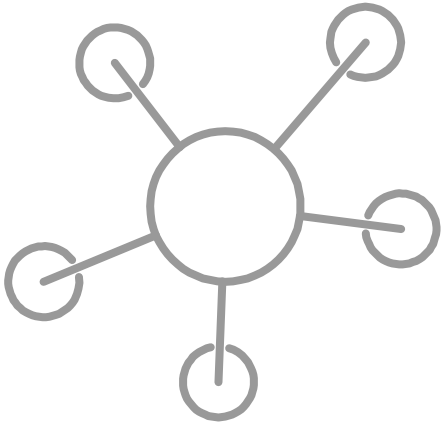

QUEL LPWAN
CHOISIR POUR SON
OBJET CONNECTÉ ?

RTONE IOT Makers

cnrs

GDR RSD

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HELLO!

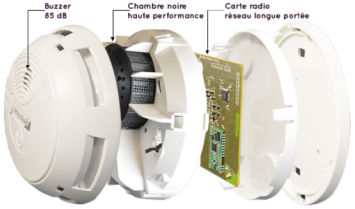
I am Alexis Duque

R&D leader at **Rtone**

PhD citi lab INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

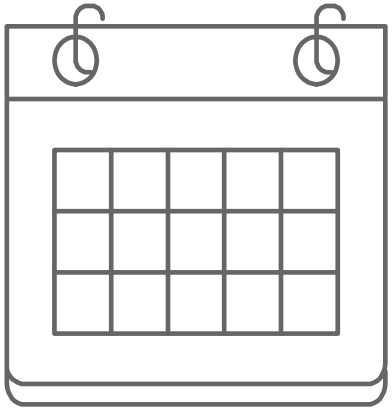
RTONE IOT MAKERS

“ We Are IoT Makers ”



SUMMARY

- Criteria of Choice
- LPWANs
- Comparison
- Use Cases



LPWAN?

CRITERIA OF CHOICE

- Power Source? Battery capacity?
- Mobility?
- Localization?
- Local? Country? Worldwide?
- Range?
- Throughput? Latency? Message frequency?
- Cost (capex/opex)? Hardware?

SIGFOX

sigfox

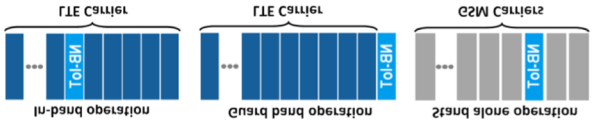
- **UNB** combined with **DBPSK**(UL) and **GFSK**(DL)
- **Unlicensed ISM** bands 868MHz in Europe
- Random Access
- Bandwidth is 100Hz
- 100**bps**
- Bidirectional **but limited**
  - 140 (UL) - 4 (DL) mess/day
- **12** bytes (UL) & 8 bytes (DL) PDU
- Range : 10km (urban) - 40km (rural)
- Encryption let to the application layer

LORAWAN

- **CSS**
- **Unlicensed ISM** bands: 868 MHz in Europe
- Bandwidth : 50 kHz and 125 kHz
- **Adaptive data rate: SF7->SF12**
- 3 class of devices: A, B, C
- 300bps - 50**kbps -** Bidirectional
  - **243** bytes PDU
- 5 km (urban), 20 km (rural)
- **Allow private network**
- Encryption w/ AES

NB-IOT

- QPSK + FDMA (UL) /OFDMA (DL)
- LTE Bands - 200 kHz bandwidth
- Inband - Guardband - Standalone
- **60 kbps DL - 30 kbps UL** w/ CAT-N1 module (R13)
  - **X2** w/ Cat-N2 module (R14)
- **Half-duplex** and unlimited
- **1600** bytes PDU
- **2s latency**
- 1 km (urban), **15km** (rural)
- LTE authentication and encryption
- **100K devices per cell**



LTE-M

- **1Mbps**(UL & DL) w/ **Cat-M1** module (R13)
- **7Mbps**(UL) & **4Mbps**(DL) w/ **Cat-M2** module (R14)
- 1,4MHz (Cat-M1) or 5MHz (Cat-M2) bandwidth
- **Only Inband mode**
- **Handover support**
- **Voice**
- LTE authentication and encryption
- **200ms** latency - 300 km/h
- **10km** (rural)

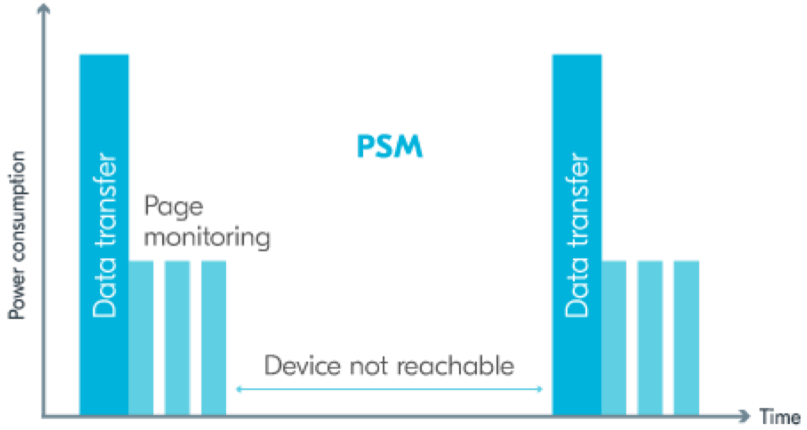
	NB-IoT	LoRaWAN	Sigfox	LTE-M
Nationwide Coverage	Africa: 0, Asia: 0, EU: 0, Americas: 0	**Africa**: **1**, **Asia**: **1**, **EU**: **3**, Americas: 0	Africa: 0, Asia: 0, **EU**: **10**, Americas: 0	Africa: 0, **Asia**: **2**, EU: 0, **Americas**: **1**
Frequency (Europe)	GSM band / LTE band (licensed) (B3,B8,B20)	868 MHz (unlicensed)	868 MHz (unlicensed)	LTE band (licensed)
VoLTE / Voice	no	no	no	yes
Duplex	HDX	HDX	HDX (limited)	HDX
Bandwidth (kHz)	180	125	192	1080
Subscription Cost	on request	on request	on request	e.g. 1.7 EUR / month (@200 kb / month)
Max. # Messages / Day	unlimited	unlimited	140	unlimited
Roaming	no	no (planned)	yes[5]	yes
exemplary data for **Module(s)**	BC95-B20	SX1272, SX1273, SX1276, SX1277, SX1278, SX1279	ATA8520E	Quectel BG96
Link Budget (dB)		150-168	156	
Transmission (TX) Power (dBm)	23	20	14	23
TX Current (max TX Power) (mA)		125 (@20 dBm)	32.7 (@14 dBm)	190 (@23 dBm)
Max Sensitivity (dBm)	-129	-130 to -148	-121.5	-107
Supply Current (µA)	PSM: 5 Idle mode: 6000	PSM: 0.1 Idle mode: 1.5	PSM: 0.005 Idle mode: 50	PSM: 10.4 Idle mode: 1990
Max Data Rate (DL/UL) (kbps)	24 / 15.625	0.018 to 40	0.6 / 0.1	375 / 375
Module Costs	**14.49 EUR**[1] (@1 unit)	from **5.61 EUR**[2] (SX1273, @1 unit)	from **2.09 EUR**[3] (@1 unit)	**33.90 EUR**[4] (@1 unit)

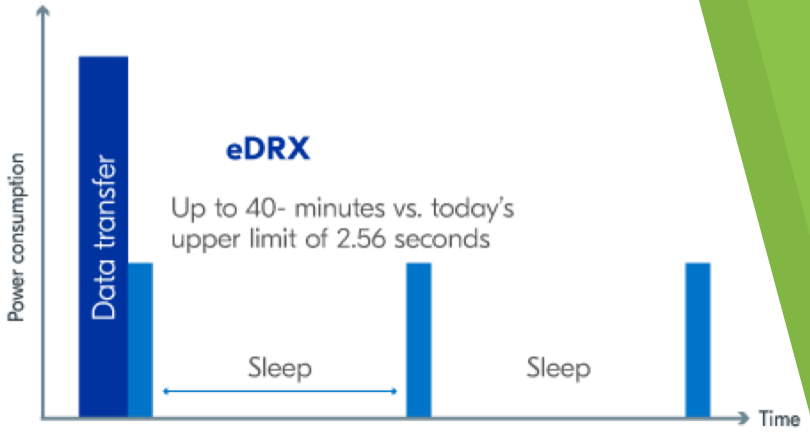
BATTERY LIFE

- **Cellular-IoT** end device consumes additional power
  - synchronous communication and QoS
  - OFDM/FDMA require more peak current.
  - NB-IoT Battery Life **>** LTE-M removing LTE features
  - Both support eDRX & PSM
- **Depend** on the **LoRaWAN device class**

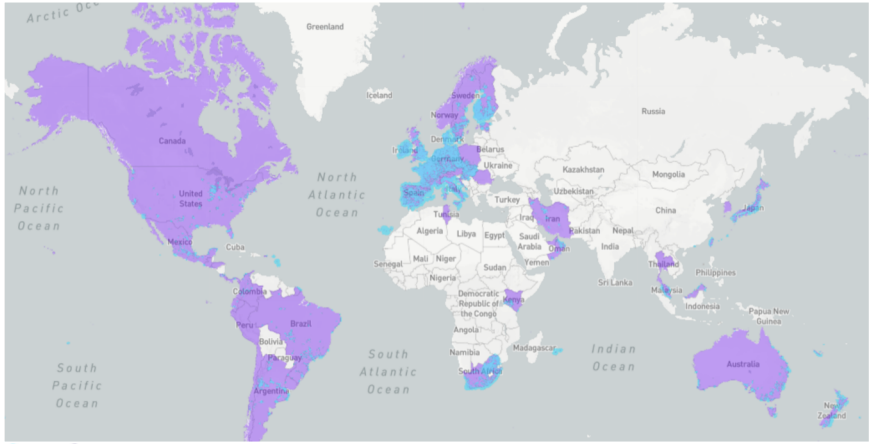
IoT devices are **in sleep mode** most of the time outside operation ⇒ **battery life is use case dependant**

Fix / Transmission Interval	Operating Mode	Estimated Battery Life
5 minutes	Normal	17 hours
5 minutes	PSM	~2 days
5 minutes	eDRX (10 s latency)	~2 days
1 hour	PSM	22.5 days
1 hour	eDRX (3 min latency)	19.8 days
4 hours	PSM	73 days
12 hours	PSM	152 days
1 day	PSM	209 days
1 day	Toggle On / Off	129 days

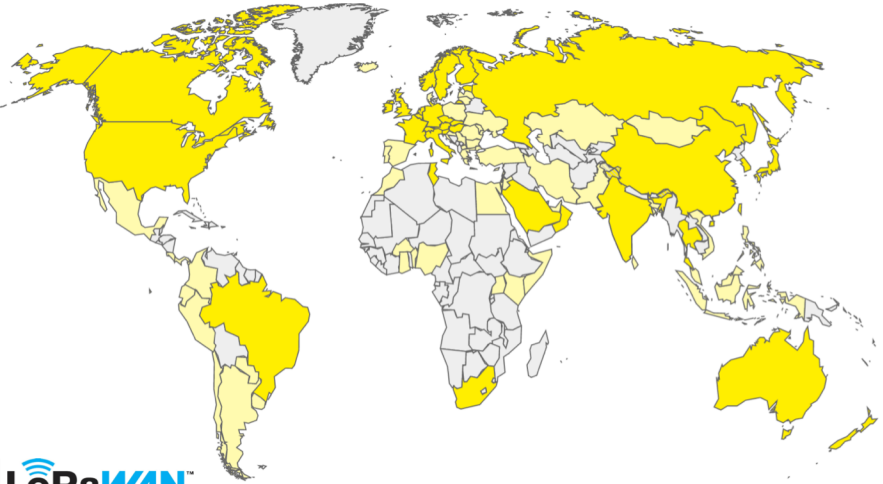




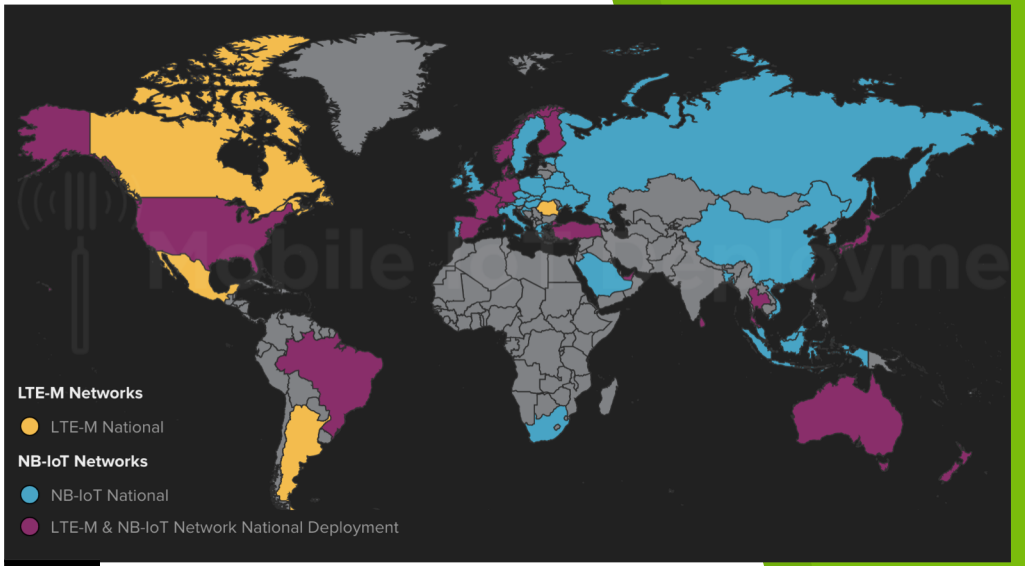
COVERAGE



sigfox

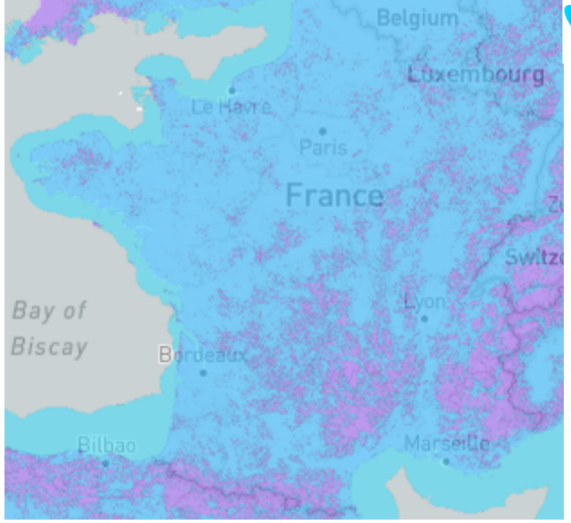


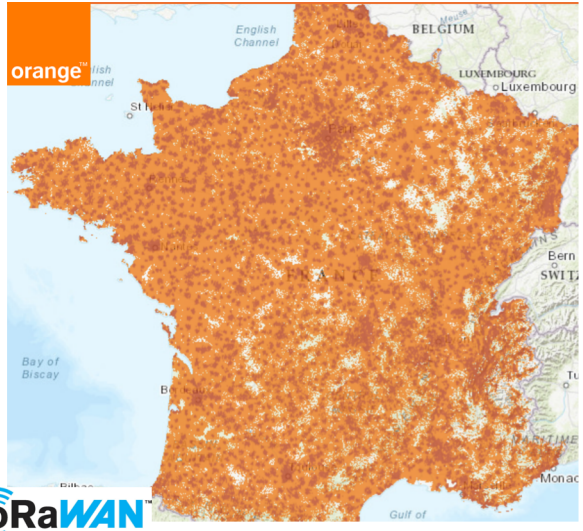
LoRaWAN

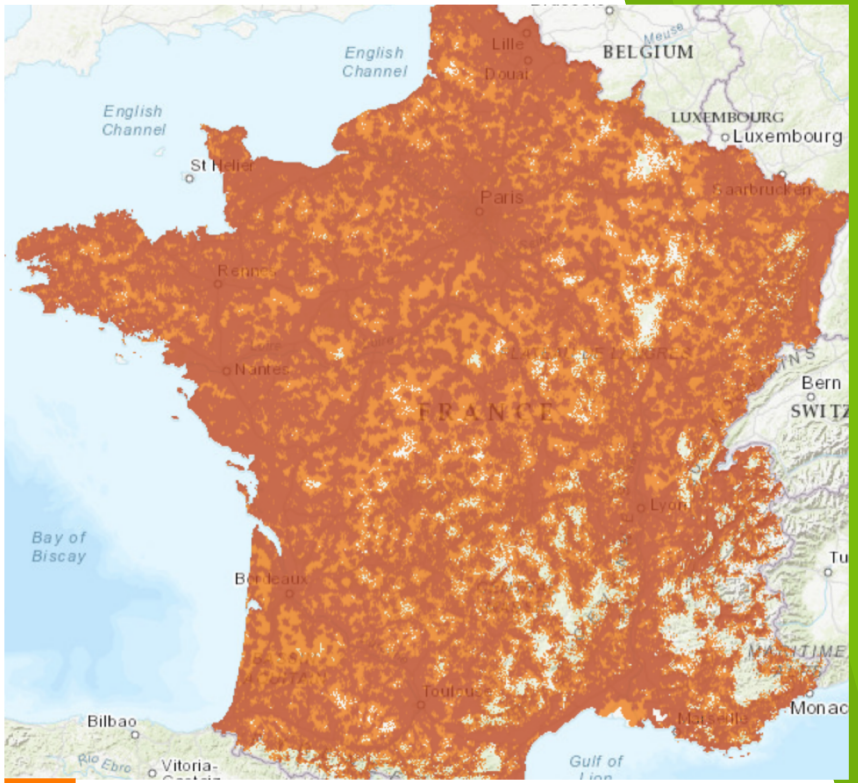


GSMA

sigfox







orange

LTE-M

LoRaWAN

QUALITY OF SERVICE

- Sigfox and LoRa can bounce interference, multipath, and fading. However, they cannot offer the **same QoS provided by Cellular-IoT**
- QoS vs ¥$€

NB-IoT is preferred for applications that require guaranteed QoS

Applications that do not have this constraint should choose LoRa or Sigfox.

SCALABILITY - DATA RATE

- **Cellular-IoT** allows up to **100K concurrent dev./cell**
- **NB-IoT** 1600B vs **LoRa** 243B vs **Sigfox** 12B.
- **LoRa** more **robust against motion** vs **Sigfox. Cellular-IoT** is designed for that.

Cellular IoT offers the advantage of very higher scalability than Sigfox and LoRa.

LATENCY

- **NB-IoT** offers the advantage of **low latency.**
- **LoRa** with **class C**
  - low-bidirectional latency.
  - expense of increased energy consumption.

For applications that doesn’t requires low latency and low data to send, **Sigfox** and **class-A LoRa** are the best options.

For applications that require **real-time, LTE-M** is required. For **low latency (~s)**, **NB-IoT and class-C LoRa** are the better choices.

LOCALIZATION CAPABILITY

- **Sigfox:** YES with **RSSI.**
- **LoRaWAN:** YES with **TDOA**
- **LTE-M / NB-IoT:** YES with **Enhanced Cell Identity (ECID) & OTDOA** but under standardization, not always deployed

COSTS

Hardware Module

- Sigfox & LoRaWAN < **2$**
- Cellular-IoT **~15$**

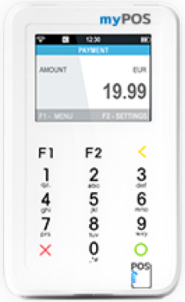
Network Operator

- Lora-Sigfox **~0.40$**/month.
- Cellular IoT **~0.60$**/MB/month

USE CASES

Lone Worker Protection System

Critical IoT - Payment



USE CASES

Real-time grid monitoring & Industrial IoT

USE CASES

Smart [Building|City]

LoRaWAN™ (Private)

USE CASES

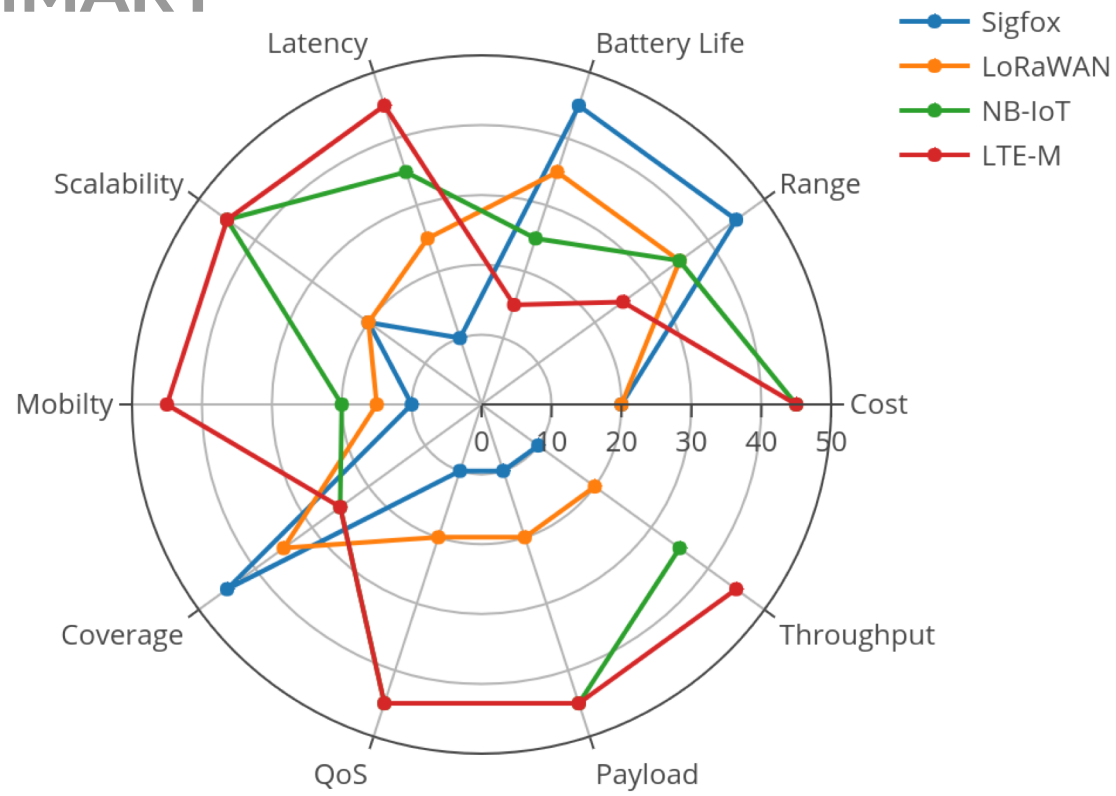
Smart Farming

USE CASES

Asset Tracking

sigfox

SUMMARY


Latency
Battery Life
Range
Cost
Throughput
Payload
QoS
Coverage
Mobilty
Scalability
0
10
20
30
40
50
Sigfox
LoRaWAN
NB-IoT
LTE-M

THANKS!

Any questions?

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alexisd@rtone.fr

REFERENCES

- B. E. Benhiba *et al.* "**Comparative Study of The Various new Cellular IoT Technologies**" in *2018 International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS)*, 2018.
- A. Ikpehai *et al.*, "**Low-Power Wide Area Network Technologies for Internet-of-Things: A Comparative Review"** *IEEE Internet Things J.*, vol. 6, no. 2, Apr. 2019.
- W. Ayoub*et al.*, "**Internet of Mobile Things: Overview of LoRaWAN, DASH7, and NB-IoT in LPWANs standards and Supported Mobility**" *IEEE Commun. Surv. Tutorials*, no. April 2016, 2018.
- S. C. Gaddam and M. K. Rai, **"A Comparative Study on Various LPWAN and Cellular Communication Technologies for IoT Based Smart Applications**" in *2018 International Conference on Emerging Trends and Innovations In Engineering And Technological Research (ICETIETR)*, 2018.
- X. Lin *et al.*, "**Positioning for the Internet of Things: A 3GPP Perspective**" *IEEE Commun. Mag.*, vol. 55, no. 12, 2017.

REFERENCES

- O. Iova *et al.*, "**LoRa from the City to the Mountains : Exploration of Hardware and Environmental Factors**" *Int. Conf. Embed. Wirel. Syst. Networks*, 2017.
- M. Bor *et al.* "**Do LoRa Low-Power Wide-Area Networks Scale ?**" 2016.
- F. Adelantado *et al.*, "**Understanding the limits of LoRaWAN**", 2016.
- https://lora-alliance.org/
- https://www.orange-business.com/fr/reseau-LTE-M
- https://www.sfrbusiness.fr/room/internet-des-objets/
- https://www.gsma.com/iot/mobile-iot/