UDC 621.39

RELIABLE INFORMATION TRANSMISSION IN 3GPP STANDARDS FOR IOT SOLUTIONS

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ДОСТОВІРНЕ ПЕРЕДАВАННЯ ІНФОРМАЦІЇ У СТАНДАРТАХ 3GPP ДЛЯ РІШЕНЬ IOT

У роботі розглядаються методи забезпечення надійності передачі інформації в стандартах 3GPP, а саме LTE-M та NB-IoT для рішень IoT. Запропоновано функціонал для досягнення максимальної надійності передачі інформації, відстані та швидкості передачі даних для додатків IoT.

The thesis examines techniques for ensuring information transmission reliability in 3GPP standards, namely, LTE-M and NB-IoT for IoT solutions. The functionality for achieving maximum reliability of information transmission, distance, and data transmission speed for IoT applications is proposed.

The 3rd Generation Partnership Project (**3GPP**) collaborates with telecommunications standards organisations to develop mobile communication technology specifications. Its best-known work is the development and maintenance of [1]:

- GSM and 2G and 2.5G standards, including GPRS and EDGE,
- UMTS and 3G standards, including HSPA and HSPA+,
- LTE and 4G standards, including LTE Advanced and LTE Advanced Pro,
- 5G NR and related 5G standards, including 5G-Advanced.

The next edition of the 3GPP 5G Advanced standard (Release 19) is expected to bring ambient IoT within 6G to increase connectivity from billions of devices to trillions [2]. "*While 5G tracked cars, appliances and shipping containers, 6G will track everything in those cars, appliances and shipping containers*," Steve Statler, CMO of Wiliot [3].

3GPP specifications enable **interoperability** between devices and networks, allowing seamless communication and roaming across various cellular operators and geographical regions. This interoperability ensures that devices can communicate effectively regardless of the network they are connected to, facilitating global deployments and scalability.

The role of 3GPP on the Internet of Things (**IoT**) is significant. It develops standards and specifications that enable connectivity, interoperability, and scalability for IoT devices and applications. 3GPP also plays a crucial role in developing standards for cellular technologies, including **LTE-M** (LTE for Machines) and **NB-IoT** (Narrowband IoT, LPWAN), which are ***optimised for IoT***

***applications*.** These standards provide a *reliable and efficient connectivity solution* for many IoT devices, from sensors and actuators to smart meters and wearables.

LTE-M [4] (also LTE-MTC and LTE Cat M) is a Low-Power Wide-Area Network (LPWAN) technology that allows the reuse of an LTE installed base with extended coverage. LTE-M, which stands for LTE-Machine Type Communication (MTC), was also developed by 3GPP to enable devices and services specifically for IoT applications. LTE-M offers a data rate of 1Mbps for 3GPP Release 13, rising to 4Mbps for Release 14, with greater mobility and voice capability over the network.

Table 1. Techniques for achieving reliable information transmission in wireless communication systems built based on 3GPP standards for IoT systems.

Radio Channel Characteristic	**Description**	**LTE-M**	**NB-IoT**
Channel Coding Type, *C*	Error correction coding is used to improve the reliability of data transmission by taking some channel resources.	Turbo codes, LDPC (Low-Density Parity-Check)	Turbo codes, LDPC (Low-Density Parity-Check)
Multiposition Keying, *M*	The modulation technique is used to encode digital data into the carrier signal.	QPSK, 16/64-QAM	QPSK
Power Control Algorithms, *P*	Algorithms are used to adjust transmit power levels dynamically to optimise signal quality and coverage.	Power control algorithms to optimise coverage and minimise interference in varying network conditions.	Utilises power control algorithms to conserve battery power and extend device battery life in IoT deployments.
Frequency Channel Width, *F*	Width of the frequency channel allocated for communication.	1.4 MHz, 3 MHz, 5 MHz, 10 MHz, or 20 MHz	From 180 kHz to 3 MHz, optimised for low-power, wide-area coverage.
Frequency Band	Frequency range within the electromagnetic spectrum used for wireless communication.	700 MHz, 800 MHz, or 1.8 GHz bands	800 MHz, 900 MHz, or 1.9 GHz
Maximum Data Rate, *V*	Maximum achievable data transmission rate supported by the radio channel.	Up to 1 Mbps, depending on channel bandwidth and network conditions.	Up to 250 kbps, optimised for low-power, low-complexity IoT applications.
Operational Distance, *L*	Maximum distance over which reliable communication can be maintained.	Several kilometres, making it suitable for applications requiring wide-area connectivity.	A few kilometres, optimised for long-range communication in low-power IoT deployments.

NB-IoT [4] (Narrowband IoT) is a radio technology deployed over mobile networks which is especially suited for indoor coverage, low cost, long battery life, and many devices. NB-IoT limits bandwidth to a single narrow band of 200kHz, offering peak downlink speeds of 26kbs in Release 13 of the 3GPP standard. Release 14 will see this increase to 127kbps.

Table 1 outlines the wireless radio channel characteristics and techniques for LTE-M and NB-IoT radio channel specifications for achieving low BER and high information transmission reliability.

Reliable information transmission refers to the ability of a communication system to deliver data accurately and consistently from a sender to a receiver, even in the presence of various impairments and challenges that can degrade the quality of the transmission. It has such characteristics as *accuracy, consistency, robustness, and timeliness*. In a reliable transmission, the information arrives at the receiver with *minimal errors* (low bit error rate, BER) or distortions, ensuring the intended message is *accurately conveyed and interpreted* on the recipient side. Reliable information transmission is usually a *pain point of wireless communication channels* rather than wired ones.

Mathematical functional for minimising BER and maximising distance L and data rate V depend on and proportional to parameters combination set such us coding type C and its rate, multiposition keying M, frequency band F, and transmitter power P:

$$\begin{pmatrix} \min BER \\ \max L \\ \max V \end{pmatrix} \propto \{C, M, F, P\}$$

Calculation of the NB-IoT and LTE-M link budget is defined in the Study on the channel model for frequencies from 0.5 to 100 GHz (3GPP TR 38.901 version 17.1.0 Release 17), ETSI TR 138 901 V17.1.0 [5].

Thus, this work shows that modern 3GPP communication standards and technologies such as LTE-M and NB-IoT have sufficient technical capabilities for building reliable networks to serve IoT traffic and applications. Further research in the scope of this work is supposed to calculate the coverage zones for both technologies based on the link budget and variety of channel parameters following the proposed mathematical functional, as well as other link budget parameters.

References

1. Third Generation Partnership Project Agreement, http://www.3gpp.org
2. Predictions for 2024 – 3GPP and Ambient IoT https://www.electronicsweekly.com
3. Wiliot Cloud and IoT, https://www.wiliot.com.
4. LTE-M vs NB-IoT – A Guide Exploring the Differences between LTE-M and NB-IoT, https://iot.telenor.com/iot-insights/lte-m-vs-nb-iot-guide-differences
5. Study on channel model for frequencies from 0.5 to 100 GHz (3GPP TR 38.901 version 17.1.0 Release 17), ETSI TR 138 901 V17.1.0 (2024-01), https://www.etsi.org