Cellular IoT Devices

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REQUIREMENTS ON CELLULAR CONNECTIVITY FOR IOT

**Low complexity low cost device**

- **Sensors, actuators, and similar devices,**
  - Usually do not require the wideband operation of LTE.

**Long (10+ years) battery life**

- **Devices are often battery-powered and battery life needs to last at least the device life-time.**

**Extended (+20dB) coverage**

- **For devices located in rural area, deserted area, or basement of a building.**

**Massive number of devices**

- **Covering all types of communication between machines.**
EVILOUTION OF CELLULAR CONNECTIVITY FOR IOT

First eMTC/NB-IoT

Rel-13
Key features:
- low complexity UE (Cat-M1/NB1):
  - Reduced bandwidth
  - New UE power class
- Extended discontinuous reception (eDRX)

Rel-14
Key features:
- New category UE (Cat-M2/NB2)
- Improved signalling

Rel-15
Key features:
- Energy efficient signalling
  - New synch signal
  - Wake-up signal

Rel-16
Key features:
- Improve signalling
  - Group wake-up signal
  - Enhanced early data transmission

2008
Rel-8
First LTE release

2015
Rel-13

2016
Rel-14

2017
Rel-15

2018
Rel-16

2019

2025

We are here

Gen.1 (Rel. 13)
1210
CAT-M1

Gen.2 (Rel. 13)
1250
CAT-M1/NB1
LOGISTIc and TRANSPORTATION - MOBIAM

Improved efficiency in transportation and tracking solutions
HEALTH and WELLNESS - CARRON
A platform for M-health
CELLULAR IOT USE CASES - EXAMPLES
EXISTING POWER SAVING FEATURES

Discontinuous Reception (DRx)
Up to 2.56 second

- Receive mode
- DRx (light sleep)
EXISTING POWER SAVING FEATURES

Discontinuous Reception (DRx)
Up to 2.56 second

Power

Time

Receive mode
DRx (light sleep)

Power Saving Mode (PSM) – Rel. 12
> One year

Uplink transmission
TAU: tracking area update
PSM
Synchronization

Active timer

EXISTING POWER SAVING FEATURES

Discontinuous Reception (DRx)
Up to 2.56 second

Extended DRx (eDRx) – Rel. 13
Up to ~ 45 minutes

Power Saving Mode (PSM) – Rel. 12
> One year
EXISTING POWER SAVING FEATURES

Discontinuous Reception (DRx)
Up to 2.56 second

Extended DRx (eDRx) – Rel. 13
Up to ~ 45 minutes

Power Saving Mode (PSM) – Rel. 12
> One year

Receive mode
DRx (light sleep)
eDRx (deep sleep)
Better reachability
Longer battery life

Uplink transmission
TAU: tracking area update
PSM
Synchronization
POWER CONSUMPTION CHARACTERISTICS

- DRx
- eDRx

Main receiver always on

Cost to listen

Light sleep

Deep sleep

Power consumption

Duty-cycle length
[also determines reachability]
POWER CONSUMPTION CHARACTERISTICS

- DRx
- eDRx

Cost to listen

Main receiver always on

Light sleep

Deep sleep

Duty-cycle length [also determines reachability]
EXISTING POWER SAVING FEATURES (Cont.)

Discontinuous Reception (DRx) and Wake-up Signalling – Rel. 15

- Wake-up signal receive mode
- DRx (light sleep)

Extended DRx (eDRx) and Wake-up Signalling – Rel. 15

- eDRx (deep sleep)
- Re-synchronization
POWER CONSUMPTION OF EXISTING SCHEMES

- **DRx**: Duty cycle with reduced power consumption.
- **eDRx**: Enhanced Duty cycle with further reduced power consumption.
- **WUS**: Wake-up scheme for improved power efficiency.

**Graph Details**:
- **X-axis**: Duty-cycle length [Sec] (also determines reachability).
- **Y-axis**: Average power consumption [mW].
- **Lines**: Blue solid lines represent Normal coverage, while dashed lines represent Extended coverage.

**Legend**:
- **Normal coverage**
- **Extended coverage**

**Comparison**:
- **4x** and **5x** improvements with and without WUS configurations.
- **10x** improvement with eDRx for No WUS scenarios.

**References**:
HOW MUCH AND WHEN/IF WAKE-UP RECEIVER SAVES?

![Diagram showing power consumption vs. duty-cycle length for different wake-up scenarios.](image)

- **No WUS**
- **With WUS**
- **With WUS + WURx**

Power Consumption [mW] vs. Duty-Cycle Length [Sec]

- **DRx**
- **eDRx**

- **Light sleep**
- **Deep sleep**

- 50x reduction
- 10-50x reduction

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SUMMARY

- **Existing feature(s):** Power saving features such as power saving mode (PSM), extended discontinuous reception (eDRX), and wake-up signalling enable connectivity and long battery life for mobile originated applications and/or delay-intolerant device-terminated applications.

- **Future feature:** A use of an extra low-power wake-up receiver as an assistance to the main receiver can enable connectivity and long battery life time for use-cases with tight requirement on device reachability.