INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

5ISS Projects

INNOVATIVE SMART SYSTEMS

IoTracking

GPS tracking for boat regattas

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Clovis OUEDRAOGO

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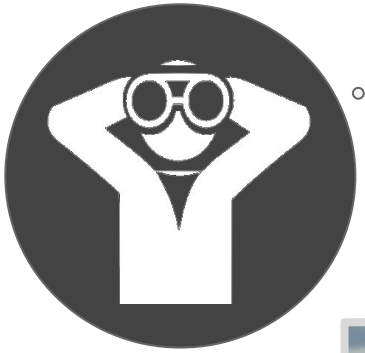
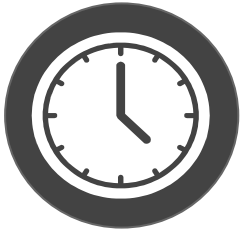
1

The project

How it was born
What its purpose was
Why we chose it

1.1 The problem to be solved





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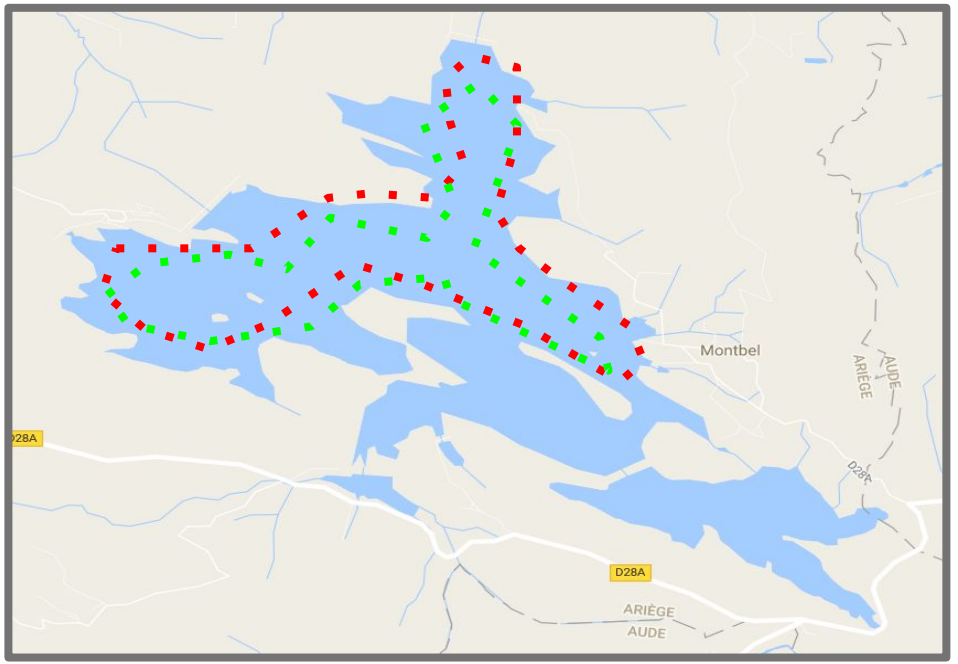
1.2 Our partner

GPS Tracking

For : Léran sailing ship's club (CVRL)

Ariege / Montbel Lake



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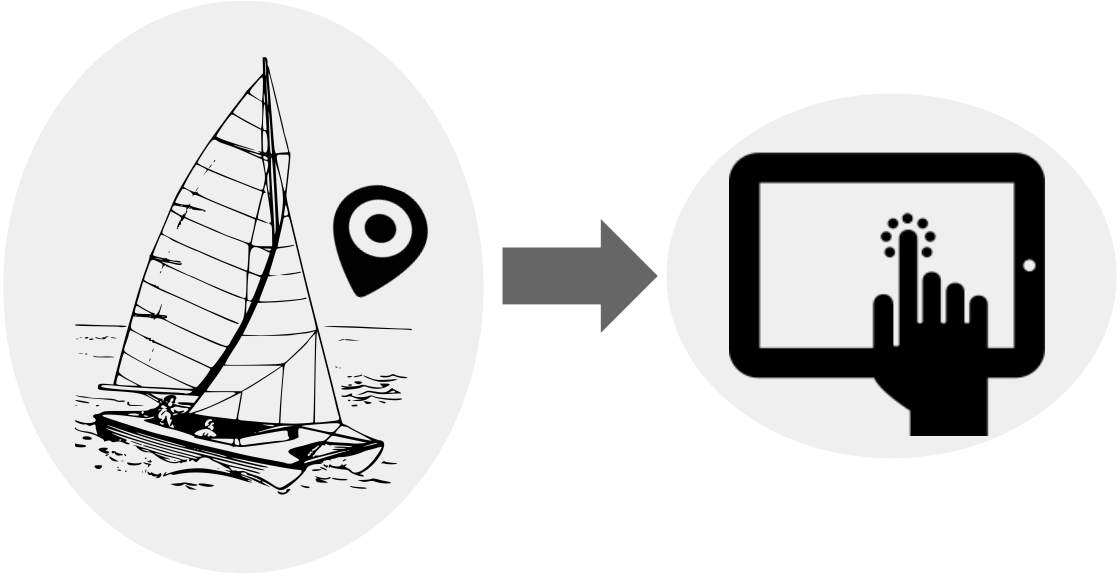
1.3 The demand: GPS boat tracking

Real-time GPS tracking of the sailboats on the lake



Follow the regatta in real time

Review one's performance when the race is finished

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2

Our project management

How we managed our team
What each of us worked on
How we planned our timeline

2.1 Project management method

October | November | December | January

Agile Framework - Scrum
Online software IceScrum

Sprint meeting every week

Planning of tasks for each work session

Task list shared with all group members

Found IceScrum too time consuming to keep up to date

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2.2 Business analysis

Value Propositions	Customer Relationships	Customer Segments
Enhanced experience during events	Technical support after sales	1st step: Low budget sailing club: CVRL
Cheap GPS tracking solution + intuitive user interface	**Channels** Sailing club community in France: FREG	2nd step: Trail enthusiasts

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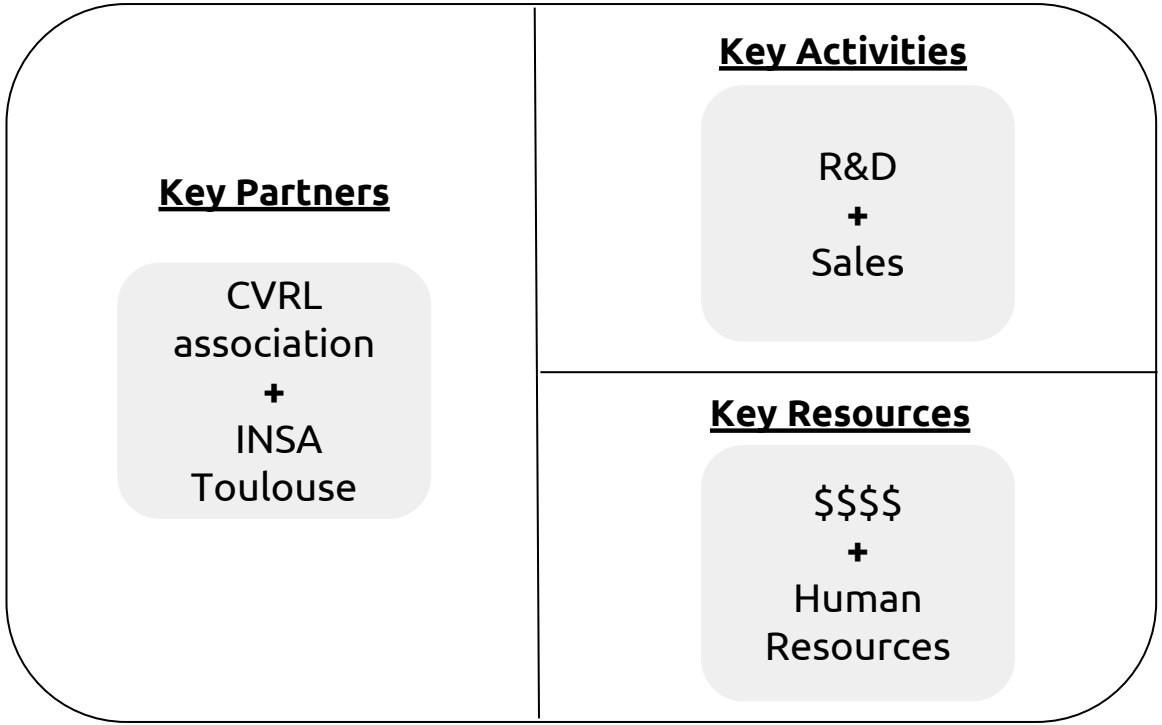
2.2 Business analysis



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3

System requirements

Requirements
Choice of network technology
Network dimensioning

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3.2 System requirements

Scalability
(up to 100 devices)

Network deployment from scratch
(no coverage)

Sealing
(IP66 standard)

Portability of the system
(must be transferable to other lakes)

Low cost

Device autonomy
(must last for at least 10 hours)

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Why LoRa ?

Constraints :

- low power
- low throughput (< 0.3 kbps)
- long range (> 3 kms)
- easily deployable

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Network dimensioning

Initial Goal : **100** devices sending **24** bits every **10** seconds !

- total network workload = 100*24/10 = 240 bps

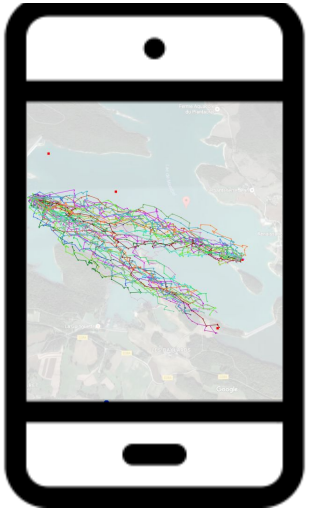
SF choice : **SF 7** (shorter range, shorter time on air)

- time on air : 30 ms

	SF 7 (50 devices)	SF 7 (100 devices)	SF 8 (100 devices)
Duty cycle	0.3%	0.3%	0.6%
Channel load	15%	30%	60%
Collision rate	20%	40%	70%

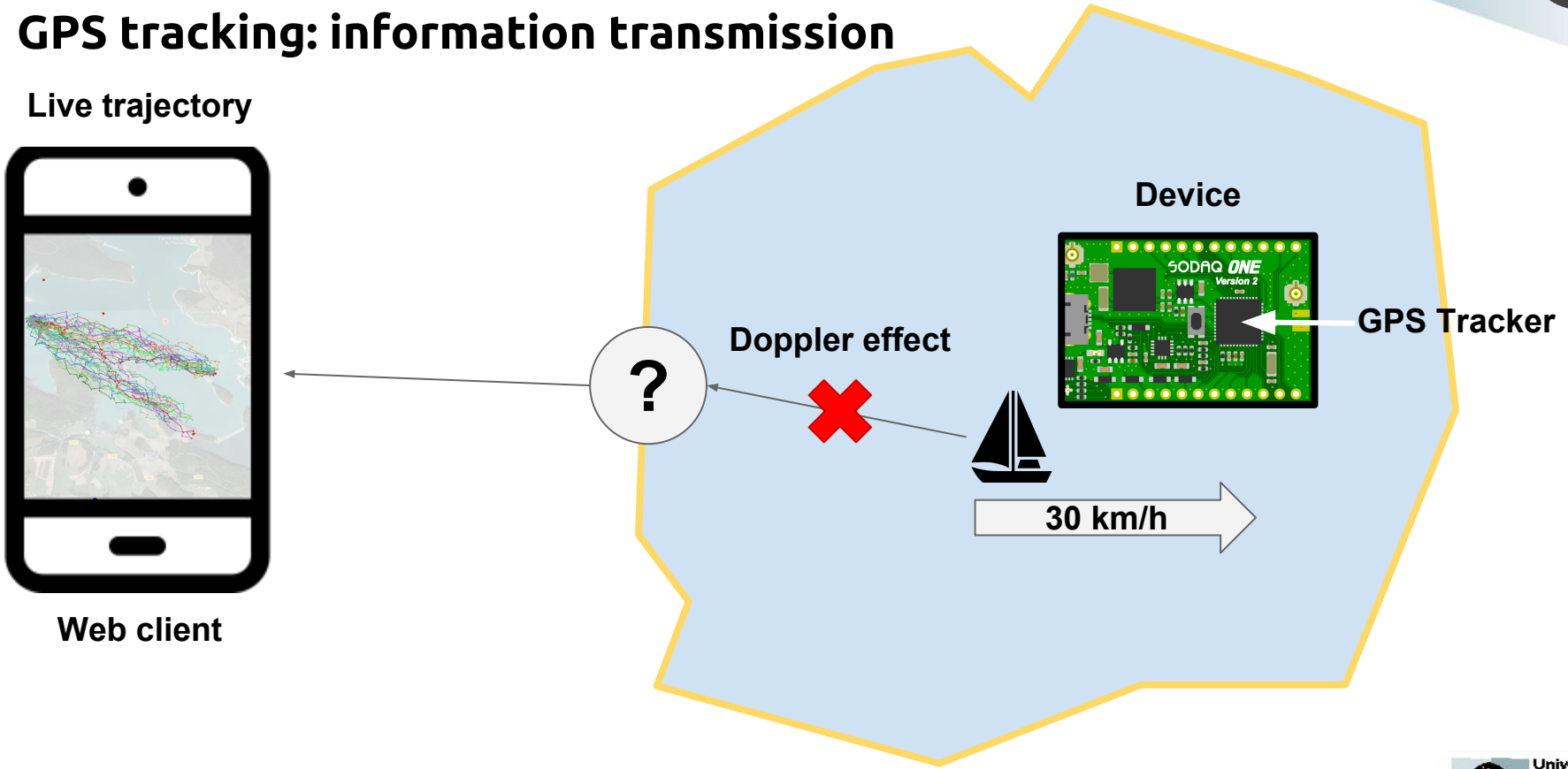
Goal: real-time tracking

Live trajectory



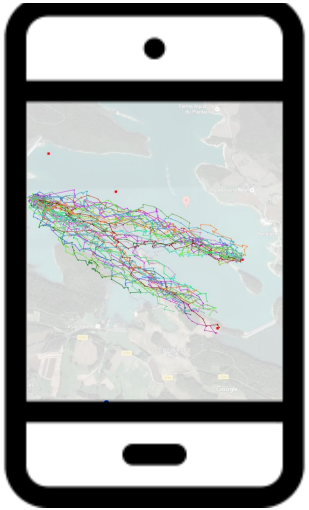
Web client

GPS tracking: information transmission



Introducing the gateways

Live trajectory

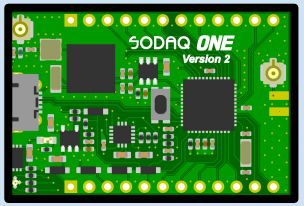


Web client

?

Gateway

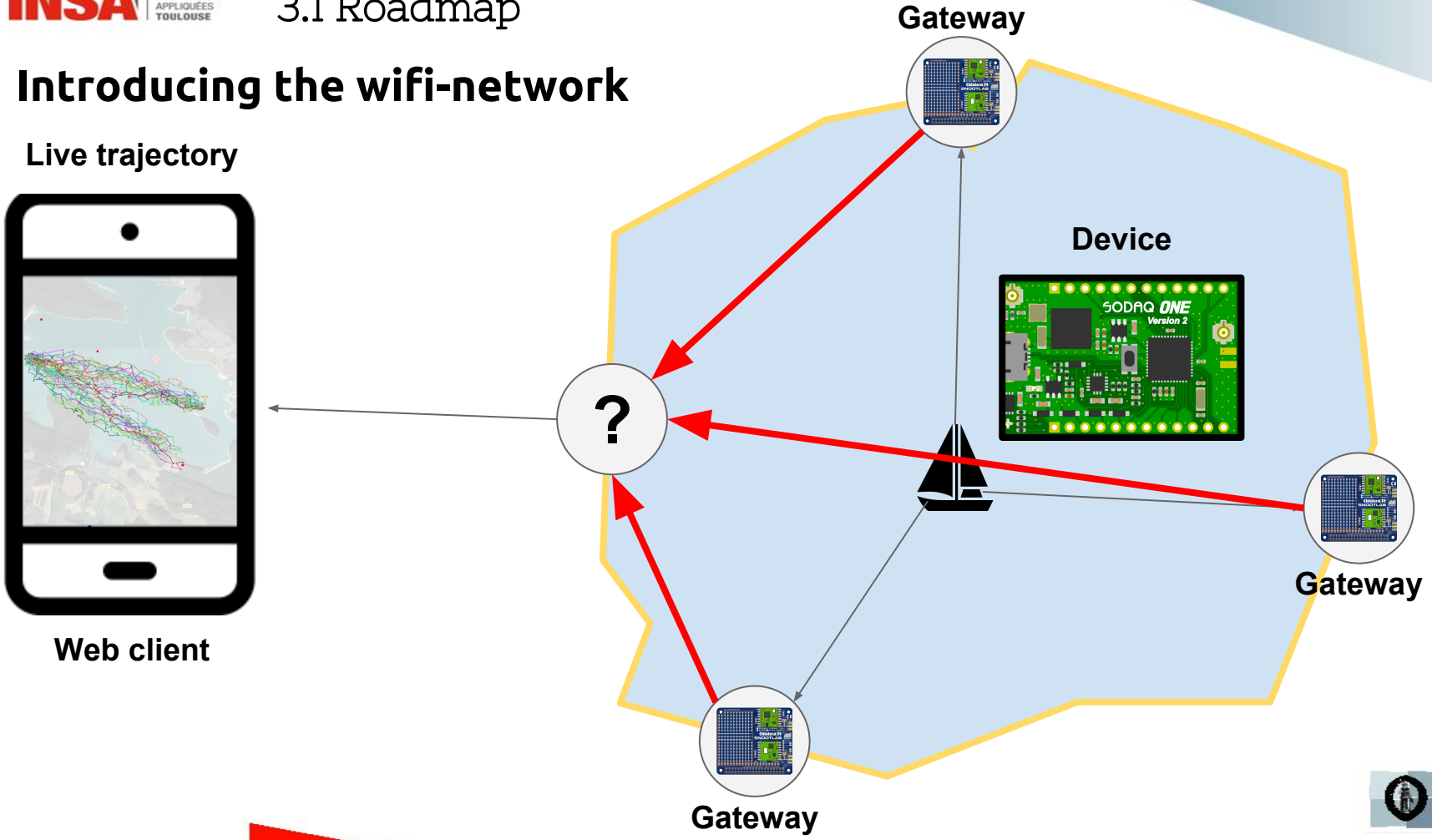
Device



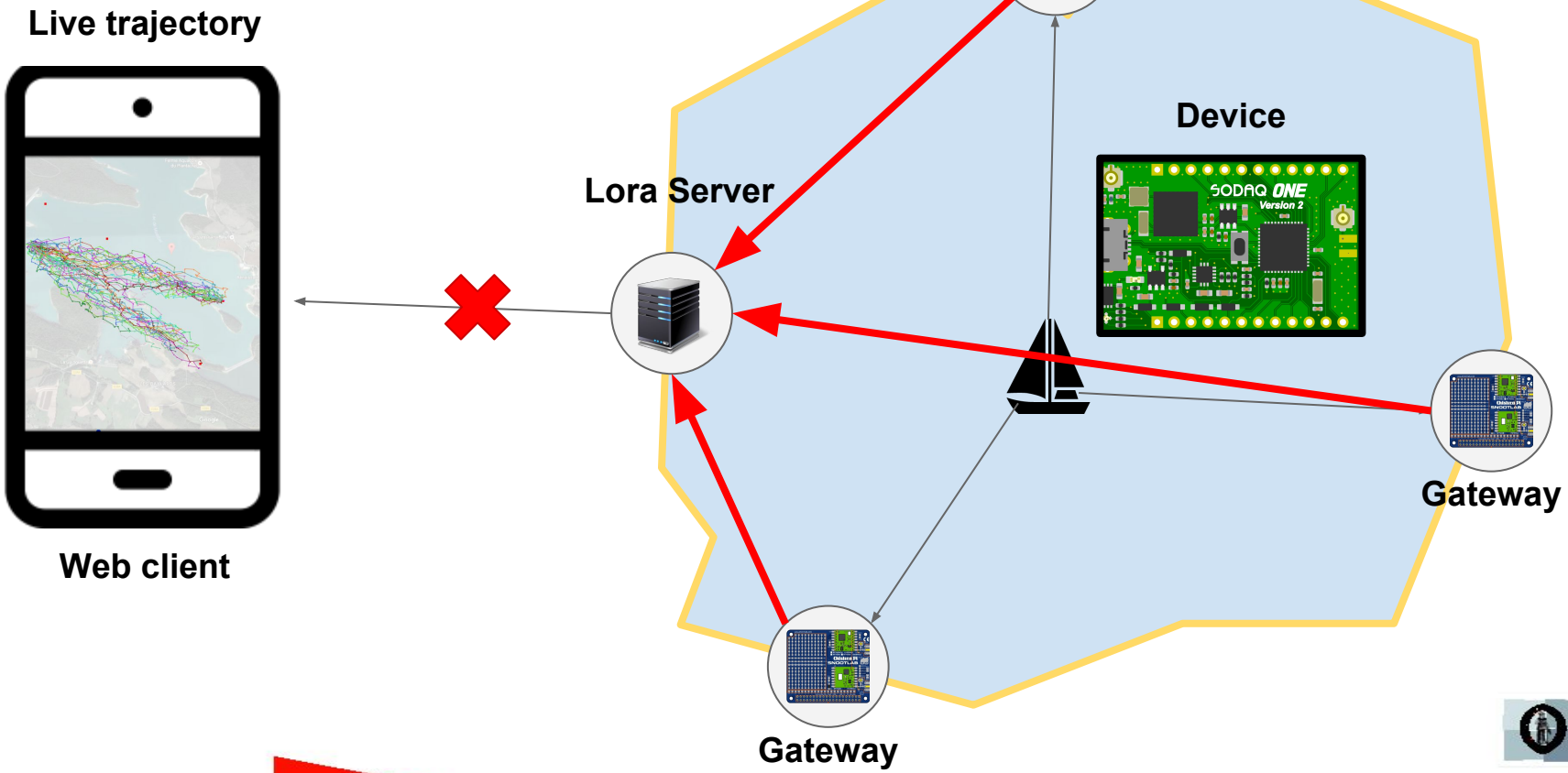
Gateway

Gateway

Introducing the wifi-network



Introducing the lora server



Introducing the web server

Live trajectory

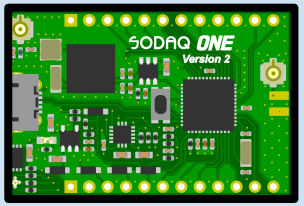
Web client

Web Server

Lora Server

Gateway

Device



Gateway

Gateway

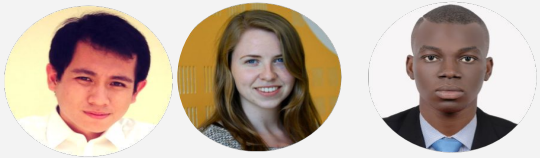
One project, two groups, four aspects

Network/Software

Device

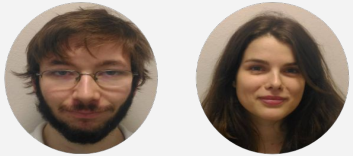
16

Hardware

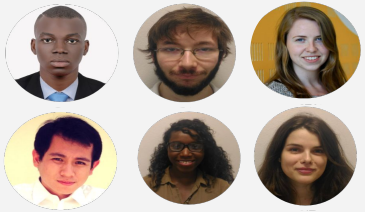


Networking

Software



Management



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5ISS Projects

HARDWARE Part

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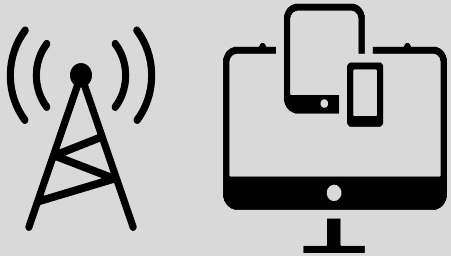
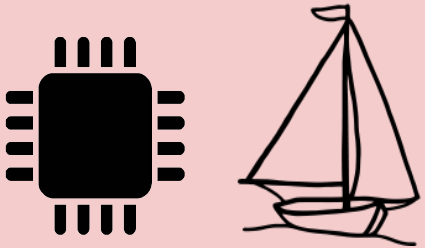
Network/Software



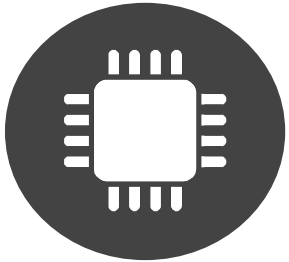
Hardware



4

Technical Solutions

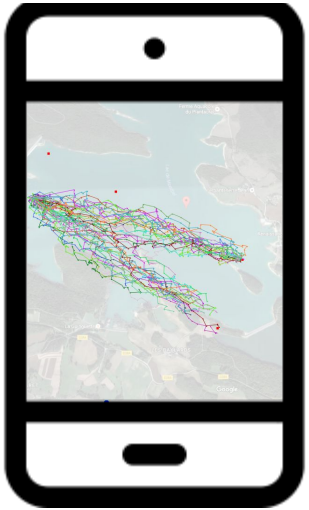
Hardware
Networking



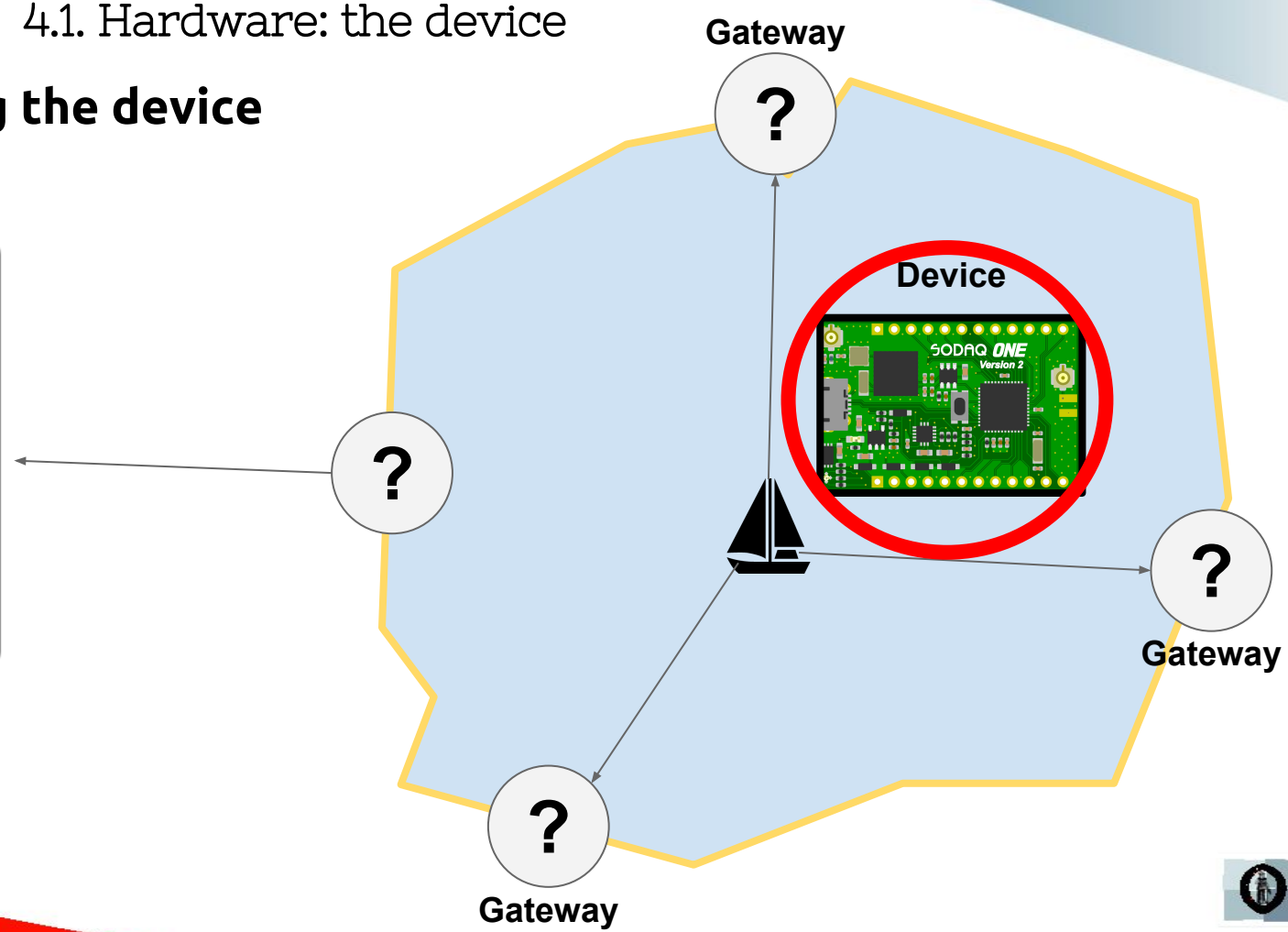
Hardware

Introducing the device

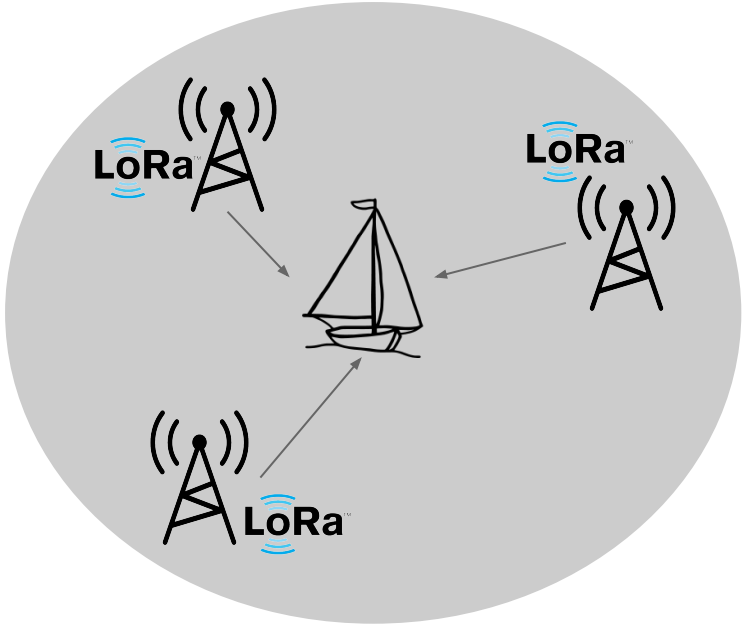
Live trajectory



Web client



4.1 Hardware: Positioning technology



Precision not good enough

GPS

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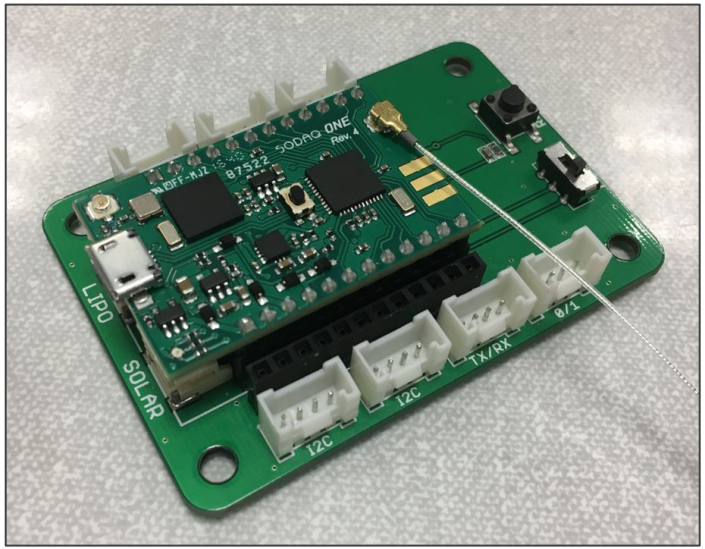
LoRaOne from Sodaq

ATSAMD21G18 - Arduino compatible **Microcontroller**	Use of Arduino libraries
Microchip RN2483 - **LoRa** module	Communication with server
uBlox EVA 7M - **GPS** Module	Geolocalisation
LMS303D - **Accelerometer** & Magnetometer	Generate interrupt
Lithium-ion, 3 Ah, 3.7 V - Rechargeable battery	Autonomy

4.1 Hardware: the device



Get GPS coordinates
Calculate relative GPS coordinates

↓

Measure battery level

↓

Send LoRa packet with GPS coordinates and battery level

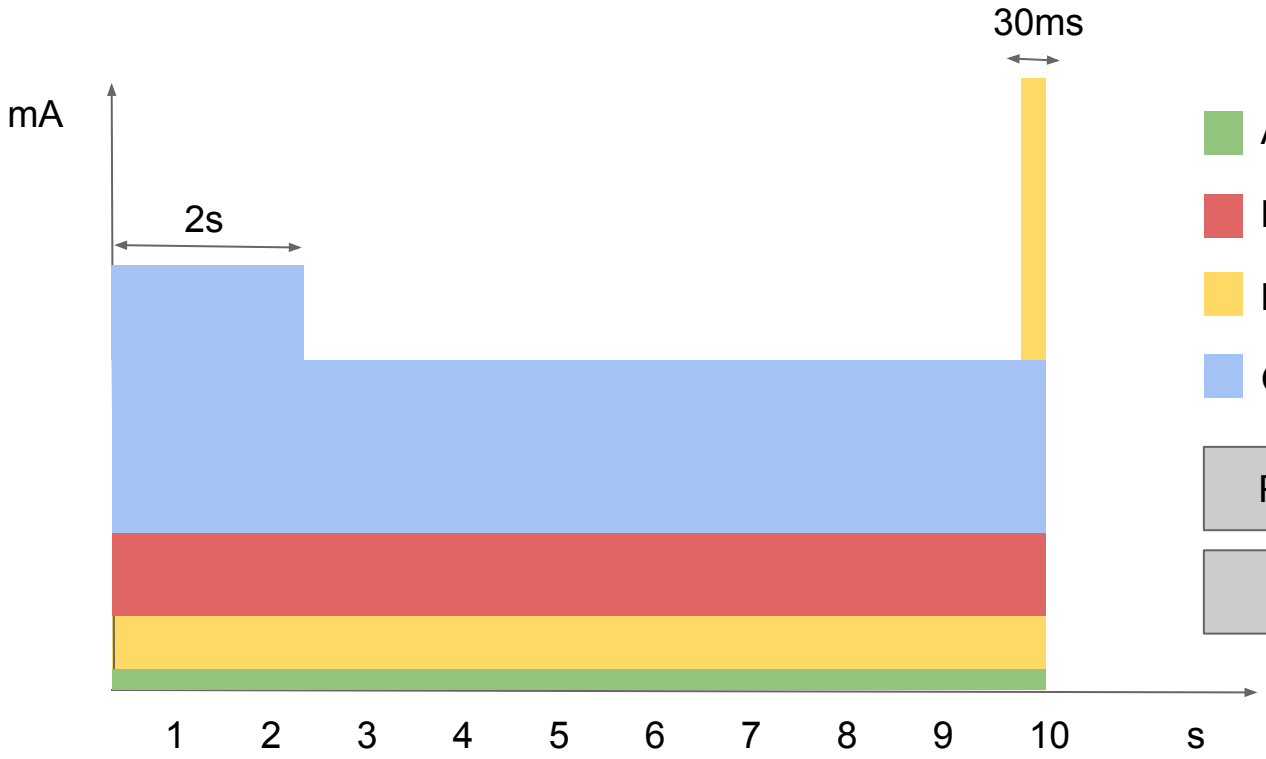
↓

Go to sleep

↓

Wake-up on interrupt (Accelerometer)

4.1 Hardware: the device



- Accelerometer (200uA)
- Microcontroller (3,64mA)
- LoRa module (2,8mA - 38,9mA)
- GPS module (16,5mA - 21mA)

Power consumption: 24,25mA

Autonomy: 124h

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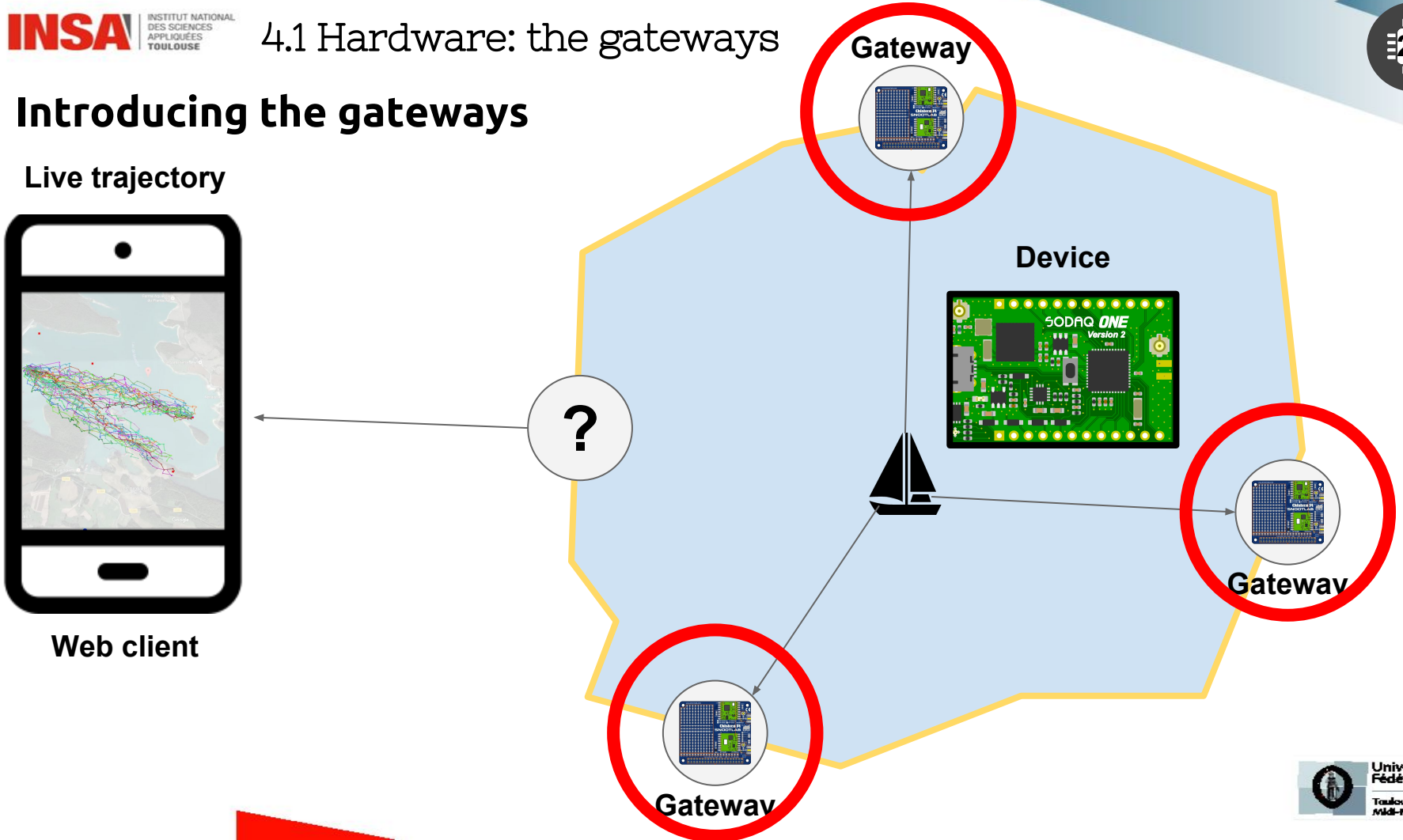
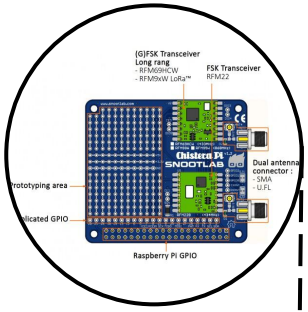
Introducing the gateways



ChisteraPi + Raspberry Pi



+

Chisteria Pi

RFM95W 868 Mhz LoRa compatible Transceiver-
Dual antenna connectors : uFL and SMA-
Prototyping padded area-

Raspberry pi 3

-1.2GHz 64-bit quad-core ARMv8 CPU
-Ethernet port
-40 GPIO pins

(Chistera + Raspberry) Pi

=

Single Channel Gateway

- Listen on configurable frequency and spreading factor
- SF7 to SF12 (6kbit/s to 300 bit/s)
- Send status updates
- Forward to two LoRa servers.

(Chistera + Raspberry) Pi

Our Gateway

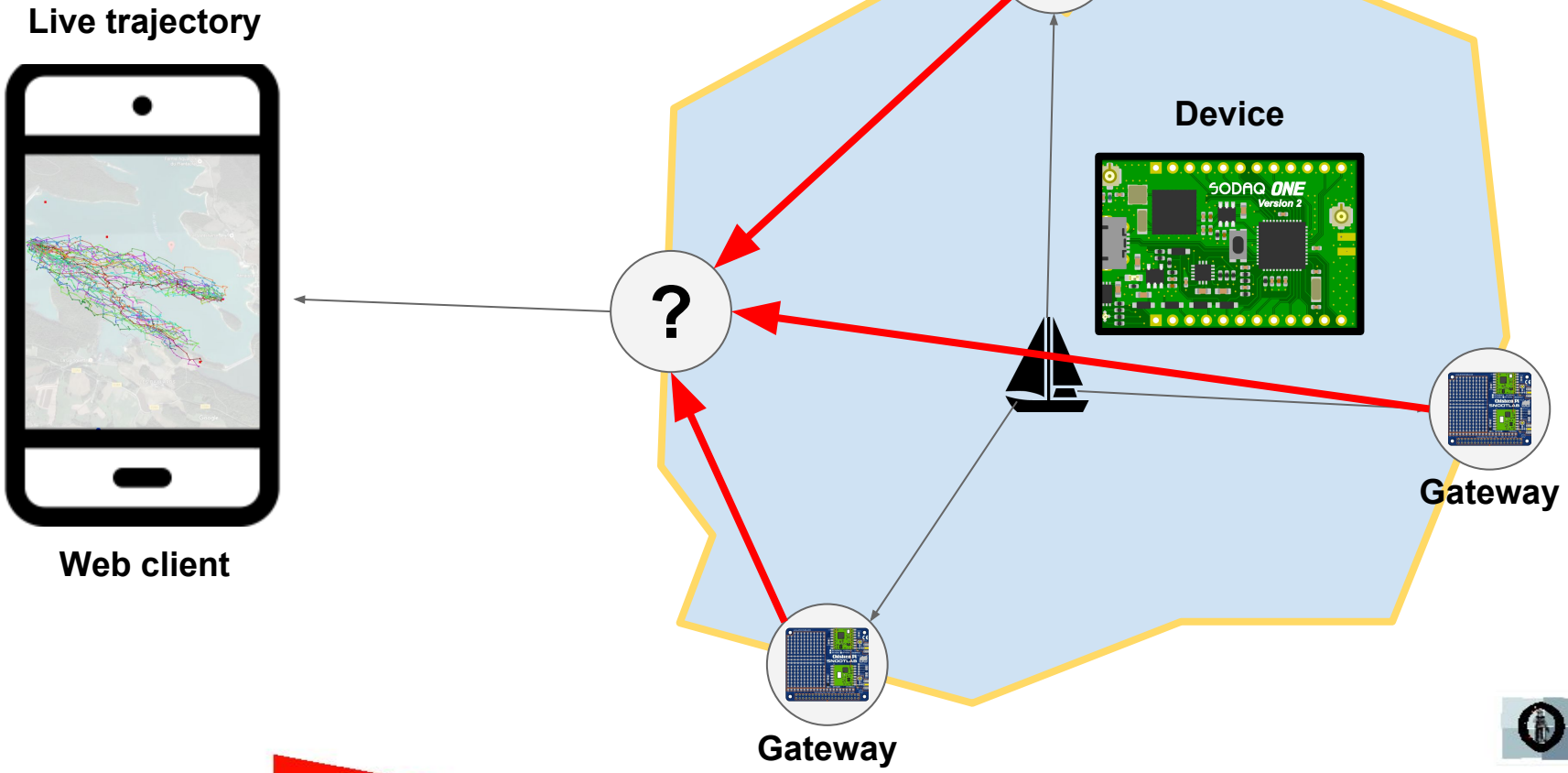
One in three packets is lost

INSA Gateway

One in ten packets is lost

Networking

Introducing the wifi-network



Why Wi-Fi ?

Range : ⇒ 3 km

No power constraints

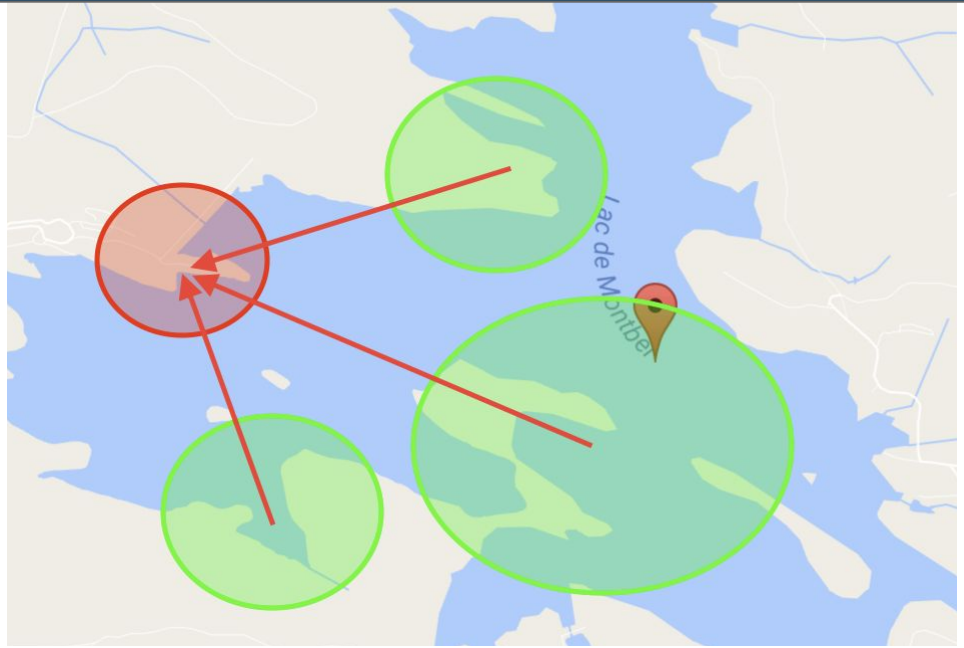
Easy to use

ISM Band used (different frequency than LoRa)

Equipment needed

- 1 omnidirectional antenna
- 3 directional antennas
- 4 modems

Strategic positions for the antennas



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Conclusion

Critic of choices
Conclusion
What we will provide to our partner

5 Critic of choices

Gateway :

- single channel ⇒ unsatisfying performance
- no **TX link** ⇒ OTTA configuration impossible

Device :

- low transmission range in a real life situation

5 Conclusion

Portability of the system
(must be transferable to other lakes)

Device autonomy
(must last for at least 10 hours)

Low cost

Sealing
(IP66 standard)

Small scale equipment

124 hours

Price << Market

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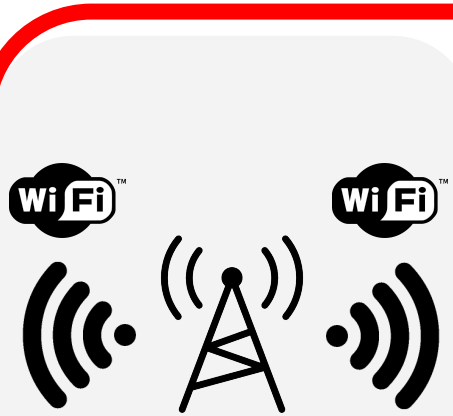
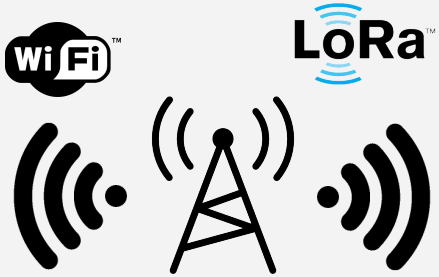
5 What we will provide to the association

Components and documentation



1 omnidirectional
3 bidirectional



3 gateways

2 devices

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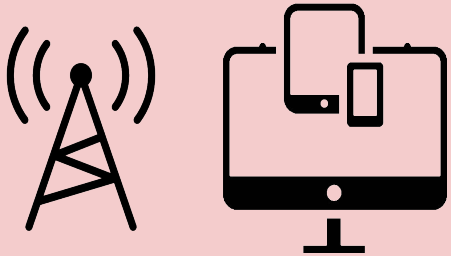
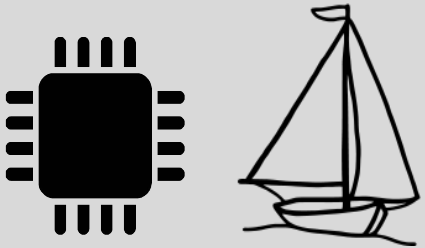
Network/Software



Device



4

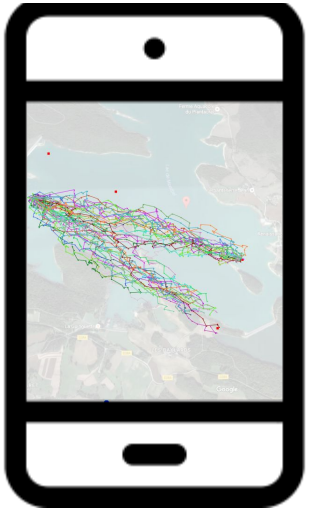
Technical Solutions

Networking
Application

Networking

Introducing LoRa

Live trajectory

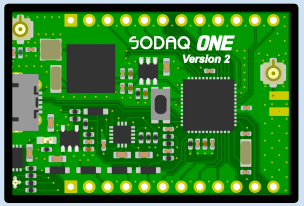


Web client

Lora Server

Gateway

Device

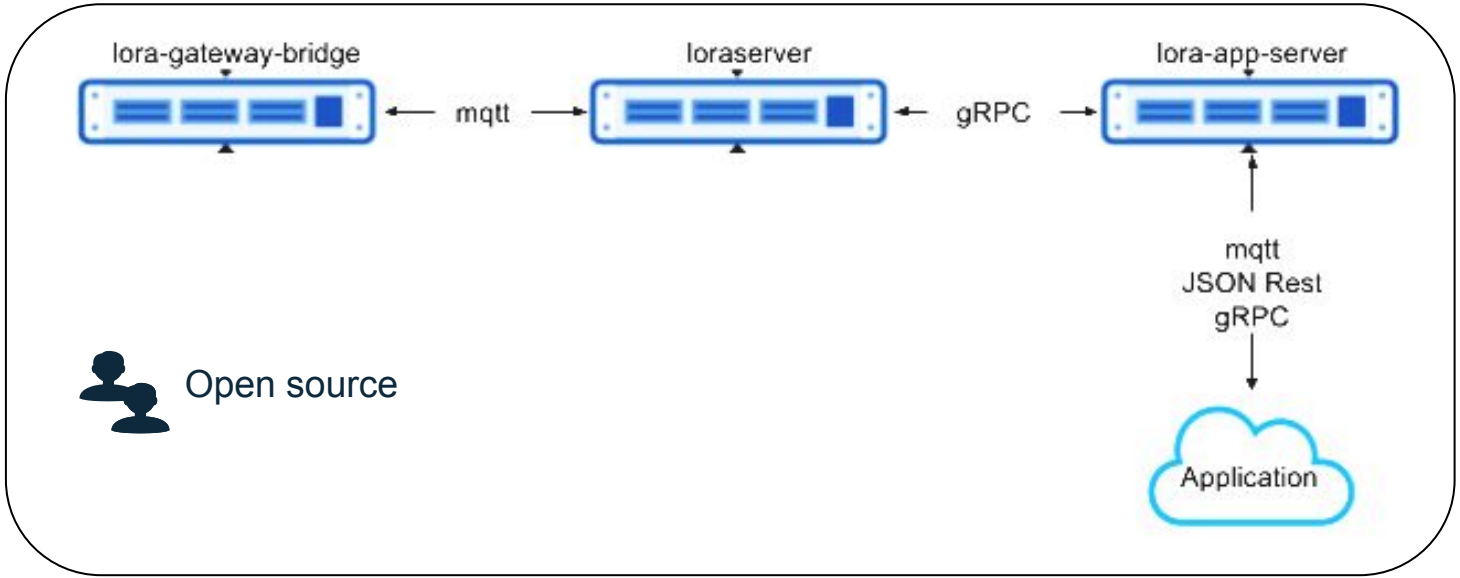


Gateway

Gateway

4.1. Networking: Loreserver components

Global architecture



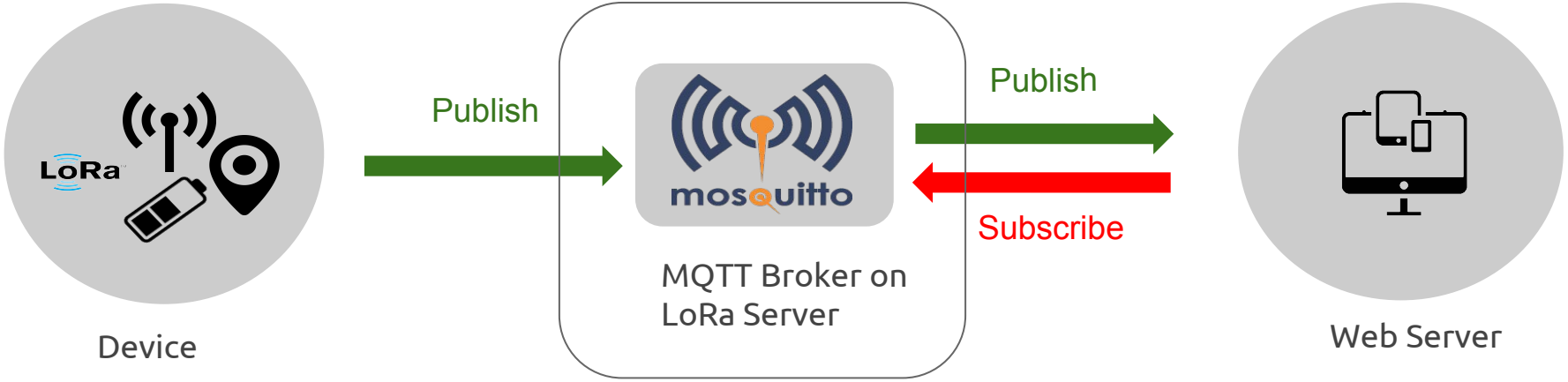
4.1 Networking: LoRa bridge

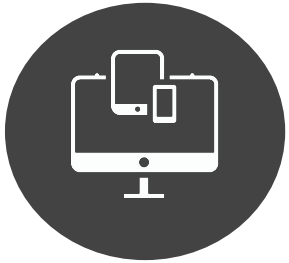
LoRaWAN

UDP packets losses are not handled

LoRa App Server

Publish / Subscribe pattern





Application

4.2 Application: the server

Key technologies

express

mongoDB.

TypeScript

JavaScript for tools

MQTT.js

Service Oriented Architecture

Data-oriented REST API : Auto-generated services

```
public static schema : Schema = new Schema({
    "startDate"         : new properties.DateProperty(),
    "endDate"           : new properties.DateProperty(),
    "races"             : new properties.ArrayProperty(new properties.ObjectProperty<Race>(Race.schema)),
    "location"          : new properties.StringProperty(),
    "name"              : new properties.StringProperty()
})
```

```
http://server.xyz/api/regatas/
GET         /{id}
GET         /
DELETE      /
POST        /
PUT         /
```


```
{
    "startDate": 1472797167854,
    "endDate": 1472800767854,
    "concurrents": [
      {
        "boatIdentifier": "cdb1c2be-defa-495a-9606-f29f66b1fd6a",
        "user": "587ab1f447a7ee51ce4b5780",
        "skipperName": "Skipper_0",
        "device": "587ab1f447a7ee51ce4b576c"
      }
    ],
    "map": "587ab1f447a7ee51ce4b5794",
    "data": "587ab1f547a7ee51ce4b5795",
    "buoys": [
      {
        "x": 635,
        "y": 432
      }
    ],
    "name": "Race_0"
  }
}
```

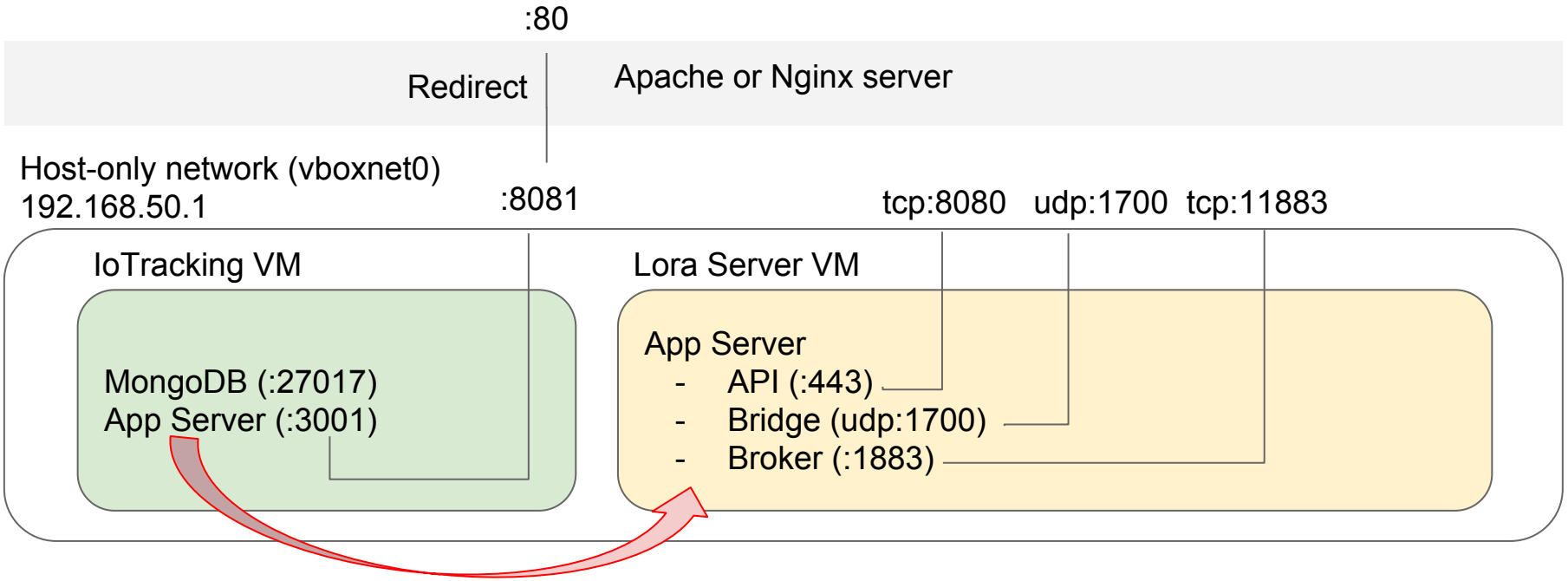
4.2 Application: the server

Keywords :

FLEXIBLE and EASY

Constraints :

- Only one physical machine with **limited resources** (no cloud)
- Deployment process must be **easy**.



Josué ALVAREZ Axel CHAUVIN Aminata DIOP Cécile DUTHOIT

4.2 Application: the Android client

Collecting buoys GPS coordinates

Write

Local file

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4.2 Application: the Android client

Exporting a collection

REST

GET(Regattas, Races)

PUT(Collection)

App Server

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4.2 Application: the web client

Implementation

Bootstrap

Services-and-components-oriented

Maintainable

Accesses

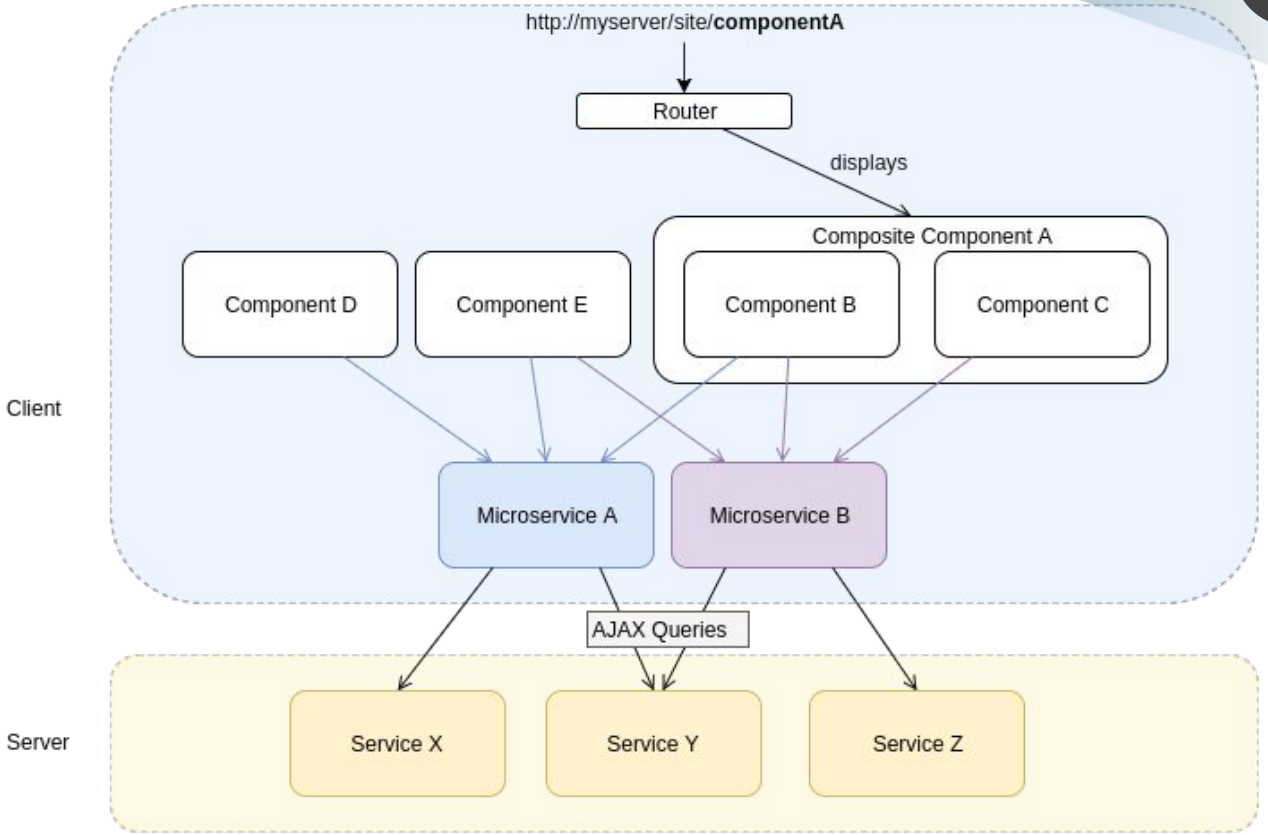
Anonymous: *people in the audience* only accesses to the upcoming regattas and the real-time regatta

Member: *member of the association* can also access its data

Staff: *staff of the association* can also proceed to any editing

4.2 Application: the web client

Services And Components



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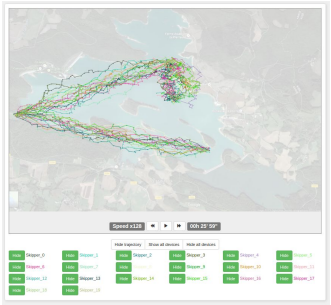
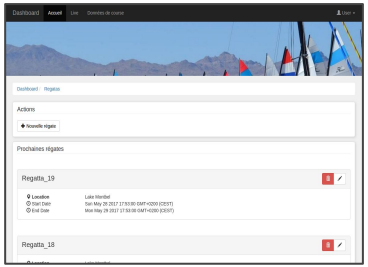
4.2 Application: the web client

Follow in real time a regatta (if there is one)





Display all regattas

See personal positions about the regattas a member participated in

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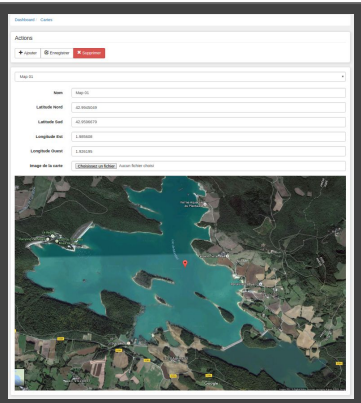
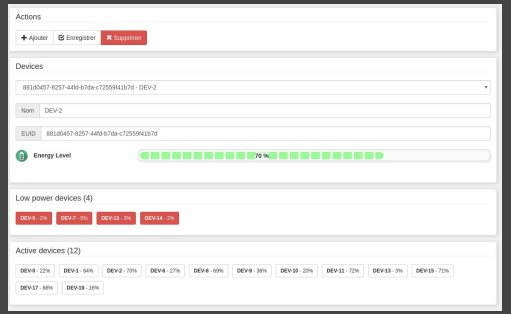
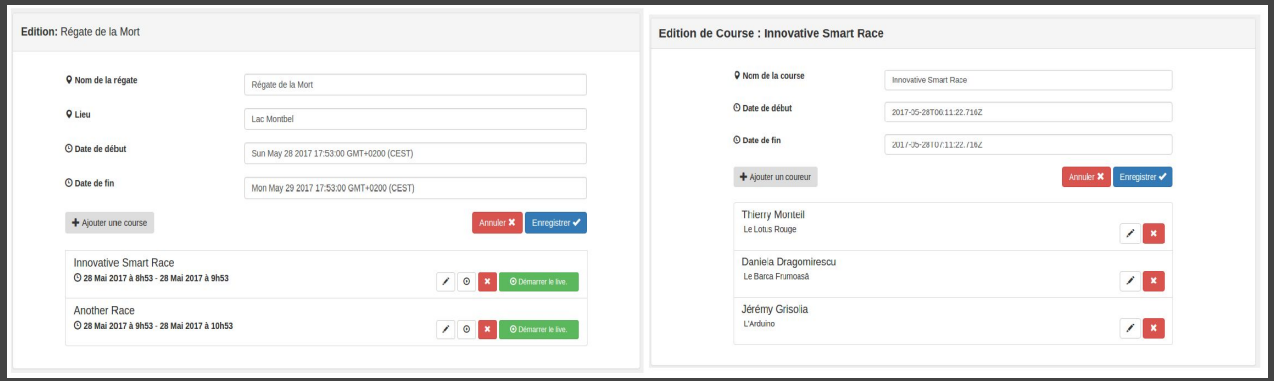
4.2 Application: the web client



Edit race maps

Edit devices





Edit regattas

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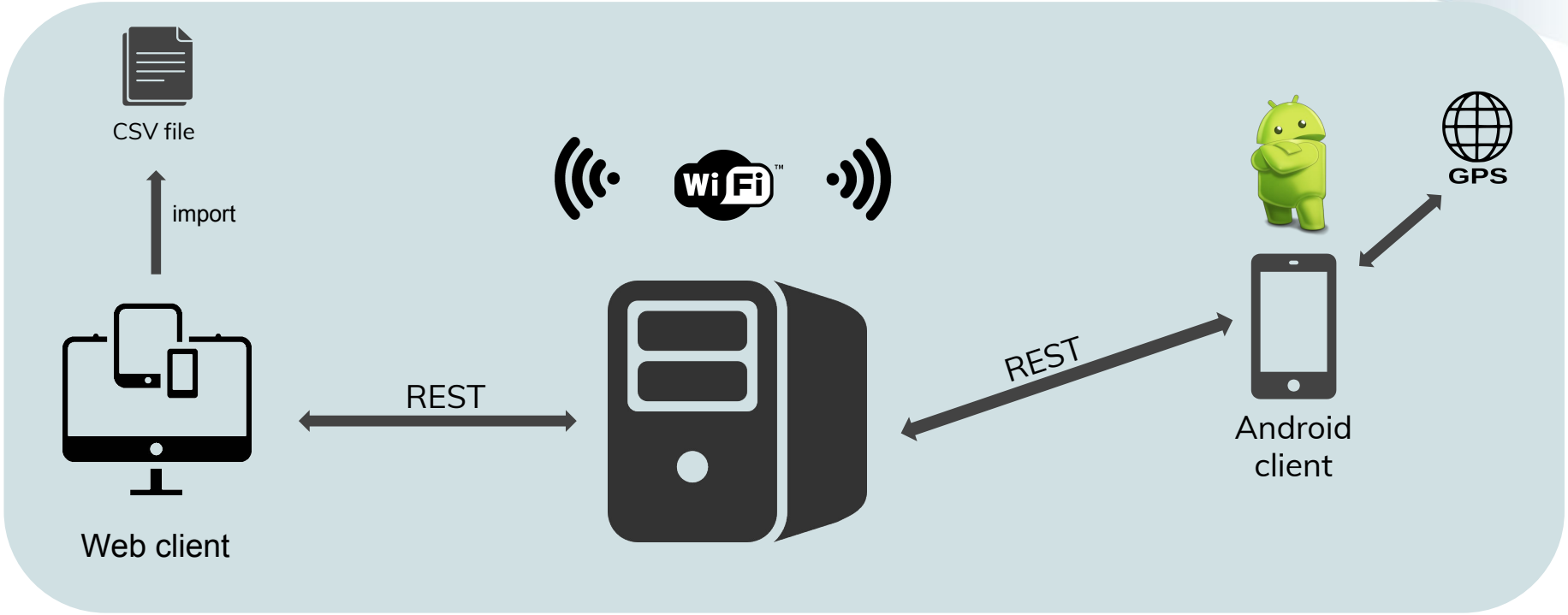
4.2 Application: global overview



5

Conclusion

Critic of choices
Conclusion
What we will provide to our partner

5 Critic of choices

Server :

- MongoDB doesn’t ensure data integrity.

System :

- Not much security implemented

5 Conclusion

Network deployment from scratch (no coverage)

Scalability (up to 100 devices)

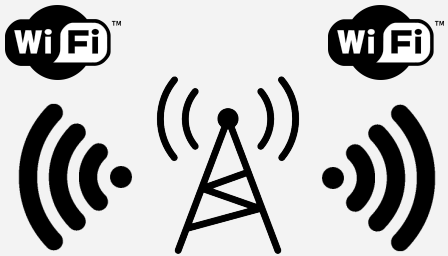
Portability of the system (must be transferable to other lakes)

Deployment	Use	Takeover
2 servers + 1 database 2 VM 2 clients	Easy-to-use	Clean development To enable takeover by another team
Easily deployable		

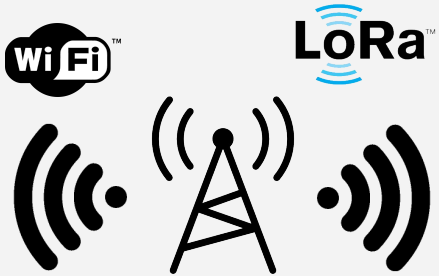
5 Conclusion

What we will provide to the association

Components and documentation



1 omnidirectional
3 bidirectional



3 gateways

X devices

6

Proof of concept

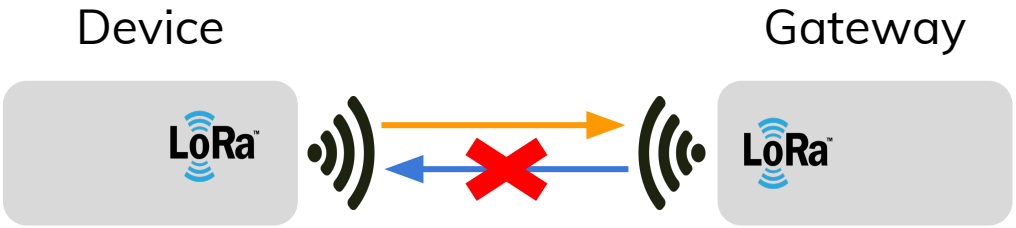
Results

Challenges and how we overcame them

6 Proof of concept

Problem : The gateway has a poor performance and don't downstream messages (tx).

Solution : The device is activated without acknowledgment



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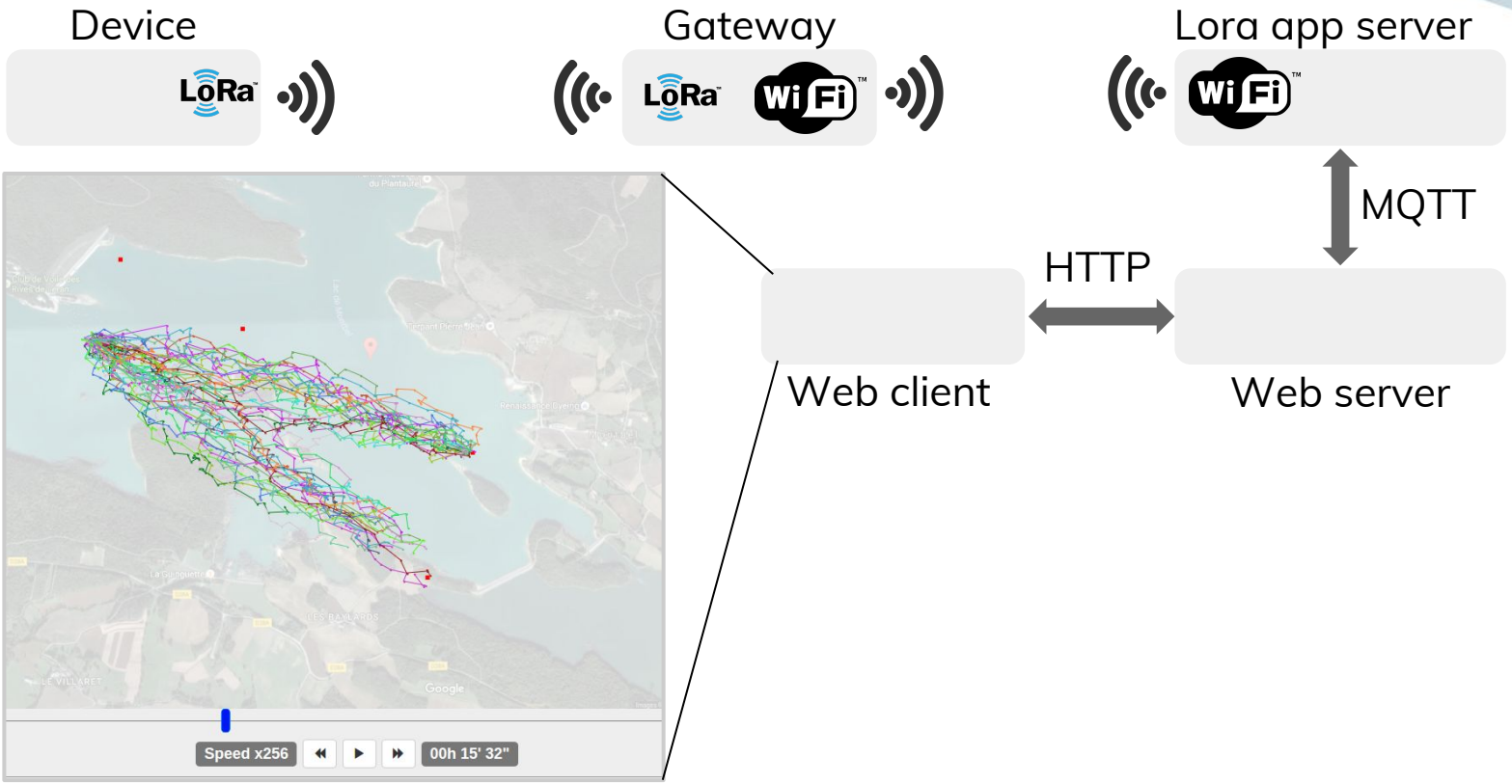
6 Proof of concept



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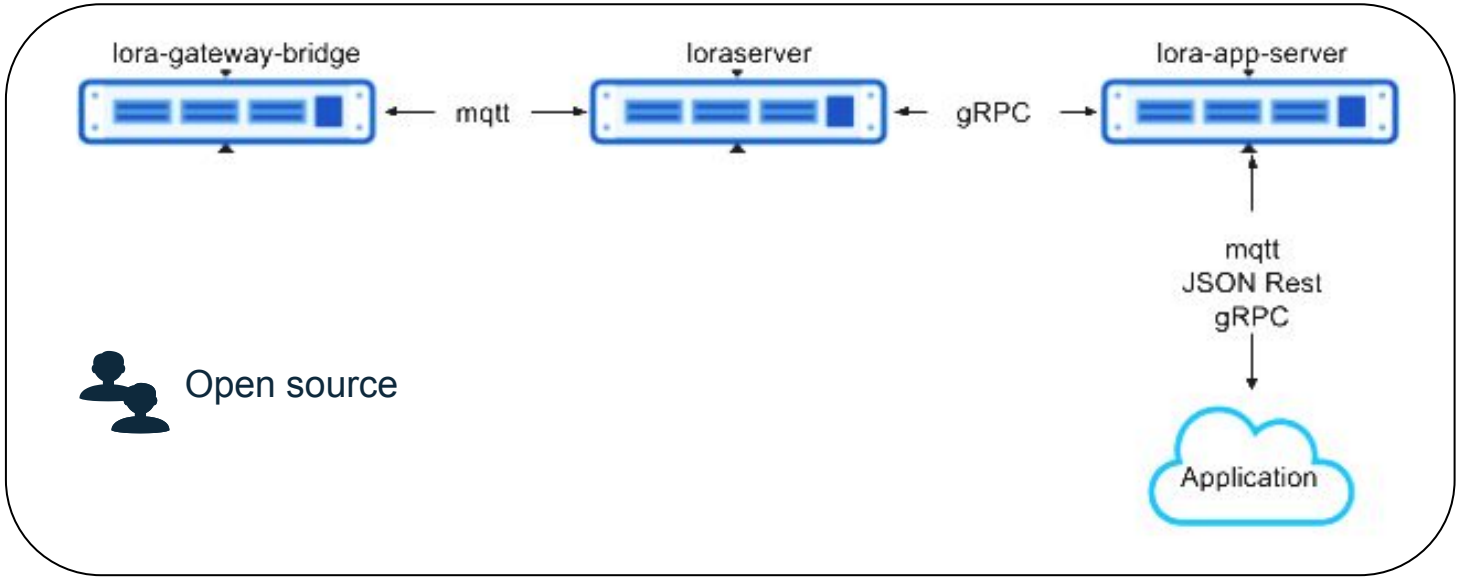
Thanks!

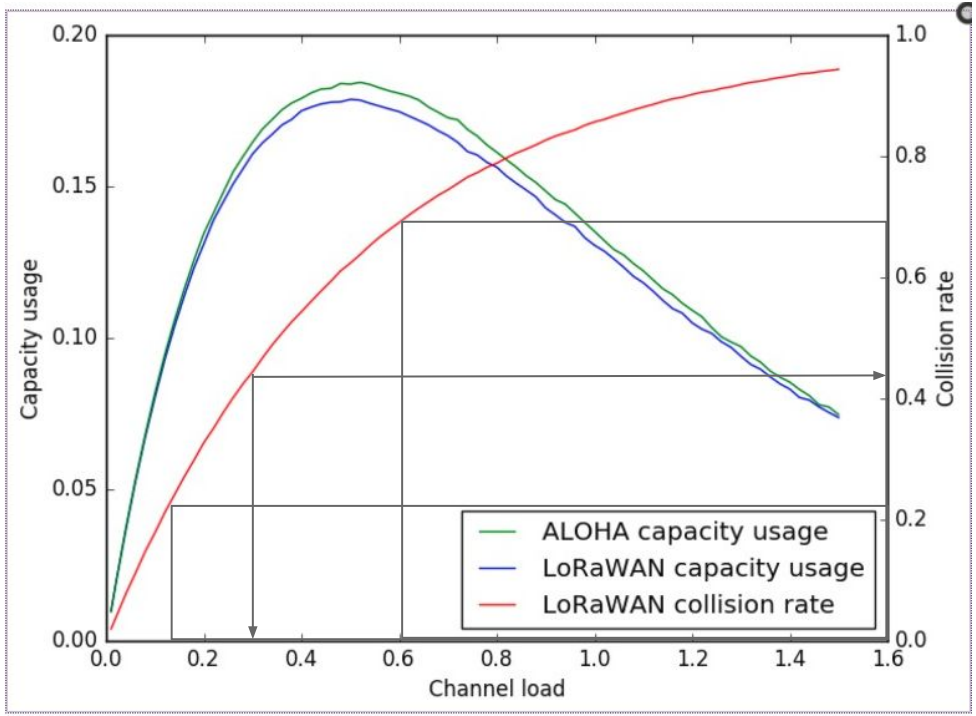
Any questions?

Assets: Networking: The LoRaServer components

Global architecture



Network dimensioning



A Study of LoRa: Long Range & Low Power Networks for the Internet of Things

Aloÿs Augustin, Jiazi Yi, Thomas Clausen, William Mark Townsley

Sensors (Basel) 2016 Sep; 16(9): 1466. Published online 2016 Sep 9. doi: 10.3390/s16091466

Assets: application code metrics

9463 lines

	Client	Server	Total
Commits	64	51	115
Additions	9949	4283	14232
Deletions	4659	110	4769
Total	5290	4173	9463