The Long Range Communication Technologies for IoT: NB-IoT

Are Mobile Radio Networks IoT-ready?

OLD SCHOOL MOBILE

Few Applications

throughput-bound

HighEnd Terminals

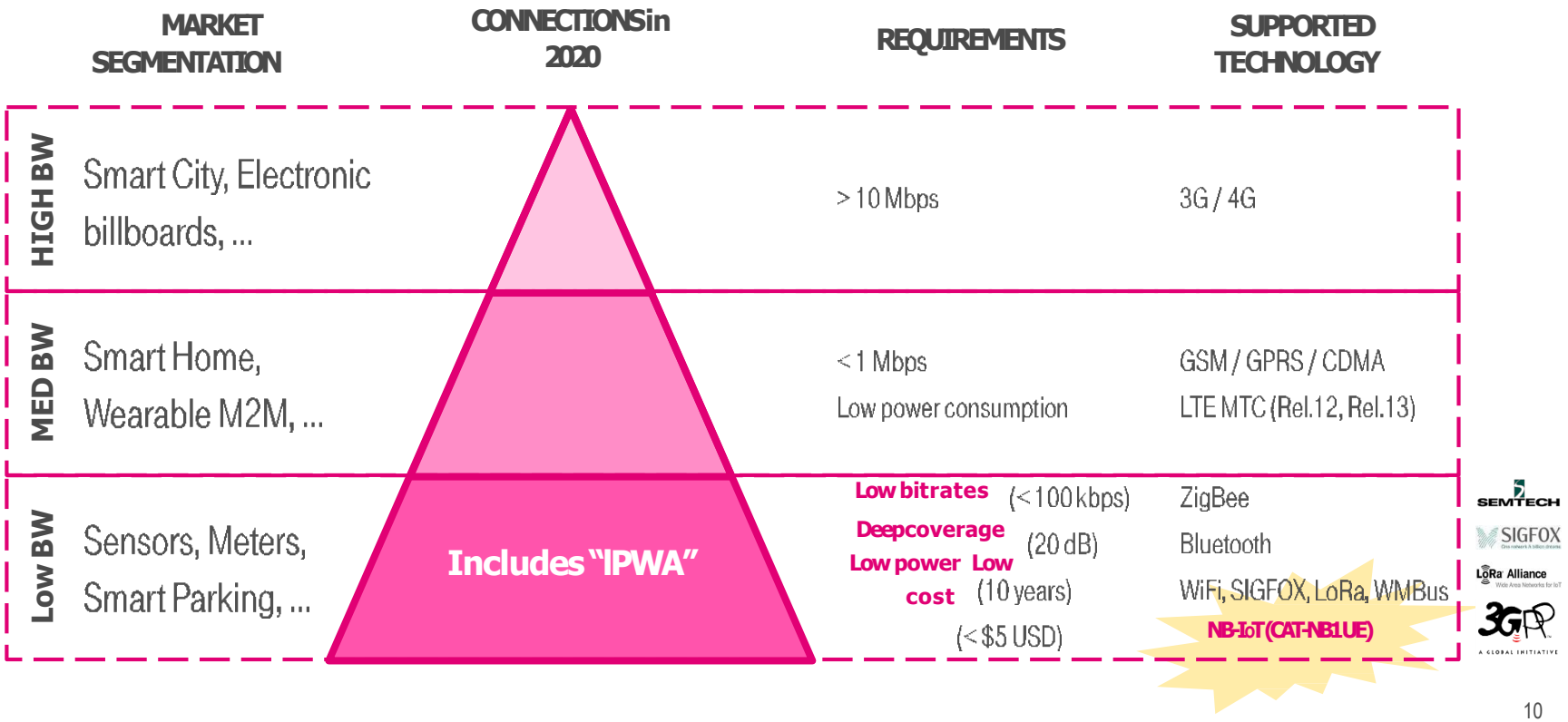
IoT-Enabled Mobile

Fragmented Applications

Many clients – Low Traffic

Simple (cheap) terminals

M2M Opportunity Segmentation



Major LPWAN Technologies Comparison

	SIGFOX One network A billion dreams	LoRa™	3GPP A GLOBAL INITIATIVE NB-IoT
Bandwidth	100 KHz	125 kHz	180 kHz
Coverage (Indoor)	149dB	157dB	164dB
Capacity	<25.000 / Cell	<40.000 / Cell	<100.000 / Cell
Throughput	100 bit/s	290 bit/s - 50 kbit/s	250 kbit/s
Bi-directional Data Transfer	No	Class dependent	Yes
Security	16 Bit	32 Bit	3GPP 128-256 Bit
Scalability	Low	Medium	High
Mobility	No	Yes	Yes
Location Support	No	Yes	GPS / Positioning
Cost per module	2 USD	12 USD	5 USD

NB-IOT in a Nutshell
KEY BENEFITS & FEATURES

Low data rates  600 bit/s up to few 100 kbit/s*	Low power consumption  battery life time up to 10 years	Low hardware cost  module < 4,-EUR**	Deep indoor penetration  +20dB link budget compared to GSM	Bi-directional communication  uplink and downlink (e.g. for software updates)
Ease of use  direct use – no coupling to HUB needed	LTE based security  SIM based, authentication, integrity, ciphering	Many devices  ≈50.000 connected devices per cell	Public network  in operator managed licensed spectrum	Standardized  3GPP Release 13

* depends on cell load and radio condition ** Industry target and requirement in 3GPP. Has to be approved by module suppliers.

General NB-IoT Requirements

Several targets were derived by 3GPP for NB-IoT:

- Minimize **signaling overhead**, especially over the radio interface
- End-to-end **security** for the complete system, including the core network
- Improved **battery life**
- Support for delivery of **both IP and non-IP data**
- Support of **SMS** as a deployment option

The benefits of NB-IoT, as compared to Sigfox and LoRA, include:

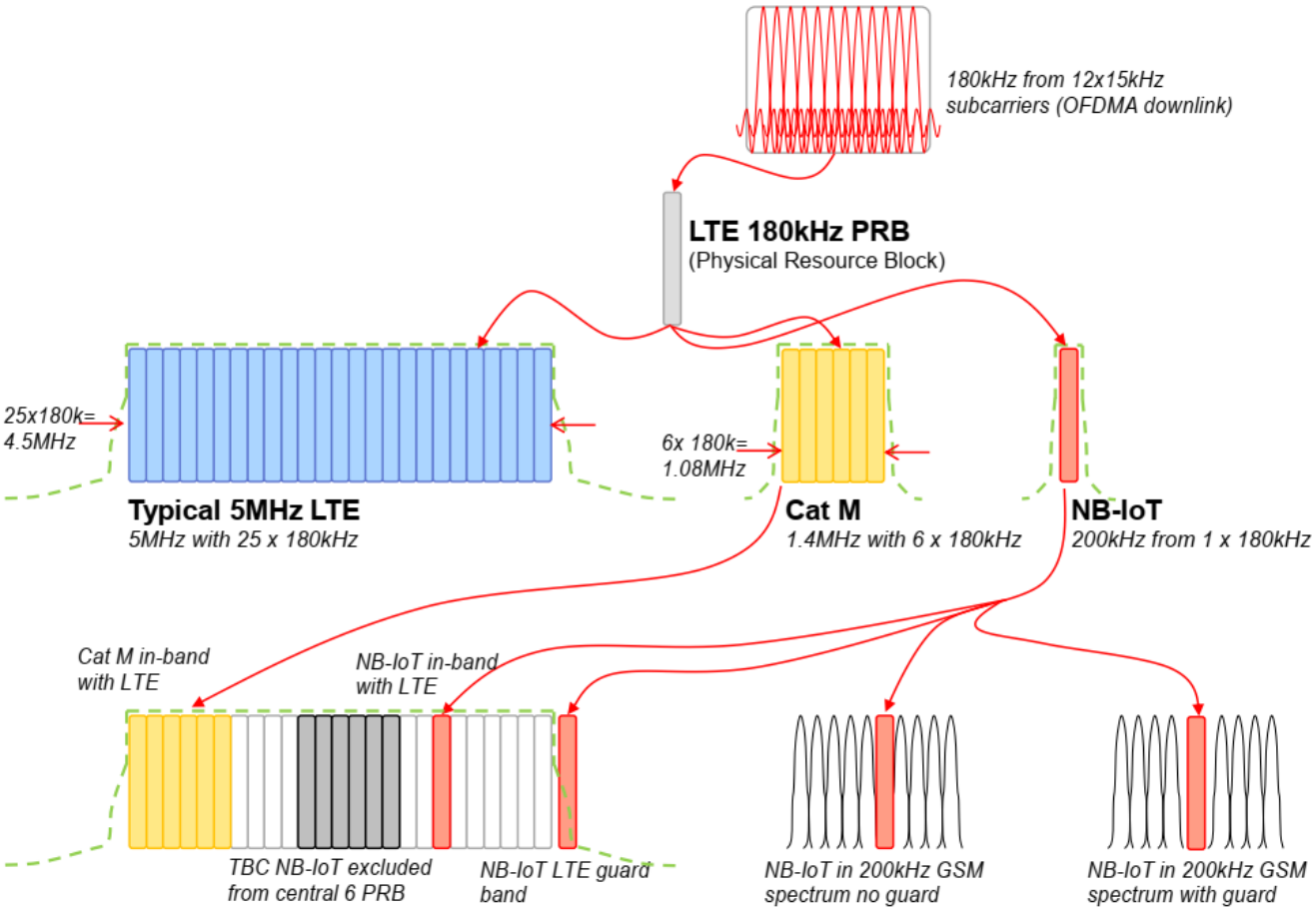
- **Standardized** technology
- **3GPP-based security** built-in
- Use of **licensed spectrum**
- Reuse of **existing mobile network equipment** and processes

Stripped LTE Features

In order to fulfill LPWA requirements, numerous LTE Release 8/9 features are not supported:

- No **handover support** for UEs in the connected state; only cell reselection in the idle state is supported
- No **Intra-RAT** interaction with other radio technologies
- No **LTE-WLAN interworking**, interference avoidance for in-device coexistence, or measurements to monitor the channel quality
- Most **LTE-Advanced features** are not supported (e.g. Carrier Aggregation, Dual Connectivity, or device-to-device services)
- No **QoS concept**, as NB-IoT is not used for delay-sensitive data packets
- Services requiring a guaranteed bit rate, like **real-time IMS**, are not offered in NB-IoT

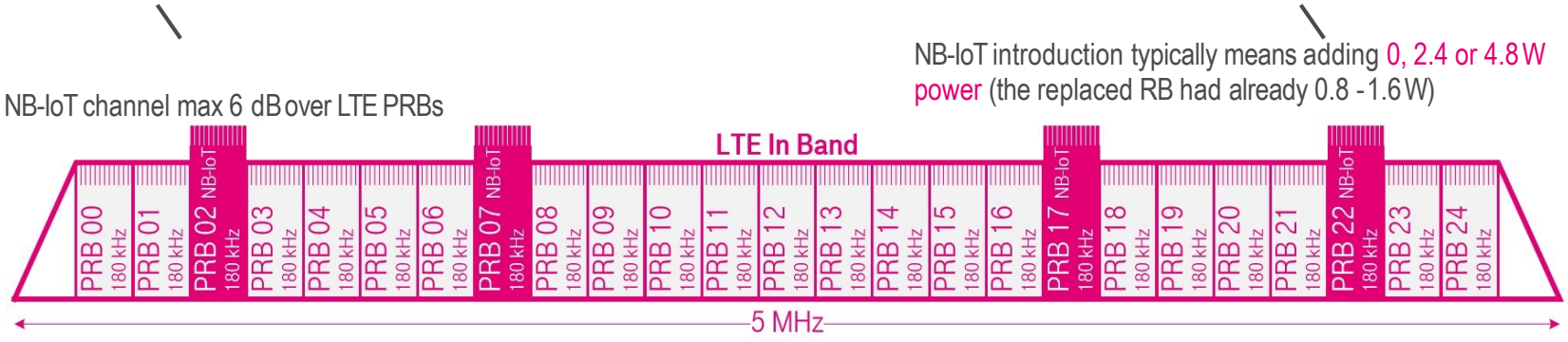
CAT-M and NB-IOT Deployment Options



In-band operation

- In-band deployments introduce NB-IoT carriers within the LTE carrier:
  - Solution is scalable by simply adding more NB-IoT carriers
  - Near-far interference to non-upgraded LTE base stations can occur; recommendation is to do a network-wide deployment

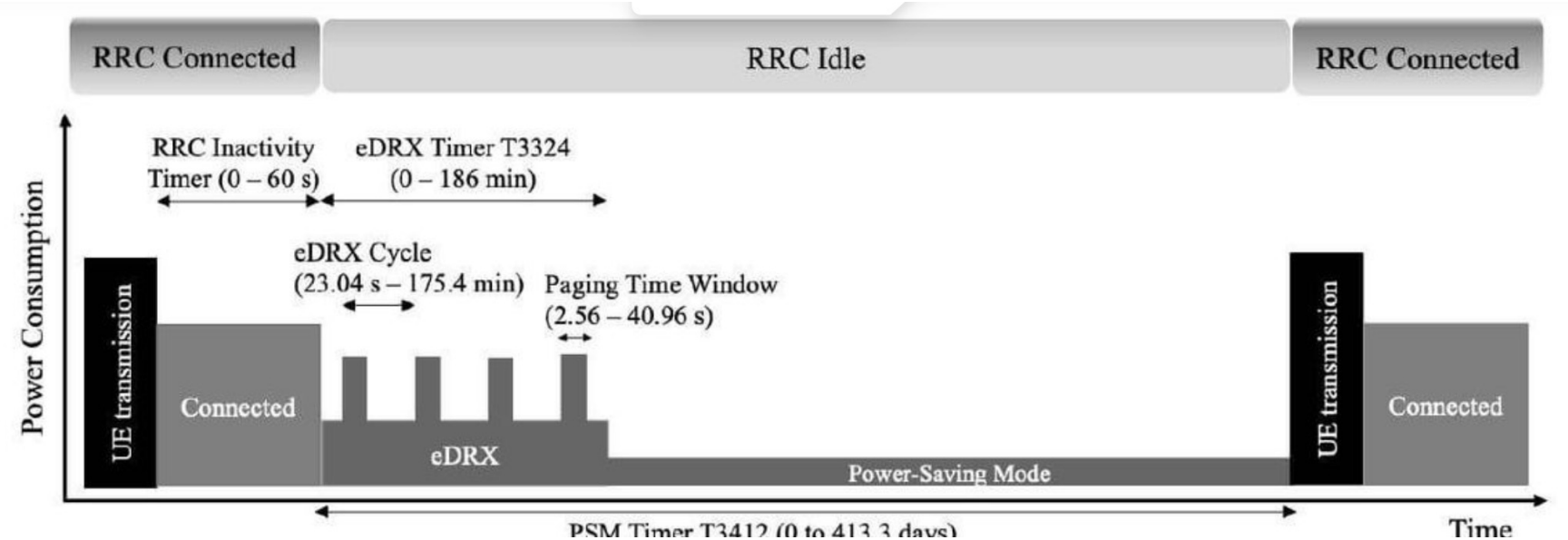
- **In-band deployments reduce the capacity (and max. speed) of the LTE carrier:**
  - NB-IoT output power is 35dBm, leading to 0.3dB reduction in case no sufficient PA power is available
  - A possible solution is to power-boost NB-IoT by 6dB (anchor carrier in multi-carrier mode)
  - Optionally, the NB-IoT baseband capacity can be dynamically shared with LTE MBB when there is no NB-IoT traffic



Power Saving Mode

- It is a specially kind of UE status that can minimize the energy consumption that is supposed to be even lower than normal idle mode energy consumption
- This is newly added feature in Release 12 and is specified in 3GPP 24.301-5.3.11 Power saving mode and 23.682-4.5.4 UE Power Saving Mode
- Similar to power-off, but the UE remains registered with the network
- No need to re-attach or re-establish PDN connections
- A UE in PSM is not immediately reachable for mobile terminating services

Power Saving Mode and eDRX



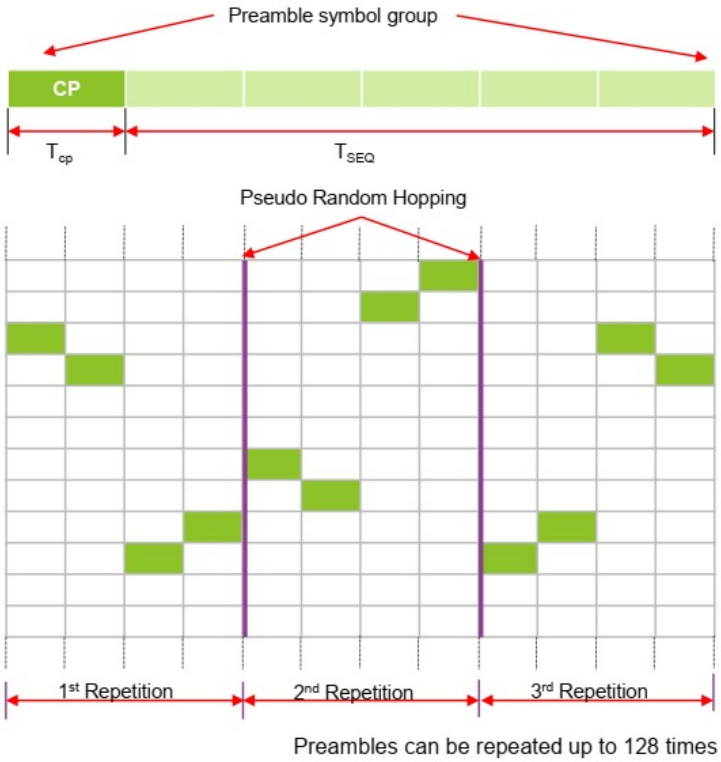
NB-IoT Key Parameters

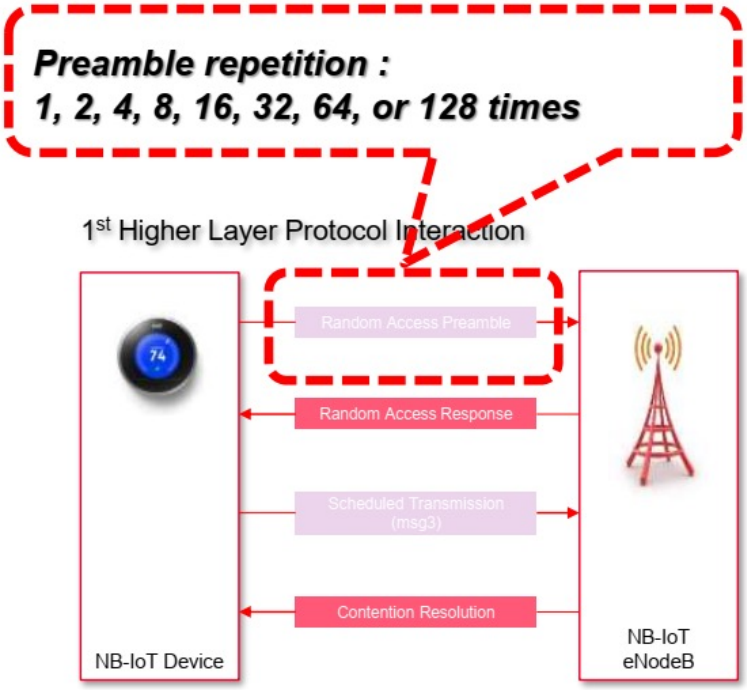
Frequency range	**NB-IoT (LTE) FDD Bands:** 1, 2, 3, 5, 8, 11, 12, 13, 17, 18, 19, 20, 25, 26, 28, 66, 70
Duplex Mode	FDD Half Duplex type B
MIMO	No MIMO support
Bandwidth	180 kHz (1PRB)
Multiple Access	**Downlink:** OFDMA **Uplink:** SC-FDMA
Modulation Schemes	**Downlink:** QPSK **Uplink:** Single Tone: π/4-QPSK, π/2-BPSK Multi Tone: QPSK
Coverage	164 dB (+20dB GPRS)
Data Rate	~25 kbps in DL and ~64 kbps in UL (multi-tone UE)
Latency	< 10 seconds
Low Power	eDRX, Power Saving Mode

Support for other features:

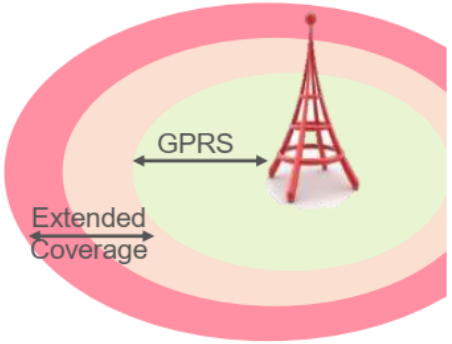
- [x] HARQ (1 process only)
- [x] UL Power Control (Open Loop only)
- [ ] RSRP, RSRQ Reporting
- [ ] CSI Reporting
- [ ] Handovers in CONNECTED
- [ ] Carrier Aggregation
- [ ] IMS
- [ ] eMBMS

Random Access Procedure

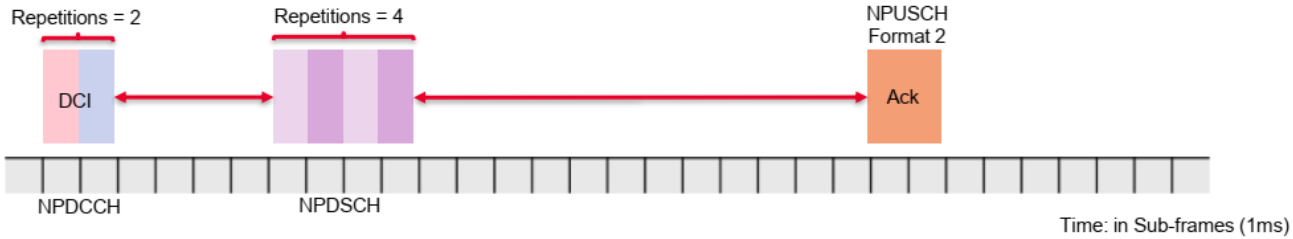




Repetitions



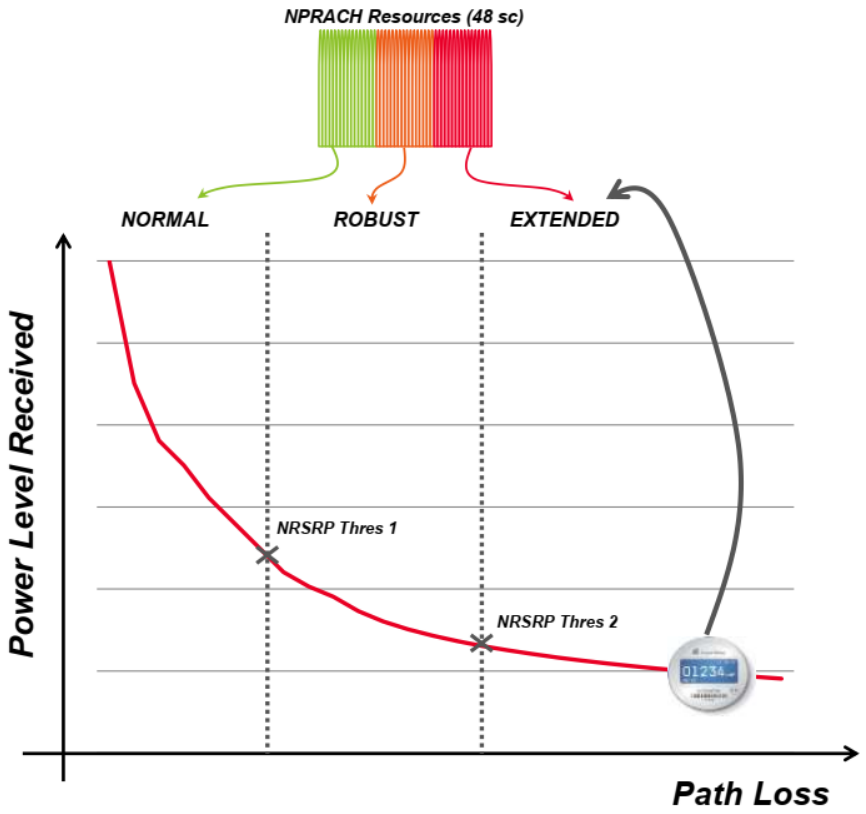
- Technique consisting on repeating the same transmission several times:
  - Achieve extra coverage (up to 20 dB compared to GPRS)
  - Each Repetition is self-decodable
  - Scrambling code is changed for each transmission to help combination
  - Repetitions are ACK-ed just once
- For NB-IoT all channels can use Repetitions to extend coverage



Example: *Repetitions used in NB-IoT in NPDCCH and NPDSCH channels*

Coverage Levels

- Up to 3 different Coverage Levels signaled via **SIB2-NB**
  - (***Normal, Robust, Extreme***)
  - ***(CE Level : 0 ,1, 2)***
  - ***(MCL : 144 db ,154 db , 164 db)***
- The coverage level selected determines the NPRACH resources to use:
  - Subset of subcarriers, ***PRACH Repetitions***, Max number of attempts, etc…
- UE derives the Coverage Level based on NRSRP measured
  - NPRACH resources to be used are determined by the Coverage Level

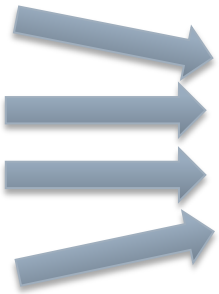


Summary

- LTE evolution is able to provide an efficient solution for Cellular IoT
  - Natural evolution of existing networks in existing or additional spectrum
  - M2M traffic can co-exist on the same carrier as other traffic if desired
- Rel-12 improvements for M2M
  - 50% modem complexity reduction compared to Cat-1 UE
  - 10+ years battery lifetime for downlink delay-tolerant traffic
- Rel-13 improvements for M2M
  - 75% modem complexity reduction compared to Cat-1 UE
  - Main cost reduction comes from reducing the UE receive bandwidth to 1.4 MHz
  - 10+ years battery lifetime for cases not targeted by Rel-12
  - 15-20 dB coverage enhancement
- Narrowband deployment
  - Introduction of a narrower LTE system bandwidth (e.g. 200 kHz) can be considered but requires substantial additional efforts compared to the improvements listed above

5G is coming to Industry

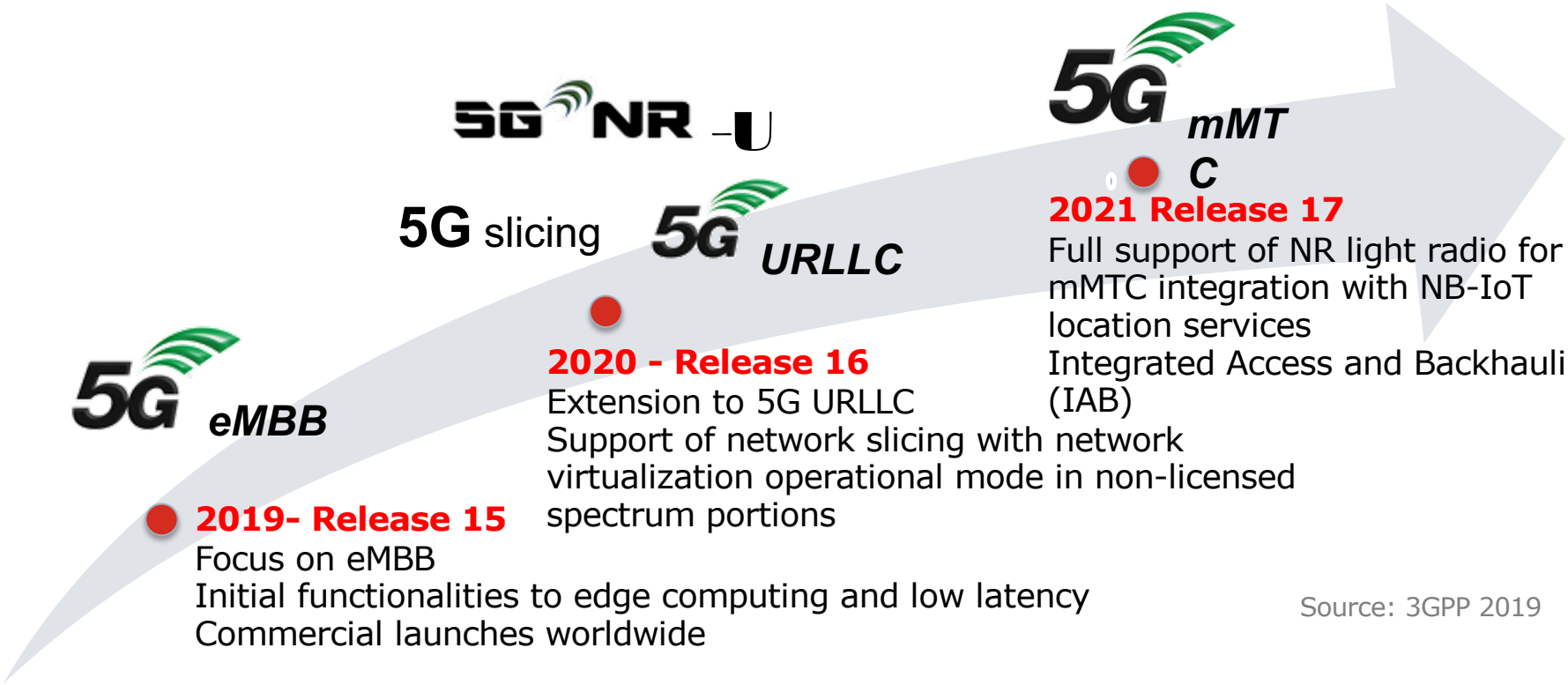
- Industry-compliant 5G nice features:
  - mmWave access, Massive MIMO
  - Network Densification
  - Slicing
  - Mobile Edge Computing (MEC)



Tactile Internet
- High Access Speed
- low latency

- Enabled/Boosted Applications
  - Immersive reality/virtual reality
  - Autonomous vehicles
  - Collaborative Robotics

5G RoadMap



Source: 3GPP 2019