SYNCHRONOUS AND SCHEDULING MECHANISM FOR RELAY
&
SMART VISION FOR WILD FIRE DETECTION

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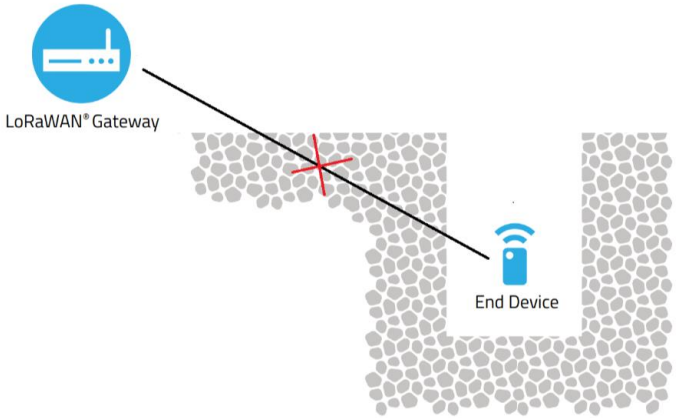
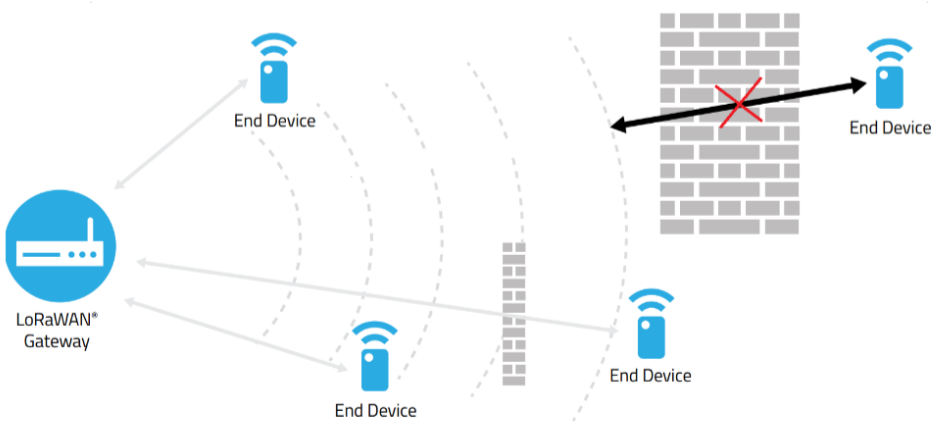
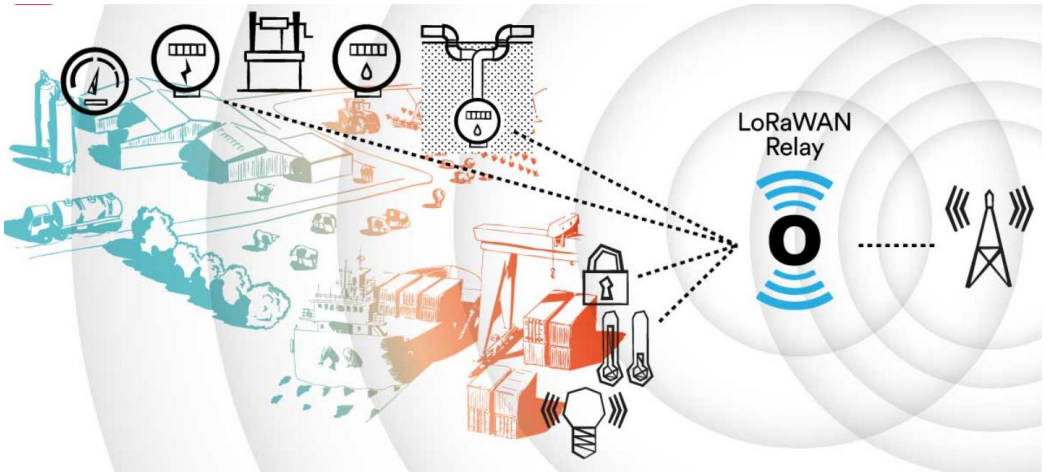
Introduction to Relay



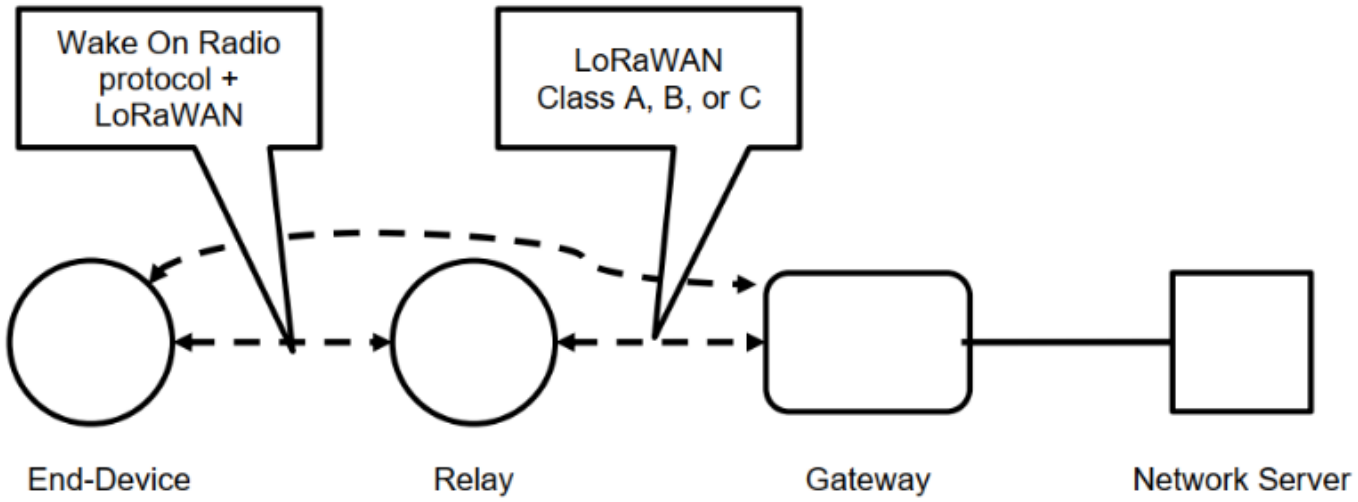




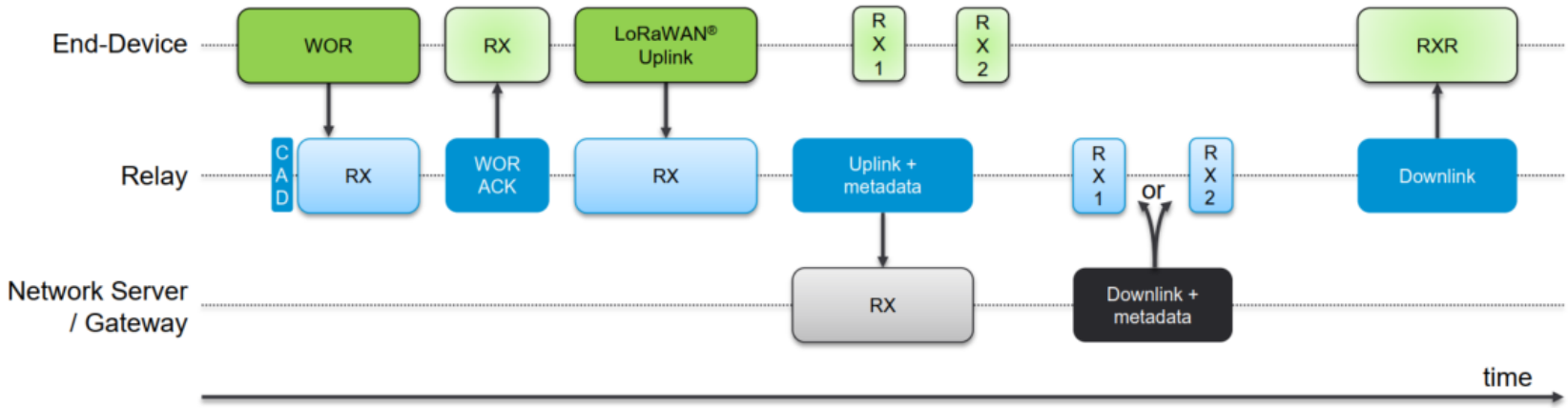
Water meter application in Vietnam

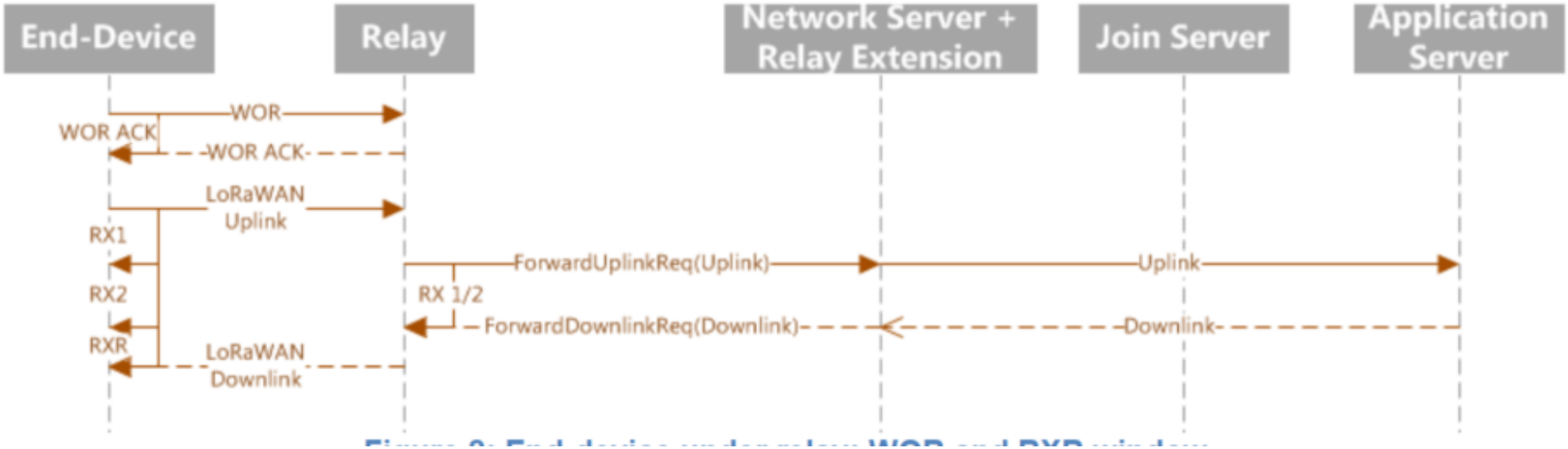
Relay specification

- The idea of Relay has been introduced in LoRaWAN Relay workshop and then presented in The Things Conference 2019
- In **September 2022**, the LoRa Alliance released the LoRaWAN Relay Specification TS011-1.0.0

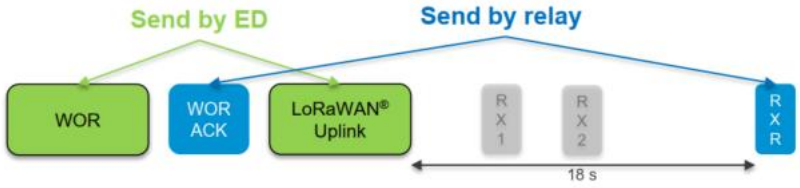


LoRaWAN Relay Specification TS011-1.0.0



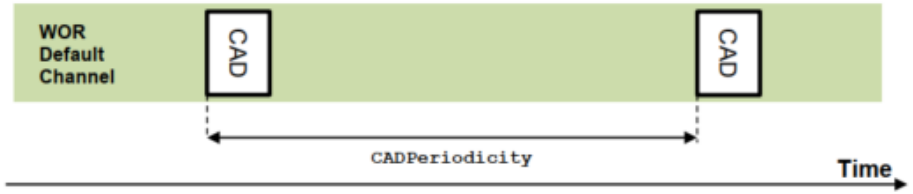


LoRaWAN Relay Specification TS011-1.0.0

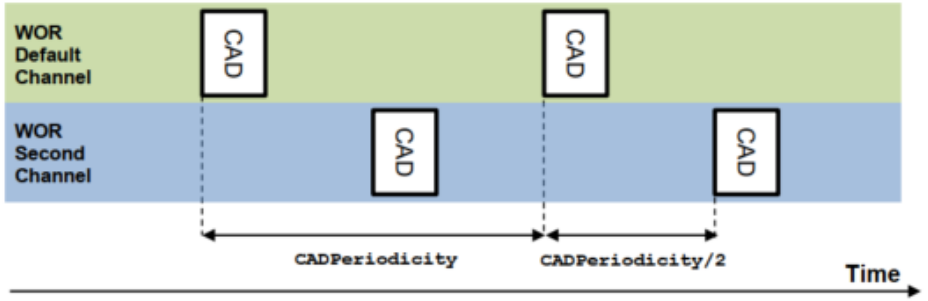


- WOR : **W**ake **O**n **R**adio
- RXR : Relay reception window
- WOR ACK: **W**ake **O**n **R**adio **Ack**nowledge

- WOR specification:
  - Variable preamble length (up to 1 s)



Only default channel



Default and second channel

LoRaWAN Relay Specification TS011-1.0.0

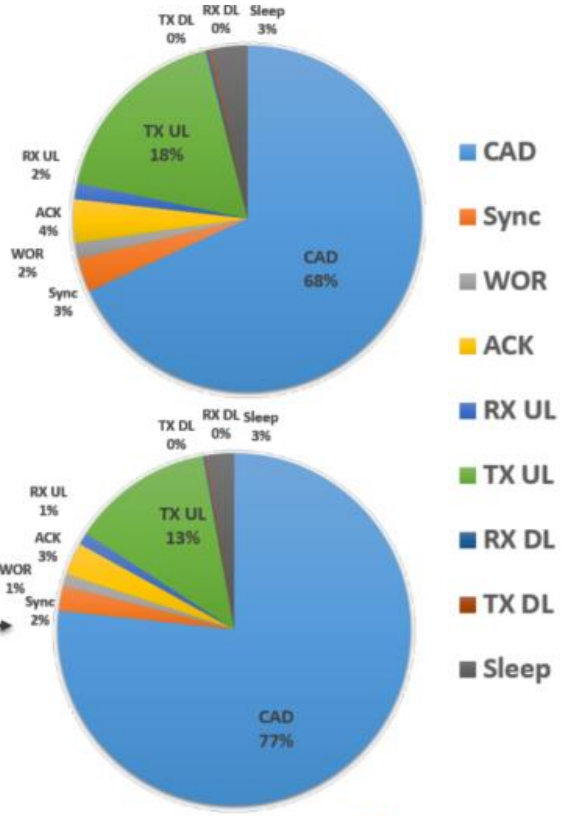
CAD every 1s with 10 end-devices:

- sending 50 bytes every hour
- receiving 20 byte once per day
- SF9 BW125 for WOR and LoRaWAN® exchange

Estimated battery* :

- 1 channel (default) : 10 years (1 x SAFT LS 33600)
- 2 channel : 7.5 years (1 x SAFT LS 33600)

Default channel only (SF9 BW125)



Default channel (SF9 BW125) + Second channel (SF7 BW125)

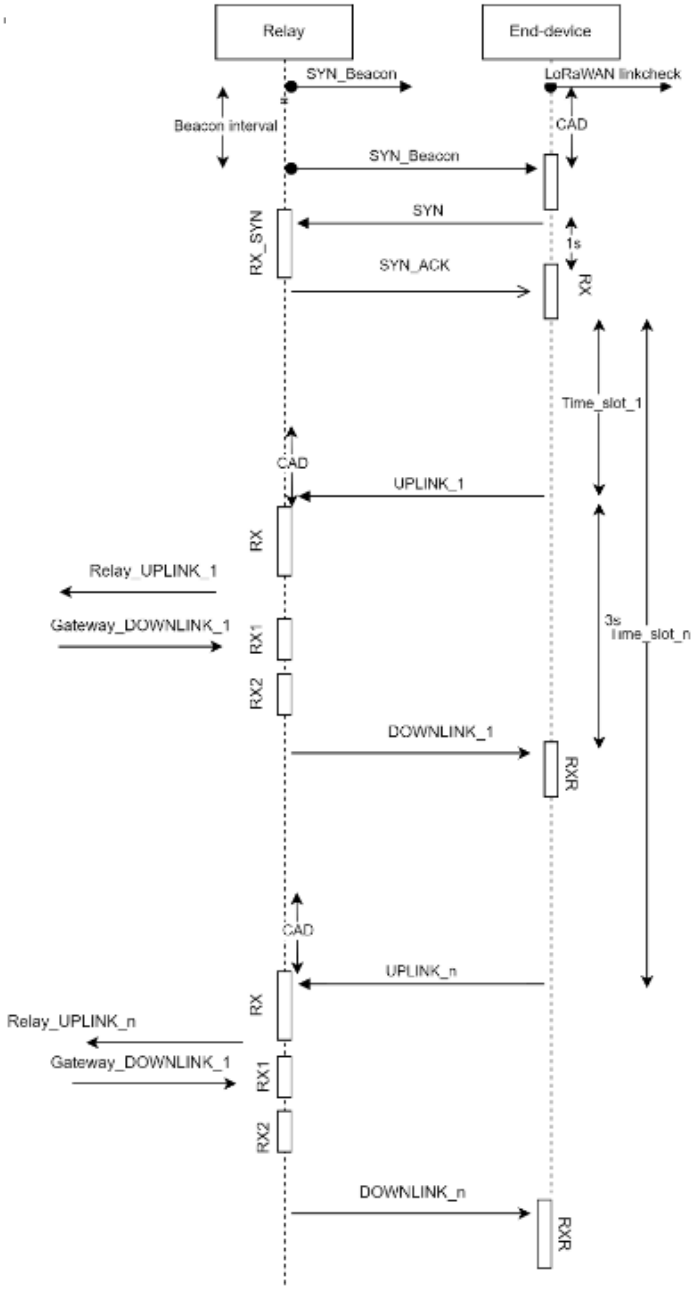
* : ±30 ppm quartz on relay and end-device. Refer to AT-cut XTAL or MCU XTAL calibration procedure. Estimation done for a SX1261

LoRaWAN

LoRa Alliance

Actual limitation is the number of end-devices (<16) and the relay frequency plan (cell network)

SYNCHRONOUS AND SCHEDULING MECHANISM



RL: SYN Beacon packet format

1 byte	4 bytes	1 byte
RelayID	Timestamp_Relay	Numslot

ED: SYN packet format

1 byte	1 byte	4 bytes	1 byte	1 byte
DevAddr	uptime	TimestampED	Channel	DR

RL: SYN ACK packet format

1 byte	4 bytes
DevAddr	Timestampslot

SYNCHRONOUS MECHANISM FOR RELAY

- **Transmission Time (T_x)**
  - SF = 9
  - BW = 125 kHz
  - Payload Size = 50 bytes
  - CRC = 1
  - IH (implicit header)= 1
  - DE (data rate optimization enabled)= 0
  - CR = 1 (coding rate of 4/5)
  - Preamble Length = 12 symbols
  - Duty Cycle = 1%

$$T_{\text{CAD}} = \frac{32}{BW} + \frac{2^{SF}}{BW} + \frac{2^{SF} \times SF}{1750 \times 10^3}$$

$$T_{\text{transmission}} = T_{\text{SYN Beacon}} + T_{\text{SYN ACK}} + T_{\text{UPLINK}}$$

$$N_{\text{max}} = \frac{DC \times T_{\text{maxchanel}}}{T_{\text{transmission}}}$$

$$T_x = \text{Preamble Time} + \text{Payload Time}$$

$$T_{\text{payload}} = \left(8 + \max\left(\left\lceil \frac{8\cdot\text{PL} - 4\cdot\text{SF} + 28 + 16\cdot\text{CRC} - 20\cdot\text{IH}}{4\cdot(\text{SF} - 2\cdot\text{DE})} \right\rceil \cdot (\text{CR} + 4), 0\right)\right) \cdot \frac{2^{\text{SF}}}{\text{BW}}$$

$$T_{\text{preamble}} = (\text{Preamble Length} + 4.25) \cdot \frac{2^{\text{SF}}}{\text{BW}}$$

Average current of Relay

Item	Value	Unit	Description
Uplink periodicity	60	minutes	
Transmision current	25	mA	SX1261 datasheet [50]
Uplink transmision time	324.608	ms	SF9, BW125, 50 bytes PL
SYN Beacon transmision time	1053.248	ms	T_{preamble}=1s, SF9, BW125, 6 bytes PL
SYN ACK transmision time	1053.248	ms	T_{preamble}=1s, SF9, BW125, 5 bytes PL
Average transmision current	**16.993**	uA	
RX current	4.6	mA	SX1261 datasheet [50]
RX time	1258.048	ms	Receiving UPLINK from end device
RX SYN time	1073.728	ms	Receiving SYN 8 bytes from end device
RX1 and RX2 current	0.11	uA	SX1261 datasheet [50]
Average receive current	**29.7949**	uA	
CAD period	60 minutes	ms	3 times before receiving time slot
CAD duration	6.985	ms	1 symbol, SF9, BW125, Formula 4.9
RX and CAD current	4.6	mA	SX1261 datasheet [50]
Average CAD current	**26.776**	nA	
Total average current	**19.89**	uA	per an end device

Average current of Relay

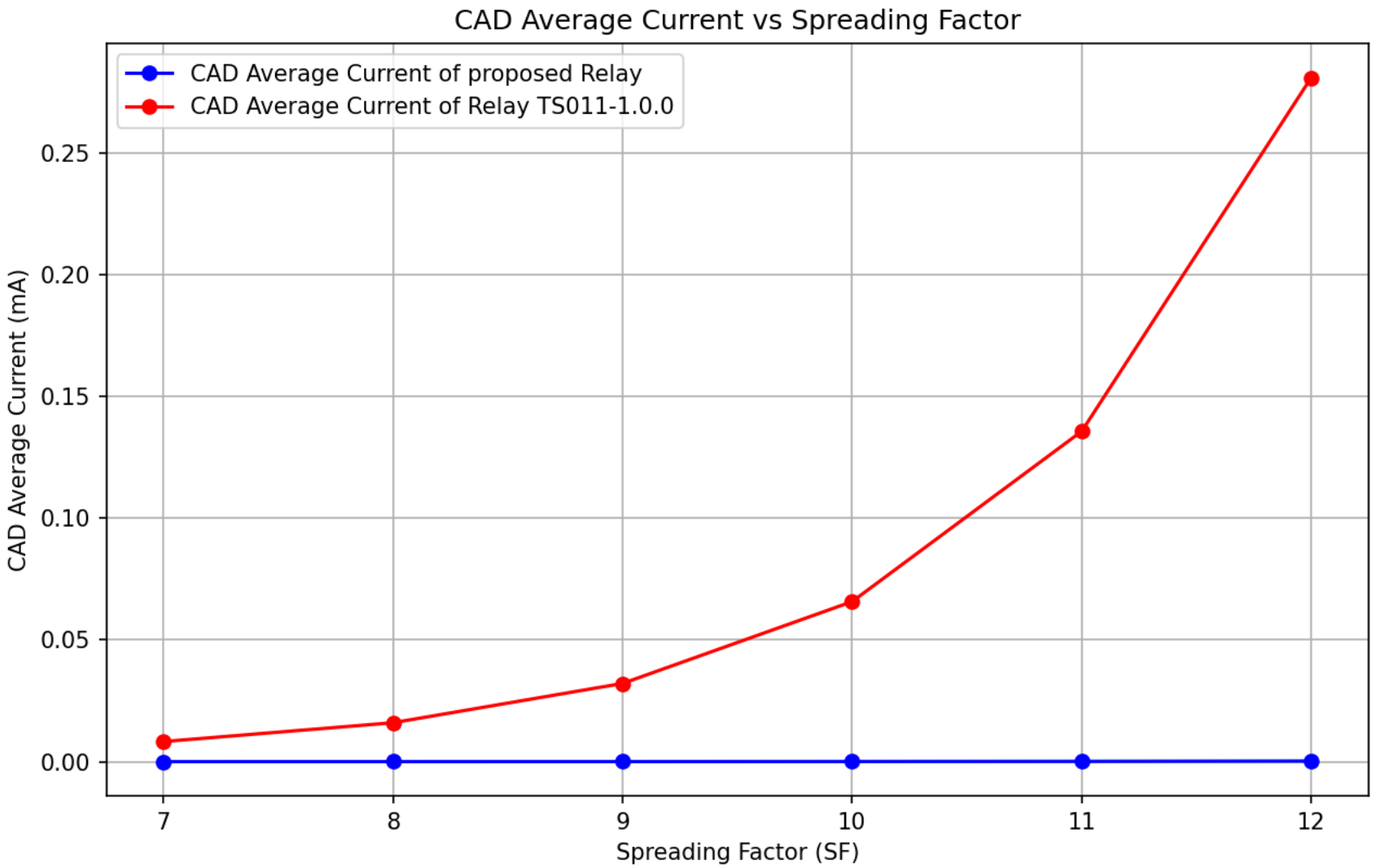
Proposed Relay mechanism

Item	Value	Unit	Description
Uplink periodicity	60	minutes	
Transmision current	25	mA	SX1261 datasheet [50]
Uplink transmision time	324.608	ms	SF9, BW125, 50 bytes PL
SYN Beacon transmision time	1053.248	ms	T_{preamble}=1s, SF9, BW125, 6 bytes PL
SYN ACK transmision time	1053.248	ms	T_{preamble}=1s, SF9, BW125, 5 bytes PL
Average transmision current	**16.993**	uA	
RX current	4.6	mA	SX1261 datasheet [50]
RX time	1258.048	ms	Receiving UPLINK from end device
RX SYN time	1073.728	ms	Receiving SYN 8 bytes from end device
RX1 and RX2 current	0.11	uA	SX1261 datasheet [50]
Average receive current	**29.7949**	uA	
CAD period	60 minutes	ms	3 times before receiving time slot
CAD duration	6.985	ms	1 symbol, SF9, BW125, Formula 4.9
RX and CAD current	4.6	mA	SX1261 datasheet [50]
Average CAD current	**26.776**	nA	
Total average current	**19.89**	uA	per an end device

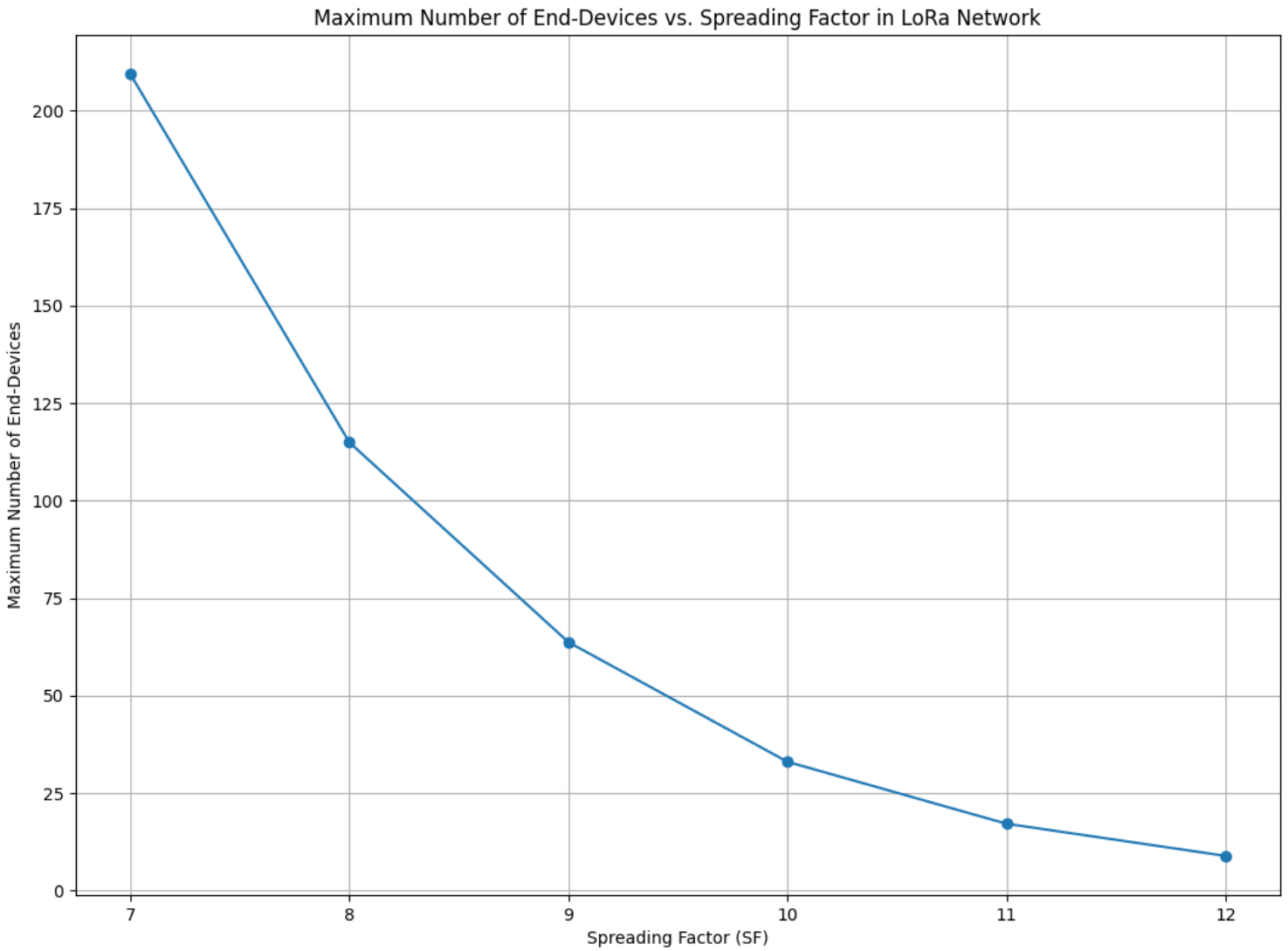
Relay specification TS011-1.0.0

Item	Value	Unit	Description
Uplink periodicity	60	minutes	
Transmision current	25	mA	SX1261 datasheet [50]
Uplink transmision time	324.608	ms	SF9, BW125, 50 bytes PL
WOR ACK transmision time	140.29	ms	SF9, BW125, 7 bytes PL
Average transmision current	**16.993**	uA	
RX current	4.6	mA	SX1261 datasheet [50]
RX time	1258.048	ms	Receiving UPLINK from end device
RX WOR time	1094.208	ms	Receiving WOR 15 bytes from end device
RX1 and RX2 current	0.11	uA	SX1261 datasheet [50]
Average receive current	**29.7949**	uA	
CAD period	1000	ms	
CAD duration	6.985	ms	1 symbol, SF9, BW125, Formula 4.9
RX and CAD current	4.6	mA	SX1261 datasheet [50]
Average CAD current	**32.132**	mA	
Total average current	**0.3837**	mA	per an end device

CAD Average Current

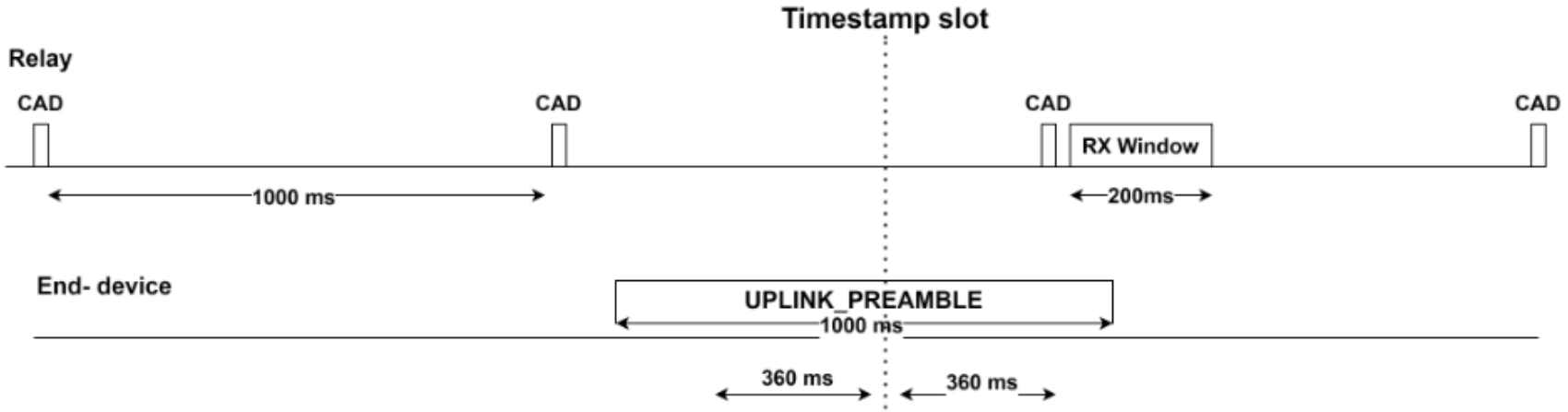


Relay – Maximum Number of end-devices



Possibility of Packet Loss

- **PDR was affected by SYNCHRONOUS Accuracy**
  - JGHC SMD3225 Crystal oscillator, 32.768 kHz, ±10 ppm
    - Over a hour, this could result in a time deviation of 3600 seconds * 0.00001 = ±0.36 seconds per hours.



- **PDR can reach 100% if time error is well calibrated**

CONCLUSION

LW Relay Spec. TS011-1.0.0

- Bidirectional
- 2 Chanel
- 10 - 16 end-devices
- Consume a lot of energy in continuously CAD
- Conflicts increase with the increasing number of end-devices.

Proposed SYN Mechanism for Relay

- Bidirectional
- Multiple Chanel
- Max 200 end-devices
- Optimize power consumption of Relay by CAD for initialization
- No conflict arises from increasing number of end-devices

- The proposed mechanism for Relay suitable for the application requiring large number of end device and have data sent periodically
- Can work for multiple channel
- Optimize power consumption of Relay
- No conflict arises from increasing number of end-devices

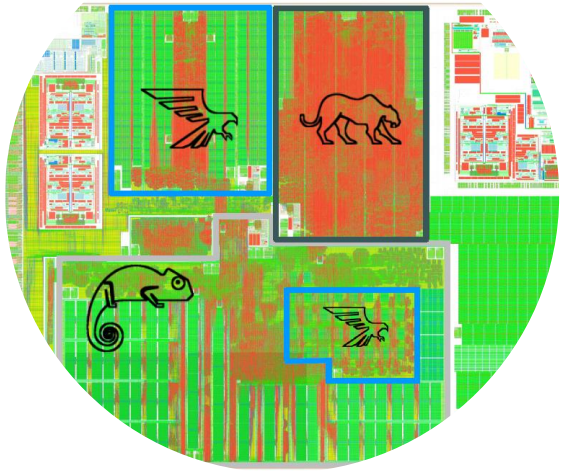
Smart Vision IoT for Wild fire detection

Vincent Huard, Manh Thao Nguyen, Fabien Ferrero

07/2024

ELLIOT Project

- ✓ **Dolphin Test chip with CNN acceleration units**
  - High AI performance (10-100 GOPS)
  - Record-breaking Energy Efficiency >2 TOPS/W
- ✓ **Space IoT communication**
  - Integration of Echostar EM2050 module
  - CP S-band antenna
- ✓ Applications :
  - Fire detection
  - Cattle tracking
  - Meteo Station



DOLPHIN DESIGN

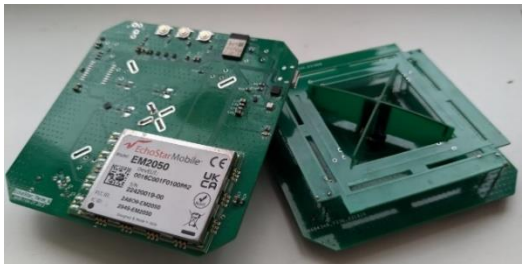
LEAT
LABORATOIRE D'ELECTRONIQUE ANTENNES ET TELECOMMUNICATIONS

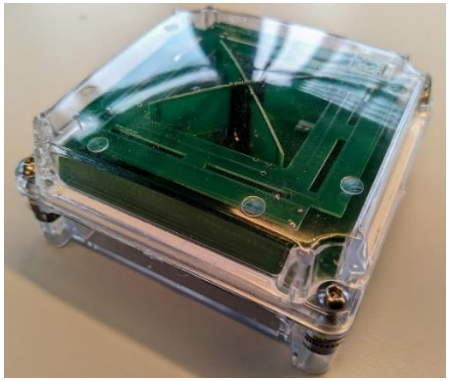
UNIVERSITÉ CÔTE D'AZUR

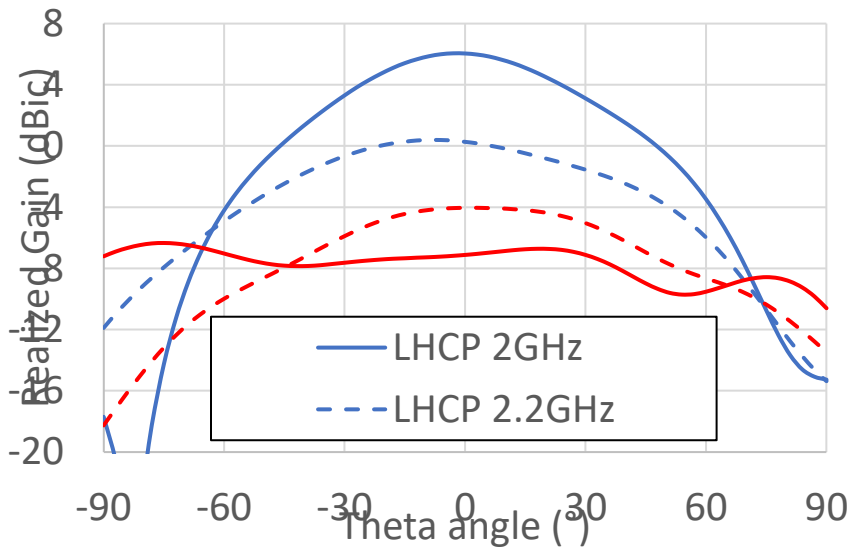
IRT SAINT EXUPÉRY

Compact terminal

- ✓ UHF and S-band antenna included
- ✓ GNSS L1 & L5 antenna and receive
- ✓ Sensors (accelerometer, Temp/hum)

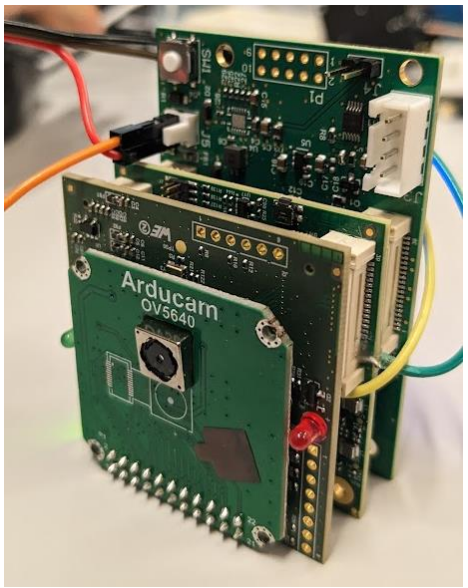


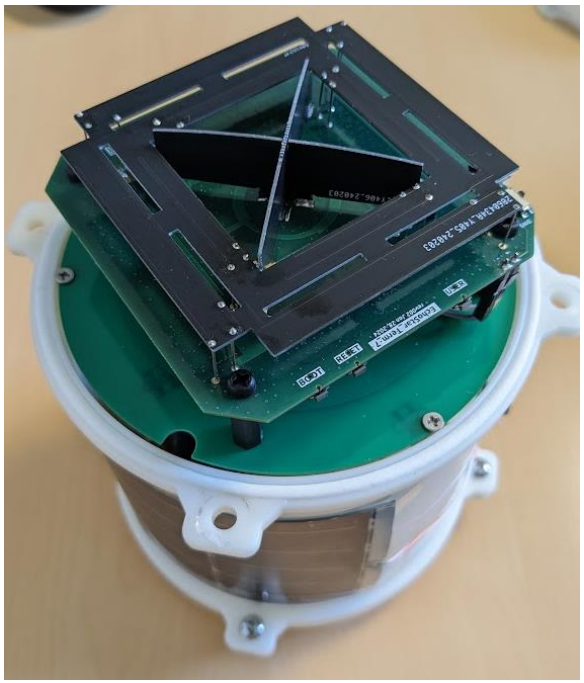




Solar terminal

- ✓ Low Power Camera
- ✓ AI accelerator
- ✓ Echostar Modem
- ✓ Solar harvester
- ✓ Lithium Battery





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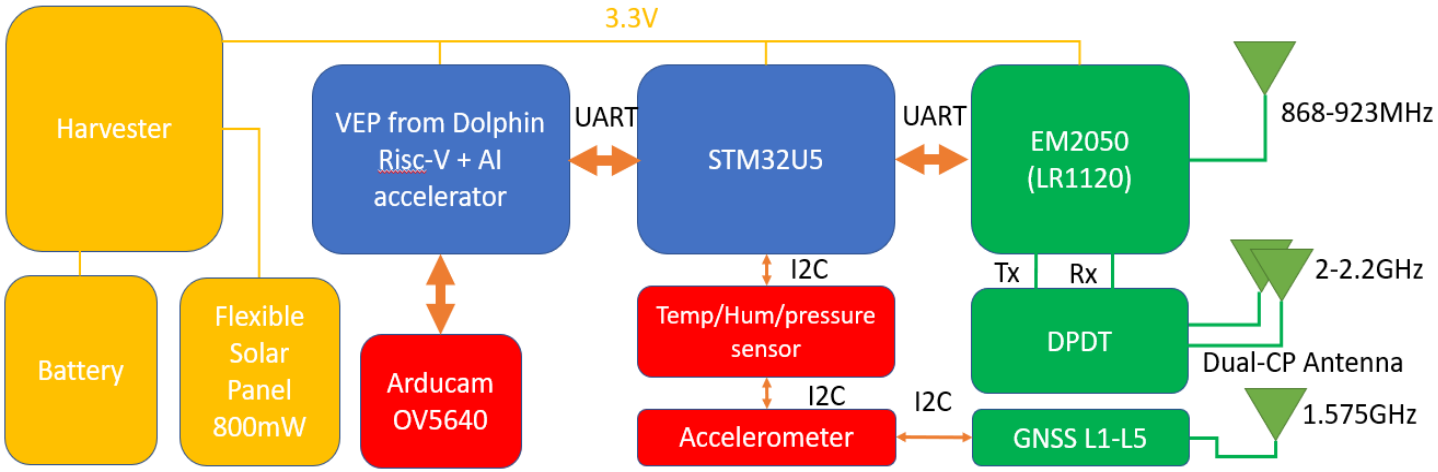

POC in Montpellier Area for wild Fire detection

- ✓ **10 terminals deploy this summer to test wild fire detection**
- ✓ **In collaboration with Montpellier Firemans**
- ✓ **Transmission to terrestrial LoRaWan and Satellite**

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Technical Co-Sponsor: Antenna Measurement Techniques Association (https://www.amta.org/)

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- Electromagnetic Measurement Methods and Techniques
- Scattering and Diffraction Measurements
- Near-Field and Far-Field Measurements
- Radar and RCS Measurements, Processing, Quantum Radar
- Microwave, Millimeter-Wave, and THz Systems
- Sensors, Quantum Sensing
- Modeling, Simulations, and Predictions of Measurements in Realistic Environments
- Inverse & Imaging Methods and Techniques
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