NB IOT RAN

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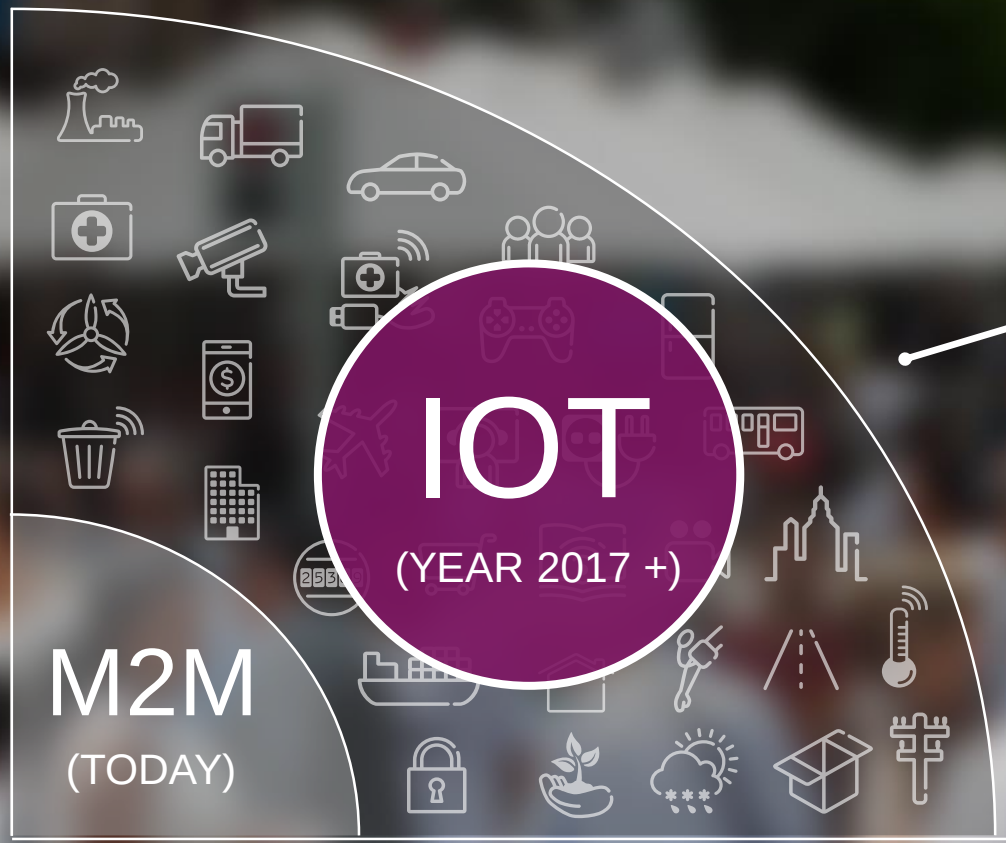
Solution Architect

MASSIVE IOT MARKET OUTLOOK



15 BILLION

PREDICTED IOT CONNECTED DEVICES IN 2021

Source: Ericsson Mobility Report

PROBLEM AREA & MOTIVATION
-MACHINE TYPE COMMUNICATION EXAMPLES

Monitoring & automation of buildings, city infrastructure, smart metering

Long battery life

Smart agriculture and farming

Low cost

Massive numbers

Remote patient monitoring

Connected vending machines

Long range

Small data

Logistics, tracking and fleet management

Smart grid distribution automation

Reliable real-time communication

Industrial manufacturing and control

Autonomous vehicles

High reliability

High availability

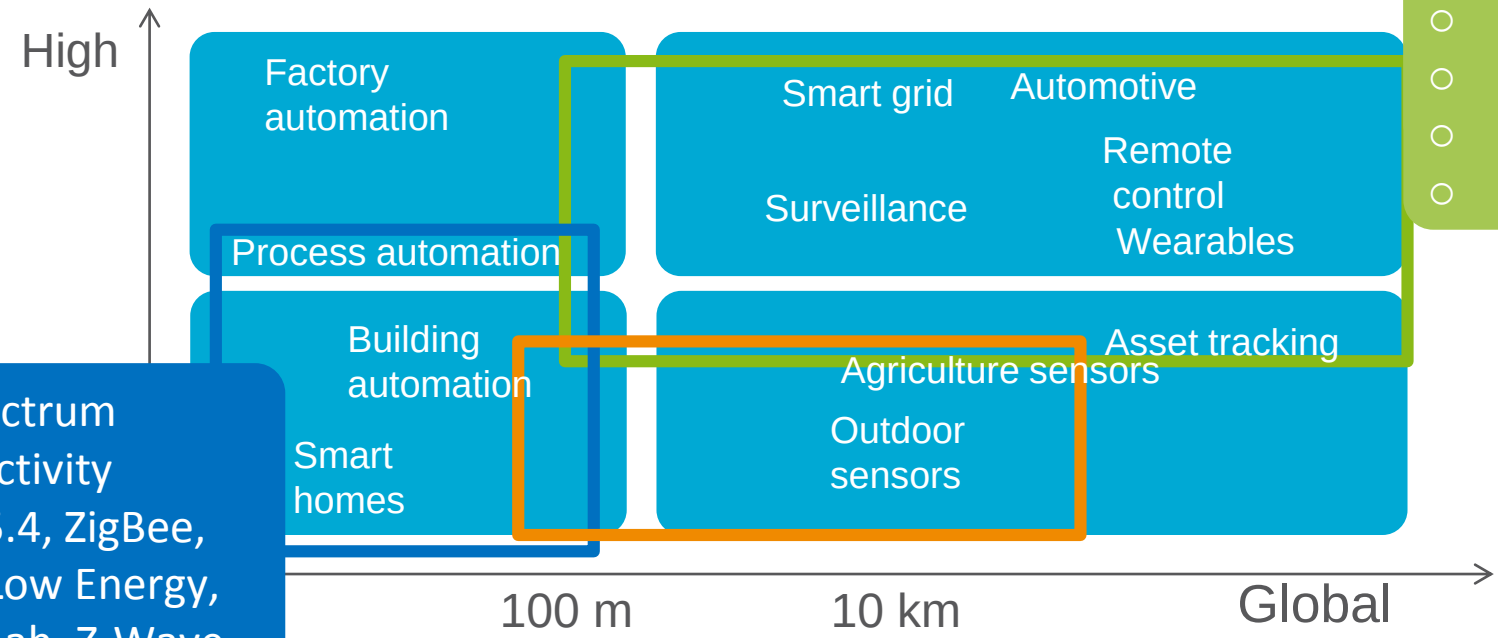
Remote control of machines

Remote manufacturing, training, surgery

Low latency

IoT SEGMENTS & CONNECTIVITY

Required quality of connectivity



Use-case area of coverage

Licensed IMT spectrum
- GSM, GSM evolution
- WCDMA
- 4G
- LTE evolution for MTC
- 5G

Unlicensed spectrum for local connectivity
- IEEE 802.15.4, ZigBee,
- Bluetooth Low Energy,
- IEEE 802.11ah, Z-Wave, …

Backhaul *cellular* or fixed

Unlicensed spectrum for long range
- Weightless (Neul)
- Sigfox
- Ingenu
- LoRa
- …

WIDE RANGE OF ACCESS REQUIREMENTS

MASSIVE IOT

SMART BUILDING

LOGISTICS, TRACKING AND FLEET MANAGEMENT

SMART METER

SMART AGRICULTURE

CAPILLARY NETWORKS

CRITICAL IOT

REMOTE HEALTH CARE

TRAFFIC SAFETY & CONTROL

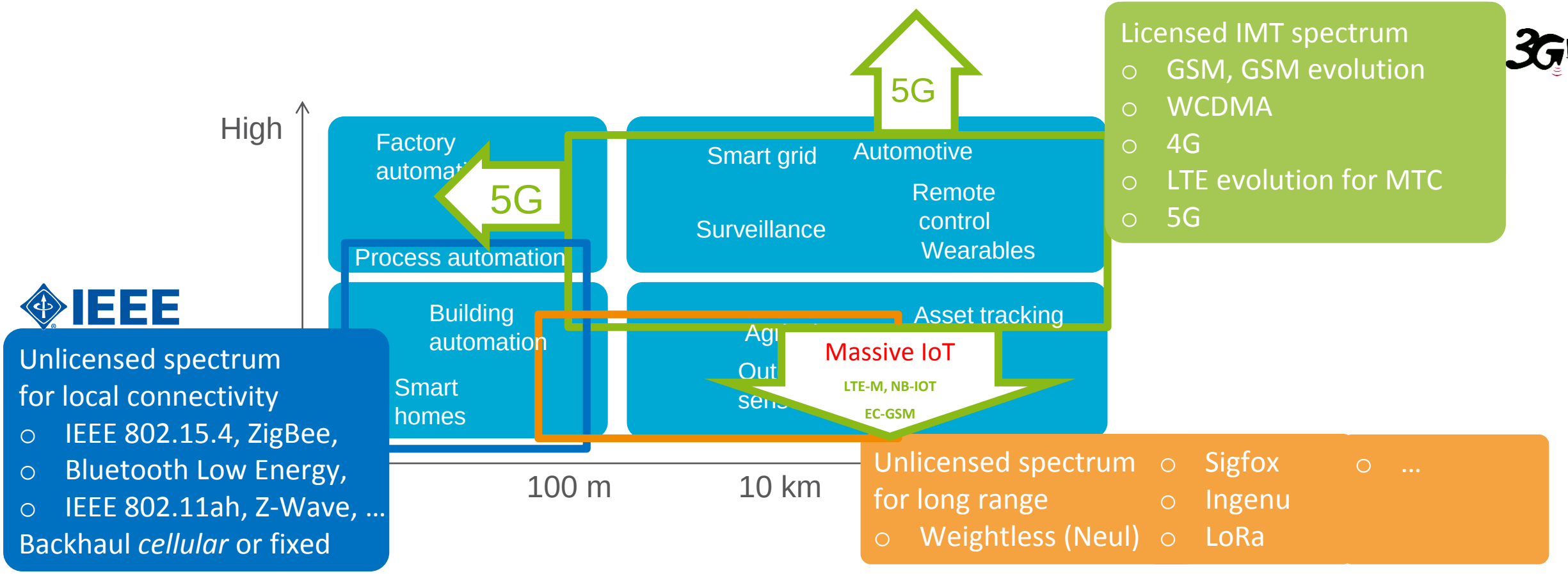
INDUSTRIAL APPLICATION & CONTROL

REMOTE MANUFACTURING, TRAINING, SURGERY

LOW COST, LOW ENERGY
SMALL DATA VOLUMES
MASSIVE NUMBERS

ULTRA RELIABLE
VERY LOW LATENCY
VERY HIGH AVAILABILITY

IoT SEGMENTS & CONNECTIVITY



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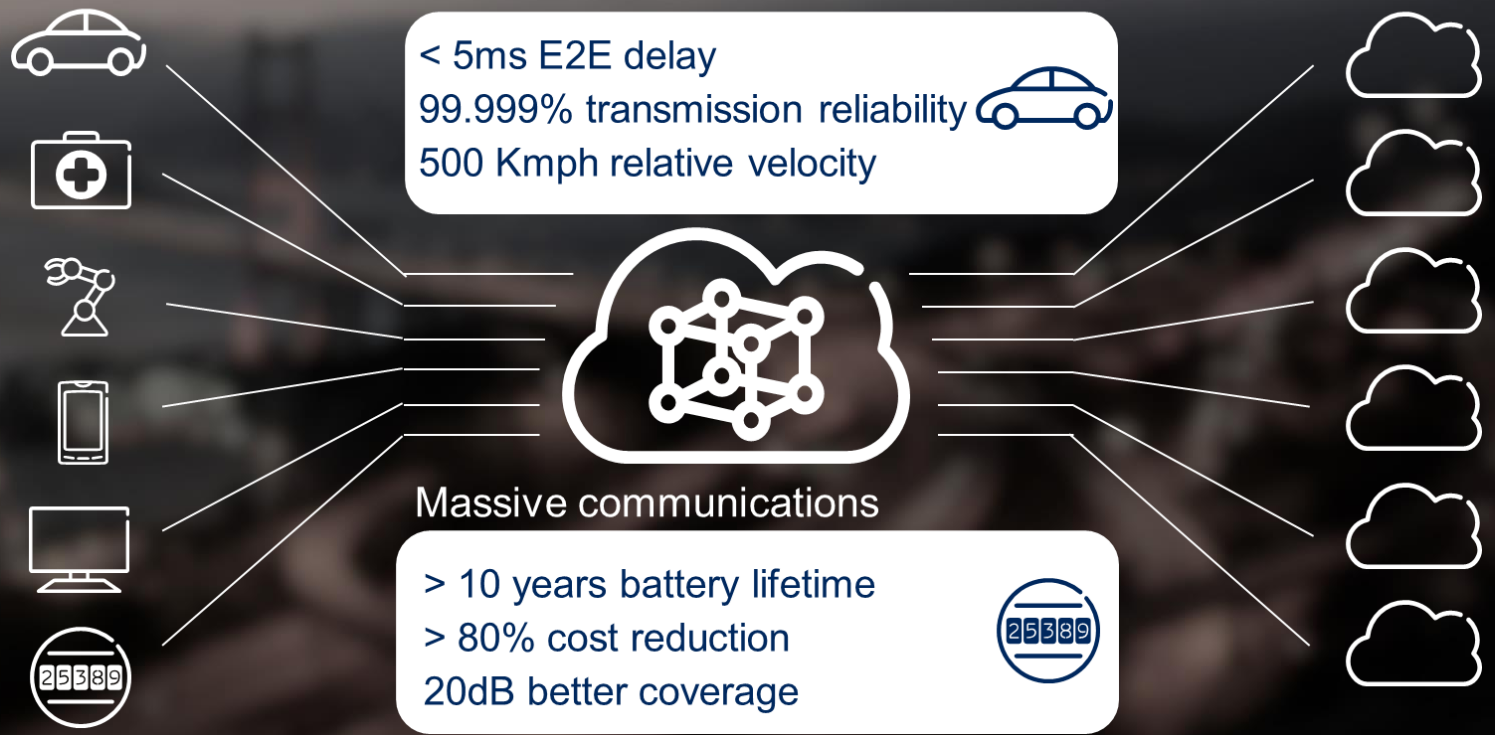
- …

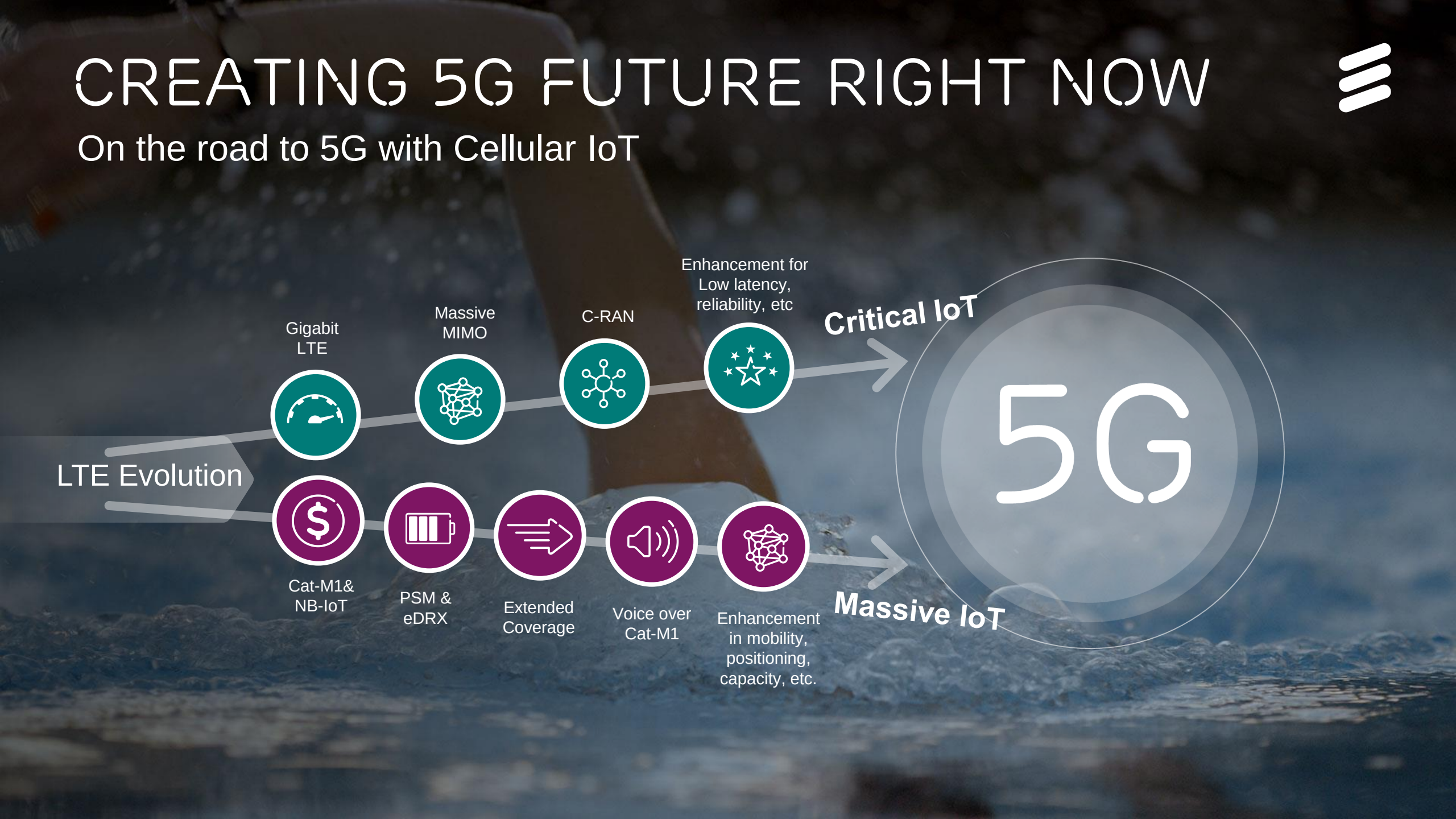
ONE NETWORK, MULTIPLE INDUSTRIES

5G USE CASES



CREATING 5G FUTURE RIGHT NOW

On the road to 5G with Cellular IoT



MASSIVE IOT REQUIREMENTS

MASSIVE NUMBER OF CONNECTIONS

Low COST

Long BATTERY LIFE

Good COVERAGE

FULL RANGE OF IOT/MTC SOLUTIONS

Standardized in 3GPP rel 13

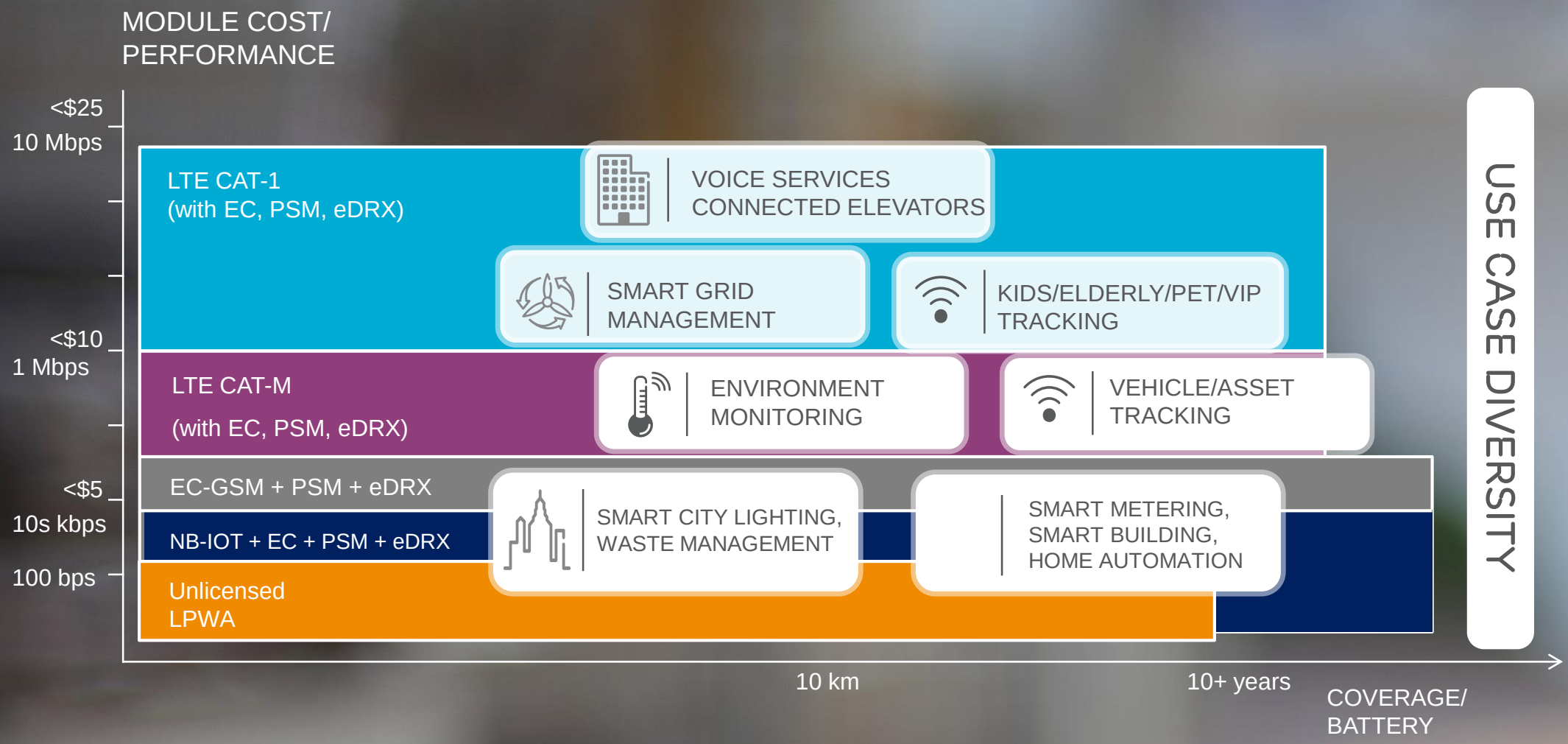
EC-GSM-IoT	**Evolution of GSM** Ultra-low bitrate applications
Cat-M1	**eMTC 1,4 MHz** Low to medium bitrate applications
NB-IoT	**New 200KHz carrier** Ultra low-bitrate applications

CELLULAR FOR MASSIVE IOT

Meeting diversity of use case requirements

	Bandwidth	Coverage	Battery life	Capacity	Throughput	Security	SLA/QoS	Mobility	Deployment
Cat-M1	1,4MHz	155dB (+15dB)	10+ Year	1M+ per cell	1/1 Mbps			300km/h	SW
NB-IoT	200kHz	164dB (+20dB)	10+ Year	200,000 per cell	230/200 kbps			240km/h	SW
EC-GSM-IoT	600kHz	164dB (+20dB)	10+ Year	190,000 per cell	230/230 kbps			50km/h	SW

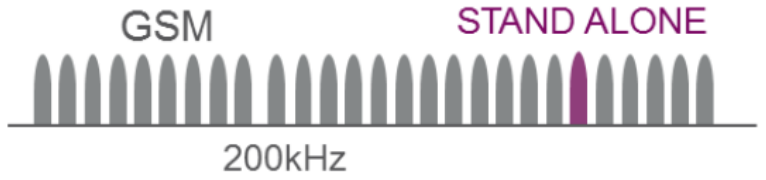
CELLULAR LPWA SERVES MUCH MORE




DESIGN
AND
FUNCTIONALITIES

NB-IOT AIR INTERFACE

- OFDMA (DL) and SC-FDMA (UL) based
- 12 subcarriers with 15 kHz spacing
- Transmission bandwidth: 180 kHz
- Basic scheduling unit time: 1 ms
- 3 different deployment options:
  - Stand-alone
  - Guard band
  - In-band



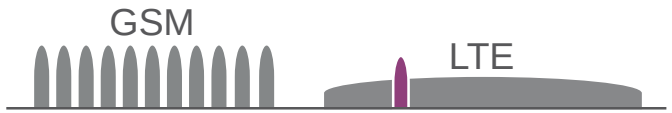
NB-IOT DEPLOYMENT COMPARISON

STAND ALONE

- Additional cost in connecting LTE DU to 900 MHz radios
- Limited capacity scaling possibilities without affecting GSM (bandwidth reduction, frequency re-planning, etc.)
- Utilize high transmit power, higher downlink device data rate

GUARD BAND

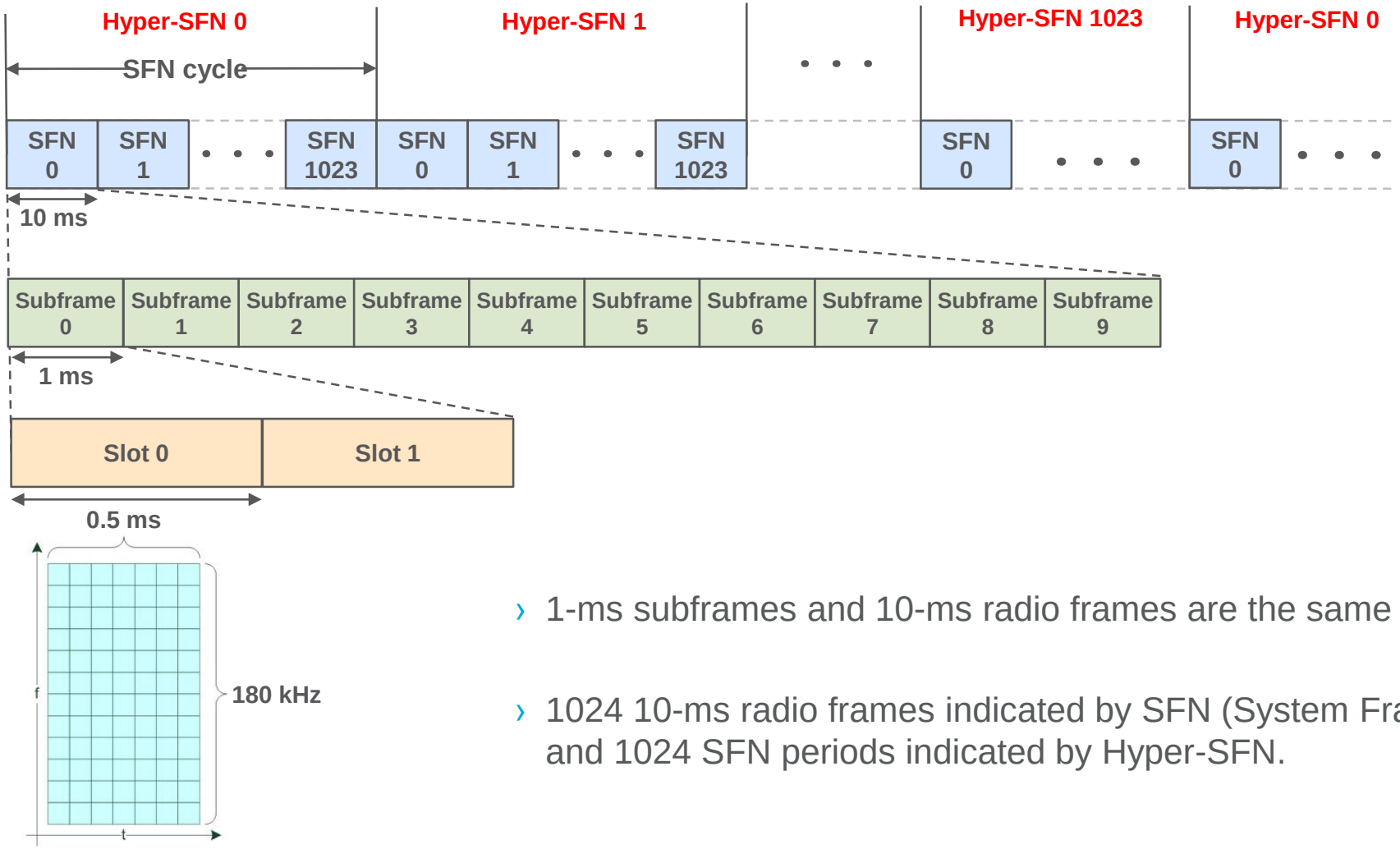
- Limited possibilities to expand capacity with more NB-IoT carriers
- Boosting may be limited
- Bigger negative effect on LTE transmit power



IN-BAND

- Very good capacity scaling possibilities
- Possibility for high boosting
- In very sparsely upgraded network, near-far interference to non-upgraded LTE base stations can occur

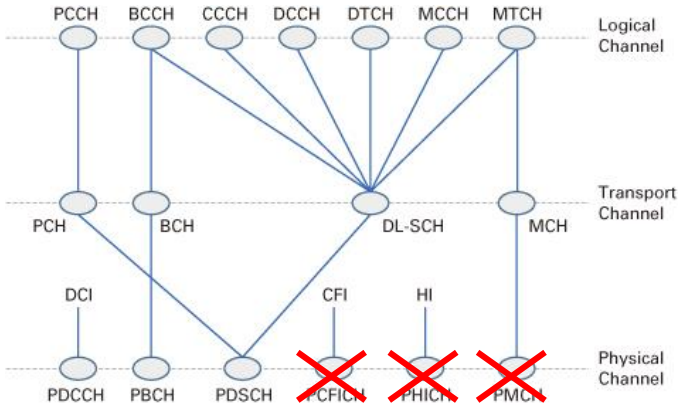
TIME STRUCTURE

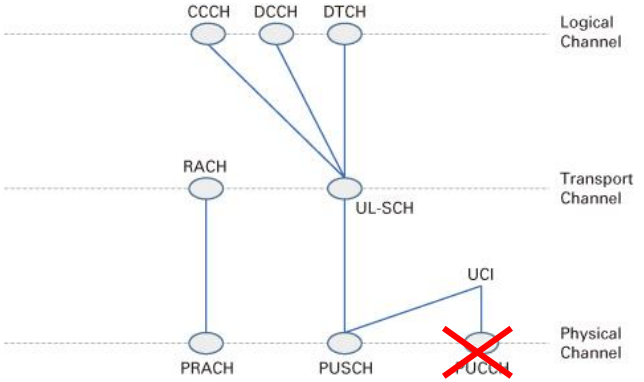


- 1-ms subframes and 10-ms radio frames are the same as in LTE.
- 1024 10-ms radio frames indicated by SFN (System Frame Number), and 1024 SFN periods indicated by Hyper-SFN.

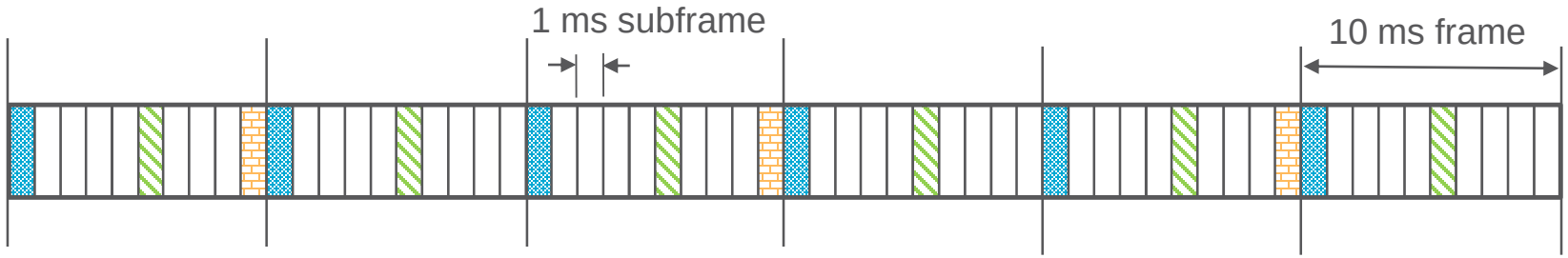
NOT SUPPORTED PHYSICAL CHANNELS

- The following LTE channels have no direct corresponding channel in NB-IoT:
- PCFICH
  - NPDCCH covers an entire subframe in subframes carrying NPDCCH so no need to indicate number of OFDM symbols for NPDCCH
  - Legacy PDCCH region indicated for in-band deployment in LTE carrier
- PHICH
  - Only asynchronous adaptive HARQ for NPUSCH
- PUCCH
  - ACK/NACK transmitted on NPUSCH format 2
    - ACK/NACK for NPUSCH is signaled via New Data Indicator in DCI
  - Random Access required for transmission of Scheduling Request (SR)





NB-IOT PHYSICAL CHANNELS



NPBCH:

- Master Information Block Narrow Band (MIB-NB)
- Subframe 0 every Radio Frame

NPSS:

- Used for cell search
- Subframe 5 in every frame

NSSS

- Used for cell search
- Subframe 9 in every even frame

NPDSCH:

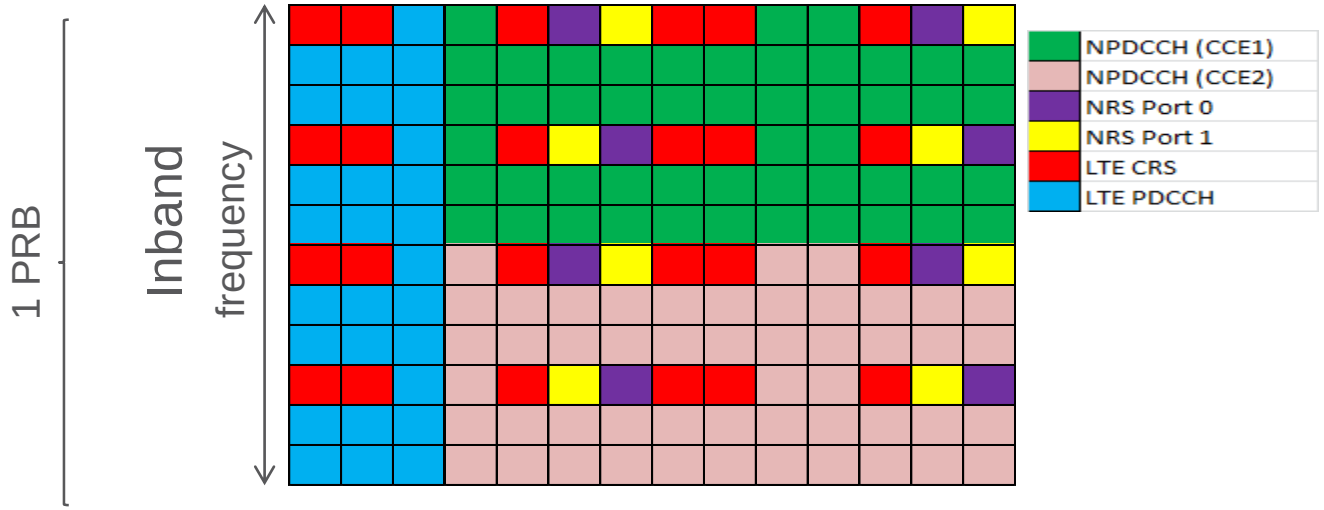
- User data and signaling
- System Information Blocks (SIBs)
- Paging

NPDCCH:

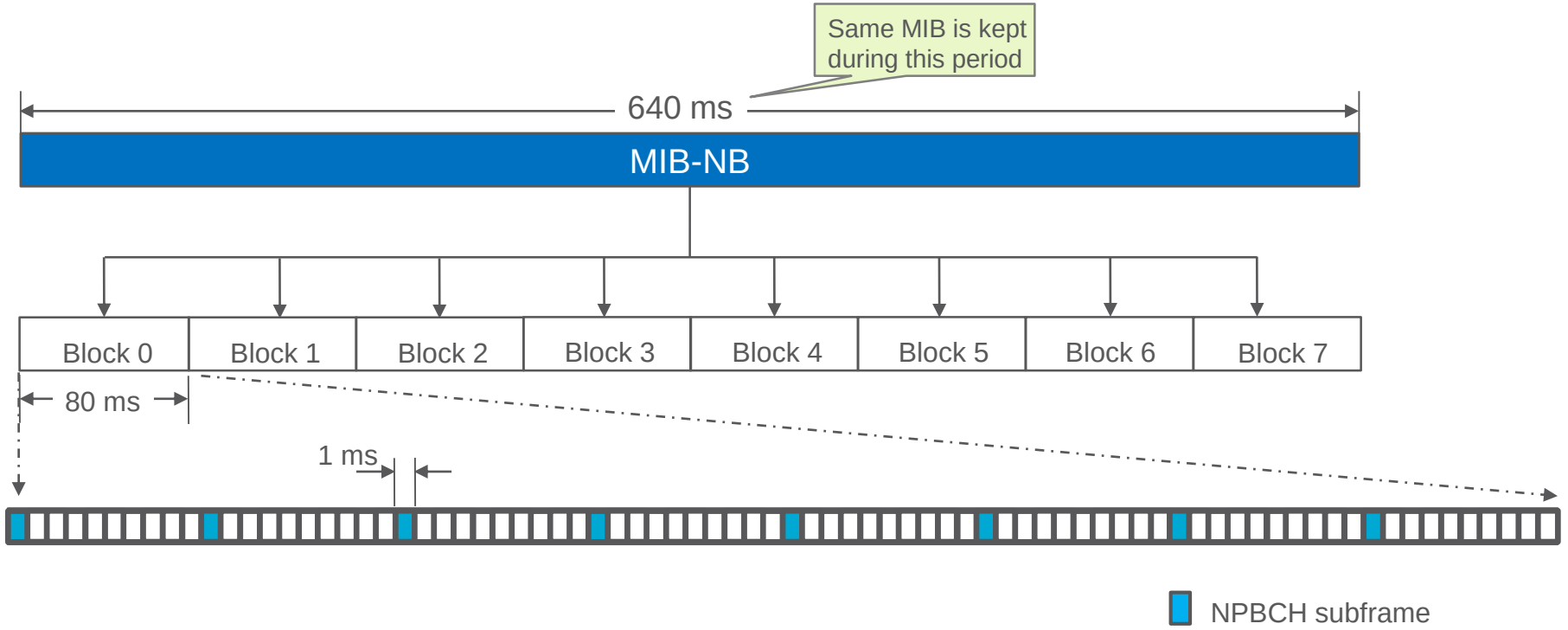
- Downlink Control Information (DCI)
- HARQ NACK (requesting retransmission)

NB-IOT PHYSICAL CHANNELS..

- Due to the reduced channel band-width most physical channels have been redesigned: NSSS/NPSS, NPBCH, NRS, NPDCCH (example below).



NPBCH (MIB-NB)



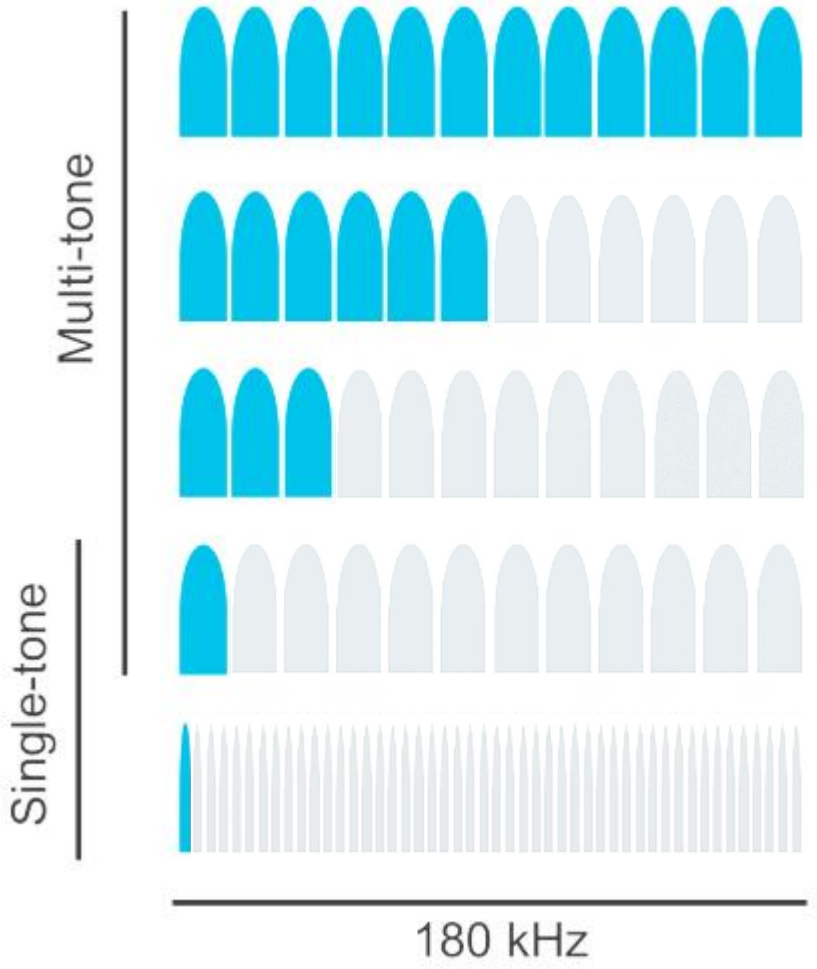
› MIB-NB is composed of 34 bits and contains information about:

- SFN
- Hyper frame number
- SIB1-NB scheduling and size
- System information value tag
- Access class barring
- Operation mode with the mode specific values
- 11 spare bits for future extensions

UL TRANSMISSION

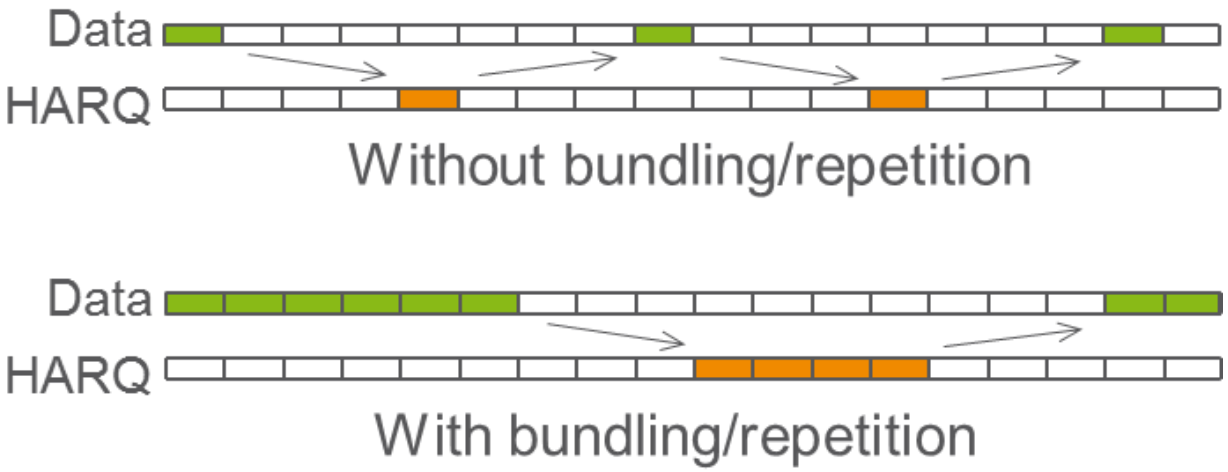
- Based on SC-FDMA over 180 kHz bandwidth

- Multi-tone transmissions use
  - 1, 3, 6, or 12 subcarriers per device
  - 15 kHz subcarrier spacing
- Single-tone transmission use
  - 1 subcarrier per device
  - 15 kHz subcarrier spacing (mandatory)
  - 3.75 kHz (optional) subcarrier spacing (not supported)
- **NPUSCH**
  - User data and signaling
  - HARQ ACK/NACK
- **NPRACH**
  - Used to access the cell
  - Multiplexed with NPUSCH



COVERAGE ENHANCEMENT

› Repetition is the main coverage enhancement technique specified in Rel-13 for Cat-M1 and NB-IOT



› Note that repetition is just one tool among others in the toolbox for coverage enhancement
  - Other means for coverage enhancement may be more efficient in a given situation
  - Other means include network densification, antenna techniques, repeaters, mesh networks, etc.

COVERAGE VS REPETITIONS

- Repetitions ensures increased coverage
  - NPRACH, NPDCCH, NPDSCH, NPUSCH, NPBCH
  - Paging, System Information
- Based on RSRP measurements the UE selects an NPRACH resource with suitable number of repetitions
- The repetition levels of the early messages would be aligned to the selection of NPRACH resource

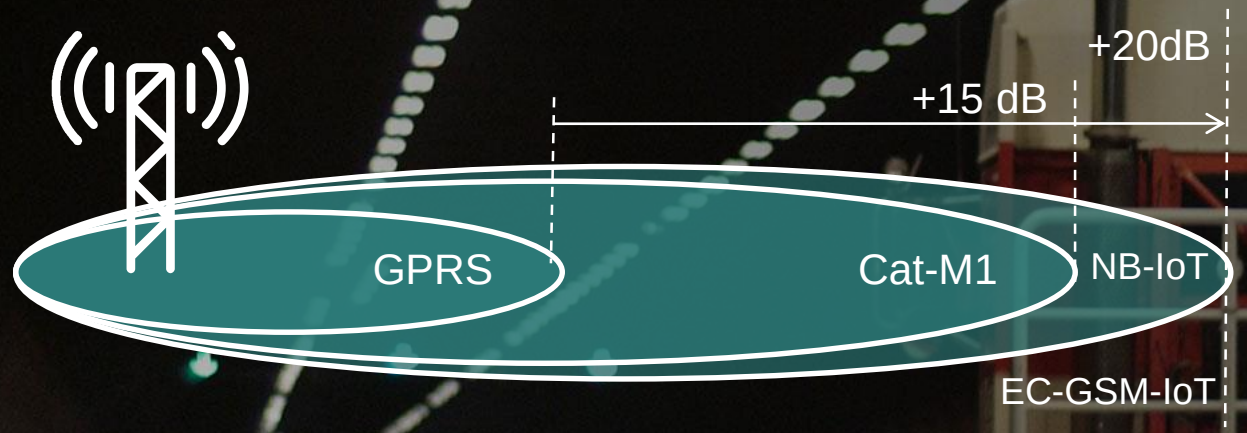
KEY FEATURES

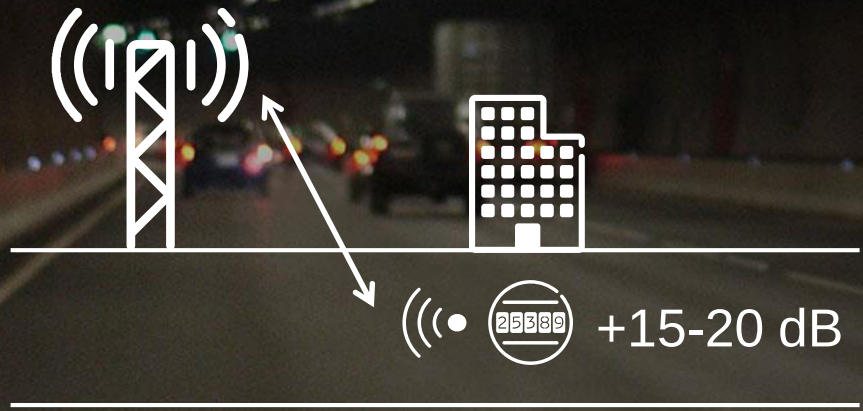
BETTER COVERAGE

EXTENDED COVERAGE MODE

COVERAGE EXTENDED BY UP TO +20 dB BY:

- Repetition of transmissions
- New control channels

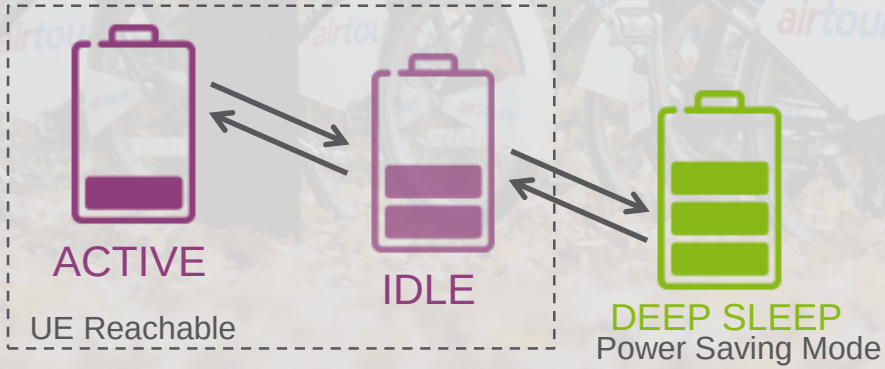




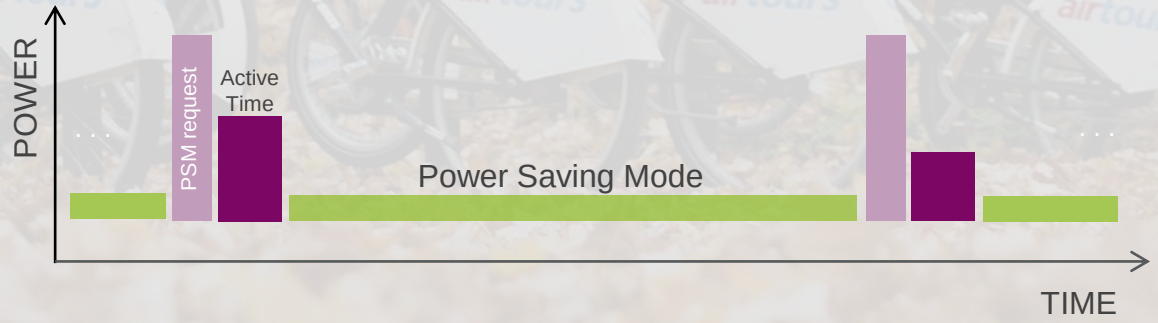
10+ YEARS BATTERY LIFE

POWER SAVING MODE

- New “Power Saving” State
- Device unreachable, but remain registered

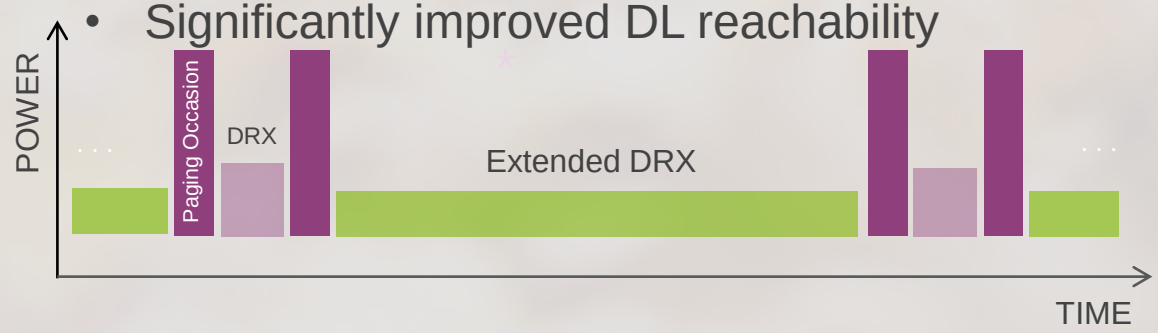


- Paging coordinated when not in PSM state
- Reducing signaling



EXTENDED DRX

- Extended sleep cycles in idle mode to eliminate unnecessary receiver activations
- Significantly improved DL reachability



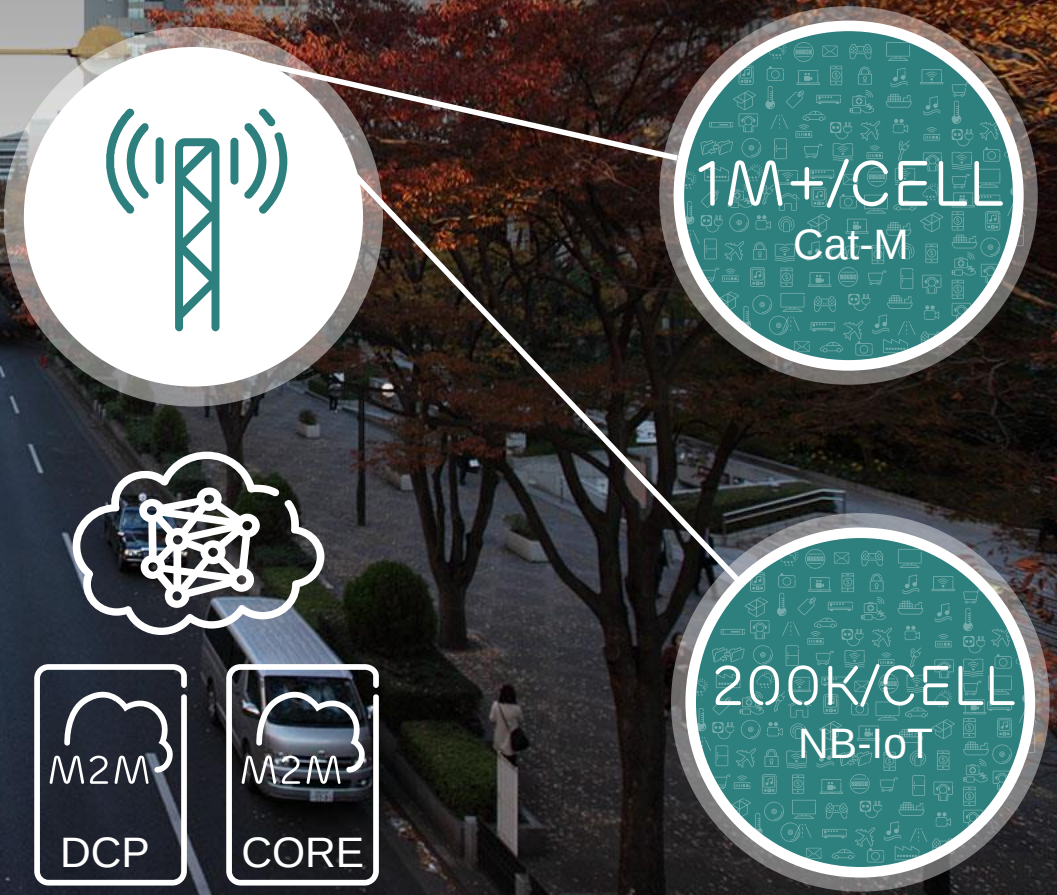
SUPPORT MASSIVE NUMBER OF CONNECTIONS

EXTREME CAPACITY

- 1M+ Cat-M devices on an LTE carrier
- 200k NB-IoT devices per NB-IoT carrier

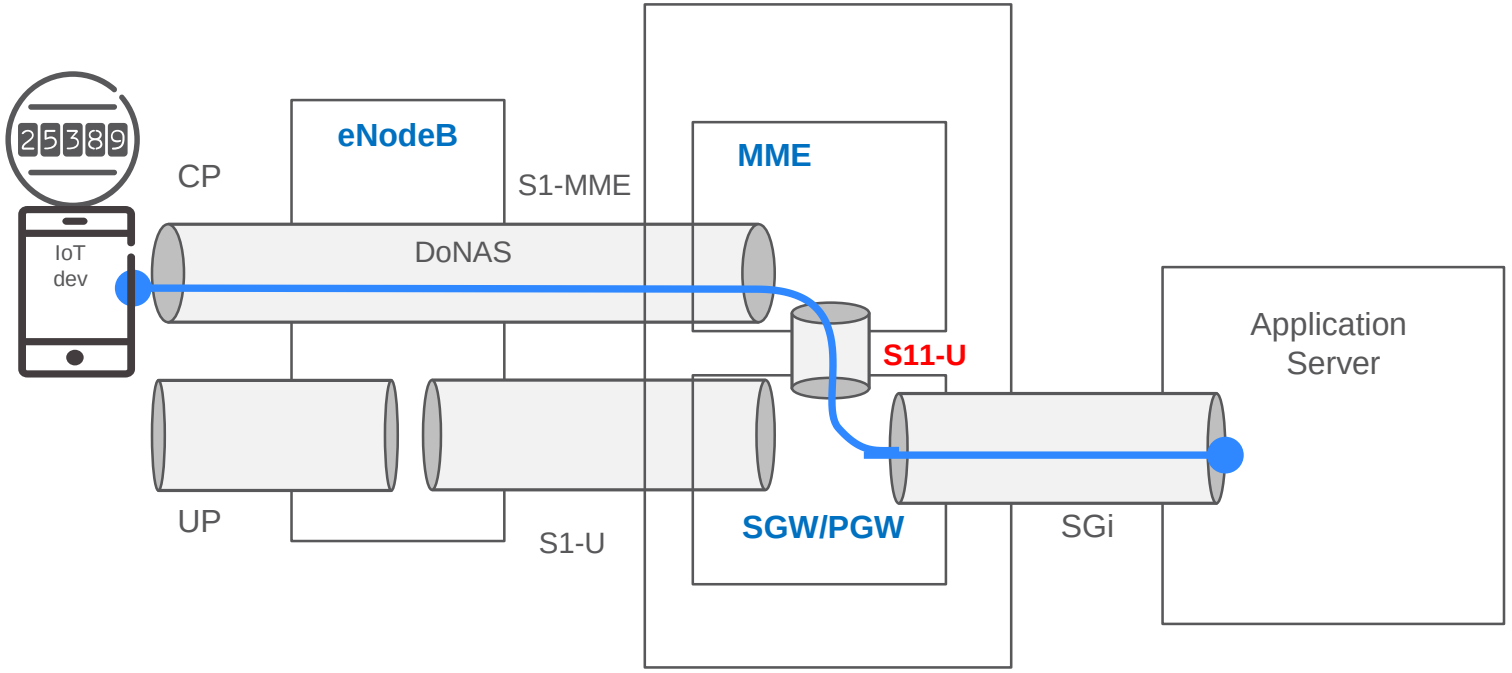
ACHIEVED BY:

- New efficient random access procedures
- New dedicated control channels for IoT
- Single-tone transmission (NB-IoT)
- Core network enhancement
- Device Connection Platform (DCP) for efficient and scalable device life cycle management



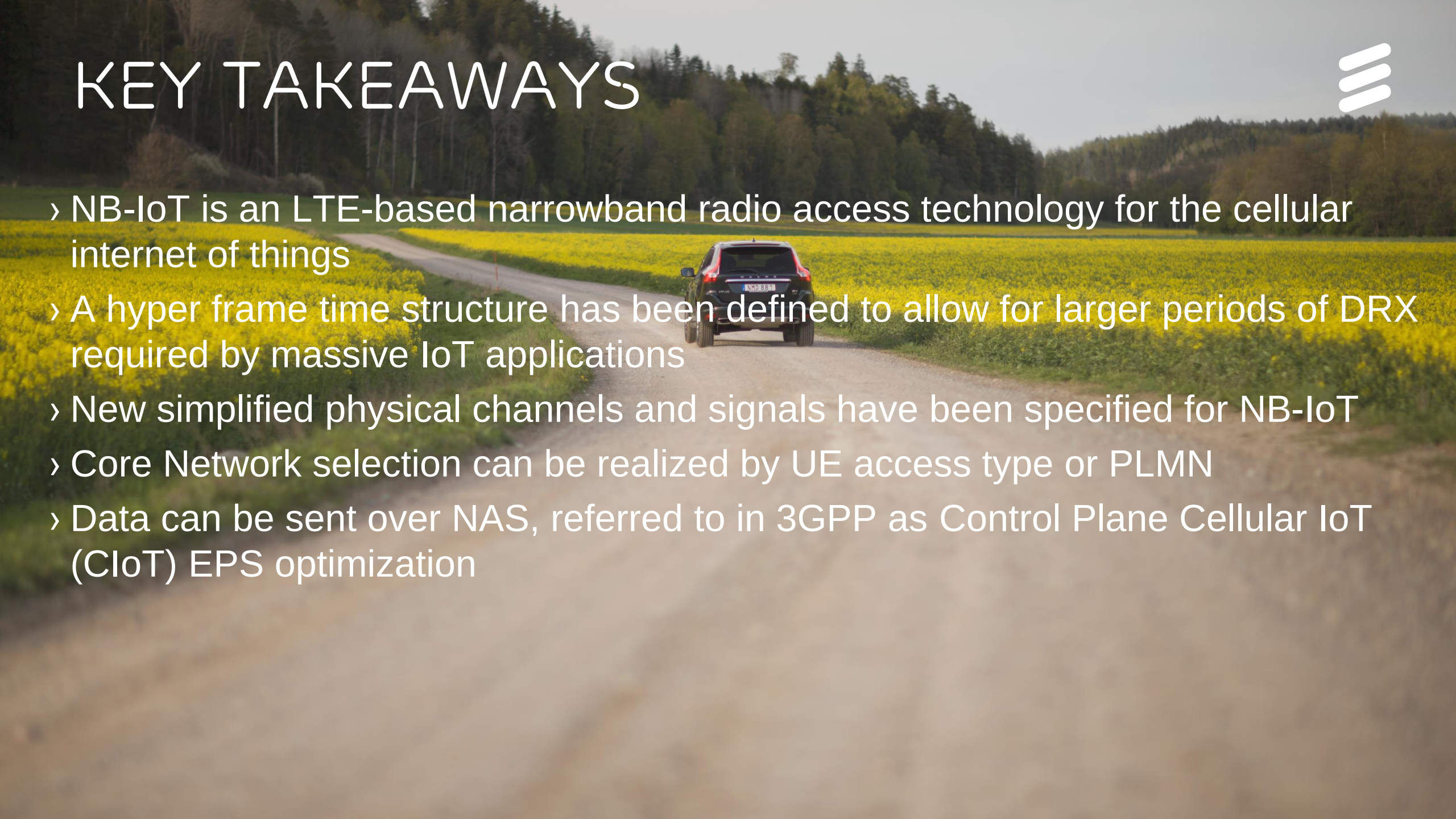
NB-IOT SMALL DATA TRANSPORT DATA OVER NAS (DONAS)

- User data over the control-plane (NAS) without data radio bearer
- Suitable for infrequent small data transfer

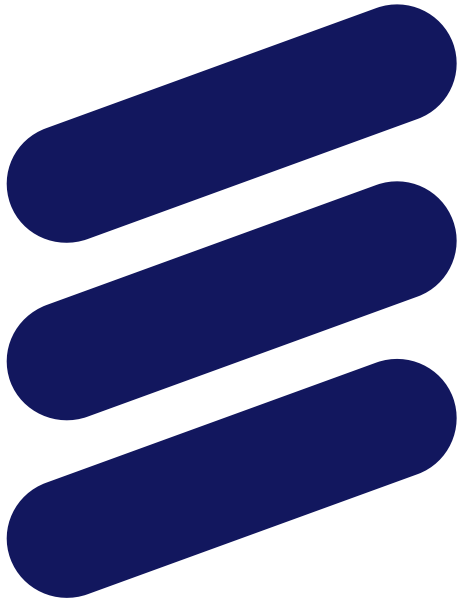


Cost efficient small data transfer through minimized signaling

KEY TAKEAWAYS



- NB-IoT is an LTE-based narrowband radio access technology for the cellular internet of things
- A hyper frame time structure has been defined to allow for larger periods of DRX required by massive IoT applications
- New simplified physical channels and signals have been specified for NB-IoT
- Core Network selection can be realized by UE access type or PLMN
- Data can be sent over NAS, referred to in 3GPP as Control Plane Cellular IoT (CIoT) EPS optimization



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