REVIEW

by Eng. PhD Slavi Yasenov Lyubomirov, professor at Plovdiv University ''Paisii of Hilendarski''

of a dissertation for the award of educational and scientific doctorate degree

in: field of higher education 5. Technical sciences
Professional field 5.3. Communication and computer technology
doctoral program "Automation of areas of the intangible sphere (medicine, education, science, administrative activities, etc.)".

Author: Anna Ilieva Bekyarova-Tokmakova

Topic: Technology-based solutions for process management in telecommunications

Scientific supervisor: Prof. Dr. Eng. Nevena Stoyanova Mileva - Plovdiv University "Paisii Hilendarski"

1. General description of the materials presented

By order No. PD-22-92 of 17.01.2025 of the Rector of Plovdiv University "Paisii Hilendarski" (PU), I am appointed as a member of the scientific jury for ensuring a procedure for the defense of a dissertation on the topic "Technology-based solutions for process management in telecommunications" for the acquisition of the educational and scientific degree "doctor" in the field of higher education 5. Technical sciences, professional field 5.3. Communication and computer technology, doctoral program Automation of areas of the intangible sphere (medicine, education, science, administrative activities, etc.). The author of the dissertation is Anna Ilieva Bekyarova-Tokmakova - a full-time doctoral student at the Department of Electronics, Communications and Information Technologies with a scientific supervisor Prof. Dr. Nevena Stoyanova Mileva from Plovdiv University "Paisii Hilendarski". The training of the doctoral student Mag. Anna Ilieva Bekyarova-Tokmakova was carried out in a full-time form at the Department of Electronics, Communications and Information Technologies (ECIT) at Plovdiv University "Paisii Hilendarski".

The set of materials on paper presented by Anna Ilieva Bekyarova-Tokmakova is in accordance with Art. 36 (1) of the Regulations for the Development of the Academic Staff of the University of Plovdiv, and includes the following documents:

- a request to the Rector of the University of Plovdiv to disclose the procedure for defending a dissertation;
- CV in European format;

- Transcript-excerpt from the Minutes of the Department Council at the Department of EKIT (PU) No. 70/09.01.2025, item 1. Preliminary discussion of the dissertation work of Anna Ilieva Bekyarova-Tokmakova;
- dissertation in a volume of 178 pages;
- abstract in a volume of 32 pages;
- list of scientific publications on the topic of the dissertation – 3 copies;
- copies of the 3 scientific publications submitted under the procedure;
- declaration of originality and authenticity of the attached documents;
- a certificate of compliance with the minimum national requirements for awarding the educational and scientific degree "doctor".

The doctoral student has submitted 3 publications, based on which he has a total score of 53 points, which meets the minimum national requirements for awarding the educational and scientific degree "doctor" in the relevant field.

2. Brief biographical data about the doctoral student

In 1995, the doctoral student, Mag. Anna Ilieva Bekyarova-Tokmakova, completed her higher education with a degree in Biologist, Ecologist at Plovdiv University "Paisii Hilendarski", where she obtained an educational qualification degree (EKS) "Master". She continued her education from 1998 to 2022 and received an OKS "Master" in Economics, MIE at the same university.

In 2021, she was enrolled in doctoral studies by order No. P33-260 of 26.01.20121 of the Rector of Plovdiv University "Paisii Hilendarski" and holds the position of assistant professor. She currently also holds the position of Head of the Department of Scientific Research, Organization of Work Processes.

He has programming skills in Python and Excel for data processing and analysis, working with ERP and CRM systems.

3. Relevance of the topic and appropriateness of the set goals and objectives

The topic of this dissertation is aimed at implementing technological solutions for optimizing business process management in the telecommunications sector. In turn, it is based on several key factors. First of all, the rapid technological development of the sector and the multitude of new services, customers and requests place high demands on telecommunications companies. The increased needs and requirements of customers also create a need for innovative approaches and effective process management. The doctoral student has found a relatively new area of management system, a

technology-based system for forecasting and managing the customer retention process in telecommunications companies. The system provides precise information and analyses for effective management of the customer base.

4. Knowing the problem

In developing her dissertation, Mag. Anna Bekyarova-Tokmakova referred to 132 literary sources. Of these, only two sources by Bulgarian scientists are presented. It is striking that a large part of the literary sources are from recent years. She shows good literary awareness by correctly citing the sources. The publications and scientific achievements of current authors, on which the claim for novelty and originality in the dissertation is based, have been critically analyzed. The large number of literary sources suggests a good knowledge of the problem by the doctoral student and her ability to cope with the tasks set. The reference to these sources and the achieved results speak of a good knowledge of the problem and its creative solution.

5. Research methodology

To solve the goal of the dissertation "Design and development of a technology-based system for forecasting and managing the customer retention process in telecommunications companies", three tasks have been set. They are well selected and their solution would lead to achieving the set goal. The research methodology chosen by the doctoral student Anna Bekyarova-Tokmakova allows achieving the set goal and obtaining an adequate answer to the tasks solved in the dissertation.

Chapter one of the dissertation presents a study on the systematization of existing technology-based solutions for process management in telecommunications. A classification of business processes is presented, which shows a rather diverse scientific view of the problem. Technological solutions in process management in telecommunications are presented when integrating the Internet of Things (IoT), cloud technologies, Big Data Analytics and Artificial Intelligence.

The second part of the dissertation is "Development of a technology-based system for managing the Business Customer Retention process in telecommunications". An analysis of the retention process in the telecommunications sector and the need to take into account the differences between the markets of individuals and business customers is presented. An author's model of the Business Customer Retention business process, developed with the Enterprise Architect software product, is proposed. Based on the information collected, the Business Customer Retention process was analyzed using the SWOT analysis tool, which is an established method for strategic planning and assessment of the current state of processes in an organization. A business customer churn forecasting system was designed and developed. An analysis was made of the validation of the results, which is a critical stage in the process of developing the churn forecasting system. Evaluation indicators were used -

accuracy, sensitivity and precision, F1-score, receiver operating characteristic curve, or ROC (Receiver Operating Characteristic). A customer churn prediction system has been created, developed using the Streamlit SDK.

The third chapter of the dissertation presents the conducted experiments and the obtained results. Based on the conducted experiments, the effectiveness of various predictive models was evaluated in order to establish which machine learning technique provides the best results in predicting customer churn. It was found that preprocessing does not affect models such as the Random Forest Classifier, whose accuracy remains unchanged and retains a value of 95%. The results show that the accuracy of Naive Bayes, the Support Vector Machine, as well as the combined models of AdaBoost with Support Vector Machine and Linear Discriminant Analysis, significantly decreases when preprocessing is applied. The obtained results of the conducted experiments confirm the research hypothesis that it is possible to develop a system that uses a real database, used daily by managers in a telecommunications operator, to reliably predict subscriber churn. The system demonstrates high values for key parameters, including accuracy, sensitivity, precision and F1-score.

6. Characteristics and evaluation of the dissertation work

The dissertation submitted for review has a total volume of 178 pages and contains 30 figures (photos, diagrams, graphs), 7 tables and 14 formulas. 132 literary sources were used, only two of which are in Cyrillic, the rest are in English. The dissertation consists of an introduction, three chapters, a summary of the results, contributions of the dissertation, a list of scientific works on the dissertation, citations and used literature. The dissertation is formatted according to the requirements, the figures are clear and understandable with an appropriate size. The content and text are well structured.

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

As a reviewer, I have no objections to the claims formulated by the doctoral student regarding the contributions. I support the contributions of the dissertation, I accept that they are scientifically applied and applied.

The contributions of the dissertation can be classified:

- scientific and applied, expressed in: applied and researched SMOTE method for preprocessing data from a real database containing 8453 records of business customers from a leading telecommunications operator, in order to solve the problem of class imbalance. An experimental study of various machine learning models was carried out, including: logistic regression, naive Bayes, random forest classifier, ADABOOST with decision tree, classifier with additional trees, decision tree, support vector machine, ADABOOST and support vector machine and linear discriminant analysis.

An assessment of their efficiency and accuracy in predicting the two main classes — "churn" and "lack of churn" was made. As a result of the analysis, the most suitable algorithms for predicting customer churn were identified. In this context, a classification of business processes in the telecommunications industry was proposed, systematizing the key aspects and the interrelationships between them. Customer Retention Process Analysis: An in-depth analysis of the Business Customer Retention process was conducted, revealing the main factors influencing customer loyalty and retention. Business Customer Retention Process Redesign: A new process design was developed to optimize customer interaction and increase the effectiveness of retention strategies.

- applied, expressed in: a comprehensive overview of technology-based solutions is presented: A detailed analysis of existing technological solutions for business process management in the telecommunications sector has been prepared. An appropriate system architecture has been justified and selected, which provides flexibility and efficiency in data processing and customer churn forecasts. This includes a detailed design of the system, including a description of the main components and functionalities necessary for its effective functioning. A prototype of the system has been created and developed, which demonstrates the applicability of the proposed solutions and concepts in a practical environment.

8. Assessment of dissertation publications

I have familiarized myself with the submitted publications on the dissertation, which are sufficient in number. The results have been published in specialized scientific publications. In connection with the dissertation work, Mag. Anna Bekyarova-Tokmakova has submitted three publications, two of which have been published in scientific publications, referenced and indexed in the world-famous databases Scopus and Web of Science, one article has been published in a collection of reports from the Scientific Papers of the Union of Scientists in Bulgaria-Plovdiv. This is grounds to assume that the results of the research on the dissertation are known to the scientific community. In the three publications, Mag. Anna Bekyarova-Tokmakova is in first place. One of the publications is the doctoral student's own. In the remaining two articles, she is co-authored with the scientific supervisor, and in one of the two there are three authors.

The presented publications reflect the essence of the topic of the dissertation. Information on the citation of one of the articles is presented.

9. Personal participation of the doctoral student

The dissertation submitted for review and the publications to it show that the doctoral student has independently conducted an experimental study of various machine learning models, assessed their effectiveness and accuracy in forecasting. Three publications on the dissertation are presented,

two of which are indexed in Scopus, essentially reflecting the results obtained from the development. In two of the articles, the doctoral student is in first place, and in one she is an independent author. This testifies to the doctoral student's significant contribution to the results obtained. I have no common publications with the doctoral student and I am not a related person, within the meaning of the law.

10. Autor's abstract

The submitted abstract is 32 pages long and faithfully reflects the content of the dissertation in a summarized form. The review of the abstract of the dissertation shows full compliance with the requirements for its preparation, as well as the adequacy of reflecting the main results and contributions of the dissertation.

11. Critical remarks and recommendations

I have no critical remarks towards the doctoral student regarding the submitted documents and scientific papers.

12. Personal impressions

I have known Anna Ilieva Bekyarova-Tokmakova, M.A., since she started working as an assistant in the Department of "ECIT" of the Faculty of Physics and Technology at the "Paisii Hilendarski" University. He approaches his teaching activities responsibly, constantly updating the content of the teaching material in the disciplines he teaches.

13. Recommendations for future use of the dissertation contributions and results

In her dissertation, the doctoral student presented directions for future development. She indicated that future research needs to include more advanced ensemble models, as well as the integration of neural networks, which can further improve the accuracy and ability to identify customers at high risk of churn.

It is emphasized that future development of the system may include additional functions for personalizing forecasts according to individual customer characteristics and adding self-learning algorithms that will allow the system to automatically adapt to new data and trends.

In this context, it becomes clear that the doctoral student has a vision and applicable ideas for future use of the scientific and applied scientific contributions of the dissertation research.

CONCLUSION

The presented dissertation represents a valuable scientific work in which the doctoral student has fulfilled the set goal and formulated tasks. It ***contains scientific-applied and applied results that***

represent an original contribution to science and meet all requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria (ADSRB), the Regulations for the Implementation of the ADSRB and the relevant Regulations of the PAISIY HILENDARSKY PU.

The dissertation shows that the doctoral student Anna Ilieva Bekyarova-Tokmakova possesses in-depth theoretical knowledge and professional skills in the scientific specialty 5.3 Communication and Computer Engineering, demonstrating qualities and skills for independent conduct of scientific research.

Due to the above, I categorically give my positive opinion. ***Assessment*** or the research conducted, presented by the above-reviewed dissertation, abstract, achieved results and contributions, and I propose to the esteemed scientific jury to award ***the educational and scientific degree "doctor"*** of Anna Ilieva Bekyarova-Tokmakova in the field of higher education: 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering, doctoral program “Automation of areas of the intangible sphere (medicine, education, science, administrative activities, etc.)”.

13.02. 2025 Reviewer: .....

(Prof. Slavi Lyubomirov, Eng., PhD)