

## REVIEW

By Professor DSc. Krasimira Stoilova  
Institute of Information and Communication Technologies –  
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of a Dissertation for awarding the educational and scientific degree "Doctor"

On topic **„Integration and Synergy between Information and Communication Technologies and Modern Banking“**

In the field of higher education 5. Technical Sciences

Professional field 5.3. Communication and Computer Technology

Doctoral Program „Computer Systems, Complexes and networks“

With author **Milvina Todorova Terzieva**

Supervisor: Professor PhD Dimitar Karastoyanov

When evaluating the dissertation work by the reviewer, the conditions of the Act on the Development of the Academic Staff in the Republic of Bulgaria (ADASRB), the Regulations for its implementation and the Regulations for the specific conditions in IICT-BAS for the implementation of the Law were decisive. Pursuant to Article 6(3) of the ADASRB, the Dissertation work must contain scientific or scientific-applied results that represent an original contribution to science. The dissertation must demonstrate that the candidate has in-depth theoretical knowledge of the relevant specialty and the ability for independent research. According to the Regulations of IICT-BAS (Art. 3., Item 1.1), the candidate's dissertation must be based on at least three scientific publications, at least one of which must be in a journal with an impact factor or in a specialized international edition (indexed in SCOPUS/ WoS).

### 1. Relevance of the problem and purpose of the research

Digitalization and the displacement of traditional banking operations by modern solutions based on information and communication technologies (ICT) have actively entered modern banking in recent years. Communication and information technologies are the backbone of many areas of the modern world, including banks. Interweaving of ICT and banking capabilities has been achieved to a level of competition. The PhD student is a representative of the banking sector and is very well acquainted with the modern solutions in the banking industry considering the dissertation. Her interest is focused on creating better banking functionality with the application of ICT for the benefit of the user. The research in the dissertation is related to the creation of an innovative information and communication product in the banking sector in order to better serve the citizens.

I think that the topic of dissertation research is relevant due to the increasingly close interaction between banking and information and communication services, as well as due to the desire to increase the quality of banking production. The doctoral student demonstrates a very good knowledge of the state of the problem, which is comprehensively presented in the dissertation.



The aim of the dissertation is: **Through the integration of ICT in modern banking, to achieve synergy between innovative methods and means of digitization in the banking environment.** To achieve this goal, she formulates the following tasks to be solved:

1. To explore and analyze innovative methods and means of digitization in a banking environment.
2. To propose an approach to integrate modern banking technologies to create a new complex banking service that will reduce the time of execution of a transaction, be accessible to all users and be better in a financial aspect.
3. To propose improving regulations for the payment industry.
4. To validate the synthesized new banking service, to carry out experimental studies and simulations of the proposed solutions. To verify and analyze the results.

Full correspondence between the set goal and tasks of the dissertation work, the chosen research methodology and the achieved results has been realized.

## **2. General characteristics of the dissertation work**

The dissertation, set out in 168 pages, is structured in 5 chapters, two Appendices, Conclusion, Contributions, List of publications on the dissertation work, Bibliography, List of used abbreviations and Declaration of originality. 108 contemporary literary sources were used, most of them from the last 5 years. A good impression is made by the doctoral student's citation of Bulgarian authors on the issues under consideration.

In the **First chapter**, an overview, analysis and systematization of existing information and communication technologies (ICT) in banking is made. Existing banking products and services, existing information and communication technologies used in banking and trends for the development of the banking sector are presented. It is concluded that the development of digitization is promising because digital processes increase the efficiency for the bank (operating cost relative to income). The PhD student is very well acquainted not only with the current situation in the banking system around the world, but also with the applied innovative solutions such as biometric user authentication, iris recognition, etc. as cyber security tools.

In the **Second chapter**, innovative methods and tools for digitization in a banking environment are explored *in fulfillment of Task 1 of the set goal*. Presented are: ICT banking service through payment cards; ICT banking service "Payment with mobile devices"; On-line banking; Mobile banking; Interactive methods and tools for remote and autonomous banking (Token, qualified electronic signature, chatbot as an element of artificial intelligence, blockchain technology). The main trends in the interaction between banking and ICT are outlined. The doctoral student is well acquainted with modern banking technologies based on ICT and relevant established standards, some of which are Electronic Fund Transfer (EFT), Real-time gross settlement (RTGS), Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET2), TARGET2-Securities, TARGET Instant Payment Settlement (TIPS), Eurosystem Collateral Management System (ECMS), etc.

In the **Third chapter**, an approach was developed for the integration of modern banking and ICT technologies to create a new complex banking service that would reduce the time for the execution of a transaction, be accessible to all users and be better from a financial aspect *in fulfilling the Task 2 of the set goal*. The main contemporary challenges facing banking institutions are presented, among which the so-called Open banking. The main existing banking technologies have been analyzed in detail with a view to integrating them into a new real-time service. Considerable attention has been given to the bank platform for fast money transfers. Ideal, properly



integrated into the new banking service. A comparison of the New Banking Service with the existing Bank Transaction and Bank Transaction using Ideal was made according to 7 indicators. The advantage of the New Service is demonstrated, supported by illustrative material.

In the **Fourth chapter**, an improvement of the developed new banking service with modern ICT was created *in fulfillment of Task 3 of the set goal*. The improvement includes 1) the so-called "space profile", including data about the sender and the recipient, stored in the system's database with a view to faster and easier execution during the next use of the service; 2) recognition of biometric data (fingerprints, face, voice and other physical characteristics) using artificial intelligence for service security; 3) integration into the new service of a chatbot as an element of artificial intelligence (AI) with the aim of convenience for the client and quality of the new service.

In the **Fifth chapter**, the developed new banking service with modern ICT is validated by conducting experiments and analyzing the results *in fulfillment of Task 4 of the set goal*. The analysis is for a cosmic user profile; biometric identification; chatbot; the money transfer; mobile and web compatibility, integration with money transfer API; security of the use of biometric data in the new service. Probabilities of problems and errors in the functioning of the new service are analyzed and ways to overcome them are given.

**The reviewer did not find any plagiarism in the dissertation.**

### **3. Characterization and evaluation of the contributions in the dissertation work**

The research in the dissertation is focused on the most important aspect of world scientific research – creation of technology, product/service for the benefit of man. The peculiarity here is that it is necessary to take into account and integrate a number of directions in modern banking and information and communication technologies. At the same time, it is mandatory to ensure the security of bank transfers and the protection of users' personal data. These two basic requirements are the main pillar of the research, which are laid down and analyzed in detail in all chapters of the dissertation. The PhD student was able to analyze, summarize and integrate existing banking solutions and modern information and communication technologies in order to fulfill the dissertation objective. She studies and successfully applies in this integration modern modeling tools such as UML (Unified Modeling Language) and web standards such as EDI (Electronic Data Interchange), XML (Extensible Markup Language), SOAP (Simple Object Access Protocol) and WSDL (Web Service Description) Language).

Improvements (speed and security) have been developed to improve the new service. The improvement of the New Service with an element of artificial intelligence (chatbot) is made for the purpose of security and data protection. A comparison was made in a test environment between bank transfer, Aidil transfer and bank transfer using integration with Aidil and chatbot (New service) according to three indicators: time to create a transaction; shipment turnaround time and customer satisfaction. From the comparison it follows that the created new service is superior in all indicators to the existing two, with the third indicator having a significant advantage.

An additional improvement of the financial service is the integration into it of the so-called "space profile", which facilitates the user's interaction with various partners in 6 areas: personal information, transfers and financial data, transaction history, preferences and interests, payment process, generalized identifier, compatibility with the banking system. The advantage of this improvement of the New service has been proven in an experimental way by comparison with existing bank services - bank transfer and Idil transfer according to 6 indicators: time to create a sent transaction; transaction time; people who can use the service in a different location from the



bank serving them; objects from which the transaction can be sent to a different location than the bank servicing them; objects in which the transaction can be received in a different location from the bank servicing them; customer satisfaction. The advantages of the New service with a space profile compared to the existing solutions are in all indicators, which, in addition to a tabular form, is also visually shown with a radar diagram.

The new service with improvements (space profile and AI chatbot) improves the process of fast international money transfer and interaction between senders and beneficiaries by increasing convenience, efficiency and cyber security. This is beneficial for both the consumers and the bank.

Comparisons of the New Service with existing solutions have been made. The comparisons prove the advantages of the New Service on various indicators. Multi-criteria analyzes were performed on a set of indicators with corresponding radar charts. The analysis of the results is supported by illustrative material in the form of diagrams.

I highly appreciate the validation of the New Service (Chapter 5) through experiments, simulations and testing. In order to validate the service, various scenarios have been created for suspected risk situations in the operation of the New Service, which essentially represents a risk analysis for its use. The testing of the New Service with a space profile was carried out under three scenarios to ensure security; for bank transactions under two scenarios; for usability and integration under two scenarios. For biometric identification, 3 testing scenarios are proposed; in terms of security of use – 3 scenarios. When integrating the chatbot into the New Service, 2 testing scenarios are proposed.

In the analysis of the probability of problems and errors (risk) in the functioning of the New Service, ways to overcome them are given, which is a strong point of the study.

There is compliance of the chosen research methodology with the set goal and tasks of the dissertation work. I believe that the doctoral student successfully managed to realize the set goal and tasks of the dissertation and **I positively evaluate the results** obtained as **scientific-applied** and applied:

1. **An innovative approach was created** with the integration of modern financial and information and communication technologies, enabling the creation of a new banking service.
2. **A new banking service has been developed** with appropriate integration of existing banking technologies with modern information and communication technologies and communication standards.
3. **The new service is compared** with existing solutions and **its advantages** in terms of speed, users, cost and scope **are proven**.
4. **ICT enhancements of the new banking service** with the so-called "space profile" **have been developed** to extend the reach of the platforms along with the necessary security and protection of the user's personal data. Other improvements include the integration of artificial intelligence (chatbot) and user biometrics for speed of communications and security of personal data. The improved service has proven advantages and utility compared to existing banking technologies.
5. **The new service has been validated** by testing 15 scenarios on different indicators. A detailed analysis of the results and the risk of using the service has been made. For the suspected risky situations, methods are proposed to overcome them.

#### 4. Publications of the dissertation on the topic of the dissertation

The results of the research in the dissertation have been published in 8 scientific publications, of which one is in a journal [2] and 7 are in conference proceedings. At least two independent



reviewers reviewed the publications. Two of the publications are independent [6] and [7]. The rest are jointly with the research supervisor, and in five of them the doctoral student is in first place [1], [3], [4], [5], [8]. This gives me reason to conclude that they are **all the personal work of the PhD student**.

The minimum requirements regarding publication activity for acquiring the educational and scientific degree "Doctor" according to Regulation on the Implementation of the Development on Academic Staff in republic of Bulgaria Act (RIDASRBA) are **30 points**. According to indicators  $\Gamma 7 - \Gamma 8$ , the doctoral student **exceeds more than 3 times the minimum requirements** of the Regulations for the specific conditions for acquiring scientific degrees and holding academic positions at IICT-BAS. Her publications to section  $\Gamma 7$  "Scientific publications in publications that are referenced and indexed in world-famous databases with scientific information" are two: [1]  $20/2=10$  points and [8]  $20/2=10$  points. The publications under section  $\Gamma 8$  "Publications in non-refereed journals with scientific review or in edited collective volumes" are: [2]  $20/2=10$  points; [3]  $20/2=10$  p.; [4]  $20/2=10$  p.; [5]  $20/2=10$  p.; [6] 20 p.; [7] 20 p. In total, according to indicators  $\Gamma 7 - \Gamma 8$ , the doctoral student has **100 points**. This gives me reason to consider that the results related to the dissertation have become known to our and the international scientific community.

## **5. Evaluation of conformity of the Abstract and the Dissertation work**

The Abstract of 31 pages in Bulgarian and 30 pages in English **fully reflects** the research, main results and contributions of the dissertation.

## **6. Using the results obtained**

During the presentation of the thesis results to internal protection, interest from banking institutions in the new service developed by the PhD student was reported, which is a very good certificate for the work done. The achieved research results benefit both banking institutions and consumers.

## **7. Critical notes and Recommendations**

The dissertation is structured very well. Each of the tasks set for the realization of the purpose of the dissertation is developed in a separate chapter. When reading the publications of the doctoral student, it can be seen that a publication was made on each of the tasks of the dissertations. A positive side of the presentation is that in each chapter the doctoral student indicates articles/reports in which the results obtained to achieve the goal of the dissertation were published. As an omission, I note the implicit citation of the author's publications. For example, on page 59 of the Dissertation at the end of §2.5 appears [Publication 3], which means that the research in this chapter is published in publication 3 of the List of Dissertation Publications; on page 75 of the Dissertation - [Publication 4]; page 81 - [Publication 1] etc.

In view of the future use of the synthesized new banking service, I recommend choosing a more appropriate name of the New service.

*Question:* How will the PhD student comment on Figure 14 on page 95 of the Dissertation (Figure 4 on page 17 of the Abstract) where communication flows do not reach their destination.

**The notes made are of a technical nature and do not detract from the contributions of the Dissertation.**

## 8. Conclusion

The Dissertation of Milvina Todorova Terzieva complies with the conditions of the ADASRB, RIDASRBA and the Regulations for the specific conditions in IICT-BAS.

The dissertation of Milvina Todorova Terzieva meets the conditions of ADASRB, RIDASRBA and the Regulations for the specific conditions in IICT-BAS. The dissertation contains scientific-applied results of an innovative nature. They have original contributions to science, which I appreciate **positively**. The objective of the dissertation work has been fulfilled. The candidate has knowledge in many areas of banking technologies, information and communication technologies, modern web standards, applying them successfully in the synthesis of a new information and communication service in the financial field. She demonstrates an ability for independent research and successful implementation of solved problems. I consider the dissertation's contributions to be significant for the banking industry and consumers. **I strongly recommend to the Honorable Scientific Jury the awarding of the educational and scientific degree "Doctor" to Milvina Todorova Terzieva in the field of higher education 5. Technical sciences, professional direction 5.3. Communication and computer technology in the doctoral program "Computer systems, complexes and networks".**

14.02.2024

Member of the Scie.  
/Prof

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