REVIEW

by **Prof. Maria Petkova Hristova**, PhD
Todor Kableshkov University of Transport - Sofia
on the dissertation thesis for the award of the educational and scientific degree "Doctor",
Scientific Field: 5. 5 Technical Sciences,
Professional Area 5.3. Communication and computer equipment
Doctoral program: Computer Systems and Technologies
Author of the PhD Thesis: **Toncho Ivanov Boyukov**
Title: **Generalized Nets as a Tool for Modeling Railway Transport in Bulgaria**
Scientific supervisors:
Acad. Prof. Dr. Krassimir Todorov Atanasov
Prof. Dr. Sotir Sotirov

1. General description of the procedure and the submitted materials

The review was prepared in accordance with the order No. UD-168/11.07.2023 of the Rector of the University "Prof. Dr. Asen Zlatarov"- Burgas, by which I was appointed as a member of the scientific jury for providing the procedure for the defense of the dissertation thesis entitled: "Generalized nets as a tool for modeling of railway transport in Bulgaria" for the acquisition of the educational and scientific degree "Doctor" in the professional field: 5.3. Communication and computer engineering. The author of the dissertation is Toncho Ivanov Boyukov, PhD student at the Faculty of Technical Sciences, with scientific supervisors Acad. Dr. Krassimir Todorov Atanasov and Prof. Dr. Sotir Sotirov.

The set of materials submitted by Toncho Ivanov Boyukov is in accordance with Article 45 (4) of the Regulations on the Conditions and Procedure for Acquisition of Scientific Degrees and Academic Positions at Prof. Dr. Asen Zlatarov University - Burgas. It includes the following documents which I have received as a member of the scientific jury:

- CV in European format;
- dissertation;
- abstract;
- list of scientific publications on the topic of the dissertation;
- copies of scientific publications on the subject of the thesis;
- declaration of originality and authenticity of the attached documents;
- reference for fulfillment of the minimum national requirements for obtaining the degree of Doctor of Education in the field of higher education: 5. Technical sciences, professional field 5.3.

2. Short biographical data about the PhD student

Toncho Ivanov Boyukov graduated in 2016 from the University „Professor Dr. Asen Zlatarov" and is a master engineer with a scientific specialty „Engineering and Technology in Transport" from professional field 5.5. Transport, Shipping and Aviation. Since 2002 he has been working as a Service Engineer at AUTOTECH-G, Burgas, and since 2020 he has been an Assistant Professor at the University. He has participated in a scientific project under the program „Young Scientists and Postdoctoral Fellows".

3. Relevance of the topic

The dissertation work of Toncho Boyukov is devoted to a very topical subject both for Bulgaria and for the European Union as a whole. In the 80s of the last century in the then Central Scientific Institute of Complex Automation (CSICA) the first attempts were made to create an automated system for monitoring train movements, but it was never completed. The main objective of the thesis is stated as „the application of generalized network theory for modeling and monitoring of railway transport processes."

Toncho Boyukov's work proposes a comprehensive generalized net model of the railway structure in Bulgaria. If this model is fully implemented programmatically and if it is connected with an appropriate interface that feeds the necessary information, it will become exactly an automated system for monitoring the movement of trains in the country.

4. Knowledge of the problem, style and language

It can be concluded from the thesis and its bibliography that the doctoral candidate has thoroughly investigated the state of research in the area under consideration. The bibliography contains 44 references, of which 30 are in Latin and 14 in Cyrillic. The concise and clearly defined aim, the logically coherent structuring of the dissertation text, the analyses and conclusions testify to a very good theoretical and applied knowledge of the doctoral candidate of the contemporary achievements in the problem area, the subject of the research. The rules of good language and scientific style of writing research papers have been observed. The text of the dissertation is clear, precise and analytical.

5. Research methodology

The methodology used is appropriate and relevant to the purpose of the work. The scientific methods applied are appropriate for a work with scientific and applied orientation: research, comparative analysis, synthesis, generalization, realization, critical analysis of the results. They contribute to the achievement of the main objective of the dissertation, which is proved by the presented results.

6. Characteristics and evaluation of the dissertation

The dissertation is structured in accordance with the chosen methodology of conducting the research, as it is structured in: introduction, six chapters, conclusion, list of publications on the dissertation and bibliography. The total volume of the thesis is 127 pages. There are 27 figures and one table in the text.

The first chapter contains brief notes on the theory of generalized nets, defined in 1982 by the first supervisor of the PhD student Krasimir Atanasov, who in 1994 gave the idea of a bidirectional generalized nets. Simple examples are given of how the apparatus of generalized nets can be used to model components of the railway structure of a railway station.

In Chapter 2, the idea of a bidirectional generalized net is substantially developed, and inaccuracies in the original definition are pointed out. The algorithm for the movement of kernels in the transitions of a bidirectional generalized net is discussed, albeit cursorily. It is shown that a bidirectional generalized net is a conservative extension of a standard generalized nets, i.e., the mode of operation and the results of a bidirectional generalized net can be described by a standard generalized nets. This is an important result for the theory of generalized nets. This chapter is the first to point out four possible extensions of bidirectional

generalized net related to the introduction of intuitionistic fuzzy estimates of predicates and of the characteristics of their kernels.

The next four chapters are devoted to specific generalized net models related to rail transportation in the country.

Chapter three contains a detailed generalized net model of the Burgas railway station. It is based on the existing station plan. The predicates of the transitions in the model make it possible to trace the conditions under which a train entering the station can reach a desired end point of the station, and a train departing from an end point of the station will reach its exits. In terms of the complexity of the railway network, the model is of medium category. There are railway stations in the country with higher complexity (e.g. Sofia, Upper Oryahovitza, etc.), but it gives an idea of how a generalized net model can be created for each of the railway stations in the country. It should be noted that this model with its 43 transitions and 79 positions is one of the most complex generalized net models ever created. It is divided into three subnetworks to be sufficiently visible.

The most complex generalized net model published to date is set out in Chapter Four. It contains a total of 57 transitions and 197 positions. Due to its large size, it is divided into 4 subnetworks, interconnected at positions that appear as output for one of the net and input for another. This model reflects all the branches of the railway lines in the country. On the one hand, with a suitable interface, it could be used to track the movement of trains in real time, and on the other hand, to simulate different situations occurring on the lines - accident, repair, etc., and decide how to change the train routes depending on these problems and the time to solve them.

To some extent, the generalized net model of Chapter 5 is a reduced model of the one in Chapter 4, although it too is in the category of generalized net models with a high degree of complexity - 20 transitions and 80 positions. It contains the main railway stations in the country that connect us with our neighbouring countries. Thus, this model reflects the connections, passenger flows and goods flows between Bulgaria on the one hand and Romania, Serbia, Greece and Turkey on the other. With an appropriate interface, this generalised net model could be used to track these flows.

Even more general is the generalised net model of Chapter 6. It reflects the linkages between different modes of transport in the country. In the future, it would be interesting to model the links between different modes of transport in a particular locality. For example, in Burgas and Varna, the public transport routes connecting the bus stations for the country, the railway stations, the airports and the ports in these cities could be determined.

In the conclusion a summary of the results achieved in the thesis is given. Good impression is made by the views formulated by the doctoral candidate for future research development on the topic.

7. Publications on the dissertation

Toncho Boyukov has submitted four scientific publications related to the dissertation, which sufficiently reflect the results and contributions in the dissertation to the specialized scientific audience. The publications have been made in the period 2021-2023 in co-authorship with the supervisors: two are in the Yearbook of the Section „Informatics", Union of Scientists in Bulgaria (one in press); one is in the Proceedings of the Jangjeon

Mathematical Society and one is in the Proceedings of 11 th International Conferfence on Intelligent Systems (IS), 2022, IEEE. In all four publications, Toncho Boyukov is ranked first. Two of the publications are in English and two in Bulgarian.

There are no citation data for the publications.

The minimum national requirements for obtaining the Ph.D. degree in the professional field 5.3. Communication and Computer Engineering have been fulfilled, according to which at least 30 points must be available in the group of indicators D - the Ph.D. student collects 49.6 points.

T. 27, para. 2 of the PP ZRADB, in which he declares that the scientific work is his personal work and the results and contributions he presents in it are derived from research conducted by him.

I have not noticed any plagiarism.

8. Contributions and significance of the development for science and practice

The results achieved in the dissertation are original and correspond to the set goal. The contributions of the work, in my opinion, can be systematized as follows:

Scientific contributions:

- For the first time, it is proposed to introduce definitions for four new extensions of "bidirectional generalized net".
- Each of the four extensions is shown to be a conservative extension of the standard generalized net, and four variants are presented that demonstrate the algorithms for the net's operation.
- Establish two theorems that show that "The functioning and performance results of any bidirectional generalized net can be represented by the standard generalized net".

Research contributions:

- Using the method of bidirectional generalized net a model of Burgas railway station is developed.
- A complete generalized net model of the whole railway network of Bulgaria was created.
- A model showing the connections between Bulgaria and its neighbouring countries has been developed.
- A model showing the connections between the different modes of transport in Bulgaria has been developed.

These contributions could be defined as enriching an existing scientific field with new knowledge.

What has been said so far shows that the developed generalized net models, if implemented programmatically and linked to an appropriate interface, could provide valuable information on passenger and freight flows in the country and from/to neighbouring countries. This would be a step towards the creation of a suitable electronic platform for rail transport in Bulgaria.

All this is evidence of the importance of the results and their applicability.

9. Abstract

The abstract complies in length and content with the requirements of the RRDA. It adequately and faithfully reflects the main points of the dissertation and the contributions made in it.

10. Critical remarks and recommendations

I have the following ***comments*** on the dissertation:

Usually, specific tasks are formulated to achieve the aim of the dissertation, which are missing here.

- The titles of the bibliography are not correctly cited in the text of the dissertation.
- There are incorrect figure numbers cited.

The critical remarks made do not detract from the good impression of the work presented

Recommendations

I recommend the PhD student to continue the research started, as the topic has a high degree of applicability and prospects for development. I suggest, for example, that in the future the author further develops the ideas of the four extensions of generalized networks, describing the algorithms for their operation and proving theorems about their conservativeness on standard generalized networks.

In order to increase visibility among the global scientific community in the field, I commend M. Eng. Toncho Boyukov in his future work to strive to publish the results of his research in scientific journals, refereed and indexed in world-renowned databases with impact factor and impact rank.

CONCLUSION

The dissertation work of mag. eng. Toncho Boyukov contains scientific and applied results that represent an original contribution and meet the requirements of the Law for the Development of Academic Staff in the Republic of Bulgaria (LADAB), the Regulations for the Implementation of the LADAB and the Regulations for the Conditions and Procedure for the Acquisition of Scientific Degrees and the Occupation of Academic Positions at the University „Prof. Dr. Asen Zlatarov".

The abstract and the publications related to the dissertation work meet the requirements for obtaining the degree of Doctor of Education and Science in the professional field 5.3. Communication and Computer Engineering. I believe that the doctoral candidate possesses in-depth theoretical knowledge in the professional field of doctoral studies, as well as proven abilities for independent scientific research.

All this gives me grounds for a positive evaluation of the dissertation and the results and contributions achieved. **I propose that the Honorable Scientific Jury award the M.Sc. Eng. Toncho Ivanov Boyukov the degree of Doctor of Education and Science in the professional field 5.3. Communication and Computer Engineering, Doctoral Program „Computer Systems and Technologies".**

02.08.2023.

Reviewer:

Подпис заличен
Чл.2 от ЗЗЛД

/Prof. Maria Hristova/