REVIEW

under the procedure for acquisition of the educational and scientific degree "Doctor

by candidate Tsvetan Krasimirov Tsokov

of the PhD Thesis entitled: "IoT platforms and protocols",

In the Scientific field: **4. Natural Sciences, Mathematics and Informatics**

Professional field: **4.6. Informatics and Computer Sciences**

The statement report has been prepared by: prof. Milen Petrov, FMI, SU, Department of software technologies as a member of the scientific jury for the defense of this PhD thesis according to Order № № 322 / 19.09.2024 -of the Director of IMI-BAN.

1. **General characteristics of the dissertation thesis and the presented materials**

As a member of the scientific jury, I received the necessary documents in electronic form, including: 1. Application; 2. Curriculum vitae (CV); 3. Order-Enrollment; 4. Protocols-Exams; 5. Order-Disbursement; 6. Order-Discussion Primary unit; 7. Protocol-Discussion Primary unit; 8. List of publications on the dissertation; 9. Copies of publications; 10. Dissertation; 11. Reference contributions in the dissertation; 12. Abstract.

The documents comply with the regulatory requirements of both the RASRB and the Regulations for the Implementation of the RSARB of the Council of Ministers of the Republic of Bulgaria and that of the BAS and IMI-BAS, which gives me grounds to review this dissertation work.

2. **Short CV and personal impressions of the candidate**

The candidate graduated from the "Bachelor's College" at the Technical University - Sofia, with a Bachelor's degree in "Computer Systems and Technologies" in 2015.

In 2017 graduated from the master's program "Distributed Systems and Mobile Technologies" at the FMI of the SU "St. Kliment Ohridski".

He was enrolled as a doctoral student with a 4-year term of study, starting from January 1, 2020. by order number 451/17.12.2019 and dismissed with the right of defense by order number 6 / 2.01.2024. of the director of IMI-BAN.

3. General characteristics of the dissertation work and the presented materials

My submitted peer review dissertation is in English and consists of 70 pages. It is structured as follows: table of contents (2 pages), list of figures and tables (2 pages), abstract (1 page). The names of the following are given in English as they are in the thesis:

In the "Introduction" part - pages 1 to 6, a brief introduction to the creation, basic definitions and structure of the dissertation is given.

In Chapter 1 "Overview of Edge/Fog distributed systems" - (from 7 to 10, 4 pages in total). The field of emerging Edge/Fog distributed computing systems is reviewed.

Chapter 2, entitled "EcoLogic IoT application" (pages 11 to 23) covers the design, development and research of the EcoLogic IoT application.

In chapter 3 "Comparative analysis of resource allocation in Edge/Fog platforms" (pages 24 - 28) a literary analysis of scientific sources is given, compared with the development in the dissertation.

In Chapter 4 "Mixed-Integer Linear Programming (MILP) model" (29-43) - a new optimization model for the delivery of microservices containers in Cloud/Fog infrastructure composed of mobile and constrained nodes with ARM architecture is considered in a network-independent way .

Chapter 5 “Results and discussion” (44-50) provides an analysis of the results comparing the times of two usage examples.

Chapter 6 "Conclusion" (51-52) - a conclusion is made and guidelines for future development are given.

Acknowledgments follow (1 page), Appendix A - list of publicly available repositories related to the dissertation work (1 page), Appendix C - list of abbreviations (1 page), Appendix C - list of terms (1 page), Contributions (2 p.), Approbation of the results (1 p.), presentations (1 p.) -, bibliography (p. 61 to 70)

The literary sources are 86 in number and show that the field is very current, as well as that the candidate knows the achievements in the field of the Internet of Things.

The aim of the dissertation work is to provide a solution for optimal resource management in modern Cloud/Edge/Nebula platforms, enabling the execution of complex IoT applications running in real time on a cluster of devices with limited computing resources moving in space. It helps to better support scenarios like connected vehicles, space computing, augmented/virtual reality, real-time audio/video streaming, etc. The solution is implemented in the most popular Cloud/Edge/Nebula platform in practice called Kubernetes and validated with a complex IoT application in a real practical environment. The present work explores in depth the concept of resource management in modern platforms, proposes new approaches, and tools to complement, upgrade, modernize and create new premises, principles, methods and models for knowledge acquisition.

4. Content analysis of the scientific and applied achievements of the candidate, contained in the presented PhD thesis and the publications to it, included in the procedure

The cited sources are 86 in number and are mainly from the last two decades.

I accept the contributions formulated by the applicant, recommending that the applicant formulate the contributions more precisely. I would summarize and classify the contributions as follows:

1) The MILP model has been improved, through different approaches: with a new delay matrix, a new node availability variable in a given region, and an objective function to minimize the movement of replicas between mobile nodes (MIN_RM); The capacity and demand vectors are replaced by direct variables (Bn, Cn, En, bp, cp, ep) used in the constraints and objective functions of the described MILP model and by modifying the steps to support dynamic continuous optimization of replicas with rolling nodes (scientific and applied contribution);

2) The MILP optimization model is implemented in a real Cloud/Edge/Nebula platform (Kubernetes) and published in public code-applied repositories (scientific-applied contribution);

3) Design, implementation and validation of a real practical IoT application (named Ecologic), for vehicle carbon emission monitoring and control, suitable for operation in smart city scenarios (applied).

5. Approbation of the results

For the competition, 2 publications are presented, which are in English. Both presented publications have two co-authors - the doctoral student and his supervisor.

[1] T. Tsokov and H. Kostadinov, “System for monitoring and control of vehicle’s carbon emissions using embedded hardwares and cloud applications”, in Service-Oriented Computing - ICSOC 2020 Workshops, H. Hacid, F. Outay, H.-y. Paik, et al., Eds., Cham: Springer International Publishing, 2021, pp. 564-577, isbn: 978-3-030-76352-7. doi: https://doi.org/10.1007/978-3-030-76352-7_50. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-030-76352-7_50; SJR (Q2).

[2] T. Tsokov and H. Kostadinov, “Dynamic network-aware container allocation in Cloud/Fog computing with mobile nodes”, Internet of Things, p. 101 211, 2024, issn: 2542-6605. doi: https://doi.org/10.1016/j.iot.2024.101211. [Online]. Available:

https://www.sciencedirect.com/science/article/pii/S2542660524001525; Impact factor (Q1).

One publication [1] is in Springer (Lecture Notes in Computer Science), and indexed in SCOPUS with SJR (2021): 0.407, Q2. The second publication [2] is in the journal "Internet of Things", indexed in SCOPUS and in WoS, respectively with SJR (2023): 1,642, Q1 and IF(2023): 6, Q1.

Both articles are in English, with the PhD student as the first co-author, and I have no doubt about the lead role of the PhD student in writing the articles.

The results were also reported at three scientific forums - two in Bulgaria and one abroad.

Of the scientific publications presented, they cover the minimum national requirements for the ONS "Doctor".

There is no proven plagiarism in the submitted dissertation and scientific works under this procedure.

6. Qualities of the abstract

The abstract is 34 pages long, and is prepared in Bulgarian and English. It corresponds to the results and content of the dissertation and is quite detailed.

7. Critical notes and recommendations

The dissertation is well laid out, with the following observations: 1) more could be desired in terms of volume, in view of the multitude of publications in the field, an analysis of the current state could be more extensive. Chapter 1 is too short - only 4 pages, it could be expanded or merged as a subsection of the next chapter. 2) A separate section with conclusions is also missing, as well as the contribution/contributions to each of the chapters; 3) the numbering of the dissertation - at the beginning it starts with pages 1-3, and then starts again with page 1. In such a case, it is recommended, if the original text is not in the volume of the dissertation, to use a separate numbering (for example, with Roman numerals) , so that there is no ambiguity when referencing parts of the dissertation; 4) in chapter 5 (p. 48) there is a sub-chapter 5.1, but no 5.2, in which case it is pointless to have sub-chapters. The same applies to chapter 6 - page 51; 5) the chapters lack a section for approval of the results of the chapter.

Contributions are not summarized and categorized according to their type - scientific, scientific-applied and applied.

It could be added to the curriculum vitae, in addition to English and Bulgarian, as well as being much more detailed, including the scientific achievements of the candidate. for example, publications, participation in scientific conferences, doctoral seminars, presentations, participation in scientific projects - if any.
I have no questions for the candidate.

Despite the remarks made, they do not reduce the contributions and the work done in terms of quality and quantity in substance, but are intended to serve to further improve the candidate's work.

8. Data and personal impressions about the candidate

I have no direct observations of the candidate's work on the dissertation, prior to this procedure and beyond the materials provided to me.

9. Conclusion

Having become acquainted with the PhD thesis presented in the procedure and the accompanying scientific papers and on the basis of the analysis of their importance and the scientific and applied contributions contained therein, **I confirm** that the presented PhD thesis and the scientific publications to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of the Act on Development of the Academic Staff in the Republic of Bulgaria, the Rules for its Implementation and the corresponding Rules at the IMI-BAN for acquisition by the candidate of educational and scientific degree "Doctor" in the Scientific field **4. Natural Sciences, Mathematics and Informatics** Professional field **4.6. Informatics and Computer Sciences** In particular, the candidate meets the minimal national requirements in the professional field and no plagiarism has been detected in the scientific papers submitted for the competition.

Based on the above, **I strongly recommend** the scientific jury to award **Tsvetan Krasimirov Tsokov**, the educational and scientific degree "Doctor" in the Scientific field **4. Natural Sciences, Mathematics and Informatics** Professional field **4.6. Informatics and Computer Sciences**.

Date: 25.10.2024 Signature: .....

/prof. Milen Petrov/