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Connecting with intelligence

Market segmentation for LPWAN technologies

Oct 2019

Why all the buzz ?

IoT market overview and segmentation

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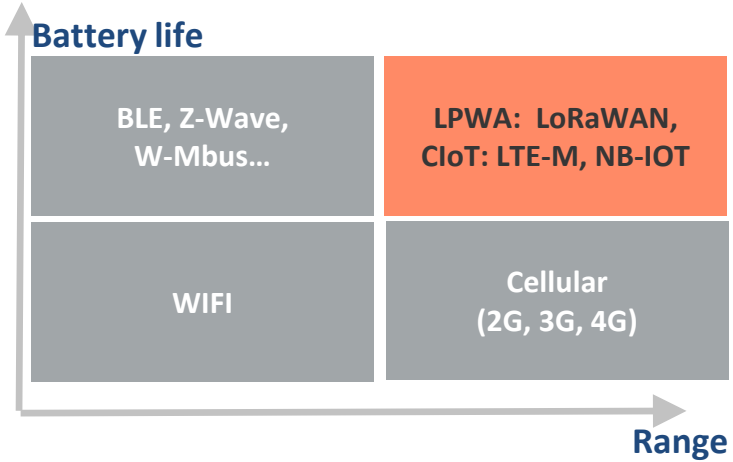
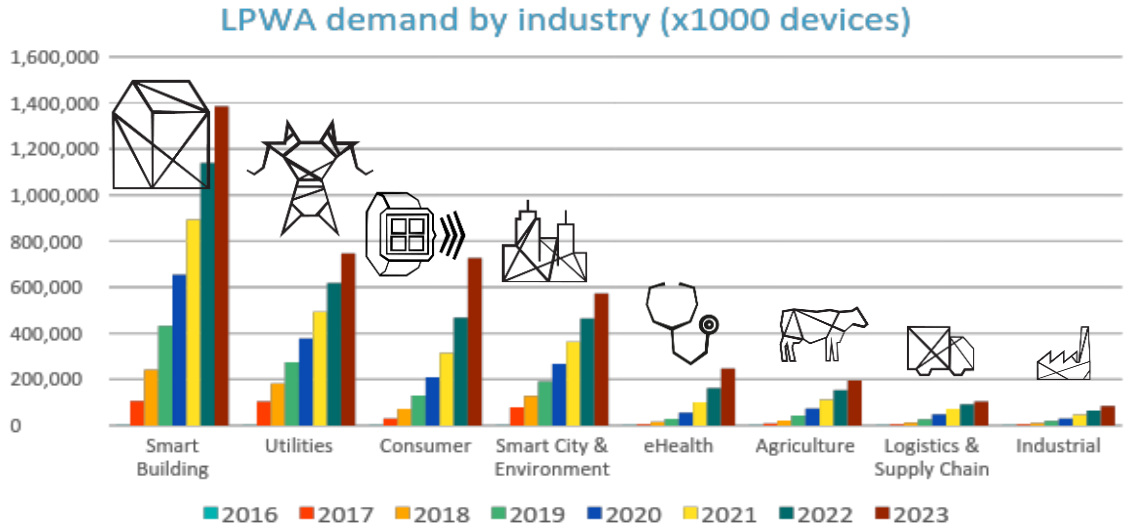
Convergence of IoT ISM band technologies to LPWAN

4 billion LPWA connected devices worldwide by **2023**





Source : Machina Research 2016

- With Cost, Battery and Range constraints solved, LPWAN technology is driving massive IoT growth
- Current short range ISM band technologies will converge towards LPWAN technology.
- LoRaWAN best positioned to capture the short range ISM band market segment.
- Opportunity for MNOs to capture and monetise short range technologies with LoRaWAN

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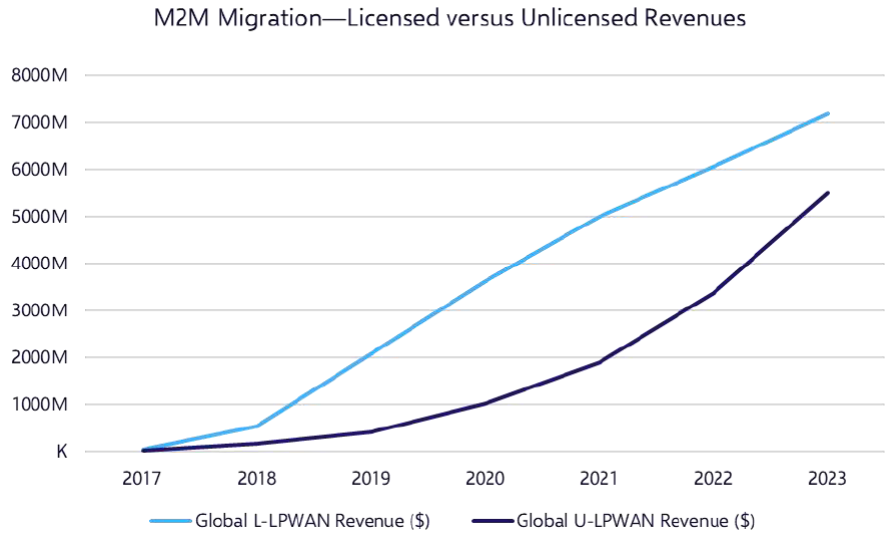
Market split for M2M migration

- U-LPWAN : Connections CAGR 181%, Revenue CAGR 159%
- L-LPWAN : Connections CAGR 145%, Revenue CAGR 128%



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LoRaWAN Overview

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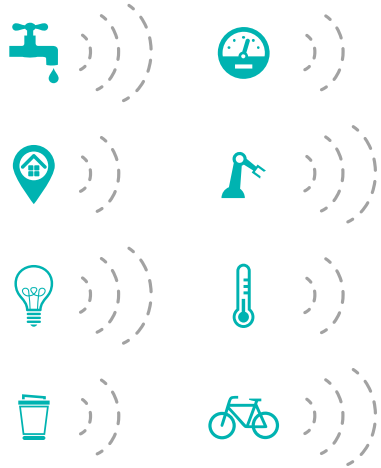
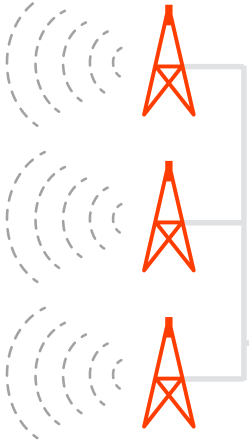
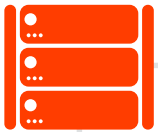
LoRaWAN Network Architecture







Network Server

NS-AS API

OSS / Supervision

Apps

AS

Up to 15 km range

Designed for billions of objects	Low battery consumption 10+ years life	Low deployment cost, unlicensed spectrum, limited network planning	Multiplier effect with every base station, Macro-diversity

AES Secured Payload

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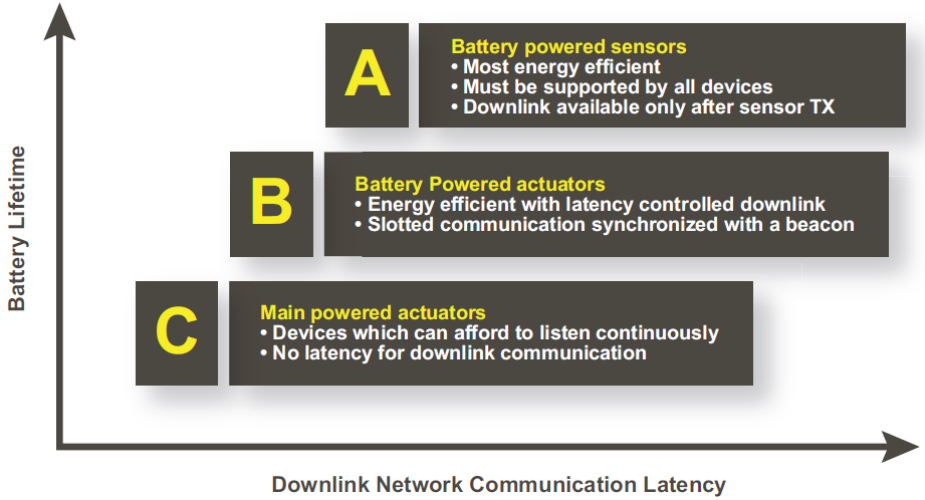
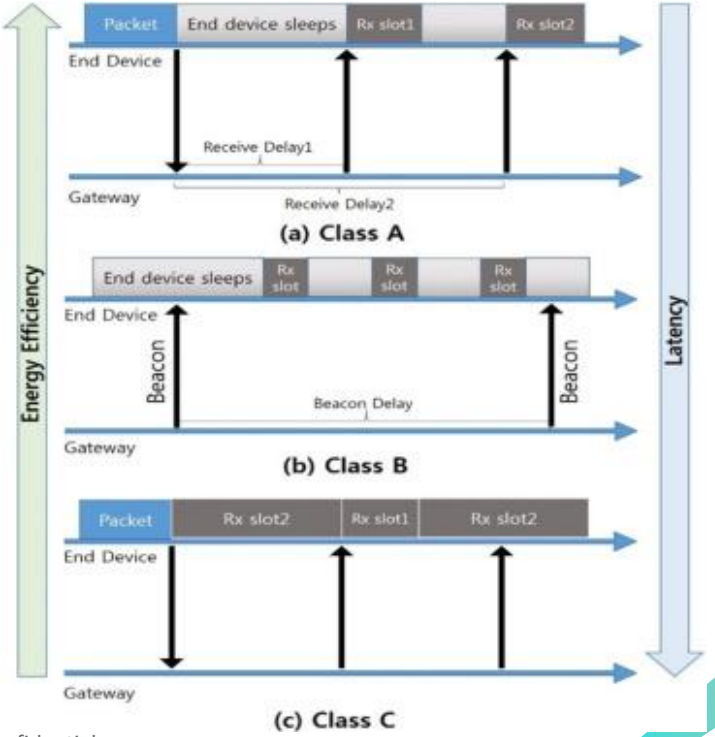
LoRaWAN Device Classes

- 3 modes to optimize all IoT use cases





Source: LoRa Alliance

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Multicast

LoRaWAN natively supports multicast/FUOTA in LoRaWAN 1.0.x

Benefits

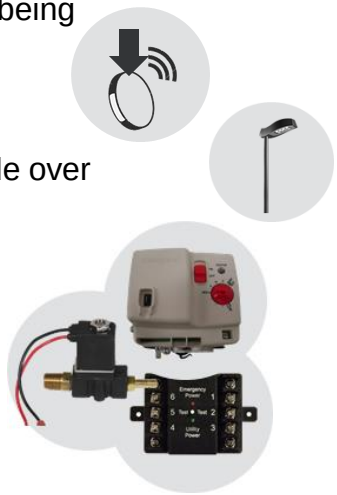
- ❑ Minimize DL radio congestion for class B & C devices
- ❑ Dynamic session setup allows optimized Class A device power consumption
- ❑ Dynamic Multicast assignment is being developed

Use cases enabled

- ★ Power efficient device FW upgrade over the air
- ★ Massive Device Reconfiguration
- ★ Synchronized device activation
- ★ Emergency actions

3GPP support for multicast is only after Rel 14

Source: https://www.qualcomm.com/news/onq/2017/06/15/lte-iot-starting-connect-massive-iot-today-thanks-emtc-and-nb-iot



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Cellular IoT Overview

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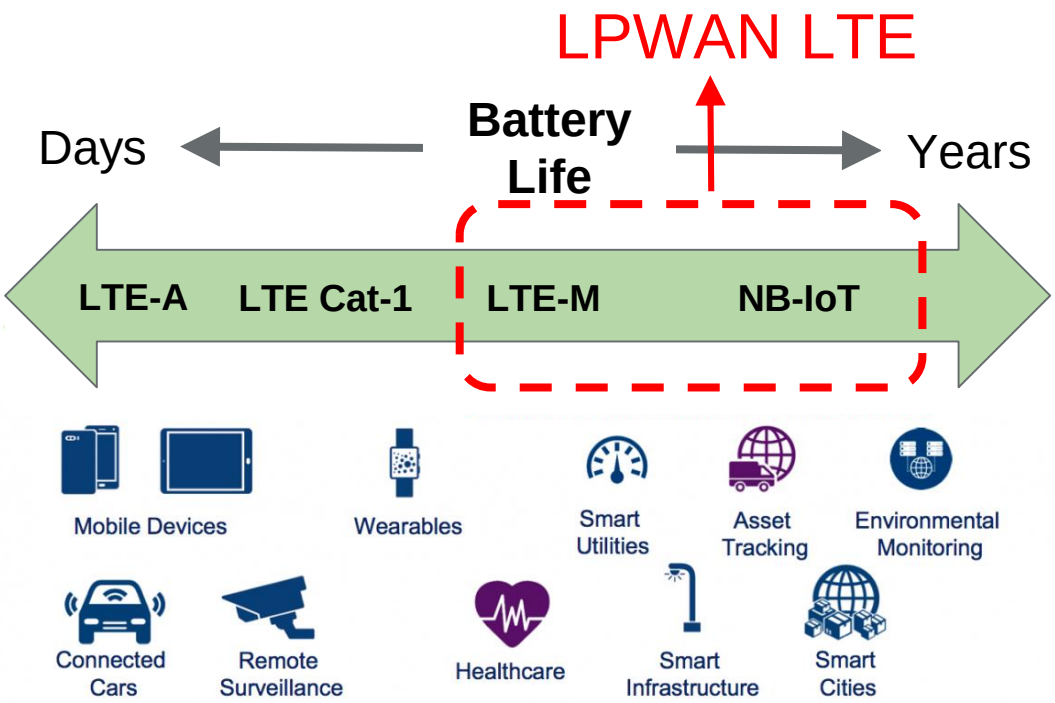
Cellular IoT Overview



- LTE Cat-M1 (1.4 MHz)
  - Full Duplex Rate (UL/DL): 1 Mbps
  - Half Duplex: 375 kbps
- LTE Cat-NB1 (180 kHz)
  - Rate (UL/DL): 200 kbps
- Modem design with reduced complexity and cost
- Enhanced Features for IoT
  - PSM
  - eDRX
  - Support for NIDD

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Link Budget Comparison for LoRaWAN Vs Mobile IoT

	Max Tx Power (dBm)	Link Budget (dB) or MCL
LoRaWAN (EU 868 MHz)	16.0 dBm	**161.5**
LoRaWAN (India 865 Mhz)	30 dBm	**175.5**
LoRaWAN (US 915 MHz)	30 dBm	**170.2**
LoRaWAN (China 470 MHz)	12.15 dBm	**164.65**
LTE Cat-M1 (Option 1*)	20 dBm	**155.7**
LTE Cat-M1 (Option 2*)	23 dBm	**160.7**
LTE Cat NB-IoT	23 dBm	**164** (**)
Sigfox (UNB)	16.0 dBm	**160**

LoRAWAN is similar to NB-IoT and better than LTE Cat-M1 and it depends on region

*Link budget calculation for 3GPP Cat-M1 is based on different assumptions, as shown in the table

Source: https://www.sierrawireless.com/resources/white-paper/coverage-analysis-lte-m-cat-m1/

** 164 dB Link Budget for NB-IoT is reached using 64 repetitions

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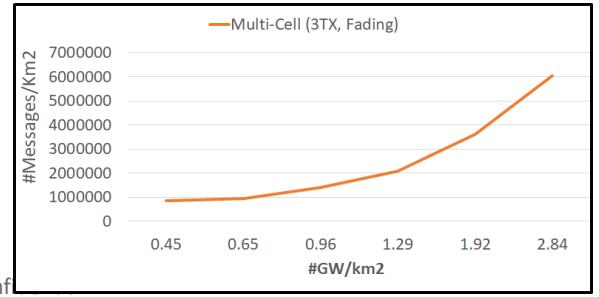
QoS Paradigm Comparison between LoRaWAN and Mobile IoT

Mobile IoT

- Licensed Spectrum
- Interference only from its own deployment (reuse 1)
- Densification of network required using small cells as traffic grows
- Cost of Small-Cells incl. Backhaul (~5k USD)[1]

LoRaWAN

- Unlicensed Spectrum
- Interference from its own deployment + other technologies
- Densification of network (Macro-Diversity + ADR)
- Cost of Pico-Cell incl. backhaul (3G/4G/LTE-M) (~300 USD)



1:http://www.senzafiliconsulting.com/Portals/0/docs/Reports/SenzaFili_SmallCellWiFiTCO.pdf

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LoRaWAN Vs Mobile IoT Power Consumption

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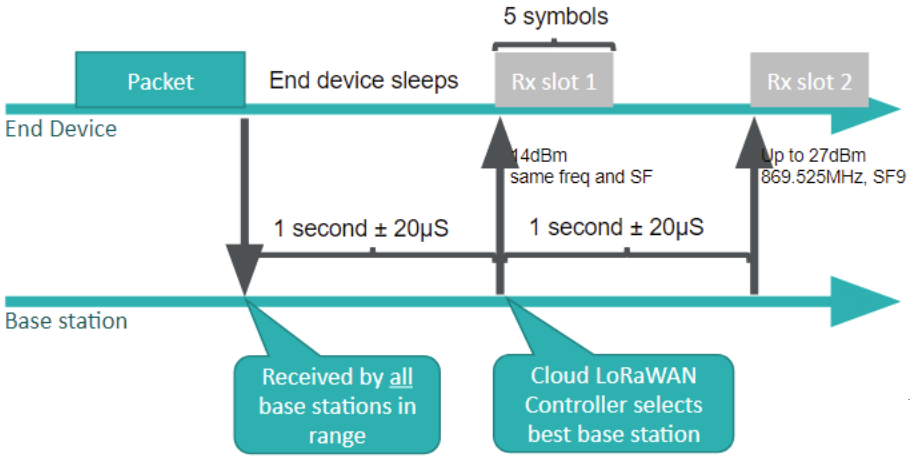
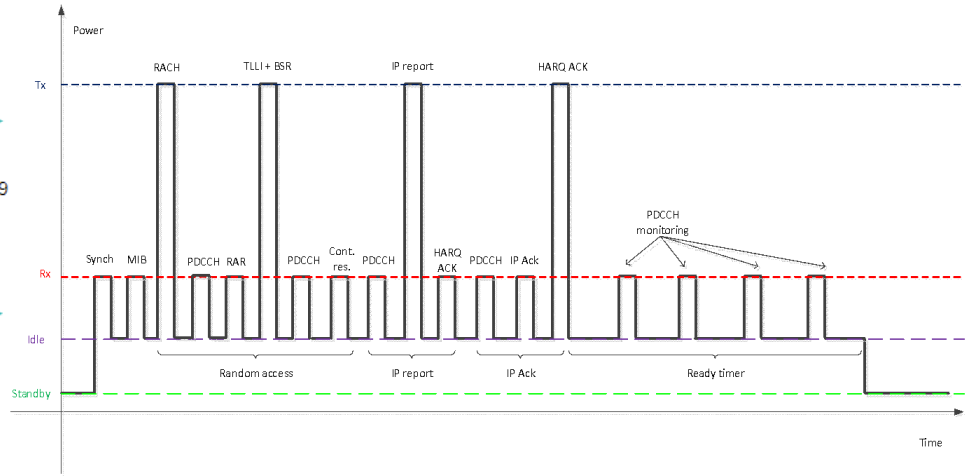
Synchronized RF PHY energy

- LoRaWAN is asynchronous
  - Device (class A) sends/receives only when needed
- LTE Cat-NB1/Cat-M1 is synchronous
  - Device has to wake up periodically to synchronize to the network

LoRaWAN Class A



LTE NB1



NB-IoT/Cat-M1 Vs LoRa Current Consumption

	TX Current	RX Current	Idle Current	Sleep Current
LoRaWAN [3] **TX Power=14 dBm (EU Regulations)**	**24-44 mA**	**12 mA**	**1.4mA**	**0.1uA**
NB-IoT **(* U-Blox Sara-N2 [2])**	**74-220 mA**	**46 mA**	**6mA**	**3 uA**
LTE Cat-M1 **(* U-blox Sara-R4 [1])**	**100-490 mA**	***(not specified)**	**9 mA**	**8uA**

NB-IoT Current Consumption is *3-5X* higher than LoRaWAN

[1] Sara R4-Series Data sheet, LTE Cat-M1 / NB1 modules. https://www.u-blox.com/sites/default/files/SARA-R4_DataSheet_%28UBX-16024152%29.pdf

[2] SARA N2-Series Data Sheet, LTE Cat-NB1 modules. https://www.u-blox.com/sites/default/files/SARA-N2_DataSheet_%28UBX-15025564%29.pd

[3] Semtech SX1272/73 Datasheet (860 MHz to 1020 MHz Low Power Long Range Transceiver) http://www.semtech.com/images/datasheet/sx1272.pdf

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NB-IoT Vs LoRa Airtime Comparison (50 Byte UL, No DL)

MCL/ (LoRaWAN SF)	144 dB / (SF7)			154 dB / (SF9)			164 dB / (SF12)		
	Tx (ms)	Rx (ms)	Idle(ms)	Tx (ms)	Rx(ms)	Idle(ms)	Tx(ms)	Rx (ms)	Idle(ms)
LoRaWAN	118	65	1500	367	238	1500	2793	1725	1500
NB-IoT ([1])	49	388	22223	311	565	22451	2190	2672	23387

[1] RAN1#82-BIS. NB-IOT - Battery lifetime evaluation https://portal.3gpp.org/ngppapp/CreateTdoc.aspx?mode=view&contributionId=659236

NB-IoT Spends significant time in Idle/RX states compared to LoRaWAN due to synchronous nature of the protocol which negatively impacts battery life

NB-IoT Vs LoRaWAN (Energy Comparison, 50 Byte UL, No DL)

MCL/ (LoRaWAN SF)	144 dB / (SF7)		154 dB / (SF9)		164 dB / (SF12)	
	Energy of 1 msg (Joule)	Sleep Energy/day (Joule)	Energy of 1 msg (Joule)	Sleep Energy/day (Joule)	Energy of 1 msg (Joule)	Sleep Energy/day (Joule)
LoRaWAN [2]	0.03	0.03	0.07	0.03	0.42	0.03
NB-IoT [1]	0.13	1.3	0.29	1.3	1.50	1.3

Energy of 1 message includes energy in (TX+RX+Idle States)

[1] RAN1#82-BIS. NB-IOT - Battery lifetime evaluation
https://portal.3gpp.org/ngppapp/CreateTdoc.aspx?mode=view&contributionId=659236
[2] Semtech 1272 Datasheet, http://www.semtech.com/images/datasheet/sx1272.pdf

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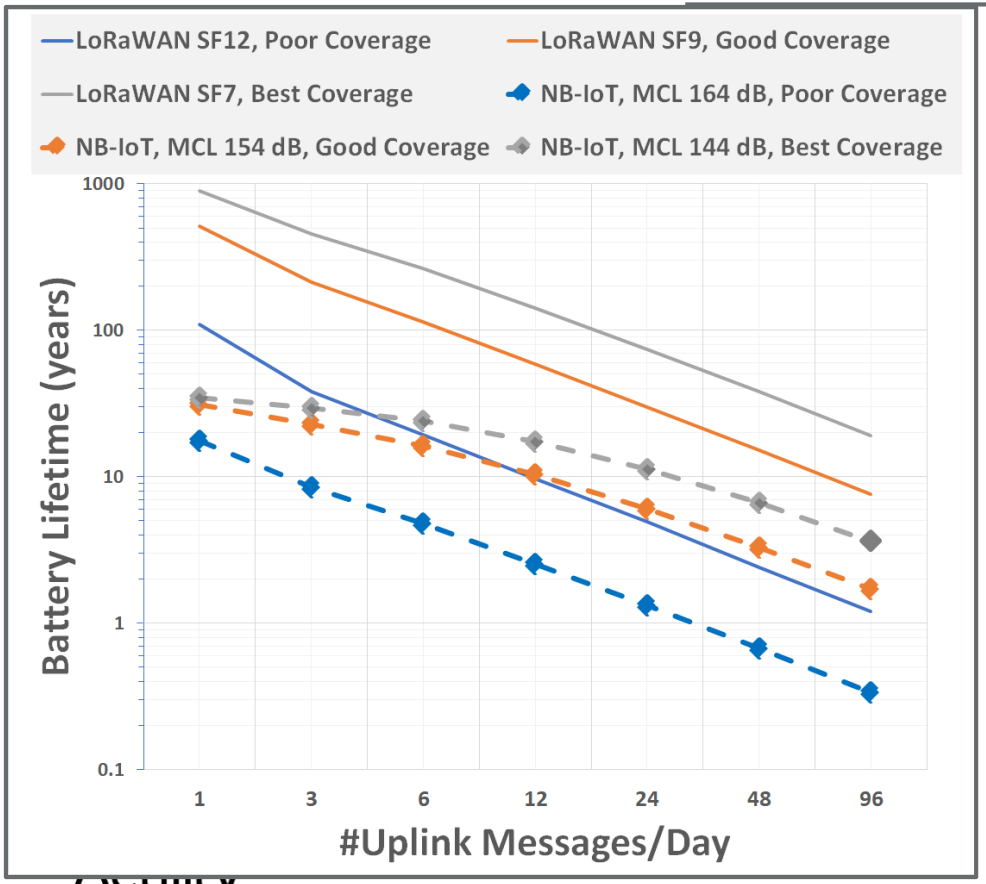
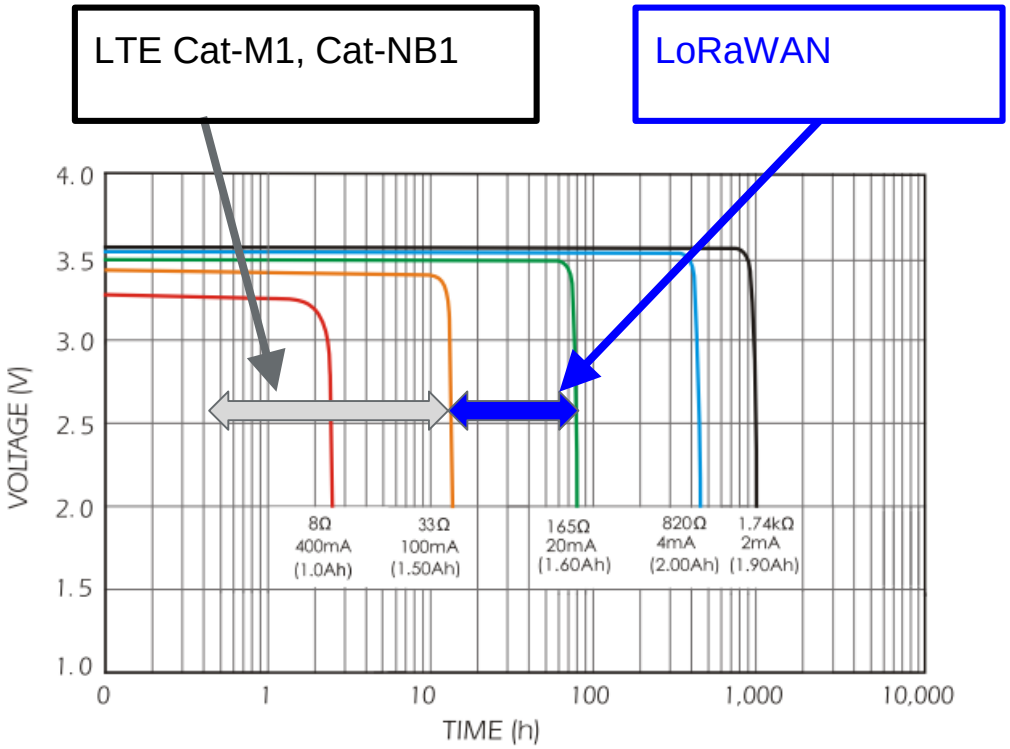
Battery Lifetime Comparison



- Assuming Perfect battery with linear decay without impact of peak current on capacity
- LoRaWAN is 3-5X more power efficient (especially at Cell Edge/Poor Coverage Scenarios)
- LoRaWAN is best suited for very small infrequent messages due to ***its simple and asynchronous nature***
- NB-IoT/Cat-M1 is most suited for premium high-bandwidth applications

Peak current impact on battery lifetime



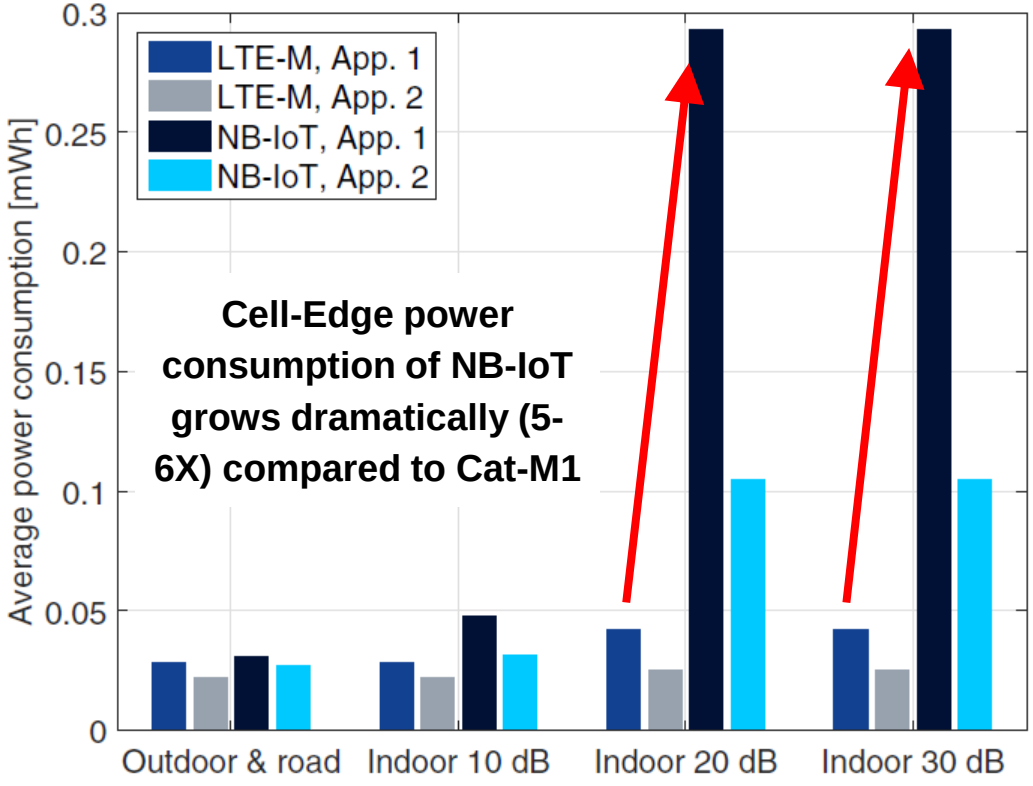
Impact of current on usable capacity

From technical specification of ER14505M Lithium-thionyl Chloride Spiral Battery

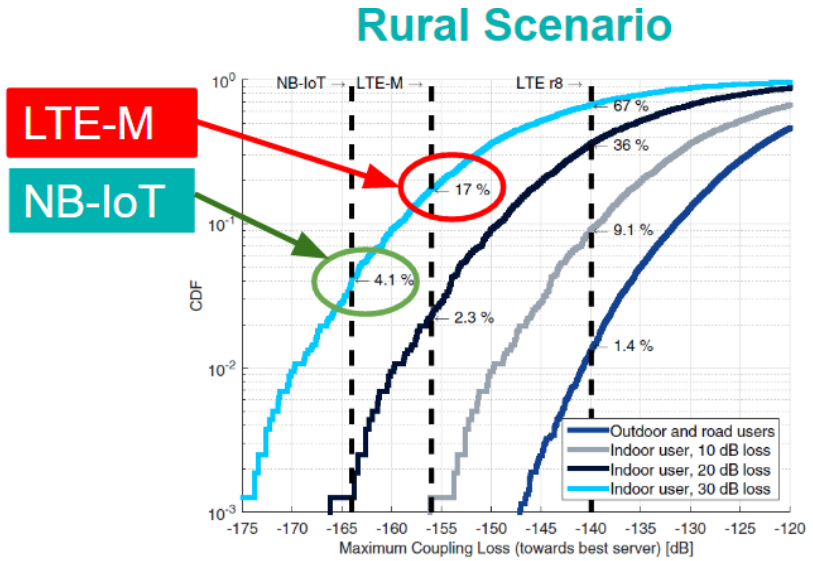
Battery chemistry and IoT :

- LiPo (used in mobile phones) : Not possible due to ~2% self discharge rate per month.
- Alkaline : OK but internal resistance increases towards end of lifetime (cannot accommodate high to peak current and long lifetime) and at low temperatures.
- **Lithium-Thionyl-Chloride (LTC)** : more expensive, self-discharge about 3%/year (requires 2x the usable capacity for 15 years lifetime). Peak-current also impacts capacity.
- Coin cell (Wearables) : only suitable for LoRaWAN. They cannot provide high peak current for NB-IoT/LTE-M

Impact of power consumption for cell-edge users (NB-IoT Vs Cat-M1)



Average device power consumption per day for UEs with MCL above 150 dB. (Rural scenario) [1]



[1] http://vbn.aau.dk/files/236150948/vtcFall2016.pdf

Conclusion

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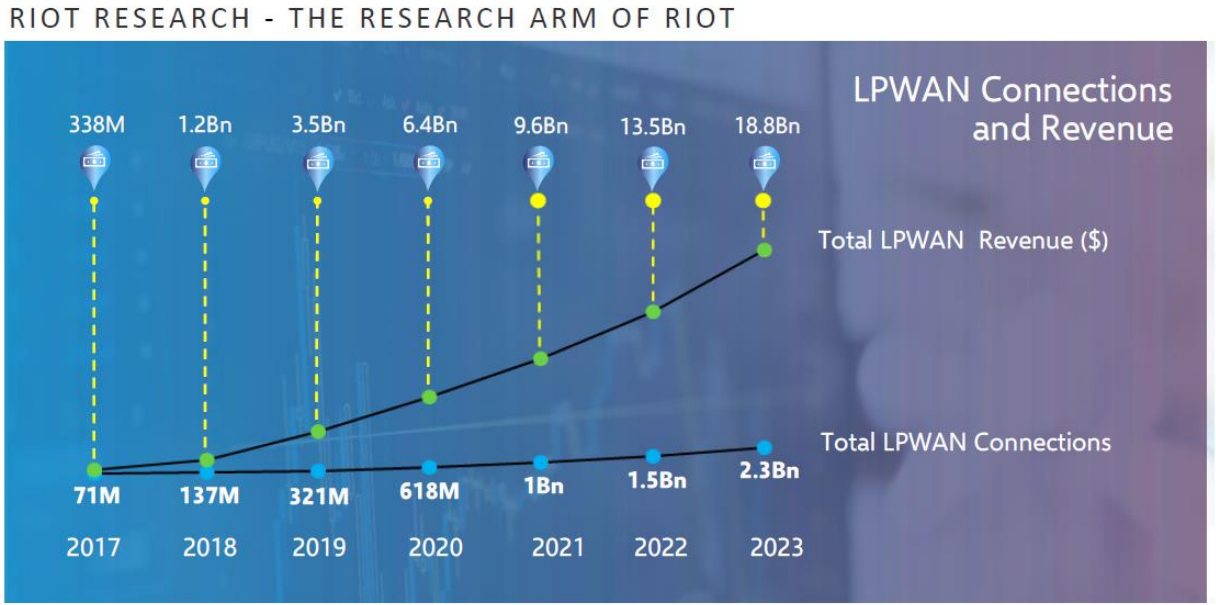
Strong Growth of LPWAN

2.2Bn LPWAN connexions by 2023 (GAGR 78%, 50% APAC, 17% EU, 15.5% US)
18.9Bn USD chipset & connectivity annual revenues (balanced across regions)



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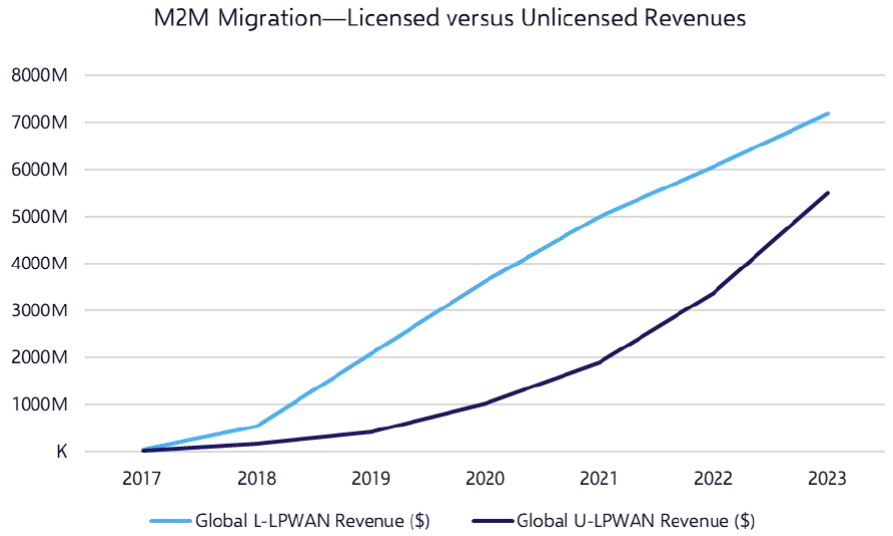

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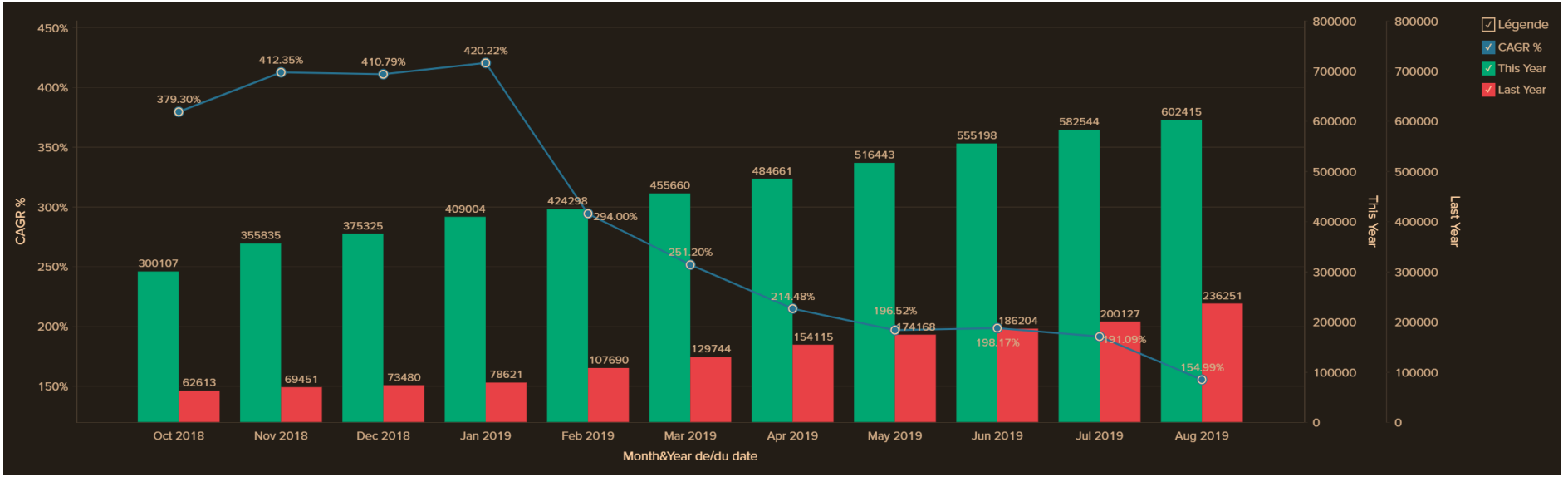
LoRaWAN Devices (# per quarter & CAGR)



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