Machine Learning in IoT

Olivier Isson

Data Science

Contents

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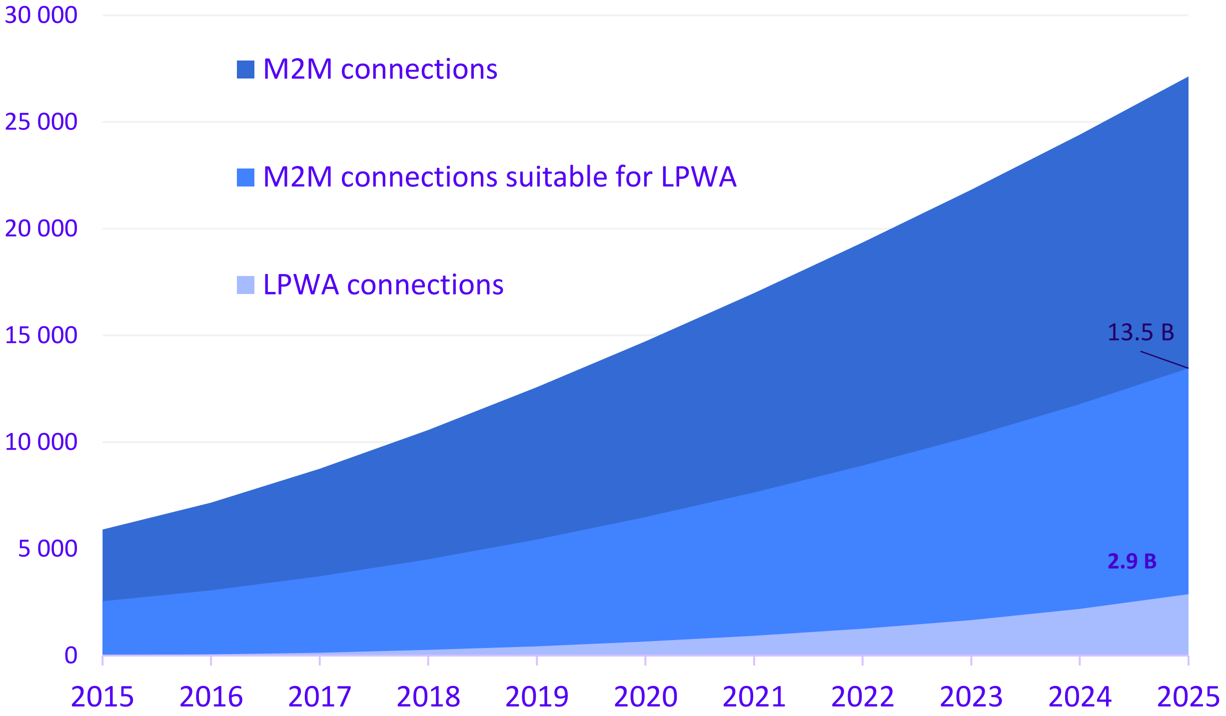
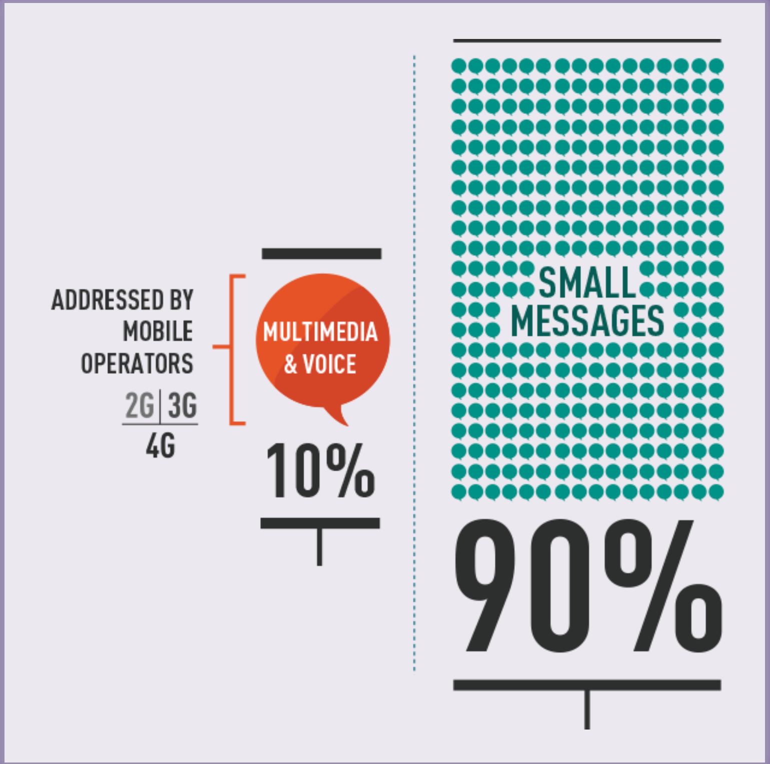
IoT - LPWAN

IoT market size worldwide



Source: Machina Research

The Internet of Things needs its Twitter!



IoT applications need

- ✓ small messages
- ✓ low cost
- ✓ low battery

2G, 3G and 4G are not optimized for IoT

Small bandwidth is optimized for small messages

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Small messages…

- ✓ **6 bytes**: GPS coordinates

  Location report with below 3m precision (GPS technical accuracy is above 3m)

- ✓ **2 bytes**: temperature reporting

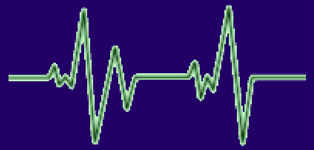
  Lab thermometer with -100°/+200° range, 0.004° precision

- ✓ **1 byte**: speed reporting

  Speed Radar up to 255km/h

- ✓ **1/8 byte**: object state reporting

  Switch report like set in day/night, hot/cold, on/off



- ✓ **0 byte**: heartbeat

  Object is in working state, battery is OK….

- ✓ **0 byte**: Request for duplex operation

  Do you have some information for me?

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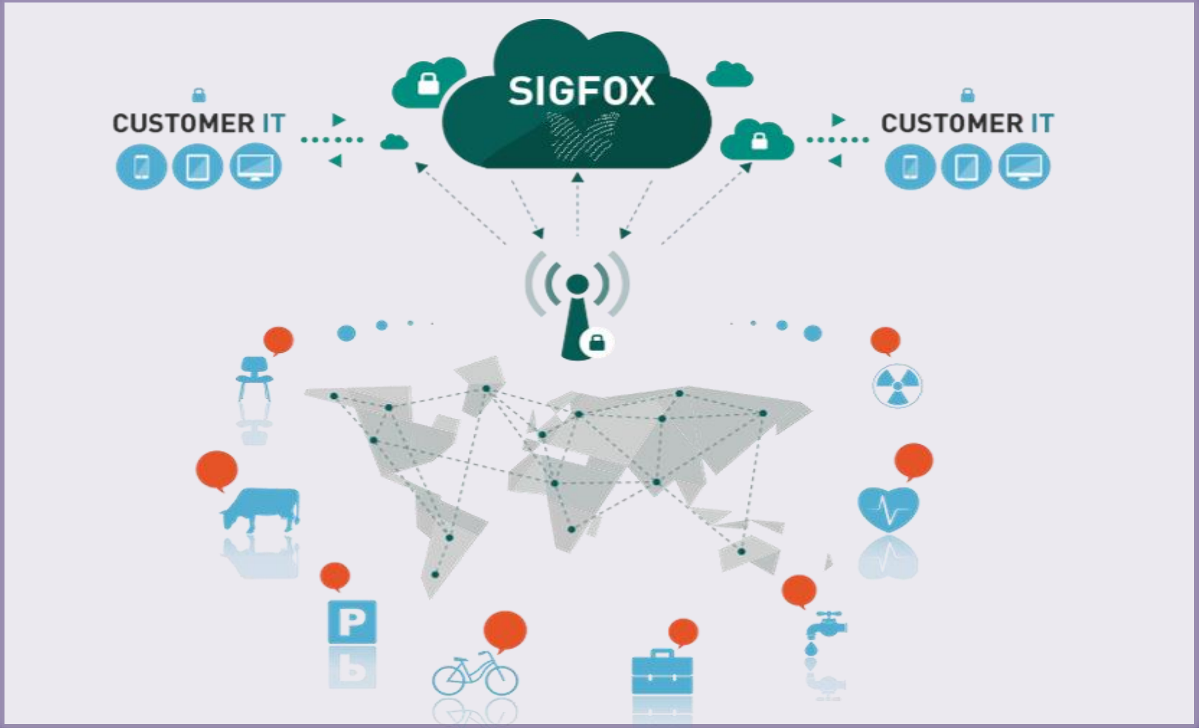
Low Power Wide Area Network

Ultra low power

Ultra long range

Energy efficient

Cost effective



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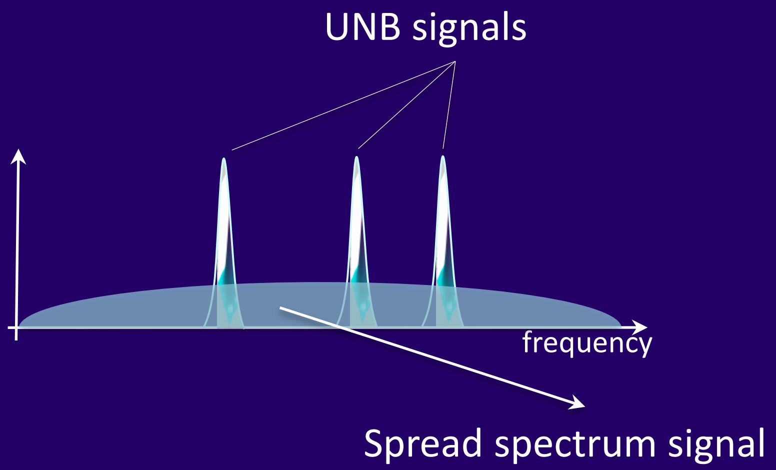
So, how is it possible?

Ultra **N**arrow **B**and signal

100-600 Hz per message

Space & **F**requency & **T**ime diversity

- ✓ High noise resilience
- ✓ Very low energy
- ✓ Long range capabilities



Use of free ISM band (868 MHz in Europe)

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So, how is it possible?

Very **Efficient** protocol

- ✓ Low redundancy to transfer a message
- ✓ No negotiation
- ✓ No Handover
- ✓ Bi-directional

12 bytes / message
Up to **140 messages** / day

A device can work up to **20 years** off two AA batteries

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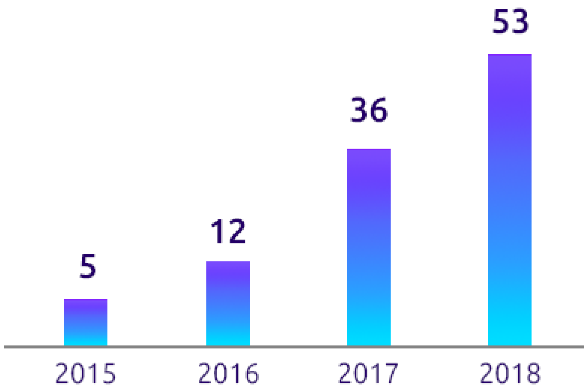
Today present in 53 countries & regions



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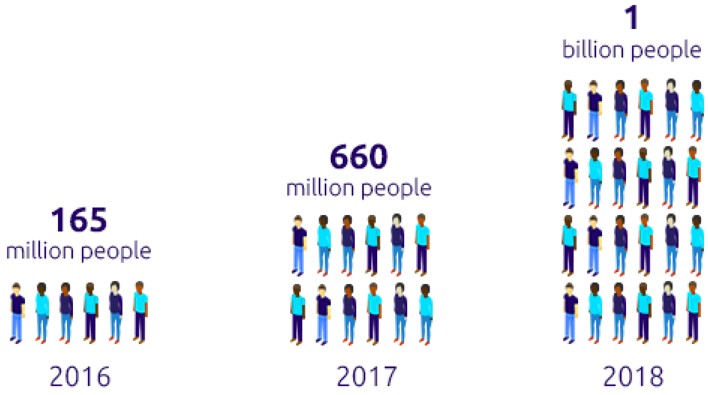
Currently covering 1 Billion people

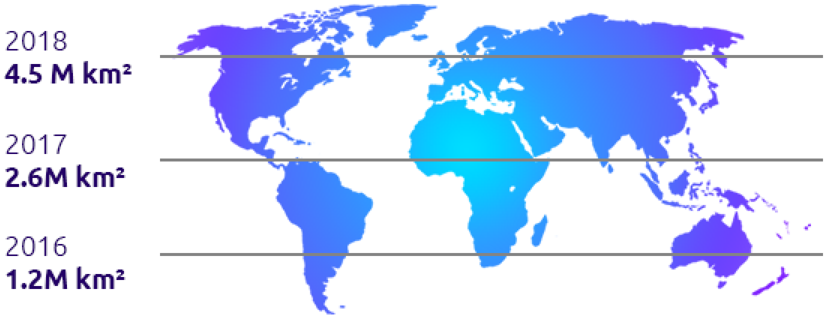


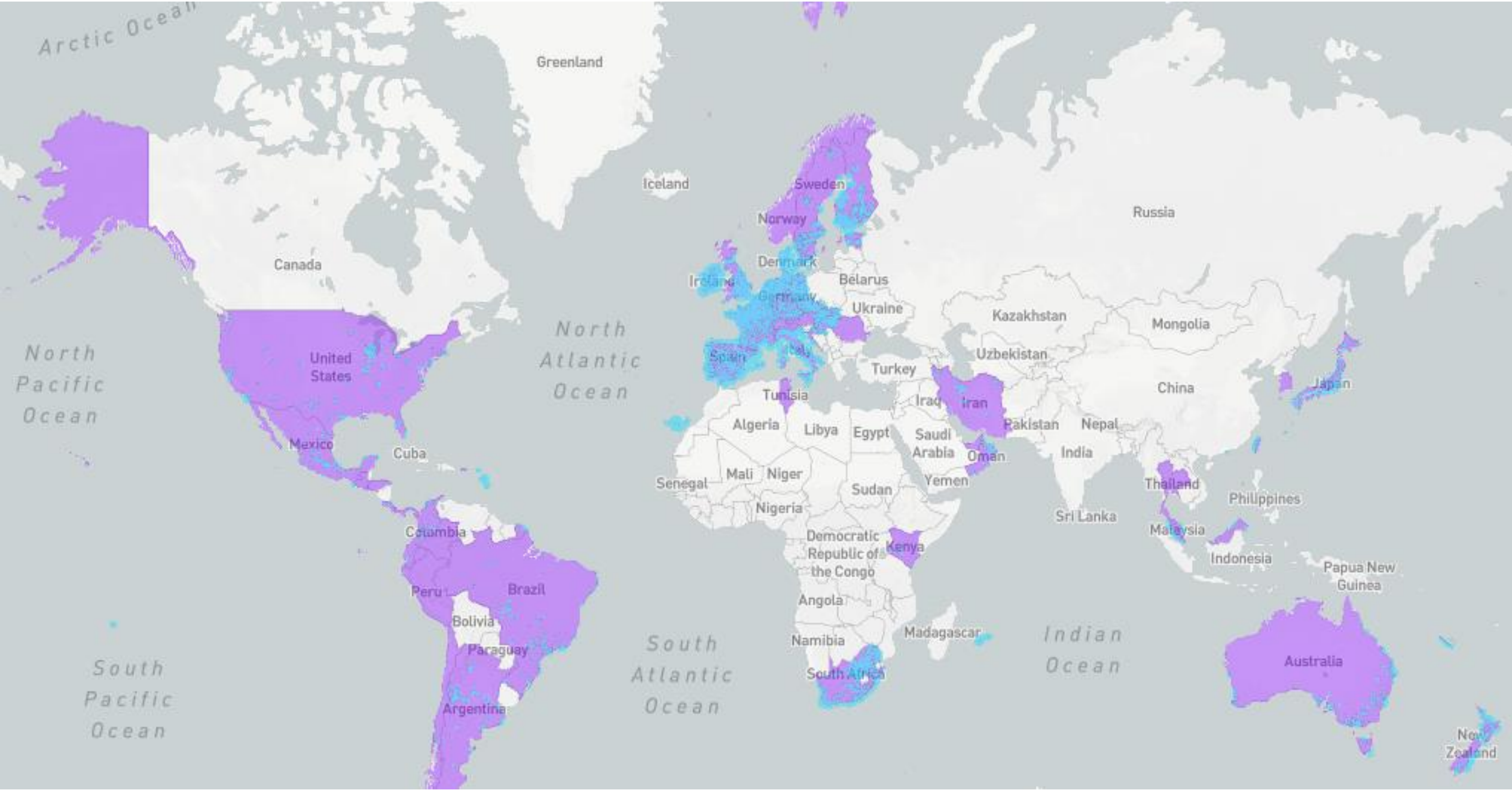
November 2018

countries & regions covered nationwide

- Belgium
- Czech Republic
- Denmark
- Finland
- France
- Italy
- Ireland
- Japan
- Luxembourg
- Malta
- Mauritius
- New Zealand
- Oman
- Portugal
- Réunion
- Singapore
- Slovakia
- South Africa
- Spain
- Taiwan
- The Netherlands

Currently spanning 4.5 million km²




Arctic Ocean
Greenland
Iceland
Sweden
Norway
Russia
Canada
Denmark
Ireland
Belarus
Germany
Ukraine
Kazakhstan
Mongolia
North Atlantic Ocean
North Pacific Ocean
United States
Spain
Italy
Uzbekistan
Turkey
Tunisia
Iraq
Iran
China
Japan
Algeria
Libya
Egypt
Saudi Arabia
Pakistan
Nepal
Mexico
Cuba
Oman
India
Senegal
Mali
Niger
Sudan
Yemen
Thailand
Philippines
Nigeria
Sri Lanka
Colombia
Democratic Republic of the Congo
Kenya
Malaysia
Indonesia
Papua New Guinea
Peru
Brazil
Angola
Bolivia
Namibia
Madagascar
Indian Ocean
Paraguay
South Atlantic Ocean
South Africa
Australia
South Pacific Ocean
Argentina
New Zealand

Visible stuff

Water metering

silver economy

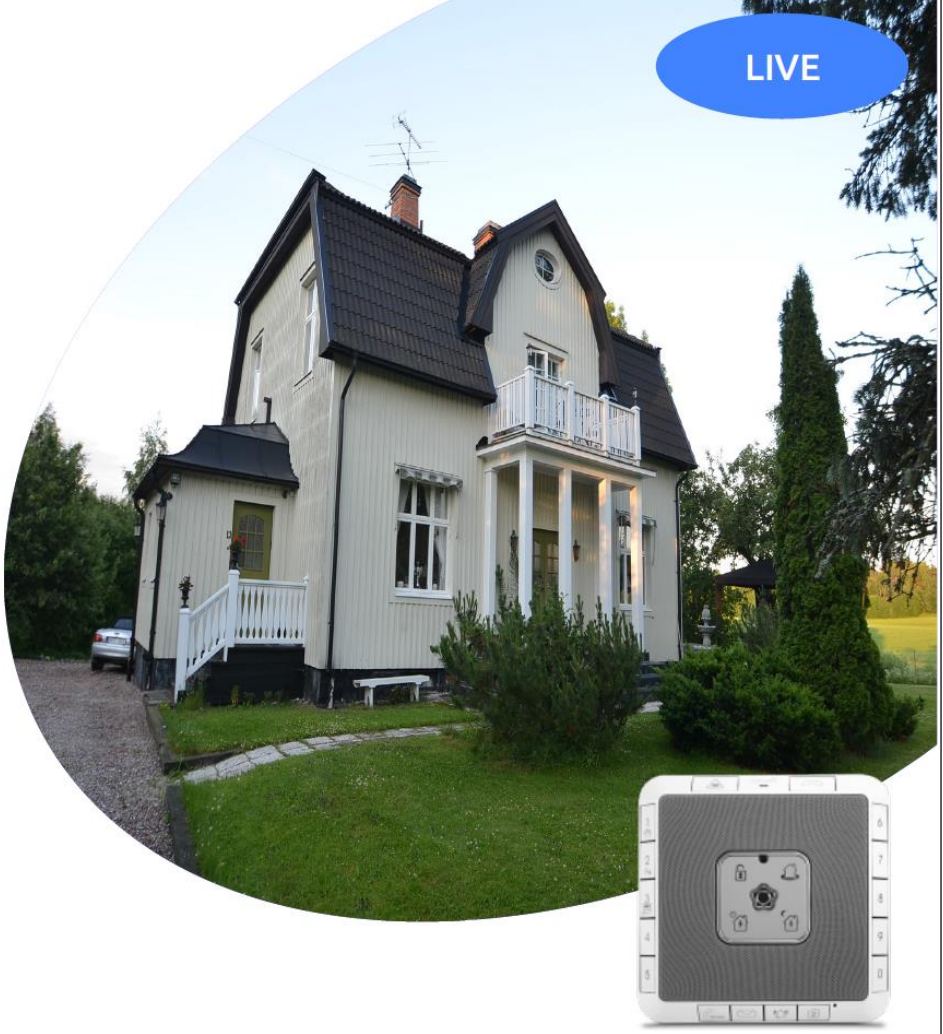
Smart parking

Less visible stuff

Home Alarm System

Challenge

Secure better households




SYSTEME D'ALARME
Votre Freebox vous alerte
en cas d'anomalie
Sirène 105 dB
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Stolen Car Recovery

TRAQUEUR
APRES-VOL ET GEOLOCALISATION

Challenge

Locate and recover stolen assets through a small and discrete GPS tracking device.

Connected Boilers

e.l.m. leblanc

Challenge

Create an affordable solution to monitor boilers and create new services for customers.

"e.l.m. leblanc early on recognized the value for our professional customers, channel partners and for end users of equipping and installing smart boilers" - Frédéric Agar, e.l.m. leblanc's president

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Optibee
connected beehive

Weenat connected fields

Projet « Surveillance Caténaire SURCA »

2

Machine Learning exemples

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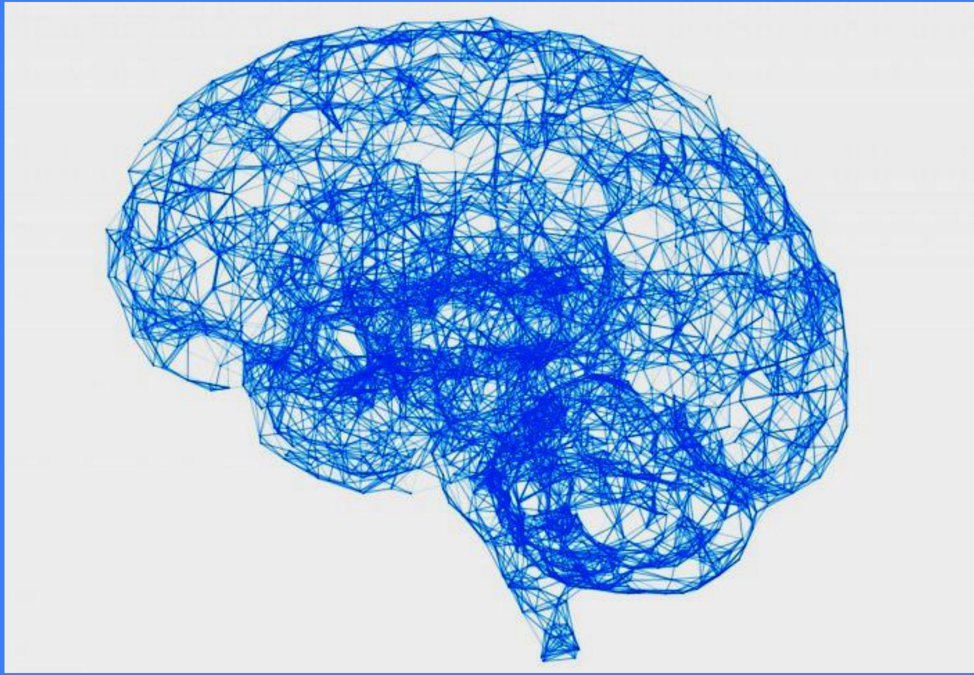
Data Science - Little Big Data

- Data Collection / storage
- Data knowledge / Analytics
- Data Intelligence / Machine learning

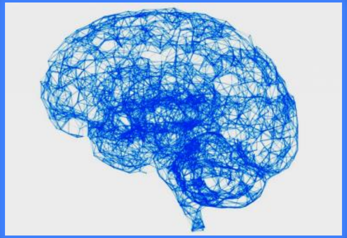
Data Science - Little Big Data

- Data Intelligence / Machine learning



Little Big Data

Data type



- Machine learning using data in the network
  - Payload data: the value of the transported data
    - Temperature, pressure, position,…
  - Metadata: all about data except its value
    - Reception date
    - Reception level
    - …

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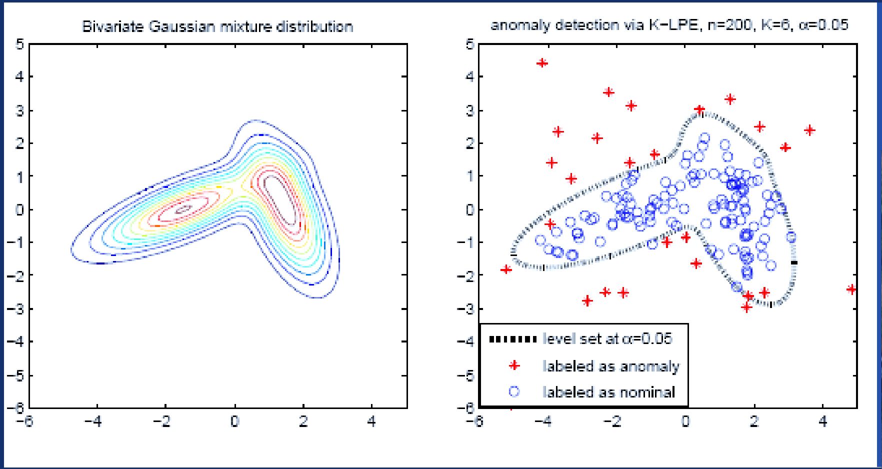
Little Big Data

- Data Intelligence / Machine learning

Anomaly detection /

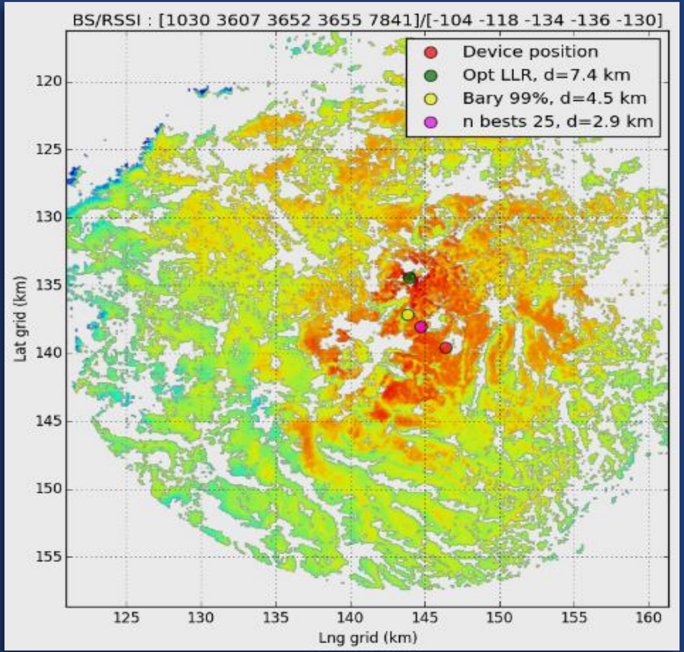
Predictive Maintenance



Little Big Data

- Data Intelligence / Machine learning

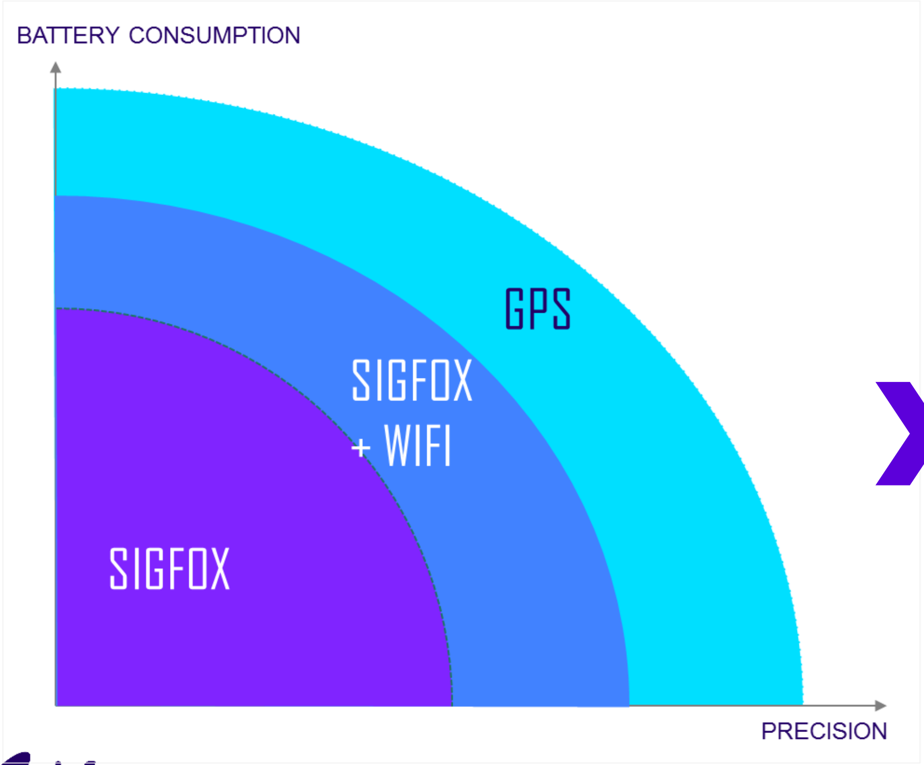
Geolocation



Geolocation business case: Louis Vuitton


MICHELIN

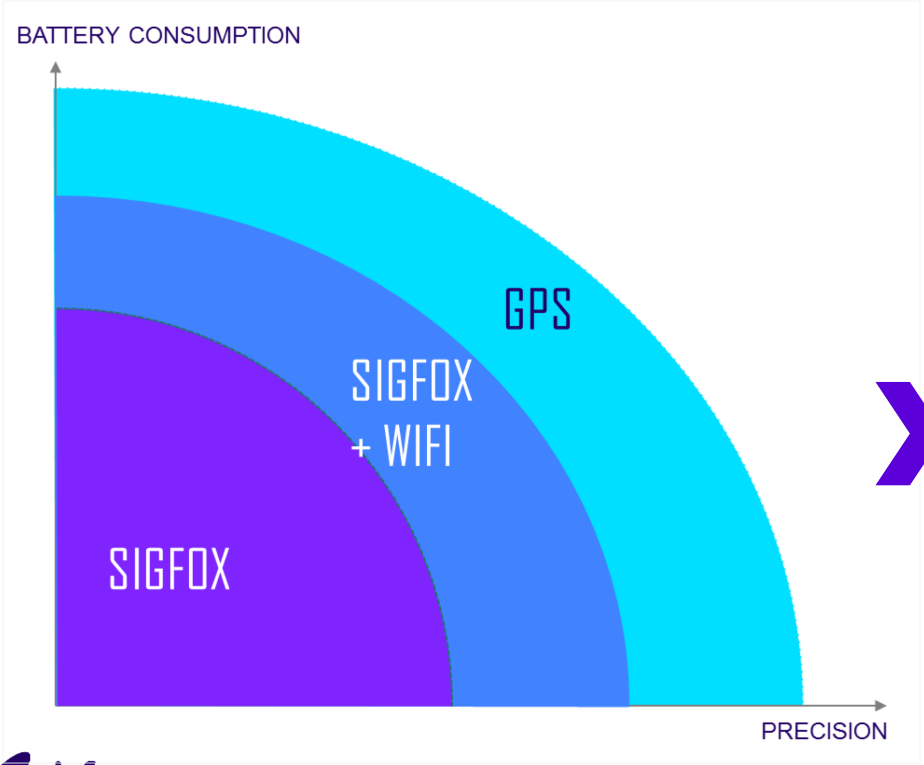
The Geolocation Challenge



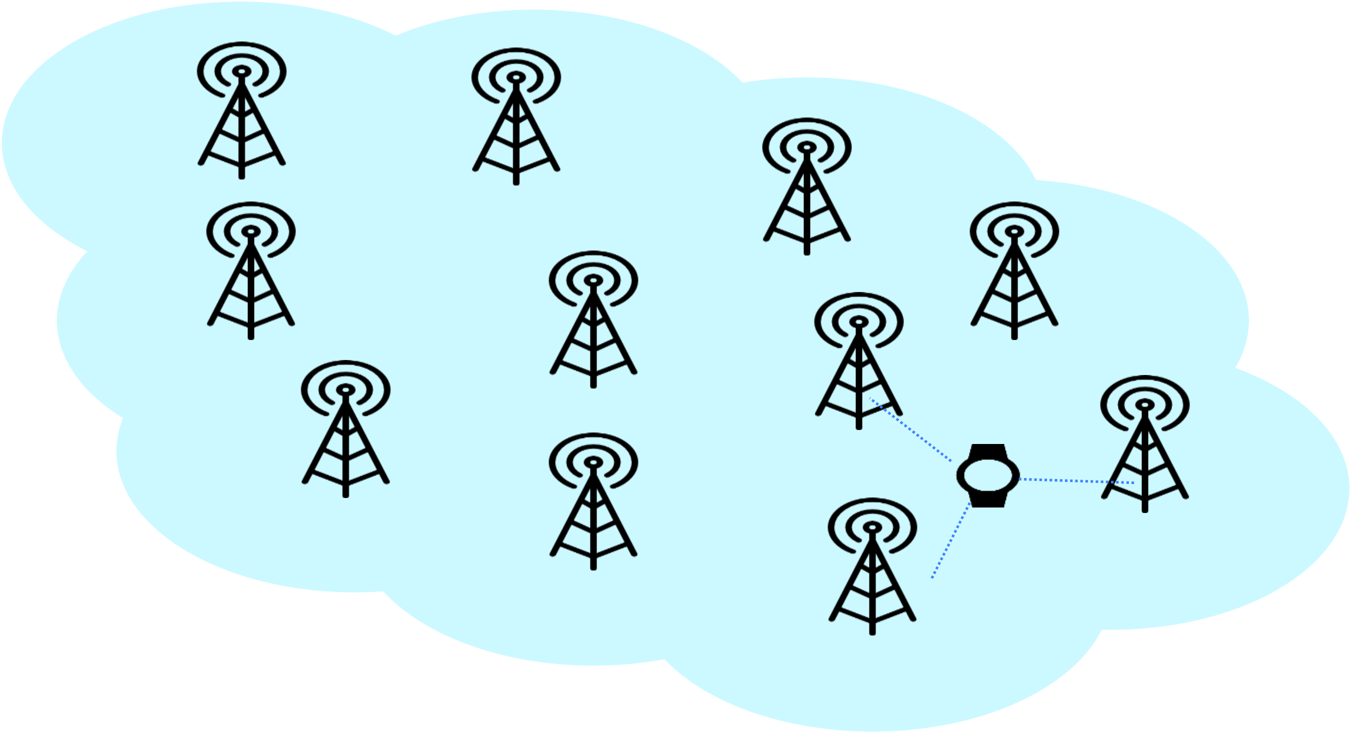
Need for a location solution without GPS:

- *Low cost module*
- *High battery life*
- *Precision target ~ 1km*

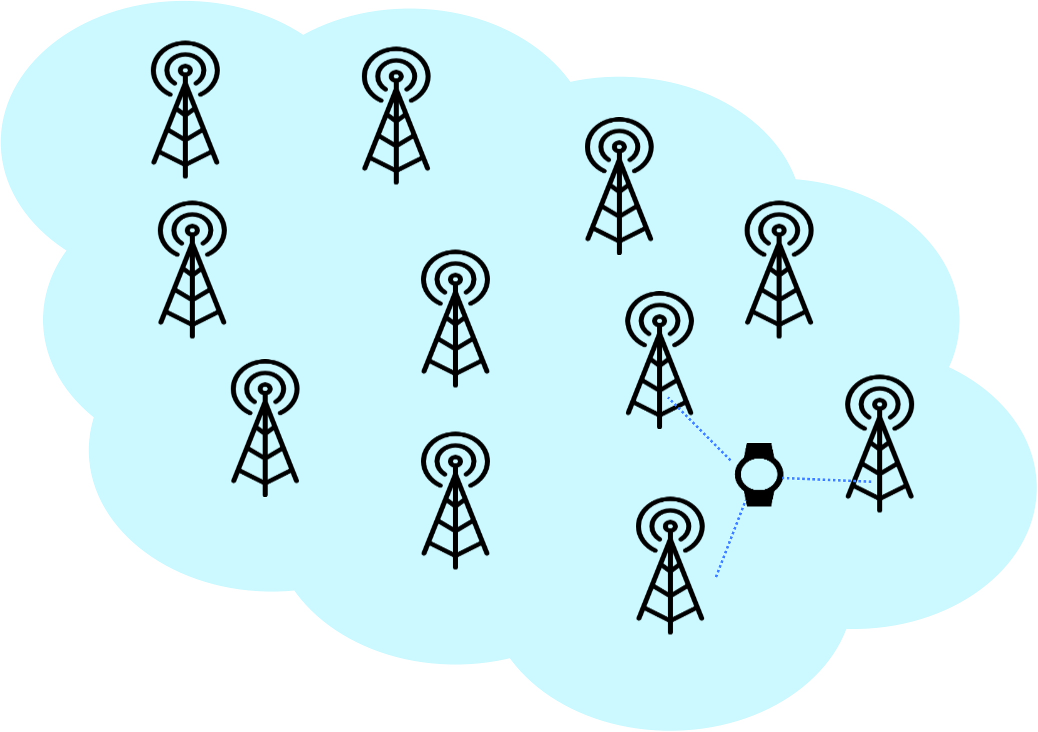
The Geolocation Challenge



Network based geolocation



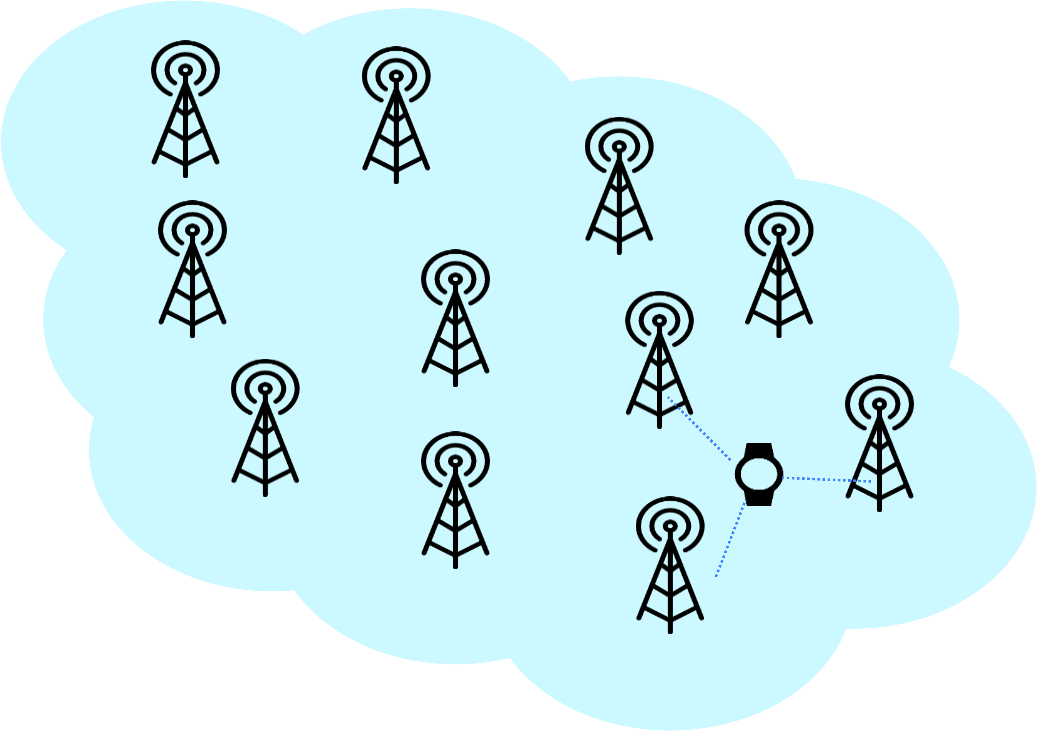
Geolocation state of the art – Time of flight



Calculate signal Time of Flight

- *Use of TDOA*
- *Estimate distances BS - Device*
- *Solve equation system: device area*

Geolocation state of the art – Time of flight



Calculate signal Time of Flight

- *Use of TDOA*
- *Estimate distances BS - Device*
- *Solve equation system: device area*

Drawbacks for LPWAN

- *UNB not well suited for precise TDOA*
- *Need network synchronization time domain (~µs).*
- *Multipath channel destroy perfs*

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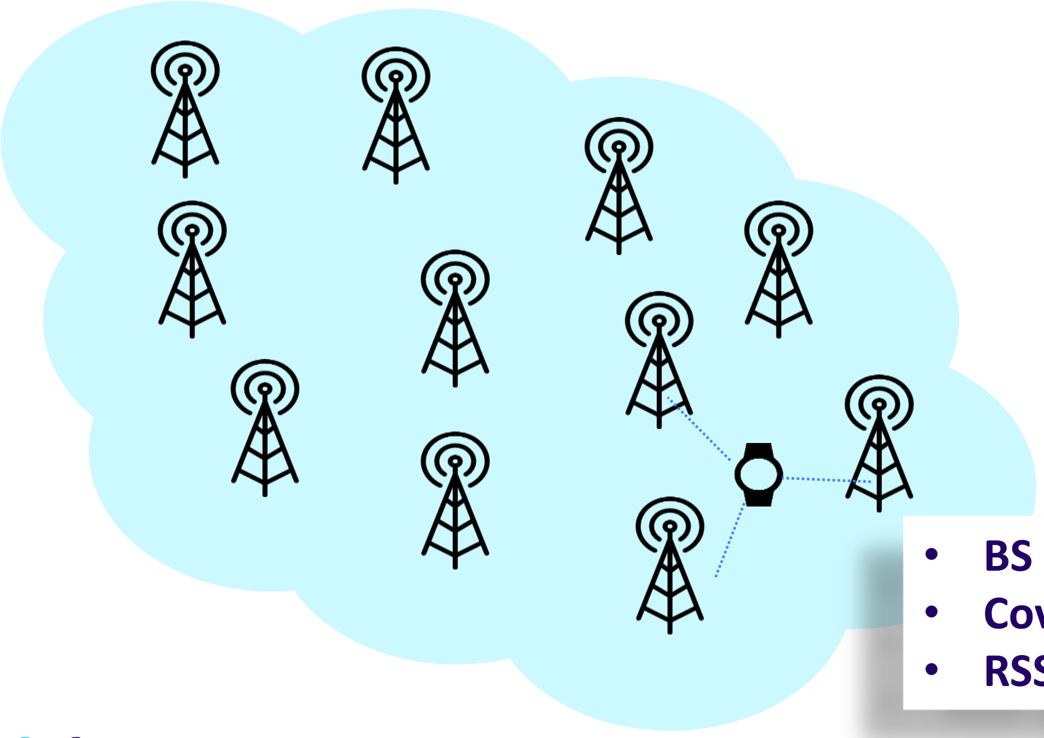
Network based geolocation– RSSI



Received Signal Strength Indicator

- *Use the received signal power*
- *Try to make a link between RSSI and device position*
- *No need for synchronized network*
- *Hard to link distance – RSSI in multipath environment*

- **BS Locations**
- **Coverage Map of each BS**
- **RSSI @ each BS**

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3

Lab: Geolocation

Geolocation Train Set

Input:

Message Id　Base station Id　Device Id　Base station position (Lat, Lng)

	messid	bsid	did	nseq	Rssi (dBm)	time_ux (ms)	bs_lat	bs_lng
0	573bf1d9864fce1a9af8c5c9	2841	473335	0.5	-121.5	1.463546e+12	39.617794	-104.954917
1	573bf1d9864fce1a9af8c5c9	3526	473335	2.0	-125.0	1.463546e+12	39.677251	-104.952721
2	573bf3533e952e19126b256a	2605	473335	1.0	-134.0	1.463547e+12	39.612745	-105.008827
3	573c0cd0f0fe6e735a699b93	2610	473953	2.0	-132.0	1.463553e+12	39.797969	-105.073460
4	573c0cd0f0fe6e735a699b93	3574	473953	1.0	-120.0	1.463553e+12	39.723151	-104.956216

Output: device position

	lat	lng
0	39.606690	-104.958490
1	39.606690	-104.958490
2	39.637741	-104.958554
3	39.730417	-104.968940
4	39.730417	-104.968940

How to apply ML techniques to Geolocation

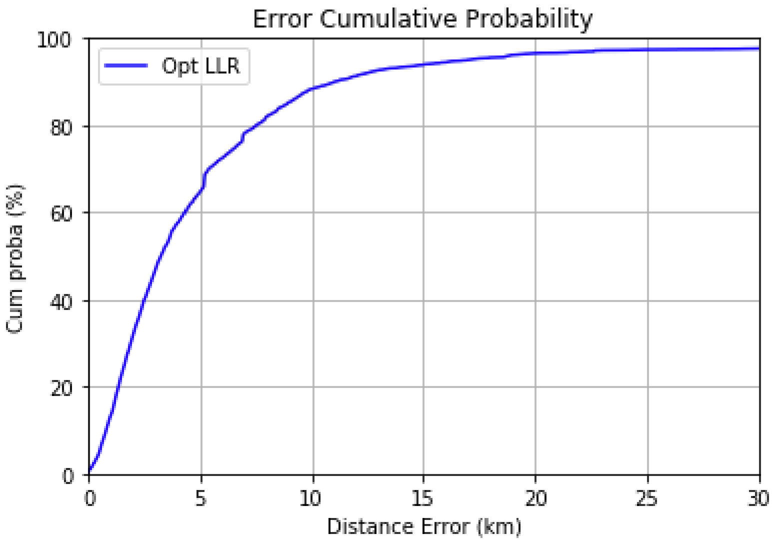
What kind of ML problems do we have?

What is the feature matrix / Ground truth ?

What kind of algorithm will we use ?

Goals

- Build feature matrix
- Build ground truth
- Plot error cumulative probability
- Compute prediction criterion: error @ 80%
- Extract prediction for the test set
    - Save result in csv file
- Build a « leave 1 device out » predictor



Error @ 80% = 7521 m

Send me your results before 12/01/2017:
Olivier.Isson@gmail.com
Groups of 3-4 people

1. Python code used to generate previous goals
2. Predicted position for test set in csv format: **pred_pos_test_list.csv**
3. Short explanation of your approach and your choices: ~ 1-2 pages, can be included into the notebook or a separate document

https://www.sensit.io/

Reward:

1 Sens'it for each team member of the winning team

Thank You