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3GPP LPWA Standards: LTE-M, NB-IoT, EC-GSM

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LTE for machines

Introduction :

- It is a machine focused variant of 3GPP LTE standard.
- It is a low power wide area technology which supports IOT through low device complexity and provides extended coverage while allowing the re-use of LTE installed base.
- LTE-M networks will co exist with 2G,3G and 4G mobile networks and benefit from all the security and privacy features of mobile networks.

Introduction :

- LTE-M enhancements promises to improve the coverage, message latency, battery life and capacity.
- LTE-M is a very versatile LPWA technology, since it supports higher data rates, real-time traffic , full mobility and voice.

LTE-M enhancements in Rel- 14 & 15 :

- 5G battery life and message latency requirements are met by LTE-M.
- Rel-14 introduces RAI which allows the device to request it be released from the connected state after it has completed all its communications.
- Rel-14 features also include increased data throughput, a new 5 MHz category-M2 device, multicast support, positioning enhancements , voice optimizations and improved mobility support.

LTE-M enhancements in Rel- 14 & 15 :

- Rel-15 enhancements to be in june 2018.
- Objectives : improved latency, spectral efficiency and power consumption.
- The spectral efficiency and system capacity is improved in the DL by introduction of higher order modulation (64QAM) and in the UL by introduction of finer granularity resource allocation.

LTE-M performance summary :

- Message latency : 6.2 seconds
- Battery life : 10.4 years
- Capacity 1 million devices per Km2 : 70 % of a 5 MHz system
- Coverage : UL - 363 bps , DL - 1200 bps
- Message latency : 6.7 seconds

LTE-M objectives

Objectives :

- Specify a new device category for M2M operation in all LTE duplex modes based on R-12 low complexity device category.
- Provide an LTE coverage improvement .
- Enhance the DRx cycle in LTE to allow for longer inactivity period and thus optimize battery life.

Long battery life :

- A device PSM was introduced in Rel-12 to significantly improve device battery life.
- A device that supports PSM will request a network for a certain active timer value during the attach or TAU procedure.
- The active timer determines how long the device remains reachable.

Low device cost :

- To reduce complexity of LTE with lower performance KPI's while still complying with the LTE system.
- These complexity reductions provide significant cost reductions.

LTE-M Rel-12 cost optimizations :

- Half - duplex FDD operation allowed. This makes it possible to operate LTE TDD time multiplexed avoiding the duplex filter.
- Reducing the device receive bandwidth to 1.4 MHz allows for substantial complexity reduction.
- Single receive chain. This removes the dual receiver chain for MIMO.
- Introducing a low data rate requirement , the complexity and cost for both processing power and memory will be reduced significantly.

LTE-M Rel-13 cost optimizations :

- Low RF bandwidth support (e.g 1.4 MHz) . it would reduce complexity as a narrowband RF design sufficient.
- A lower device power class of 20 dbm will allow integration of the power amplifier in a single chip solution.

Standardization independent cost optimizations :

- Optimized technology for RF and mixed signal processing.
- With higher volume, the integration of single one chip solutions becomes feasible.
- Support for only single RAT and single band RF.
- Cost erosion of CMOS technology.

Low deployment cost :

- LTE-M shares capacity with the legacy LTE networks.
- It operates on a 1.4 MHz carrier or 6 PRB.
- The IOT device will always listen to the centre 6 PRB for control information like any normal device.
- Reusing LTE for narrowband IOT systems takes advantage of existing technology as well as installed system base.

Full coverage :

- LTE-M provides 15db additional link budget enabling about seven times better area coverage.
- NB LTE-M provides 20db additional link budget enabling about ten times better area coverage.
- The coverage enhancement can be achieved using a combination of techniques including power boosting of data and reference signals, repetition/transmission and relaxing performance requirements.

Massive no. of devices :

- LTE was designed for few simultaneous users with high data rates.
- IOT traffic requires support for many users each having a low data rate.

Optimization of core networks

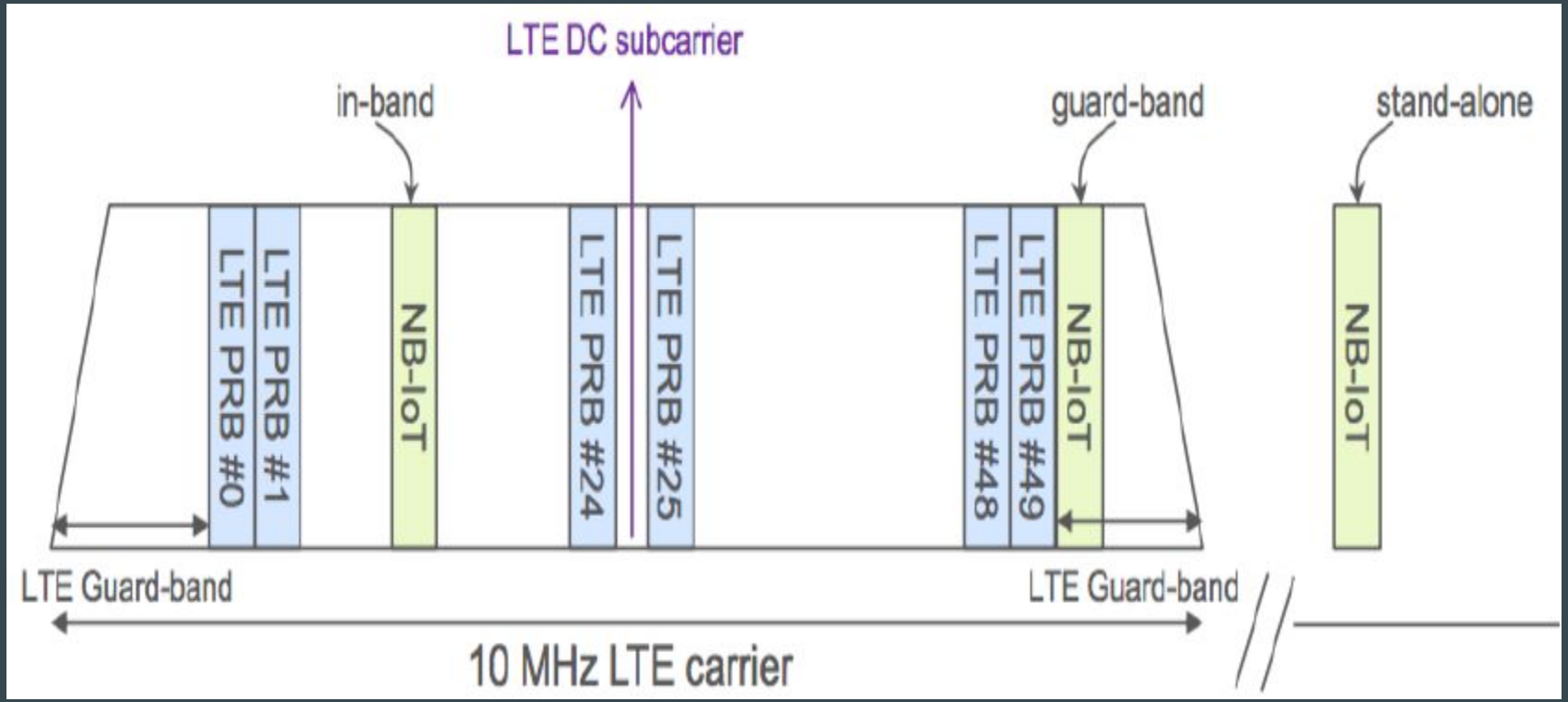
Core network optimization :

- Normal broadband traffic is latency critical and needs to be scheduled immediately.
- Monitoring of certain events or sensors may be correlated and could be detected in the network. E.g water leakage based on multiple water utility readings.
- An interface exposing the IOT data to an application platform needs to be provided.

Core network optimization :

- A dedicated MME may be required for subscription management as the pricing and changing models for IOT may be very different compared to voice and data.
- Subscription and signalling optimization may be required for a large set of devices.
- Group based paging is required for optimizing signalling.

Deployment options :



Considerations of LTE - M :

- PPP connections are not the norm
- Security and power are oil and water

LTE - M task force :

- Facilitate commercial launches of LTE-M solutions globally.
- Reduce complexity of LTE-M device introduction.
- Drive and proliferate LTE-M applications in vertical markets for new business opportunities.
- Promote collaboration between all LTE-M industry partners to ensure interoperability of solutions.

LTE-M Deployment bands

Deployment bands ：

- Supported bands : 1,2,3,4,5,7,8,11,12,13,18,19,20,26,27,28,31,39,41.
- Rel-14 added 25 and 40.

LTE-M Data architecture

Data architecture ：

There are two main network attach options to support connectivity:

- Attach with PDN connection.
- Attach without PDN connection.

Data connectivity options :

- IP over CP
- IP over UP
- Non-IP over CP
- Non-IP over UP

Data connectivity options :

- For MO services, data could be transmitted at any time if needed.
- For MT services, data can only be transmitted in accordance with PSM and eDRX timers, which is the only time that the device is reachable by the network.
- For services that occasionally transmit reasonably small amounts of data, the utilization of control plane will optimize the power consumption due to the fact that amount of signalling required and air time is reduced.

3GPP MIOT features :

- UE low access priority indicator
- AS level congestion control
- MME/SGSN control of overload
- Congestion control at the PGW/ GGSN
- Optimizing the periodic LAU/RAU/TAU signaling
- Protection in case of PLMN selection
- Device triggering
- SMS in MME

EC-GSM

EC-GSM- IOT :

- EC-GSM-IOT is a standard based low power wide area technology.
- It is based on eGPRS and designed as a high capacity, long range , low energy and low complexity cellular system for IOT communications.
- The optimisations made in EC-GSM-IOT that need to be made to existing GSM networks can be made as a software upgrade , ensuring coverage and accelerated time to market.

EC-GSM- IOT :

- EC-GSM-IOT networks will co-exist with existing 2G, 3G,4G networks.
- It will also benefit from all the security and privacy mobile network features , such as support for user identity confidentiality, entity authentication, data integrity and mobile equipment identification.

EC-GSM- IOT group objectives :

- Reduce complexity of EC-GSM-IOT device introduction.
- Drive and proliferate EC-GSM-IOT applications in vertical markets for new business opportunities.
- Promote collaboration between all EC-GSM-IOT industry partners to ensure interoperability of solutions.

EC-GSM

EC-GSM- IOT :

- Deployment : in GSM band
- Modulation : TDMA/FDMA , GMSK , 8PSK
- Downlink peak data rate : 70 kbps (GMSK) , 240 kbps (8PSK)
- Uplink peak data rate : 70 kbps (GMSK) , 240 kbps (8PSK)
- Latency : 700 ms to 2 seconds
- Technology bandwidth : 200 Khz per channel
- Duplex technology : half duplex and FDD
- Transmit power class : 33 dbm , 23 dbm

EC-GSM- IOT applications :

- M2M / IOT applications
- Voice
- Data
- SMS

EC-GSM- IOT benefits :

- Long battery life
- Lower device cost compare to existing GSM/GPRS devices
- Variable rates using GMSK/8PSK
- Support for high number of subscriber devices
- Improved security compare to GSM/EDGE

Basic idea :

Basic idea of achieving extended coverage is as follows :

- For CCCH (common control channel) : it does blind retransmission/repetition
- For data channel : for the data channels, a combination of blind repetitions of the lowest MCS supported in EGPRS today, i.e MCS-1 and HARQ retransmissions.

Motivation :

- It is to deploy the technology simply by changing the software on existing GSM network.
- It is designed in such a way that this software change does not influence on the device with existing technology.