

# REVIEW

## of a dissertation for the acquisition of educational and scientific degree “Doctor”

**Field of higher education** - 5. Technical Sciences,

**Professional direction:** 5.3. Communication and computer equipment

**Doctoral programme:** „Communication networks and systems“

**Author:** M.Sc.Eng. Nikolay Petkov Manchev

**Topic:** “Development and research of a low energy wireless communication platform for the Internet of things”

**Reviewer:** Prof. Emil Ivanov Iontchev, PhD

### 1. Topic and relevance of the dissertation

The concept of the Internet of Things involves connectivity and information exchange among billions of physical objects, integrated into various communication networks through the internet. It finds application in various fields such as: smart cities; healthcare; industry; agriculture; transportation and more. The number of connected objects is continuously increasing, necessitating the creation of new communication networks and alternative standards with low energy consumption. The vast amount of data generated by these objects requires advanced methods for processing, storage, analysis, and information extraction. The need for security and data protection in the exchanged information is also escalating.

In order to find a solution to these problems, in the dissertation, an in-depth study has been done to select an appropriate communication network that provides security and protection of data, the possibility of their storage and analysis, the possibility of easy expansion. Elements of the communication network architecture have been implemented, algorithms for optimization of power consumption of the power source have been developed.

The above considerations lead me to the conclusion that the topic and specific tasks outlined in the dissertation are relevant.

### 2. Review of cited literature

The dissertation is structured with an introduction, four chapters, a conclusion (including scientific-applied and applied contributions), utilized literature, a list of publications, spanning 141 pages with 78 figures and 6 tables. It concludes with five appendices, totaling 62 pages.

For the development of the dissertation, the doctoral student referenced a total of 130 sources, comprising 88 books and articles and 42 online resources. They are all in English. These sources are incorporated into the dissertation and appropriately cited in the presented material. The dissertation's objective is defined based on in-depth research in the first chapter. It is *"To develop and investigate a platform for low-energy wireless communications in the context of the Internet of Things, using low-energy hardware components with sufficient computational capacity, employing open-source software tools or a finalized software product with no possibility of modification"*. Four tasks are outlined for its execution, sequentially solved in the individual chapters of the dissertation.

The critical analyses and research, along with the obtained results, demonstrate that the author possesses a thorough understanding of the problem and can make analytical and critical

interpretations of the literature used. This has enabled the successful completion of the assigned tasks and the achievement of results with significant scientific-applied and applied contributions.

### **3. Research methodology**

The selected research methodology is adequate for the objective and tasks set in the dissertation, incorporating analytical, simulation, and practical methods and approaches outlined in individual chapters. An analytical model has been developed to explore the wireless transmission environment, its characteristics, and its impact on data transmission within the low-energy, wide range LoRaWAN network - in both indoor and outdoor areas, urban and rural environments. The model can assess the influence of various network parameters on the performance of the communication protocol. A methodology for synthesizing an experimental setup and conducting simulation and practical investigations of processes related to data processing, transmission, and reception through the built communication channel based on LoRaWAN protocol. Various evaluation parameters and quality indicators, such as equivalent isotropically radiated power (EIRP), electromagnetic field intensity, spectral and vector characteristics of the signal, signal-to-noise ratio, received signal strength indication (RSSI) etc., were used as criteria for determining the quality of service. A methodology for determining their values using the developed model has been suggested.

The obtained results provide a basis to assert that there is a complete alignment between the chosen research methodology and the set objective and tasks of the dissertation.

### **4. Contributions of the dissertation**

The contributions claimed by the doctoral candidate are scientific-applied and applied. They exhibit the following characteristics: new approaches and methods for research have been proposed, new and modified devices and systems have been developed and algorithms for their control and investigation have been formulated.

#### **Scientific-Applied Contributions:**

1. Established and investigated proven algorithms for message encryption using the low-energy LoRaWAN protocol, ensuring the security and reliability of transmitted data. Proposed is the use of the linearly changing frequency (Chirp) method, contributing to enhanced data security by utilizing a narrower frequency band employed in wireless communications.

2. Proposed an approach for determining the coverage efficiency in low-energy wireless networks in urban environments, based on specific indicators categorized into three groups: reliability, latency and credibility.

3. Proposed an algorithm presenting a practical approach for implementing an RF gateway and sequence for conducting experimental studies in both indoor and outdoor zones.

4. Explored the impact of the signal-to-noise ratio on the quality of wireless coverage in a specific outdoor area. Conducted a comparative assessment between practically obtained results and simulation results in the same radio coverage area, focusing on parameters such as end device characteristics, RF gateway parameters, coaxial line attenuation, etc.

#### **Applied Contributions:**

1. Practically implemented a communication system end device using the LoRaWAN low-energy protocol for wireless communication with remote control of electrical contacts with feedback on the state of the contacts.

2. Practically implemented a solar-powered end device tested over a period of 3 years under various meteorological conditions. Its cost-effectiveness was achieved through a newly created software library for optimizing end device consumption during data non-transmission periods.

3. Proposed and implemented the capability for VPN connectivity of multiple routers with the implemented low-energy communication system using the LoRaWAN protocol, aiming to

store data at a specific location. In such a case, the need to purchase additional hardware for data storage is eliminated, providing opportunities for data processing, analysis, visualization, and research from a centralized point.

I accept the formulated contributions by the doctoral candidate. I believe that they accurately reflect the achievements of the candidate resulting from the conducted research and will find practical applications.

## **5. Publications and citations of publications on the dissertation**

In connection with the dissertation work, six scientific publications are presented. One of them is independent, while the remaining five are co-authored. There is a publication in English in the Journal of Engineering Science and Technology Review, with an SJR indicator of 0.189, indexed in Scopus. The others are reports from scientific conferences, listed in the national reference list of contemporary Bulgarian scientific publications with peer review – three of them were presented at the international scientific conference UNITECH in 2020, 2021, and 2022. Two of them at the national scientific conference TechCo in 2021 and 2022. The publications present the conducted research and outline the main conclusions of the dissertation work. There is no information about citations of the publications included in the dissertation.

## **6. Authorship of the obtained results**

I believe that the achieved results are the work of the doctoral candidate under the scientific and methodological guidance of his supervisors. His personal involvement in the development and implementation of experimental studies is undoubtedly evident. Proof of this is the candidate's publications, as well as the information from the attached report on meeting the minimum national requirements and the requirements of the Regulations for acquiring the educational and scientific degree of "Doctor" at the Technical University of Gabrovo. Mag. Eng. Manchev, concerning the points in Section A - 50 points and Section G - 30 points, has correspondingly earned 50 points for Section A and 54.98 points for Section G. The PhD student has also fulfilled the minimum requirements of TU - Gabrovo for the number of scientific publications to obtain the scientific degree "Doctor". According to the Scopus database report, the doctoral candidate has 13 citations of articles related to the dissertation topic, although not included in the dissertation itself. The doctoral candidate has also participated in two scientific research projects.

## **7. Abstract and author's reference**

The abstract of the dissertation is 34 pages long and is formatted in accordance with the requirements of the Regulations on the conditions and procedure for acquiring scientific degrees at TU-Gabrovo. It accurately presents the content, essential aspects of the research, achieved theoretical and practical results, and the defined scientific-applied, and applied contributions found in the full text of the dissertation. A list of publications on the dissertation's topic is also provided, along with an English language summary.

## **8. Opinions, recommendations and remarks on the dissertation**

The PhD student has taken into account the comments and recommendations provided by me during the preliminary discussion of the dissertation. However, there are still some editorial oversights, such as:

- Two different names are used for the same parameter SF;
- The contributions are not documented in a separate section but are included in the conclusion;
- Specific information, in the form of page numbers or figure numbering indicating where they should be located and correctly assessed, is not added to the presented

contributions.

The dissertation's topic is in a prospective scientific field and my recommendation to M.Sc.Eng. Nikolay Manchev is to continue his scientific and applied work in this direction.

## **9. Conclusion**

I believe that the presented dissertation meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria. The achieved results give me grounds to give a **positive evaluation** of the dissertation and to propose to the esteemed Scientific Jury to **award the educational and scientific degree of 'Doctor' to M.Sc.Eng. Nikolay Petkov Manchev** in the field of higher education 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering, Doctoral program “Communication Networks and Systems”.

Date: 31.01.2024

Reviewer:.../signature/.....  
/Prof. Emil Iontchev, PhD/