REVIEW

on a dissertation for obtaining the Degree Doctor of Philosophy

Author Eng. Marieta Metodieva Haka
Dissertation Title: Approaches to increasing the security of IoT networks

Member of the scientific jury: Prof. Teodor Iliev, PhD, University of Ruse "Angel Kanchev"

1. Relevance of the problem addressed in the dissertation in scientific and applied scientific aspects

The dissertation submitted for review addresses issues related to the integration of Internet of Things (IoT) applications with the aim of developing approaches to enhance security in IoT networks implemented with ZigBee. Traditional secure communication schemes in IoT networks are based on basic mathematical operations – doubling, scalar multiplication based on doubling, bilinear doubling, exponential operation, scalar multiplication over an elliptic curve, or point multiplication. These traditional approaches are expensive and require high computing power and overload the bandwidth, which affects efficiency. Due to the intensive nature of the costs and high resource requirements, traditional approaches are not suitable for IoT devices with limited resources.

The chosen scientific field of research in the dissertation – developing approaches to improving security in IoT networks implemented with ZigBee – is undoubtedly relevant both globally and for our country. This is evidenced by the annual international scientific conferences and symposiums on this topic, such as IEEE INFOCOM, International Network Conference, International Conference on Wireless Communications, etc. Every year, dozens of publications in the field of Industry 4.0 and 5G mobile networks appear in renowned international scientific journals from the IEEE series: Communications Magazine, Transactions on Wireless Communications, in the Journal of Sensors, Journal of Wireless and Mobile Systems, etc. In recent years, a number of significant scientific monographs have been published in the field of the Internet of Things and fifth-generation mobile networks, such as: P. Chatterjee, R. S. Bhadoria, Y. Pathak, "5G and Beyond the Future of IoT"; S. Velliangiri, M. Gunasekaran, P. Karthikeyan "Secure Communication for 5G and IoT Networks"; A. Khang, V. Abdullayev, V. Hahanov, V. Shah "Advanced IoT Technologies and Applications in the Industry 4.0 Digital Economy." All this confirms the promising and topical nature of the chosen field of research in the dissertation.

2. Level of knowledge of the problem and creative assessment of the material

The doctoral student demonstrates in-depth knowledge of the state of the art on the topic of the dissertation, expressed both through the scope and depth of interpretation of the sources used in the literature review. The list of references includes 164 sources, of which 1 is in Cyrillic and 163 are in Latin.

All cited publications from articles in journals and collections of reports sufficiently reflect the global level achieved in the field of broadband communication

systems and, more specifically, research into methods and means of improving security in communications in an IoT network implemented with ZigBee technology.

3. Compliance of the chosen research methodology with the stated aim and objectives of the dissertation

Based on the results of the study of the problem and taking into account its specificity, the methodology, mathematical apparatus, and other research tools that I consider appropriate for solving the tasks set and achieving the goal of the dissertation have been determined. Therefore, there is full correspondence between the set goal and the results achieved in the dissertation.

4. General analytical characteristics of the dissertation

The dissertation has a total length of 163 pages and is structured in three chapters, a conclusion, contributions, a list of references, a list of publications on the topic of the dissertation, a list of citations of publications, a list of figures, a list of tables, and three appendices. It contains 126 figures (3 figures in the first chapter, 10 figures in the second chapter, 77 figures in the third chapter, and 36 figures in the appendices), 4 tables, and 6 mathematical expressions.

Chapter I, "Analysis of Approaches for Improving the Security of IoT Networks," is devoted to the analysis of various approaches for ensuring data storage security and achieving integrity and confidentiality in communications between nodes in IoT networks. At the end of the chapter, the main objective of the dissertation is defined and the necessary tasks to be solved are formulated.

Chapter II, "Security in IoT Networks Based on ZigBee Technology," presents the structure and functionality of existing approaches to security management in key exchange in ZigBee technology. It also defines the necessary functionalities for a simulator that provides the ability to study security in ZigBee networks for IoT.

Chapter III, "Experimental Research and Results," is devoted to presenting the results of research related to security in ZigBee networks, both in a simulation and in a real environment.

5. Assessment of the contributions in the dissertation and their significance

I accept the results achieved in the dissertation of doctoral student Eng. Haka, and I define the contributions presented as scientific, scientific-applied, and applied.

Scientific contributions:

- ✓ An analytical expression for calculating the security level in ZigBee networks and a scale for determining the degrees of security level have been proposed.
- ✓ An adaptive approach for improving the security level in ZigBee networks is proposed.

Scientific and applied contributions:

- ✓ A system of indicators has been defined for evaluating simulation products for security research in ZigBee networks.

Applied contributions:

- ✓ A simulator has been developed to study security processes in ZigBee networks.

- ✓ A prototype ZigBee network for IoT has been developed, in which security has been experimentally studied and the proposed scale for determining security levels has been applied.

6. Assessment of the degree of personal involvement of the doctoral student in the contributions

In all five scientific publications, PhD student Marieta Metodieva Haka is listed first, which is proof of her leading role in conducting scientific research. The scientific ideas and approaches presented and defended at scientific forums are an assessment of the PhD student's personal contribution. Eng. Haka has demonstrated her ability to develop and solve scientific problems, to write competently and in a scientific style, to express herself accurately and to justify her choices logically. It follows from all this that the materials presented in the dissertation are the doctoral student's own work.

The dissertation is a comprehensive and original scientific work.

7. Assessment of publications related to the dissertation

Attached to the documents are five publications by the doctoral student – one article in the scientific journal "The Journal of CIEES", one in an international scientific conference abroad and three in scientific conferences in the country. All publications were made in the period 2024–2025, with the doctoral student listed as the first author in all of them. I consider the doctoral student's participation in all publications to be equal.

Four of the publications are referenced in the Scopus database.

There is no data on the impact factor, but there is data on a total of six citations of one of the publications, four of which are self-citations.

I consider that these publications contain the main contributions claimed in the dissertation.

8. Direct economic impact achieved from the results of the dissertation

I have not been provided with information about the implementation or use of the results obtained from the dissertation, economic effect, etc.

9. Recommendations for future use of the contributions

The results obtained in the research conducted in the dissertation can be considered useful recommendations for the modernization or design of 5G mobile technologies, as well as for networks based on IoT wireless technologies, and can lead to increased network security.

10. Assessment of the abstract's compliance with the requirements for its preparation, as well as its adequacy in reflecting the main provisions and scientific contributions of the dissertation

The abstract presented is 36 pages long and includes 47 figures, 7 mathematical expressions, and 4 tables. The numbering of the formulas, figures, and tables corresponds to that in the dissertation. It is structured according to the logic and sequence of the dissertation and I believe that it fully reflects the author's research and provides a comprehensive overview of the results obtained.

11. Critical remarks on the dissertation

In principle, I have no comments on the substance of the dissertation, but the following recommendations and comments can be made regarding the layout of the explanatory note:

- ✓ There are some stylistic, terminological, and editorial errors, which do not affect the quality of the work.
- ✓ In the list of references used in the dissertation, Internet sources are not cited in accordance with generally accepted rules.
- ✓ It is striking that over 99% of the literature used is in English. It would be good to consider scientific publications by teams or scientists from Bulgaria and other countries working on similar scientific problems.

The recommendations and comments made do not detract from the work of the doctoral student, and I hope that work on the scientific topic will continue because it is interesting and relevant.

12. Conclusion

The topic of the dissertation is relevant and interesting. The work has sufficient scope and depth of research. Scientific and applied results of significance for theory and practice in communication and computer engineering have been obtained.

The results of the research conducted are sufficiently significant for the procedure for awarding the educational and scientific degree of "doctor." Five publications have been made on the dissertation by Eng. Marieta Haka. The scientific community has been given the opportunity to familiarize itself with the research conducted and the results obtained.

The doctoral student has completed her doctoral studies and clearly demonstrates her ability to conduct independent scientific work.

I believe that the presented dissertation meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria. In view of the above, I propose that the distinguished members of the scientific jury award **Eng. Marieta Metodieva Haka** the educational and scientific degree of "**Doctor**" in the professional field 5.3. Communication and Computer Engineering, and doctoral program "Computer Systems, Complexes, and Networks."

08 January 2026

Reviewer: .....
(Prof. Teodor Iliev, PhD)