Machine Learning in IoT

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IoT - LPWAN

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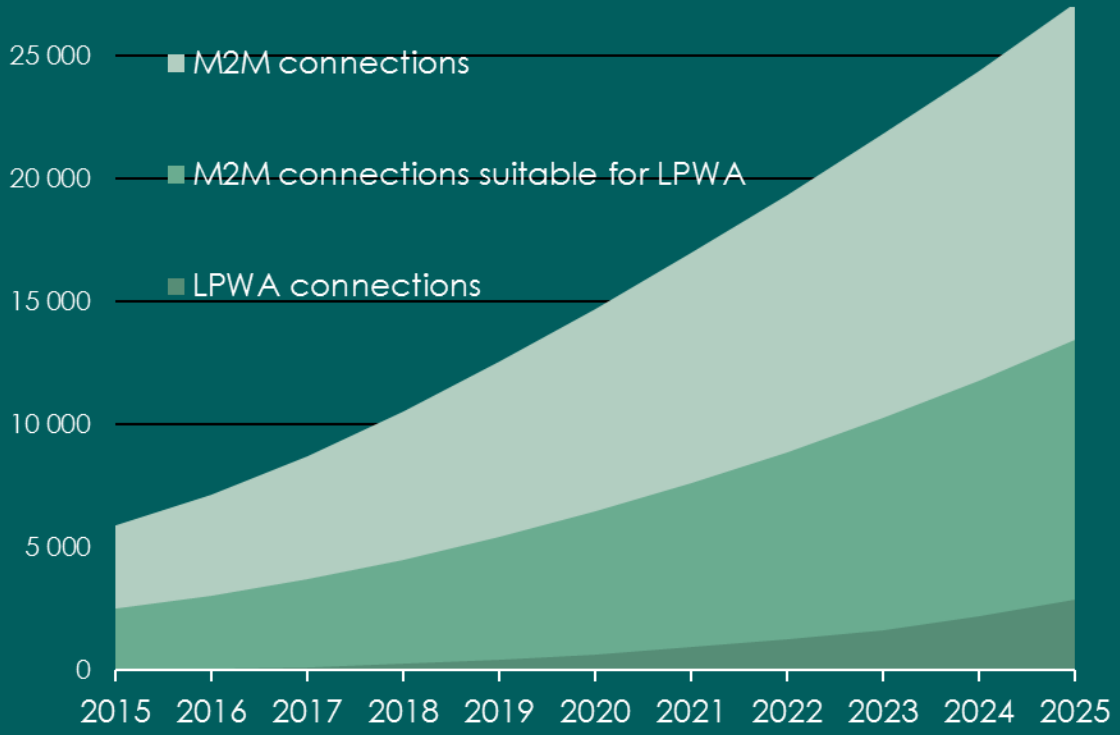
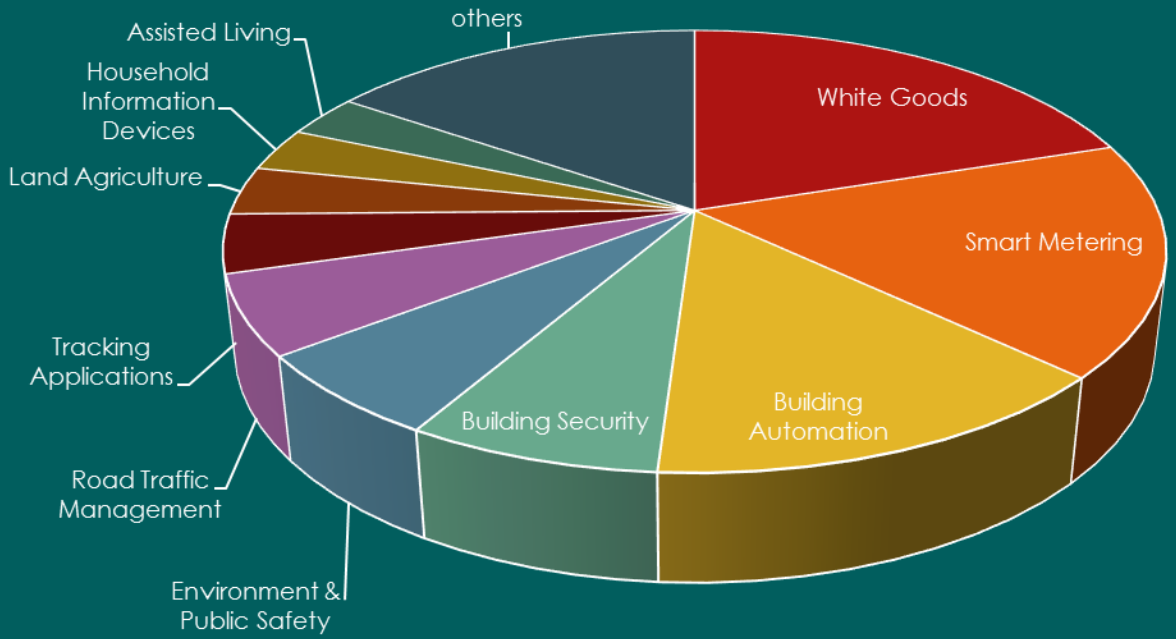
Forecasted connections worldwide (Millions)



Source: Machina Research

Top applications expected

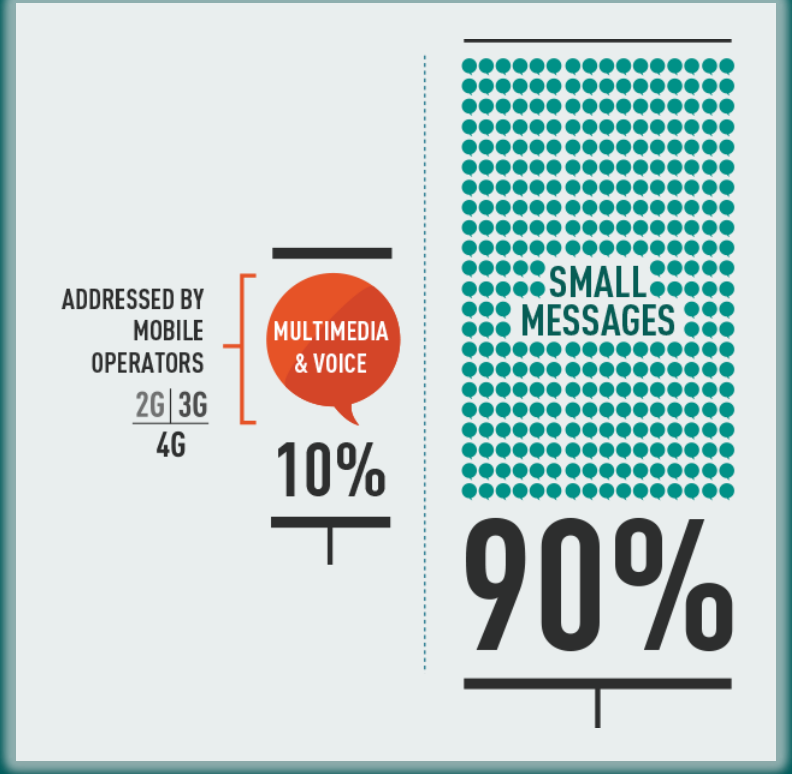


Key take away points

- ✓ 4 applications represent 60% of the volumes of LPWAN connections:
  - white goods monitoring
  - Smart metering
  - Building management
  - Building security

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

Small messages…

- ✓ **6 bytes**: GPS coordinates

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

- ✓ **2 bytes**: temperature reporting

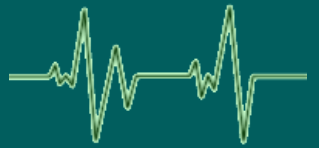
  Lab thermometer with -100°/+200° range, 0.004° precision

- ✓ **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?

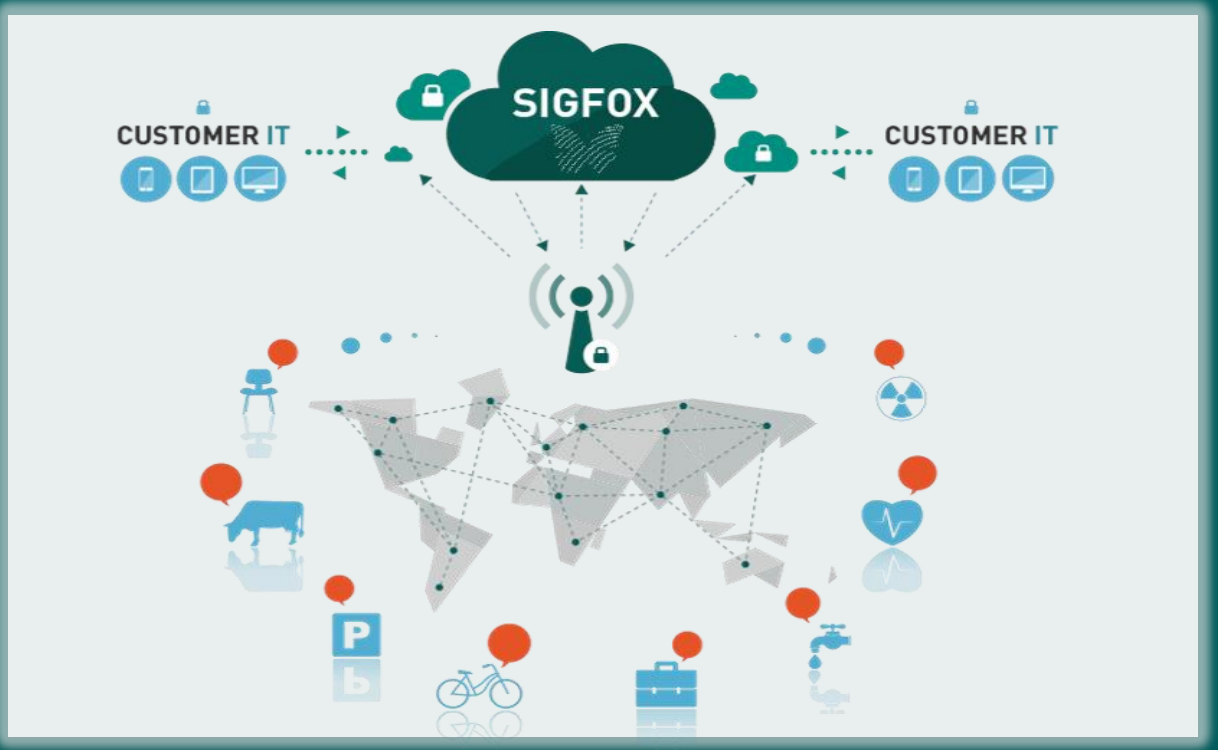
Low **P**ower **W**ide **A**rea **N**etwork

Ultra low power

Ultra long range

Energy efficient

Cost effective



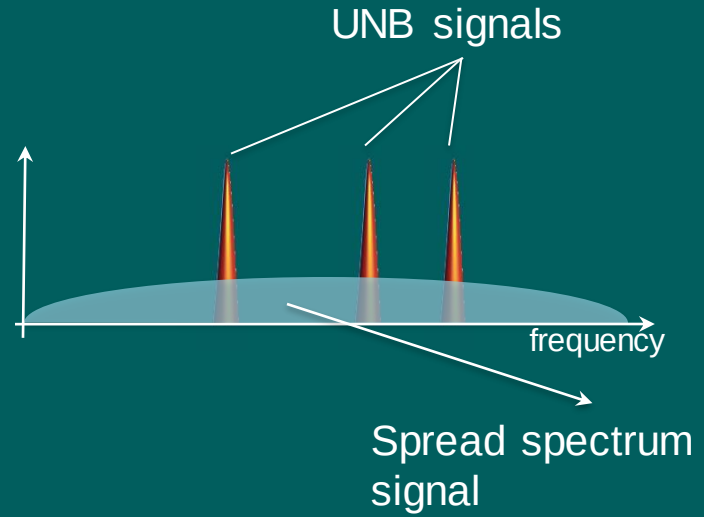
So, how is it possible?

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)

So, how is it possible?

SIGFOX™

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

SIGFOX™

we sell a connectivity solution & Data services

we don’t make devices

Sigfox technology is **royalty free**

Key facts about Sigfox

- 1.6 million square kilometers covered (> 600.000 square miles)
- 451 million people
- 28 countries
- On track to cover more than 60 countries by 2018
- Millions of connected objects already registered on the network across all 5 continents
- With its ecosystem of partners, Sigfox has launched a revolutionary way to think about connectivity thanks to the world's first, ultra-low cost IoT modules starting from just $2.00.
- 150 M€ record fund raising in November 2016 (total amount of 277 M€ since 2011)

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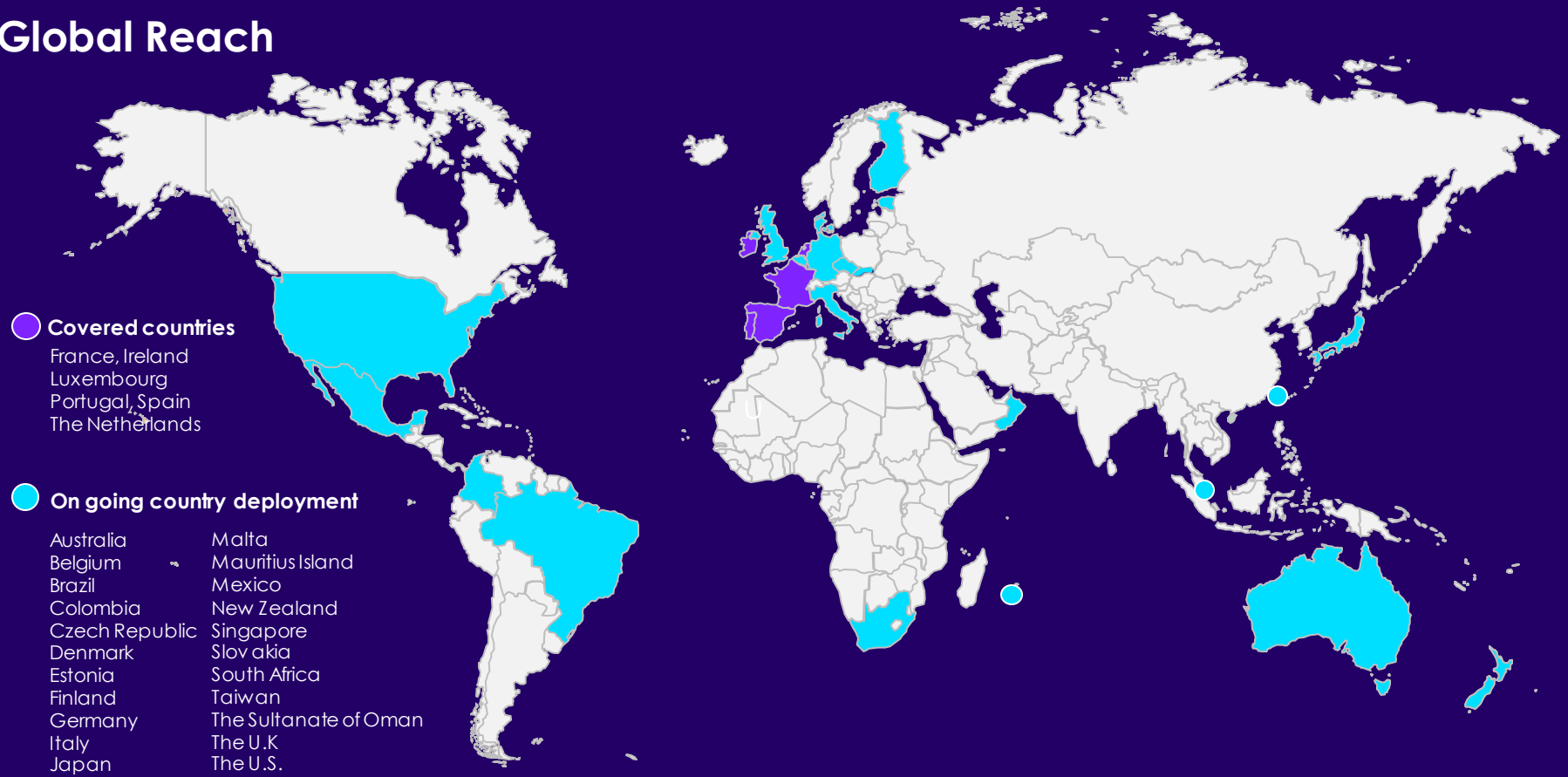
Global Reach



Covered countries

France, Ireland
Luxembourg
Portugal, Spain
The Netherlands

On going country deployment

Australia
Belgium
Brazil
Colombia
Czech Republic
Denmark
Estonia
Finland
Germany
Italy
Japan
Malta
Mauritius Island
Mexico
New Zealand
Singapore
Slovakia
South Africa
Taiwan
The Sultanate of Oman
The U.K
The U.S.

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Visible stuff

SIGFOX™

Water metering

silver economy

Smart parking

Less visible stuff


Optibee
connected beehive


STEPLA
connected cow


Weenat
connected fields

intesens
THE CONNECTED MAINTENANCE

Projet « Surveillance Caténaire SURCA »

SENSE CONNECT SHARE

2

Machine Learning exemples

Data Science - Little Big Data

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

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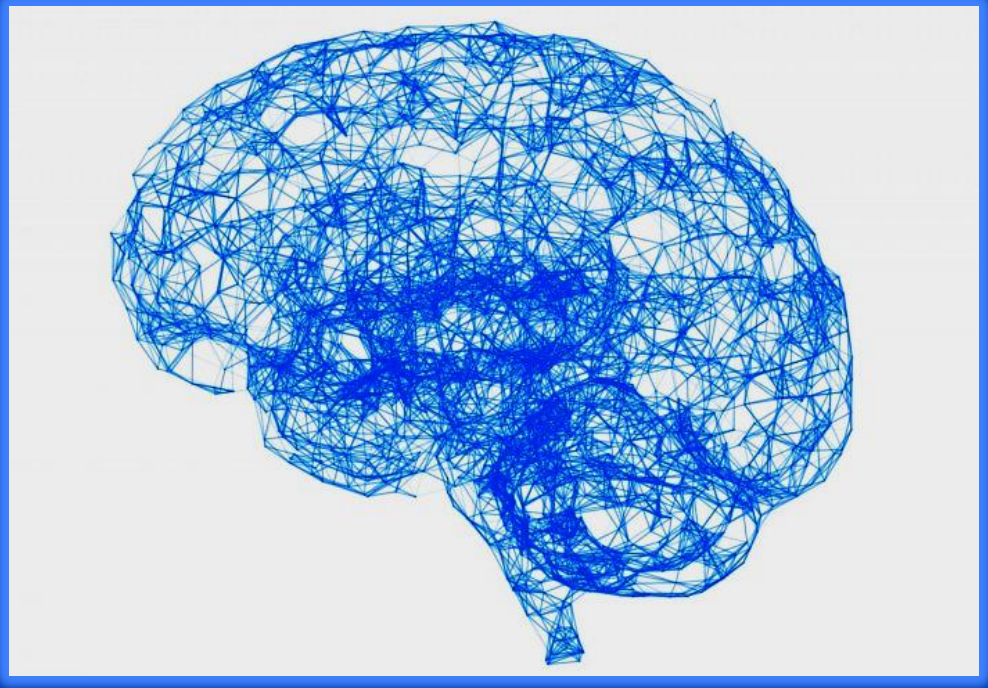
Data Science - Little Big Data

- Data Intelligence / Machine learning



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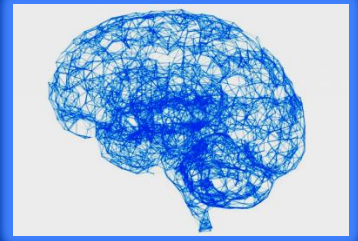
Little Big Data

Data type



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

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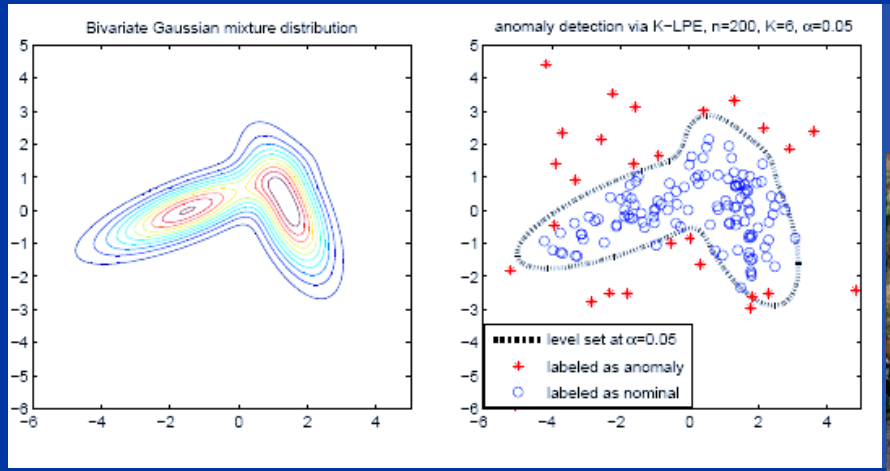
Little Big Data

- Data Intelligence / Machine learning

Anomaly detection /

Predictive Maintenance



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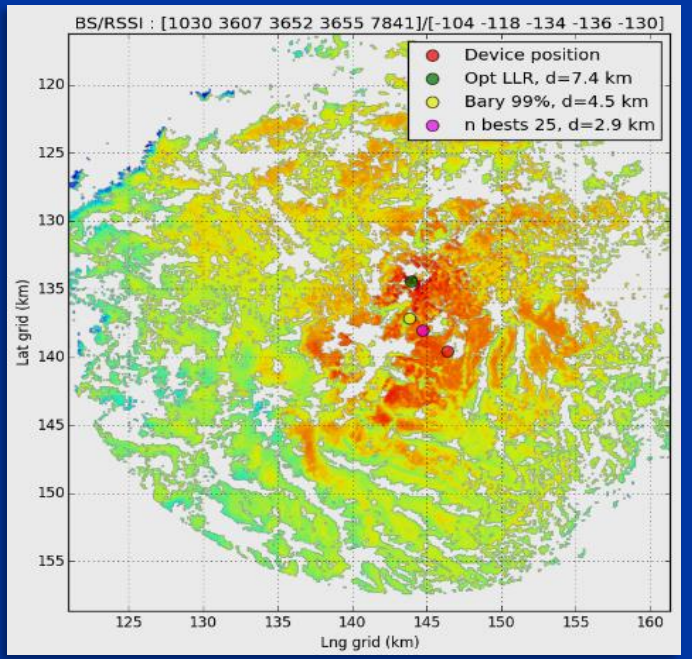
Little Big Data

- Data Intelligence / Machine learning

Geolocation



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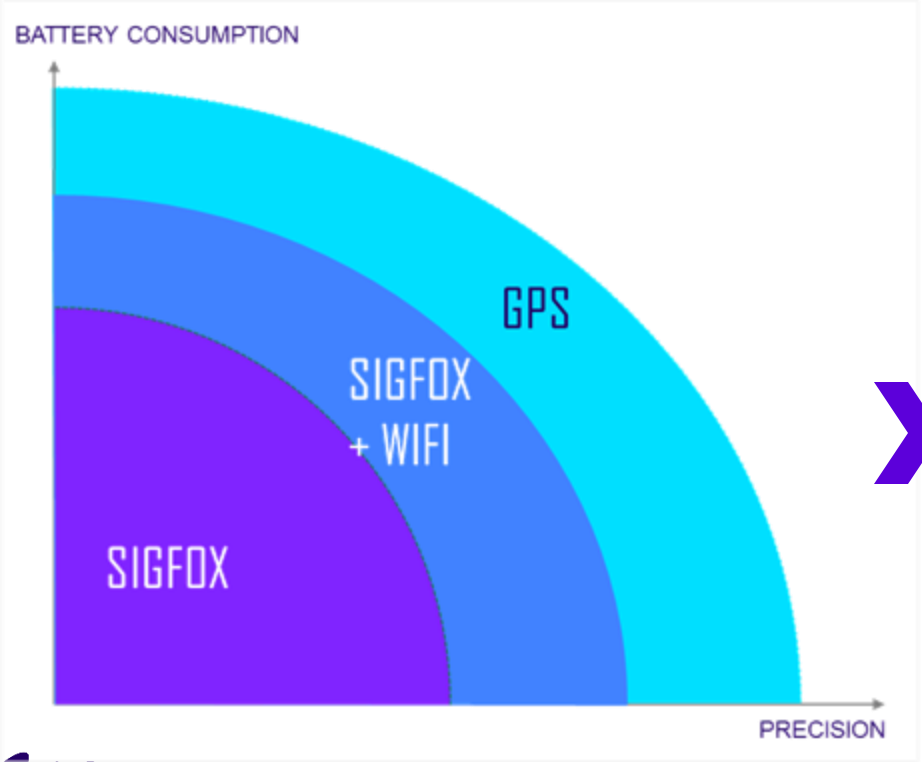
The Geolocation Challenge



There is a need for a location solution for device that can be directly established by sigfox without the use of GPS:

- *Low cost module*
- *High battery life*
- *Precision > 1km*

They are many uses cases that can be interested by these features :

- *Entry/exit of an area*
- *Tracking / Path validation*
- *Last reported position*
- *…*

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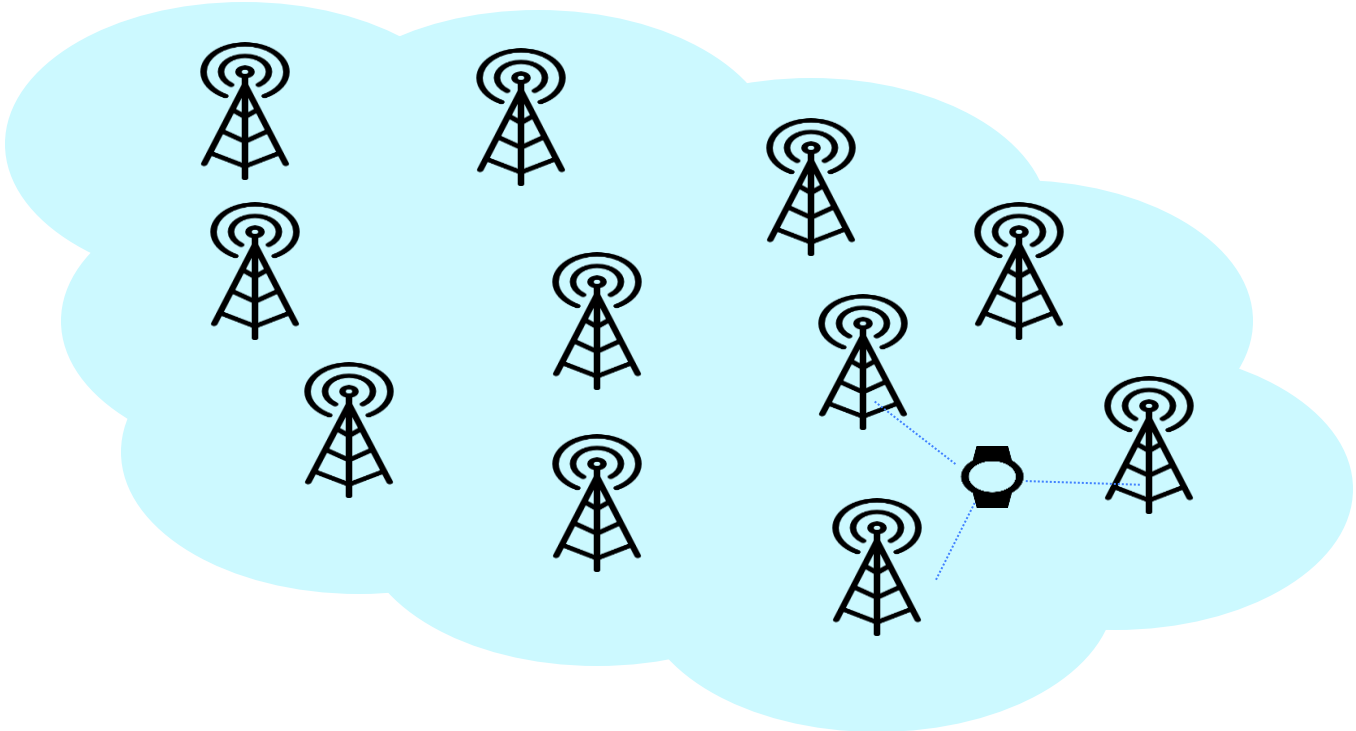
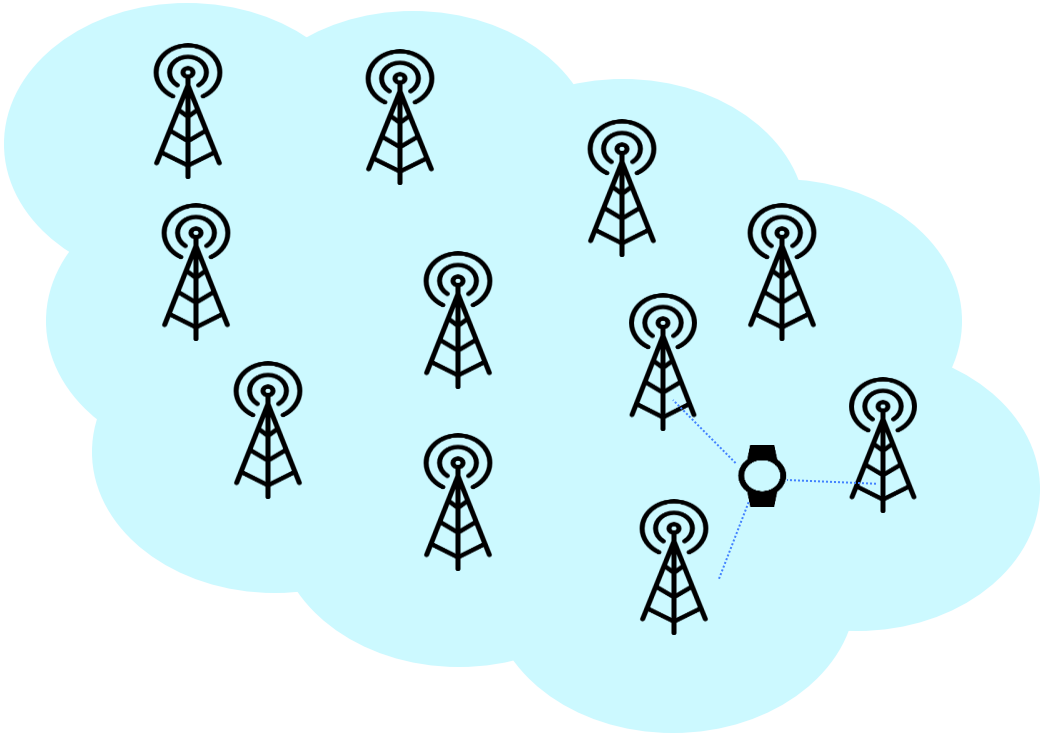
Network based geolocation



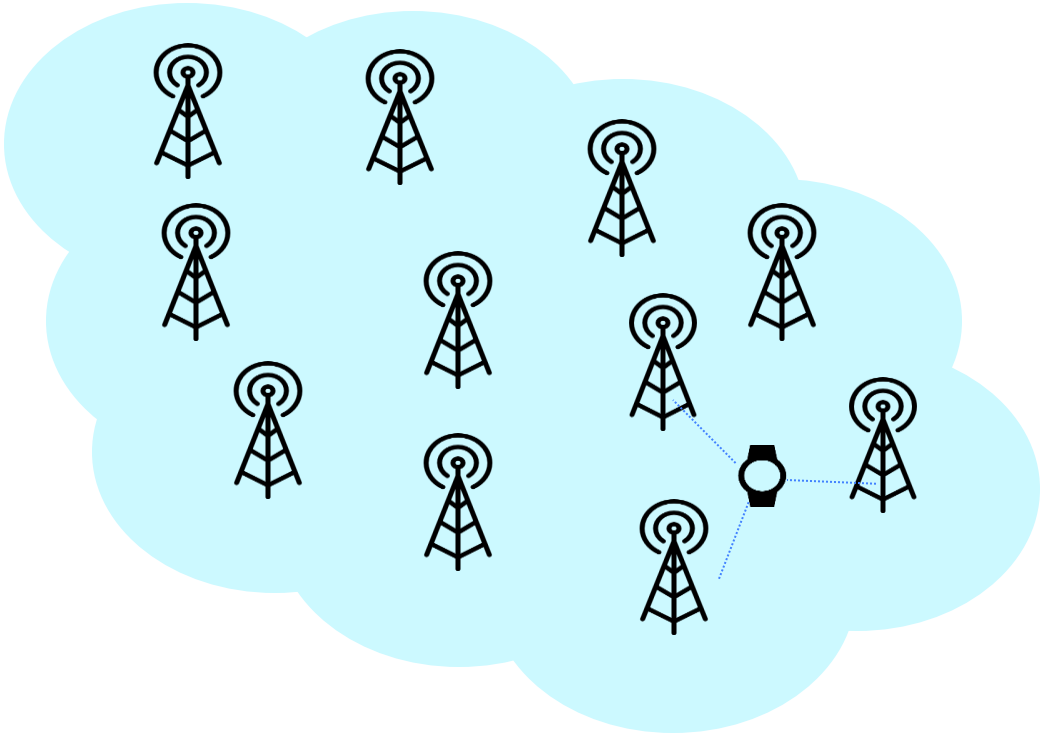
Geolocation state of the art – Time of flight



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



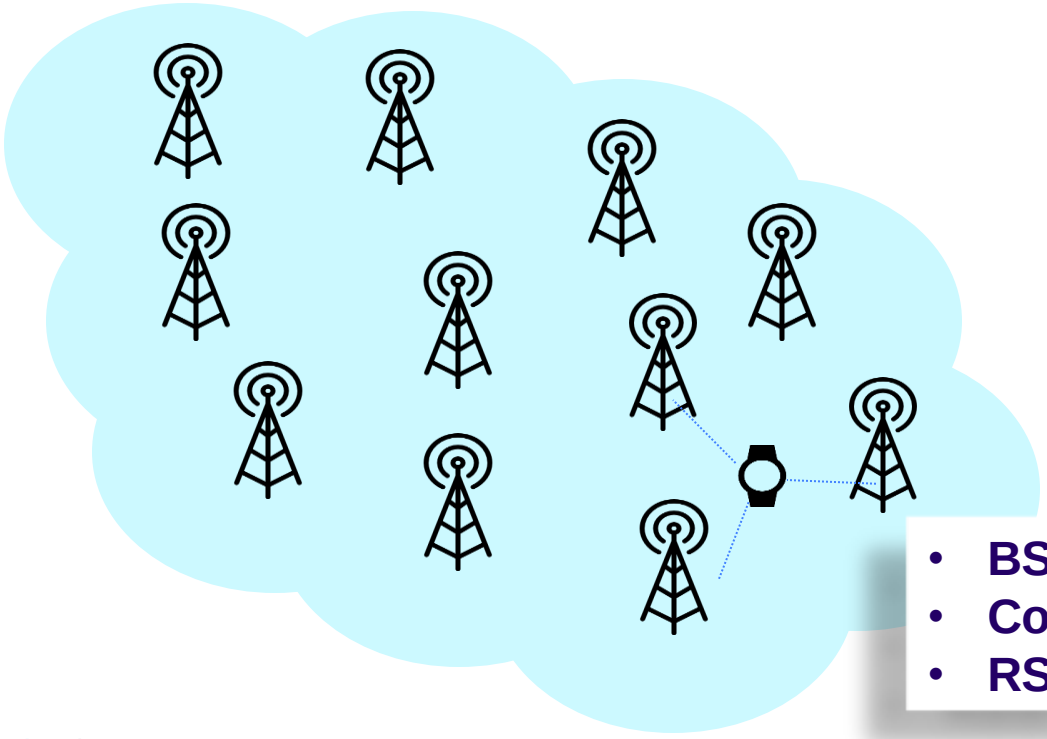
Calculate signal Time of Flight

- *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*

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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Lab: Geolocation

Geolocation Train Set

Input:

Message Id

Base station Id

Device Id

Base station position (Lat, Lng)

	objid	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 distribution
- Compute prediction criterion: error @ 80%
- Extract prediction for the test set
- Build a « leave 1 device out » predictor

Send me your results before 13/01/2017:
Olivier.Isson@gmail.com
Groups of 3-4 people

- Python code used to generate previous goals
- Predicted position for test set in csv format: pred_pos_test_list.csv
- Short explanation of your approach and your choices (~ 10 lines)

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Thank You