The**Dropwatcher**

A **REAL WORLD LORAWAN** APPLICATION ON RIOT

Inria Chile

WHO DO WE WORK WITH ?

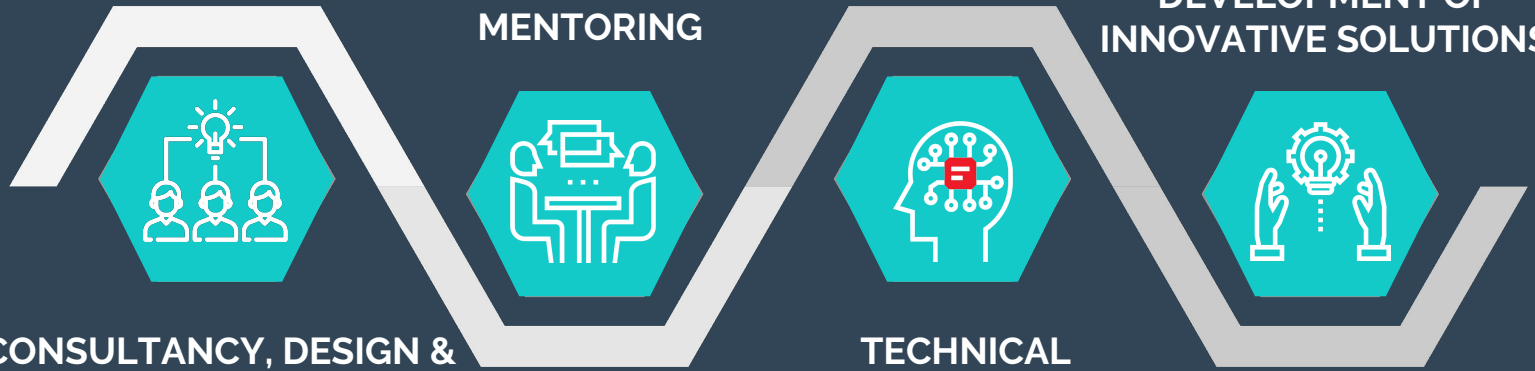
INDUSTRY

ACADEMIA

/UDEC
/PUCV
/UDP
/UACh
/UV
/PUC
/UAI
/UCHILE
/UFRO
/UTFSM

Strategic partner for the development and transfer of innovative solutions, connecting the academic world and the research with the real needs of companies.

WHAT DO WE DO?


CONSULTANCY, DESIGN & CO-CREATION
MENTORING
TECHNICAL ADVISING
DEVELOPMENT OF INNOVATIVE SOLUTIONS

INTEGRATION OF TECHNOLOGIES

ARTIFICIAL INTELLIGENCE

- Signal processing
- Robotics
- Machine Learning

INTERNET OF THINGS

- Operating Systems
- Network technologies

DATA

- Big Data
- Data Analysis
- Data Science
- Data Engineering

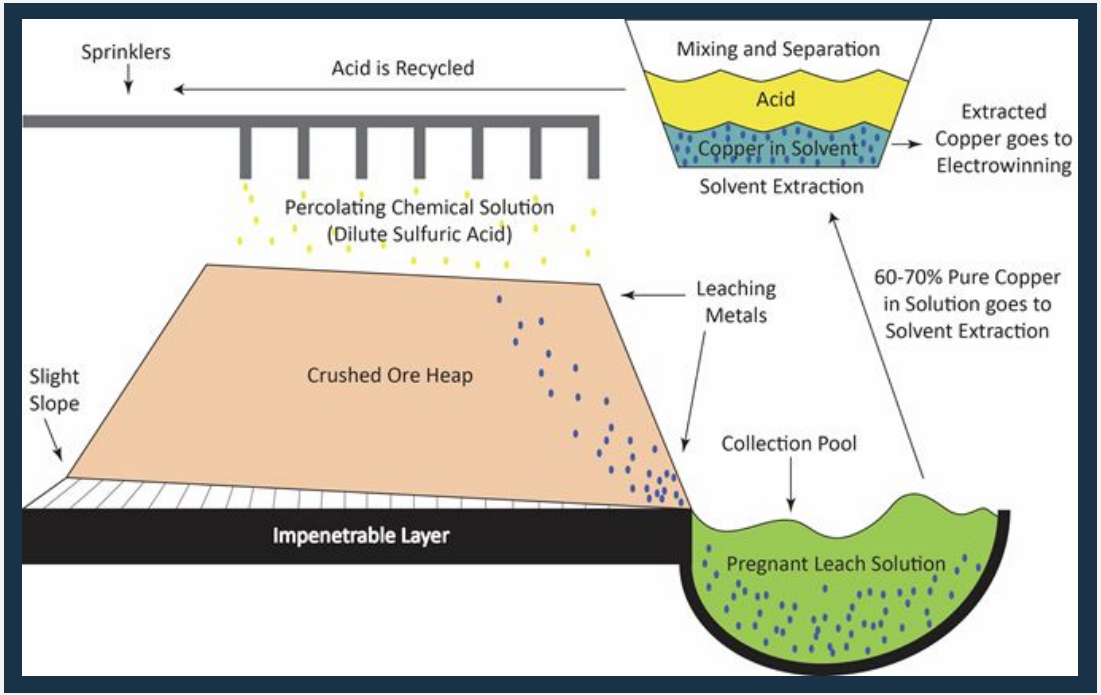
COMPUTER SIMULATION

- Modeling
- High Performance Computing

HEAP LEACHING PROCESS

(Source: biohydro.cl)

HEAP LEACHING



Source: superfund.arizona.edu

THE **PROBLEM**

Constant Flow in Sprinklers Is Important
• Low flow affects copper extraction efficiency • High flow can collapse the heap • Millions of dollars in losses

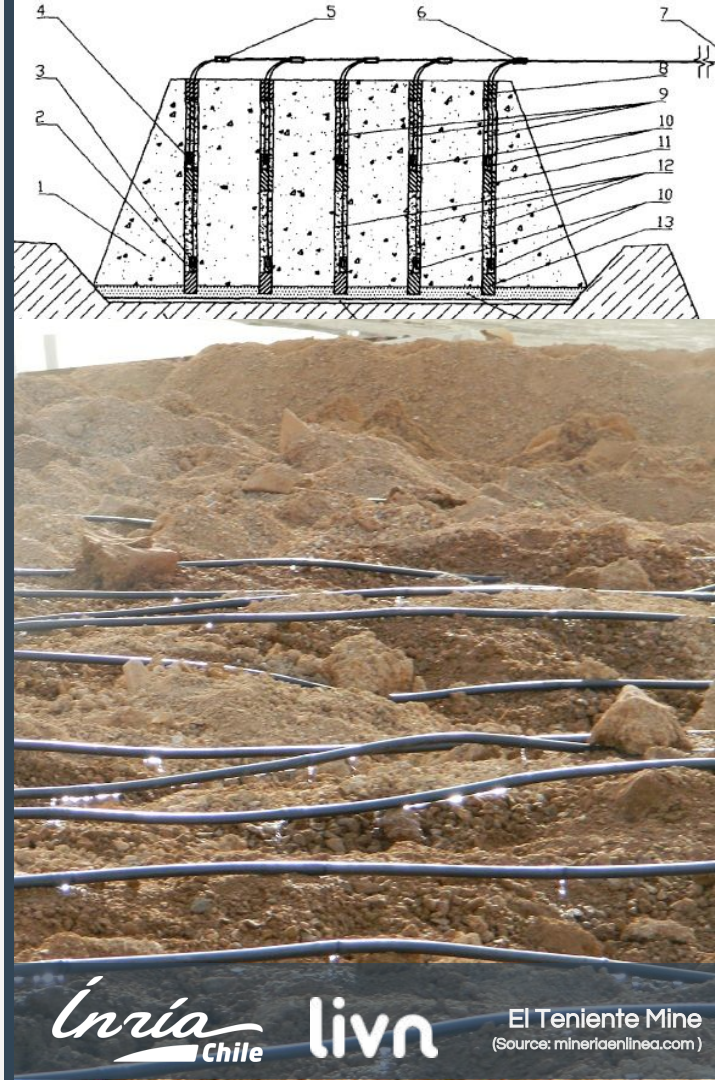
Hard to measure
• Current approach based in human reading • Not accurate • Low sampling rate

THE **PROBLEM**

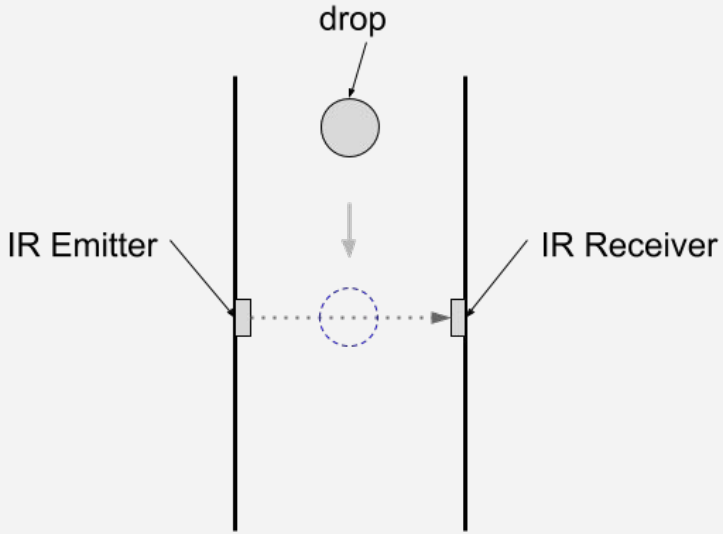
Contest launched by **Telefónica I+D** to monitor acid flow going into a copper heap.

Requirements

- Low cost IoT device.
- Flow monitoring every 10 minutes
- LoRaWAN connectivity
- Run on batteries for 6 months



OUR PROPOSED **SOLUTION**



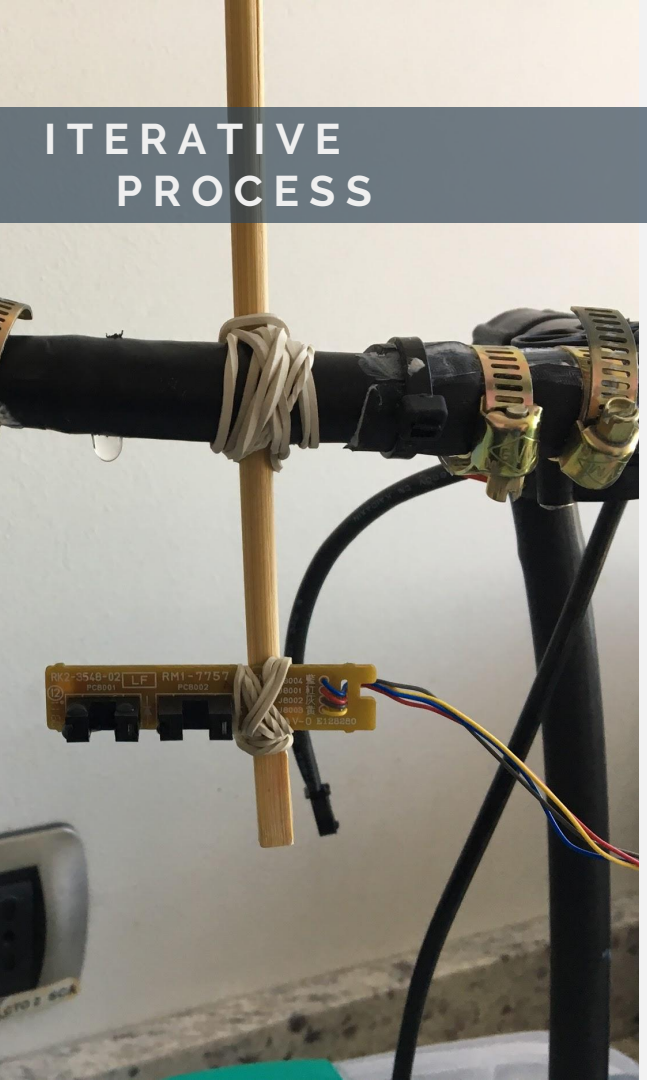
$$F = \frac{nV}{T}$$

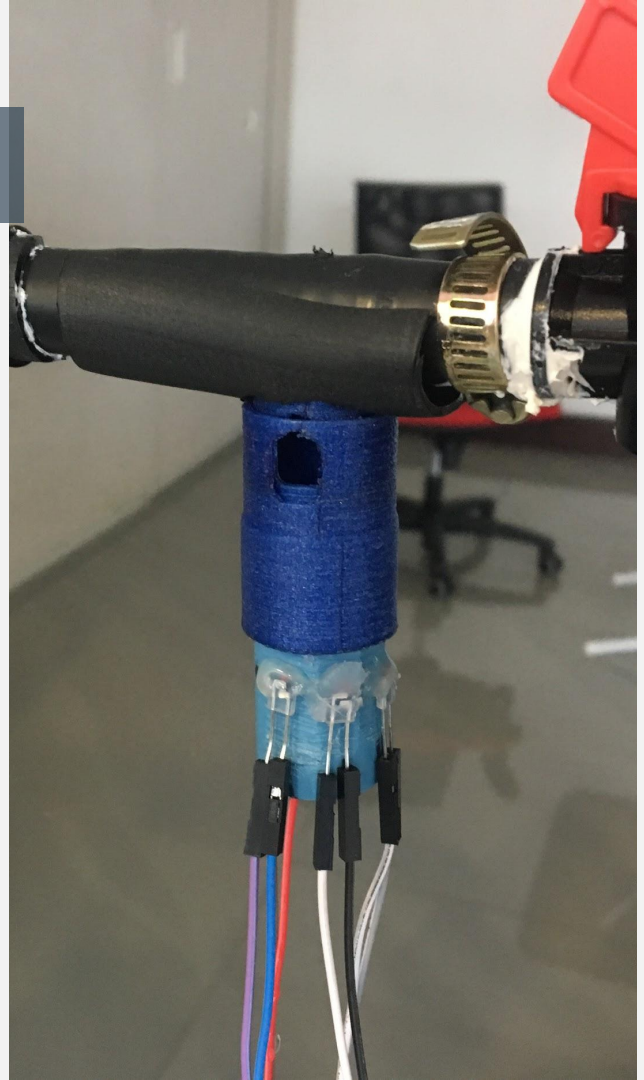
Where:

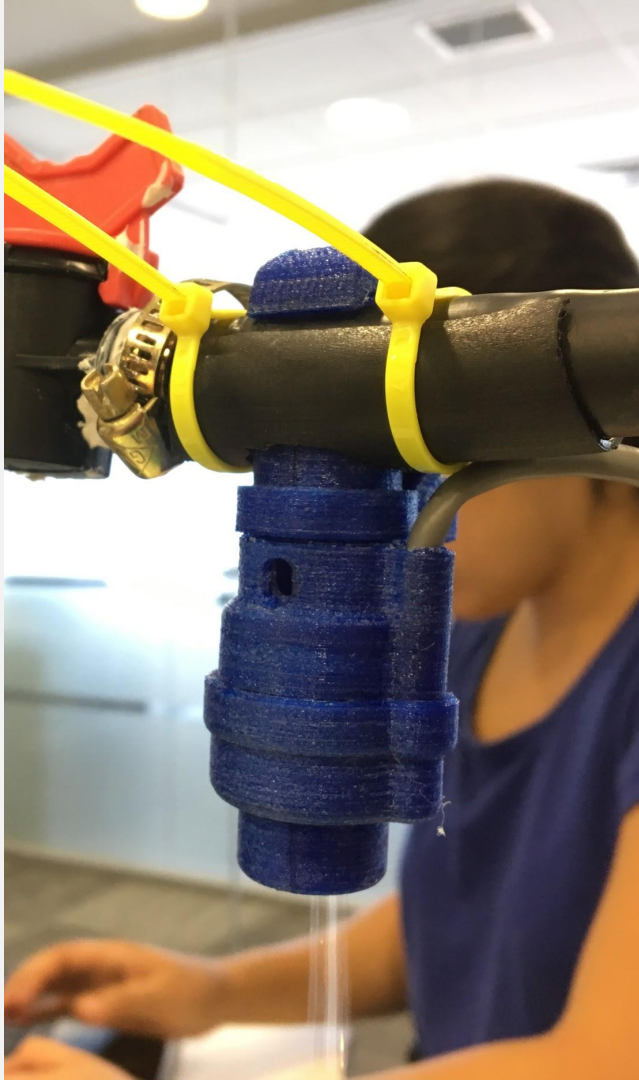
F = estimated flow
n = number of drops
V = average drop volume
T = sampling period

(Source: mineriaenlinea.com)

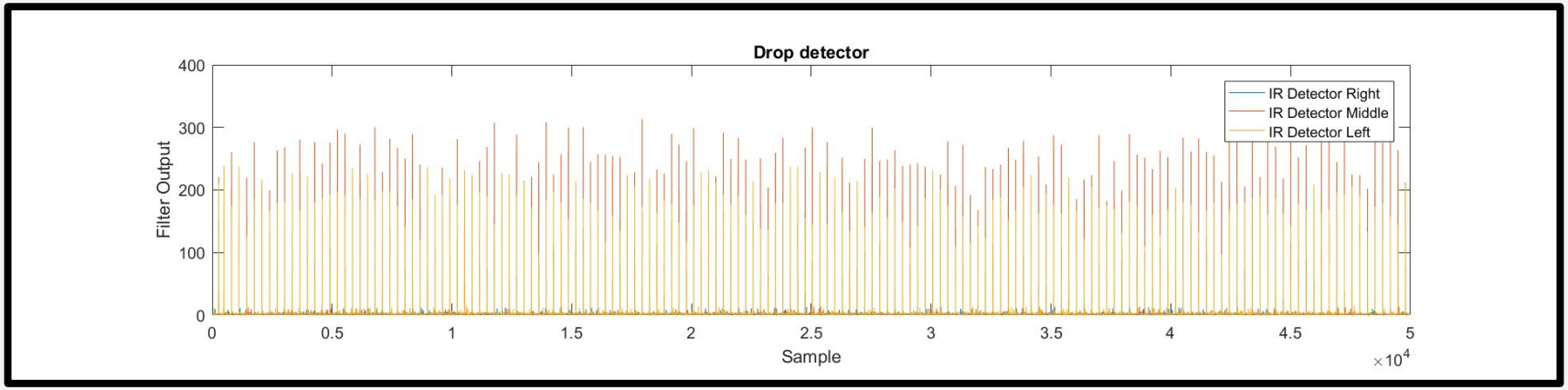
ITERATIVE PROCESS







DROP **DETECTION**



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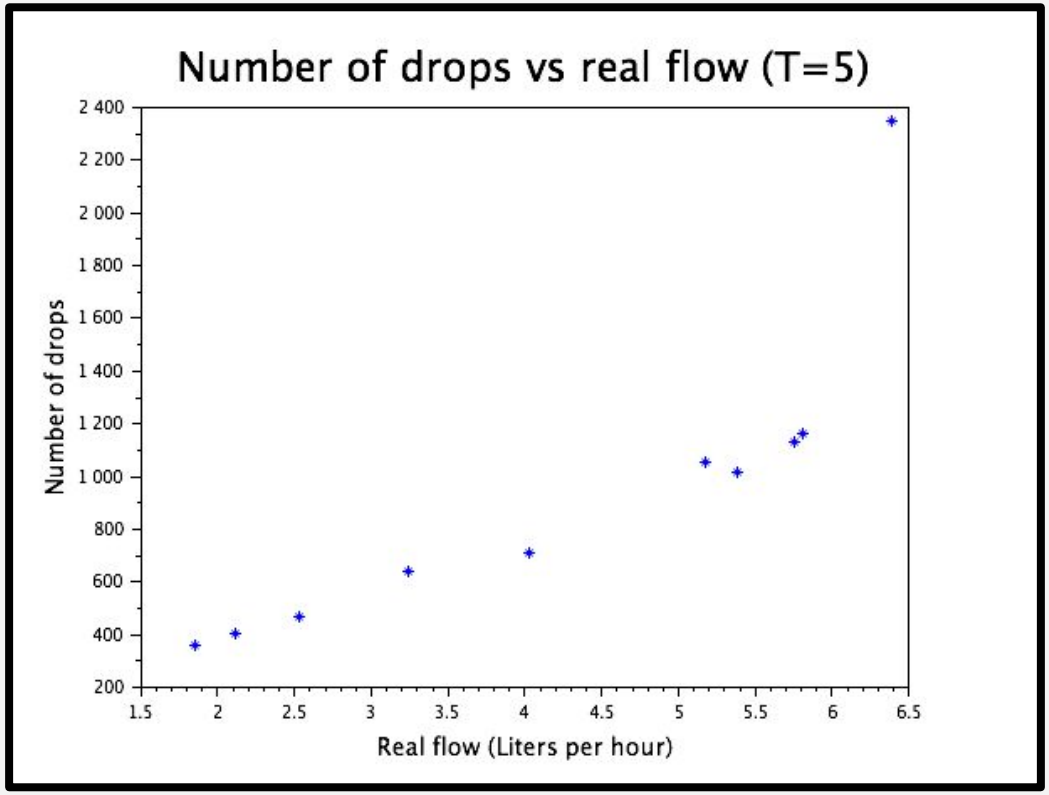
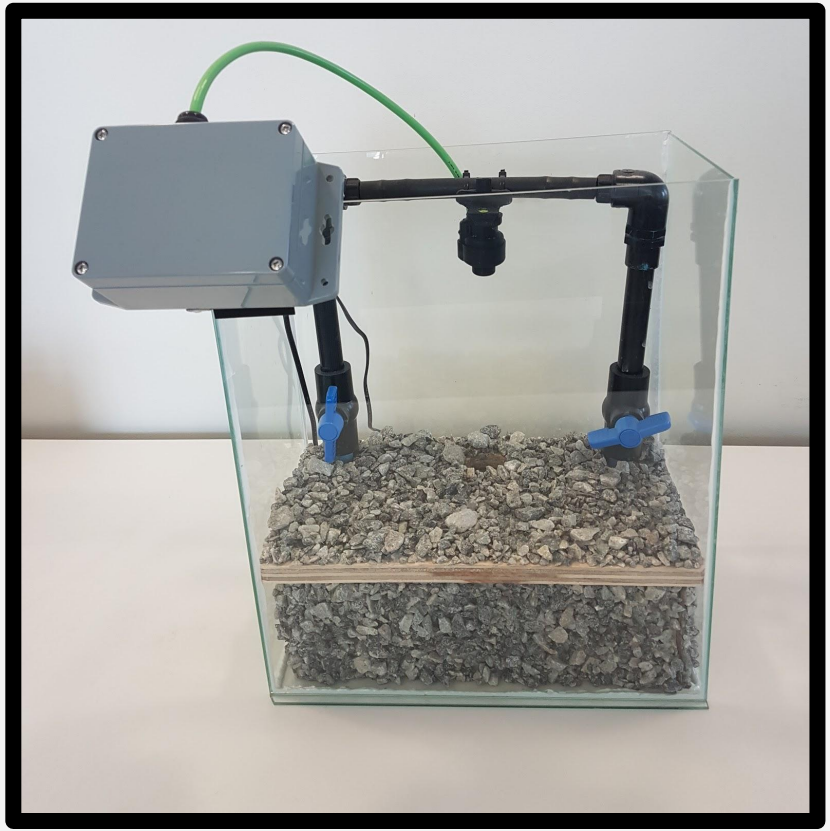
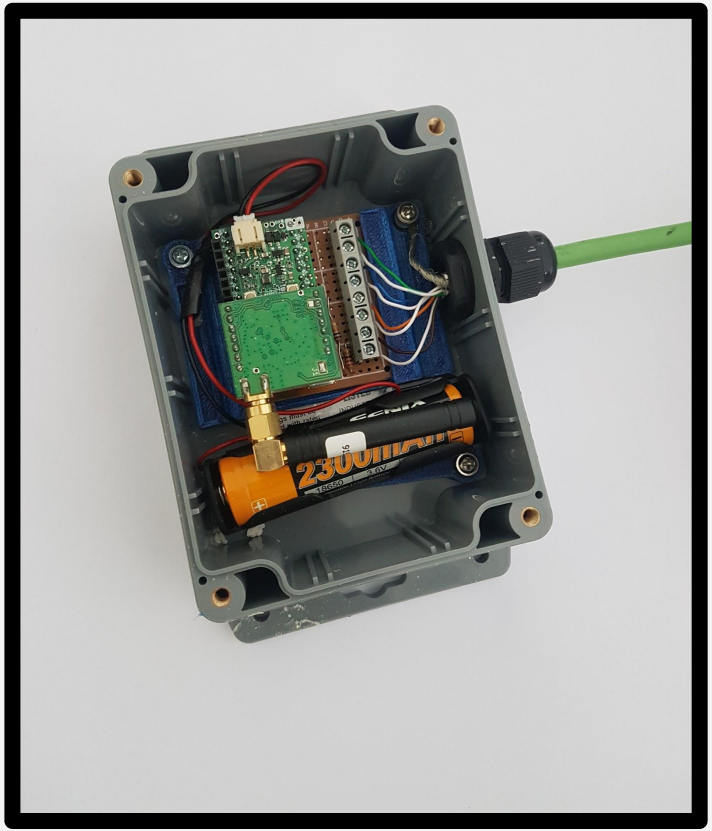
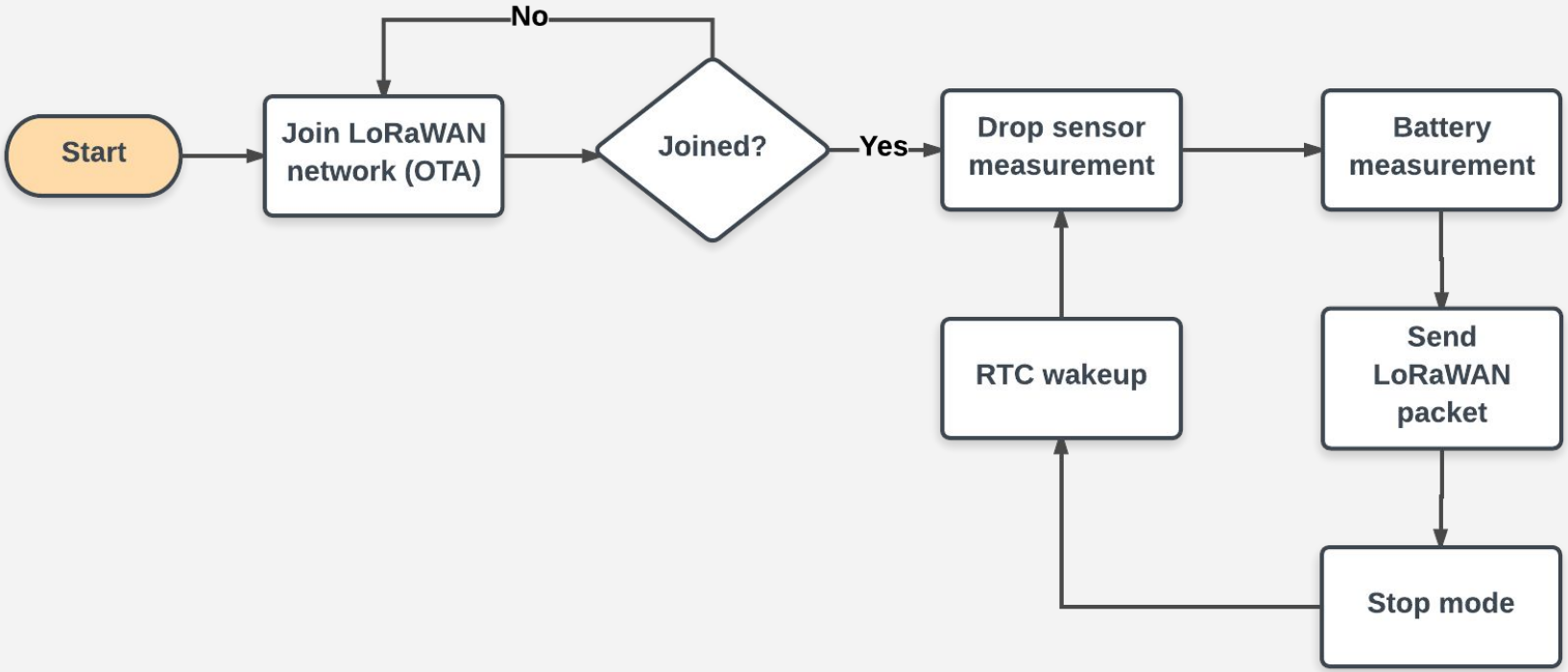


THE **DROPWATCHER**



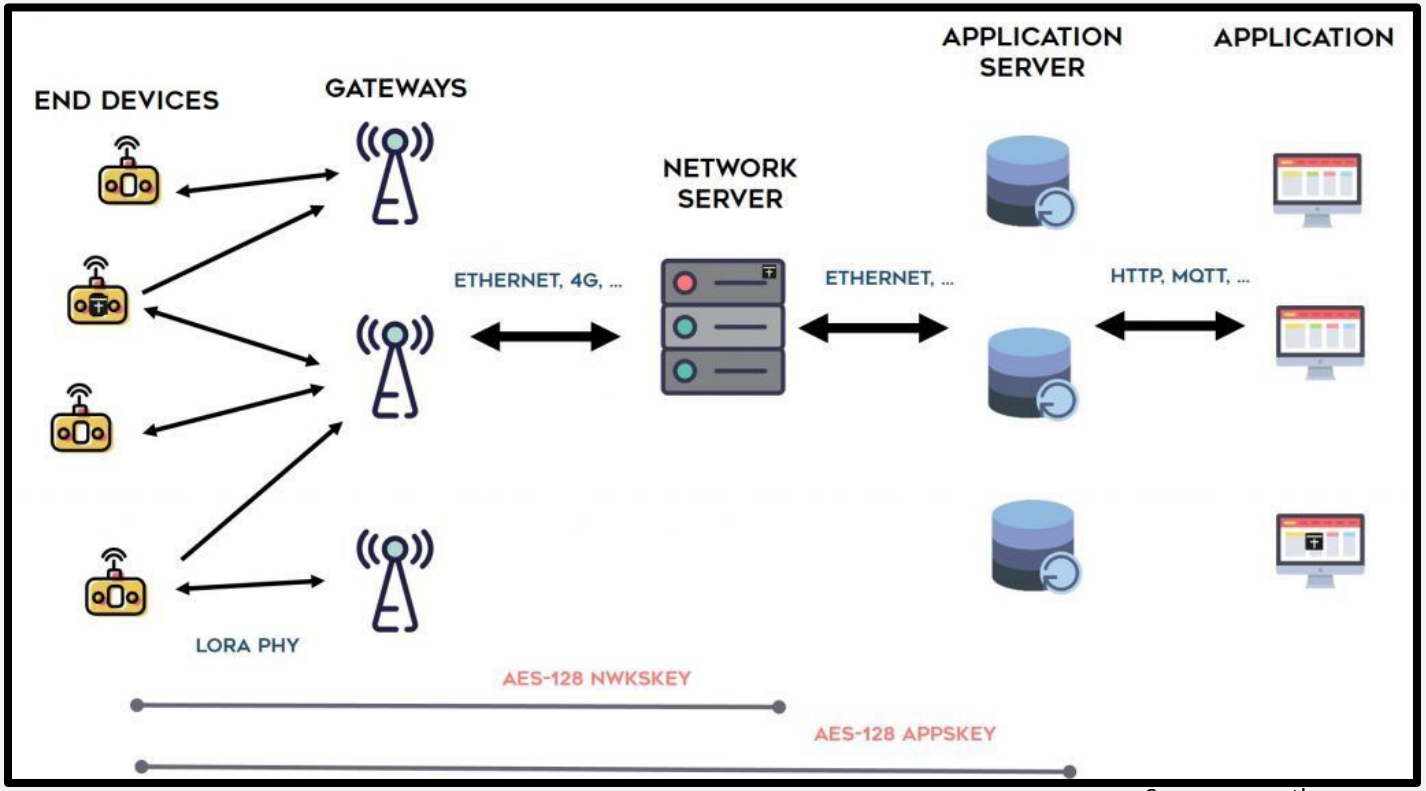


HOW IT **WORKS**


No
Start
Join LoRaWAN network (OTA)
Joined?
Yes
Drop sensor measurement
Battery measurement
RTC wakeup
Send LoRaWAN packet
Stop mode

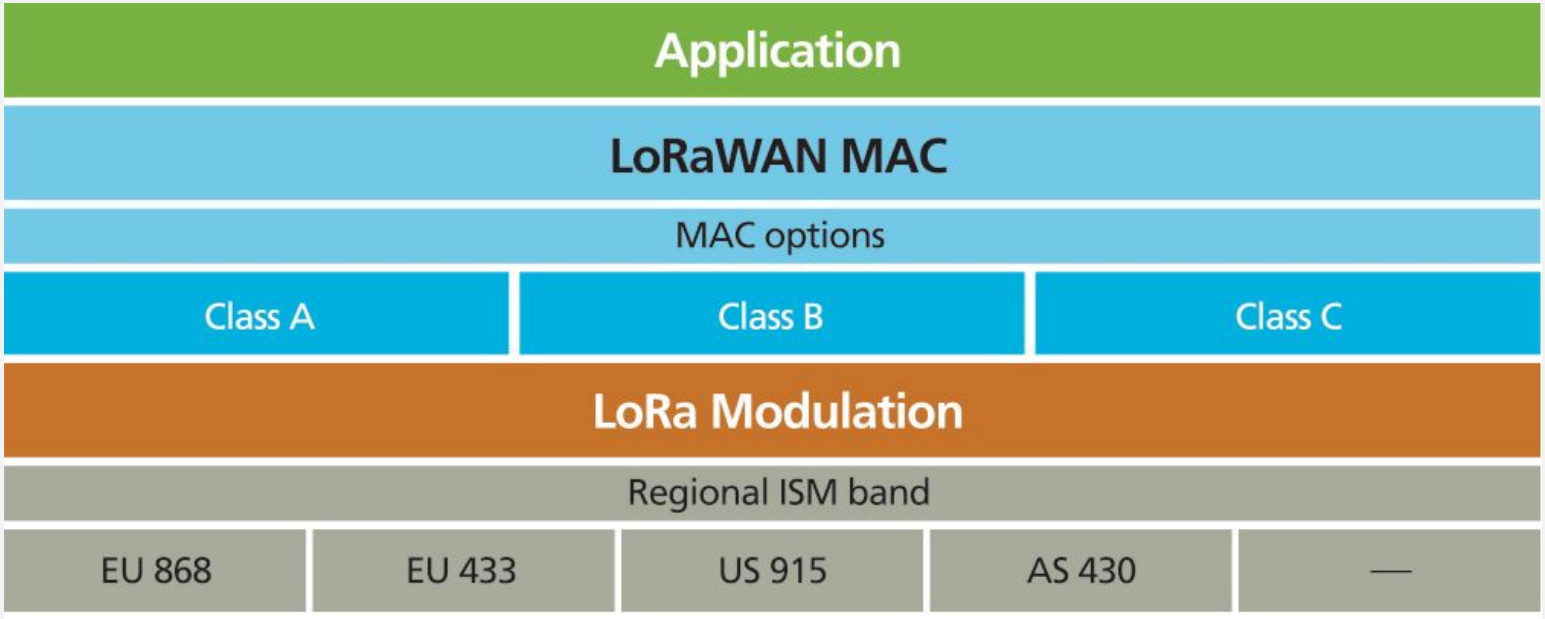
Brief **LoRaWAN** overview

LoRaWAN **architecture**



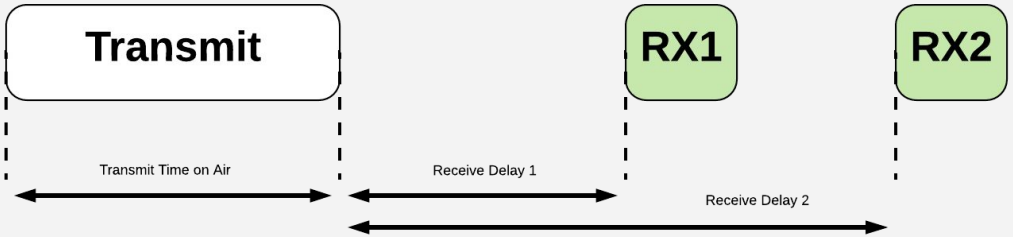
Source: zerynth.com

LoRaWAN communication **stack**



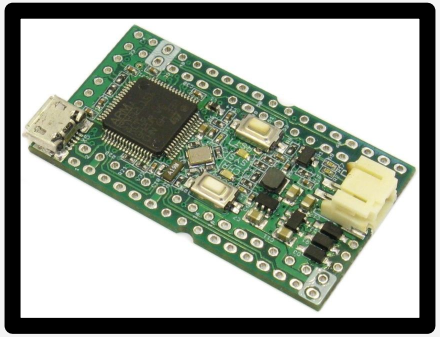
OUR LORAWAN **SETTINGS**

- **Class A:** minimum average power consumption.
  - Two short receive windows after uplink
- US-915 band

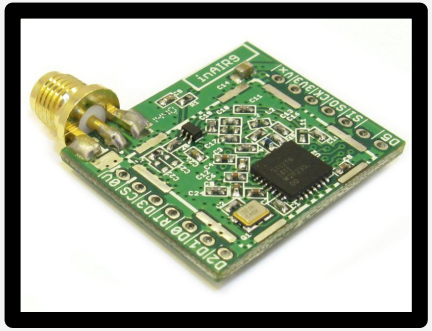


LoRaWAN on RIOT

THE **INCEPTION**



Modtronix
NZ32-SC151

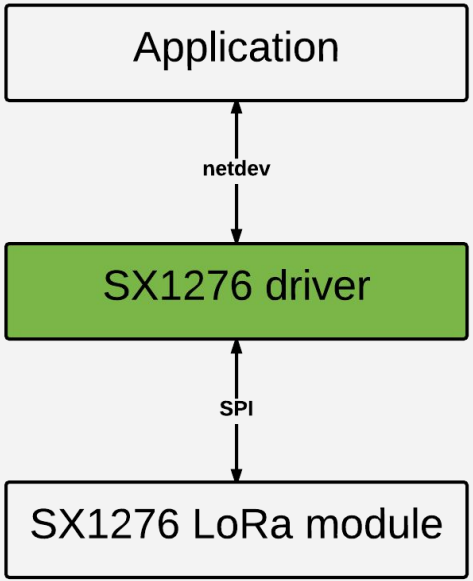


Modtronix
inAir9A
(SX1276)

Everynet
Gateway v2.1

LORA **MODULE** (SX1276)

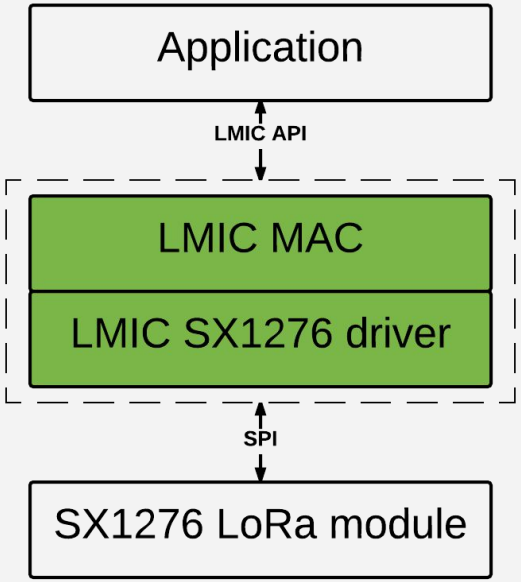
- Pull Request of SX1276 driver (#6002)
- Netdev adoption
- Currently merged with support for SX1272 too.



(Source: mineriaenlinea.com)

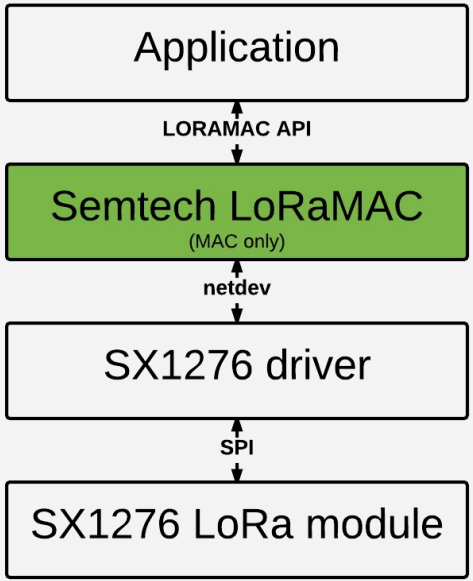
LMIC

- IBM LoRaWAN implementation
  - Implements Class A and Class B
  - Arduino LMIC
- Proof of Concept
- On-going PR (#7640)

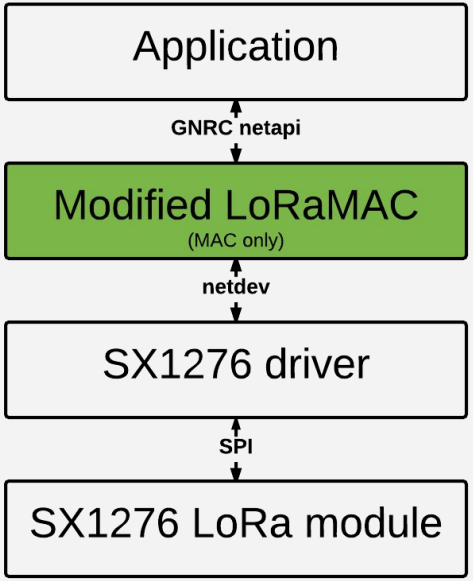


SEMTECH **LORAMAC**

- Reference implementation
  - Class A and C
  - ADR
- Ported just the MAC layer
- Flaws during OTA
  - Some part of the logic runs in ISR context
  - ISR overflow in some boards.

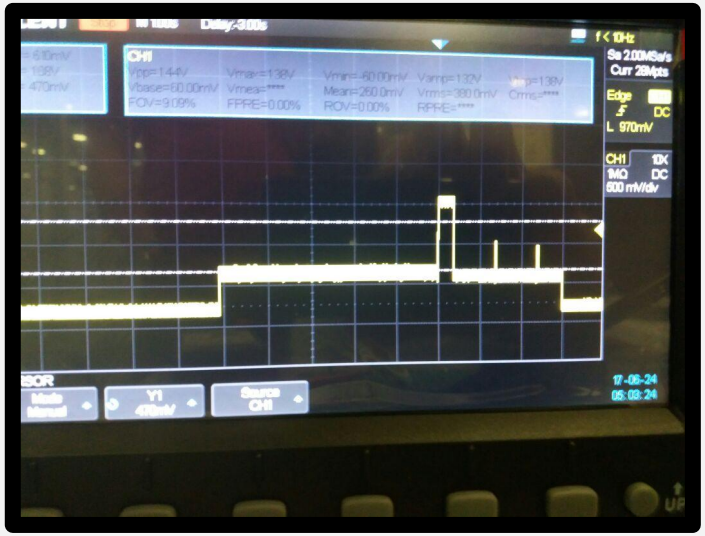


MODIFIED SEMTECH **LORAMAC**



LOW POWER

- Stop mode not implemented for STM32L1 CPU.
  - Used Unwired Devices Low Power Management implementation
- Unable to reach CPU power consumption in stop mode
  - 40 uA while in stop mode
  - We got 0.5 uA in a Nucleo L1 in a further iteration, same software and CPU.



SOME **TESTS**

- Settings
  - Unconfirmed messages
  - 8 bytes payload
  - Sending every 30 seconds
  - 14 dB
- > 99% Packet Reception Rate
- Board ran out of batteries (2300 mAh) after ~ 40 days
  - As expected!

SOME **TESTS**

Node	# Packets	PRR	SNR	RSSI
1	5502	99.3%	11 dB	-26.2 dB
2	5505	99.7%	9.7 dB	-22.2 dB
3	5581	98.8%	10.1 dB	-34.3 dB
4	5476	98.8%	10.4 dB	-31.9 dB
5	5560	99.7%	10.6 dB	-24.4 dB
Avg	**5524**	**99.26%**	**10.36 dB**	**-27.8 dB**

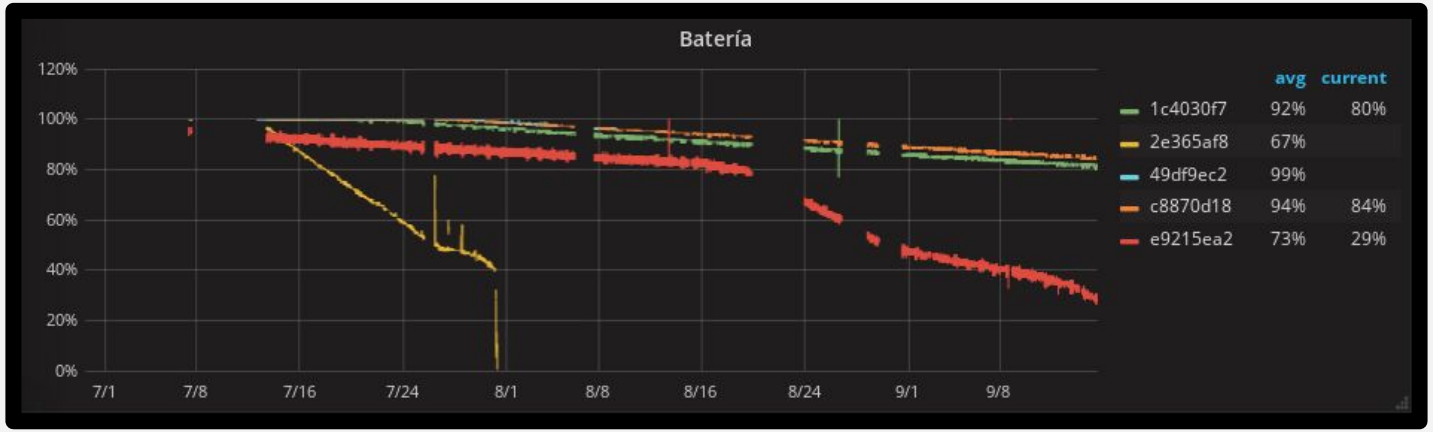
Deployment & Results

DEPLOYMENT: July 7th, 2017

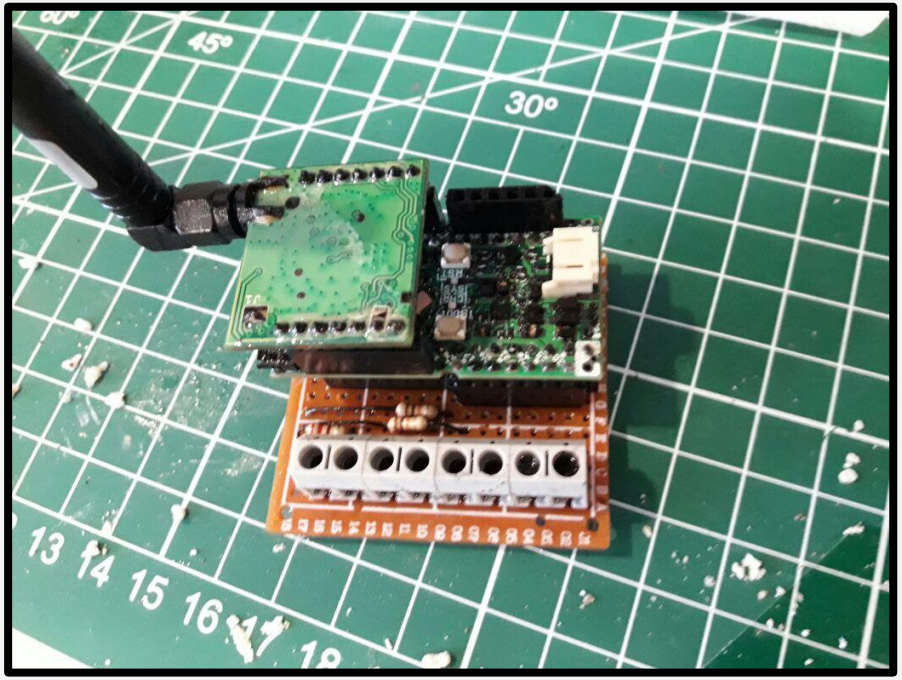
AFTER A **WEEK**

ENDURANCE

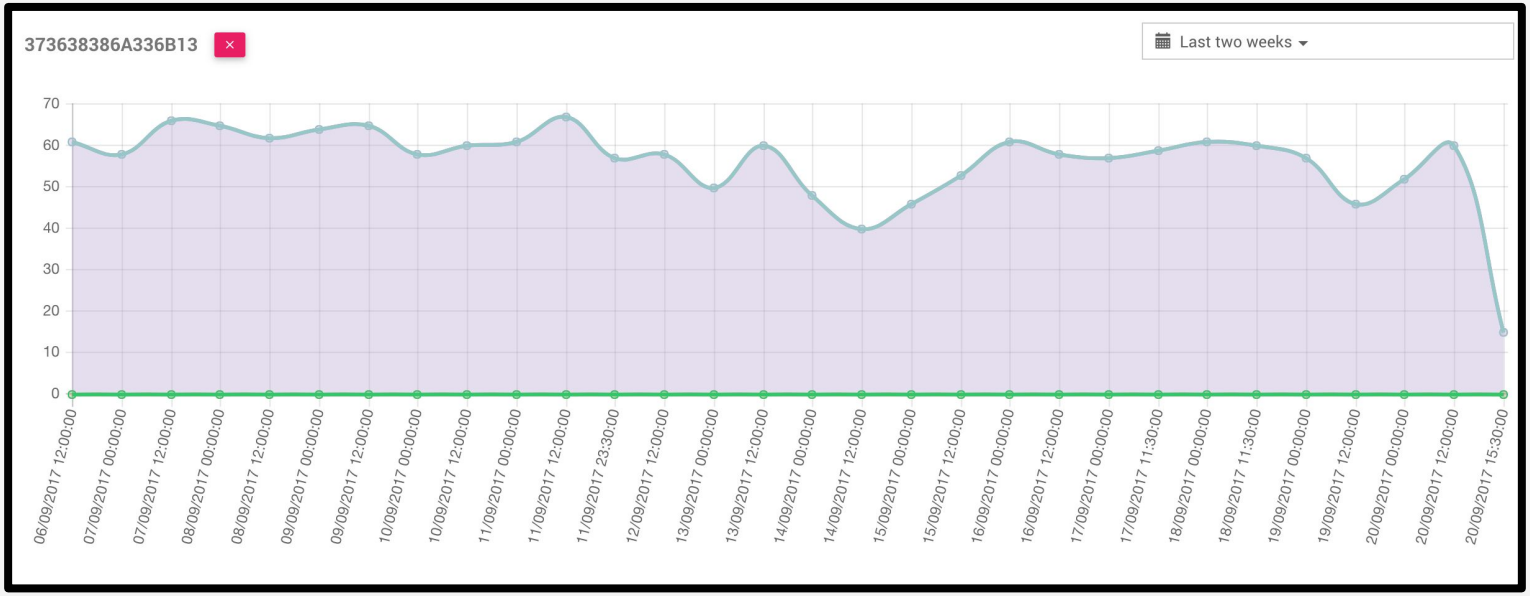
- Nodes were shut down on september 22nd.



SOME DAYS AGO

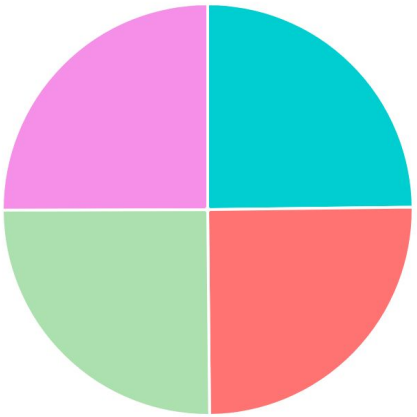


LORAWAN **PERFORMANCE**



LORAWAN **PERFORMANCE**

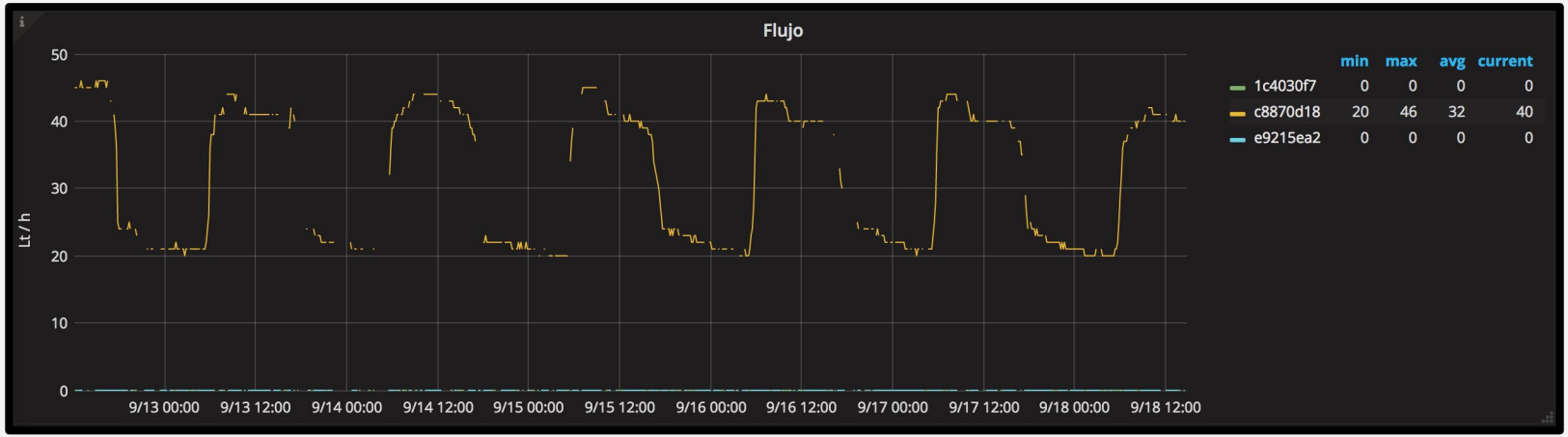
Statistics by device



Packets by datarate

Device EUI	373638386A336B13
Uplink packets	1685
Downlink packets	0
Uplink packets (with payload)	1685
Downlink packets (with payload)	0
PRR	79.9%
RSSI (average)	-115.6 dB
RSSI (last)	-112 dB
SNR (average)	2.0 cB
SNR (last)	1.8 cB

DROP **SENSOR**


Flujo
50
40
30
20
10
0
Lt / h
9/13 00:00
9/13 12:00
9/14 00:00
9/14 12:00
9/15 00:00
9/15 12:00
9/16 00:00
9/16 12:00
9/17 00:00
9/17 12:00
9/18 00:00
9/18 12:00
min max avg current
1c4030f7 0 0 0 0
c8870d18 20 46 32 40
e9215ea2 0 0 0 0

LESSONS LEARNED

- LoRaWAN performance
  - Low Power
  - Range
- Design process is crucial
  - Fail fast
  - Unit test vs Integration test
- Importance of community

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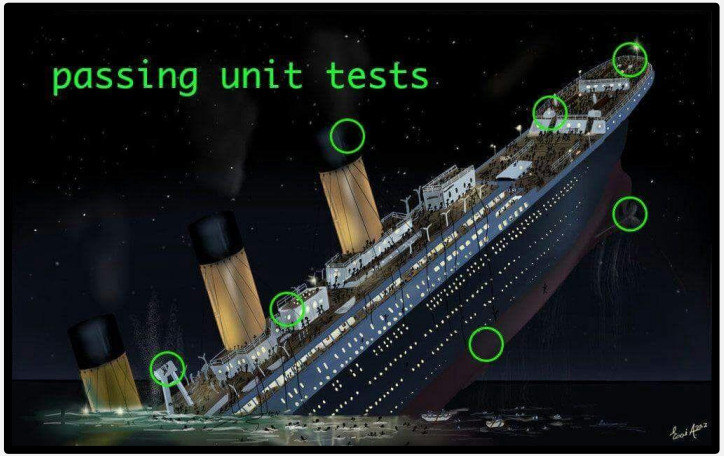

EPILOGUE

- Future of the DropWatcher?
- Let’s integrate LoRaWAN into RIOT!
  - LMIC
  - Semtech LoRaMAC
  - GNRC LoRaWAN stack?

Github Inria-Chile: https://github.com/Inria-Chile/RIOT

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