LTE/5G IoT standardization status and NTT DOCOMO activity

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5G

eMBB

URLLC

mMTC

10^6 devices/km^2 *1
NTT DOCOMO’s Activity towards eMBB

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbps</td>
<td>682</td>
<td>788</td>
<td>988</td>
<td>1288</td>
<td>5G</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2018 May</td>
<td>2019 Spring</td>
<td></td>
</tr>
</tbody>
</table>

「LPWA」: Low Power Wide Area

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## NTT DOCOMO’s Activity towards IoT

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Cellular IoT Cat.1</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>Cellular IoT eDRX</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>Cellular IoT LoRa®</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>Cellular IoT NB-IoT</td>
<td></td>
</tr>
</tbody>
</table>

‘LPWA’ : Low Power Wide Area
# IoT related System

<table>
<thead>
<tr>
<th></th>
<th>Cellular IoT (Rel-13)</th>
<th>Dedicated NW IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spec.</td>
<td>3GPP</td>
<td>LoRA Alliance</td>
</tr>
<tr>
<td>Freq.</td>
<td>Licensed band</td>
<td>Unlicensed band</td>
</tr>
<tr>
<td>Peak Rate (DL/UL)</td>
<td>10M/5Mbps 1M/1Mbps</td>
<td>21.25K/62.5Kbps</td>
</tr>
<tr>
<td>Voice</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Mobility</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

- **Cat.1**
  - 3GPP
  - Licensed band
  - 10M/5Mbps, 1M/1Mbps
  - Yes
  - Yes

- **LTE-M**
  - 10M/5Mbps, 1M/1Mbps
  - No
  - No

- **NB-IoT**
  - 21.25K/62.5Kbps
  - No
  - No

- **LoRA**
  - LoRA Alliance
  - Unlicensed band
  - 50K/50Kbps
  - No

- **SIGFOX**
  - Specific
  - Unlicensed band
  - 600/100bps
  - No
Introduction & timeline in 3GPP

• In **Release-13** 3GPP has made a major effort to address the IoT market

• The portfolio of technologies that 3GPP operators can now use to address their different market requirements includes:

  1. **eMTC**
     - Further LTE enhancements for Machine Type Communications, building on the work started in Release-12 (UE Cat 0, new power saving mode: PSM)

  2. **NB-IOT**
     - New radio added to the LTE platform optimized for the low end of the market

  3. **EC-GSM-IoT**
     - EGPRS enhancements which in combination with PSM makes GSM/EDGE markets prepared for IoT

• Freeze of the protocol specifications is targeted for Q2-16
# Summary for eMTC, NB-IOT and EC-GSM-IoT

<table>
<thead>
<tr>
<th></th>
<th>eMTC (LTE Cat M1)</th>
<th>NB-IOT</th>
<th>EC-GSM-IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deployment</strong></td>
<td>In-band LTE</td>
<td>In-band &amp; Guard-band LTE, standalone</td>
<td>In-band GSM</td>
</tr>
<tr>
<td><strong>Coverage</strong>*</td>
<td>155.7 dB</td>
<td>164 dB for standalone, FFS others</td>
<td>164 dB, with 33dBm power class</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>154 dB, with 23dBm power class</td>
</tr>
<tr>
<td><strong>Downlink</strong></td>
<td>OFDMA, 15 KHz tone spacing, Turbo Code, 16 QAM, 1 Rx</td>
<td>OFDMA, 15 KHz tone spacing, TBCC, 1 Rx</td>
<td>TDMA/FDMA, GMSK and 8PSK (optional), 1 Rx</td>
</tr>
<tr>
<td><strong>Uplink</strong></td>
<td>SC-FDMA, 15 KHz tone spacing Turbo code, 16 QAM</td>
<td>Single tone, 15 KHz and 3.75 KHz spacing SC-FDMA, 15 KHz tone spacing, Turbo code</td>
<td>TDMA/FDMA, GMSK and 8PSK (optional)</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>1.08 MHz</td>
<td>180 KHz</td>
<td>200kHz per channel. Typical system bandwidth of 2.4MHz [smaller bandwidth down to 600 kHz being studied within Rel-13]</td>
</tr>
<tr>
<td><strong>Peak rate (DL/UL)</strong></td>
<td>1 Mbps for DL and UL</td>
<td>DL: ~250 kbps</td>
<td>For DL and UL (using 4 timeslots): ~70 kbps (GMSK), ~240kbps (8PSK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL: ~250 for multi-tone, ~20 kbps for single tone</td>
<td></td>
</tr>
<tr>
<td><strong>Duplexing</strong></td>
<td>FD &amp; HD (type B), FDD &amp; TDD</td>
<td>HD (type B), FDD</td>
<td>HD, FDD</td>
</tr>
<tr>
<td><strong>Power saving</strong></td>
<td>PSM, ext. I-DRX, C-DRX</td>
<td>PSM, ext. I-DRX, C-DRX</td>
<td>PSM, ext. I-DRX</td>
</tr>
<tr>
<td><strong>Power class</strong></td>
<td>23 dBm, 20 dBm</td>
<td>23 dBm, others TBD</td>
<td>33 dBm, 23 dBm</td>
</tr>
</tbody>
</table>

*In terms of MCL target. Targets for different technologies are based on somewhat different link budget assumptions (see TR 36.888/45.820 for more information).
eMTC

• Objectives
  – Long battery life: ~10 years of operation with 5 Watt Hour battery (depending on traffic and coverage needs)
  – Low device cost: comparable to that of GPRS/GSM devices (as in the 3GPP work item description)
  – Extended coverage: >155.7 dB maximum coupling loss (MCL)
  – Variable rates: ~10 kbps to 1 Mbps depending on coverage needs

• Deployment
  – Can be deployed in any LTE spectrum
  – Coexist with other LTE services within the same bandwidth
  – Support FDD, TDD and half duplex (HD) modes
  – Reuse existing LTE base stations with software update

• Main PHY/RF features
  – Narrowband operation with 1.08 MHz bandwidth
  – Frequency hopping with narrowband retuning for frequency diversity
  – TTI bundling/repetition to achieve large coverage enhancements
  – New UE power class of 20 dBm
  – Further cost reduction beyond Cat 0 (no wideband control channel, reduced TM support, reduced HARQ)
Objectives
- Even lower cost than eMTC
- Extended coverage: 164 dB maximum coupling loss (at least for standalone)
- Long battery life: 10 years with 5 Watt Hour battery (depending on traffic and coverage needs)
- Support for massive number of devices: at least 50,000 per cell

Main simplification
- Reduced data rate/bandwidth, mobility support and further protocol optimizations

NB-IOT supports 3 modes of operation:
- **Stand-alone**: utilizing stand-alone carrier, e.g. spectrum currently used by GERAN systems as a replacement of one or more GSM carriers
- **Guard band**: utilizing the unused resource blocks within a LTE carrier’s guard-band
- **In-band**: utilizing resource blocks within a normal LTE carrier
NB-IOT (cont’d)

• Main PHY features
  – Narrow band support of 180 kHz
  – Supports two modes for uplink
    • Single tone with 15 kHz and/or 3.75 kHz tone spacing
    • Multiple tone transmissions with 15 kHz tone spacing
  – No support of Turbo code for the downlink
  – Single transmission mode of SFBC for PBCH, PDSCH, PDCCH
  – New narrowband channels:
    • NPSS, NSSS, NPBCH, NPDCCH, NPDSCH, NPUSCH, NPRACH

• Main radio protocol features
  – Single HARQ process
  – Only RLC AM mode with simplified status reporting
  – Two PDCP options:
    1. SRB 0 and 1 only. No AS security (NAS security is used instead). PDCP operating in transparent mode.
    2. SRB 0, 1, 2 and one DRB. AS security, which is cached upon RRC connection release.
  – For PDCP option 2, RRC connection suspend/resume procedures to maintain AS security context.
  – Significantly reduced broadcast system information
Enhanced DRX for NB-IOT and eMTC

- Extended C-DRX and I-DRX operation
  - Connected Mode (C-eDRX):
    - Extended DRX cycles of 5.12s and 10.24s are supported
  - Idle mode (I-eDRX):
    - Extended DRX cycles up to ~44min for eMTC
    - Extended DRX cycles up to ~3hr for NB-IOT
Main upper layer features for NB-IOT and eMTC

• UE and Network negotiate capabilities and preferences for types of NAS/core network optimizations
  – This may be used for core network selection
  – Changes in Attach procedure required

• There are two different data transfer optimization features agreed for NB-IOT and eMTC:
  – Mandatory for NB-IoT/Optional for eMTC: “CP optimization”
    • Enables Small data over NAS using encrypted NAS PDUs
    • Support for RoHC Header Compression for IP PDN connection
    • Architecture Change: MME, S-GW and P-GW may be combined in one entity (e.g. C-SGN)
  – Optional for NB-IoT and eMTC: “UP optimization”
    • User plane based with RAN context casheing in idle mode to enable connection suspend/resume procedures on radio/S1 interface

• Other optional new features
  – Support for non-IP data (2 flavours: non-IP PDN via P-GW, non-IP via SCEF)
  – Attach without PDN connectivity
  – SMS transfer without combined attach
  – Storing and usage of coverage level in MME to avoid unnecessary repetitions over the air
EC-GSM-IoT

• Objectives
  – Long battery life: ~10 years of operation with 5 Wh battery (depending on traffic pattern and coverage needs)
  – Low device cost compared to GPRS/GSM devices
  – Extended coverage:
    • 164 dB MCL for 33 dBm UE,
    • 154 dB MCL for 23 dBm UE
  – Variable rates:
    • GMSK: ~350bps to 70kbps depending on coverage level
    • 8PSK: up to 240 kbps
  – Support for massive number of devices: at least 50,000 per cell
  – Improved security compared to GSM/EDGE
EC-GSM-IoT (cont’d)

• Main PHY features
  – New logical channels designed for extended coverage
    • Repetitions to provide necessary robustness to support up to 164 dB MCL
  – Overlaid CDMA to increase cell capacity (used for EC-PDTCH and EC-PACCH)

• Other features
  – Extended DRX (up to ~52min)
  – Optimized system information (i.e. no inter-RAT support)
  – Relaxed idle mode behavior (e.g. reduced monitoring of neighbor cells)
  – 2G security enhancements (integrity protection, mutual authentication, mandate stronger ciphering algorithms)
  – NAS timer extensions to cater for very low data rate in extended coverage
  – Storing and usage of coverage level in SGSN to avoid unnecessary repetitions over the air
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