



REVIEW

Вх. № РД 20-581 / 31.03.2026

1. General information

Reviewer: Prof. Evdokia Nikolaeva Sotirova, PhD, Field of higher education 4. Natural sciences, Mathematics and informatics, Professional field 4.6. Informatics and computer science, Burgas state university „Prof. Dr. Asen Zlatarov“.

Grounds for the preparation of the review: I have been appointed as a member of the scientific jury by order No. RD-06-32/30.01.2026 issued by the Rector of University of Economics – Varna, Prof. Evgeni Stanimirov, PhD, and Protocol No. 1 from the first meeting of the scientific jury.

Author of the dissertation: Petar Dimitrov Dimitrov, PhD candidate in field of higher education 4. Natural sciences, mathematics and informatics, Professional field 4.6. Informatics and computer science, Doctoral program „Informatics“.

Title of the dissertation: Universal two-factor authentication for protecting web-based information systems.

2. Information about the PhD candidate

Petar Dimitrov Dimitrov was born on December 10, 1996, in Varna, Bulgaria. In 2010, he obtained a Bachelor's degree in Tourism from University of Economics – Varna. In 2011, he earned a Master's degree in Corporate Finance, and in 2015, a Master's degree in Business Information Systems from the same university.

His professional career began in 2007 as a programmer at University of Economics – Varna, where he continues to work to the present day. Throughout his professional development, he has held various positions related to software development, system administration, and participation in national and university projects. Since 2014, he has been Head of the „Software Development“ Unit at the Center for Research and Application of New Information and Communication Technologies at the same university. According to the submitted CV, the candidate has substantial practical experience in the design and implementation of business information systems, development of web portals, database management, and ICT project management. He has also conducted practical classes in “Operating Systems,” “Server-Side Programming,” and “Advanced Business Information and Communication Technologies” for students at the University of Economics – Varna.

Petar Dimitrov Dimitrov was enrolled as a full-time PhD candidate (state-funded position) in the doctoral program “Informatics” at the Department of Informatics by Order No. RD 17-170/29.01.2018. He was granted the right to defend his dissertation by Order No. RD 17-389/09.02.2021.



3. General presentation of the dissertation

The dissertation is structured in 167 pages and includes a list of abbreviations, an introduction, three chapters, a conclusion, a bibliography of 129 references (27 of which are internet sources), a statement of contributions, and a list of publications related to the topic.

In the introductory section, the PhD candidate justifies the relevance of the research through an in-depth analysis of the increasing cyber threats and the limitations of traditional authentication mechanisms. The research framework is clearly defined, including the object, subject, aim, and tasks of the study, as well as the applied methodology and scope of the research. The object of the study comprises modern authentication systems in web-based information environments, while the subject focuses on methods and models for implementing secure and robust two-factor authentication using the FIDO2 and WebAuthn standards. The main objective of the dissertation is to develop and implement a strong authentication model aimed at improving the security and reliability of access to information systems. To achieve this objective, specific research tasks have been formulated, focusing on the analysis, modeling, and practical implementation of the proposed solution.

In *Chapter I: Theoretical and Practical Prerequisites for the Implementation of WebAuthn*, a systematic and comprehensive theoretical review of existing authentication methods is presented, including password-based mechanisms, cryptographic approaches, and multi-factor authentication. A strong positive impression is made by the critical analysis of their vulnerabilities and the well-argued justification for the adoption of modern standards such as FIDO2/WebAuthn.

In *Chapter II: Authentication Model Based on the FIDO2 and WebAuthn Standards*, the PhD candidate develops a conceptual, logical, and communication model for universal two-factor authentication based on the FIDO2 and WebAuthn standards. An analytical evaluation of the security, performance, and scalability of the proposed solution is carried out, and its integration aspects in real information environments are examined. The proposed model is logically consistent and well-argued, demonstrating a solid understanding of contemporary requirements for security systems.

In *Chapter III: Implementation of WebAuthn in the Web-Based Information System of the University of Economics – Varna*, the practical realization of the proposed model is presented through its implementation in a web-based information system. The architectural solutions, technological environment, and specific mechanisms for registration and authentication are analyzed, along with the possibilities for application in educational and institutional environments. It may be considered beneficial to further enhance the experimental validation of the proposed solution through the use of quantitative performance indicators.

In the *Conclusion*, the achieved scientific and applied results are summarized, the degree of fulfillment of the stated objectives and tasks is assessed, and key conclusions and directions for future research in the field of secure authentication are formulated.



I consider that the dissertation is well-structured, with a clear logical organization, coherent presentation, and a well-defined distinction between the theoretical, modeling, and applied parts.

4. Evaluation of the structure and content of the dissertation

The structure of the dissertation complies with the requirements of Art. 56 of the Regulations for the Development of the Academic Staff at University of Economics – Varna. The presentation is logically consistent and well-balanced, with a clear distinction between the theoretical, modeling, and applied parts of the study. The individual chapters are interconnected and form a coherent and consistent scientific line leading to the achievement of the stated objectives and tasks.

The content of the dissertation is appropriate to the topic and reflects the current state of the researched problem. The PhD candidate demonstrates a good understanding of contemporary approaches and technologies in the field of secure authentication, successfully combining theoretical analysis with the development of an original model and its practical implementation. A particularly strong aspect is the connection between the developed model and its application in a real information environment, which adds practical value to the research. At the same time, in certain parts, the presentation is more descriptive in nature; the analytical depth could be further enhanced through clearer comparison with existing solutions and approaches.

The abstract is 36 pages long and presents the content of the dissertation in a clear, structured, and systematic manner. It correctly reflects the relevance of the research, the formulated research thesis, the objectives and tasks, the object and subject of the study, as well as the applied methodology. The main scientific and applied results, as well as the validation of the research, are presented. The text is logically consistent, well-structured, and appropriately illustrated.

In terms of language and style, the text meets the standards of academic writing and is characterized by clarity, precision, and consistent use of terminology. The presentation is clear and well-structured, and no significant linguistic or stylistic inaccuracies are identified.

5. Identification and evaluation of the scientific and applied contributions of the dissertation

The presented contributions reflect the main results of the research; however, they could be formulated more clearly and structured more systematically.

I define them as follows:

Scientific Contributions:

- 1) An architectural model for phishing-resistant authentication based on the FIDO2 and WebAuthn standards has been developed and analytically justified. The model is adapted to the specifics of distributed web-based information systems.



- 2) The concept of WebAuthn has been extended, with the technology considered not only as an authentication mechanism but also as a means for cryptographic confirmation of actions within information systems.

Scientific and applied contributions:

- 1) A practical architectural model for the implementation of WebAuthn has been developed, tailored to an existing technological environment (PHP/MySQL) and adapted to the specifics of a university information system.
- 2) A practical integration of WebAuthn into a real information system (WSDB at University of Economics – Varna) has been achieved, demonstrating the applicability and effectiveness of the proposed solution in a real environment.
- 3) A mechanism for cryptographic signing of actions has been proposed and implemented, ensuring the linkage between authenticated identity and specific operations within the information system (e.g., entering grades).
- 4) The feasibility of using WebAuthn as a universal mechanism for secure authentication and traceability of actions, applicable in university and administrative information systems, has been demonstrated.

The main emphasis of the contributions is of a scientific and applied nature, with particularly significant results related to the development and implementation of the proposed solution in a real information environment.

6. Publications and participation in scientific forum

According to the list of the author's publications presented in the dissertation and the abstract, the research results are reflected in a total of 7 scientific publications. Of these, 4 are conference papers, including 2 presented at the international Geoconference SGEM held in Varna and indexed in Scopus, 1 presented at an international conference in Sofia, and 1 at a conference of young researchers in Varna. Three of the publications are articles published in the journal *Izvestia of the Union of Scientists – Varna*, two of which are in press. Two of the publications are single-authored.

The presented publications correspond to the topic of the dissertation and reflect the main results of the research. The minimum requirements under *Group G* for Professional Field 4.6. Informatics and Computer Science are fulfilled, based on the list of publications included in the dissertation and the abstract.

In the separately submitted report on the fulfillment of the minimum national requirements, a total of 4 publications indexed in Scopus are listed, two of which differ from those included in the dissertation and the abstract. This indicates a certain inconsistency between the different lists of publications. This inconsistency does not affect the fulfillment of the minimum requirements but could be refined for greater clarity and consistency.

Based on my verification in Scopus, excluding self-citations of all co-authors, Petar Dimitrov has an *h-index*=2, which indicates an emerging but tangible recognition of his research results.



I consider that the publication activity of the PhD candidate ensures the necessary validation of the research results and meets the requirements for the award of the educational and scientific degree „Doctor“.

7. Established or Non-Established Plagiarism in the dissertation, the associated publications, and the abstract. Established or non-established use of incorrect data or improper citation of other researchers' scientific works;

I have no evidence of plagiarism in the dissertation, the associated publications, or the abstract. Furthermore, no cases of improper use of other researchers' results or incorrect citation of the referenced literature have been identified.

8. Critical Remarks and Recommendations

I have no significant critical remarks regarding the structure, content, or scientific orientation of the dissertation. The research is logically consistent, well-argued, and demonstrates clear practical applicability.

It would be beneficial to provide a more in-depth experimental validation of the proposed model through the use of quantitative performance and security indicators.

I recommend that the PhD candidate further expand his publication activity in international journals with a higher level of indexing.

9. Questions to the PhD candidate

I have the following questions to the PhD candidate:

- 1) What are the main limitations of the proposed architecture when implemented in large-scale and distributed systems with high load, and how can they be addressed?
- 2) Can the proposed mechanism for cryptographic signing be considered an alternative to the qualified electronic signature, and what are its limitations?

10. Conclusion

My overall assessment of the dissertation, the abstract, the publications, and the scientific activity of Petar Dimitrov Dimitrov is entirely positive. The dissertation contains scientific-applied and applied results that constitute an original contribution to the field and demonstrate that the PhD candidate possesses in-depth theoretical knowledge, the ability for critical analysis, and the capacity to conduct independent scientific research.

The dissertation fully complies with the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, its implementing regulations, as well as the criteria set by the Regulations for the Development of the Academic Staff at University of Economics – Varna.

This gives me sufficient grounds to confidently recommend that the esteemed members of the Scientific Jury award Petar Dimitrov Dimitrov the educational and scientific degree



„Doctor“ in Professional Field 4.6. Informatics and Computer Science, Doctoral Program
„Informatics“.

27.03.2026

Burgas

Reviewer:..

(Prof. Evdokia N. Sotirova, PhD)



REVIEW

of a dissertation authored by PhD student Petar Dimitrov Dimitrov, on the topic “Universal two-factor authentication for the protection of web-based information systems”, presented for the acquisition of the educational and scientific degree “Doctor” in the professional field 4.6. “Informatics”, doctoral program “Informatics”

The review was prepared by: Prof. Dr. Silvia Stoyanova Parusheva, habilitated in professional field 4.6. Informatics and Computer Science

Grounds for preparing the review

The review was prepared on the basis of the Order of the Rector of the University of Economics – Varna No RD 06-32/30.01.2026 and the Decision of the Scientific Jury of the meeting on 11.02.2026 for the election of the Chairman, reviewers and drafting opinions.

1. Doctoral Student Data

PhD student Petar Dimitrov Dimitrov is a full-time PhD student at the Department of Informatics at the University of Economics – Varna. He is studying under the doctoral program “Informatics”, and his scientific supervisor is Prof. D.Sc. Pavel Petrov.

Doctoral student Dimitrov graduated consecutively from the University of Economics - Varna, acquiring a Bachelor's degree in Tourism (2010) and two Master's degrees - in Corporate Finance (2011) and Business Information Systems (2015). Throughout his educational and professional career, he has demonstrated a deep interest in information technology, combining his academic development with active work in the software industry.

Petar Dimitrov's professional path is closely connected with the University of Economics - Varna, where since 2014 he has held the position of Head of the Software Development Sector at the Center for Research and Application of New Information and Communication Technologies. He has extensive experience in the design and development of large-scale information portals and systems, incl. projects for the Ministry of Education and Science



such as “Student Practices – 2” and “Support for Inclusive Education”. At the same time, he actively participates in a number of intra-university and national research projects aimed at the modernization of the educational environment and the implementation of innovative partnership networks between the university and business.

His research interests are focused in the areas of cybersecurity, information systems, system administration and databases. His teaching activities include conducting exercises in disciplines such as “Operating Systems”, “Advanced Business Information and Communication Technologies” and “Server Programming” at the University of Economics-Varna. At present, the PhD student has published 4 scientific articles and 5 reports, some of which are indexed in the world scientometric database Scopus.

2. Overall presentation of the dissertation

Petar Dimitrov's dissertation is presented in a volume of 168 pages, structured in an introduction, three chapters, a conclusion, a list of references (129 sources), a reference to the contributions to the dissertation and a list of publications on the work.

The research is focused on the implementation of modern passwordless authentication methods based on the FIDO2 and WebAuthn standards in the academic information environment.

The subject of the study is web-based information systems and user authentication processes in them, and the subject covers the mechanisms and technological models for security based on the FIDO2 and WebAuthn standards. The main goal of the dissertation is the design and implementation of a conceptual and applied model for passwordless authentication, which will increase the level of data protection and integrity in an academic environment. To achieve it, 4 tasks have been outlined: implementation of a critical analysis of existing technologies, development of a comprehensive architectural framework and practical integration of the development into the real information system WSDB of the University of Economics – Varna, incl. through experimental testing of the possibilities for digital signing of student grades.



The presented work demonstrates logical integrity and completeness and helps to move from the theoretical problem through architectural design to the actual operation in a large-scale institutional environment.

3. Assessment of the structure and content of the dissertation

The dissertation has a standard structure of dissertation research, and there is a logical connection and balance between its individual parts. The author demonstrates the ability to systematize complex technological matter, moving sequentially from theoretical formulation to conceptual modeling and subsequent software implementation.

In the **introduction**, the author justifies the relevance of the topic, pointing out the essential need for a transition to cryptographic methods for protection against the background of growing cyber threats. The object, subject and purpose of the work are defined. The scientific thesis about the applicability of WebAuthn as a universal security solution is formulated.

Chapter One is a systematic analytical review of authentication methods – from the storage of passwords in plain text and their hashing, through one-time passwords (OTP), to qualified electronic signature. The author critically examines the vulnerabilities of these traditional mechanisms to phishing and man-in-the-middle (MitM) attacks, which theoretically argues the advantages of the WebAuthn protocol.

Chapter Two is conceptual and architectural in nature. In it, the PhD student proposes models of interaction between the main components in the FIDO2 ecosystem: authenticator, client (browser) and Relying Party server. The logical structure of data for storing public keys and communication flows during registration and verification are described. This section serves as a theoretical framework for subsequent practical development.

The **third chapter** describes the practical implementation of the proposed model in the university information system WSDB of the University of Economics – Varna. The author presents a software implementation of PHP and JavaScript, describing in detail the processes of managing WebAuthn objects. An original moment in the chapter is the attempt to extend the standard



authentication to a mechanism for “digital signing” of student assessments in order to ensure the integrity of the electronic main book.

The **conclusion** synthesizes the main conclusions and outlines guidelines for the future development of the system, including in the context of post-quantum stability.

The literature reference used includes current sources, most of which are in English. The citation of the latest specifications of the W3C and FIDO Alliance from 2024 and 2025 makes a good impression, which proves that the dissertation monitors the development of technologies and bases its research on the most modern world standards.

4. Identification and evaluation of scientific and applied contributions in the dissertation

Based on the presented dissertation and the results achieved in it, I confirm the existence of the following contributions, which are scientifically applied and applied in nature:

1. Systematization and theoretical justification of the transition to passwordless authentication (scientifically applied contribution).

The contribution is expressed in an in-depth critical analysis of the evolution of protection methods. The author successfully argues the concept of WebAuthn not just as a technological alternative, but as a new approach that solves fundamental problems of password authentication and second-factor vulnerabilities (OTP/SMS). This contribution is defended in Chapter One.

2. Development of a comprehensive architectural framework for the integration of FIDO2 standards (scientific and applied contribution).

The PhD student offers a detailed architectural model that adapts world standards (WebAuthn API) to the specifics of the Bulgarian academic environment and the widely used infrastructure (PHP/MySQL). An important achievement here is the formalization of the logical data model for public key management, which has methodological value for future developments.

3. Practical implementation and software implementation in a real operating environment (applied contribution).



This is one of the strongest aspects of work. A really working integration into the WSDB information system of the University of Economics-Varna is proposed. The full cycle of registration and authentication with different types of devices (hardware keys and platform authenticators) proves the applicability and scalability of the solution.

4. Experimental validation of a digital data signing mechanism (attached contribution).

The contribution consists in the innovative attempt to use WebAuthn outside of its standard login role and to apply it to ensure the integrity of specific actions – in this case, the signing of student grades. Although at an experimental level, this approach offers a technological solution to a pressing problem in the administration of higher education.

5. Publications and participation in scientific forums

A total of 7 publications are presented on the topic of the dissertation, of which 3 are categorized as scientific articles and 4 as scientific papers. The participation of the PhD student in prestigious international forums such as SGEM and ICAICTSEE, where the publications are referenced in the world database Scopus is impressive. This is a testament to the recognition of research in the international scientific community.

The volume of publications presented fully covers and even exceeds the minimum national requirements for acquiring the educational and scientific degree “Doctor”. The scientific results are concentrated mainly in conference proceedings, while the in-depth presentation of the study in established periodical scientific journals with a high impact factor is still pending.

From the reference attached by the doctoral student, it can be seen that the minimum national requirements for an educational and scientific degree “Doctor” in the field of higher education 4 have been met. “Natural Sciences, Mathematics and Informatics” in indicator group “G” with 120 points.



6. Established or unfound plagiarism in the dissertation and abstract

The StrikePlagiarism system was used to check the dissertation, and the reported values of similarity coefficient 1 (KP1 – 30.24%) and coefficient of similarity 2 (KP2 – 27.09%) are relatively high for the final phase of doctoral research. Although some of these coincidences are due to the terminological apparatus and the PhD student's own publications, there are grounds for requiring additional clarifications from the PhD student, namely:

It is necessary for him to provide a reference and explanations with arguments regarding the difference in the subject and tasks between the current dissertation and his other work, defended at the Naval Academy - Varna. What is the share of the new, author's contribution, developed specifically for the needs of the doctoral studies at the University of Economics-Varna?

7. Critical notes, recommendations and questions to the dissertation

I have no fundamental criticism of the structure and technical implementation of the dissertation, as I have presented detailed recommendations in the previous discussions of the work in the department, which the author has taken into account. However, in the context of the final version of the dissertation and the results of the software check for plagiarism, I consider it mandatory for the PhD student to give answers to the questions raised above.

I recommend the PhD student in his future research work to focus on publishing the results of his applied developments in scientific articles in established refereed international journals with an impact factor.

I have the following question: What is the proposed procedure for regaining access if a user (faculty or student) loses their only registered WebAuthn hardware key?



8. Conclusion

Based on the presented materials and the in-depth analysis carried out, I believe that the dissertation and the accompanying documentation meet the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its implementation, as well as the internal regulations of the University of Economics – Varna.

The dissertation has the necessary scientific and applied contributions, demonstrates in-depth theoretical knowledge and skills for independent research work.

On the basis of Art. 59, para. 6 of the Regulations for the Development of the Academic Staff at the University of Economics – Varna, I propose to the esteemed Scientific Jury to award the educational and scientific degree of “Doctor” to Petar Dimitrov Dimitrov in the professional field 4.6. “Informatics and Computer Science”.

04.04. 2026

Prepared the review:

Varna

(Prof. Dr. Silvia Parusheva)