

RWS-180012

Workshop on 3GPP Submission Towards IMT-2020

24-25 October 2018

Brussels, Belgium

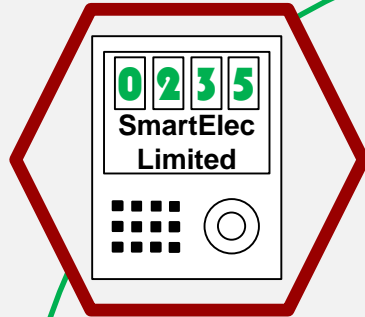


3GPP's Low-Power Wide-Area IoT Solutions: NB-IoT and eMTC

Low-power wide-area IoT

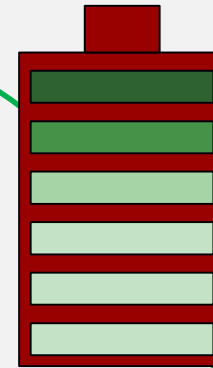
Connection density

1 000 000
UEs/km²



UE battery life

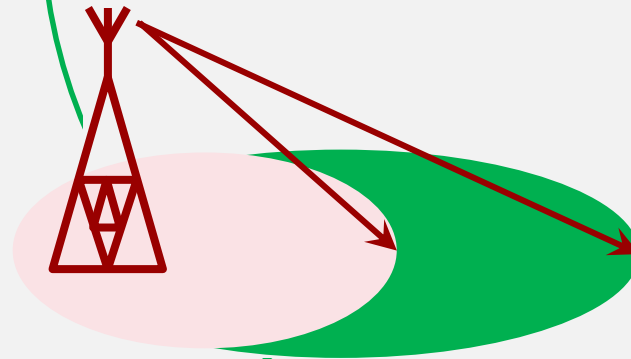
10 – 15 years in
164 dB MCL



Four KPIs for 3GPP LPWA IoT solutions

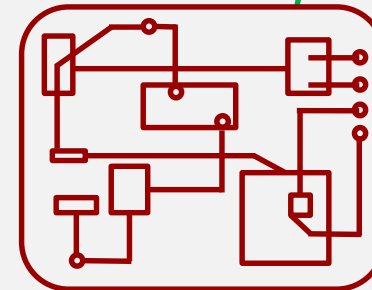
Coverage extension

164 dB MCL
@ 160 bps

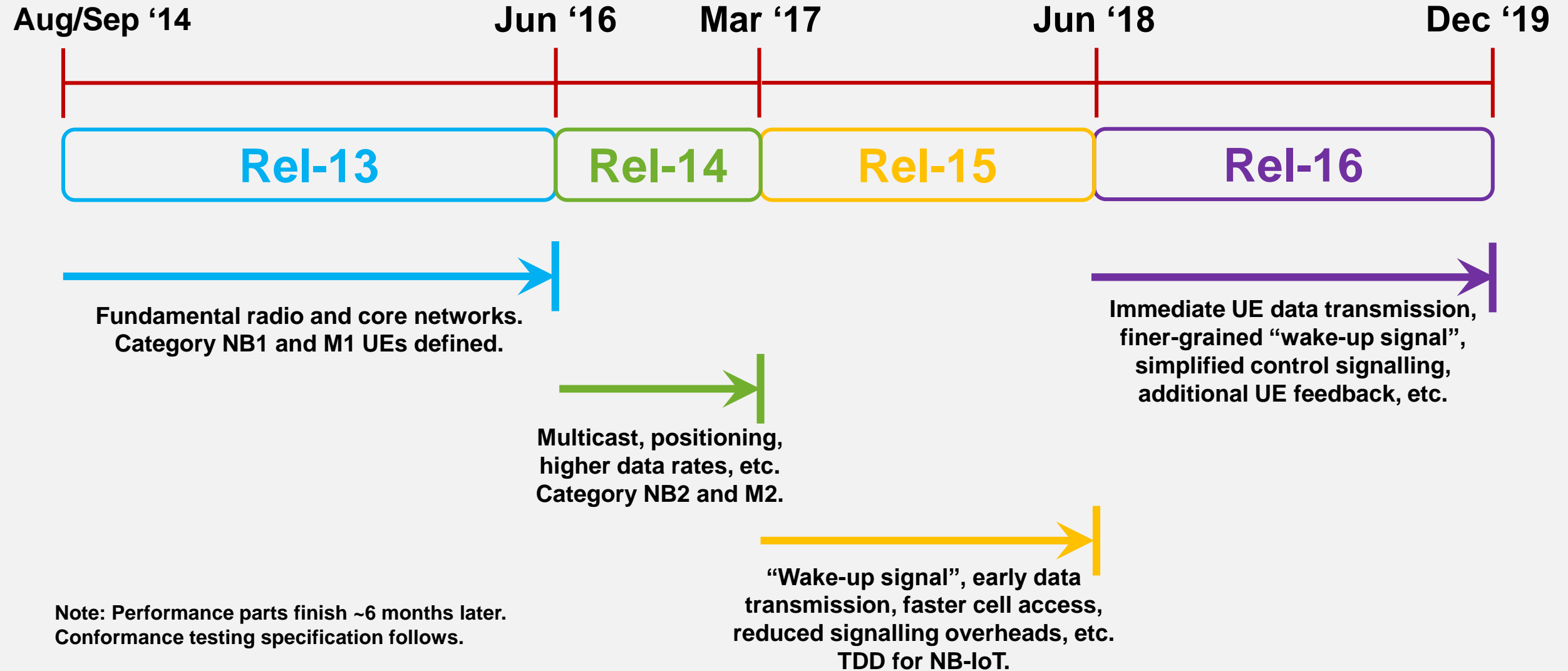


UE complexity and cost

Ultra-low

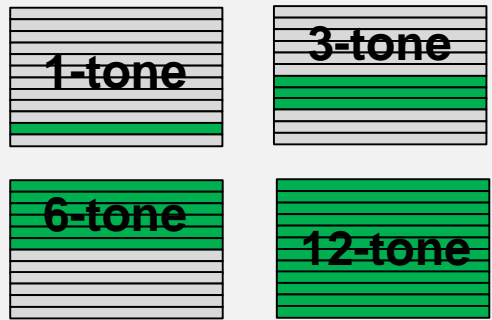


NB-IoT and eMTC project timelines

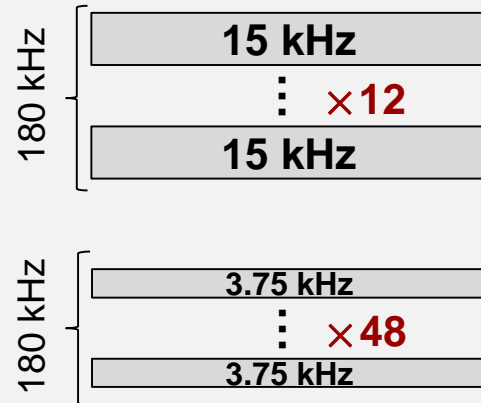


mMTC connection density

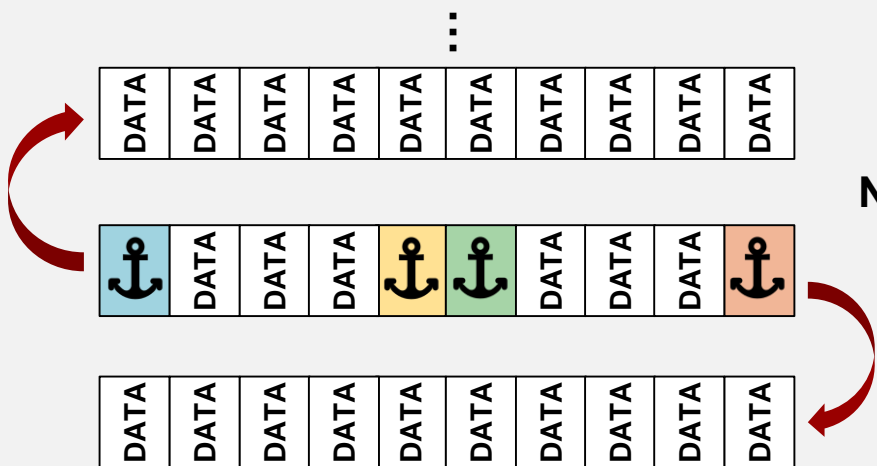
NB-IoT



Single-tone and 3/6/12-tone UL allocations

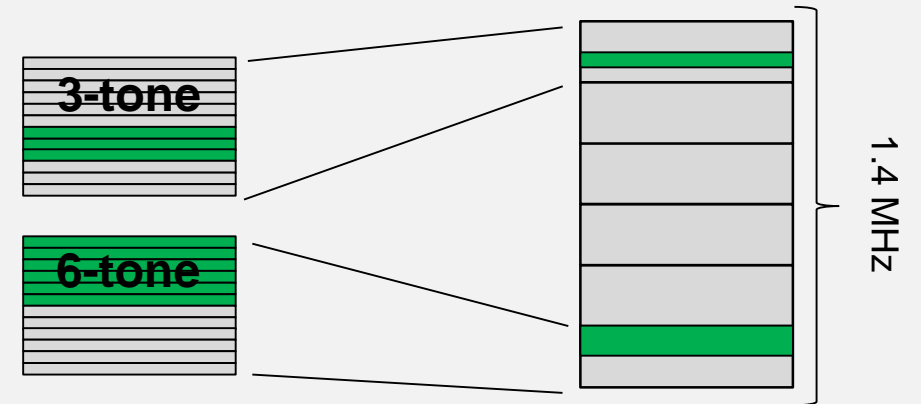


Dense subcarrier spacing

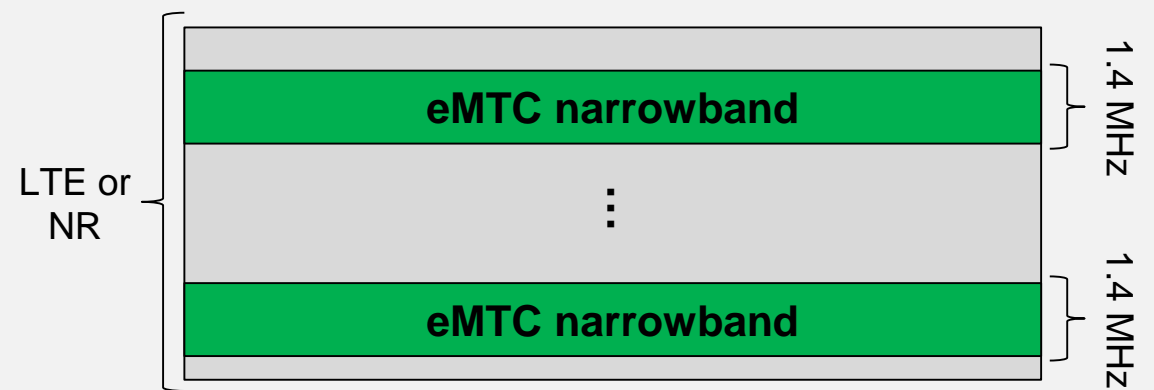


Non-anchor carriers for capacity and load-balancing

eMTC

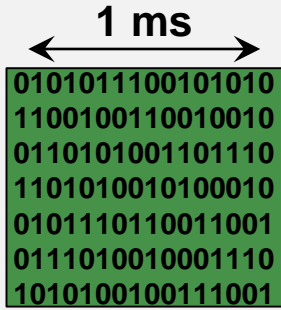


3- and 6-tone allocations within a PRB of a 1.4 MHz narrowband



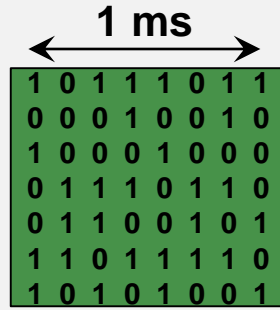
Deploy multiple independent eMTC narrowbands within LTE/NR bandwidth

Ultra-low UE complexity: Signal processing simplifications



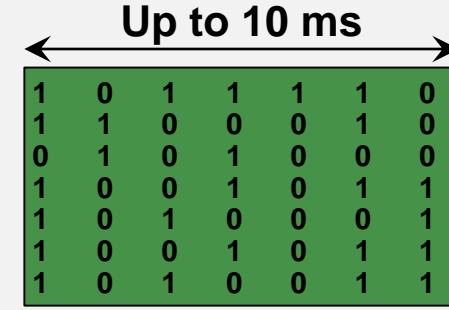
Cat. 1 data

10 000 bits / ms



Cat. M1 data

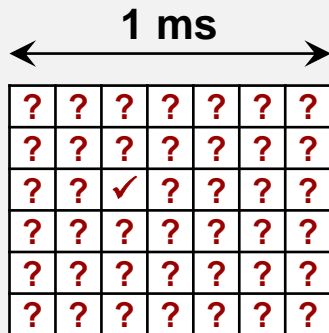
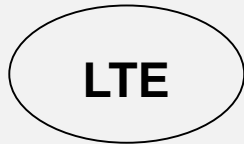
1000 bits / ms



Cat. NB1 data

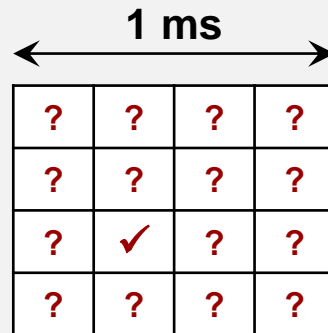
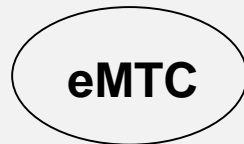
UL: 1000 bits / up to 10 ms

DL: 680 bits / up to 10 ms



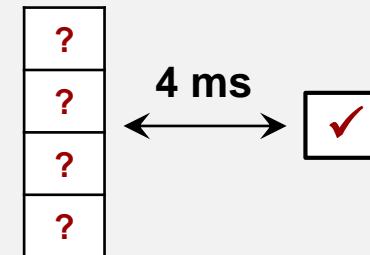
Control channel

~40 candidates / ms



Control channel

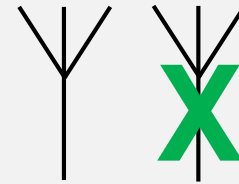
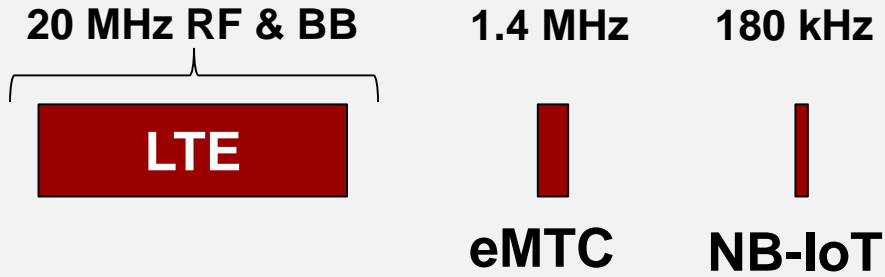
~16 candidates / ms



Control channel

~1 candidate / ms

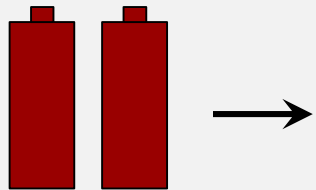
Ultra-low UE complexity: Hardware simplifications



Single receive RF chain for UE

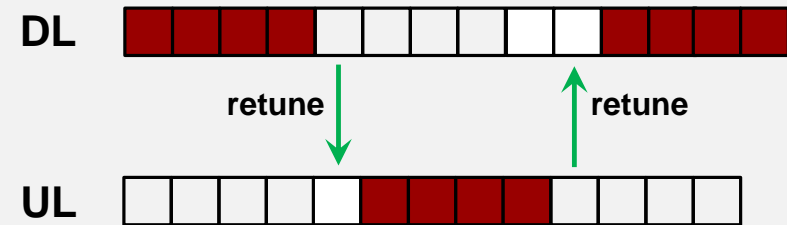
RF bandwidth \Rightarrow RF hardware cost

BB bandwidth \Rightarrow signal processing cost



20 dBm and 14 dBm UE transmit power classes

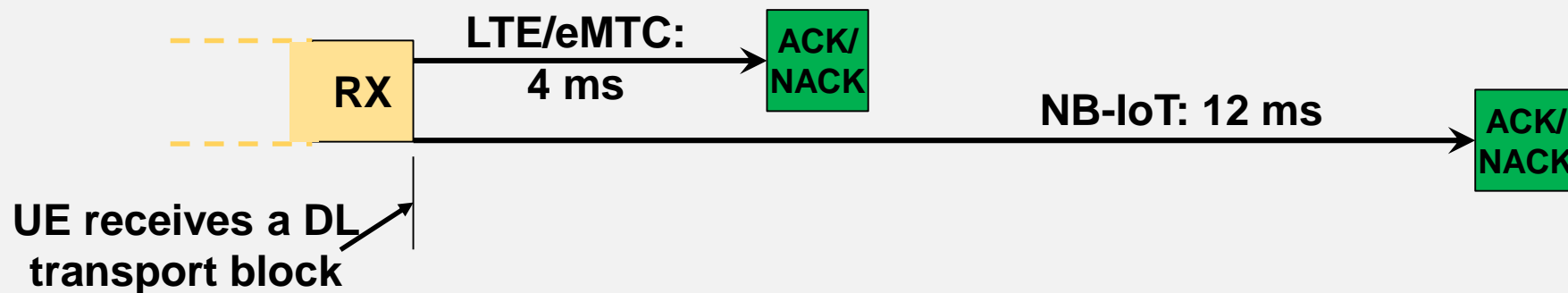
Lower peak current requirement allows cheaper, smaller batteries



Half-duplex operation allows removal of duplexer from UE
(Mandatory NB-IoT, optional eMTC)

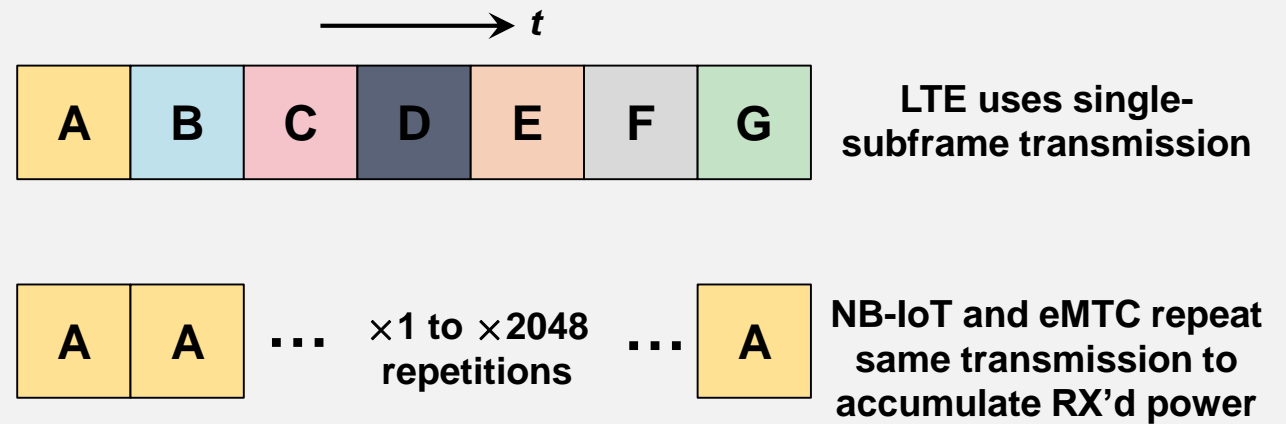
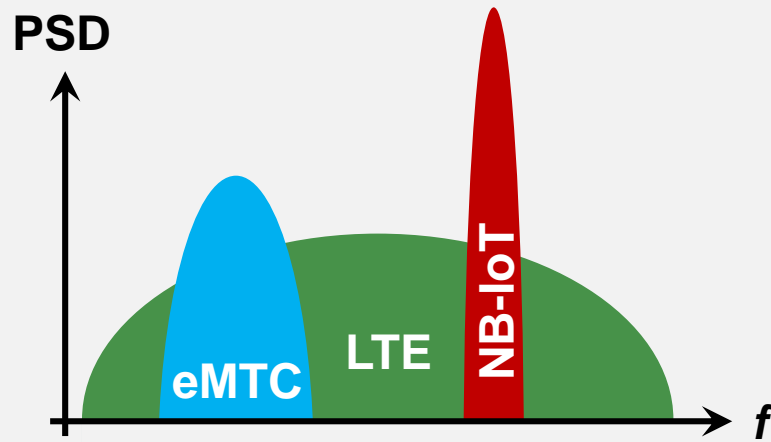
Ultra-low UE complexity: Further steps in NB-IoT

- NB-IoT takes additional steps to allow low-cost hardware:
 - Downlink uses convolutional encoding, removing need for turbo decoder in UE
 - 1 or 2 HARQ processes, instead of 8 in LTE/eMTC, reduces memory for data buffering
 - Synchronization signals with low complexity, optimised for reception in deep coverage
 - Maximum modulation is QPSK instead of 16-QAM, lessening EVM requirements
 - UE is allowed a much longer time to decode a reception before reacting to it, e.g. for DL:

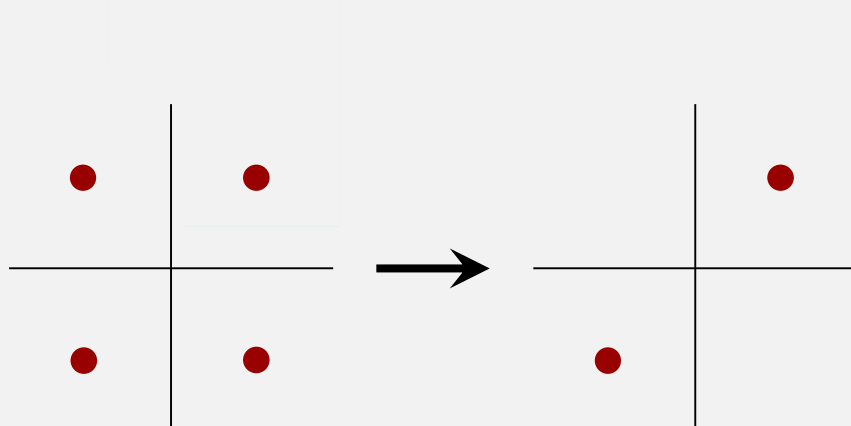


- 40 ms gap after each 256 ms of transmission during UL, allowing UE to re-sync to DL
 - Allows lower-cost non-temperature compensated crystal oscillators to be used in chipsets
 - Mandatory in NB-IoT UEs, optional for eMTC

Coverage extension

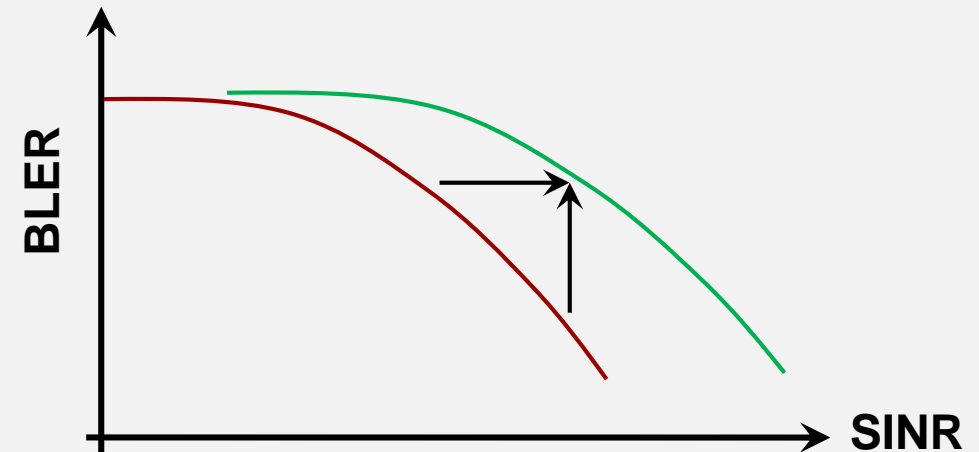


PSD boost in bandwidth as small as 3.75 kHz



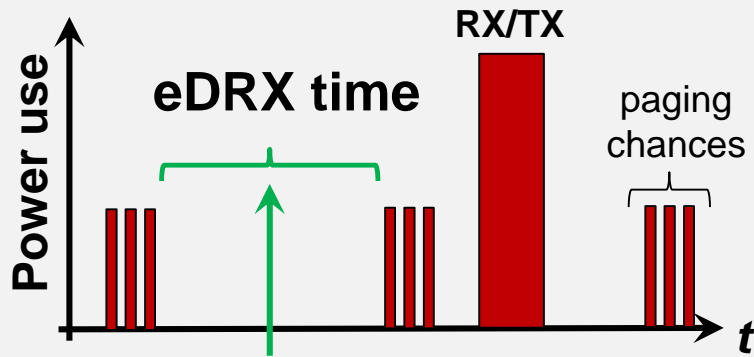
Low-PAPR $\pi/2$ -BPSK modulation
(and $\pi/4$ -QPSK in NB-IoT)

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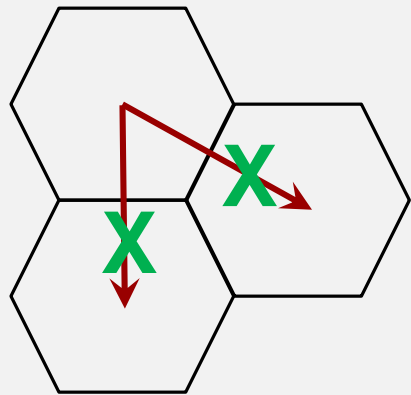
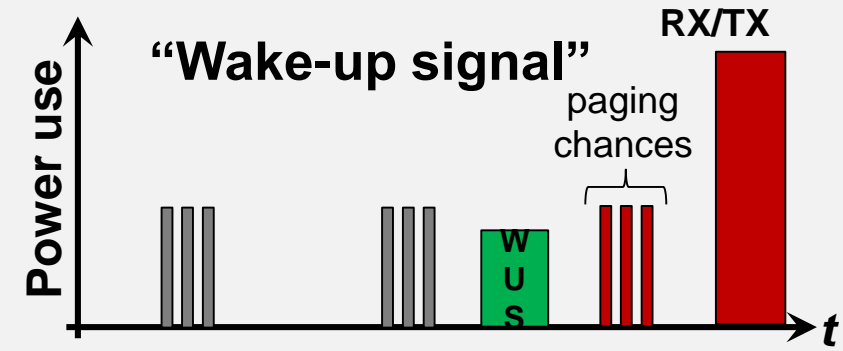
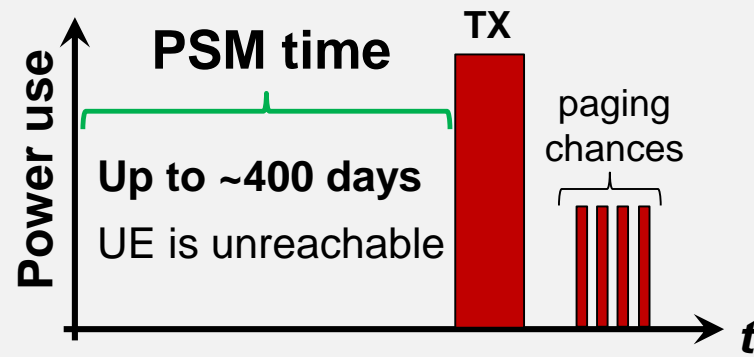


Relaxed requirements to tolerate lower SINR regimes

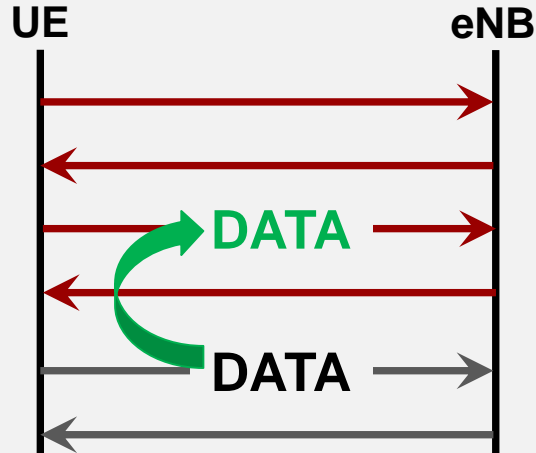
Battery life 10 – 15 years



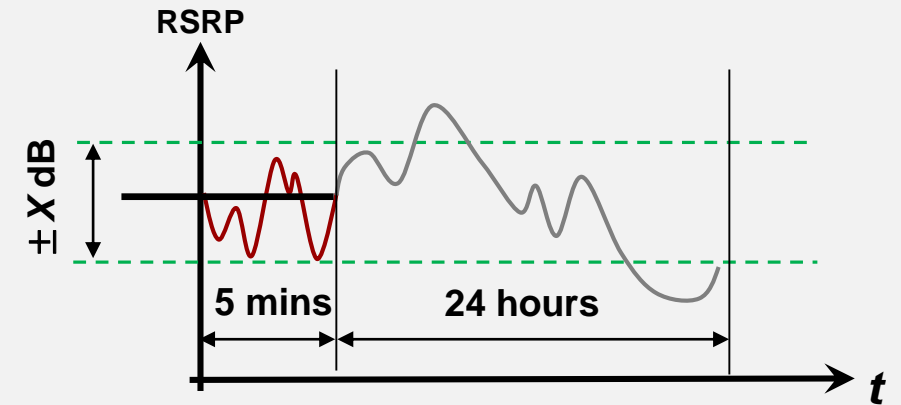
NB-IoT: ≤ 3 hr
eMTC: ≤ 40 min



NB-IoT: No handover measurements / signalling



Earlier data transmission, without tx/rx'ing to complete connection

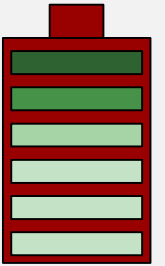


Stationary UE can suspend measurements of neighbour cells

Hallmarks of 3GPP LPWA IoT technologies

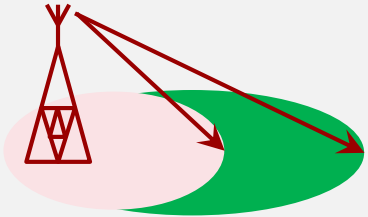
Battery life of 15 years or more on 2AA cells (5 Wh)

- Optimised for small infrequent packet transmissions e.g. 50-200 bytes few times/day
 - Transfer data earlier with fewer transmissions, and less battery consumption
- Maximise time UE can spend in low-power states and eliminate avoidable UE RX/TX



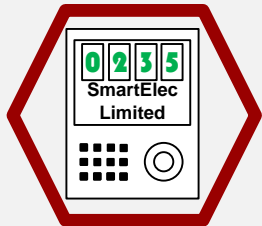
Support for normal to moderate coverage and deep coverage scenarios

- Repetition, PSD boosting, and low-PAPR transmissions
- In good coverage, NB-IoT and eMTC do not need repetitions



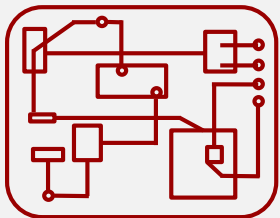
mMTC connection density of $\geq 1\,000\,000$ UE/km²

- Small resource allocations, 3.75 kHz subcarriers (NB-IoT), scalable network capacity
- Reduced signalling overhead to free-up resources for connecting more devices per cell



Complexity and cost is much lower than MBB devices

- Reduced RF and baseband bandwidths of 1.4 MHz for eMTC and 180 kHz for NB-IoT
- Relaxed signal processing requirements, with further relaxations in NB-IoT



CONTACT
Matthew Webb
matthew.webb@huawei.com

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