Narrow Band for IoT

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INNOVATIVE SMART SYSTEMS

SUMMARY

Introduction

- Narrowband IoT (NB-IoT) is a Low Power Wide Area Network (LPWAN) radio technology standard developed by 3GPP (3rd Generation Partnership Project) to enable a wide range of cellular devices and IoT services

- Release 13 was launched in June 2016

- Main goal: achieve **indoor/outdoor coverage**, low cost, long battery life, and to support massive machine-type communication (mMTC)

- In competition with networks like LoRa and Sigfox

Physical Layer - Frequencies, BW & Data Rate

- Only uses **licensed** LTE frequency bands, differently from Sigfox and LoRa that use Unlicensed ISM (Industrial Scientific and Medical) bands

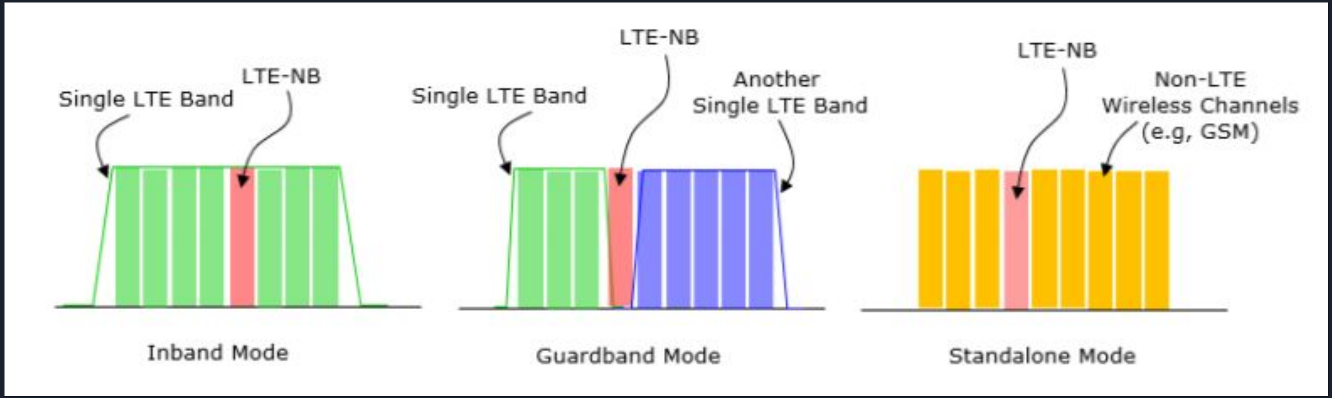
- Frequency band of **180 kHz** bandwidth => low cost

- Data rate for transmission is limited at **250 Kbits/s**

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit			Downlink (DL) operating band BS transmit UE receive			Duplex Mode
	F_{UL_low}	–	F_{UL_high}	F_{DL_low}	–	F_{DL_high}	
1	1920 MHz	–	1980 MHz	2110 MHz	–	2170 MHz	HD-FDD
2	1850 MHz	–	1910 MHz	1930 MHz	–	1990 MHz	HD-FDD
3	1710 MHz	–	1785 MHz	1805 MHz	–	1880 MHz	HD-FDD
5	824 MHz	–	849 MHz	869 MHz	–	894MHz	HD-FDD
8	880 MHz	–	915 MHz	925 MHz	–	960 MHz	HD-FDD
11	1427.9 MHz	–	1447.9 MHz	1475.9 MHz	–	1495.9 MHz	HD-FDD
12	699 MHz	–	716 MHz	729 MHz	–	746 MHz	HD-FDD
13	777 MHz	–	787 MHz	746 MHz	–	756 MHz	HD-FDD
17	704 MHz	–	716 MHz	734 MHz	–	746 MHz	HD-FDD
18	815 MHz	–	830 MHz	860 MHz	–	875 MHz	HD-FDD
19	830 MHz	–	845 MHz	875 MHz	–	890 MHz	HD-FDD
20	832 MHz	–	862 MHz	791 MHz	–	821 MHz	HD-FDD
25	1850 MHz	–	1915 MHz	1930 MHz	–	1995 MHz	HD-FDD
26	814 MHz	–	849 MHz	859 MHz	–	894 MHz	HD-FDD
28	703 MHz	–	748 MHz	758 MHz	–	803 MHz	HD-FDD
31	452.5 MHz	–	457.5 MHz	462.5 MHz	–	467.5 MHz	HD-FDD
66	1710 MHz	–	1780 MHz	2110 MHz	–	2200 MHz	HD-FDD
70	1695 MHz	–	1710 MHz	1995 MHz	–	2020 MHz	HD-FDD

Physical Layer - Modes of operation

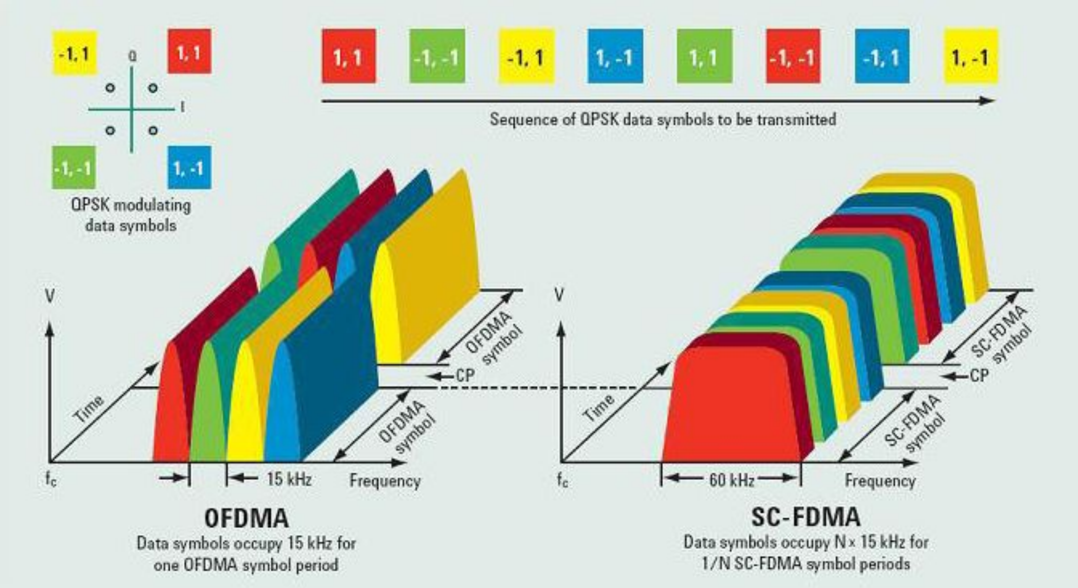
Flexible deployment with 3 modes of operation:



Physical layer - Modulation

NB-IoT employs the **quadrature phase-shift keying (QPSK)** modulation, with different methods:

- For downlink => Orthogonal Frequency-Division Multiple Access (OFDMA)
- For uplink => Single-Carrier Frequency Division Multiple Access (SC-FDMA)



Physical layer - Channel access

For downlink we have 3 channels:

- NPBCH, the narrowband physical broadcast channel
- NPDCCH, the narrow band physical downlink control channel
- NPDSCH, the narrow band physical downlink shared channel

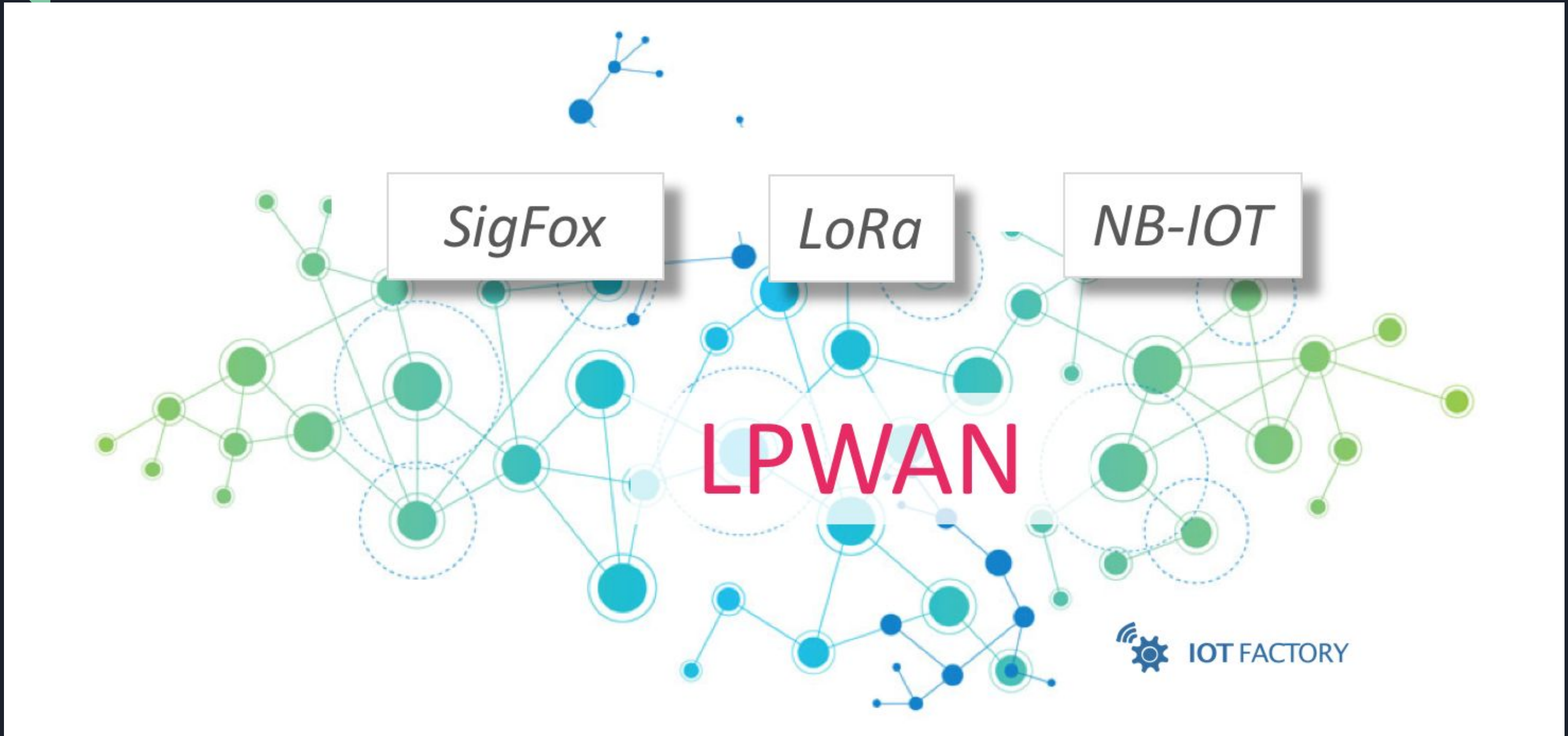
For the uperlink we have 2 channels:

- NPUSCH, the narrowband physical uplink shared channel
- NPRACH, the narrowband physical random-access channel

MAC Layer

- Power Consumption
- Security

MAC Layer - Power consumption



MAC Layer - Power consumption

U-Blox Sara N211 NB-IoT chip

MAC Layer - Power consumption

Theoretical number : *“10 years of connectivity with a single battery”*

MAC Layer - Power consumption

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Without Power Saving Mode (PSM)

OVERALL RESULTS FROM THE NB-IOT EXPERIMENTAL STUDY

	Packet Interval	Avg. Current Consum.	Expec. Batt. Life
Comm. Netw. A	30 s	27.7 mA	8.16 days
Comm. Netw. B	30 s	57.7 mA	5.00 days
Priv. Netw.	30 s	20.4 mA	9.97 days

MAC Layer - Power consumption

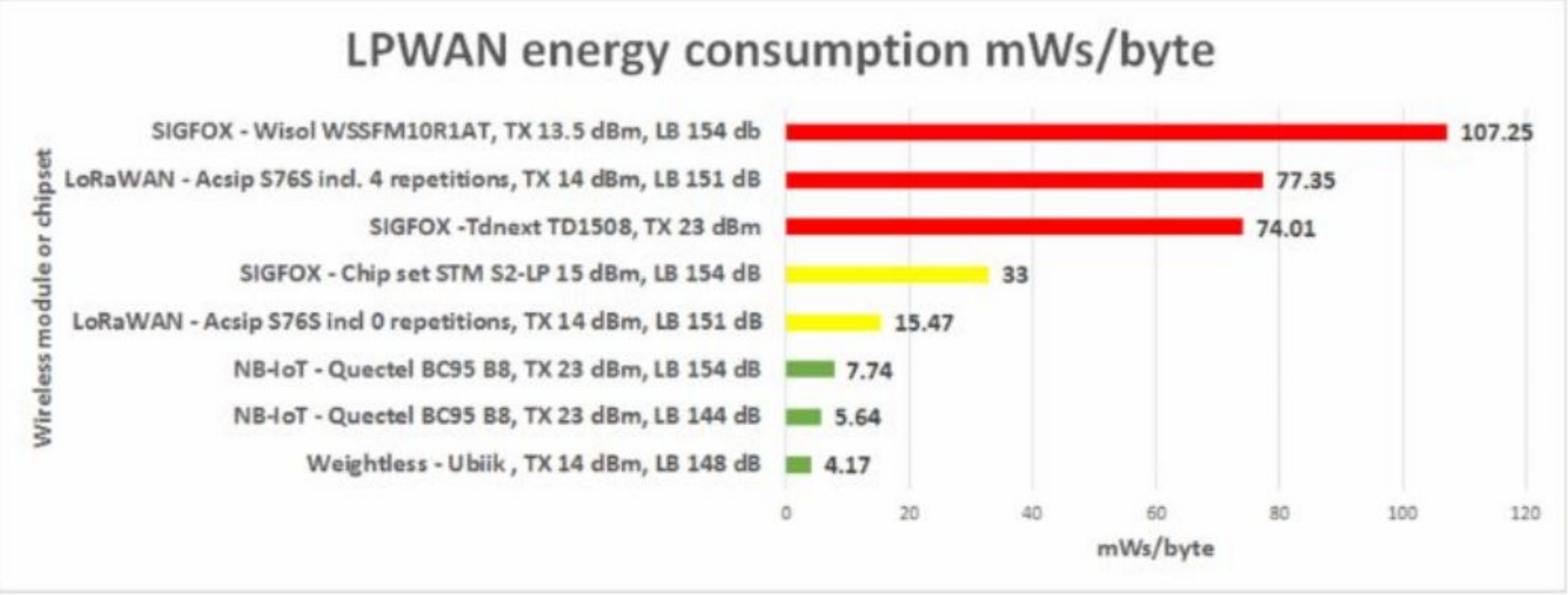
Theoretical number : *"10 years of connectivity with a single battery"*

With Power Saving Mode (PSM)

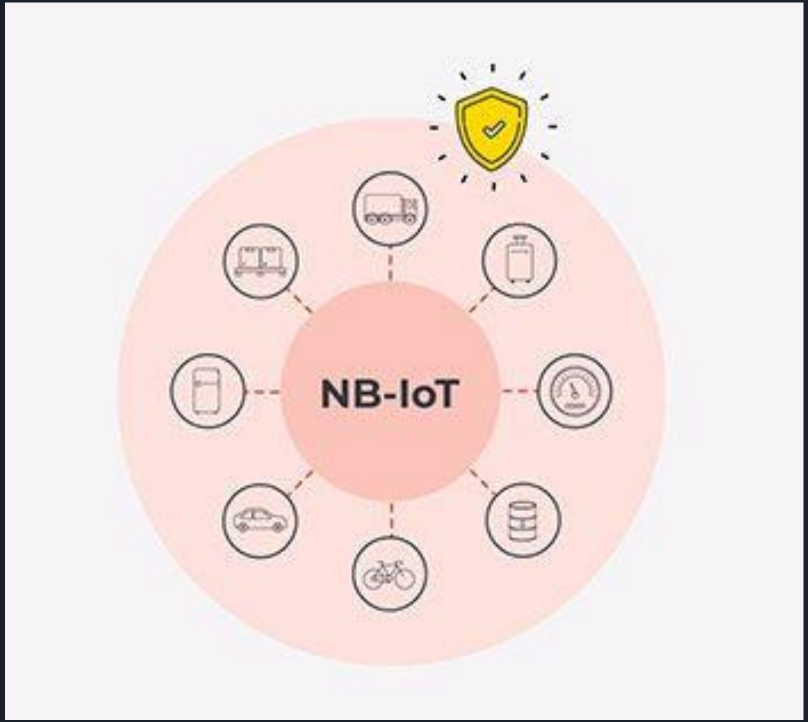
ACHIEVABLE NB-IOT BATTERY LIFETIME IN OPTIMIZED NETWORK CONFIGURATIONS

	Packet Interval	PSM Active	Optimized Peripheral
Comm. Netw. A	30 s	10.69 days	21.9 days
	5 m	12.81 days	222.65 days
	1 h	13.08 days	4.62 years
	1 d	13.10 days	10.89 years
Comm. Netw. B	30 s	6.00 days	7.3 days
	5 m	11.72 days	76.65 days
	1 h	12.97 days	2.12 years
	1 d	13.10 days	9.77 years
Priv. Netw.	30 s	9.97 days	18.25 days
	5 m	12.70 days	175.2 days
	1 h	13.07 days	4.01 years
	1 d	13.10 days	10.73 years

MAC Layer - Power consumption



MAC Layer - Security



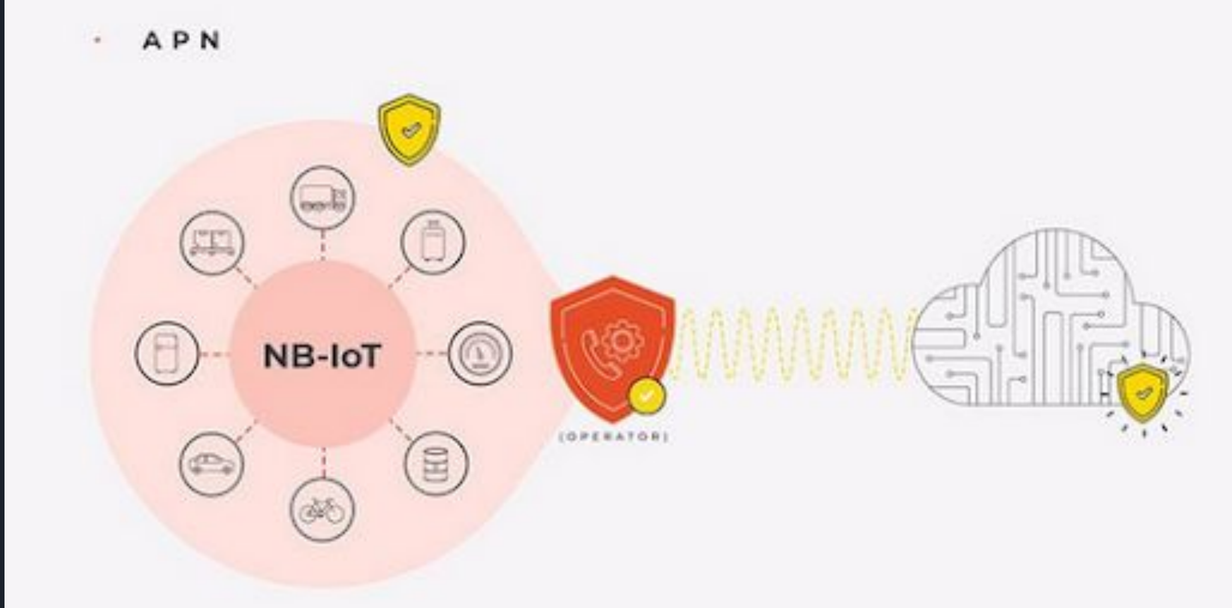
MAC Layer - Security

Authentication : The data which are sent to the cloud are authorized and are not replaced with another.

Encryption : External observer cannot understand the exchanged messages. Only the cloud with the decryption key can retrieve the messages.

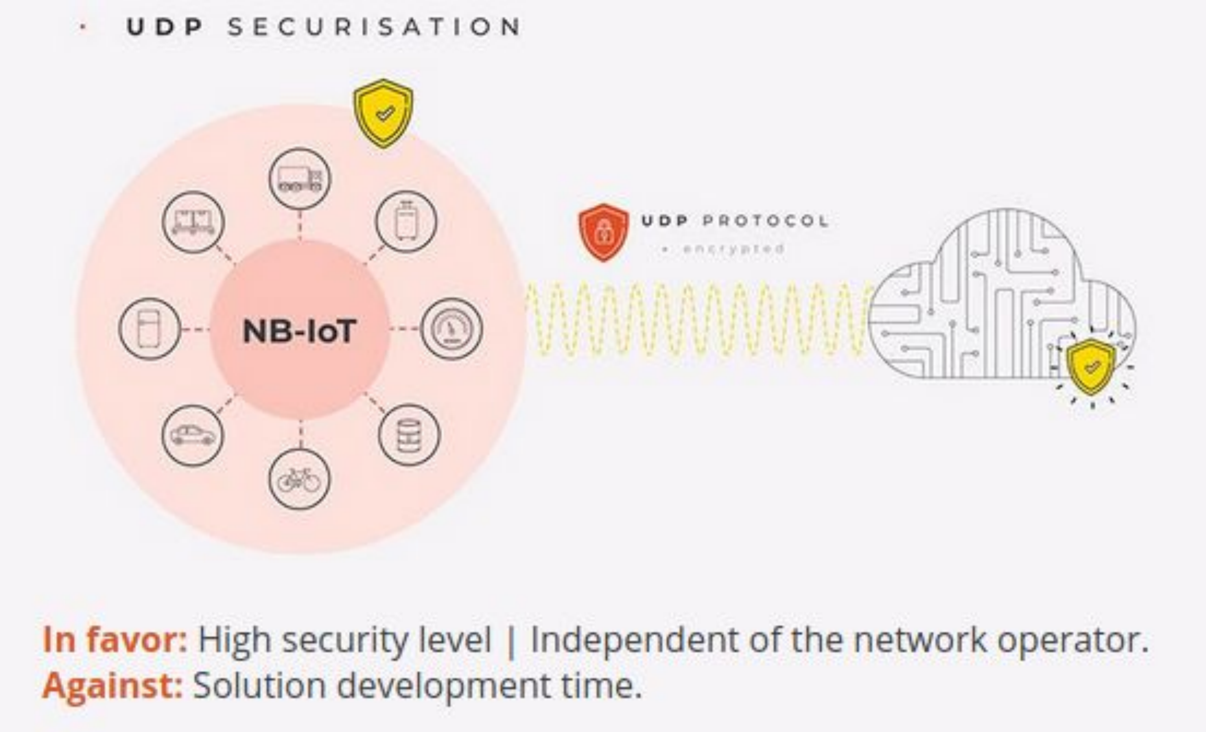
Non-manipulation : The exchanged messages are not altered

MAC Layer - Security



In favor: High security level | Rapid solution development.
Against: It implies costs for the customer | Little flexibility to operator changes.

MAC Layer - Security



Overview

Comparison between the different LWAN technologies (NB-IoT, Sigfox and LoRa):

Quality of service

- Sigfox and LoRa employ unlicensed spectra and asynchronous communication protocols
- **NB-IoT assures QoS** employs a licensed spectra and an LTE-based synchronous protocol

Energy consumption & Latency

- NB-IoT presents a **higher consumption of energy** due to its synchronous protocol and QoS
- NB-IoT presents a lower latency than LoRa and Sigfox

Overview

Scalability & Payload

- NB-IoT allows connectivity of up to **100K devices** per cell (compared to 50K per cell for Sigfox and LoRa)
- NB-IoT allows the transmission of up to **1600 bytes** of data (LoRa allows 243 bytes of data and Sigfox 12 bytes of data)

Range

- Sigfox: 10 km (in urban area), 40 km (in rural)
- LoRa: 5 km (urban) and 20 km (rural)
- NB-IoT: 1 km (urban), 10 km (rural) => lowest range

THANK YOU

for your

Attention