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MACHINE TO MACHINE (M2M) COMMUNICATIONS-PART I

BASICS & CHALLENGES

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Overview

- Introduction
  - Definition
  - Vision
  - Scenarios
- Challenges
- Machine To Machine (M2M) Communications within 3GPP LTE
- Discussion/Summary

INTRODUCTION

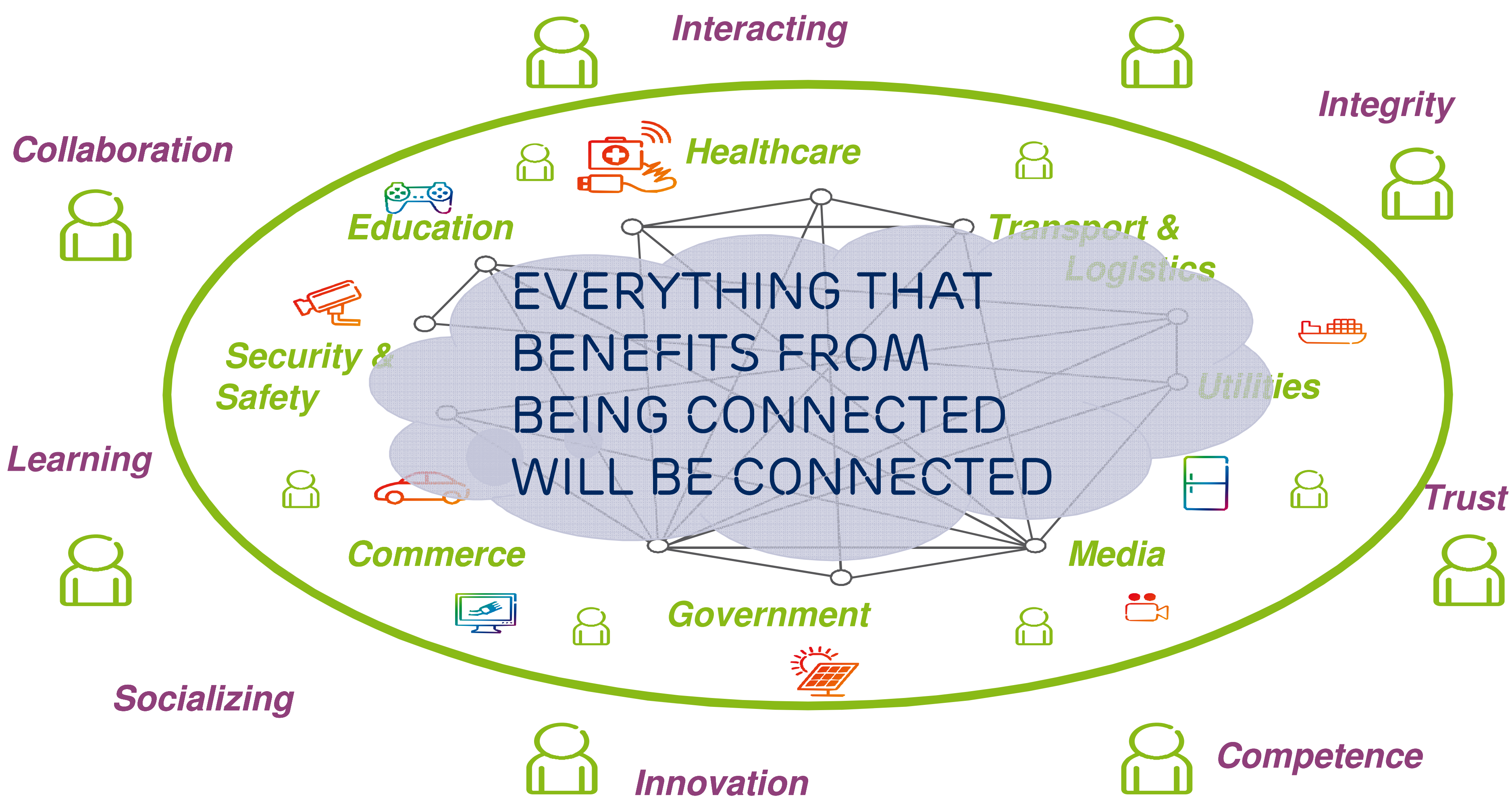
- DEFINITION
- VISION
- SCENARIOS/USE CASES

Definition

- Communication among machines, sensors, devices or "things"
- Communicating entities of various capabilities in terms of hardware/software and processing capacity
- Traffic of various
  - Patterns &
  - Requirements in terms of delay, energy consumption, robustness

Often quite different from those of mobile phones or tablets

Vision - Network Society



Use Cases

Healthcare · *Transport & Logistics* · *Utilities* · *Building automation*

Meters and Sensors

- Sensor, actuators, meters, connected things
- Small, simple, low-cost, low energy consumption
- In-building, outdoor

Utilities · *Government* · *Security & Safety* · *Industrial automation*

Critical Communication

- Embedded devices
- High reliability and availability
- Low delay
- Coverage
- Autonomous operation
- Private, public, hybrid communication

Transport & Logistics

Intelligent Transport Systems

- Connecting vehicles, transport infrastructure and transport management
- Incl. safety-related services
- Low delay
- High mobility

Education · *Commerce* · *Media*

Connected Consumer Electronics

- Similar to MBB for personal communication

CHALLENGES

- M2M CHARACTERISTICS
- RADIO INTERFACE DESIGN

Challenging Characteristics

- Different use cases impose different challenges/requirements
  - Low Latency
  - Low Cost
  - Low Energy Consumption
  - High coverage

- Common characteristic for all use cases
  - Very High Number of Devices

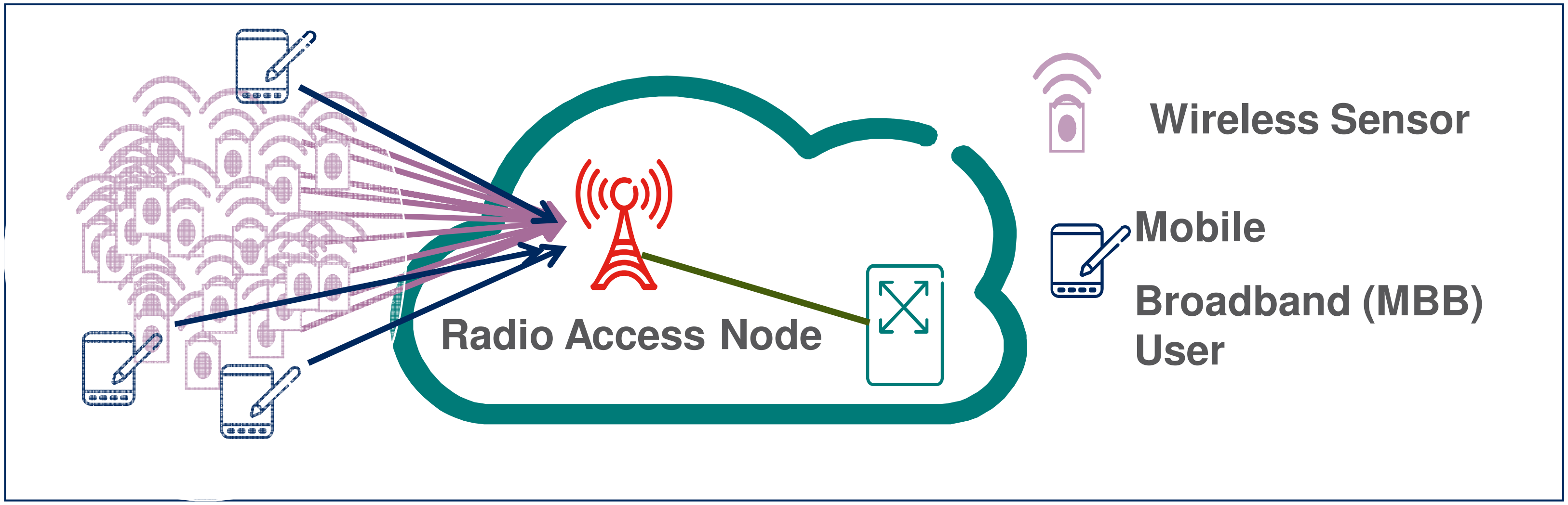
- Requirement for cooperation with normal mobile phones & tablets

500 B Connected Devices

- Radio Interface
  - Signaling Overhead
  - Need for
    - L1 Control
    - Radio Resource Management
    - Mobility Management

  algorithms with the lowest overhead
- Architecture impact
  - Centralized or coordinated approach (related to algorithms)
- Radio Access & Core Network Overload
  - Hardware limitations & processing power have to be considered
  - Possibly massive deployment of network nodes needed
- Low Cost & Low Energy Consumption
  - Essential for the mass use of sensors

Radio Interface Choice
Unique Radio Interface

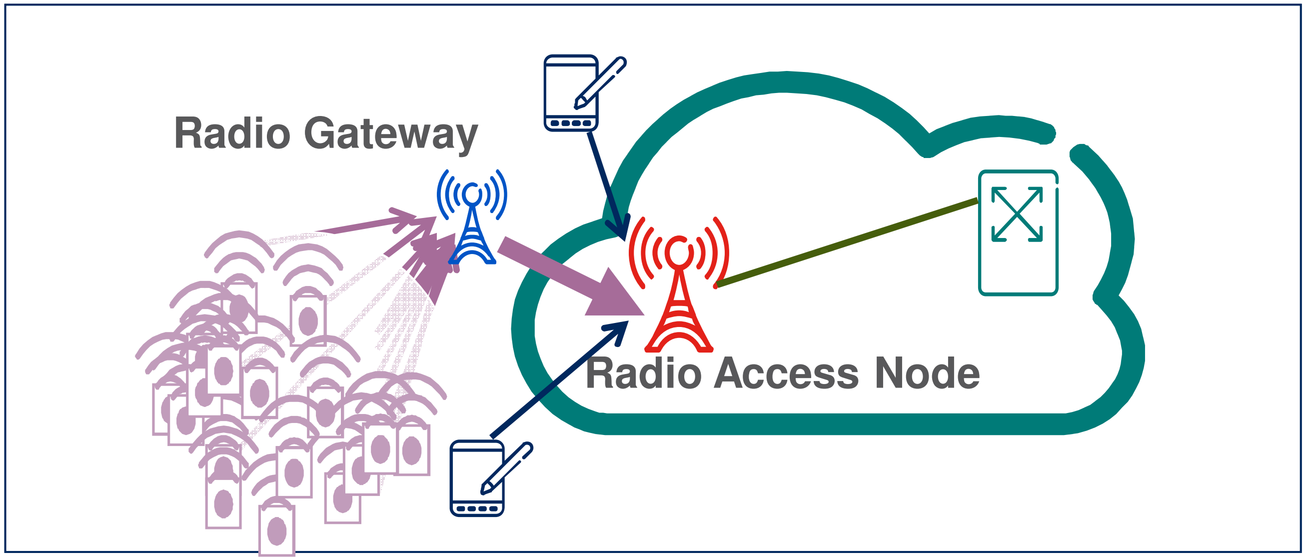


- Wireless sensors and mobile broadband (MBB) users access the radio access technology (RAT)
  - via the same access points-network nodes
  - with the same radio frame & protocol structure
  - Possibly via the same radio access network

Radio Interface Choice
Unique Radio Interface - Discussion

- Benefit
  - All types of wireless sensors (stand-alone or embedded to mobile phones, tablets, or other devices) can be accommodated within a cellular network
- Drawback
  - Single radio interface fitting all types of devices & traffic very challenging to design
- Main solution in this track
  - Modular radio interface & protocol structure accommodating:
    - Complete operation for MBB & some wireless sensors with adequate hardware capabilities & no limitations in energy consumption
    - "Light", or "degraded" version for devices with low requirements in data rates, latency of low cost
    - Variant for devices with low latency & ultra reliability requirement

Radio Interface Choice
Separate Radio Interfaces

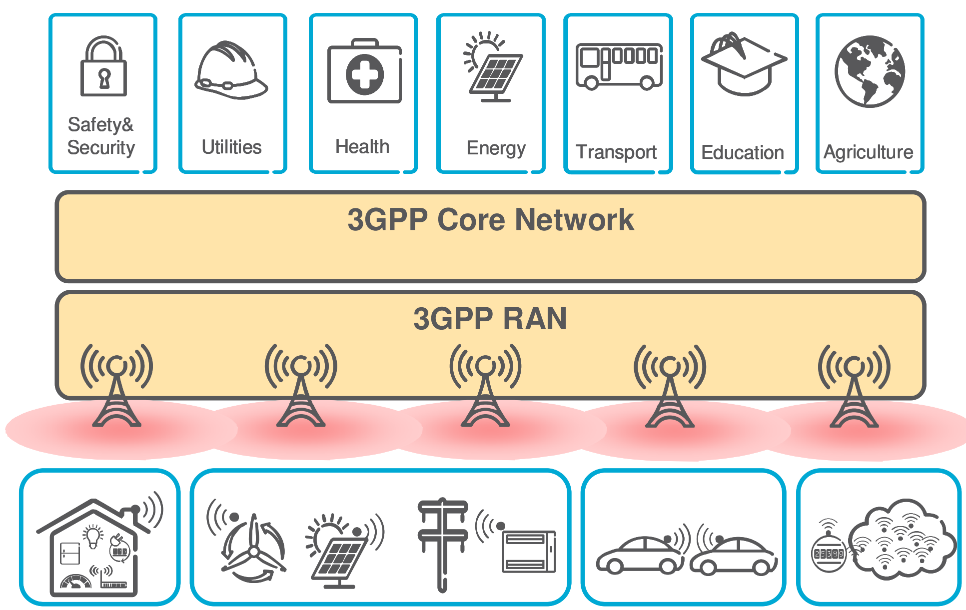


- MBB Users communicate to radio access nodes (base stations, relays, wireless access points) as usually
- Wireless sensors communicate via radio gateways or radio access nodes (if possible)
- Different radio interfaces used
  - "Evolution of LTE Advanced" for MBB
  - "ZigBee like" or other low energy radio interfaces for sensors

Radio Interface Choice
Separate Radio Interfaces - Discussion

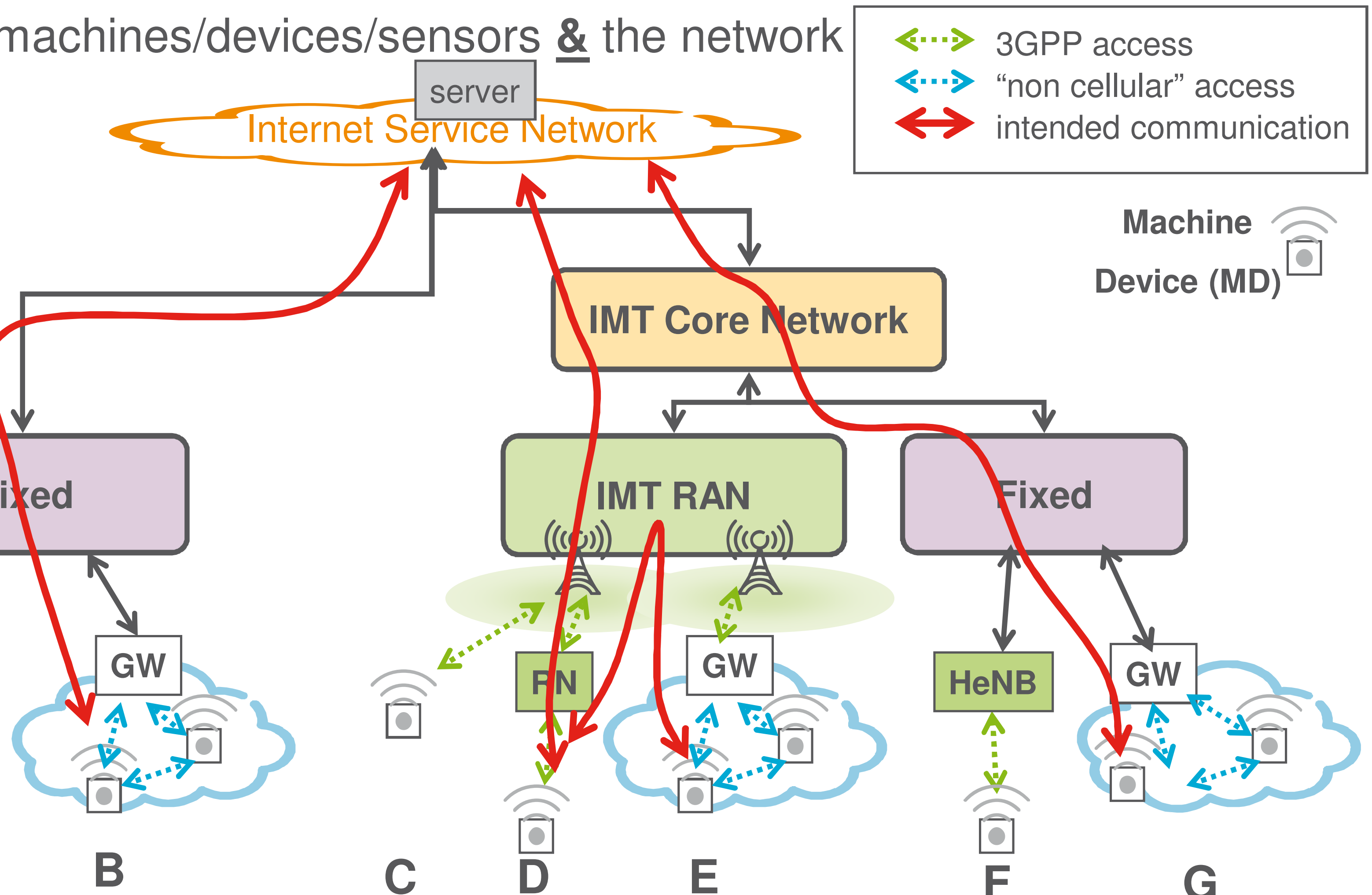
- Benefit
  - Simplest solution
- Drawback
  - Need for deployment of radio gateways (& radio access nodes for MBB users) in areas without coverage for MBB users
  - Probably network nodes of higher cost and complexity (and probably mobile phones & tablets ?)
    - Due to support of two separate radio interfaces
- Main Solution in this track
  - Full blown LTE Advanced Evolution ("5G") for MBB users
  - Deployment/use of radio access gateways accommodating traffic from sensors

M2M FOR WITHIN 3GPP



Machine Type Communications (MTC)

- Refer to communications
  - between machines/devices/sensors **via** the network (fixed or wireless)
  - between machines/devices/sensors **&** the network

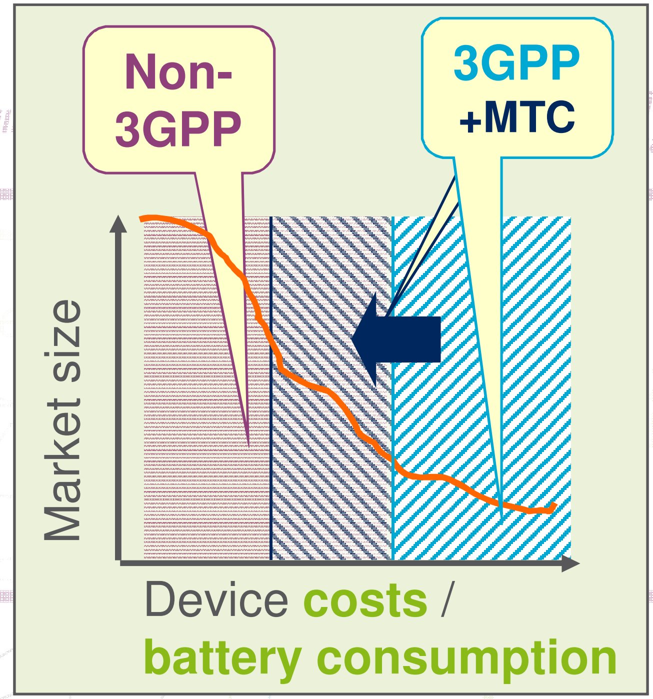


The Networked Society
M2M Use Cases

Healthcare *Transport & Logistics* *Utilities* *Building automation*

Meters and Sensors

- Sensor, actuators, meters, connected things
- Small, simple, low-cost
- Small data, delay-tolerant
- In-building, outdoor



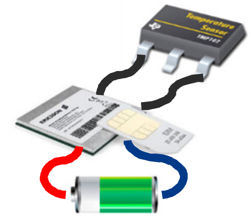
Intelligent Transport Systems

Connected Consumer Electronics

Focus of 3GPP for MTC until now

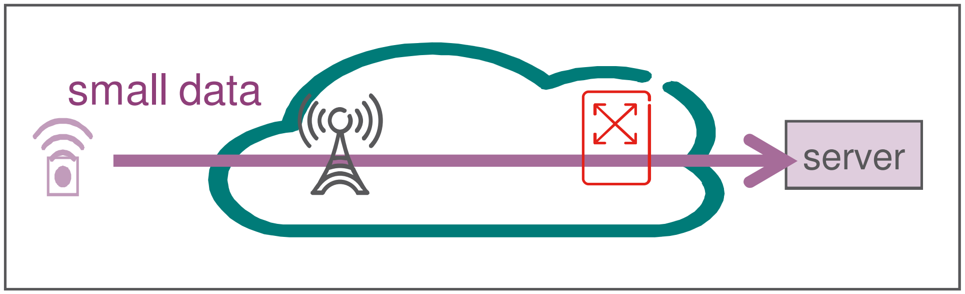
Focus of MTC enhancements for Rel-12

MTC devices in focus



- Infrequent small data transmission,
  - E.g. 100 byte temperature reading every 30 min.
- Mainly uplink transmission
  - Downlink reachability not typical
- Delay tolerant messaging, low data rate
- Often stationary devices
  - E.g. home automation, agriculture, aquaculture, …

Objectives

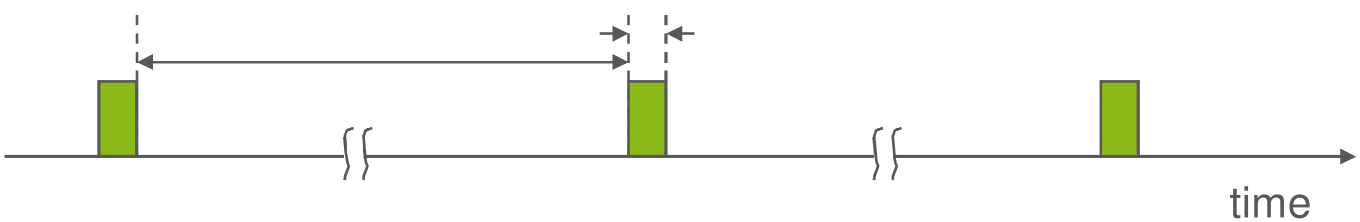


UE battery consumption

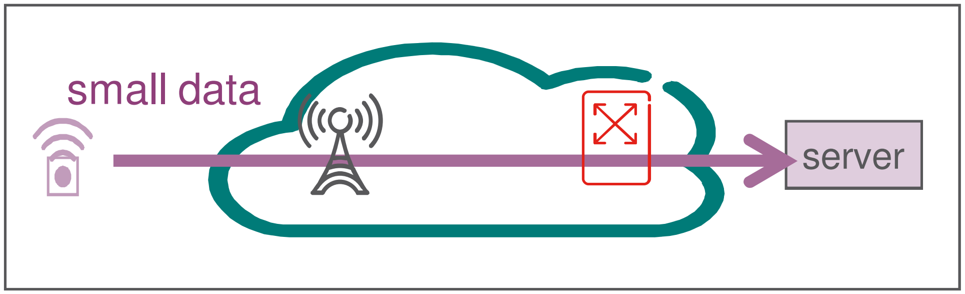
- ➔ Minimized UE transceiver activity
- ➔ Minimize signaling overhead

UE cost and complexity

- ➔ Enable UE half-duplex operation

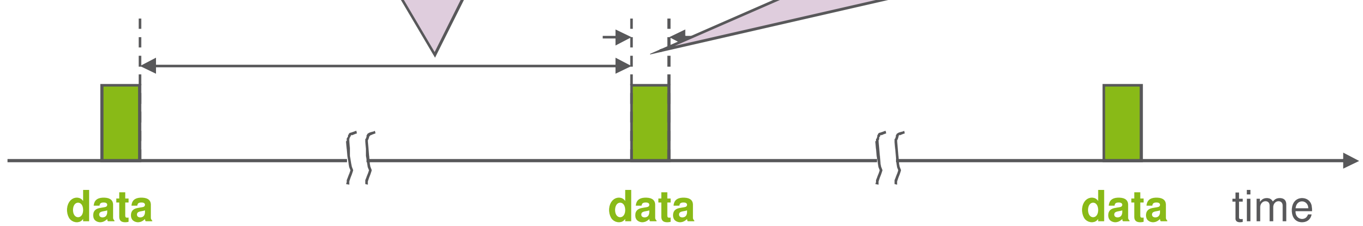


Approach



Long non-active periods
- Minimize terminal RX activity
  - long paging Discontinuous RX (DRX)
  - delay-tolerant DL traffic
- Enable terminal half-duplex operation

Active periods
- Minimize terminal RX and TX activity
  - Maximize DRX times
  - No fast power control
- Minimize signaling for data transfer
  - Avoid connection setup
- Enable UE half-duplex operation

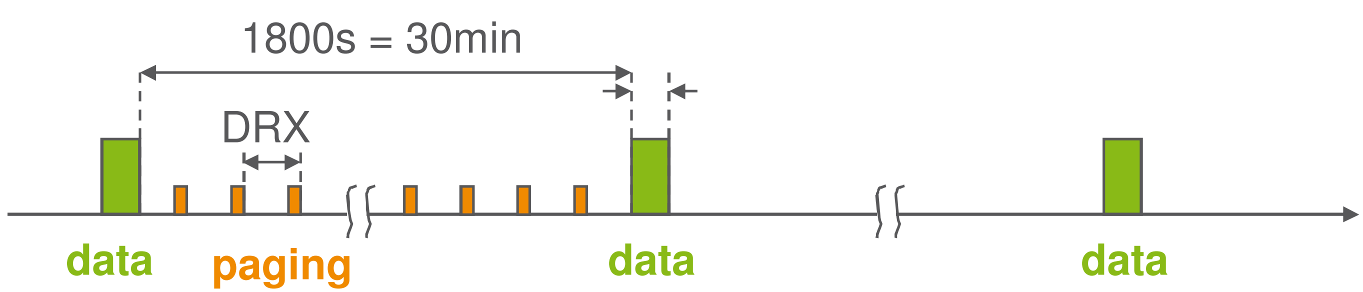


Discontinuous reception (DRX)

- Connected Mode
  - Active connection/session
  - Terminal known at cell level at the network
- Idle mode
  - terminal only needs to listen to one page indicator in one paging occasion per paging cycle
  - Terminal known at the routing area level
- DRX enables power saving by allowing sleep;
  - DRX times are times when the UE is allowed to turn it’s receivers off
- Sleep mode - while connected
  - Terminal only wakes up periodically so as to listen to system and scheduling information

Quick Assessment

- UE sending 240 bytes every 30 min
- LTE terminal power model (2020):
  - coarse clock negligible (long-time sleep)
  - fine clock 8mW (sync)
  - RX 111mW / TX 177 mW
- Max. paging / DRX cycle (5.12 s) as default ⇨ increase
  - 50 ms sync before TX or RX



Increased DRX Cycle Length

Battery capacity is 6.5 kJ.

DRX Cycle length	10.24 s	20.48 s	81.92 s	163.84 s	1800 s
Gain in energy cons.	~50 %	~75 %	92 %	95 %	98 %
Battery lifetime	110 days	7 months	2 years	3.5 years	~9 years

- Comparison of longer cycles to current maximum of 5.12 s

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- **16 times longer DRX / paging cycle**
- **10 times long battery life**

Uplink tx: E-DCH vs RACH

DRX cycle length	5.12 s	10.24 s	20.48 s	81.92 s	1800 s
Gain in energy cons.	5 %	10 %	17 %	40 %	74 %

- We increase the cycle length and calculate the gain in total energy consumption over the whole period of 1800 s
- Comparison of UE transmitting using E-DCH vs. RACH

- **Battery lifetime increase by >2 achievable via E-DCH vs. RACH**
- **But only for long paging DRX, otherwise paging dominates**

Long DRX drawbacks

- Need to identify MTC devices

- UE specific DRX settings required

- Downlink reachability

Summary/Discussion

- Challenges related to introduction of machine type communication to 3GPP
- 3GPP systems not devised for this type of communication
- Considerable engineering work required

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