LTE-M and NB-IoT Networks

CoE Training on Traffic engineering and advanced wireless network planning

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Bangkok, Thailand

Objectives

- Present the evolution of LTE towards LTE-M and NB-IoT for IoT services introduction

I. Introduction

II. LTE-M

III. NB-IoT

IV. State of Art

I. Introduction

LPWA could account 70% of Cellular IoT Connections in 2020

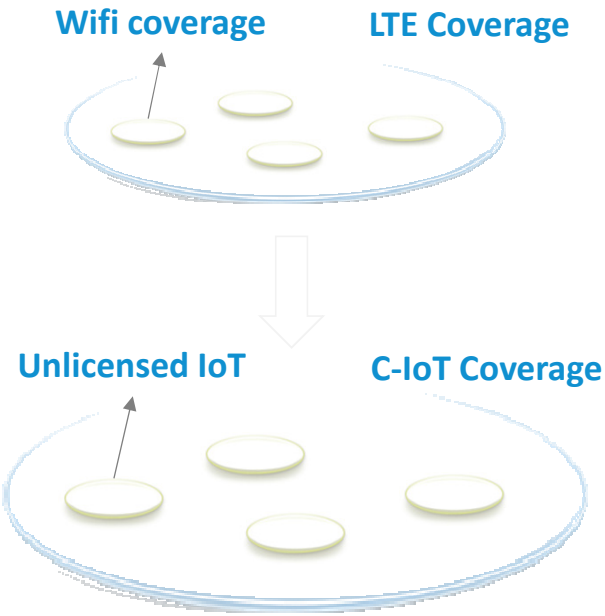
Market Segment	Connections in 2020 (Billion)	Requirements	Technology
● CCTV(Camera) ● In-vehicle Entertainment…	0.2B	l >10Mbps	3G/4G
● IoT Gateway Backhaul ● Wearable ● …	0.8B	l ~1Mbps l Low power consumption	2G/3G/Cat-1 Cat-M1
● Sensors, Meters ● Asset Tracking ● Smart Parking ● Smart agriculture …	2B	l Low Throughput (<100kbps) l Deep Coverage (20dB) l Low power (10 Years) l Low cost (<$5)	Short Range Tech. Sigfox, LoRa NB-IoT

LPWA: Low Power Wide Area

C-IoT provides wide WAN coverage

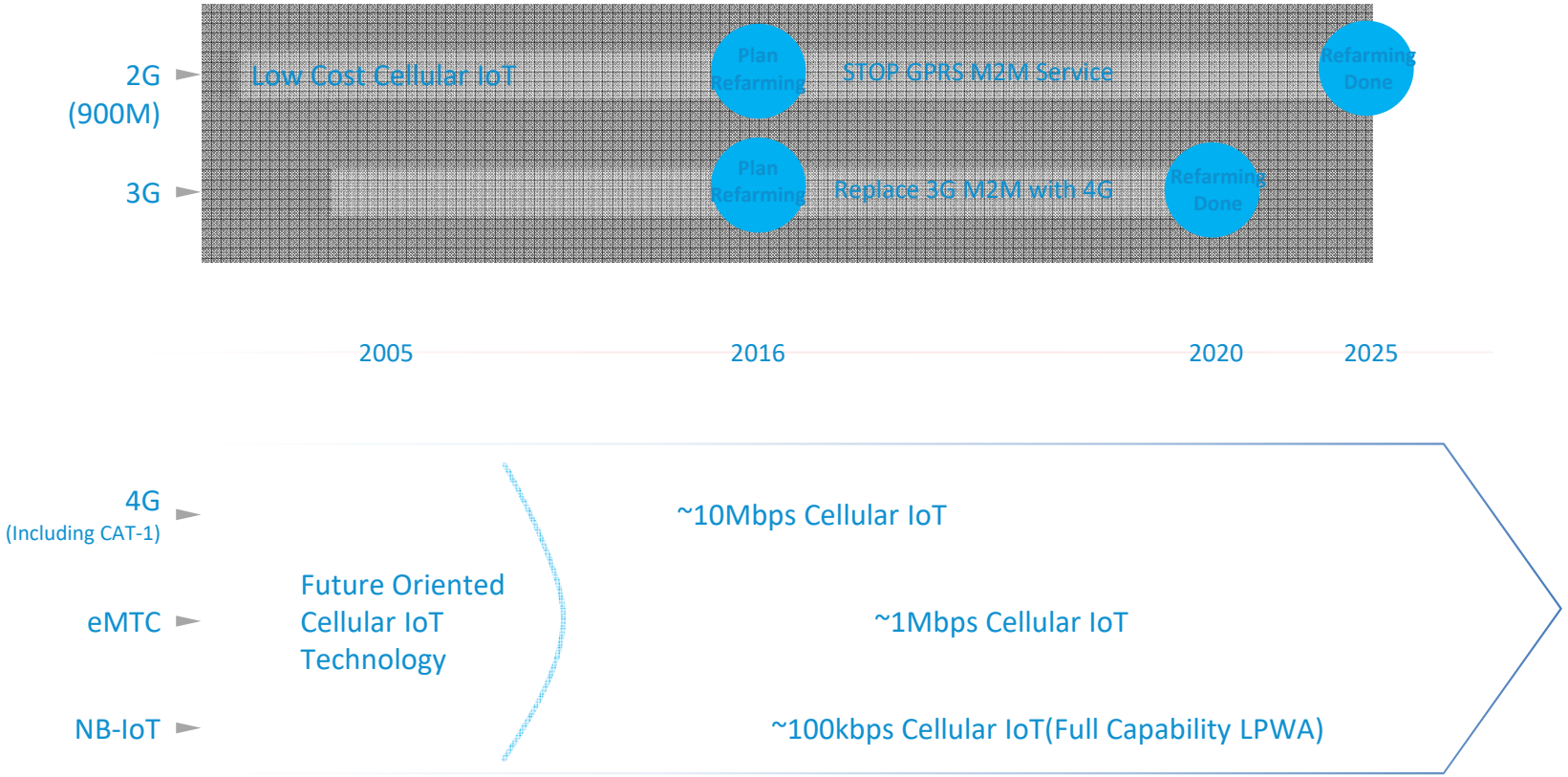
C-IoT

- **Re-use existing Cellular network**
- **Carrier-grade Reliability**
- **4G-Like Security**
- **Roaming**



- Unlicensed technology is for local coverage
- C-IoT is for wide coverage

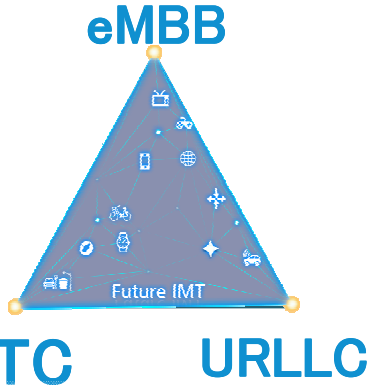
Future Oriented Cellular IoT Network: NB-IoT+eMTC+4G



NB-IoT/eMTC Standard's evolution path to 5G

NB-IoT	
Rel-14	Rel-15
• Positioning: E-CID, OTDOA • SC-PTM • 14dBm output power • Peak throughput improvement (DL 114kbps/UL 142.5kbps)	• TDD NB-IoT • RRM measurement, latency improvement • **NPRACH enhancement** • **Differ group QoS**
eMTC	
Rel-14	Rel-15
• Positioning: OTDOA • SC-PTM • VoLTE coverage improvement (5dB) • 5MHz/20MHz bandwidth (UL 3Mbps/7Mbps; DL 4Mbps/27Mbps)	• Capacity improvement: Sub-PRB eMTC (45KHz) • **64QAM** • Low UE output power

Technology: NR、LTE to cover high band and low band

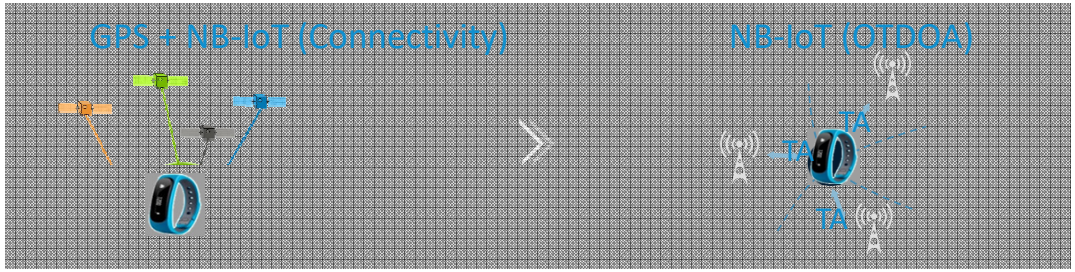


Technology: NB-IoT,

- mMTC NR will not be considered until R17;
- NB-IoT will be used to cover 5G mMTC use case before R17

R14: Positioning to simplify device requirement

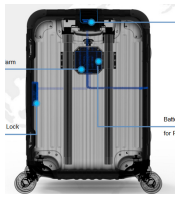
NB-IoT Tracking Technologies Overview:



- Device cost: ~50USD
- Accuracy: 10m
- Latency:30s
- Power consumption: **0.3**mAh/Report

- Device cost: ~40USD
- OTDOA: 30~50m
- Latency:10s
- Power consumption: **0.2**mAh/Report

NB-IoT Tracker



BaaS Business Model:

Kids tracking (GizmoPal)

Monthly service fee: 5USD

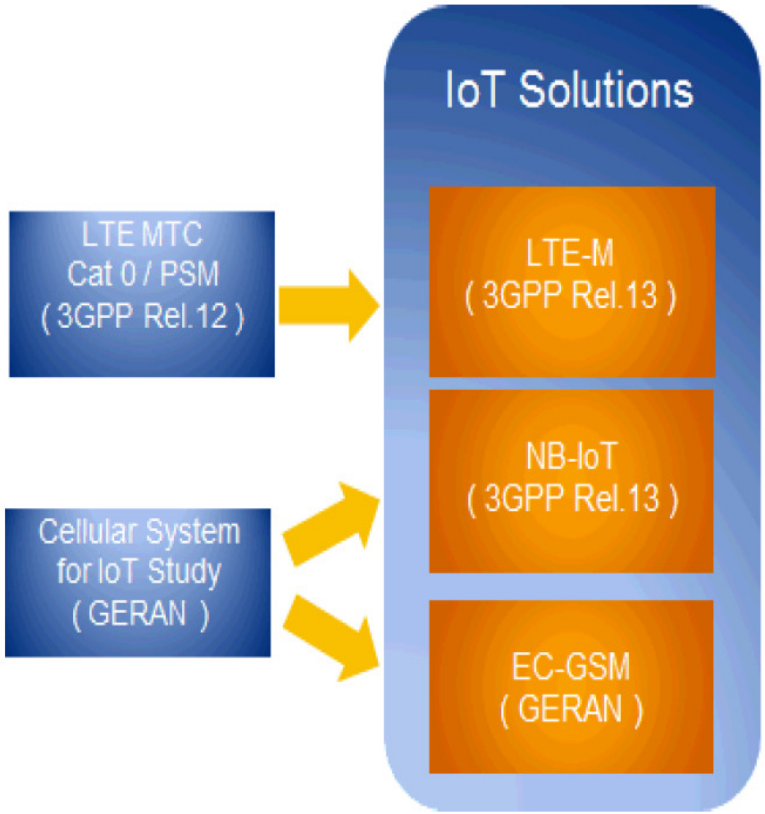
Kids tracking (Filip2 Tracker)

Monthly fee:

USD10 for voice and data

Release-13 3GPP evolutions to address the IoT market

- **eMTC**: LTE enhancements for MTC, based on Release-12 (UE Cat 0, new PSM, power saving mode)
- **NB-IOT**: New radio added to the LTE platform optimized for the low end of the market
- **EC-GSM-IoT**: EGPRS enhancements in combination with PSM to make GSM/EDGE markets prepared for IoT

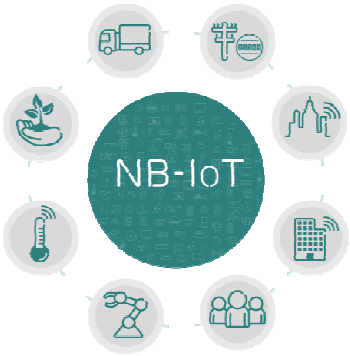


Main eMTC, NB-IoT and EC-GSM-IoT features

	eMTC (LTE Cat M1)	NB-IOT		EC-GSM-IoT
Deployment	In-band LTE	In-band & Guard-band LTE, standalone		In-band GSM
Coverage*	155.7 dB	164 dB for standalone, FFS others		164 dB, with 33dBm power class 154 dB, with 23dBm power class
Downlink	OFDMA, 15 KHz tone spacing, Turbo Code, 16 QAM, 1 Rx	OFDMA, 15 KHz tone spacing, 1 Rx		TDMA/FDMA, GMSK and 8PSK (optional), 1 Rx
Uplink	SC-FDMA, 15 KHz tone spacing Turbo code, 16 QAM	Single tone, 15 KHz and 3.75 KHz spacing SC-FDMA, 15 KHz tone spacing, Turbo code		TDMA/FDMA, GMSK and 8PSK (optional)
Bandwidth	1.08 MHz	180 KHz		200kHz per channel. Typical system bandwidth of 2.4MHz [smaller bandwidth down to 600 kHz being studied within Rel-13]
Peak rate (DL/UL)	1 Mbps for DL and UL	DL: ~50 kbps UL: ~50 for multi-tone, ~20 kbps for single tone		For DL and UL (using 4 timeslots): ~70 kbps (GMSK), ~240kbps (8PSK)
Duplexing	FD & HD (type B), FDD & TDD	HD (type B), FDD		HD, FDD
Power saving	PSM, ext. I-DRX, C-DRX	PSM, ext. I-DRX, C-DRX		PSM, ext. I-DRX
Power class	23 dBm, 20 dBm	23 dBm, others TBD		33 dBm, 23 dBm

II. LTE-M

Current status



A GLOBAL INITIATIVE

April 2014	May 2014	March 2015	August 2015	November 2015	Jun 2015	2017+
Narrowband proposal to Connected Living	3GPP 'Cellular IoT' Study Item	GSMA Mobile IoT created	3GPP alignment on single standard	1st live pre-standard NB-IoT message	Full NB-IoT 3GPP Standard Released	Commercial rollout

Evolution of LTE-M

Comparison with LTE-M

Attribute	CAT-1	LTE-M		NB-IOT	
		Rel 13	Rel 14	Rel 13	Rel 14
Spectrum	LTE bands	LTE bands Stand Alone (1.4MHz)		LTE Bands Stand Alone (200KHz)	
Typical MNO	LTE Coverage	Good LTE Coverage		Mix LTE and 2G	
Bandwidth	20 MHz	1.08MHz (CAT-M1)	5 MHz (CAT-M2)	180kHz	
Number of DL Antennas	2	1		1	
Duplex Modes	FD-FDD/TDD	HD-FDD, FD-FDD,TDD		HD-FDD	
UL Modulation	QPSK, 16QAM	QPSK, 16QAM		Pi/2 BPSK, Pi/4 QPSK	
DL Modulation	QPSK, 16QAM	QPSK, 16QAM		QPSK	
Spectral Efficiency	V.Good	Good		OK	
Power Class	Class 3 (23dBm)	Class 3 (23 dBm) Class 5 (20 dBm)		Class 3 and 5	* 14 dBm
UL Multple Access	LTE SC-FDMA	LTE SC-FDMA		LTE SC-FDMA + Single tone transmission with 3.75kHz and 15kHz bandwidths	

LTE to LTE-M

3GPP Releases	8 (Cat.4)	8 (Cat. 1)	12 (Cat.0) LTE-M	13 (Cat. 1,4 MHz) LTE-M
Downlink peak rate (Mbps)	150	10	**1**	**1**
Uplink peak rate (Mbps)	50	5	**1**	**1**
Number of antennas (MIMO)	2	2	**1**	**1**
Duplex Mode	Full	Full	**Half**	**Half**
UE receive bandwidth (MHz)	**20**	**20**	**20**	**1.4**
UE Transmit power (dBm)	**23**	**23**	**23**	**20**

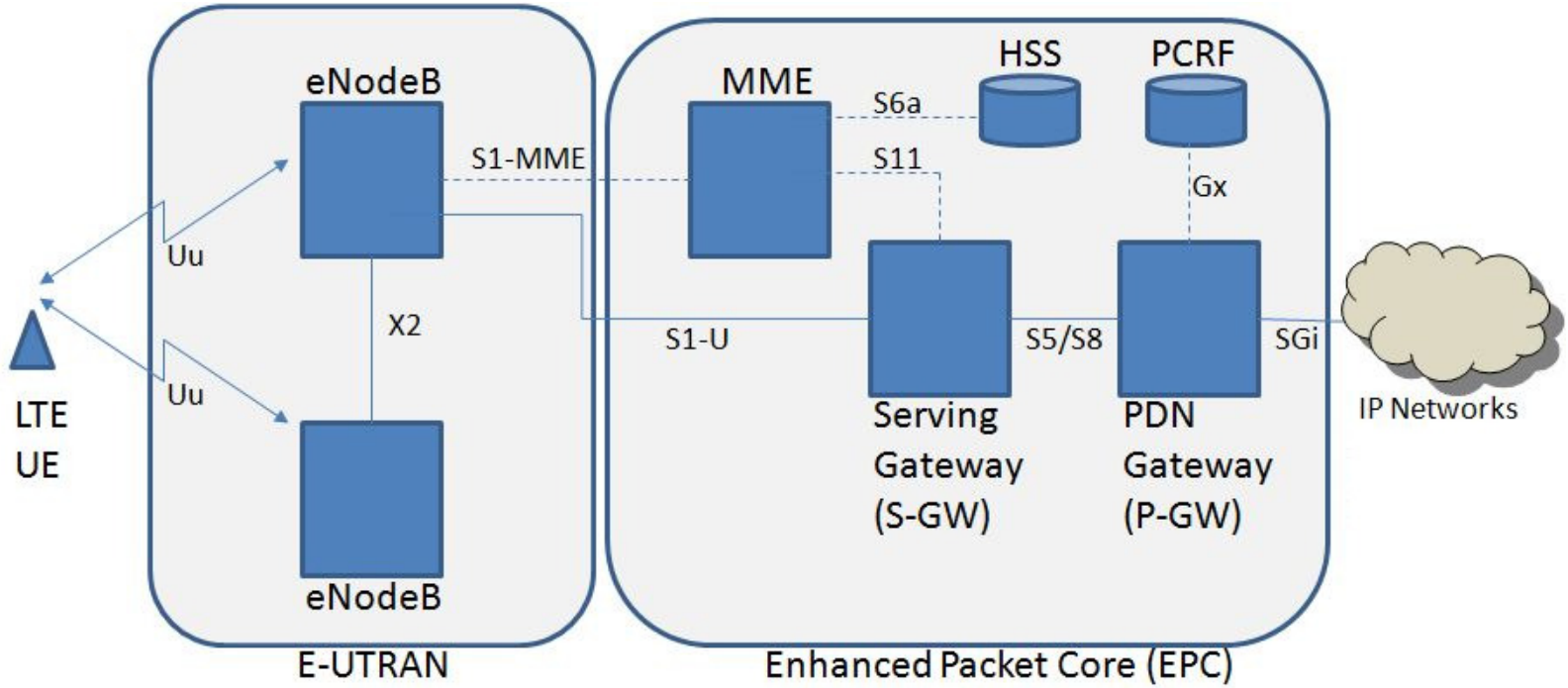
Release 12

- New category of UE ("Cat-0"): **lower complexity** and low cost devices
- **Half duplex FDD** operation allowed
- **Single receiver**
- Lower data rate requirement (Max: 1 Mbps)

Release 13

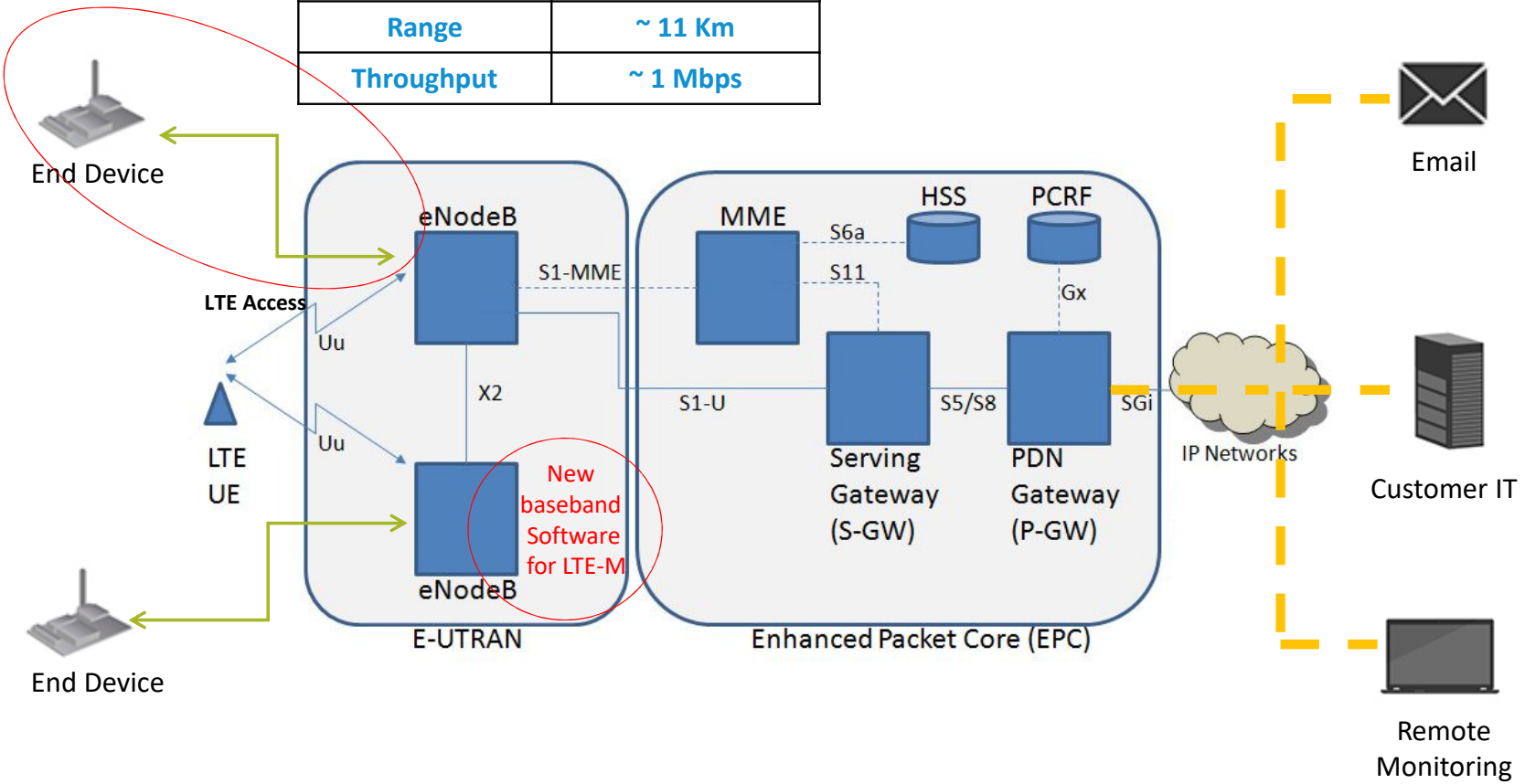
- Reduced receive bandwidth to 1.4 MHz
- **Lower device power** class of 20 dBm
- 15dB additional link budget: **better coverage**
- More **energy efficient** because of its extended discontinuous repetition cycle (eDRX)

Present LTE Architecture

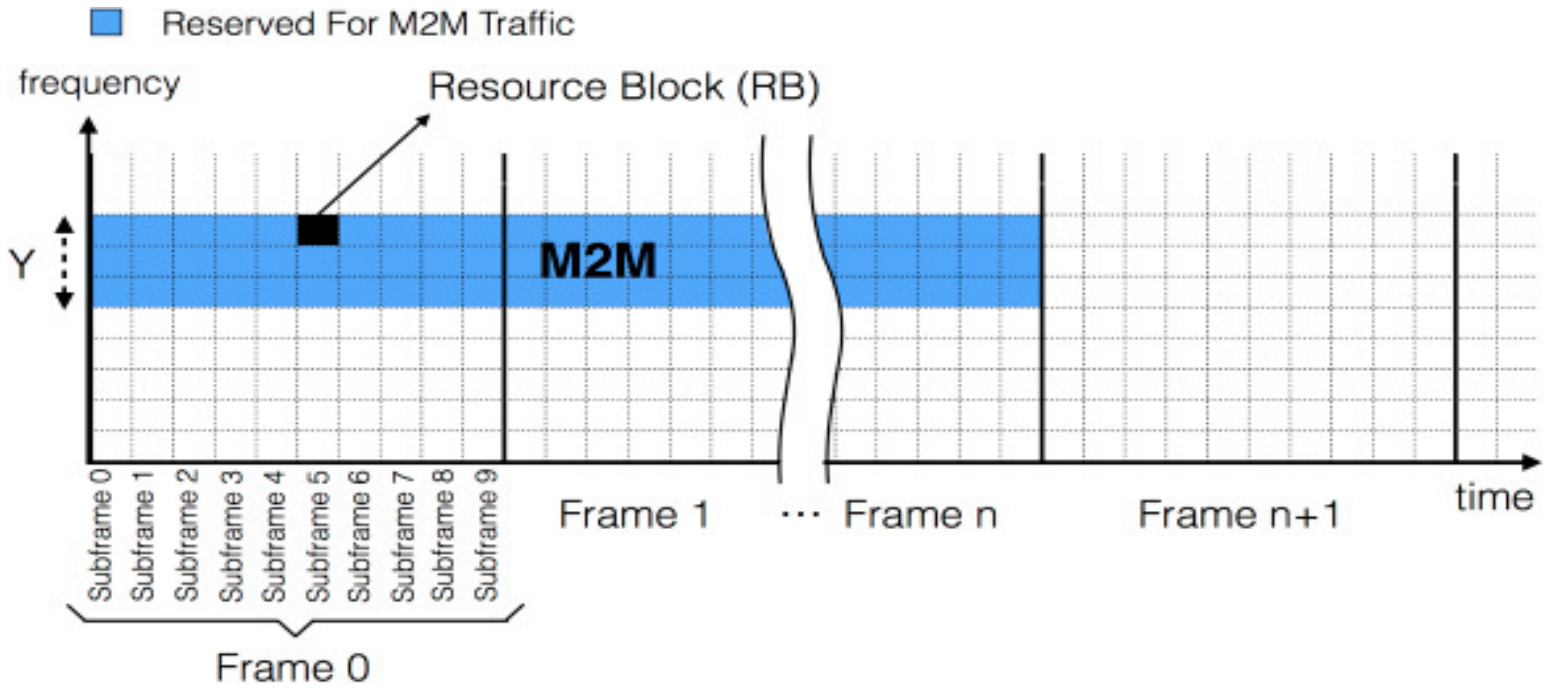


Architecture

Frequency Band	Narrow Band
Access	LTE-M
Range	~ 11 Km
Throughput	~ 1 Mbps

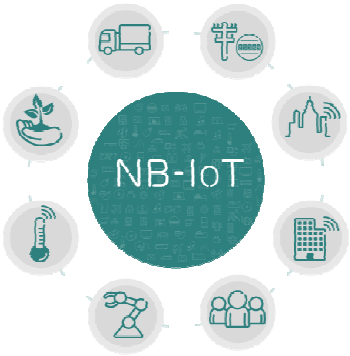


- Licensed Spectrum
- Bandwidth: 700-900 MHz for LTE
- Some resource blocks allocated for IoT on LTE bands



III. NB-IOT

Current status



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Spectral Efficiency	V.Good	Good		OK	
Power Class	Class 3 (23dBm)	Class 3 (23 dBm) Class 5 (20 dBm)		Class 3 and 5	* 14 dBm
UL Multple Access	LTE SC-FDMA	LTE SC-FDMA		LTE SC-FDMA + Single tone transmission with 3.75kHz and 15kHz bandwidths	

NB-IoT main features and advantages

Reuses the LTE design extensively: numerologies, DL OFDMA, UL SC-FDMA, channel coding, rate matching, interleaving, etc.

June 2016: core specifications completed.

Beginning of 2017: commercial launch of products and services.

NB-IoT is non backwards compatible version of LTE targeted for cellular based IoT applications.

Main features

Objectives

- Lower cost than eMTC
- Extended coverage: **164 dB maximum coupling loss** or link budget (at least for standalone) to be compared to GPRS link budget of 144dB and LTE of 142.7 dB
- Receiver sensitivity = **-141 dBm**
- Long battery life: **10 years** with 5 Watt Hour battery (depending on traffic and coverage needs)
- Support for massive number of devices: at least **50.000 per cell**

Main simplification

- Reduced data rate/bandwidth, mobility support and further protocol optimizations

3 modes of operation:

- **Stand-alone:** stand-alone carrier, e.g. spectrum currently used by GERAN systems as a replacement of one or more GSM carriers
- **Guard band:** unused resource blocks within a LTE carrier's guard-band
- **In-band**: resource blocks within a normal LTE carrier

Main features

Main **PHY features**:

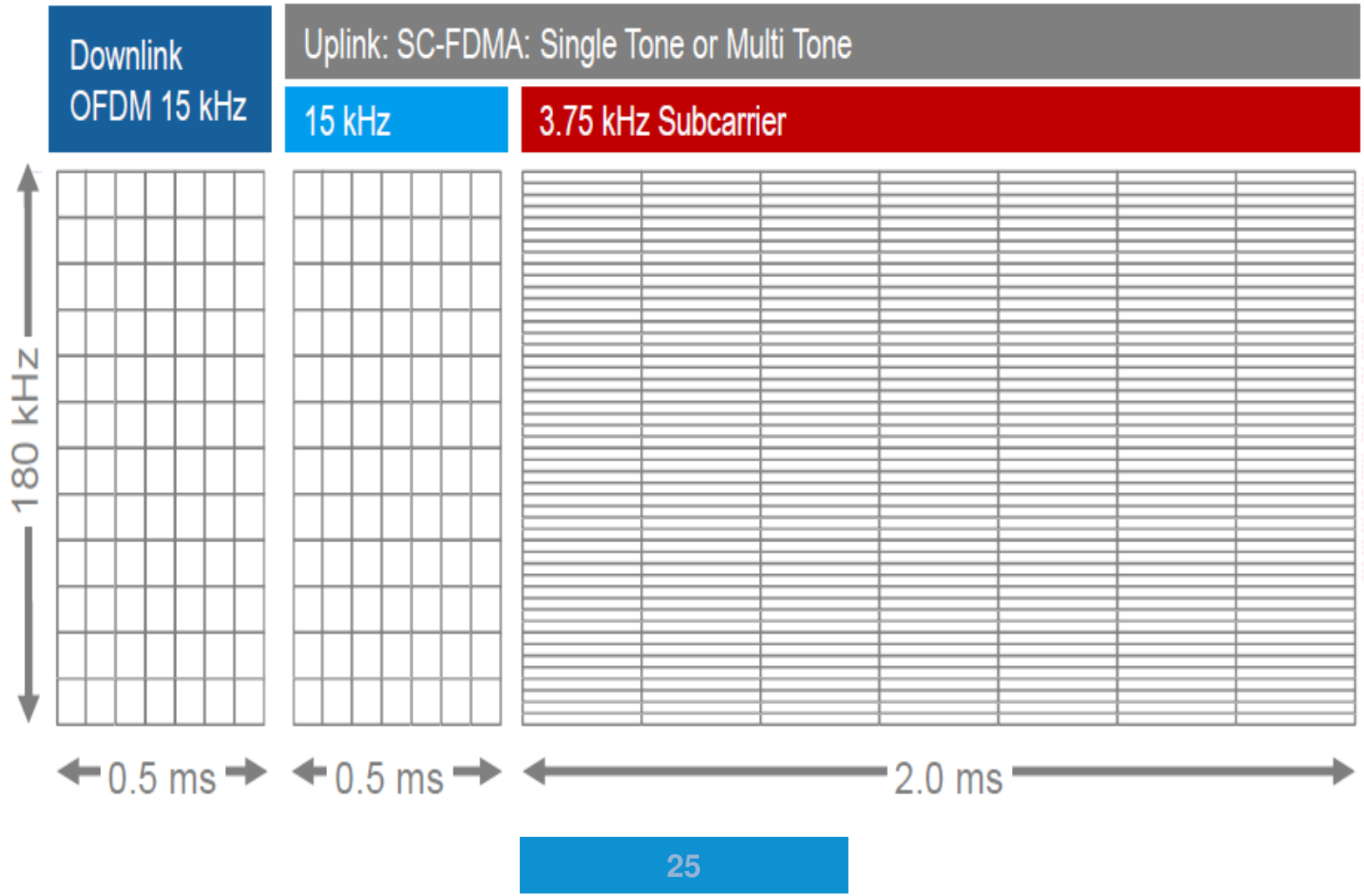
- Narrow band support of **180 kHz**
- Supports **two modes** for uplink
  - ***Single tone*** with **15 kHz** and/or **3.75 kHz** tone spacing
  - ***Multiple tone*** transmissions with **15 kHz** tone spacing
- No support of Turbo code for the downlink
- Single transmission mode of SFBC for PBCH, PDSCH, PDCCH
- New narrowband channels: NPSS, NSSS, NPBCH, NPDCCH, NPDSCH, NPUSCH, NPRACH

Instantaneous peak rates: **170 kbps** (DL) and **250 kbps** (UL)

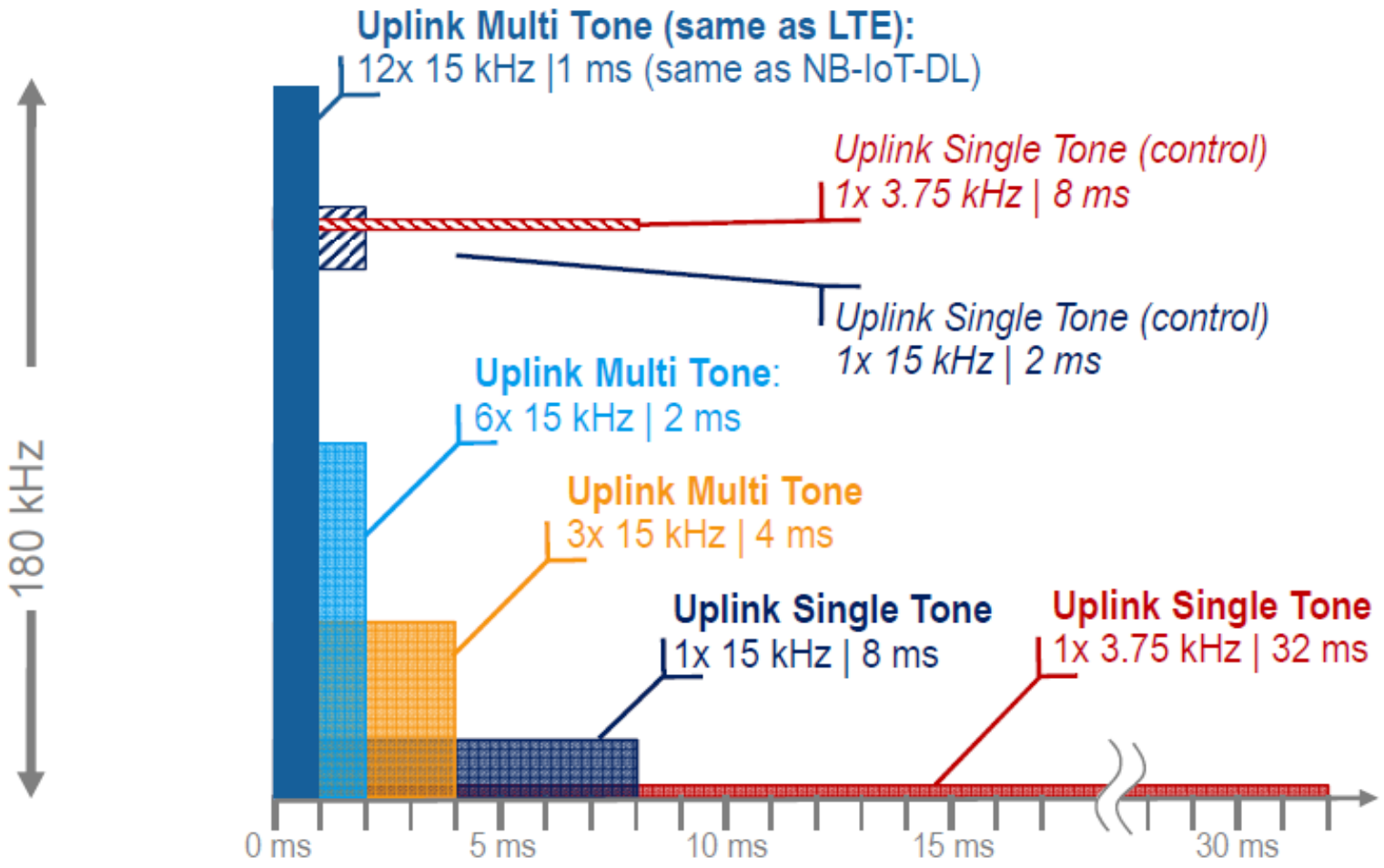
Main **radio protocol features**:

- Single HARQ process
- Only RLC AM mode with simplified status reporting
- Two PDCP options:
  - SRB 0 and 1 only. No AS security (NAS security is used instead). PDCP operating in TM.
  - SRB 0, 1, 2 and one DRB. AS security, which is cached upon RRC connection release. RRC connection suspend/resume procedures to maintain AS security context
- Reduced broadcast system information

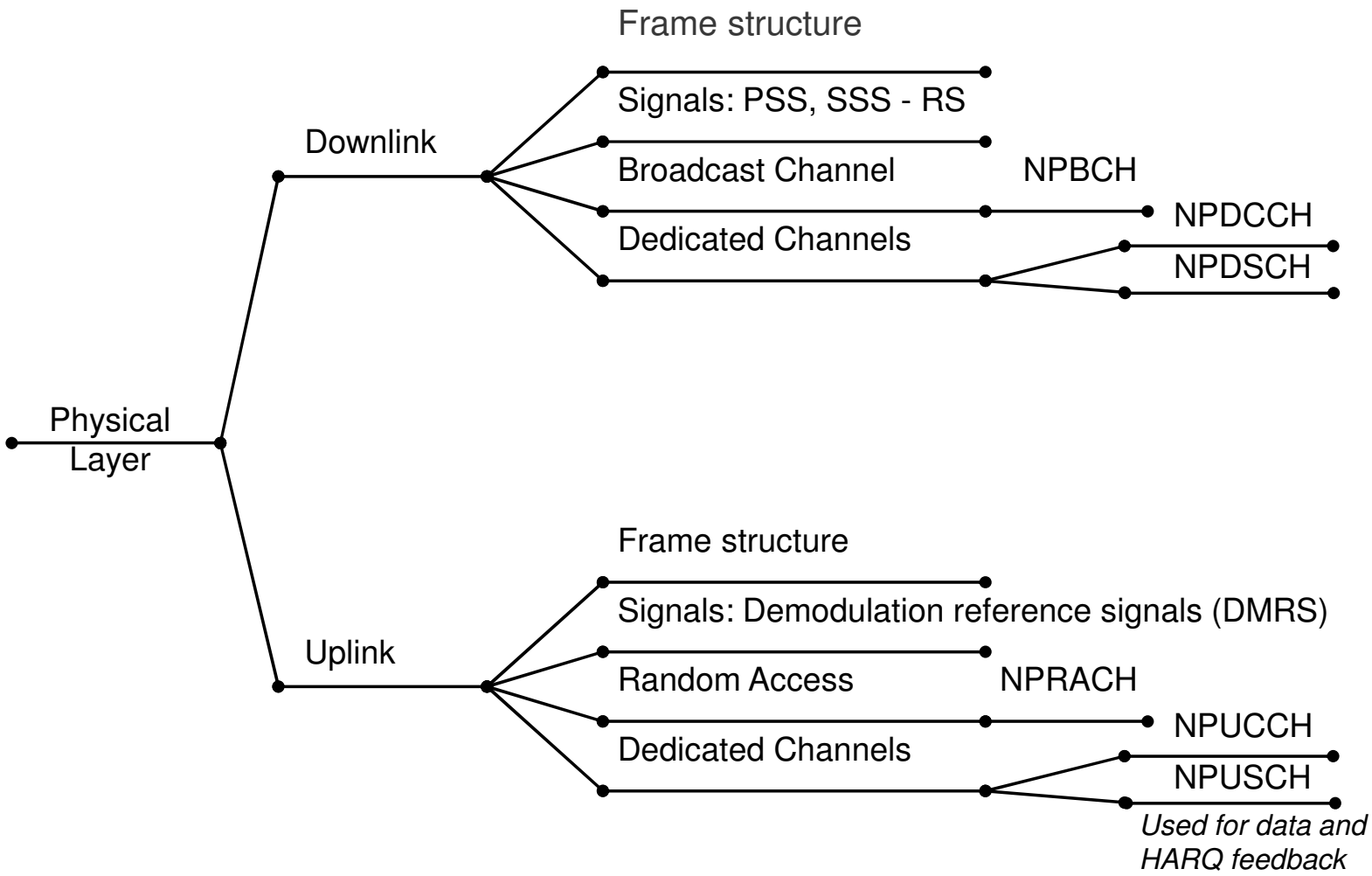
Frame and Slot Structure – NB-IoT – 7 symbols per slot



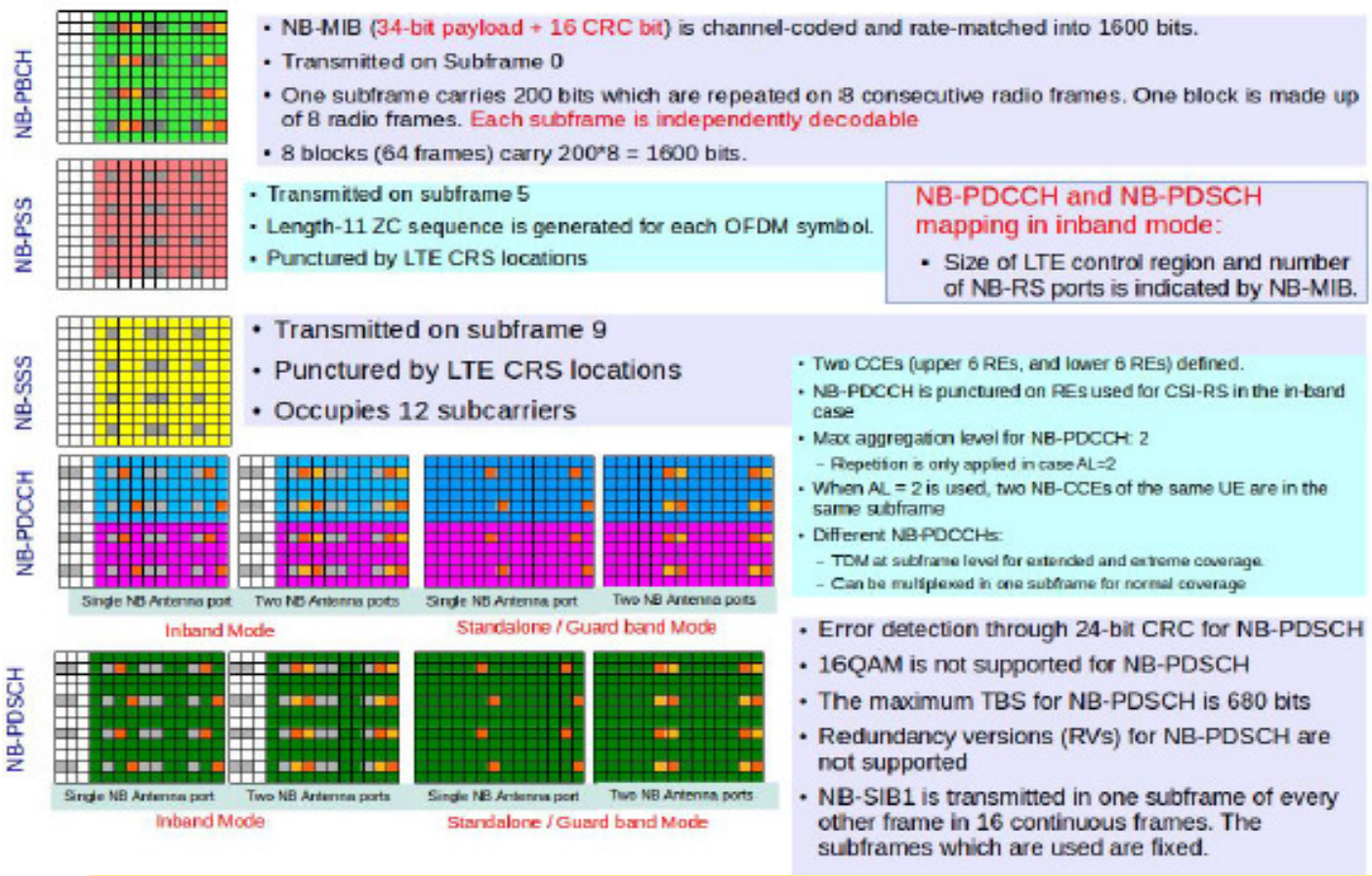
Transmission bandwidth and delays



NB-IoT Channels



Physical downlink channels



- NB-MIB (34-bit payload + 16 CRC bit) is channel-coded and rate-matched into 1600 bits.
- Transmitted on Subframe 0
- One subframe carries 200 bits which are repeated on 8 consecutive radio frames. One block is made up of 8 radio frames. Each subframe is independently decodable
- 8 blocks (64 frames) carry 200*8 = 1600 bits.

- Transmitted on subframe 5
- Length-11 ZC sequence is generated for each OFDM symbol.
- Punctured by LTE CRS locations

NB-PDCCH and NB-PDSCH mapping in inband mode:

- Size of LTE control region and number of NB-RS ports is indicated by NB-MIB.

- Transmitted on subframe 9
- Punctured by LTE CRS locations
- Occupies 12 subcarriers

- Two CCEs (upper 6 REs, and lower 6 REs) defined.
- NB-PDCCH is punctured on REs used for CSI-RS in the in-band case
- Max aggregation level for NB-PDCCH: 2
  - Repetition is only applied in case AL=2
- When AL = 2 is used, two NB-CCEs of the same UE are in the same subframe
- Different NB-PDCCHs:
  - TDM at subframe level for extended and extreme coverage.
  - Can be multiplexed in one subframe for normal coverage

- Error detection through 24-bit CRC for NB-PDSCH
- 16QAM is not supported for NB-PDSCH
- The maximum TBS for NB-PDSCH is 680 bits
- Redundancy versions (RVs) for NB-PDSCH are not supported
- NB-SIB1 is transmitted in one subframe of every other frame in 16 continuous frames. The subframes which are used are fixed.

Maximum Transmission Block Size = **680 bits**
Inband mode: **100 to 108 symbols** – *Standalone/Guard band mode*: **152 to 160 symbols**

Packets transmission on the PUSCH

Smallest unit to map a transport block: *resource unit (RU).*

NPUSCH format 1

- 3.75 kHz subcarrier spacing, an RU = 1 subcarrier in the frequency range, and 16 slots in the time range (length of 32 ms).
- 15 kHz subcarrier spacing 4 options:

Number of subcarriers	Number of slots	RU Duration
1	16	8 ms
3	8	4 ms
6	4	2 ms
12	2	1 ms

  - RUs with one subcarrier, *BPSK* or *QPSK*,
  - Other RUs: *QPSK*.

NPUSCH format 2

RU always composed of one subcarrier with a length of 4 slots.

- 3.75 kHz subcarrier spacing the RU has an 8 ms duration,
- 15 kHz subcarrier spacing has an 2 ms duration.

Modulation scheme: *BPSK*.

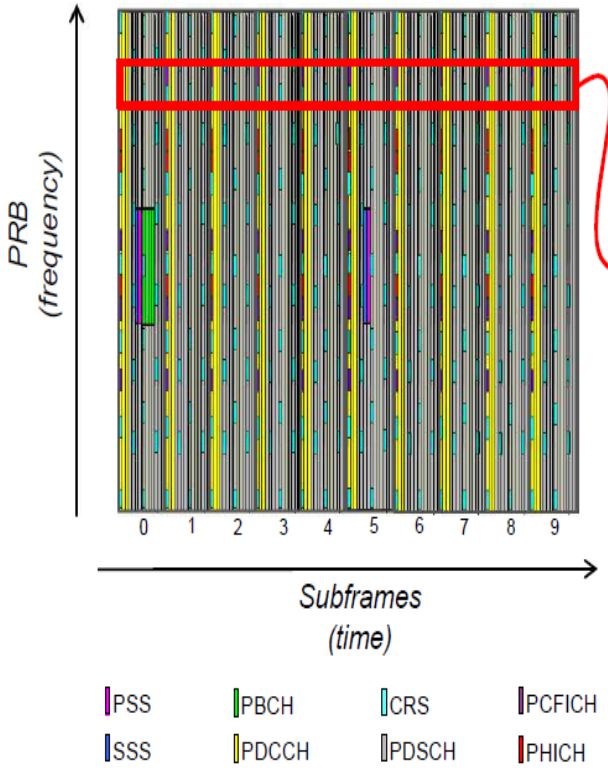
Physical channel	Transport channel	Number of carri-ers	Modulation scheme	Channel coding
NPUSCH format 1	UL-SCH	1 (single-tone)	π/2-BPSK π/4-QPSK	Turbo 1/3
		> 1 (multitone)	QPSK	
NPUSCH format 2	UCI	1 (single-tone)	π/2-BPSK	Block 1/16

UCI: *Uplink Control Information*

Downlink Frame Structure

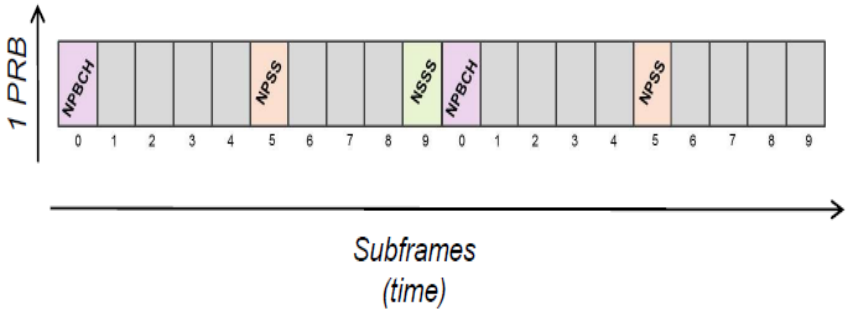
LTE

Channels are time and frequency multiplexed;
Multiple channels per subframe



NB-IoT

Each physical channel occupies the whole PRB;
Only one channel per subframe



Narrowband Primary Synchronization Signal (NPSS)
Transmitted in subframes#5 in all Radio Frames
NRS are not transmitted

Narrowband Secondary Synchronization Signal (NSSS)
Transmitted in subframes#9 in even Radio Frames
NRS are not transmitted

Narrowband Broadcast Channel (NPBCH)
Transmitted in subframes#0 in all Radio Frames
NRS are transmitted

Rest of valid DL subframes available for NPDCCH or NPDSCH
NRS are transmitted

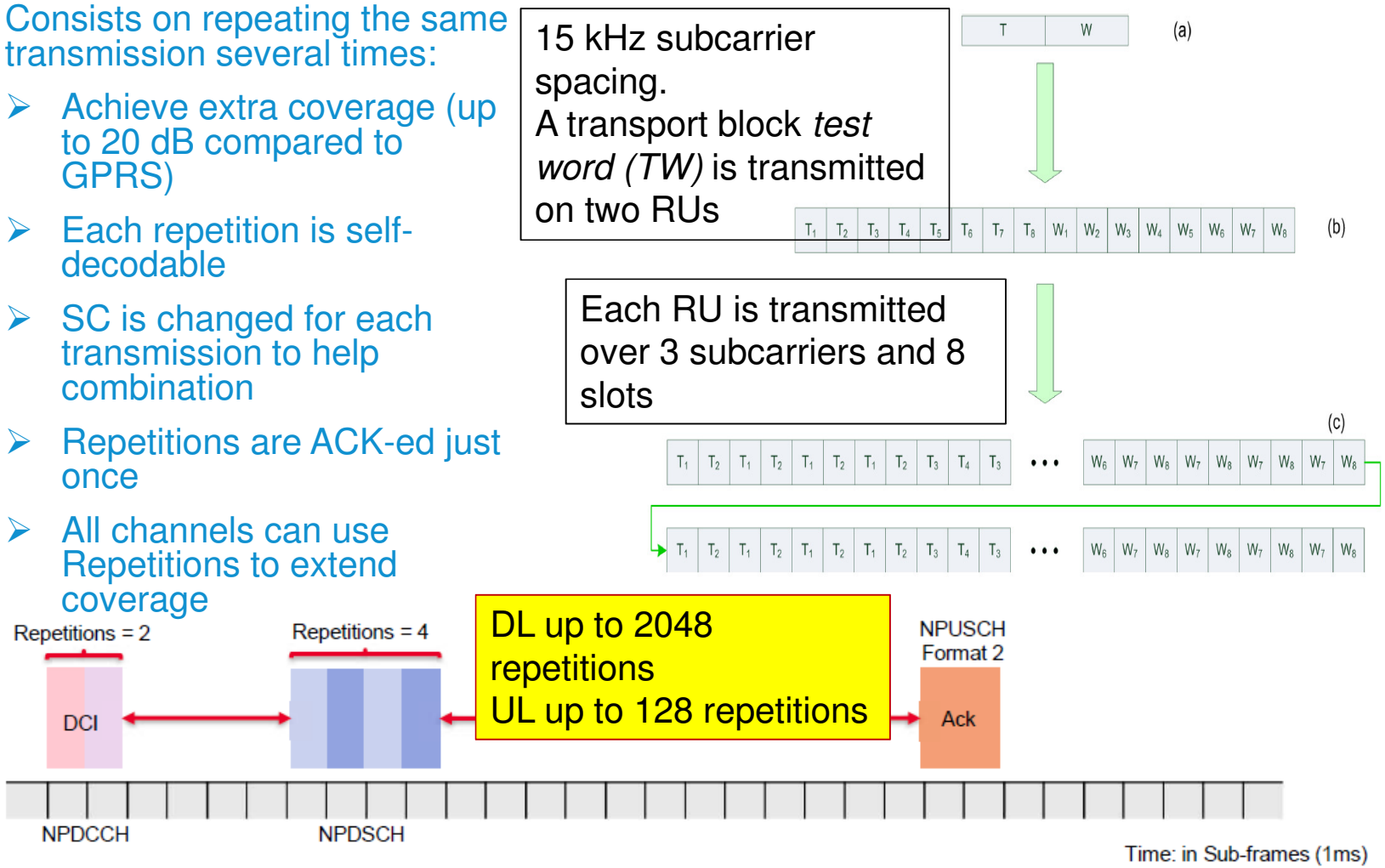
NB-IoT Repetitions

Consists on repeating the same transmission several times:

- Achieve extra coverage (up to 20 dB compared to GPRS)
- Each repetition is self-decodable
- SC is changed for each transmission to help combination
- Repetitions are ACK-ed just once
- All channels can use Repetitions to extend coverage

15 kHz subcarrier spacing.
A transport block *test word (TW)* is transmitted on two RUs

Each RU is transmitted over 3 subcarriers and 8 slots



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

NB-IoT link budget

Link Budget	15kHz	3.75 kHz
(a) Transmit power (dBm)	23	23
(b) Thermal noise (dBm/Hz)	-174	-174
(c) Receiver noise figure (dB)	3	3
(d) Occupied channel bandwidth (Hz)	15 000	3 750
(f) Effective noise power (b)+(c)+10log_10(d) (dBm)		
(g) Required SINR (dB)	-11.8	-5.7
(h) Receiver sensitivity (c)+(g) (dBm)	-141	-141
(i) Maximum coupling loss (a)-(h)	164	164

23 dB improvement over LTE
Urban: Deep in-building penetration
Rural: Long rage (10 – 15 km)

Capacity

NB-IoT supports massive IoT capacity with **only one PRB in both UL and DL**.

NB-IoT can support multiple carrier operation to get more IoT capacity.

Sub-PRB UE scheduled bandwidth is introduced in the uplink, including single-subcarrier NPUSCH.

Based on a traffic model with a split of devices is:

- 80%: MAR (Mobile Autonomous Reporting) periodic
- 20%: Network Command is MAR periodic.

➲ NB-IoT with one PRB supports more than 52,500 UEs per cell.

Enhanced DRX for NB-IOT and eMTC

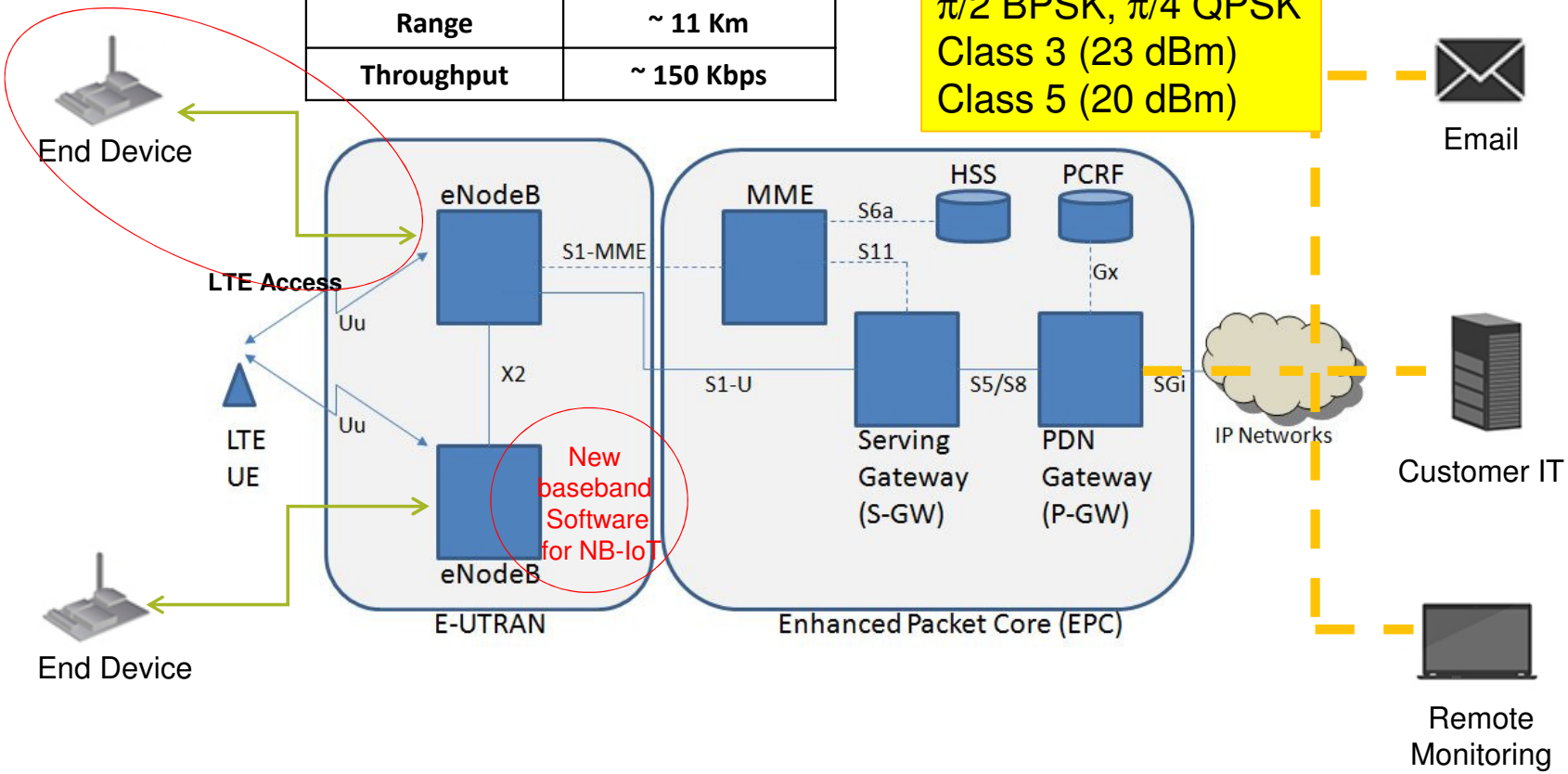
Extended C-DRX and I-DRX operation

- Connected Mode (C-eDRX):
- Extended DRX cycles **of 5.12s** and **10.24s** are supported
- Idle mode (I-eDRX):
- Extended DRX cycles up to **~44min for eMTC**
- Extended DRX cycles up to **~3hr for NB-IOT**

Architecture

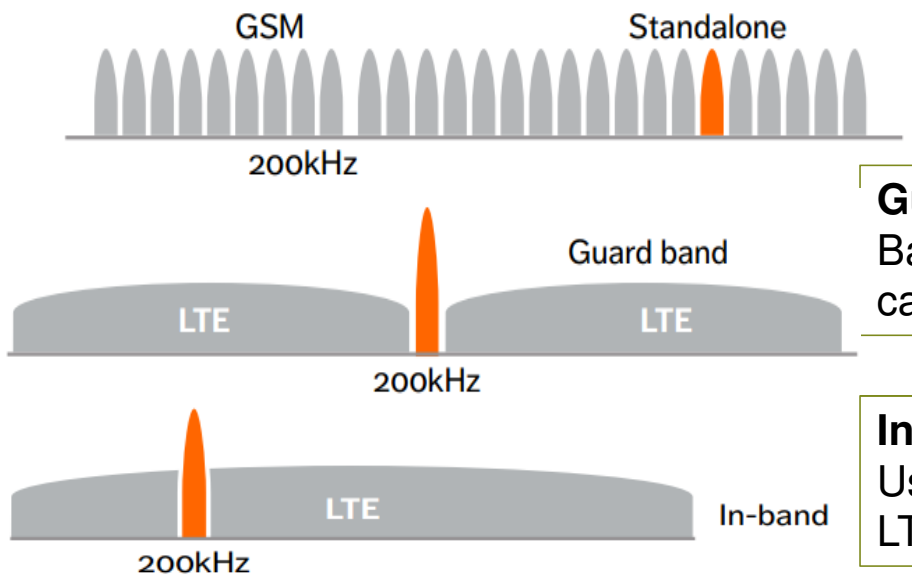
Frequency Band	Ultra Narrow Band
Range	~ 11 Km
Throughput	~ 150 Kbps

HD-FDD
π/2 BPSK, π/4 QPSK
Class 3 (23 dBm)
Class 5 (20 dBm)



Spectrum and access

- Designed with a number of deployment options for **GSM , WCDMA** or **LTE** spectrum to achieve spectrum efficiency.
- Use **licensed spectrum**.



Stand-alone operation

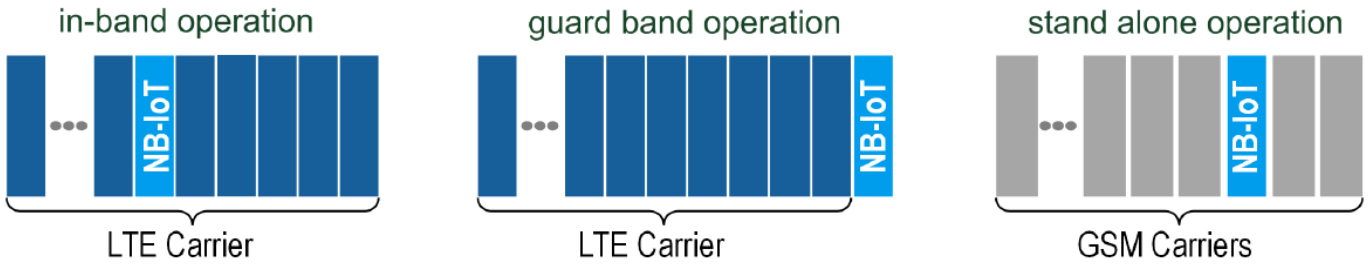
Dedicated spectrum.
Ex.: By **re-farming GSM channels**

Guard band operation

Based on the unused RB within a LTE carrier's **guard-band**

In-band operation

Using **resource blocks** within a normal LTE carrier

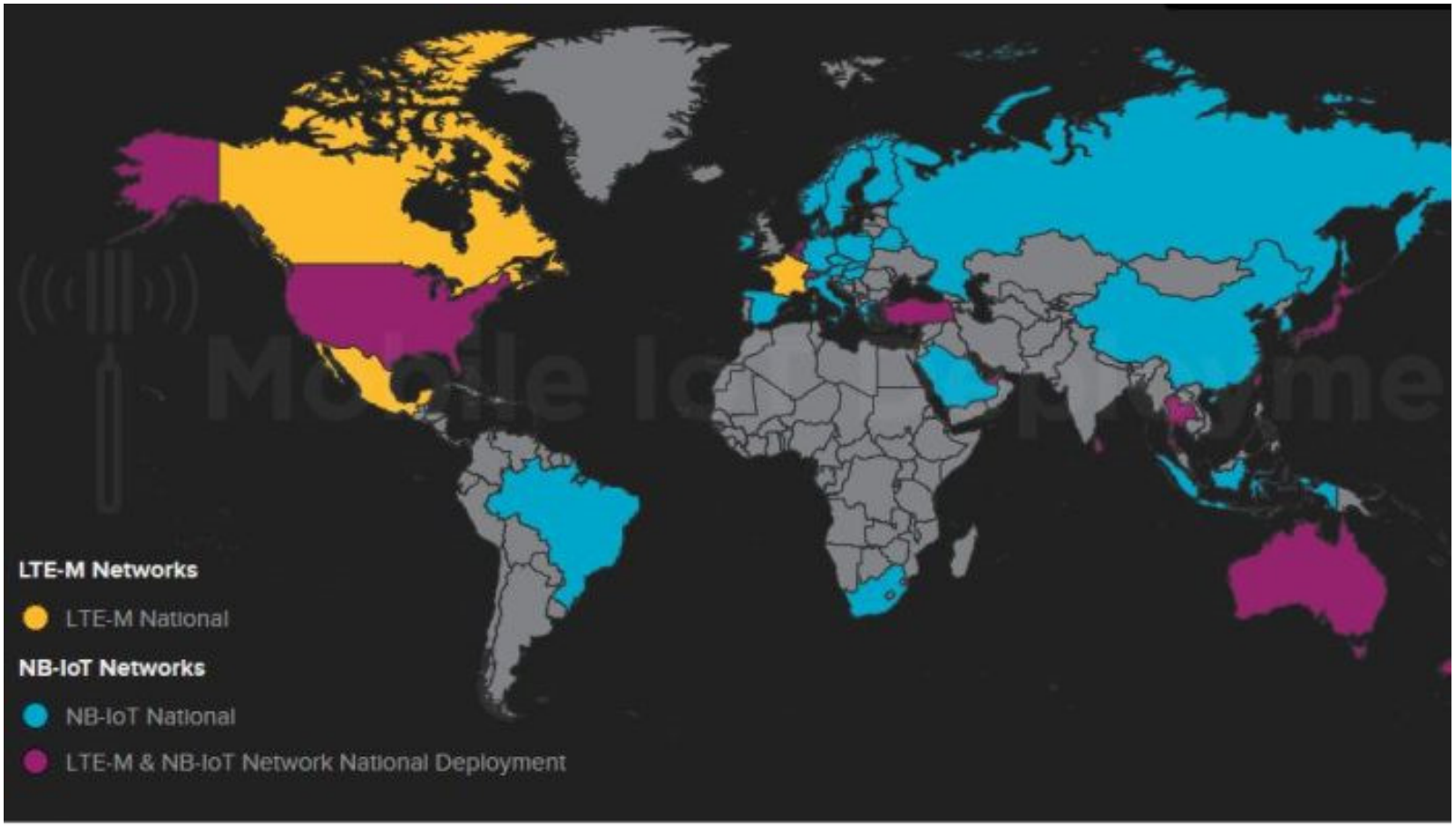


LTE-M to NB-IoT

3GPP Release	12 (Cat.0) LTE-M	13(Cat. 1,4 MHz) LTE-M	13(Cat. 200 KHz) NB-IoT
Downlink peak rate	1 Mbps	1 Mbps	**300 bps to 200 kbps**
Uplink peak rate	1 Mbps	1 Mbps	**144 kbps**
Number of antennas	1	1	1
Duplex Mode	Half	Half	Half
UE receive bandwidth	20 MHz	1.4 MHz	**200 kHz**
UE Transmit power (dBm)	23	20	**23**

- **Reduced throughput** based on single PRB operation
- Enables **lower processing and less memory** on the modules
- 20dB additional link budget ➔ **better area coverage**

LTE-M Networks in 2019



Mobile IoT Deployments

IV. State of Art

A. Regulation

Frequency bands of SRDs

Global 9-148.5 kHz; 3,155-3,400 kHz

Only in Europe 9 kHz- 47 MHz (specific SRDs)

Only in Americas 7,400-8,800 kHz

138.20-138.45 MHz

169.4-216 MHz

312-315MHz (non Europe)

402-405 MHz medical devices

470-489 MHz (normally individually licensed)

823-832 MHz and 1,785-1,805 MHz

862-875 MHz in some Asian counties

862-876MHz Non-Specific SRDs

915-921 MHz (in some countries)

5,150-5,350 & 5,470-5,725 MHz

57-64GHz, 76-77GHz, 77-81GHz

ISM bands

6,780 kHz; 13,560 kHz

27,120 kHz; 40.68 MHz

433.92 MHz

915 MHz

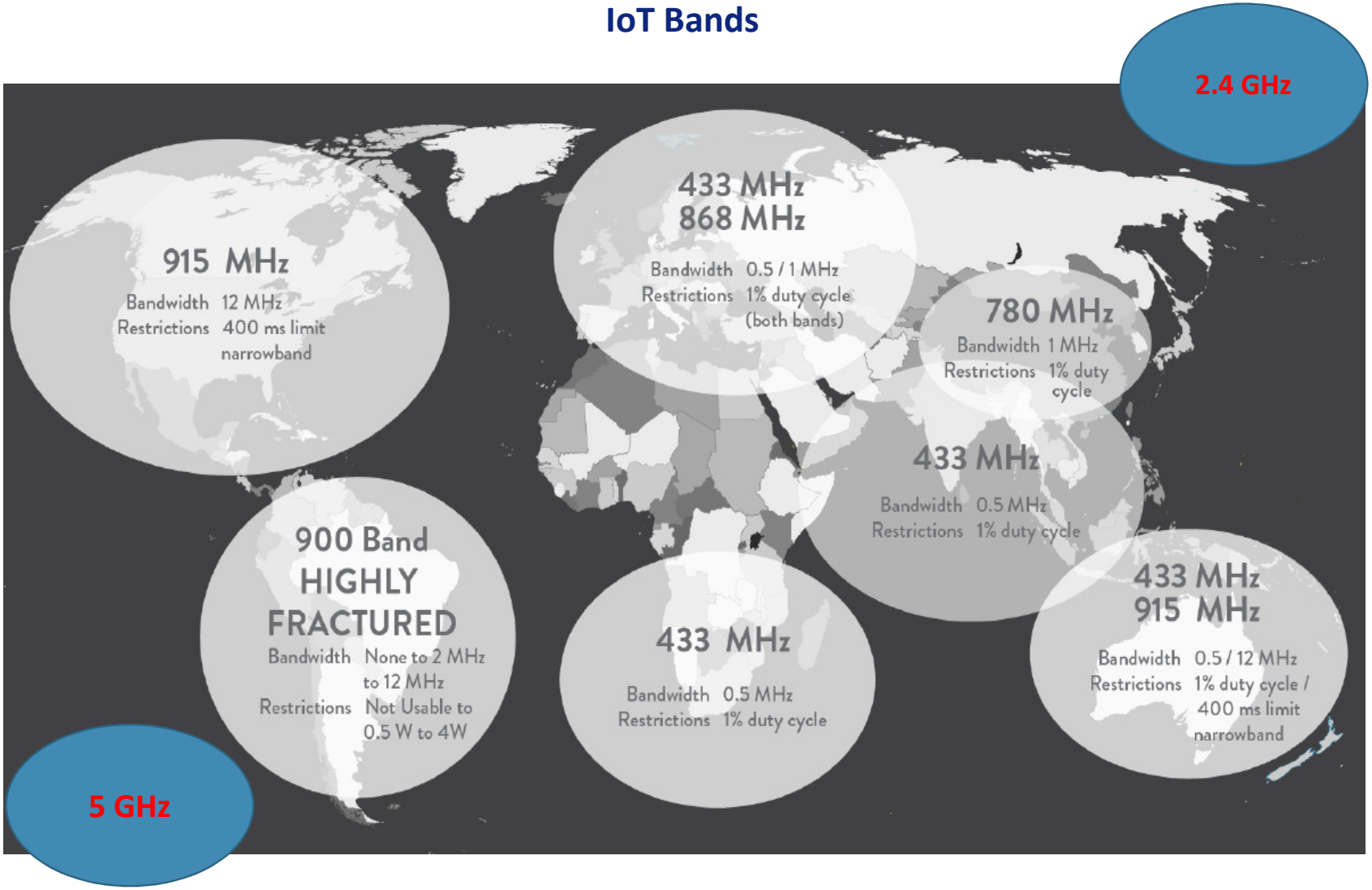
2,450 MHz; 5,800 MHz

24.125 GHz; 61.25 GHz

122.5 GHz; 245 GHz

non-ISM candidate bands for SRDs

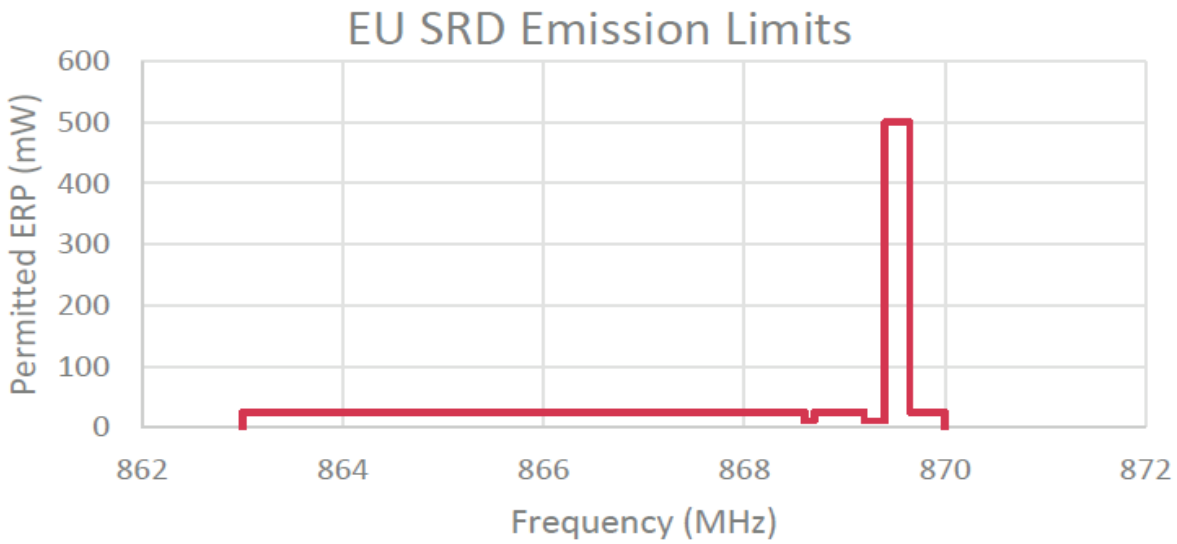
IoT Bands


2.4 GHz
915 MHz
Bandwidth 12 MHz
Restrictions 400 ms limit narrowband
433 MHz
868 MHz
Bandwidth 0.5 / 1 MHz
Restrictions 1% duty cycle (both bands)
780 MHz
Bandwidth 1 MHz
Restrictions 1% duty cycle
433 MHz
Bandwidth 0.5 MHz
Restrictions 1% duty cycle
433 MHz
915 MHz
Bandwidth 0.5 / 12 MHz
Restrictions 1% duty cycle / 400 ms limit narrowband
900 Band
HIGHLY FRACTURED
Bandwidth None to 2 MHz to 12 MHz
Restrictions Not Usable to 0.5 W to 4W
433 MHz
Bandwidth 0.5 MHz
Restrictions 1% duty cycle
5 GHz

IOT regulations

Link	Activity rate	Power
DL	10%	25 mW
UL	1%	500 mW

Arcep France



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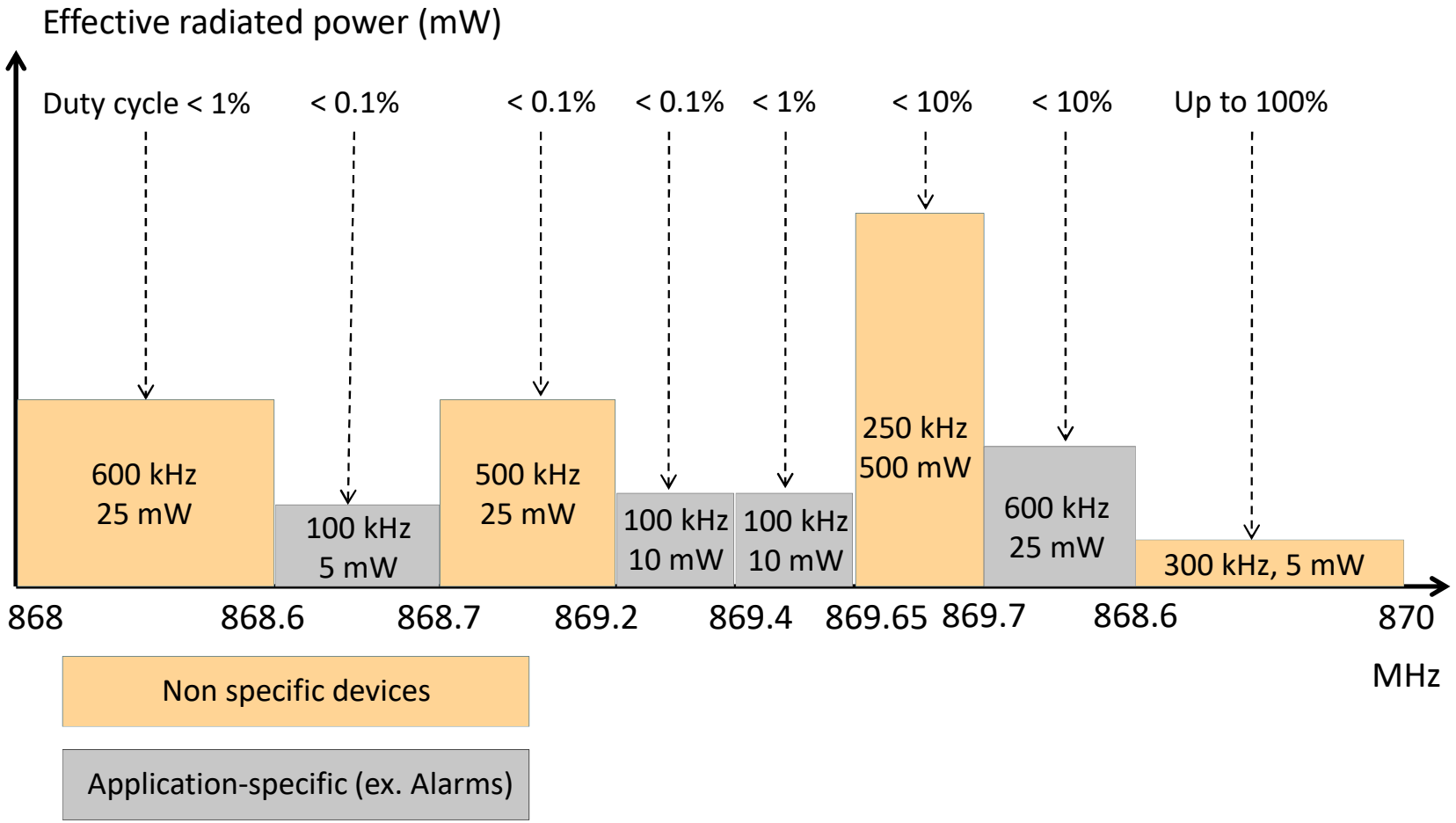
ISM 868MHz Band Plan



B. Prices

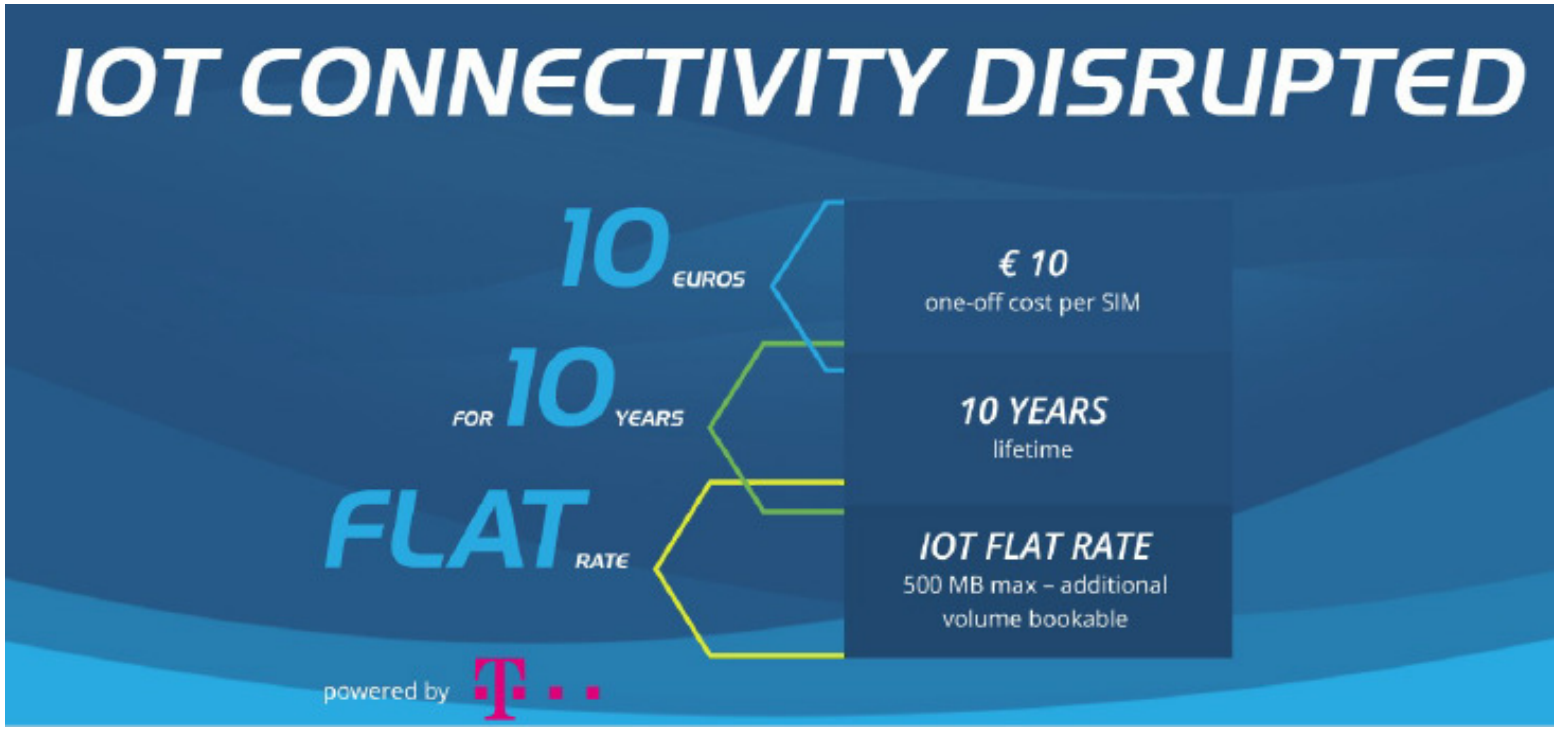
NB-IoT pricing in Deutsche Telekom

Deutsche Telekom

1. The **NB-IoT Access** entry package is available from **EUR 199** and includes a **6-month activation of up to 25 SIM-cards with 500 KB per SIM** pooled in Germany's NB-IoT network. As a further optional add-on – a private APN with IPsec-key encryption is available.
2. The **NB-IoT Access & Cloud of Things** entry package is available from **EUR 299** and additionally includes direct access to Deutsche Telekom's Cloud of Things platform for device and data management.

August 2019: New tariffs
7.95 Euro (LPWA) once for 6 MB in the S tariff.
1000 MB including 250 SMS in tariff M costs **16.95 Euro** (M2M)

T-Mobile NB-IoT Offer



SK Telecom (South Korea) LoRaWan prices

SK Telecom completed a nationwide LTE-M rollout in March 2017 but only LoRaWAN services are available.

Price plans for LoRaWAN-based IoT services:

1. 350 won (**$0.30**) per month per device for a 100kb allocation
2. 2,000 won (**$1.77**) for a 100MB allocation.

Discounts available for multiple lines, ranging from 2% for those using 500 lines for 10% for those using 10,000 lines. Excess data will be charged at 0.005 won per 0.5KB.

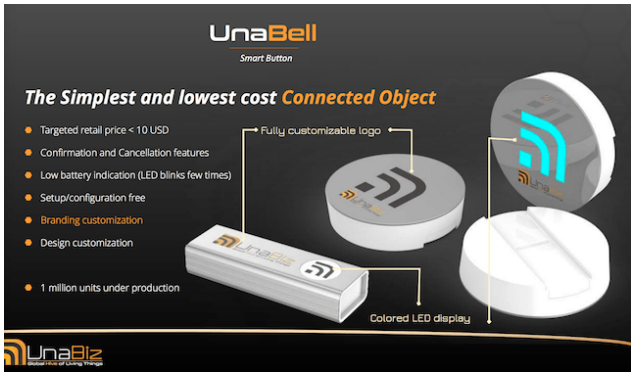
LoRa plans cost just a tenth of the price of its LTE-based IoT services.

Price Plan	Data Allowance* (Frequency of communication)	Monthly Flat Rate (VAT Excluded)	Examples of Services	Note
Band IoT 35	100KB	KRW 350	Metering and monitoring services (e.g. Advanced Metering Infrastructure (AMI), environmental monitoring, water leakage monitoring, etc.)	- Discount benefits for long-term contracts: Ranging from a 5% discount for two-year contracts to a 20% discount for 5 year-contracts - Multi-line discount: Ranging from a 2% discount for those using 500 lines to a 10% discount to those who use 10,000 lines
Band IoT 50	500KB	KRW 500		
Band IoT 70	3MB	KRW 700	Tracking services (e.g. locating tracking For people/things, asset management, etc.)	
Band IoT 100	10MB	KRW 1,000		
Band IoT 150	50MB	KRW 1,500	Control service (e.g. safety management, lighting control, shared parking, etc.)	
Band IoT 200	100MB	KRW 2,000		

**Data usage exceeding the data allotment provided will be charged at KRW 0.005 per 0.5KB.*

UnaBiz (Singapore) Sigfox prices

Network subscription charges: **US$0.75 per device per month**, which comes with a data plan for up to 140 messages per day.
Qualified channel partners who **commit to volume** can ultimately enjoy subscription charges from as low as **US$0.75 per device per year**.



Jonathan Tan, Vice President Business Development & Sales, UnaBiz said, *"Sigfox's technology is built for massive deployment and we are offering ultra-low cost connectivity to grow exponentially the base of devices that can access the network. Compared to existing local networks, businesses on our global network can generate savings of at least 90% off data plan subscription charges."*

AT&T LTE-M services pricing

The new prepaid plans, which target develc
businesses, include three tiers of data and text messages:

1. 1 gigabyte of data valid for up to 1 year and 500 text messages for **$25**;
2. 3 GB of data valid for up to 1 year and 1,000 text messages for **$60**;
3. 5 GB of data valid for up to 2 years and 1,500 text messages for **$100**.

Synthesis

Country	Operator	Technology	Price/End-device/month	Conditions (/end-device/month)
Germany	DT	NB-IoT	US$ 1.60	85 KB
			US$ 2.40	“ + Cloud
South Korea	SK Telecom	LoRaWAN	US$ 0.30	100 KB
			US$ 1.77	100 MB
Singapore	UnaBiz	Sigfox	US$ 0.75	140 messages
USA	AT&T	LTE-M	US$ 2.08	83 MB and 42 messages
			US$ 5	250 MB and 84 messages
			US$ 4,2	210 MB and 63 messages

LPWA connections forecast – by tech

	2018		2023		2026		CAGR
NON-CELLULAR	116m	93.67%	576m	53.02%	1.343bn	37.64%	34%
LoRaWAN	24m	19.11%	237m	21.86%	636m	17.84%	59%
Sigfox	4m	3.18%	112m	10.27%	431m	12.09%	70%
Other	88m	71.38%	227m	20.9%	275m	7.71%	13%
CELLULAR	8m	6.33%	510m	46.98%	2.224bn	62.36%	92%
LTE-M	1m	0.85%	221m	20.37%	925m	25.93%	102%
NB-IoT	7m	5.49%	289m	26.61%	1.299bn	36.43%	88%
TOTAL	123m	-	1.086bn	783%*	3.567bn	229%*	51%

Source: ABI Research

Comparison — ABI and IHS are about in line, whether they are counting connections or shipments: there is a 12 million delta between their 2021/2023 LoRa/LoRaWAN forecasts, which stretches to about 27 million for Sigfox and 66 million for NB-IoT. This looks surmountable over two-to-three years (2021-2023).

LPWA shipments forecast – by tech

	2019		2020		2021		CAGR
NON-CELLULAR	134.8m	56.19%	221.5m	53.77%	343.2m	55.5%	37%
LoRa	98.16m	40.91%	161.6m	39.23%	249.7m	40.39%	37%
Sigfox	27.95m	11.65%	52.82m	12.82%	85.04m	13.75%	
Other	8.7m	3.63%	7.07m	1.72%	8.4m	1.36%	-1%
CELLULAR	105.2m	43.81%	190.4m	46.23%	275.2m	44.5%	
LTE-M	20.28m	8.45%	28.8m	6.99%	52.29m	8.46%	37%
NB-IoT	84.88m	35.36%	161.6m	39.24%	222.9m	36.05%	38%
TOTAL	240m	-	411.9m	71.64%*	622.4m	50.13%*	37%

Source: IHS Markit

Quizz – LTE-M and NB-IoT

1) What are the main changes introduced in LTE-M for IoT services?
2) What are the main changes introduced in NB-IoT for IoT services?
3) Why regulators define an activity rate in IoT?
4) Is the activity rate applicable to LTE-M and NB-IoT?
5) By which value the link budget is improved in NB-IoT?

Thank you!