

OPINION

for the acquisition of ESD "Doctor"

in the field of higher education **5. Technical Sciences**

in professional field **5.3. Communication and computer technology**

in the scientific specialty – **Communication networks and systems**

Author: Eng. Nikolay Petkov Manchev

Dissertation topic: Development and research of a low energy wireless communication platform for the Internet of Things

Member of the scientific jury: Prof. Eng. Teodor Bozhidarov Iliev, PhD

1. Topic and relevance of the dissertation work

The topic of the dissertation is in the field of low-power wireless communications (LoRa and LoRaWAN), in the context of the Internet of Things (IoT), as well as applications with large geographical coverage, low but reliable data transmission rates and long life of battery power sources. The storage of data coming from different Internet networks connected to the transceiver radio frequency gateways, as well as the visualization of the data, both in real time and in a certain time range, is an important task related to the efficient use of the frequency spectrum and the quality of service (QoS).

The chosen scientific area for research in the dissertation - developed and researched a platform for low-power wireless communications in the context of the Internet of Things, using low-power hardware components with sufficiently large computing capacity, which use open source software tools or with a final software product with impossibility for change is undeniably relevant, both globally and for our country.

All this confirms the perspective and relevance of the chosen area for research in the dissertation work.

2. Research methodology

Eng. Manchev has formulated the following general goal: *to develop and research a platform for low-energy wireless communications in the context of the Internet of Things, using low-energy hardware components with sufficiently large computing capacity, which use open-source or finite-source software tools finished software product with no possibility of modification.*

Appropriate instrumentation have been used in the simulation studies. The chosen methodology for analytical and simulation studies is adequate. The methods used for computer modeling and analysis in the environment of Radio Mobile and The Thinks Network Mapper, has allowed the PhD student to realize estimated values of the network capacity and to evaluate the performance of the platform for low-energy communications. The results of the research are presented in graphic and tabular form, with the corresponding analysis and conclusions.

3. Contributions to the PhD thesis

My personal opinion is that the contributions of the dissertation work have a scientific and applied contributions with significance and usefulness in the development of new low-energy communication protocols and improvement of the coding of the communication channel. In my opinion, they can be summarized as follows:

Scientific and applied contributions:

1. Algorithms for encryption of messages using the low-energy LoRaWAN protocol have been established and studied, which ensure the security and reliability of transmitted data. The use of the linearly varying frequency (Chirp) method has been proposed, which contributes to greater data security by using a narrower frequency band used in wireless communications;
2. An approach is proposed to determine the coverage efficiency of low-energy wireless networks in an urban environment, based on certain indicators, divided into three groups - reliability, delay and credibility;
3. An algorithm is proposed, presenting a practical approach for the implementation of an RF gateway and a sequence in conducting the experimental studies in a closed and open area;
4. The influence of the signal-to-noise ratio on the quality of wireless coverage in a specific open area is investigated. A comparative assessment was made between the practically obtained results and the simulation results in the same radio coverage area, as the object of research are the parameters of the final device, the RF gateway, the attenuation in the coaxial line, etc..

Applied contributions:

1. A terminal device of a communication system has been practically realized using the low-energy LoRaWAN protocol for wireless communications with remote control of electrical contacts with contact state feedback;
2. Realized solar powered end device that has been tested over a period of 3 years under different weather conditions. Its economy is achieved through the newly created software library for optimization of end device consumption during non-transmission of data;
3. The possibility of VPN connectivity of several routers with the implemented low-energy communication system using the LoRaWAN protocol has been proposed and implemented, in order to store the data in a certain place. In such a case, the need to purchase additional hardware to save the data is eliminated, while also providing opportunities for processing, analyzing, visualizing and researching the data from one centralized point.

4. Publications and citations of publications on the dissertation work

The main results obtained during the development of the PhD thesis have been published in 6 scientific papers. Three of the papers were presented at the International Scientific Conference "Unitech", two at the national conference "TechCo" and one at the peer-reviewed international journal "JESTR", one of them being independent, and the other five being prepared in co-authorship with the scientific supervisor.

The publications were made during the period 2019–2022 and contain the most essential moments of the research conducted by Eng. Nikolay Manchev and I believe that they gave the scientific community the opportunity to familiarize themselves with his dissertation work.

I accept the participation of the doctoral student in all co-authored publications as equal.

There is no data on citations of the publications presented in the dissertation.

5. Authorship of the obtained results

The one independent publication of Eng. Manchev, as well as the one publication in which he is in first place, are proof of his leading participation in the conduct of scholarly research on his dissertation work. The presented scientific ideas and approaches presented and defended in various scientific forums are an assessment of the doctoral student's personal contribution. It follows from all this that the materials presented in the dissertation work are the independent development of the doctoral student.

6. Critical comments and recommendations

The most of the assessment of the PhD student's research and creative work has been consistently set out above in the opinion. Here I will focus only on some remarks and recommendations for the future work of Eng. Nikolay Petkov Manchev:

1. There are some stylistic, terminological and some editorial errors that do not determine the quality of the work;
2. The reference section is not arranged according to accepted requirement;
3. I recommend the PhD student to continue his research work in this field and focus more on publishing scientific material in prestigious journals in Bulgaria and abroad and on scientific conferences indexed in Scopus and WoS.

The established remarks and recommendations do not belittle the work of the doctoral student on scientific topics and the achievements of the dissertation.

7. Conclusion

My personal opinion is that the presented PhD thesis **meets** the requirements of the Law for the Development of Academic Staff in the Republic of Bulgaria. The achieved results give me grounds to propose to **obtain** the educational and scientific degree "Doctor" from Eng. **Eng. Nikolay Petkov Manchev** in:

in the field of higher education 5. Technical Sciences

in professional field 5.3. Communication and computer technology

in the scientific specialty – Communication networks and systems

January 31, 2024

Member of the scientific jury: /signature/

/Prof. Teodor Iilev, PhD/