REVIEW

on a dissertation for obtaining the Degree Doctor of Philosophy

Author Eng. Dimitar Nikolov Todorov
Dissertation Title: Methods and Tools for Load Balancing and QoS Enhancement in SDN-Based 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

Contemporary research in the field of load balancing and service quality improvement in software-defined networks (SDN) is increasingly focused on routing optimization through the application of classical algorithms and methods, as well as the application of additional network parameters when determining routes. The development of effective routing mechanisms in SDN is critical to realizing the vision of a self-governing network—an intelligent, scalable, and load-resistant communications infrastructure capable of meeting the dynamic requirements of current and future digital applications.

The chosen research area in the dissertation, related to the study and development of new routing algorithms that provide better utilization of the network topology, is undoubtedly relevant both globally and for our country. The algorithms proposed in the dissertation aim to provide a balanced distribution of network traffic, as well as better network quality of service (QoS) indicators. All this confirms the promising nature and relevance of the chosen field of research in the dissertation.

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

Eng. Todorov demonstrates in-depth knowledge of the issues related to 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 137 sources, of which 1 is in Cyrillic and 136 are in Latin.

All cited publications from articles in journals and collections of reports sufficiently reflect the global level achieved in the field of software-defined networks and, more specifically, research on routing algorithms that provide better utilization of network topology.

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 is 140 pages long and is structured in three chapters, a conclusion, contributions, a list of publications on the topic of the dissertation, a list of references, a list of figures, a list of tables, and four appendices. It contains 30 figures (12 figures in the first chapter, 4 figures in the second chapter, 5 figures in the third chapter, and 9 figures in the appendices), 46 tables, and 19 mathematical expressions.

Chapter I, "Analysis of Methods and Means for Routing and Improving Service Quality in SDN Networks," is devoted to the evolution of computer networks and the transition from traditional network architecture to network function virtualization (NFV) and software-defined networks (SDN). The architectures of NFV and SDN are presented, as well as the SDN management protocol OpenFlow. The combined SDN-NFV architecture and its importance for modern network infrastructures are examined. Approaches to ensuring quality of service (QoS) and methods for balancing network load are analyzed. The algorithms for static and dynamic traffic routing are examined, with a summary of their main advantages and disadvantages in the context of traffic management in SDN 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, "Methods and Means for Improving Service Quality in Software-Defined Networks," presents the main motives for developing routing algorithms for SDN networks. A system of indicators for evaluating the effectiveness of static and dynamic routing algorithms in SDN networks is proposed.

Chapter III, "Experimental Research and Results," is devoted to presenting the results obtained from research on different network topologies with different numbers of nodes, and the results are analyzed in order to evaluate the effectiveness and quality of the service.

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

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

Scientific contributions:

- ✓ An algorithm for static traffic routing in SDN networks is proposed, which provides balanced traffic distribution and improved quality of service.
- ✓ An algorithm for dynamic traffic routing in SDN networks is proposed, which manages network traffic according to network load.

Scientific and applied contributions:

- ✓ A system of indicators for evaluating static routing algorithms in SDN-based networks has been defined.
- ✓ A system of indicators for evaluating dynamic routing algorithms in SDN-based networks has been defined.
- ✓ A system of indicators for evaluating SDN controllers has been defined.

Applied contributions:

- ✓ An SDN controller has been developed for researching static and dynamic routing algorithms.

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

The single independent publication by doctoral student Dimitar Nikolov Todorov and the four in which he is listed as first author are proof of his leading role in conducting scientific research. The scientific ideas and approaches presented and defended at scientific forums are an assessment of the doctoral student's personal contribution. Eng. Todorov has demonstrated his ability to develop and solve scientific problems, to write competently and in a scientific style, to express himself accurately and to justify his choices logically. It follows from all this that the materials presented in the dissertation are the doctoral student's own work.

The scientific and practical value of the dissertation is demonstrated by the fact that the results obtained are applicable in practice.

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 "Computer Science and Technology" and four in international scientific conferences in the country – International Conference Automatics and Informatics (ICAI) and International Scientific Conference on Communications, Information, Electronic and Energy Systems – CIEES 2021. All publications were made during the doctoral program, and the doctoral student is listed first 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 22 citations of the publications (in the Scopus database), three of which are self-citations.

I believe 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 accepted as useful recommendations for network traffic management in various situations, as well as in creating effective solutions for better utilization of network infrastructure, ensuring uniform and optimal load on routers and network connections.

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 31 pages long, including 4 figures, 8 mathematical equations, and 6 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:

- ✓ The dissertation is presented in only three chapters. The author could enrich this material by expanding the scope of the research to increase its scientific and applied contributions, which in turn would lead to practical results and implementations.
- ✓ Some of the results presented in tabular form should be figures, for example: Tables 3.4; 3.5; 3.6; 3.7; 3.8, etc..

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. Dimitar Nikolov Todorov. The scientific community has been given the opportunity to familiarize itself with the research conducted and the results obtained.

The doctoral student has completed a full doctoral program and clearly demonstrates the 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. Dimitar Nikolov Todorov** the educational and scientific degree of "**Doctor**" in professional field 5.3. Communication and Computer Engineering, in the doctoral program "System Programming."

08 January 2026

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