Attributes and testing challenges of IoT terminals – NB-IoT as an example (hot technology – NB-IoT)

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2017.10.31

Course Objectives:

- Overview of the testing for traditional communication terminals
- Standardization progress of NB-IoT and key technologies
- Analysis of the testing difference between NB-IoT terminals and LTE terminals
- Recommendations for the testing and progress of industrial certificate

- Overview of testing for traditional communication terminals
  - Three-Level certificate
  - CE, FCC, GCF, PTCRB, Operators
  - About CTTL-Terminal Lab
- Standardization progress of NB-IoT and key technologies
- Analysis of the testing difference between NB-IoT terminals and LTE terminals
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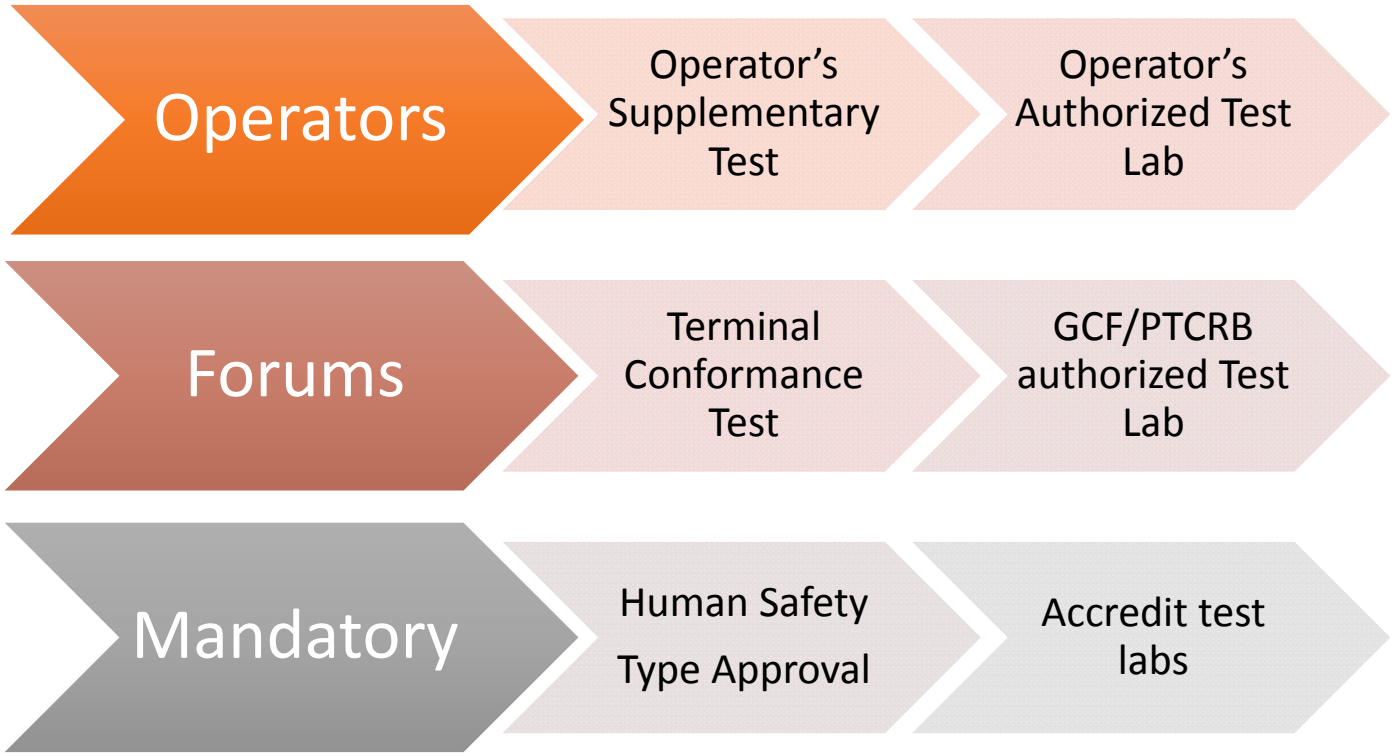
Certification of traditional LTE Terminal

Three Levels of testing certification：

- Mandatory test:
  - CE in European area
  - FCC in America
  - CCC, CTA in China
  - Tests in Canada, Japan, Australia, Russia, Singapore, Vietnam,….
- Industrial forum
  - GCF in European
  - PTCRB in north America
- Operator’s acceptance / supplementary test
  - T-Mobile US, AT&T, Verizon, Sprint
  - Orange, Vodafone
  - Softbank, DoCoMo , KDDI,….

Three-level Certification assure terminal quality



Standards requirement of CE&FCC

CE:

- Directive: basic requirements like LVD, EMC, RED,
- harmonized Standard: Conformance test methods like ETSI, CENELEC, CEN

FCC:

- FCC Title 47 CFR (Code of Federal Regulations) :
  - Part2: General
  - Unlicensed device: Part 15*, Part 18(ISM)
  - Licensed device: Part22*, 24*, 27*
  - GPO maintain above standards
- ANSI, OET65C, IEEE-1528

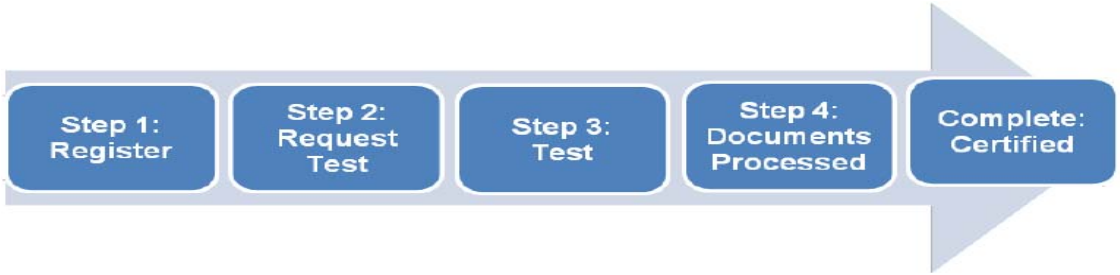
Standards requirement of GCF&PTCRB

GCF:

- Conformance Test
- Interoperate Test
- Field Test
- Performance Test(Audio, Throughput, Battery life, OTA)

PTCRB:

- Conformance Test
- AE Test
- OTA, AT, TTY



Operators:

- customized tests for operators' specific service.
- For Better user experience

CTTL-Terminal Lab

中國泰爾實驗室

CAICT 中国信息通信研究院

1 Tests

- EMC/SAR/Safety/OTA
- RF/Protocol/SIM/Audio/application/
- Profile/IOT

2 Technologies

- GSM/WCDMA/CDMA/TD-SCDMA/LTE
- Wi-Fi/Bluetooth/NFC/USB
- AGPS/MIMO/HAC

3 Testing environment

- Over 50M Euro equipment
- R&S, Anite, Anritsu, AT4, Agilent, Spirent,
- ETS-Lindgren, SPEAG

4 Global standards

- 3GPP, 3GPP2, ETSI, OMA, GSMA, ITU
- IEC, CTIA, IEEE, CISPR,CCSA

5 Global certificate

- CE/FCC/IC/ACA/CCC/NAL/NTRA etc.
- GCF/PTCRB/CTIA/NFC/Wi-Fi/BT/USB

6 Global market

- China/Europe/Australia
- USA/Canada/Japan

Anite Anritsu Discover What's Possible™ ROHDE&SCHWARZ SPIRENT

3GPP 中国通信标准化协会 China Communications Standards Association ITU oma Open Mobile Alliance ETSI World Class Standards

Authorizations & accreditation

Accreditation

Operators

Forums

Mandatory

其他:

Partners & Customers

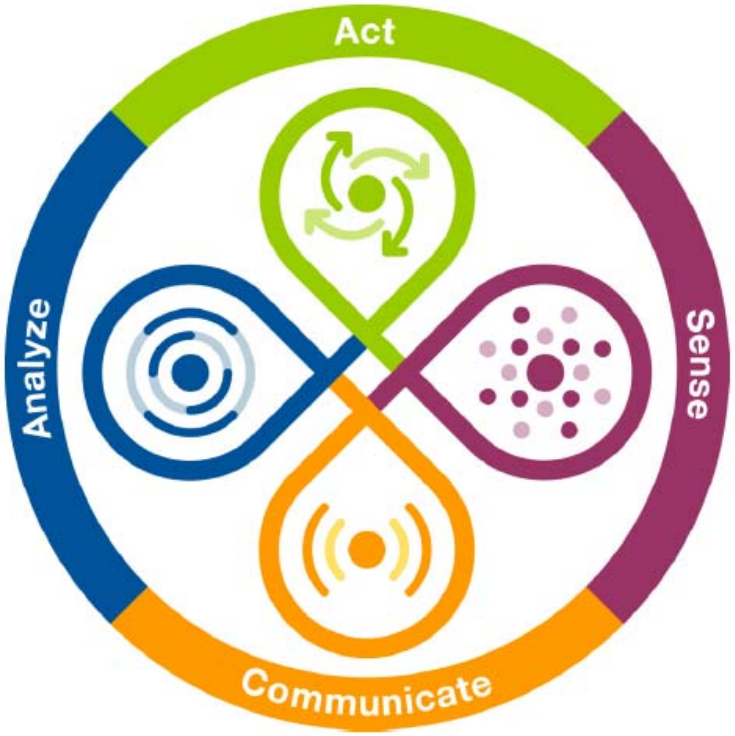
Mobile Manufacturers and design house

Operators

Chipset manufacturers

- Overview of the testing for traditional communication terminals
- Standardization progress of NB-IoT and key technologies
  - Standard development in 3GPP
    - Typical IoT Project
    - Industry trend - IoT market
    - IoT market - LPWAN
    - Evolution of NB-IoT standard
    - Three IoT technologies in 3GPP Release 13
  - Key technologies
- Analysis of the testing difference between NB-IoT terminals and LTE terminals
- Recommendations for the testing and progress of industrial certificate

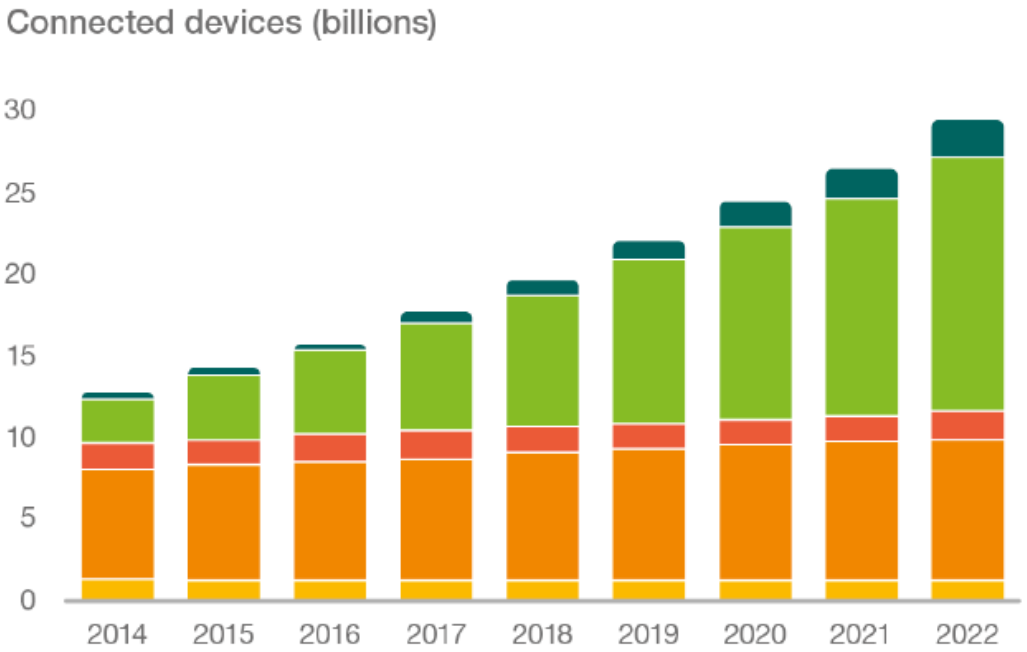
Typical IoT Project



By 2020, more than 80% of new IoT projects will be deployed with a wireless networking architecture

Gartner

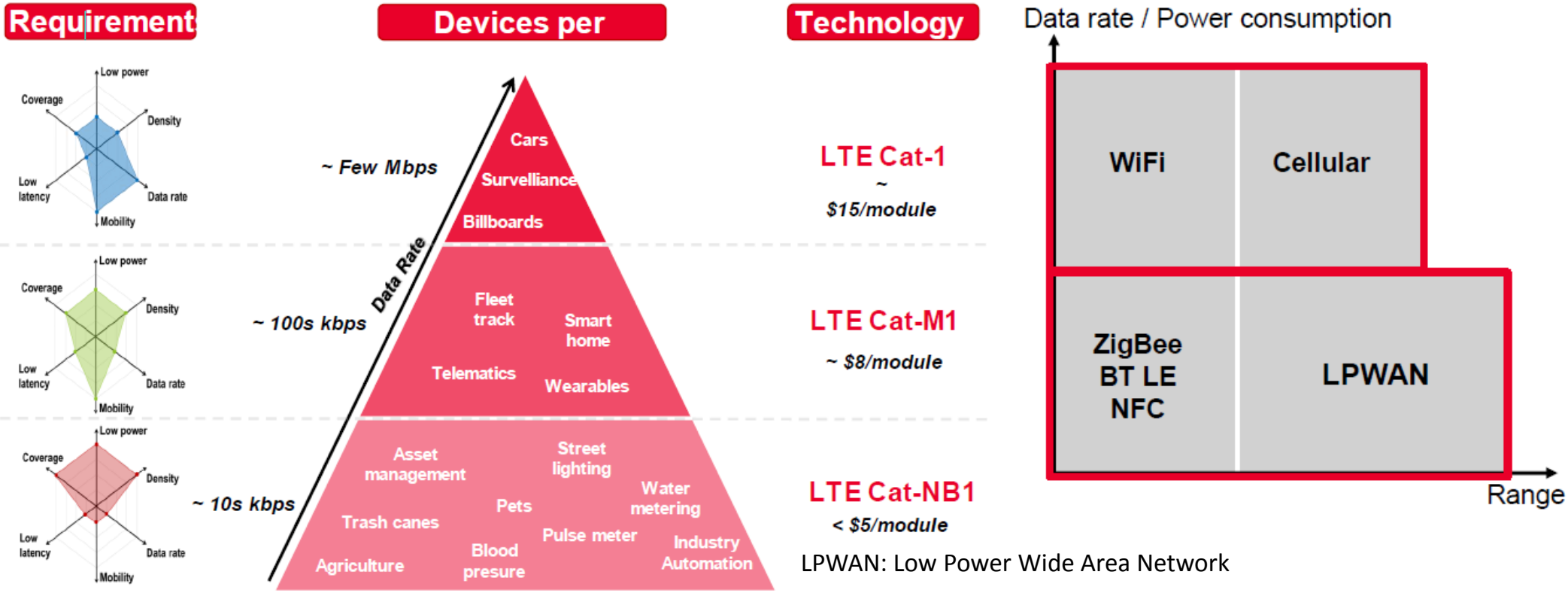
Industry trend - IoT market



	2016	2022	CAGR
Wide-area IoT	0.4	2.1	30%
Short-range IoT	5.2	15.5	20%
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.3	8.6	3%
Fixed phones	1.4	1.3	0%
	16 billion	29 billion	

Source: Ericsson

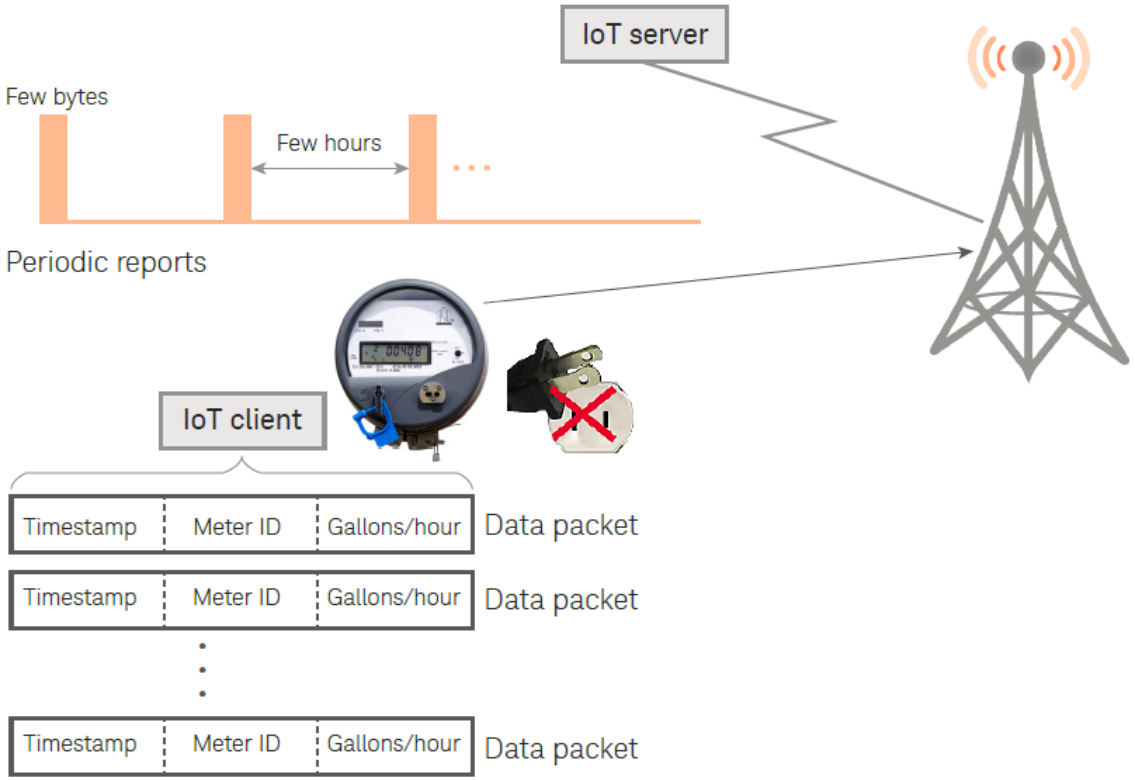
IoT Market - LPWAN



LPWAN: Low Power Wide Area Network

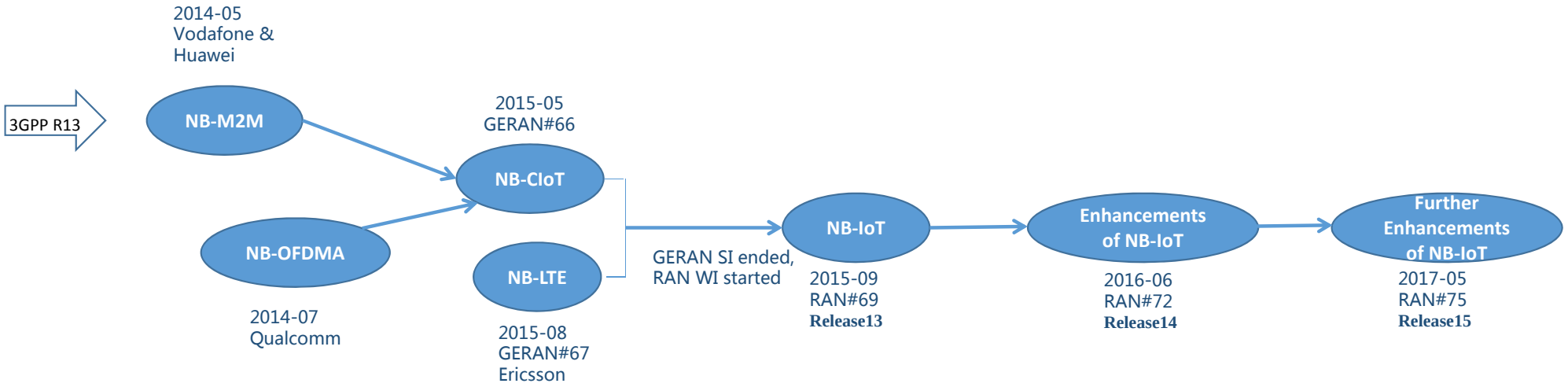
Source: Keysight

An example of LPWAN – Water metering



Source: Keysight

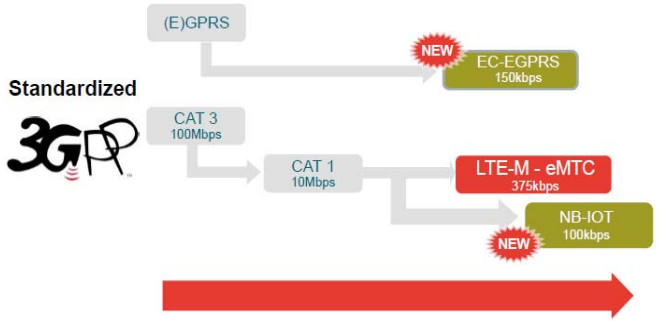
Evolution of NB-IoT standard



3GPP NB-IoT status：

- R13: Conformance Test 100% in Aug.2017(RAN#76)
- R14: Perf part WI will be done in Dec.2017(RAN#78)
- R15: WI ongoing

Three LPWAN standards in 3GPP Release 13



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

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, 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: ~50 kbps UL: ~50 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).*

- Overview of the conformance testing for traditional communication terminals
- Standardization progress of NB-IoT and key technologies
  - Standard development in 3GPP
  - Key technologies
    - Simplified physical channels
    - Flexible Network deployments
    - Enhanced battery life performance
    - Extremely low cost terminal
    - Enhanced coverage
    - Mass connection
    - R14, R15 enhancement
- Analysis of the testing difference between NB-IoT terminals and LTE terminals
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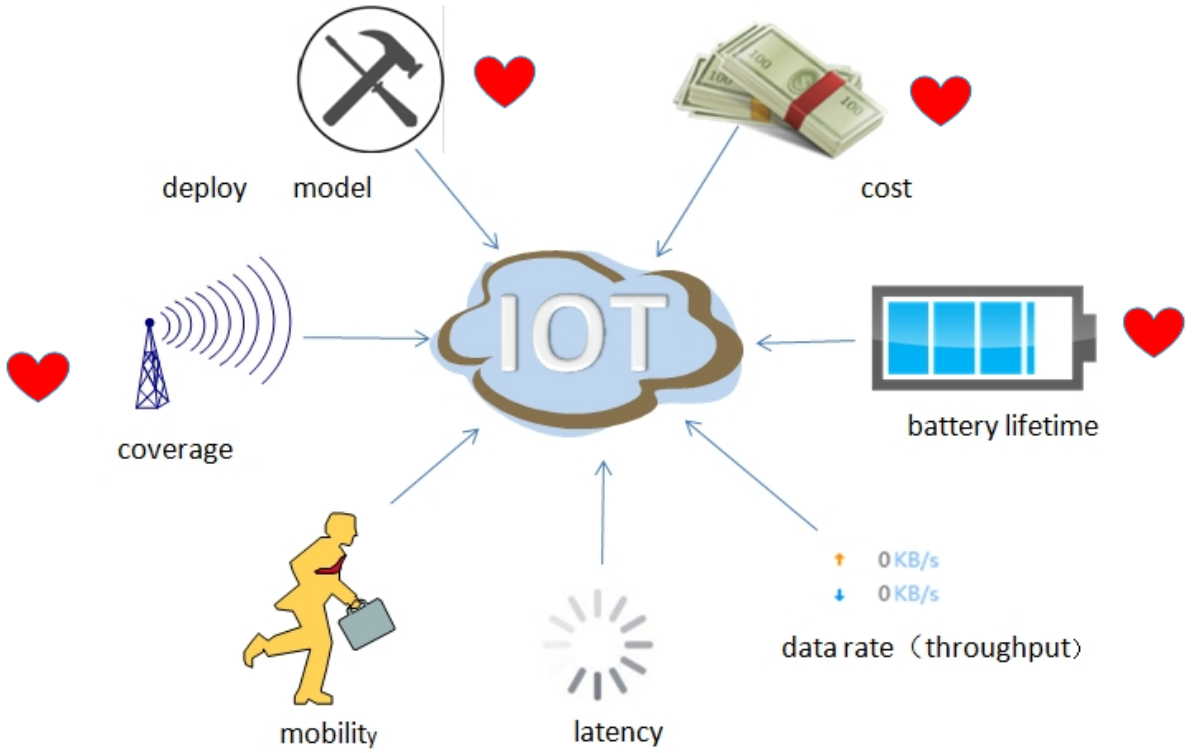
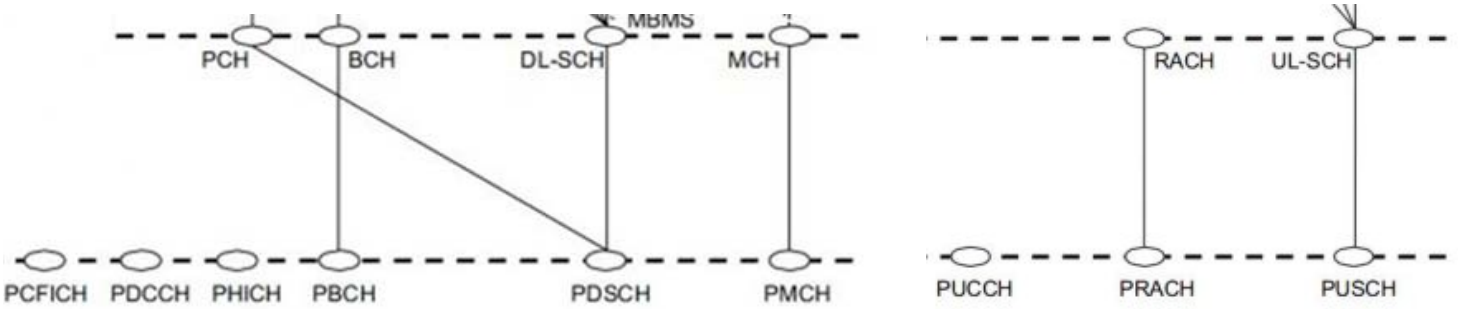
Advantages of NB-IoT

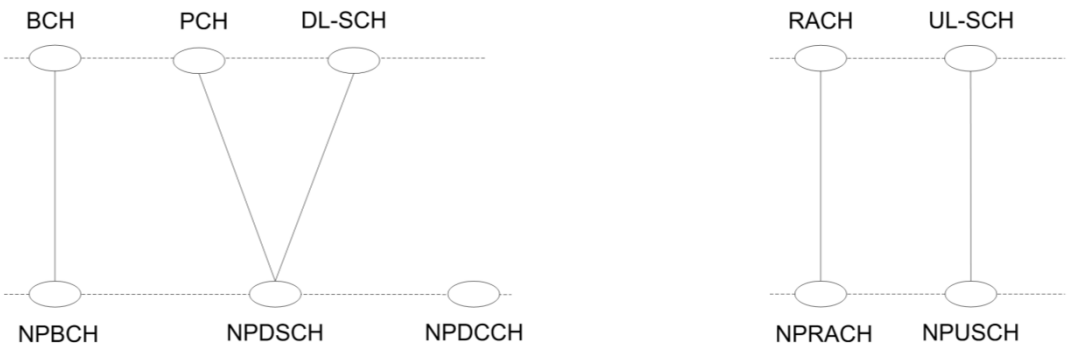


Simplified physical channels

LTE channels

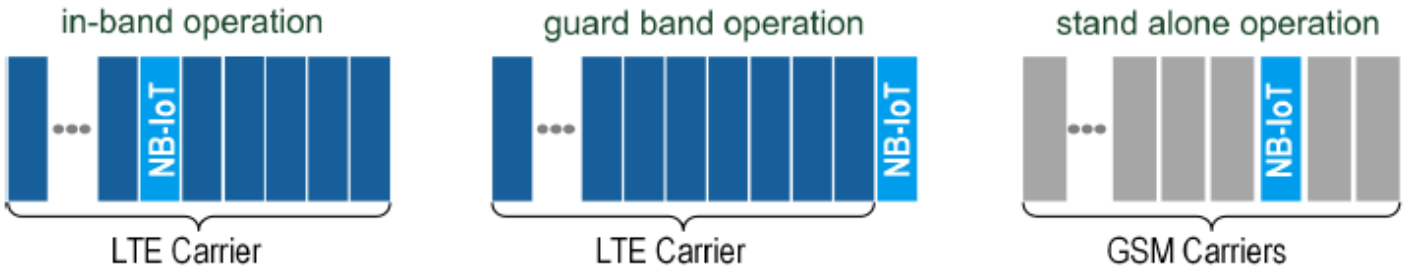


NB-IoT channels



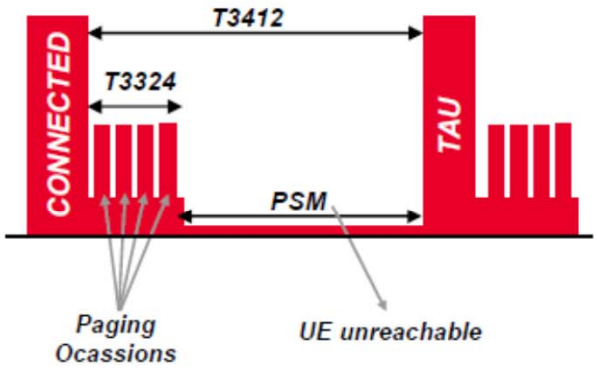
Flexible Network Deployment

- *Standalone operation mode, a* possible scenario is the utilization of currently used GSM frequencies(aka GSM refarming)
- *Guard band operation mode,* utilizing the unused resource blocks within an LTE carrier's guard-band(10% of bandwidth)
- *In-band operation mode:* utilizing resource blocks within an LTE carrier

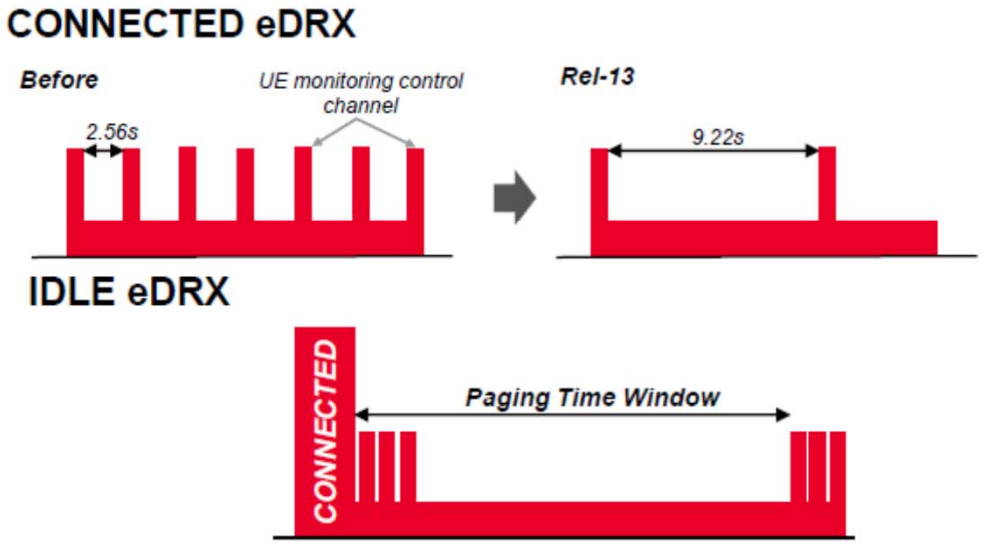


Enhanced Battery life performance

Rel-12 Power Saving Mode (PSM)



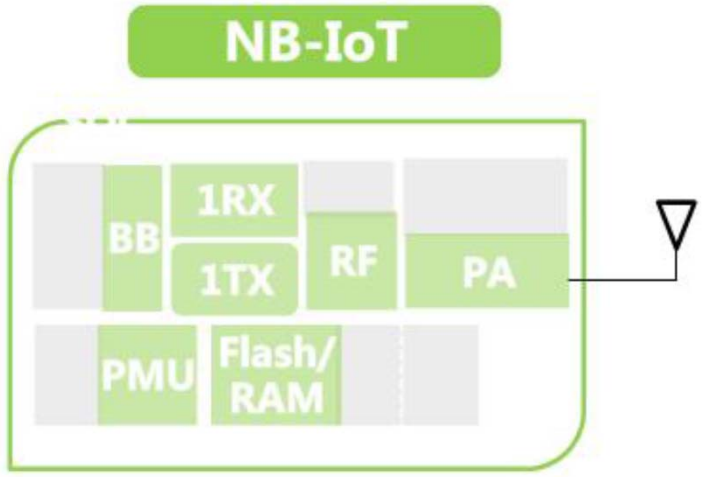
Rel-13 Enhanced DRX (eDRX)



Extremely low cost terminal

- *Goal：* chips<1dollar, module<5dollars, 15% of LTE terminal cost
- *Low Tput + narrow BW + only basic functions → lower complexity*

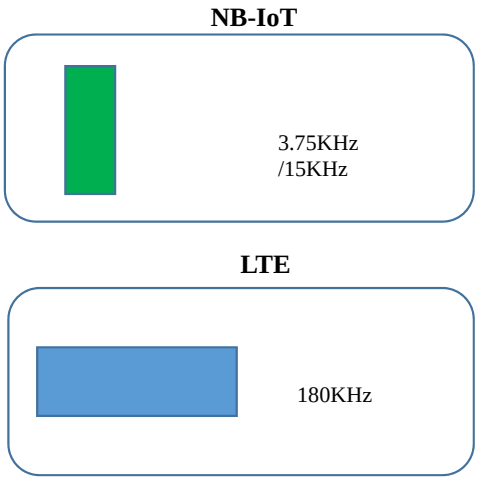
Features	Average overall UE cost reduction gains
Half Duplex FDD (HD-FDD)	7%-10%
Uplink Tx power Reduction	10%-12%
Transmission mode (TM) reduction	2%-10%
Peak Rate reduction	10.5%-21%
Reduced bandwidth (BW) for both RF and baseband for DL and UL.	~39%
Single receive RF	24%-29%

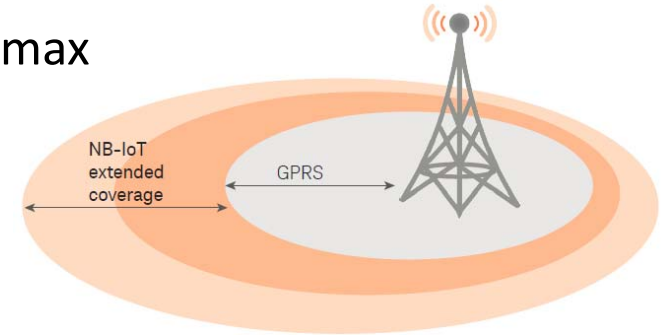


SOC design as a example

Enhanced coverage

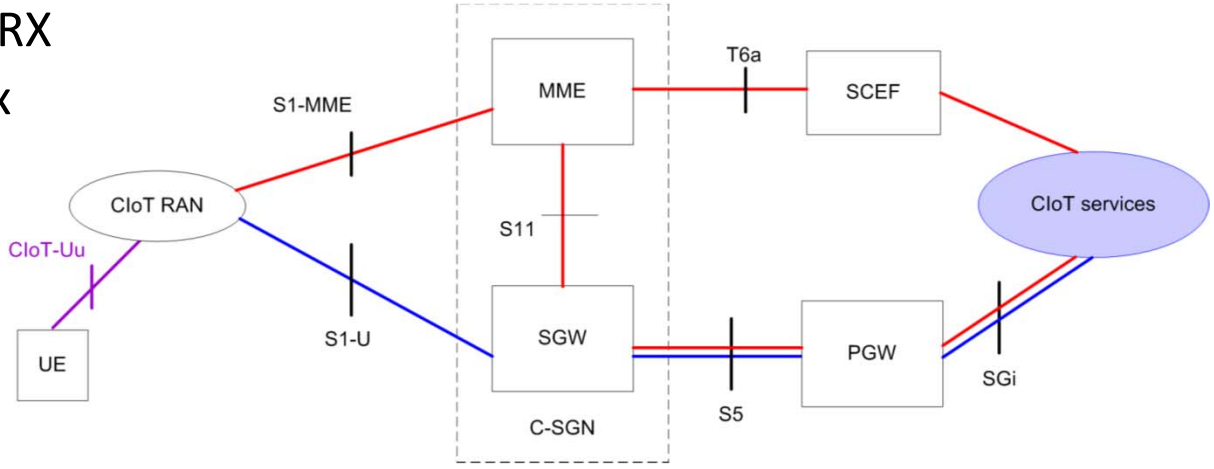
- *Goal:* 20dB Higher than GPRS / LTE, better coverage in basement, underground garage, pipeline, etc.
- *Main Features:*
  - High PSD
  - Repetition transmit on both uplink & downlink
  - Low order modulation
  - Basic MIMO
  - Delay tolerance: 10s max
  - Sub-G





Mass Connection

- *Goal: support 50000+ terminals in one cell (50~100 times of LTE cat3 capacity)*
- *Main features:*
  - *Optimized EPS for small data:* User Plane/ Control Plane EPS optimization
  - *Low spectrum occupied:* 200KHz(1RB)
  - *Sleeping mode:* PSM, eDRX
  - *Delay tolerance*: 10s max
  - Non-IP data transfer



Enhancements of NB-IoT in R14, R15

- *General Goals:*
  - Support More features, provide better performance, maintain current R13 standards' merits
- *R14 Main features:*
  - Positioning supported
  - Multicast supported
  - Mobility enhancement on RRC-Connection & high speed scenario
  - New power class(lower power consumption)
  - NPRACH/Paging on a non-anchor NB-IoT PRB(data only in original R13)
- *R15 Main features:*
  - *TDD, Small Cell, enhanced standalone, lower latency, etc.*
- *NB-IoT is the foundation for 5G-IoT mMTC!*

- Overview of the testing for traditional communication terminals
- Standardization progress of NB-IoT and key technologies
- Analysis of the testing difference between NB-IoT terminals and LTE terminals
  - RF test
  - RRM test
  - Protocol test
  - Battery life test
- Recommendations for the testing and progress of industrial certificate

NB-IoT RF Features

- Downlink difference:
  - Half Duplex
  - No PCFICH, no PHICH,
  - No high order Modulation & Multi-stream MIMO(single antenna)
  - Fixed BW: only 180 KHz
  - Enhanced coverage: repetitions
  - 3 operation modes: Standalone, In-band, guard band
  - Anchor , non-anchor
- Uplink difference:
  - No PUCCH
  - Single-tone, Multi-tone transmission mode
  - 3.75KHz subcarrier

NB-IoT RF Test difference with LTE

- Transmitter
  - Test scope: similar to LTE like *Max/min Power, power dynamic, signal quality, output emission, transmit intermodulation*
  - Test environment: similar to LTE like *normal, HT, LT*
  - Power class: 3(23dBm), 5(20dBm)
  - Subcarrier: 3.75KHz, 15KHz, single-tone, multi-tone
  - Modulation: BPSK, QPSK
- Receiver
  - Test scope and environment : similar to LTE like Reference sensitivity, ACS, Blocking, Intermodulation; *normal, HT, LT*
  - With or without repetition;
  - Fixed Downlink BW

NB-IoT RF Test difference with LTE

- Receiver:
  - Modulation: QPSK, BPSK
- Performance
  - Channels: Only NPDCCH and NPDSCH
  - MIMO: only TM1, TM2
  - In 3 Operation modes
  - Anchor , Non-anchor

NB-IoT RRM Test difference with LTE

- RRM Features：
  - NB-IoT was designed for fixed/low speed scenario in R13
  - Without Inter-RAT
  - Mobility only in idle mode
- RRM Tests:
  - Test scope: similar to LTE like Cell re-selection, re-established, intra-freq, inter-freq, TA, radio-link-monitor
  - Idle mode is similar to LTE
  - Support Normal or Enhanced coverage
  - No Inter-RAT and handover test in R13

NB-IoT Protocol Test difference with LTE

- Protocol Features and Tests:
  - CP EPS optimization: small data via NAS
  - UP EPS optimization: Suspend & Resume
  - Non-IP data transfer
  - Extended coverage
  - Anchor, Non-anchor carrier (multi-carriers)
  - eDRX, PSM
- Protocol Tests:
  - Idle mode, Attach procedure, Data transfer
  - RLM, RRM, RLF
  - Core network Node selection
  - Non-IP Data transfer

NB-IoT Battery Life Test difference with LTE

- About Battery life test of LTE terminal
  - Required by GCF-PC based on GSMA TS.09
  - Required by AT&T based on CTIA Battery life test
- NB-IoT Battery life features:
  - 10 years battery life design
  - New Sleeping mode(PSM, eDRX)
  - Ultra low sleeping current (μA)
- NB-IoT Battery life test:
  - Idle mode
  - Connect mode, UL/DL small data transfer
  - Sleeping mode, PSM, eDRX

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  - CE
  - GCF
  - PTCRB
  - Operator

CE-RED for NB-IoT

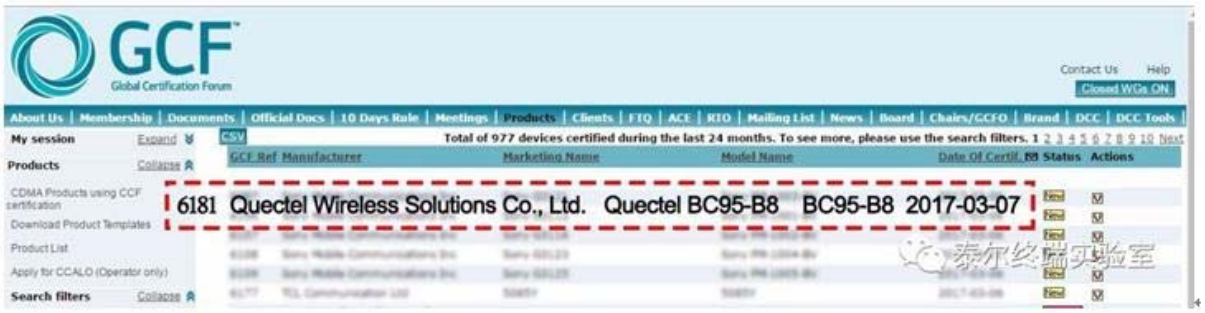
- Draft version is still in discussion
- Similar to LTE terminal requirements
- RF conducted test cases may include following:
  - *Transmitter*
    - Max/min Power
    - ACLR
    - Spurious emission
  - *Receiver*
    - Reference sensitivity
    - ACS
    - In-band/out of band Blocking
    - Intermodulation

GCF conformance test for NB-IoT

- Work Items:
  - WI-259 RF Conformances
  - WI-258 RRM Conformance
  - WI-257 Protocol Conformance
  - WI-266 USIM/USAT conformance
- Band:
  - FDD1,3,5,8,20,28
- Test Cases:
  - RF(30), RRM(12), Protocol(75), USIM(41)

The world’s First NB-IoT Conformance test system validation for GCF Certificate

- 2017-01-18, Korea, GCF CAG#49
  - CTTL-terminal lab
  - StarPoint SP8630, Validation Accepted by GCF



NB-IOT TEST REPORT
No.I17Z60183-GPM01

for

Quectel Wireless Solution Co.,Ltd.

Product Name: BC95-B8

Model Name: BC95-B8

Marketing Name: Quectel BC95-B8

with

Hardware Version: v1.1

Software Version: BC95B8HAR01A03W16

Issued Date: 2017-03-07

Note:The test results in this test report relate only to the devices specified in this report.This report shall not be reproduced except in full without the written approval of CTTL.

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The World’s first NB-IoT Module GCF test report

PTCRB conformance test for NB-IoT

- NB-IoT is in progress in PTCRB/PVG meetings
  - RFT-147 was started on PVG#78 meeting in Shanghai(2017-08)
  - RF, RRM, Protocol Testing for PTCRB conformance
  - Validation is in progress, implementation expected in 2017-11
- eMTC is in higher priority for north America

Operator test for NB-IoT

- Mainly In Europe and Asia, NB-IoT are being invested
  - Strong interest from other operators worldwide
- 20+ MNOs are deploying or committed to deploy NB-IoT:
  - *China Telecom*: Upgrading 300K BS, full nationwide coverage in 2017 (originally 800MHz CDMA refarming);
  - *China Mobile*: Trialing and deploying (originally 900/1800MHz GSM refarming);
  - *China Unicom*: commercial trialing in Shanghai and other cities. Full nation wide coverage in 2018;
  - *Vodafone*: German, Spain, Ireland, Netherlands and other countries.
  - *DT*: German, Holland and other European countries.
  - *KT & LG U+:* Full nationwide coverage, commercial stage.
  - Etisalat, Orange, TIM, T-Mobile…

Operator test for NB-IoT

- Purpose:
  - Assure NB-IoT Modules/Terminal fulfils MNOs own requirements
- Content:
  - Throughput and RF performance
  - OTA
  - Battery life
  - Connectivity
  - Positioning(by GPS/Glonass/Beidou)
  - Others
  - Based on 3GPP, CCSA, TAF and MNOs standards

Thanks!

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