Educational Webinar

5G Bootcamp
An Online Learning Event

What is Next in Cellular IoT

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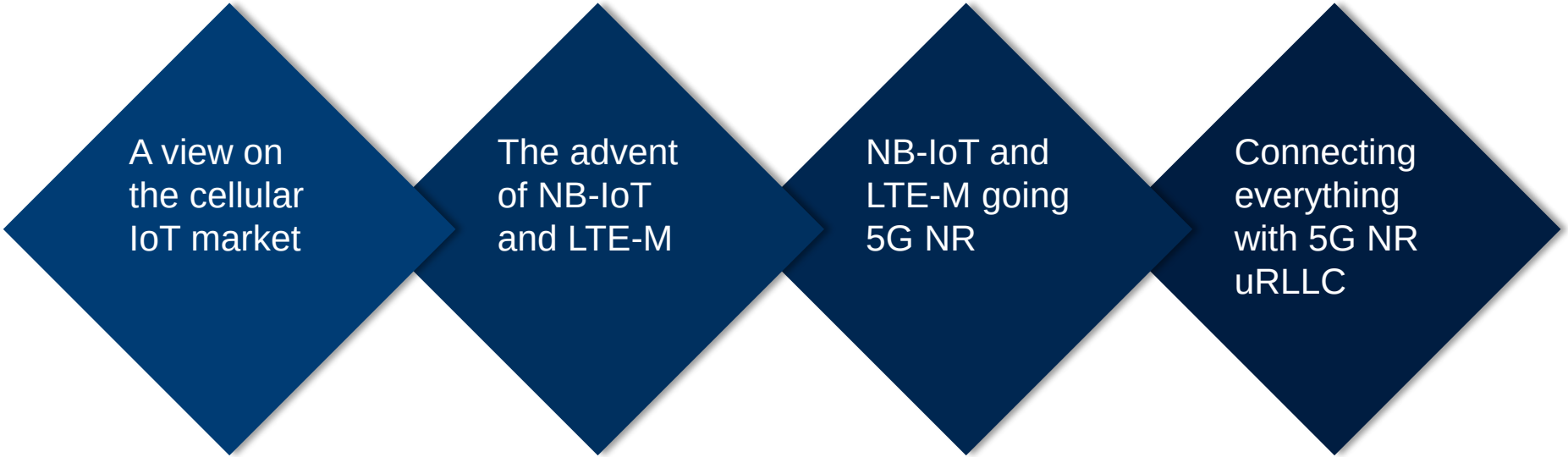
ROHDE&SCHWARZ
Make ideas real

Outline


A view on the cellular IoT market
The advent of NB-IoT and LTE-M
NB-IoT and LTE-M going 5G NR
Connecting everything with 5G NR uRLLC

The Internet of Things

Everything that can benefit
from being connected
will be connected

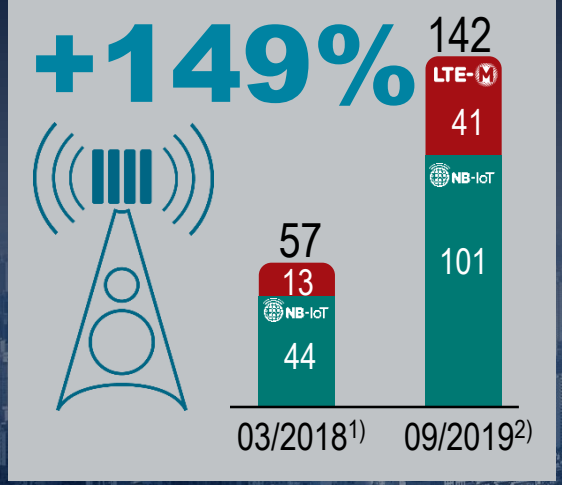
Expecting almost 24 Bn connected IoT devices in 2024 based on around 13 Bn connected IoT devices today

- Short-Range (18 Bn)
- Cellular WAN (4 Bn)
  At the end of 2024, NB-IoT and Cat-M are expected to account for close to 45% of all cellular IoT connections. In the future, NB-IoT and Cat-M will be able to fully co-exist in spectrum bands with 5G NR
- Non-cellular LPWAN (2 Bn)

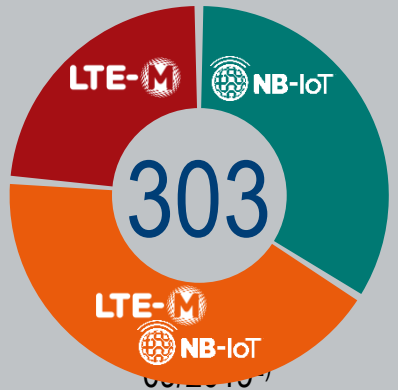
Sources: based on Ericsson Mobility Report (June 2019) and own estimations
https://www.ericsson.com/4a517b/assets/local/mobility-report/documents/2019/emr-q2-2019-update.pdf

Where we are today with NB-IoT and LTE-M

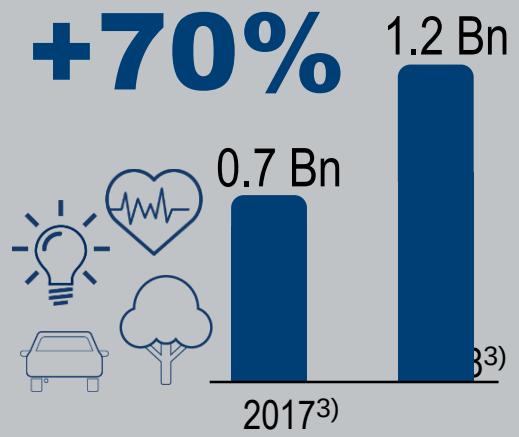
Deployed/launched networks



More than 300 devices



Cellular IoT subscriptions



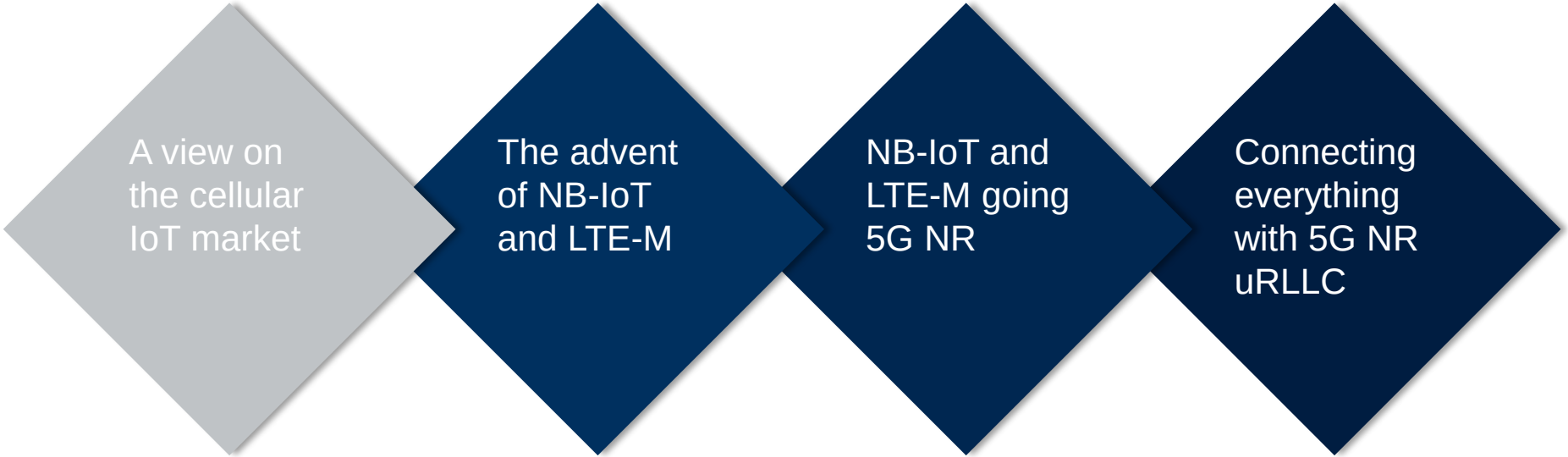
Sources:

[1)] GSA: NB-IoT and LTE-M: Global market status (March 2018)

[2)] GSA: NB-IoT and LTE-M: Global ecosystem and market status (September 2019)

[3)] Berg Insight: The global M2M/IoT communications market – 4th edition (May 2019)

Outline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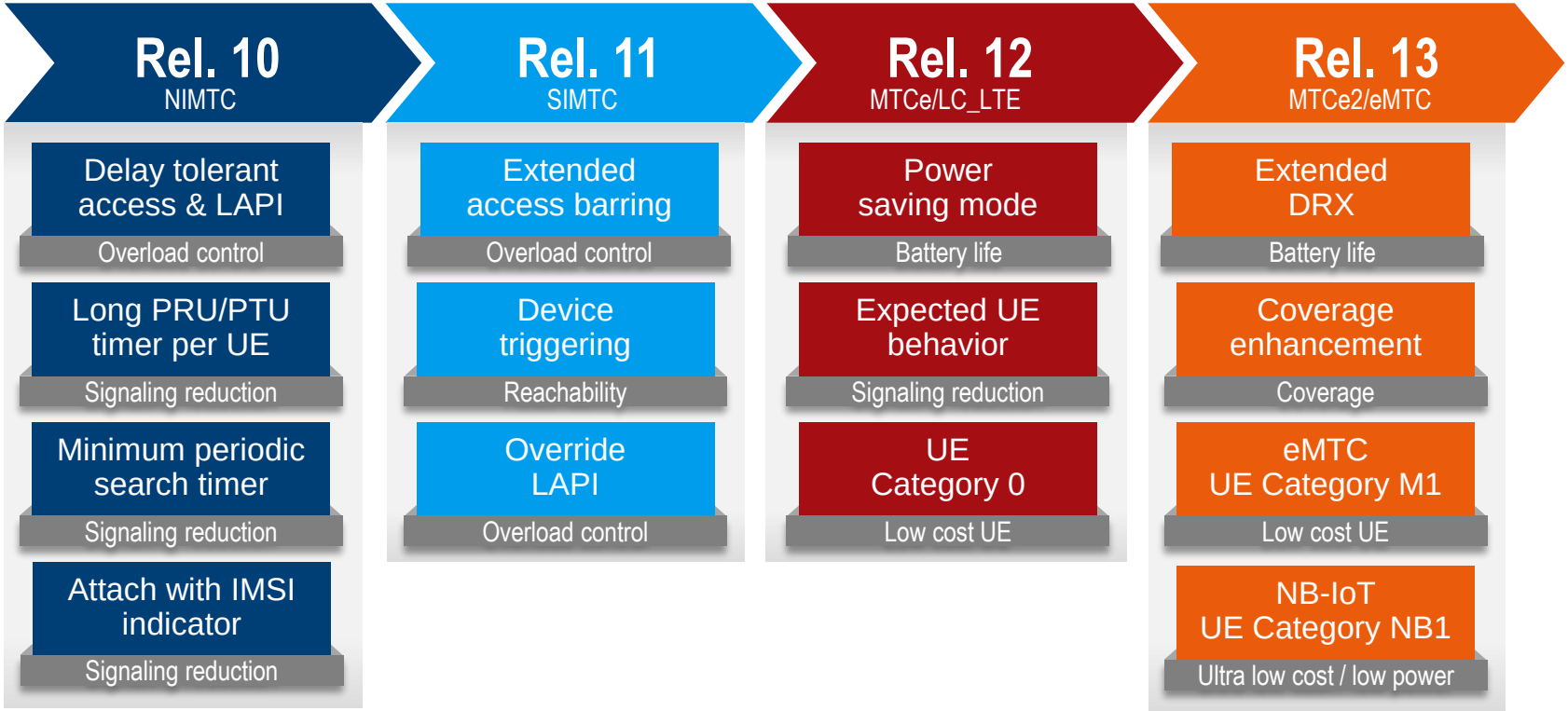
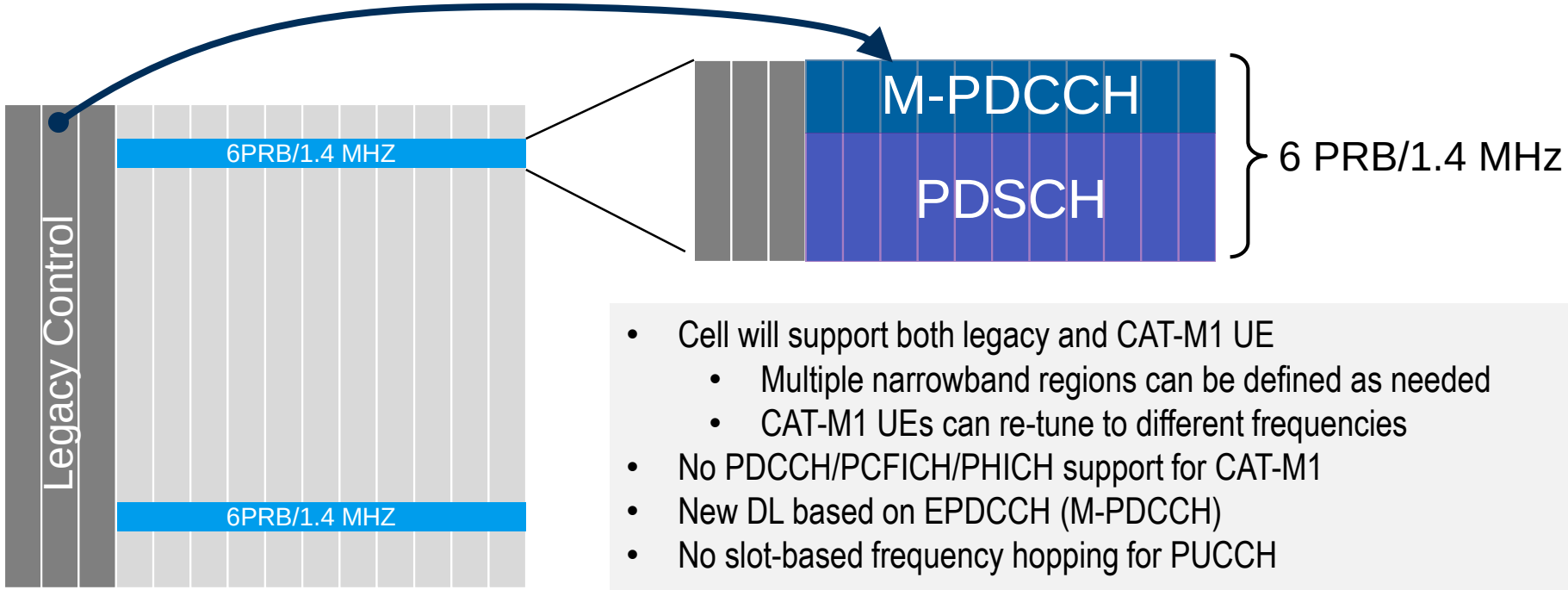
A little history on Machine-Type-Communication LTE/LTE-A



LTE Cat.M1 – 1.4 MHz DL channel support



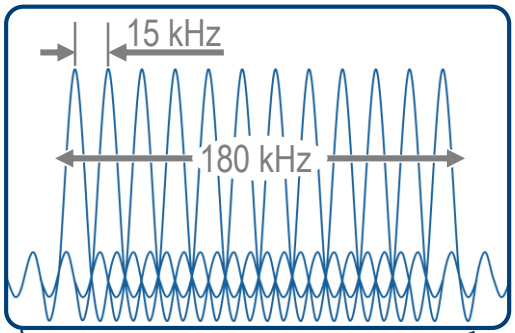
- Cell will support both legacy and CAT-M1 UE
  - Multiple narrowband regions can be defined as needed
  - CAT-M1 UEs can re-tune to different frequencies
- No PDCCH/PCFICH/PHICH support for CAT-M1
- New DL based on EPDCCH (M-PDCCH)
- No slot-based frequency hopping for PUCCH

Narrowband-IoT (Cat-NB1)

The uplink and downlink total transmission bandwidth is 180 kHz

Downlink: OFDM with 15 kHz subcarrier spacing (1PRB)

Uplink: SC-FDMA with 3.75 kHz and 15 kHz for single-tone transmissions and optional multi-tone transmissions with 15 kHz subcarrier spacing



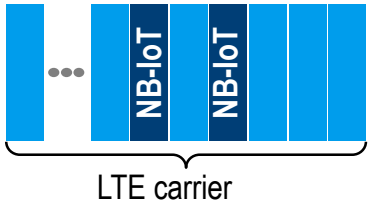
Only FDD in **half-duplex mode** (analog to UE Cat. 0 half-duplex Type B), no TDD in Rel. 13

Reduced downlink **transmission schemes**:

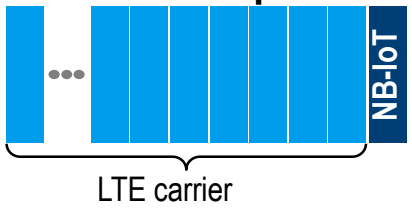
TM1: single antenna port, TM2: two antenna ports, using transmit diversity

Only **mobility** in IDLE mode is supported

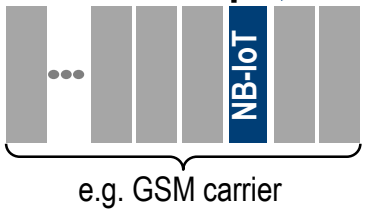
In-band operation



Guard-band operation

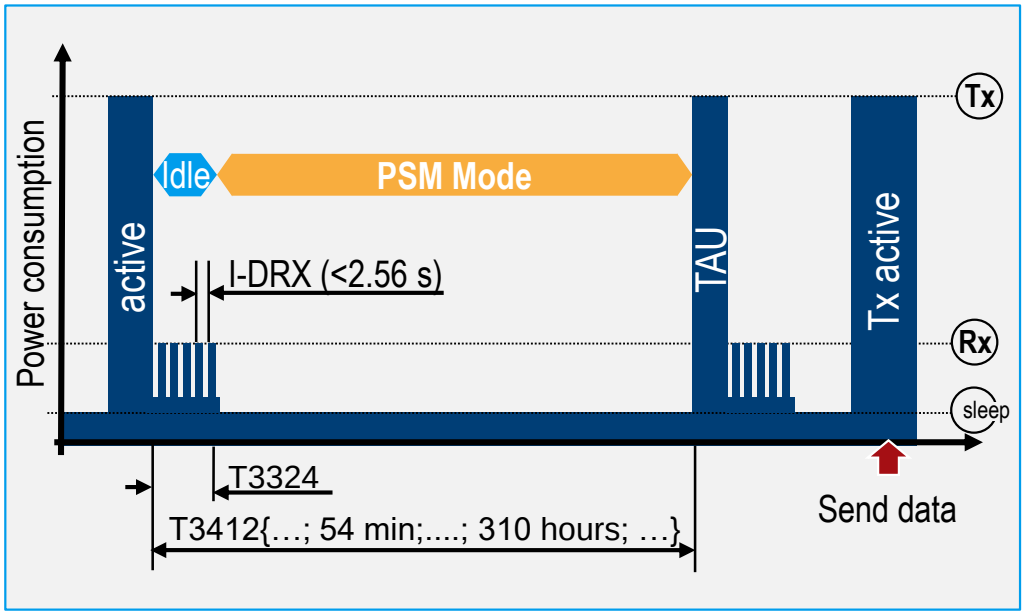


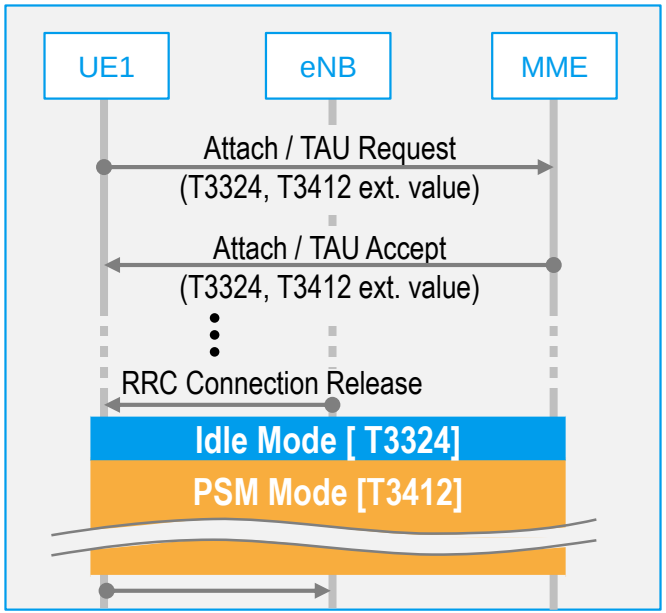
Standalone operation



MTC features like Power Save Mode (PSM), extended DRX (eDRX) cycle are valid

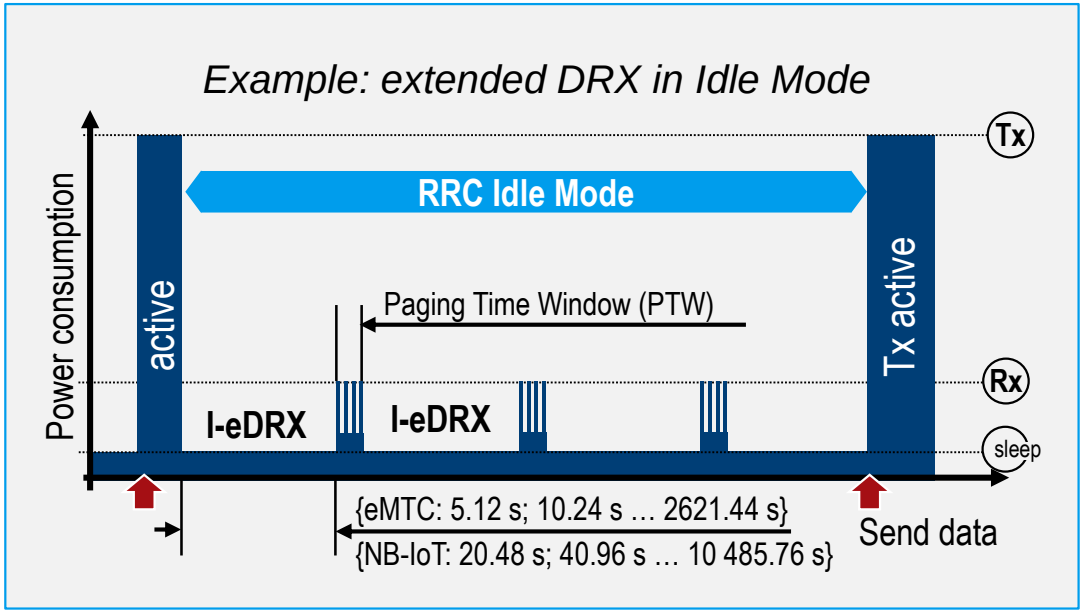
Power Saving Mode (PSM) for deep sleep operation

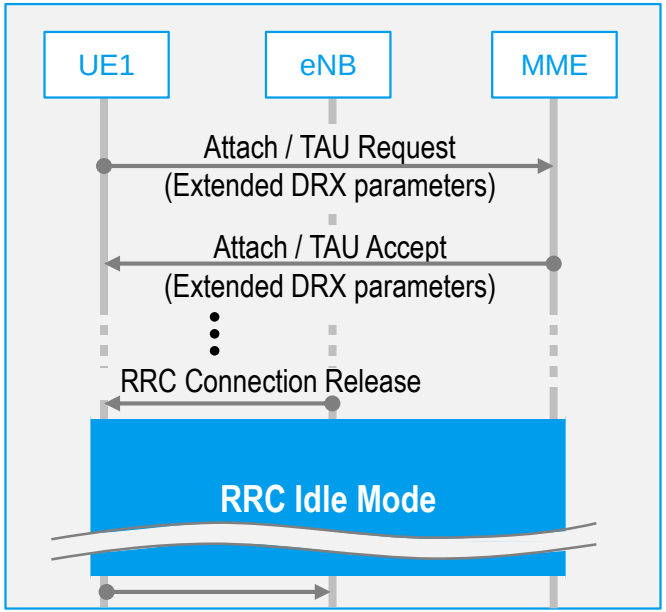




UE remains registered with the network and there is **no need to re-attach or re-establish PDN connections** – saves power, but UE isn't reachable in PSM Mode

Extended discontinuous reception (eDRX)



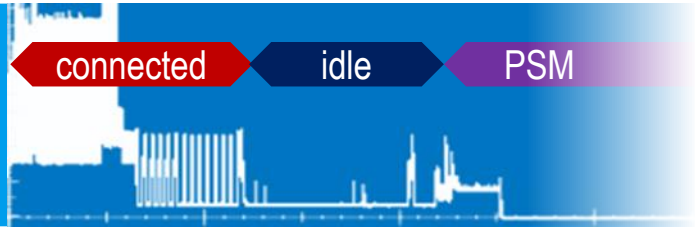


Energy consumption can be reduced significantly with longer cycles for discontinuous reception (DRX), if certain degree of mobile terminating services reachability is acceptable.

Let’s talk about connected mousetraps

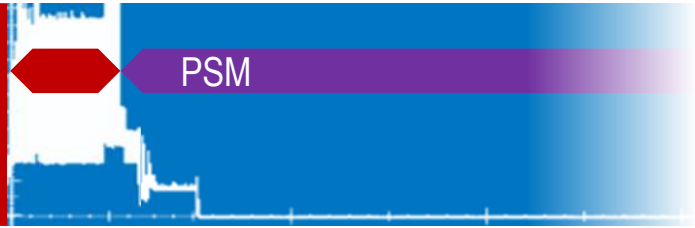
No or very limited use of downlink communication of the application

Use of PSM mode with long TAU timer (T3412 = 310 hours)



Switch directly to PSM mode by setting T3324 activity timer to zero

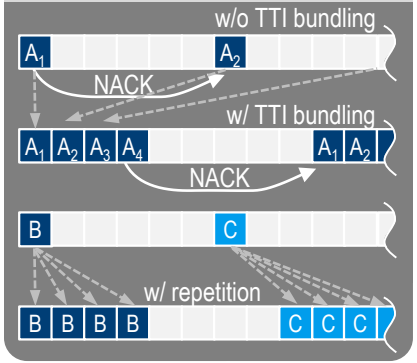
Use ‘Release Assistance Indication’ for quick switch to PSM



Coverage enhancement techniques

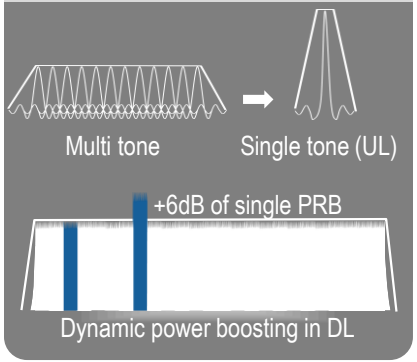
Redundant Transmission

Transmitting the same transport block multiple times in consecutive sub-frames or repeatedly sending the same data



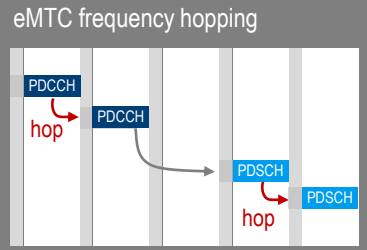
Power Spectral Density

Put all the power together on some decreased bandwidth e.g. a single tone or boost dynamically some carriers e.g. PRB power boosting



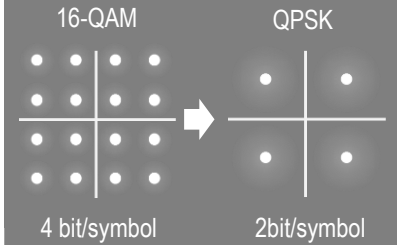
Frequency hopping

Frequency hopping within the band provides diversity and can avoid interference issues and finally improve coverage

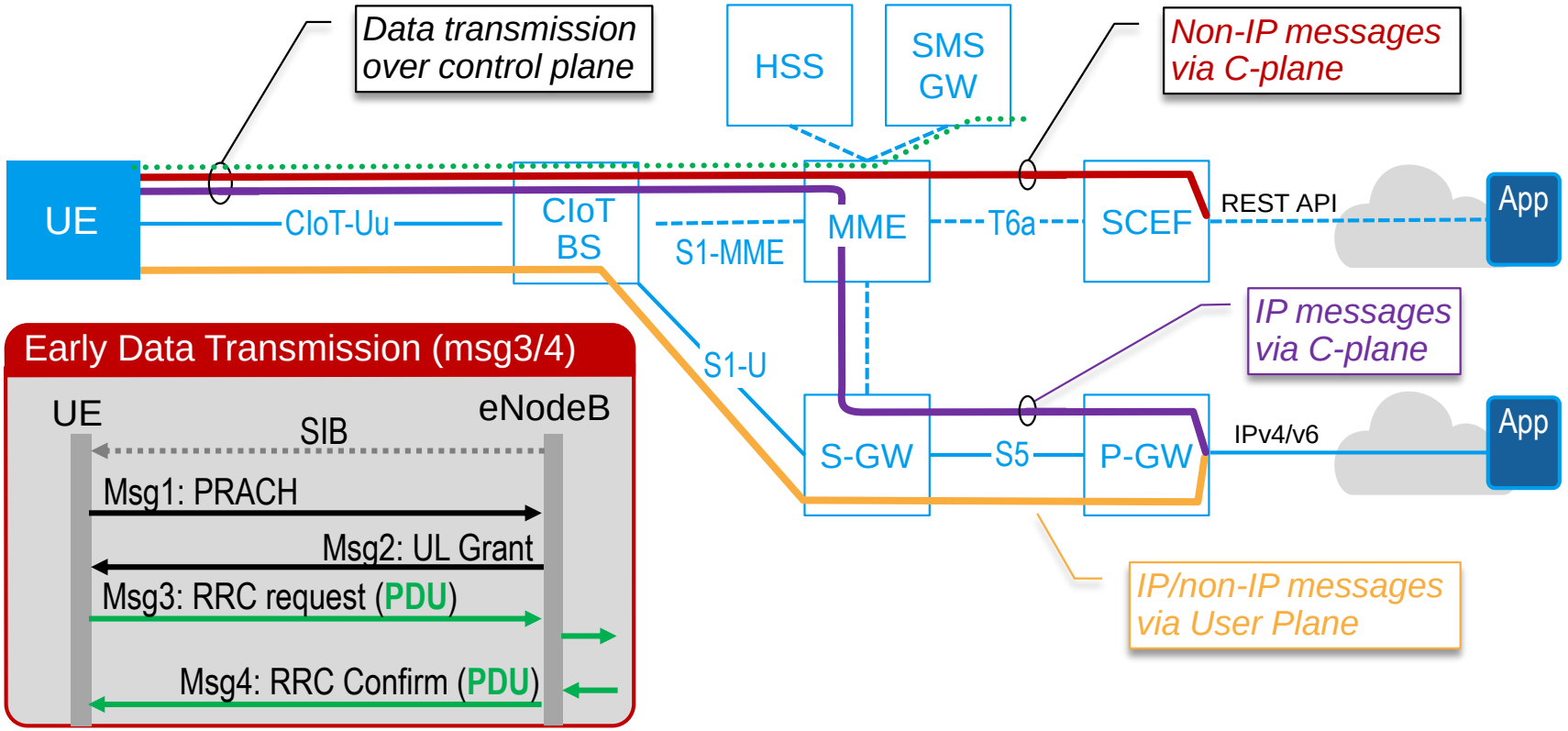


Lower Order Modulation

E.g. by utilizing QPSK instead of 16-QAM, the SINR is reduced significantly, but decreasing the modulation efficiency.



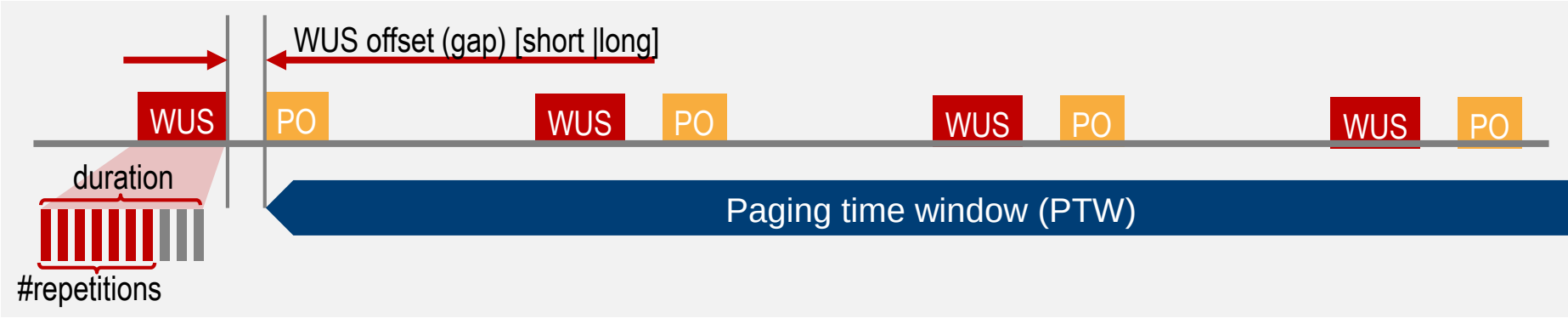
Early data transmission (EDT) in an optimized architecture



Improve power efficiency during reception of paging in idle / connected-mode DRX by a wake-up signal (WUS)

Introduction of a Wake up Signal(WUS) to indicate that the UE shall attempt to receive paging in that cell for the next N≥1 Pos

► UE will decode PDCCH for paging only if necessary



- Optional feature dependent on UE capability of WUS support
- WUS offset: short: 40 ms, 80 ms, 160 ms, 240 ms , or long gap (1s, 2s)

4G technologies available today for different IoT applications

LTE (Cat-1bis …Cat-4)

- Native LTE (TDD/FDD)
- Full bandwidth of up to 20 MHz
- Seamless mobility
- High data rate

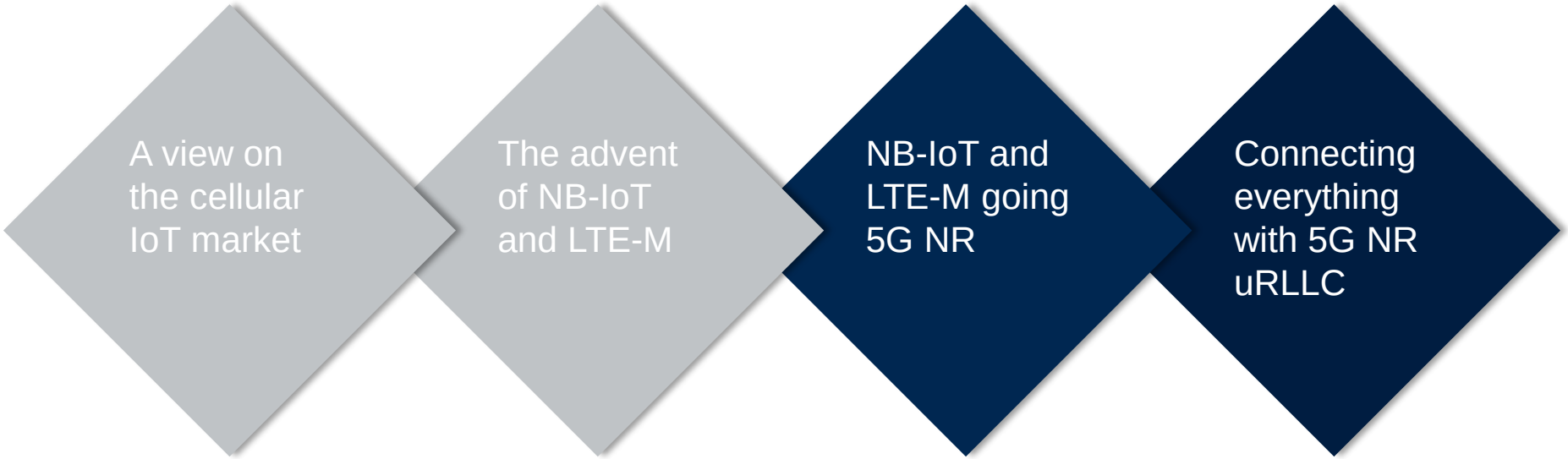
LTE-M (Cat-M1/2)

- In-band LTE (TDD/FDD)
- Reduced bandwidth (1.4/5 MHz)
- Half-duplex optional
- Limited mobility
- Data rate of up to 1 Mbps
- Indoor coverage
- VoLTE support

NB-IoT (Cat-NB1/2)

- In-band, guard-band, standalone LTE (FDD only)
- Narrowband of 180 kHz
- Half-duplex only
- Nomadic mobility (reconnection)
- Low data rate (< 100 kbps)
- Deep coverage

Outline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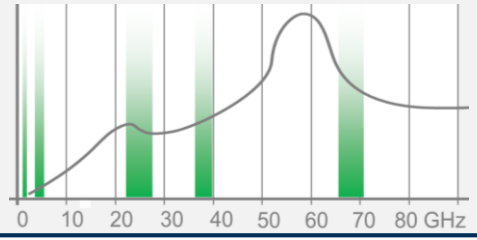
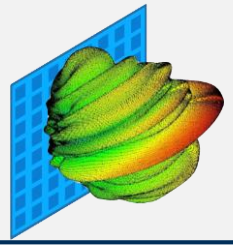
5G NR builds on four key technology components

New Spectrum



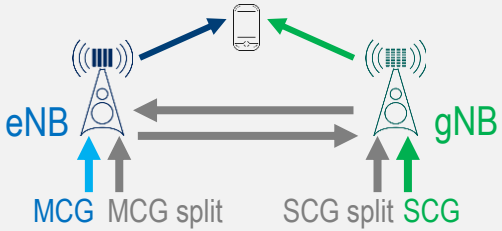
- < 1GHz
- ~ 3.5 GHz
- ~ 26/28/39 GHz

Massive MIMO & Beamforming



- Hybrid beamforming
- > 6GHz also UE is expected to apply beam steering

Multi-Connectivity



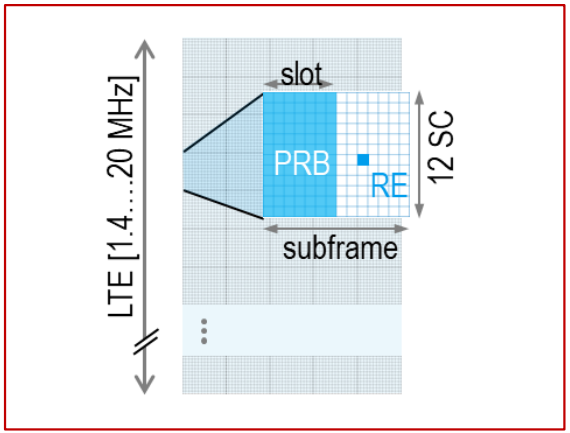
Initially based on Dual Connectivity with E-UTRA as master

Network virtualization

- Flexible physical layer numerology
- Network Slicing
- NFV/SDN

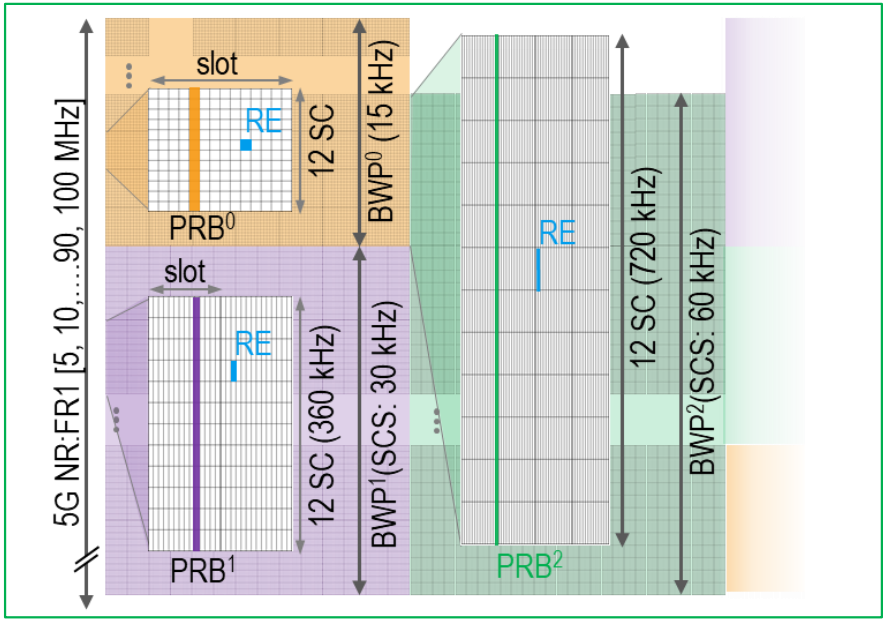
5G adds much more flexibility to address different use uses

Fixed numerology based on 15 kHz subcarrier spacing

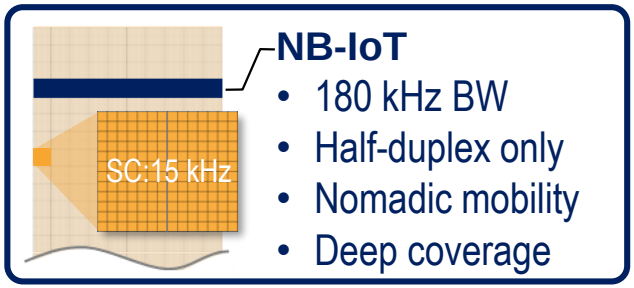


Additional uses cases besides mobile broadband especially in the IoT space: URLLC & mMTC

Flexible numerology e.g. 15 kHz, 30 kHz or 60 kHz in FR1. Dynamic assignment of different BWPs

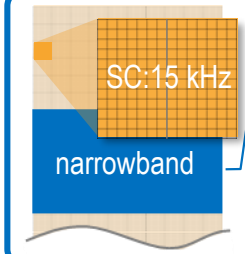


NB-IoT/LTE-M and will coexist in 5G NR



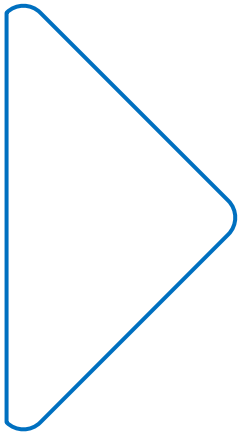
NB-IoT

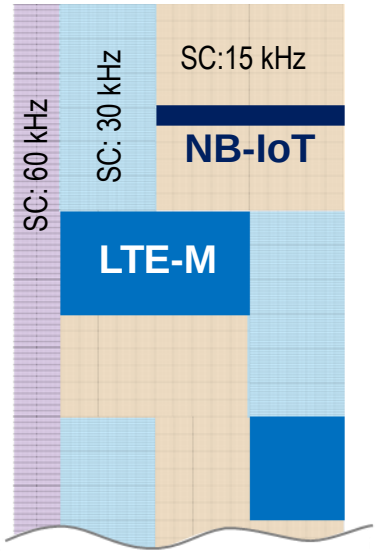
- 180 kHz BW
- Half-duplex only
- Nomadic mobility
- Deep coverage



LTE-M (eMTC)

- In-band LTE
- 1.4/5 MHz BW
- up to 1 Mbps
- VoLTE support

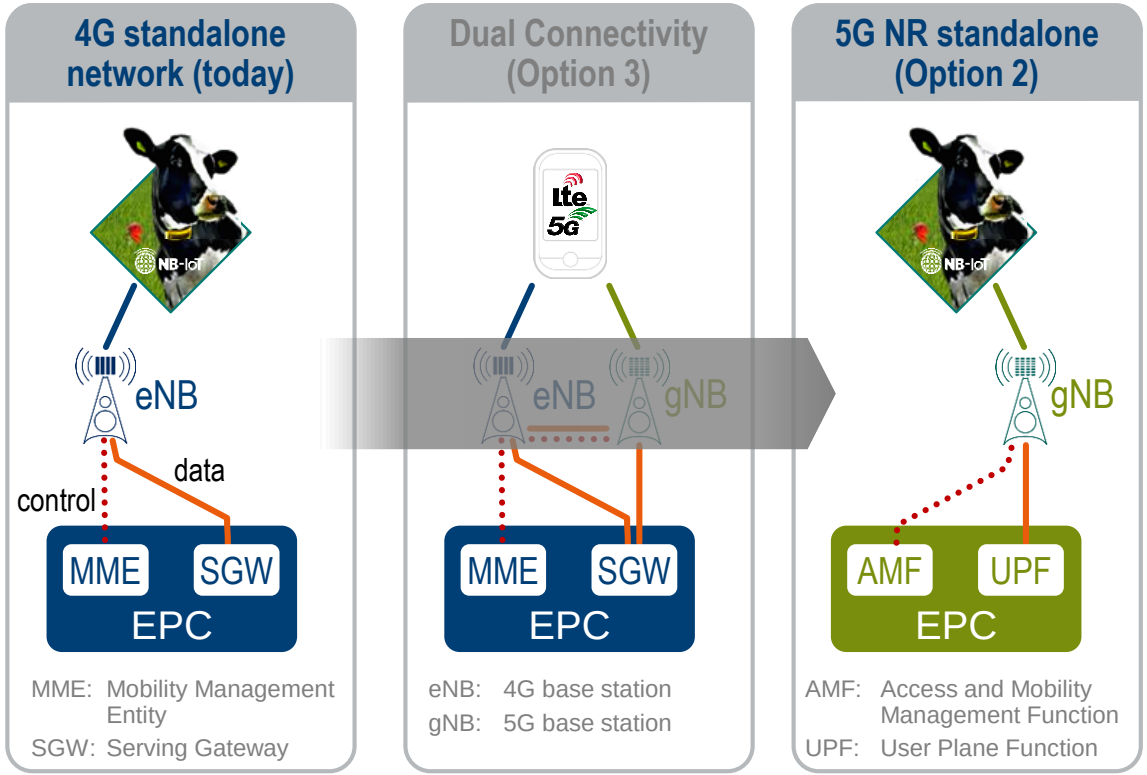




5G NR for mMTC

- 5G numerology allows easy integration
- In-band LTE-M and NB-IoT support in the 15 kHz SC regions (Rel.16)
- Non-standalone (NSA) deployment with LTE EPC and standalone (SA) with 5G core supported

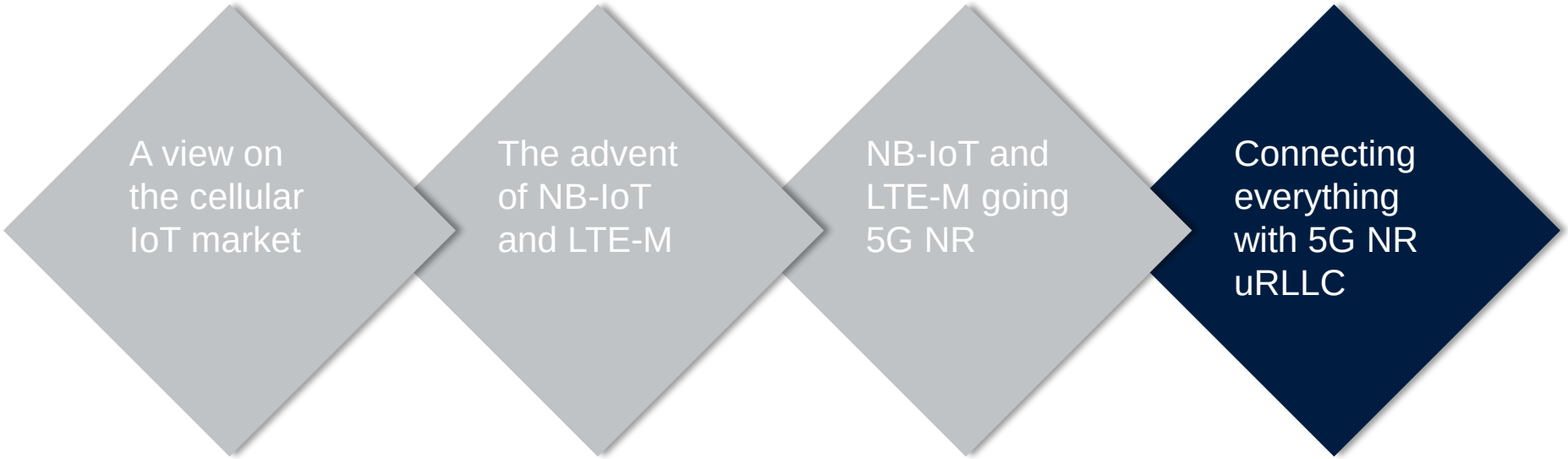
Only supporting standalone operation in 5G



3GPP R16 work items:

- Support of eDRX (Idle/Connected)
- EDT (early data transmission) over NSA and U-plane
- Inter-UE QoS for data over NAS (resource prioritisation UEs)
- Support of restriction of use of Coverage Enhancement
- Delivery of expected UE Behaviour information to RAN

Outline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High diversity of 5G applications in smart factory, ….

mMTC

- Sensors
- Door looks
- Screwdrivers
- ……

eMBB

- VR/AR human-machine i/f
- Handhelds
- Surveillance CAMs

uRLLC

- Robots
- Automated guided vehicles (AVG)

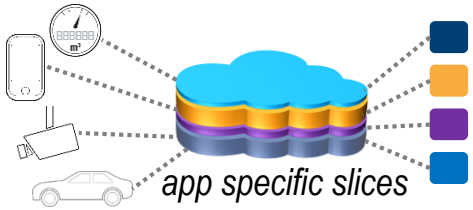
which require safe, reliable and secure operation 24/7/365

The magic triangle of communication is smart factories

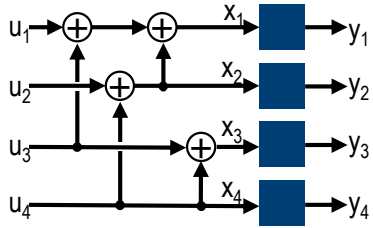
- Security is a must!
- Reliability is essential, but on different levels
- Strongest latency requirements apply for specific applications (e.g. AGV)

5G NR technology cornerstones to meet reliability and latency requirements

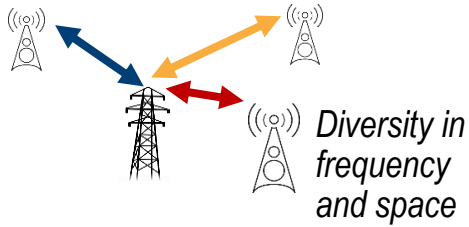
Network Virtualization



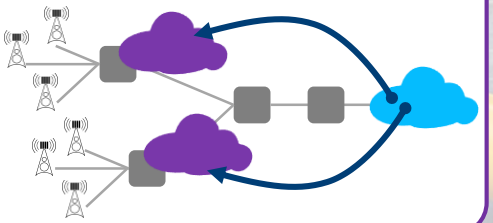
Robust coding



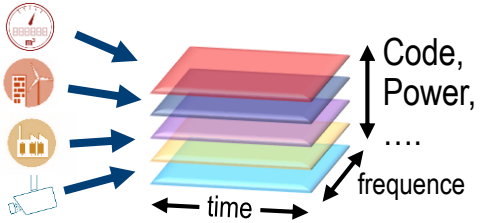
Multipoint connectivity



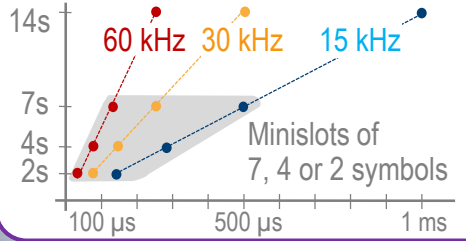
Mobile edge computing



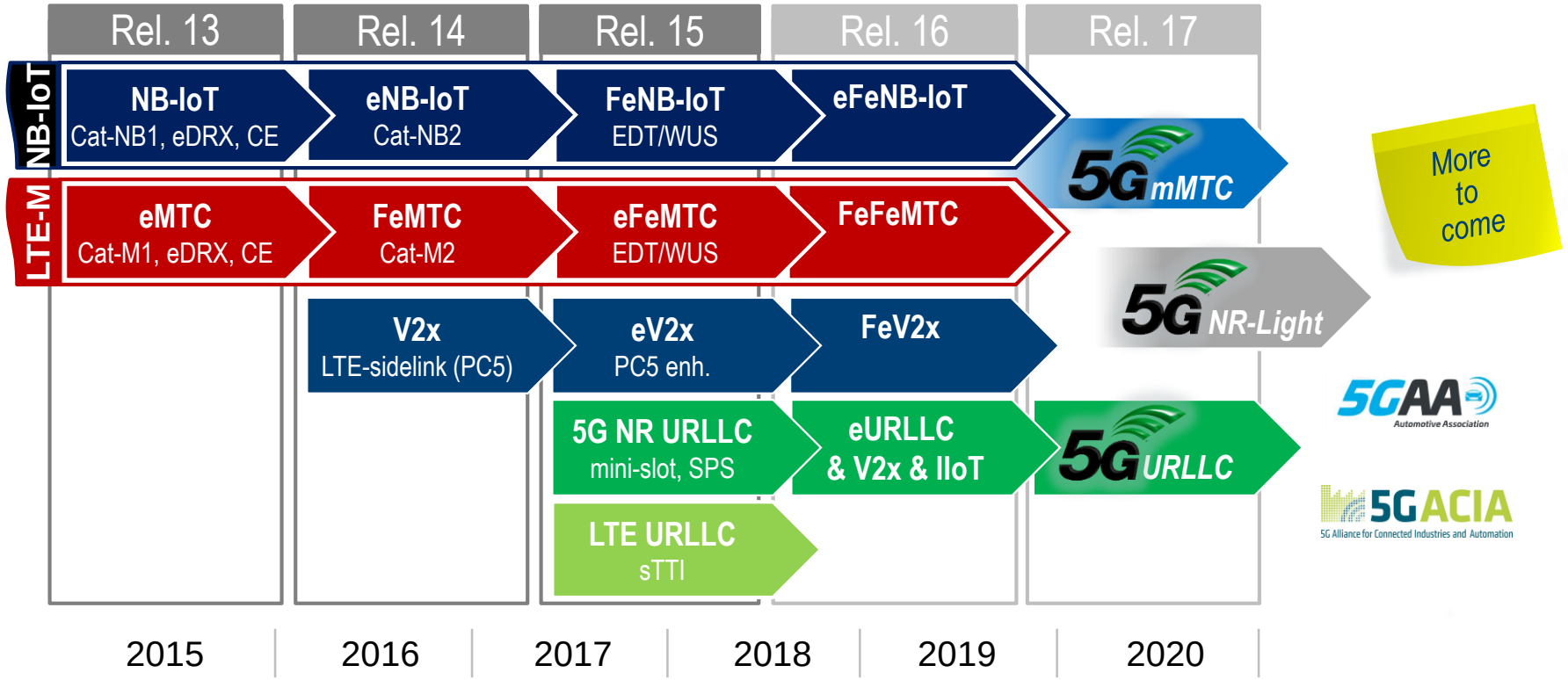
Grant free access



Minislots – short symbols



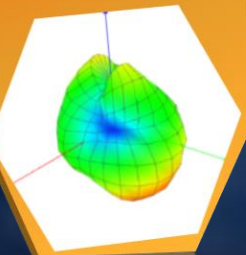
On the road to 5G – we are just on the starting point



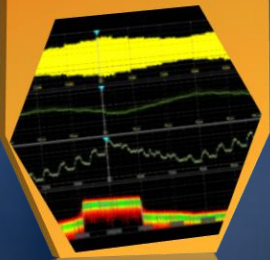
We help our customers to become successful in the IoT market based on our experience and our dedicated IoT test solutions

Network scanning, optimization & benchmarking

RF design verification and conformance testing

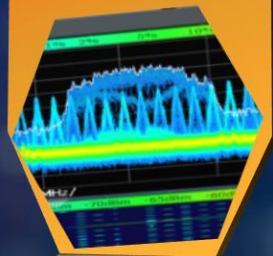


Low power design & battery lifetime optimization

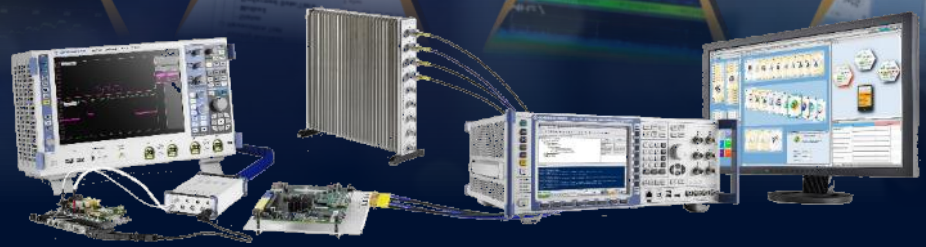


Verifying secure IP communication

Interference analysis and avoidance



Protocol conformance and end-to-end performance



Recommended readings

Thank you very much

ROHDE&SCHWARZ
Make ideas real