

R E P O R T

by Assoc. Prof. Dr. Maya Georgieva Bozhilova

Bulgarian Defence Institute "Professor Tsvetan Lazarov"

on a Thesis for awarding the educational and scientific degree 'Doctor'

Field of higher education 4. Natural Sciences, Mathematics, and Informatics

Professional field: 4.6. Informatics and Computer Science

Doctoral program: "Informatics"

Title: **"Internet of things platforms and protocols"**

Author: **Tsvetan Krasimirov Tsokov**

According to Order No. 322 dated September 19, 2024, issued by the Director of the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences (BAS), I have been appointed as an external member of the Scientific Panel for the defence of the Thesis. This report has been prepared in accordance with the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria.

From the documents and scientific papers provided to me electronically for the procedure, I have confirmed that Tsvetan Krasimirov Tsokov meets the requirements for awarding the educational and scientific degree 'Doctor,' in accordance with the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its Implementation, and the Rules for the conditions and procedures for acquiring academic degrees and occupying academic positions at Bulgarian Academy of Sciences (BAS) and the Institute of Mathematics and Informatics at BAS (IMI-BAS), as well as that no plagiarism, proven through the legally established procedure, has been found in the scientific papers.

1. General characteristics of the Thesis

The presented Thesis is written in English and consists of 76 pages. Its structure includes a table of contents, an introduction, six chapters, acknowledgments, three appendices, reference for scientific contributions, list of publications related to the dissertation, list of presented talks at scientific forums, and bibliography with 85 sources.

This structure meets the generally accepted requirements for awarding the educational and scientific degree 'Doctor'. The Thesis is of a scientific and applied nature. The bibliography shows that the doctoral candidate is well acquainted with the state of the art in the field in which he is working.

2. Biographical data of the candidate

Tsvetan Krasimirov Tsokov obtained a Bachelor's degree in 2015 from the Technical University of Sofia, specialising in "Computer Systems and Technologies." In 2017, he obtained a Master's degree from the Faculty of Mathematics and Informatics at Sofia University "St. Kliment Ohridski," in the Master's program "Distributed Systems and Mobile Technologies". Since January 1, 2020, he has been enrolled as a part-time doctoral student in the doctoral program "Informatics", in the section "Mathematical Foundations of Informatics" at IMI – BAS. By Order No. 6 dated January 2, 2024, from the Director of IMI–BAS, he was approved for defence.

Since 2013, Tsvetan Tsokov has been a Senior Software Developer at SAP Labs Bulgaria.

3. Major scientific and scientific-applied achievements

The objective achieved in the Thesis is to provide a solution for optimal management of computational and network resources in modern Cloud/Edge/Fog platforms, enabling the execution of complex real-time IoT applications on a cluster of devices with limited computational resources that are dynamically changing their location.

The first chapter reviews Edge/Fog computing platforms. It addresses the main challenges related to supporting new real-time application scenarios, identifying key characteristics and parameters of the platforms necessary to solve these challenges.

The second chapter is dedicated to the description of the IoT application EcoLogic. The functions of EcoLogic are related to monitoring and controlling carbon emissions from vehicles in smart city scenarios. The application is used as a real-world system to evaluate the resource planning platform in dynamic Cloud/Edge/Fog environments with mobile infrastructure nodes.

The third chapter presents a comparative analysis of key results known in

the scientific field regarding resource allocation in Edge/Fog platforms. These results are summarized and compared against the parameters identified in the first chapter.

In the fourth chapter, a new network-aware Mixed-Integer Linear Programming (MILP) optimization model is proposed for the deployment of microservice containers in dynamic Cloud/Edge/Fog infrastructures composed of mobile nodes with ARM processor architecture. The variables, constraints, and objective functions of the model are described. The objective functions aim to maximize the total number of deployed business applications, minimize the total movement of replicas between nodes, and minimize network latency for business applications to ensure optimal planning.

The fifth chapter presents two examples. An execution time results are shown, to demonstrate how the described MILP model handles the identified major features of Edge/Fog computing platforms within a real mobile environment. The examples are conducted in a test environment that uses Kubernetes as a Cloud/Fog platform and container-based virtualization. Their aim is to evaluate realistic workload represented by the EcoLogic sample IoT application. The results show reduction in the total end-to-end network latency compared to other state of the art solutions.

The sixth chapter contains conclusions and identified directions for future work.

I accept the scientific and applied contributions formulated by the author in the contributions report, which essentially enhance existing knowledge in the scientific field and apply theory to solve specific practical problems.

In addition, I would like to highlight as essential applied contributions the publicly available resources (Appendix A) that are results of the Thesis.

4. Approbation of the results

The results obtained during the Thesis research were published by the PhD student, in co-authorship with his supervisor, in the following two scientific papers:

- 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 – ICSSOC 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 0.407 in 2021 – Q2 (2021)

- T. Tsokov and H. Kostadinov, "Dynamic network-aware container allocation in Cloud/Fog computing with mobile nodes", Internet of Things, Article 101211, 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 6.0 (2023) – Q1 (2023).

According to the national legal requirements, the necessary points for the educational and scientific degree of "Doctor" for the indicators in Group Γ are 30. The two publications generate a total of 135 points in the professional field 4.6 "Informatics and Computer Science," which exceeds the required minimum by more than four times.

In addition, results from the Thesis research have been presented at three scientific forums.

5. Qualities of the Thesis summary

The summary in Bulgarian consists of 35 pages and accurately reflects the content and the main results of the Thesis.

The summary in English consists of 32 pages and accurately presents both the content as well as the scientific and applied contributions of the Thesis.

6. Critical notes

I have no critical notes.

7. Conclusion

The candidate for awarding the educational and scientific degree 'Doctor' demonstrates deep knowledge of the subject area, as well as the skills necessary to implement the proposed solutions in working applications. I believe that the Thesis titled "IoT Platforms and Protocols" represents a complete scientific study. The analysis provided in the previous sections shows that the Thesis fully meets the requirements for awarding the educational and scientific degree "Doctor," as specified in the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its application, and the Rules for the conditions and procedures for acquiring academic degrees and occupying academic positions at the Bulgarian Academy of Sciences and the Institute of

Mathematics and Informatics at BAS.

All of the above gives me a good reason to confidently give my positive evaluation of the PhD Thesis titled "IoT Platforms and Protocols" and strongly recommend the Scientific Panel to award **Tsvetan Krasimirov Tsokov** the educational and scientific degree "Doctor" in the field of higher education 4. Natural Sciences, Mathematics, and Informatics, professional field 4.6. Informatics and Computer Science.

Date: 24/10/2024

Member of the Scientific Panel:

(Assoc. Prof. Dr. Maya Bozhilova)