

XII CÁTEDRA INTERNATIONAL DE INGENIERÍA

The Internet of Things?



UNIVERSIDAD
NACIONAL
DE COLOMBIA

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OSCAR CARRILLO
MAROUA MEDDEB



Session 6

IoT LPWAN Protocols

Low Power, Low Data Communication

Then: People sending messages



Now: Machine driven wireless



LPWAN Addresses Technology Gap



Traditional Cellular

Low battery life
High Cost
MNO controlled



NB-IoT
Sigfox

LPWAN

Long Range
Low data rates
Long battery life



Local Area Network

Short Range
Low battery life

Short range
Medium battery life

802.15.4

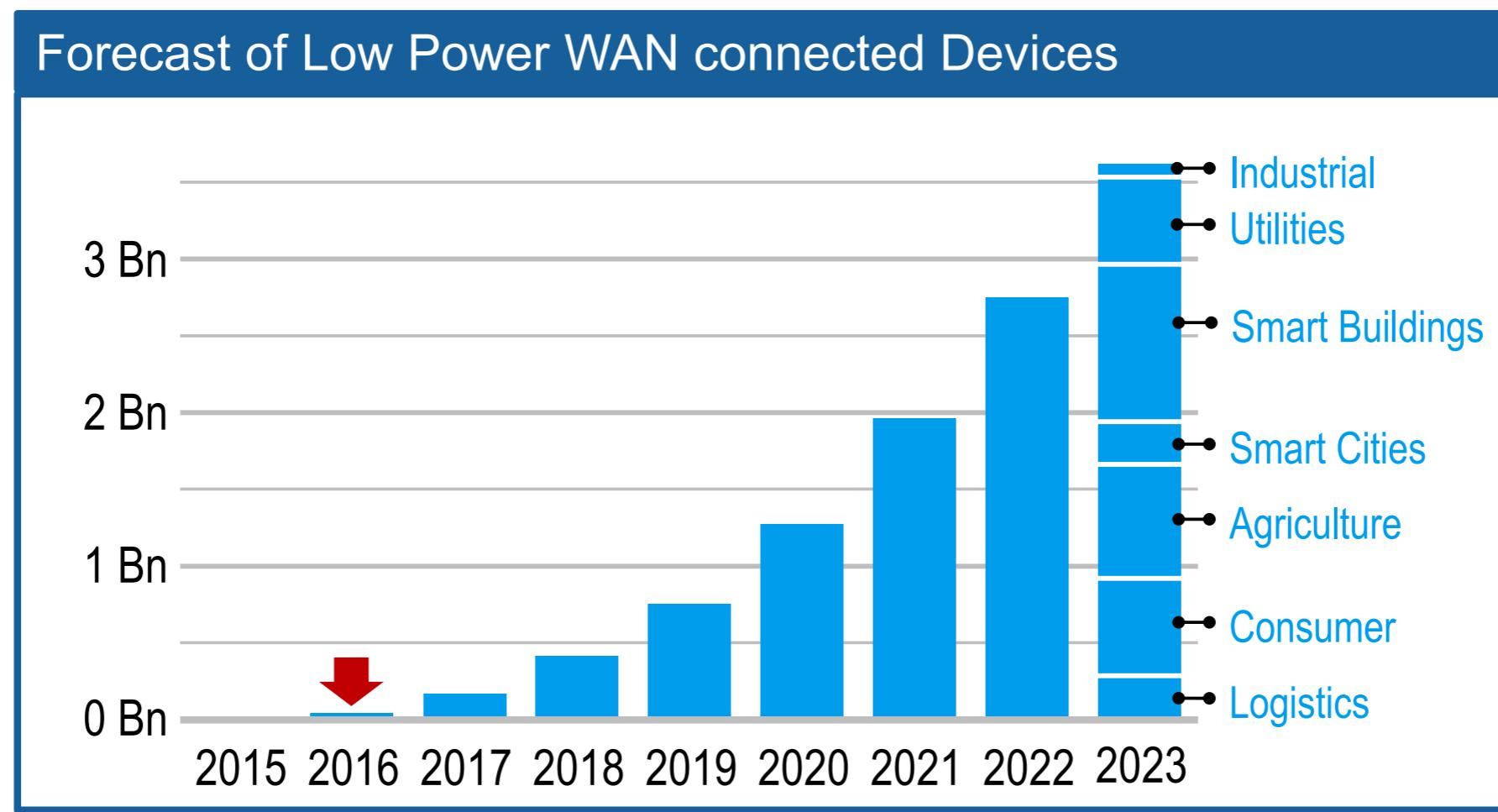


Bluetooth®

Personal Area Network

Short Range
Medium battery life

Low-power wide-area networks (LP-WAN) will enable applications which sense literally Everything Everywhere Anytime



3GPP addresses the LPWA market especially with LTE-M/NB-IoT

LTE (Cat-1bis ...Cat-4)

- Native LTE (TDD/FDD)
- Full bandwidth of up to 20 MHz
- Seamless mobility
- High data rate

LTE-M (Cat-M1/2)

- In-band LTE (TDD/FDD)
- Reduced bandwidth (1.4/5 MHz)
- Half-duplex optional
- Limited mobility
- Data rate of up to 1 Mbps
- Indoor coverage
- VoLTE support

NB-IoT (Cat-NB1/2)

- In-band, guard-band, standalone LTE (FDD only)
- Narrowband of 180 kHz
- Half-duplex only
- Nomadic mobility (reconnection)
- Low data rate (< 100 kbps)
- Deep coverage



eNB-IoT (Rel. 14)

power consumption, positioning, mobility and more

Data rate improvements

- New UE category NB2 with max UL and max DL TBS of 2536 bits, optional support of two HARQ with TBS of 1352/1800 bits (UL/DL)

1 Mill devices per km²

- Both anchor and up to 15 non-anchor carriers can be used for paging and for random access procedure

Mobility

- Connected mode mobility realized by RRC connection re-establishment triggered by radio link failure (RLF)
- AS Release Assistance Indication

New Power Class

- New power class of 14 dBm to support coin-cell battery operation e.g. for wearables with relaxed MCL of 155 dB

Device positioning

- E-CID support
- OTDOA support based of specific narrowband positioning reference signal (NPRS)
- Measurements in idle mode

Group messaging/updates

- Adoption of Rel.13 Single Cell point-to-Multipoint (SC-PTM) feature with an maximum TBS value for NPDSCH of 2536 bits in idle mode



feMTC (Rel. 14)

power consumption, positioning, VoLTE and more

Data rate improvements

- Max uplink TBS of 2984 bits (M1)
- 10 DL HARQ processes
- HARQ-ACK Bundling in HF-FDD
- Faster frequency retuning (guard period of less than 2 symbols)

New UE Category

- New UE category (M2) with max TBS of 4008/6968 bits (UL/DL) and optionally support of 5 MHz (wideband) for PDSCH/PUSCH
- M2 device can operate as M1

Mobility

- Mobility in connected mode
- Intra-frequency and inter-frequency measurements (RSRP/RSRQ) in CE mode

VoLTE support

- Optimized parameter for VoLTE like new PUSCH repletion factors, restricted modulation schemes (QPSK) and adjusted scheduling delays

Device positioning

- E-CID support
- OTDOA support based on positioning reference signal (PRS) adapted for LTE-M (e.g. frequency hopping support, long cycles)

Group messaging/updates

- Adoption of Rel.13 Single Cell point-to-Multipoint (SC-PTM) feature
- Supported only in idle on 1.4 or 5 MHz

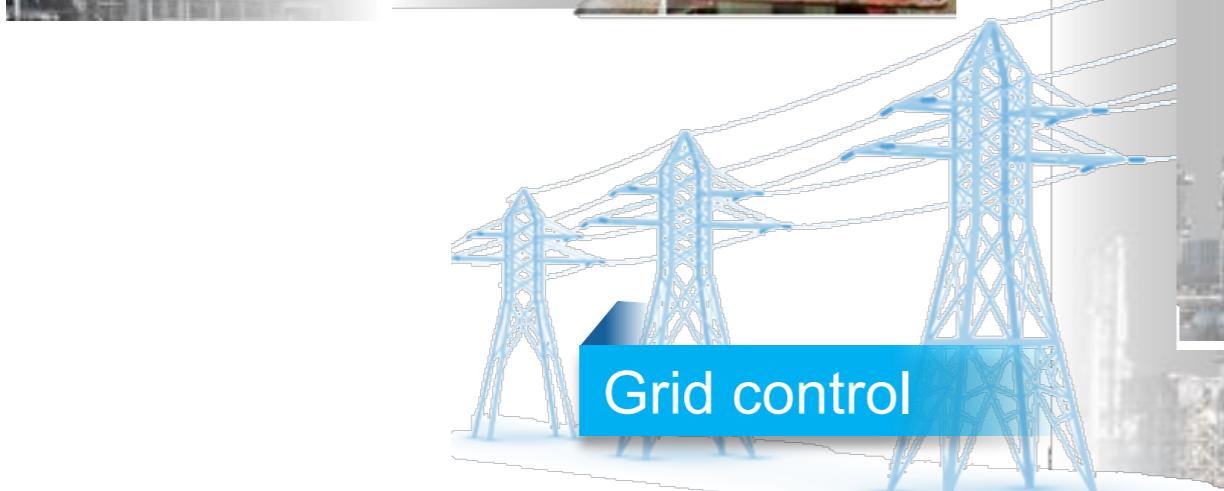
But, can we connect already everything? What about?



Remote driving



Traffic control



Grid control



Remote surgery



Process control

“Everything that will benefit from being connected will be connected”

Ericsson, 2010

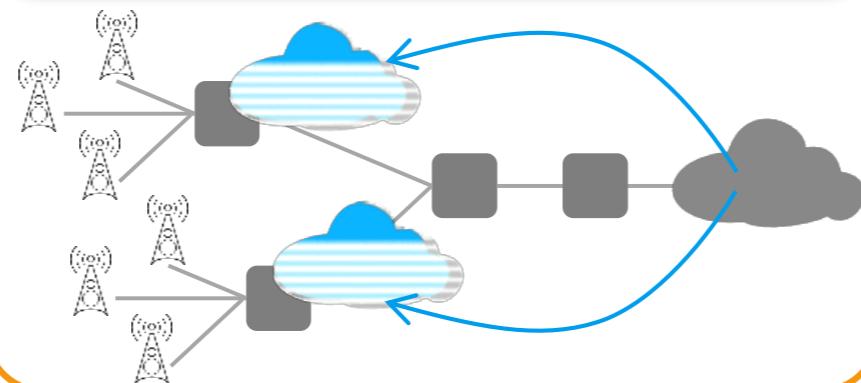
Low latency communication

Proximity

Reduce
signaling

Improve
speed

Mobile Edge Computing



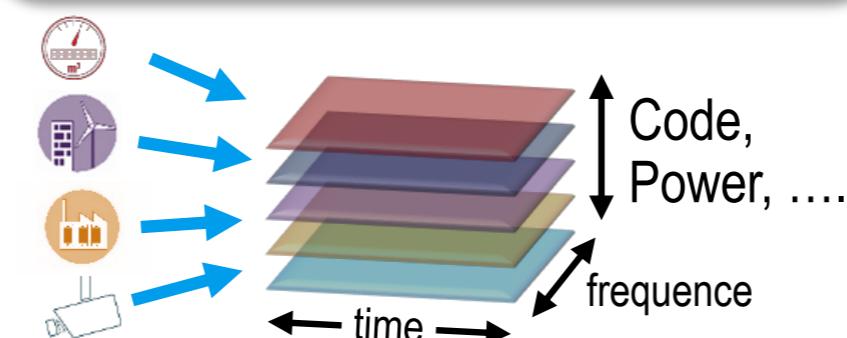
Short TTI

14 symbols | 1 ms

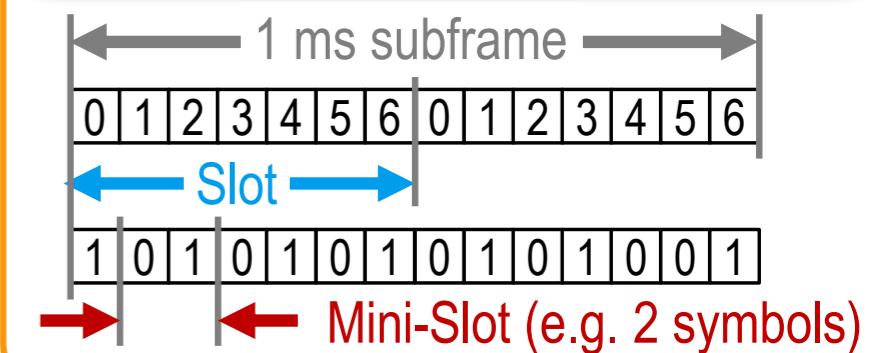
7 symbols | 0.5 ms

2 symbols | 0.14 ms

Grant free access



Mini slots

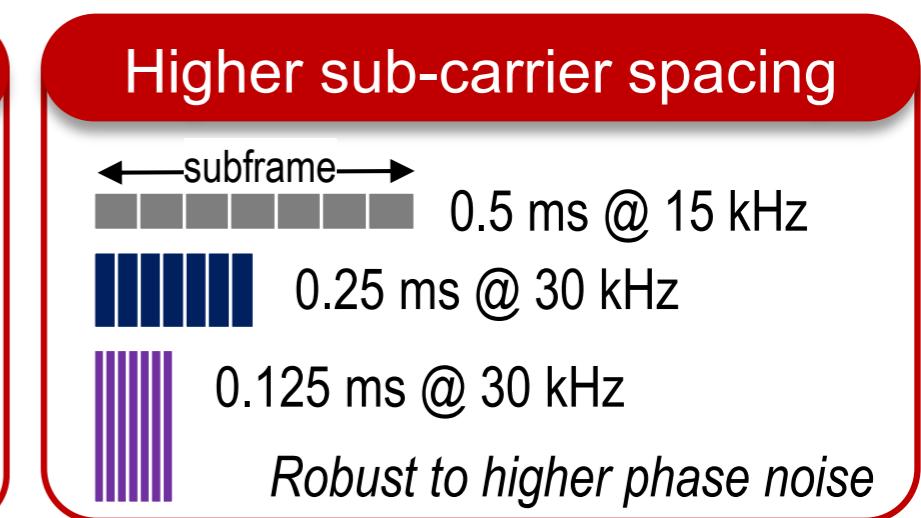
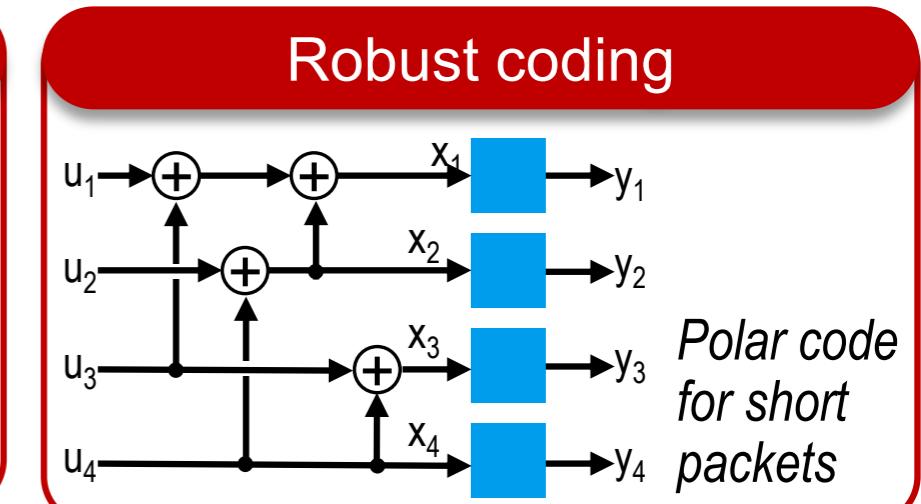
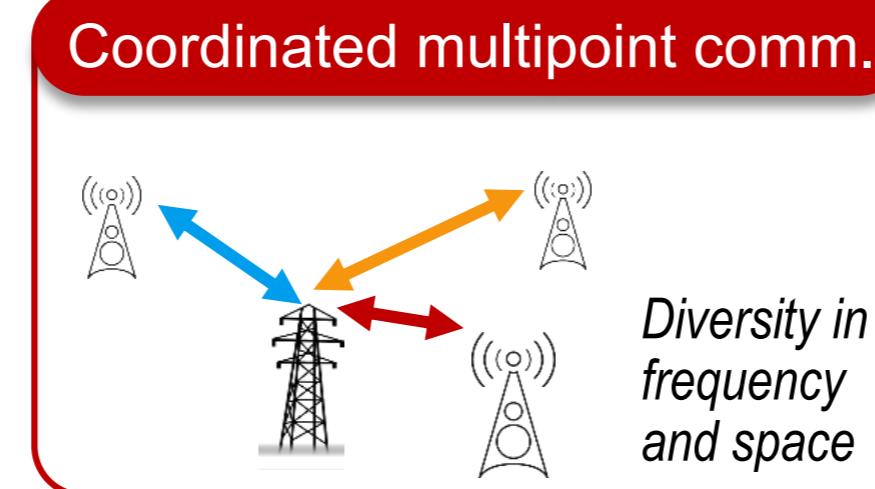
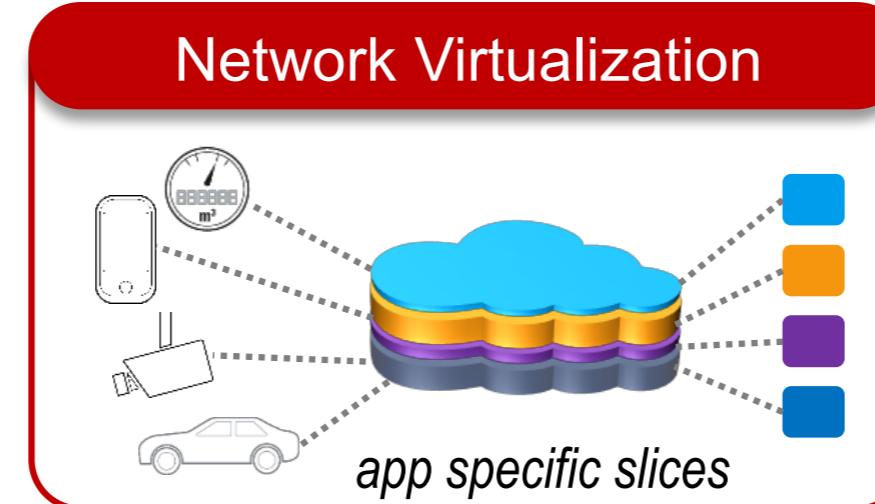


Highly Reliable Communication

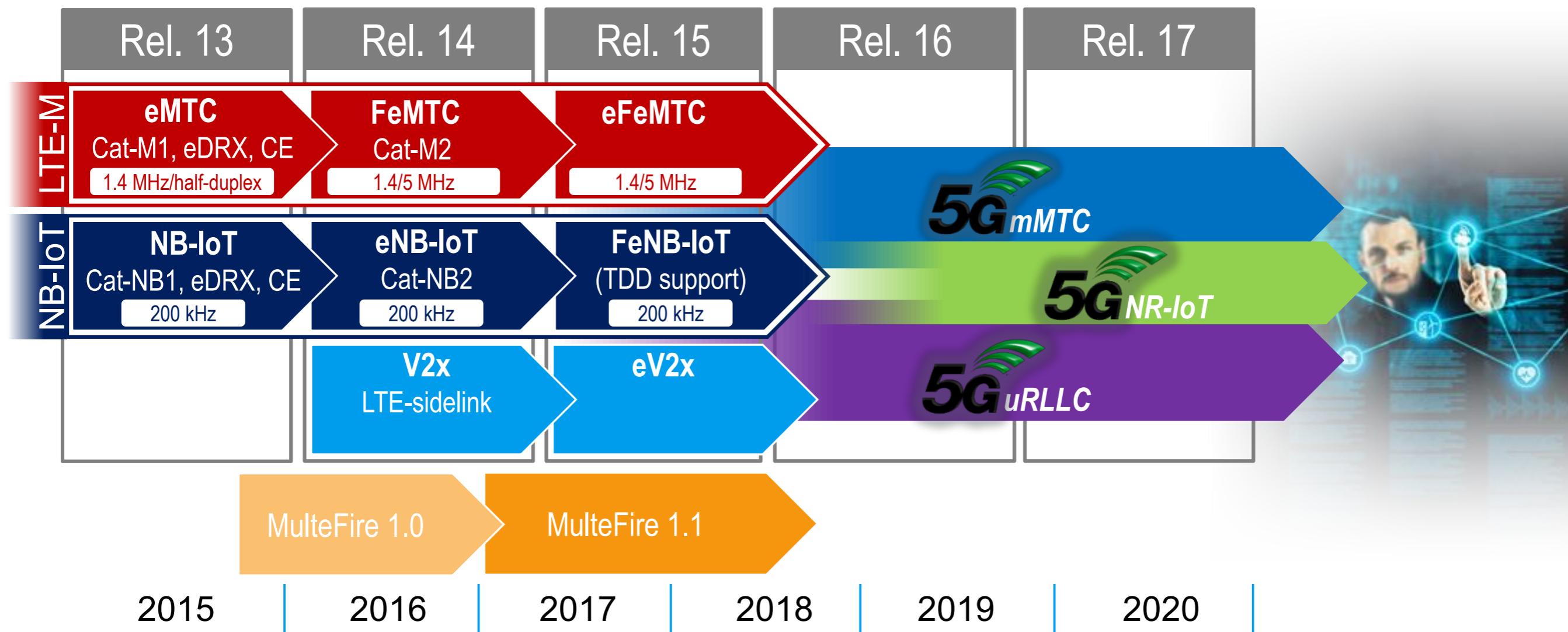
Separate network

Reduce error rate

Diversity



On the road to 5G, we are just starting !

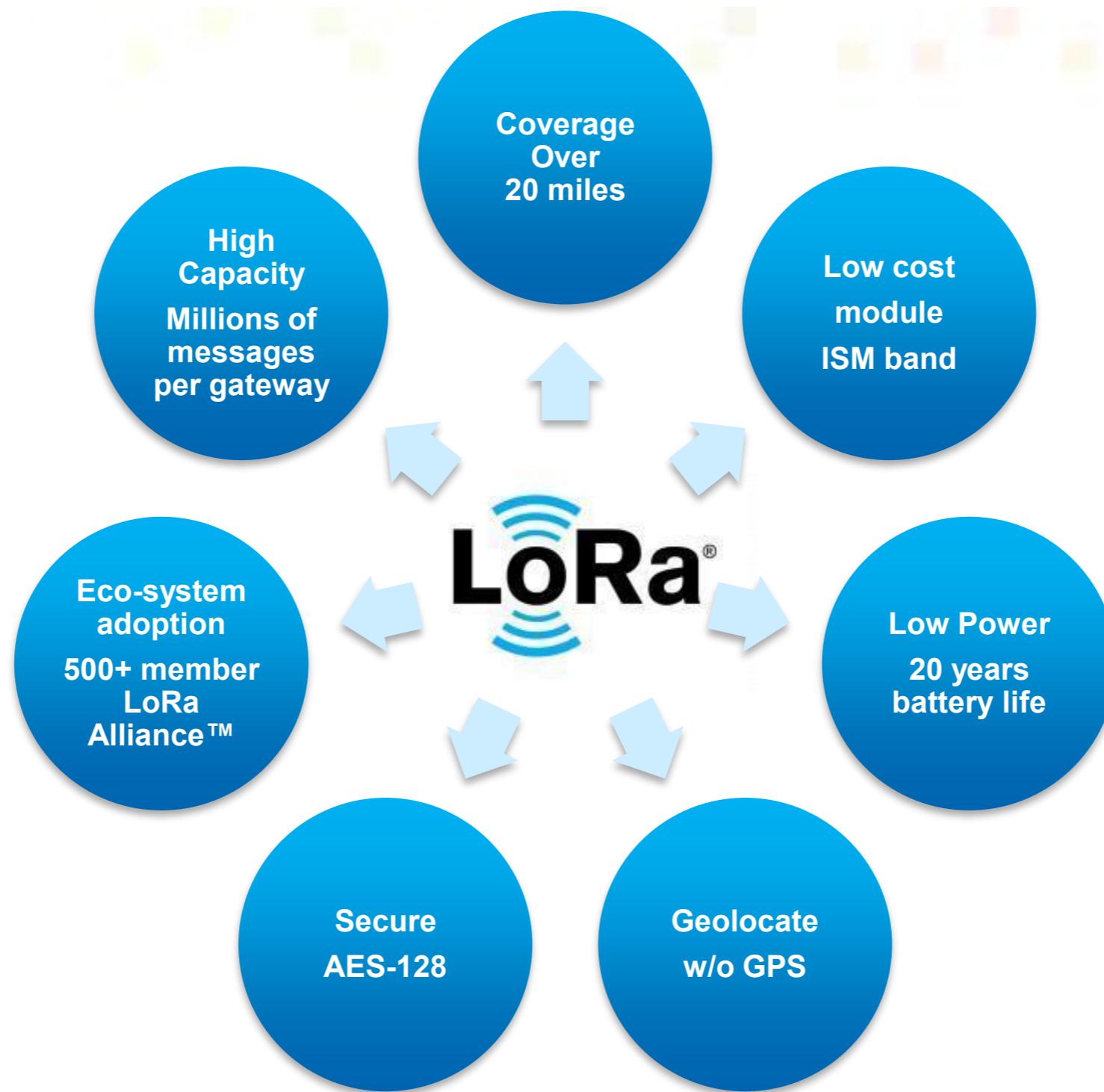


LP-WAN technologies in ISM/ SDR bands shaking the market

	 sigfox	 LoRaWAN	 uGENU simply genius	 WEIGHTLESS-N	 WEIGHTLESS-W	 WEIGHTLESS-P
Technique	Ultra Narrow Band (UNB)	Chirp Spread Spectrum	DSSS RPMA	Ultra Narrow Band (UNB)	DSSS	Narrow Band (NB)
Modulation	UL: DBPSK DL: GFSK	Frequency Chirps	UL:DBPSK DL:DBPSK	UL:DBPSK DL: -	16-QAM.... DBPSK	GMSK, QPSK
Channel BW (UpLink)	ETSI: 100 Hz FCC: 600 Hz	125 kHz 250 kHz 500 kHz	1 MHz	200 Hz	6/7/8 MHz	12.5 kHz
Band	ISM/SDR < 1 GHz	ISM/SDR < 1 GHz	ISM/SDR 2.4 GHz	ISM/SDR < 1 GHz	TV white space 470-790 MHz	ISM/SDR < 1 GHz
Driver	 sigfox	 SEMTECH	 uGENU simply genius	 nwave	 neul	 M2COMM

LoRa

LoRa Vision

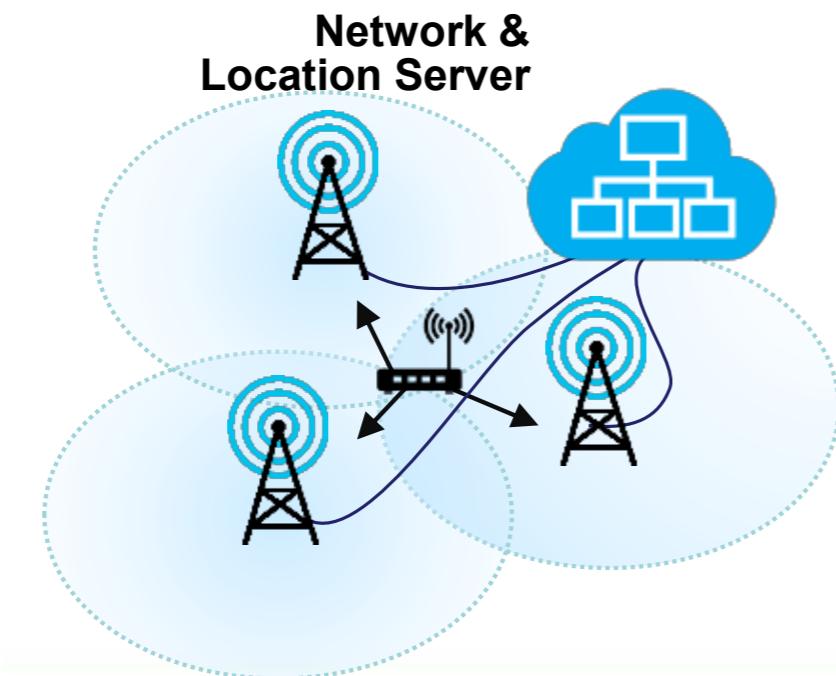


LoRa Brief History

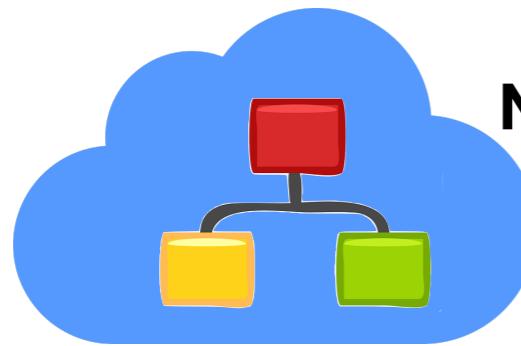
- 2012: Semtech acquires Cycléo (Grenoble)
- 2013: Launch of first LoRa radio by Semtech
- 2014: First mobile network operator trials
- 2015:
 - Launch of LoRa Alliance
 - Multiple sensors, gateways, modules available
 - Public, private, hybrid network deployments
- Today:
 - Over 500 LoRa Alliance members
 - Low power geolocation



LoRa geolocation feature



LoRaWAN Network



Network server

Gateway



DR5
Ch6



DR3
Ch4



DR5
Ch2



DR1
Ch2



*Multi-channel gateways

- Simultaneous reception of messages
- Scalable capacity
- Indoor or outdoor
- Adaptive data rate
- Supports geo-location

*LoRaWAN sensors

- Smart building
- Smart city
- Agriculture
- Supply chain
- Smart energy
- Insurance
- Smart health

LoRaWAN examples



Smart meter



Leak detection



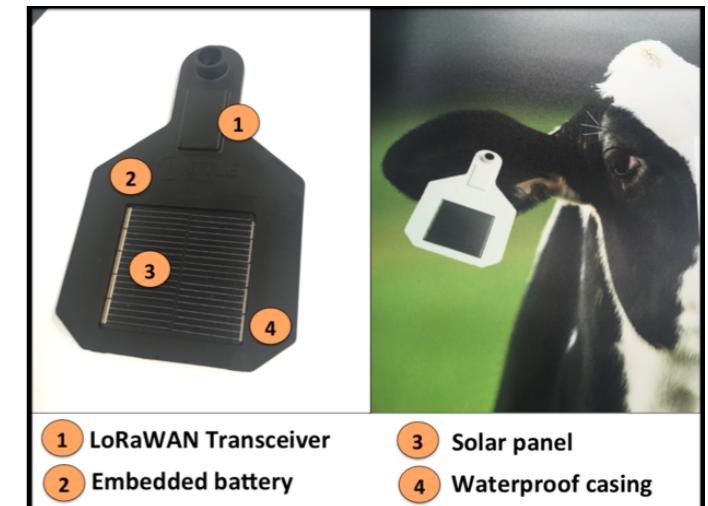
Parking sensor



Asset Tracker



[https://www.youtube.com/watch?
v=2m9nAAv7GM4](https://www.youtube.com/watch?v=2m9nAAv7GM4)

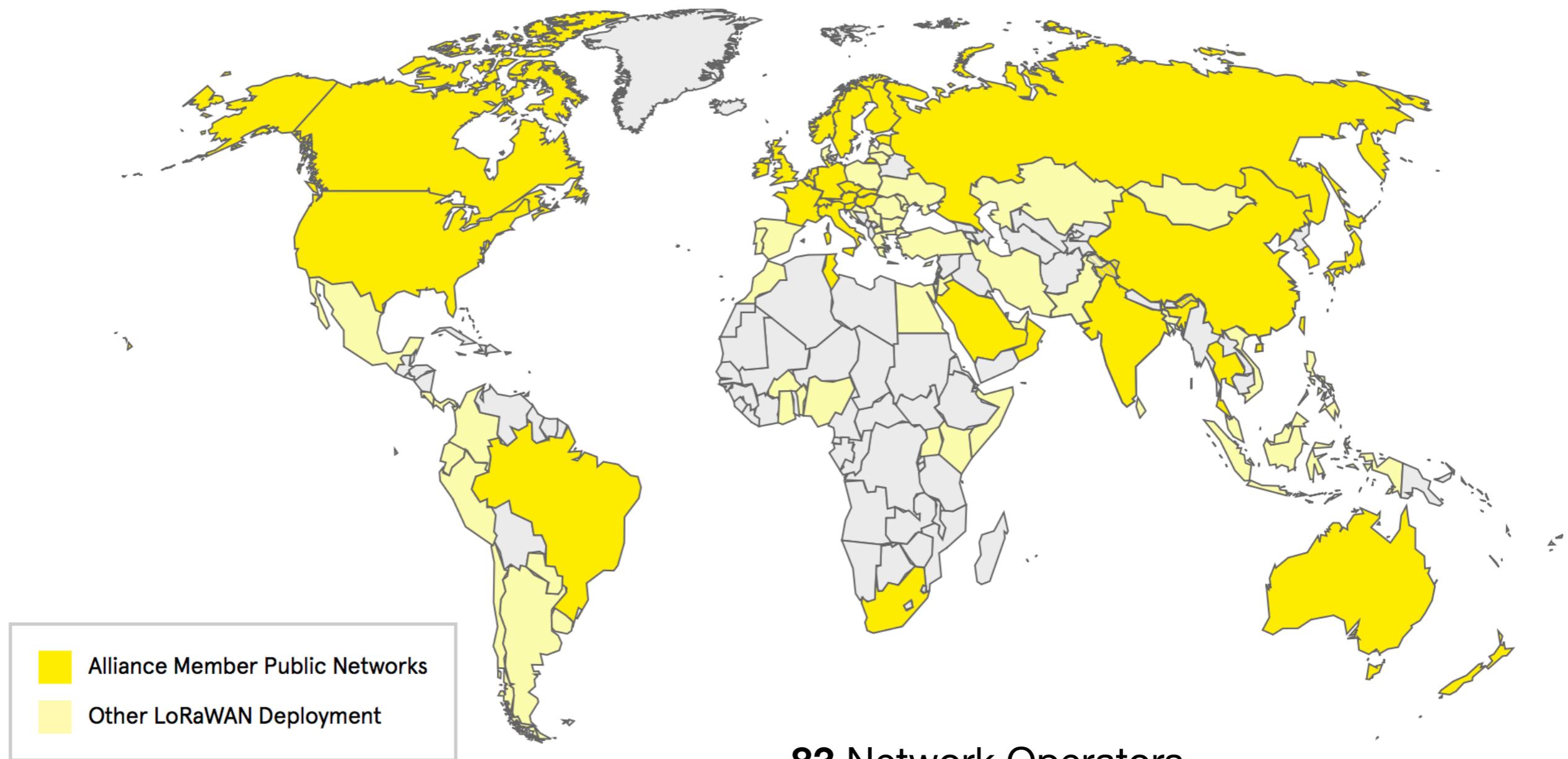


Cattle monitor

LoRaWAN for sensor nodes

- LoRaWAN specification defined by the LoRa Alliance
- Open source stack for ARM Cortex-M MCUs
- Portable to other MCU or CPU architectures
- Option 1: GitHub
 - <https://github.com/Lora-net/LoRaMac-node> (Master & develop branches)
 - <http://stackforce.github.io/LoRaMac-doc/> (Documentation)
- Option 2: ARM mbed
 - <https://developer.mbed.org/teams/Semtech/code/>
 - Many sample applications on mbed™ platform

LoRaWAN Coverage

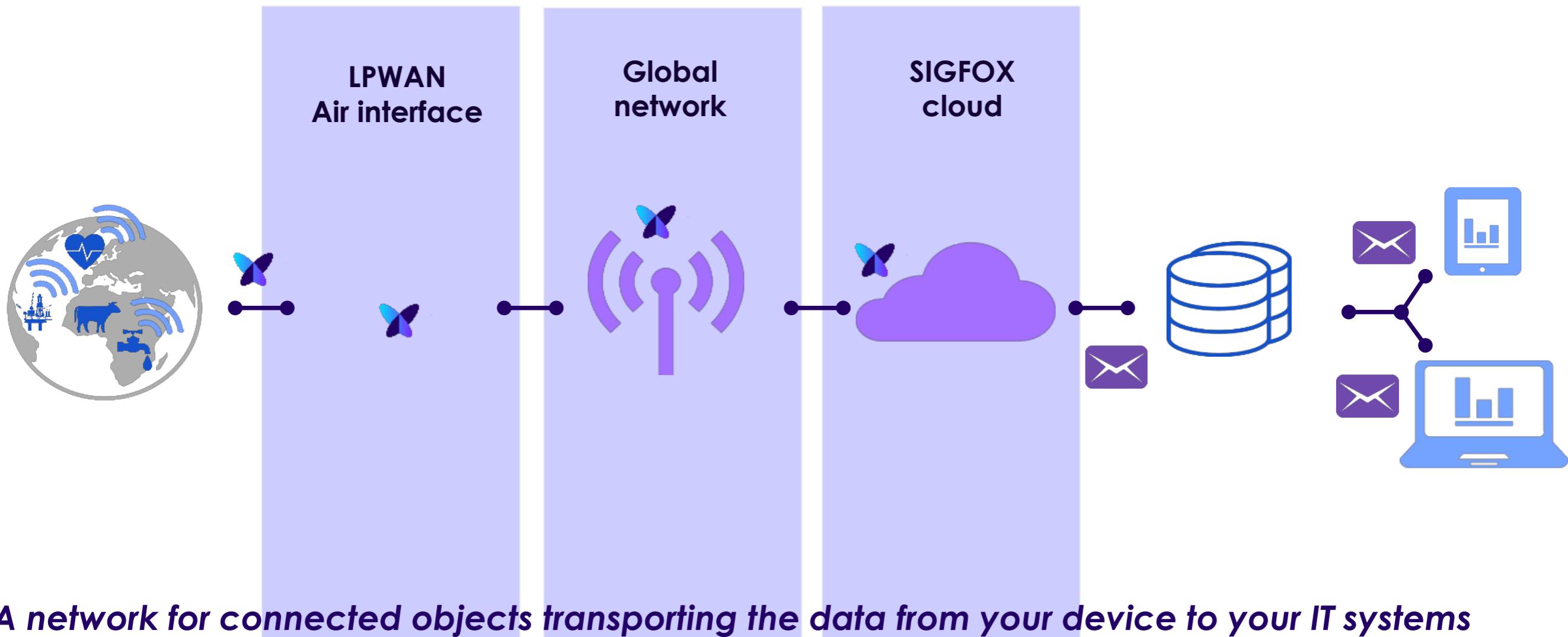


83 Network Operators
57 Alliance Member Operators
49 Countries operating in
95 Countries with LoRaWAN Deployments

SigFox

Make Things Come Alive

What it provides ?



SigFox services

Connection



Admiral Blue

Admiral Ivory

Cognition



Monarch

Location



Atlas

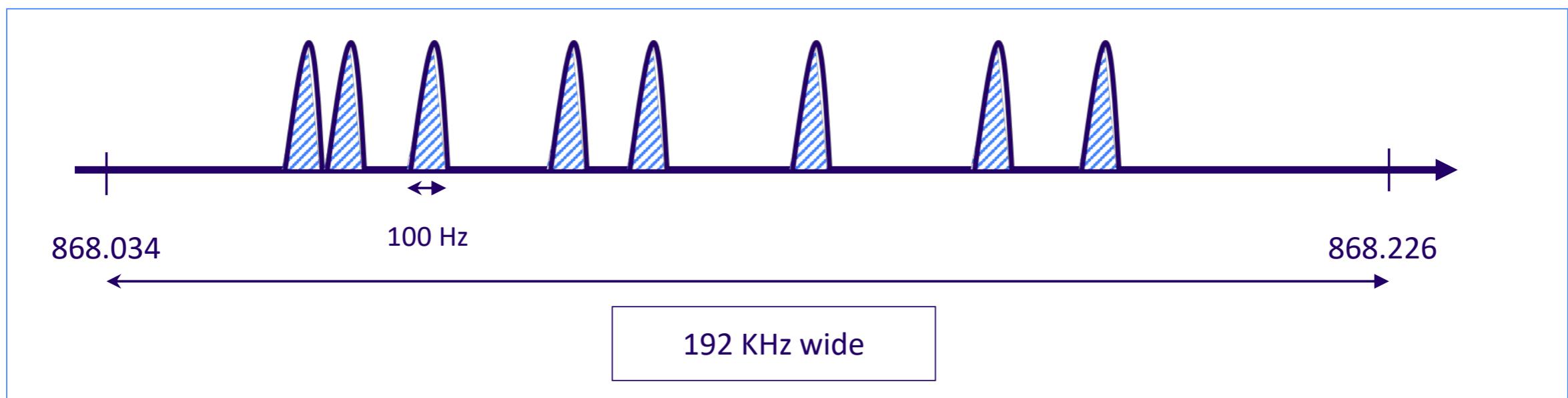
```
10011100 00101000 00010110 00111010 10000  
10111101 01011010 10001100 10101010 111011  
100100100 11010110 10101100 01011111 001110  
01001011 00100011 00011011 110100011 000111  
101110000 10111101 10101010 01011010 100110  
100000010 11100110 00011010 10010010 100000  
00100011011101111 10010011 10000000 011001  
010011001 11010100 10001101 01100111 000001  
011100001 10100100 01001000 00110111 001000  
101100111 11111100 01111101 01111101 110110  
011100010 10011100 01100010 01011111 110100  
111001100 10010010 01010011 11011011 110001  
00011111 00001000 01011011 010011  
010010 01100011 00001000 01001100 000010  
010010 10001100 110111100 10011000 100111  
00100010 11100100 00011010 10010010 100000  
01000011 00100001 00010111 01000011 000111  
101110000 10111101 10101010 01011010 100110  
100000010 11100110 00011010 10010010 100000  
00100011011101111 10010011 10000000 011001  
010011001 11010100 10001101 01100111 000001  
011100001 10100100 01001000 00110111 001000  
101100111 11111100 01111101 01111101 110110  
011100010 10011100 01100010 01011111 110100  
111001100 10010010 01001001 11011011 110001  
000100011 00010001 11100010 01011011 110001
```

SigFox Technical Details

- Ultra Narrow Band
- Random Access
- Cooperative Reception
- Small messages
- Security

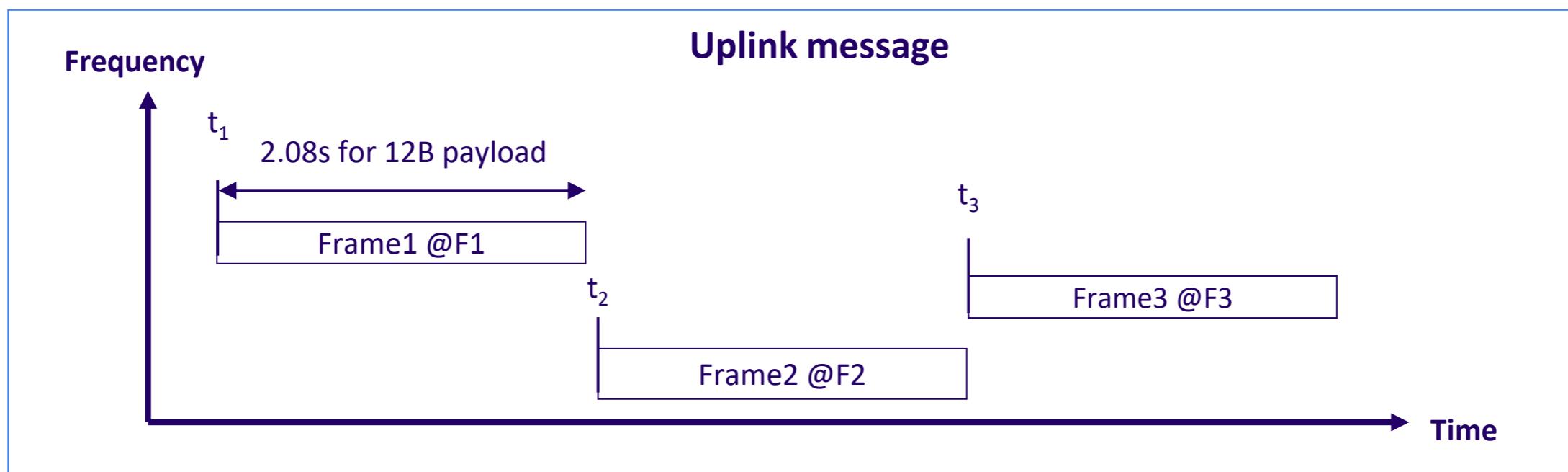
Ultra Narrow Band

- Currently spreads on a 200KHz part of the spectrum
- High spectrum efficiency $1\text{bit/s} = 1\text{Hz of bandwidth}$
- Each message is $\sim 100\text{Hz}$ wide



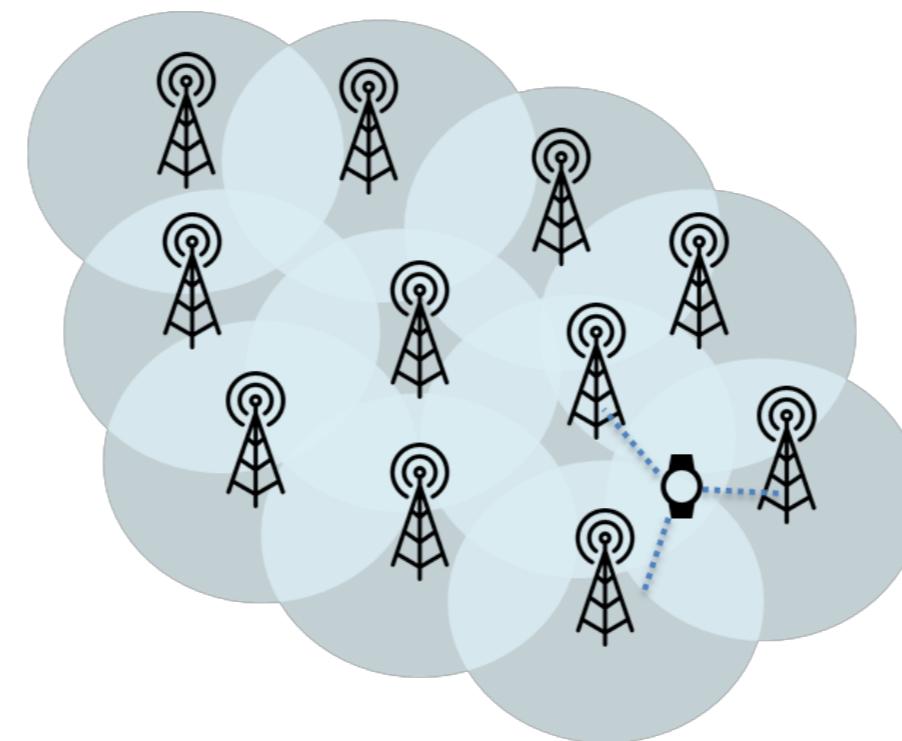
Random Access

- Unsynchronized transmission between the network and the device
- The device transfers a small amount of energy on a random frequency with no protocol overhead (frequency hopping)
- SIGFOX Base stations permanently listen to the spectrum and interpret received UNB signals
- The same frame is sent 3 times enabling time and frequency diversity

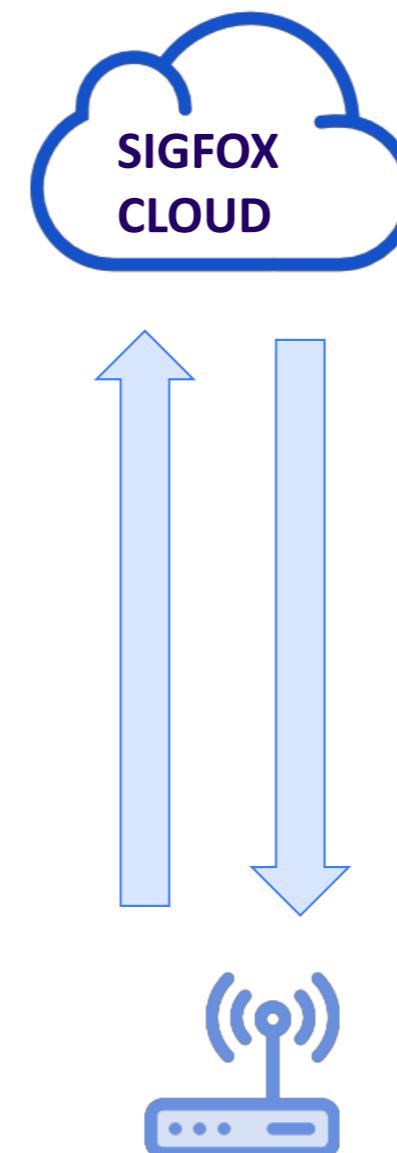


Cooperative Reception

- The radio planning is done in a way that in average a message is received by 3 different Base stations
- The spatial diversity increases the chances of receiving the message without errors on one of the nearby base stations



Small Messages



UPLINK *12-Byte payload*

- Sensor data
- Event status
- GPS fix
- Application data

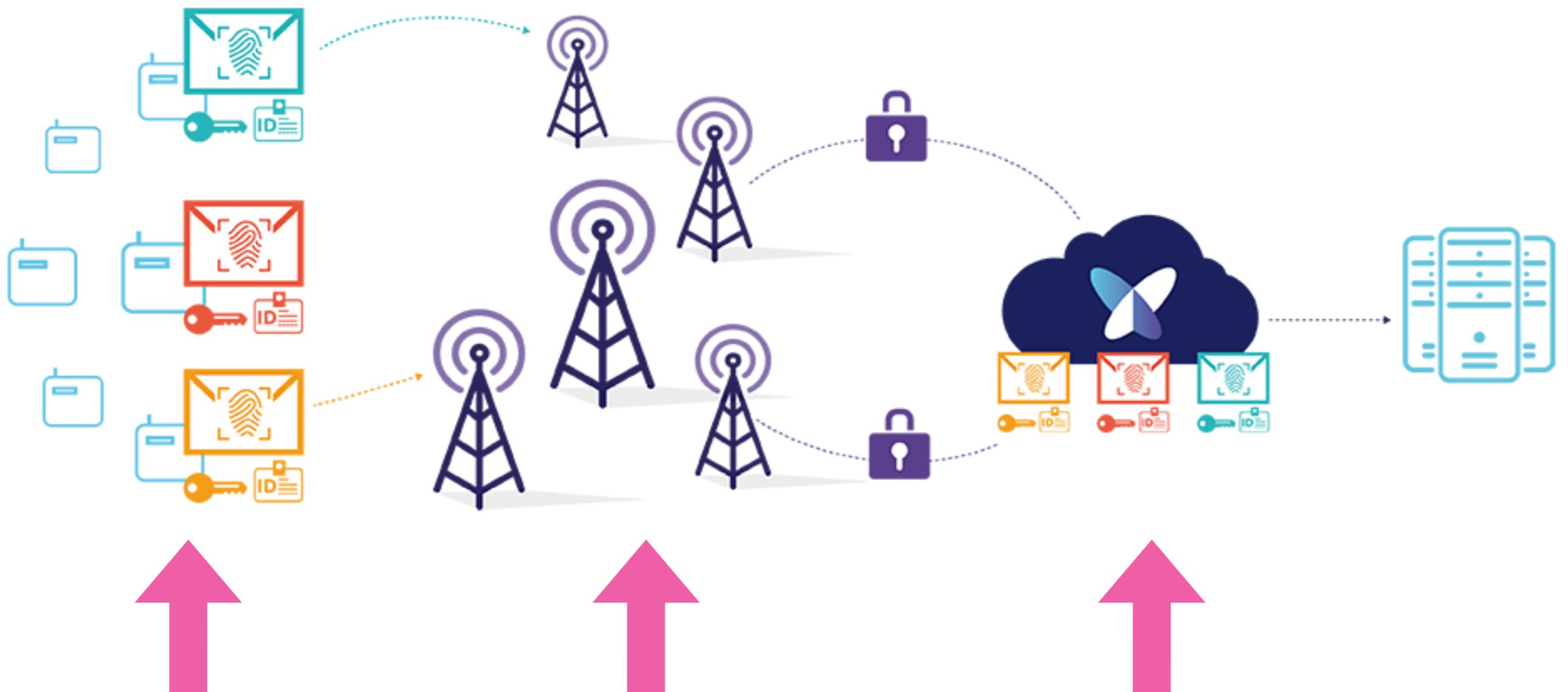
1 % duty cycle for Objects
Up to 6 messages/hour

DOWNLINK *8-Byte payload*

- Action / actuator trigger
- Device management
- Application parameter setting

10 % duty cycle for Base Stations
4 guaranteed downlink msg/day

Security



- Sigfox ReadyTM device not connected thru IP
- payload cyphering and secure element as an option
- Random frequencies.
- anti-jamming
- Secure transmission
- Authentication and Integrity
- Anti replay

Use cases

Assets Management and Tracking
Freight Monitoring



Smart Building Management
Office management
Smart metering



Infrastructure monitoring
Preventive maintenance



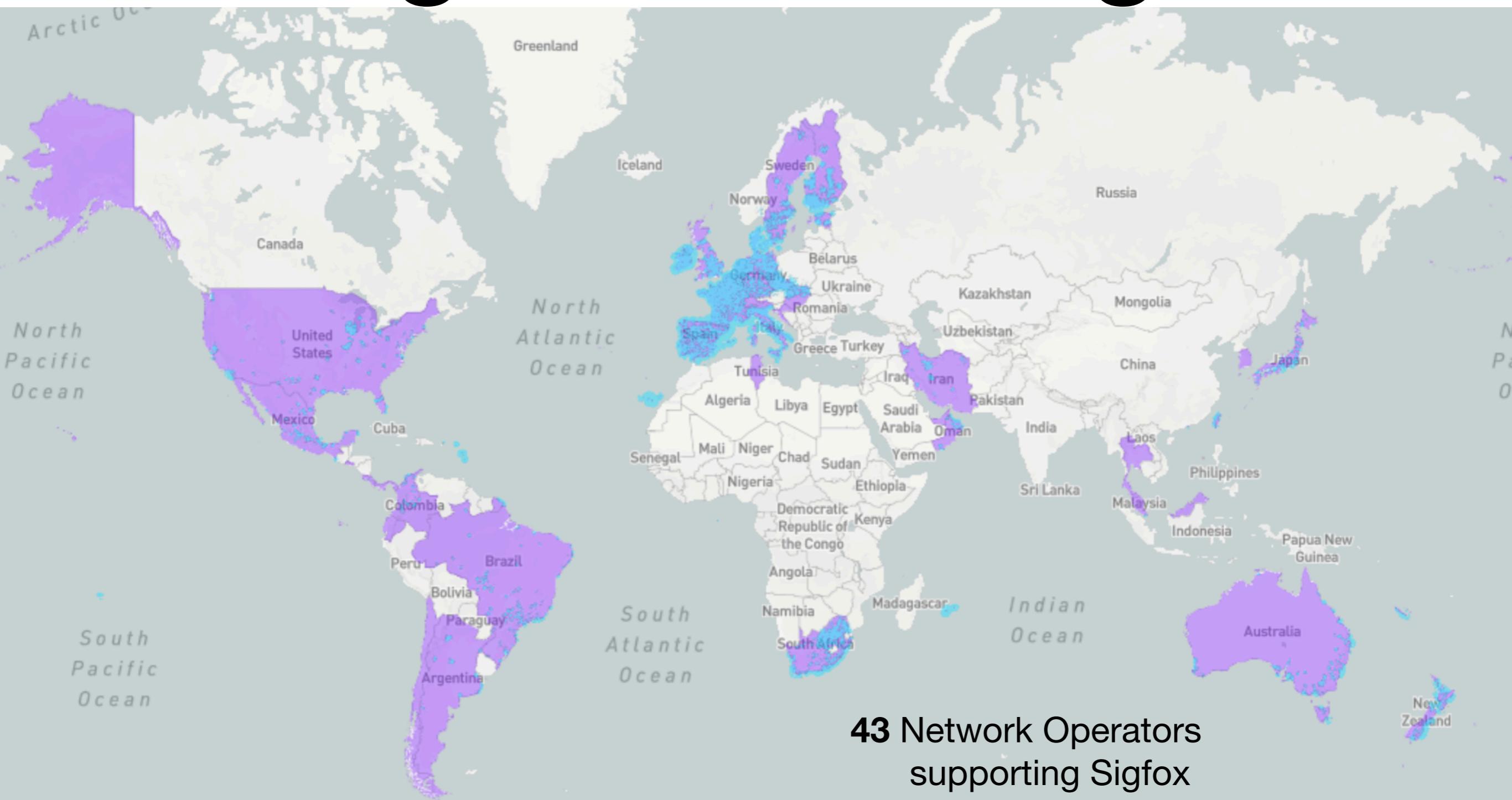
Customer satisfaction



Security as a backup
Stolen vehicle recovery



SigFox Coverage



Useful links

- sigfox.com for general and coverage information
- partners.sigfox.com for existing solutions ranging from RF modules to application platforms
- resources.sigfox.com to access useful documentation and ask questions
- build.sigfox.com a guide for building a device from design to industrialization

Hands on

IPv6, MQTT

IoT Lab

- <https://www.iot-lab.info/tutorials/understand-ipv6-subnetting-on-the-fit-iot-lab-testbed/>
- <https://www.iot-lab.info/tutorials/contiki-coap-rpl-tschi/>
- <https://www.iot-lab.info/tutorials/public-ipv6-coap/>
- Discover MQTT
<https://www.iot-lab.info/tutorials/mqtt-sn-using-riot-with-a8-m3-nodes/>

Questions ?

