point communication : LoRa, Bluetooth LE
  - No Infrastructure : Ad-hoc network
  - No data collect scheme
- Wireless Sensors Network Infrastructure
  - Exchange management ( Media access management..)
  - Data collect and routing to datastore
  - Infrastructure : WiFi, LoRaWAN, Sigfox
    - Increasing number of sensors ?
    - Few antennas ?
    - Environment with radio frequency interference ?

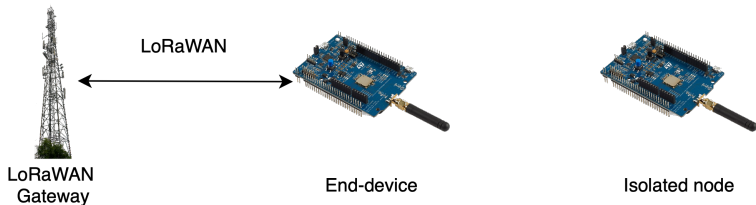
# LoRaWAN architecture



Source: from LoRaWAN white book.

# Use case in the LoRaWAN architecture

- LoRaWAN  $\Rightarrow$  all end-device is in the range of a Gateway
  - and if not ?
- **Isolated node**: out of range of the gateway
  - Cavern, suburb, tube
  - Sewer
  - Datacenter, robot factory
  - Radio frequency interference environment

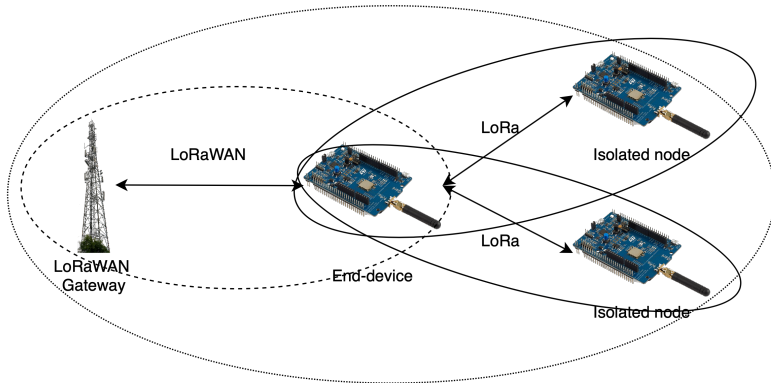


How to avoid isolated nodes ?

- Expand the infrastructure
- LoRaWAN Relay dedicated device
- **Add to an end-device a relaying function**

# LLWURP: LoRa/LoRaWAN Uniform Relay Protocol

- Relay node is not a dedicated device
- Same code executes on all nodes
- Uniform architecture (no specific node )



Range of Relay node



Range of isolated node



Range of LoRaWAN Gateway

# Overview

## 1 Context

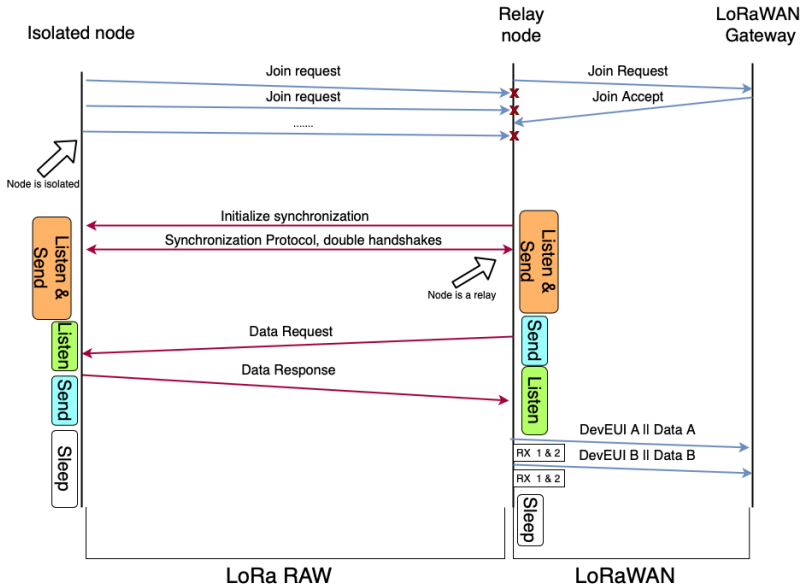
## 2 LLWURP: LoRa/LoRaWAN Uniform Relay Protocol

- LoRa/LoRaWAN Uniform Relay Protocol scheme
- Development stack
- Problem 1: LoRaWAN session
- Problem 2: Counter of uplink
- Extension: More than 1 Isolated node

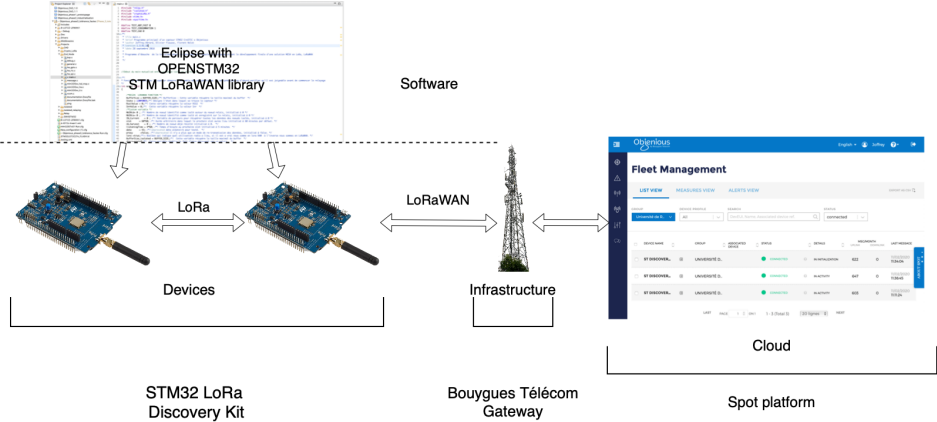
## 3 Conclusion



# LLWURP: LoRa/LoRaWAN Uniform Relay Protocol scheme

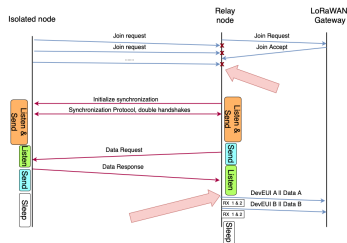


# Development stack



# Problem 1: LoRaWAN session

- Swapping LoRaWAN to LoRa
- Loss all LoRaWAN session elements :
  - NwkSKey
  - AppSKey



## Simple solution

New Join request procedure  $\implies$

- The power consumption is impacted
- Greatly increases the number of messages

## Our solution

Save the session elements of the Join request procedure  
Use Activation By Personalization mode

# Problem 2: Counter of uplink

## Normal behaviour

MESSAGE DATE	CONTENT	RESULT	COUNT
11/02/2020 14:51:32	Technical Downlink	✓ Sent	16
11/02/2020 14:51:29	battery_level1 devEUI:70b3d5499c3dd0ac.temper..	✓	17
11/02/2020 13:46:38	Technical Downlink	✓ Sent	15
11/02/2020 13:46:34	battery_level1 devEUI:70b3d5499c3dd0ac.temper..	✓	16
11/02/2020 12:41:43	Technical Downlink	✓ Sent	14
11/02/2020 12:41:40	battery_level1 devEUI:70b3d5499c3dd0ac.temper..	✓	15
11/02/2020 11:36:48	Technical Downlink	✓ Sent	13
11/02/2020 11:36:45	battery_level1 devEUI:70b3d5499c3dd0ac.temper..	✓	14
11/02/2020 10:31:54	Technical Downlink	✓ Sent	12

## With LoRaWAN session Storage

MESSAGE DATE	CONTENT	RESULT	COUNT
27/11/2019 10:12:21	Technical Downlink	✓ Sent	24
27/11/2019 10:11:42	Technical Downlink	✓ Sent	23
27/11/2019 10:11:03	Technical Downlink	✓ Sent	22
27/11/2019 10:10:24	Technical Downlink	✓ Sent	21
27/11/2019 10:09:45	Technical Downlink	✓ Sent	20
27/11/2019 10:09:06	Technical Downlink	✓ Sent	19
27/11/2019 10:08:27	Technical Downlink	✓ Sent	18
27/11/2019 10:07:48	Technical Downlink	✓ Sent	17
27/11/2019 10:06:30	Technical Downlink	✓ Sent	16

Source: Spot by Objenious

## Problem

Uplink don't appear yet → The data sent by our relay don't appear on the Spot platform

## Problem 2: Counter of uplink

Fields	Packet 1	Packet 2 and more
Message Type	Data	Data
MACPayload	32180F0E8000000231 D1793997B7AA376FE3	32180F0E80010002F4 DA240493C487880F70
MIC from packet	632A4B0D	6FC5CAB3
MIC expected	632A4B0D	6FC5CAB3
DevAddr	0E0F1832	0E0F1832
FCtrl	80	80
<b>FCnt</b>	<b>0000 (Big Endian)</b>	<b>0001 (Big Endian)</b>
Message Type	Unconfirmed Data Up	Unconfirmed Data Up
<b>FCnt</b>	<b>0</b>	<b>1</b>

### Our solution

Modifying the counter management

## Extension: More than 1 Isolated node

- Several relay nodes within the range of a single isolated node

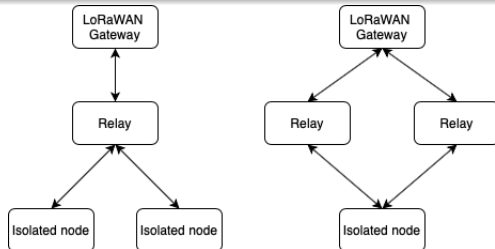
### Our solution

Isolated node choose the relay node.

- Several isolated nodes within the range of a single relay node

### Our solution

Make a local synchronization on sliding RXs for each isolated node and limit the number of nodes be able to be relayed.



# Up all datas of the isolated node

- Agregation ?
  - Depends of size of the data
  - Maximum length of a LoRaWAN uplink (Datarate..)
  - Identifying the data and the sensor relayed
- Without Agregation ?
  - Greatly increases the number of messages

## Our solution

Make an agregation of all isolated nodes to minimize the power consumption.

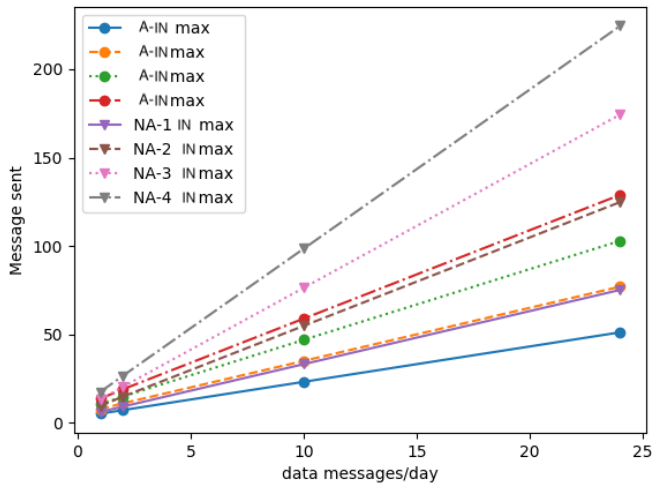
*Payload :*

*< DevEUI\_A; Data\_A; DevEUI\_B; Data\_B; ...DevEUI\_N; Data\_N >*

## Cost on the power consumption

What additional energy cost will there be on the relay nodes, relaying more isolated nodes with or without aggregation?

# Energy management: Agregation vs without





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## LLWURP: LoRa/LoRaWAN Uniform Relay Protocol

- Solution to collect isolated nodes
- LoRa to LoRaWAN relay protocol
- Relay node is fully 1.0 LoRaWAN compatible
- Isolated node only need receive and transmit in LoRa

- Security
  - Security : no encryption in LoRa
  - Secure element in 1.1 LoRaWAN specification
- Fault on system nodes
  - Relay node
  - Isolated node
  - Antenna

Thanks for your attention