3GPP Standards for the Internet-of-Things

Dino Flore

Chairman of 3GPP RAN

(Qualcomm Technologies Inc.)

Introduction & timeline

- 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

- Protocol specifications to be finalized in Q2-16

Summary for eMTC, NB-IOT and EC-GSM-IoT

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

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)

NB-IOT

- 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: ~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

© 3GPP 2016   **7**

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 caching 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

© 3GPP 2016   **8**

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: ~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

Thanks