

## REVIEW

**By Prof. Asya Georgieva Stoyanova-Doycheva, PhD**

Faculty of Mathematics and Informatics at the University of Plovdiv “Paisii Hilendarski”

of a dissertation for awarding the educational and scientific degree “**doctor**”

in field of higher education

*4. Natural sciences, Mathematics, and Informatics,*

professional field

*4.6. Informatics and Computer Science*

doctoral program

*Informatics*

**Author of the dissertation:** *Irina Krasimirova Krasteva*

**Topic:** **Blockchain-based synchronization of personal assistants**

**Scientific supervisor:** *Prof. Stanimir Stoyanov, PhD,*

*Faculty of Mathematics and Informatics at the University of Plovdiv “Paisii Hilendarski”*

### **1. General presentation of the submitted materials**

By order № RD 21-236 of 29 January 2024 of the Rector of the University of Plovdiv “Paisii Hilendarski” (PU), I have been appointed as a member of the scientific jury to participate in a procedure for the defence of a dissertation on the topic of **Blockchain-based synchronization of personal assistants** for acquiring the educational and scientific degree “doctor” in field of higher education 4. Natural sciences, Mathematics, and Informatics, professional field 4.6. Informatics and Computer science, doctoral program Informatics. The author of the dissertation is Irina Krasimirova Krasteva – a full-time doctoral student at the Department of Software systems, with scientific supervisor Prof. Stanimir Nedyalkov Stoyanov from FMI at the University of Plovdiv “Paisii Hilendarski”.

The set of materials presented to me by Irina Krasimirova Krasteva on electronic media is in accordance with Article 36 (1) of the Law on the Development of the Academic Staff of the University of Plovdiv and includes the following documents:

- an application form to the Rector of PU for initiating a procedure for the defense of a dissertation work;
- CV in European format;
- minutes from the department council related to reporting the readiness to open the procedure and preliminary discussion of the dissertation;
- a dissertation;
- an abstract in Bulgarian and in English;

- a list of scientific publications on the topic of the dissertation;
- copies of the scientific publications;
- a declaration of originality and authenticity of the attached documents;
- a certificate of compliance with the minimum national requirements;
- a certificate for participation in projects from the Department for Scientific Research;
- an opinion of scientific supervisors on the readiness of the dissertation for defence before a scientific jury.

The doctoral student has submitted 4 publications.

## **2. Brief biographical data for the doctoral student**

Irina Krasteva graduated from Plovdiv University "Paisii Hilendarski", Faculty of Mathematics and Informatics, with a Bachelor's degree in 2010 and from the University of Plovdiv with a Master's degree in 2015, majoring in Financial Management. Irina Krasteva has been an assistant professor at the Computer Systems Department since 2019 and a full-time PhD student at the same department since 2018. Irina Krasteva teaches classes in the discipline "Software Technologies", where the main direction is the documentation and analysis of object-oriented software products using the Unified Modeling Language. Irina Krasteva has also taught an elective course for masters students on Blockchain Technologies.

## **3. Relevance of the topic and appropriateness of the set goals and tasks**

The topic of blockchain-based synchronization of personal assistants is interesting and relevant. It provides an opportunity for innovation in technology, combining intelligent personal assistants with Blockchain technologies. The main objective of the research is to analyze and conduct experiments on the synchronization of intelligent personal assistants with Blockchain technologies, proving that this approach is meaningful, effective and usable. An additional goal is the development and testing of Blockchain-based models synchronized with personal assistants and their application to different adaptations of the Virtual-Physical Space ViPS.

Many projects and research are using Blockchain for various applications including data management, cyber security, identification and in the field of artificial intelligence. The implementation of Blockchain in multi-agent systems is part of a broad trend of innovation in digital technologies.

Considering the objectives of the dissertation, it can be said that the topic is relevant and reflects on the possibility of improving security, trust, transparency and data management in multi-agent systems by meeting modern requirements for smart and safe technologies.

#### **4. Knowledge of the research problem**

Irina Krasteva has a wide knowledge in the field of the studied problem, which can be seen from the large number of literature sources cited in the bibliographic reference of the dissertation (Sources) - 150 sources. Also in Chapter 1 "Motivation and Research of the Problem Statement" of the dissertation, the PhD student consistently discusses the possibilities of using Blockchain technologies in synchronization with agents in a multi-agent cyber-physical system. Basic concepts and technologies related to Blockchain, types of Blockchains, decision making techniques in Blockchains, applications using Blockchains, major issues related to Blockchain technologies are presented. The doctoral student also discusses the ideas and technologies of the built Virtual Physical Space (ViPS), what basic properties and characteristics the personal assistants have in the built ViPS. All this gives me reason to believe that the PhD student knows well the field of the research problem.

#### **5. Research methodology.**

The chosen methodology for the development of the dissertation follows the objective. Firstly, the main characteristics of Blockchain technologies and personal assistants are discussed. It is concluded that the synchronization between agents in a cyber-physical and social environment with a system built on blockchain technology can be realized by means of a specialized oracle blockchain agent.

In order to achieve the main objective, which is "To analyze and conduct experiments on reconciling intelligent personal assistants with blockchains", the following tasks are formulated:

1. Development and testing of a model of "Electronic School Diary", built on the basis of synchronization between intelligent agents and using Blockchain technologies in the framework of adaptation of reference architecture in the field of secondary education.

2. Development and testing of a model for the application of technology in the adaptation of the ViPS architecture in smart agriculture.

The presented models for the "Electronic School Diary" and the application in smart agriculture serve as concrete examples of the possibilities of blockchain-based synchronization of personal assistants. The experimental approach, by creating a prototype and conducting experiments, demonstrates the possibility of successfully integrating Blockchain technologies in multi-agent systems.

## 6. Characteristics and evaluation of the dissertation work

The dissertation is 139 pages long with the literature included. The total number of literature sources used is 150, of which 8 are internet sources and 7 in Bulgarian.

The dissertation is structured in an Introduction, four Chapters, a Conclusion, a Bibliography, a declaration of originality of the contributions and publications on the dissertation.

The Introduction presents the problem addressed in the dissertation and gives a clear vision of the stated aim, additional goal and objectives.

The following is **Chapter 1** "Motivation and Research of the Problem Statement" - This section argues the need for the current research by presenting and summarising the key features, benefits and challenges of Blockchain technology. It also discusses the characteristics of cyber-physical and cyber-physical-social systems, with a focus on the Virtual Physical Space (ViPS) reference architecture. Conclusions are drawn for the application of Blockchain technology in multi-agent systems.

The **second chapter** discusses BLISS (Brezovo`s Learning School Space), which is an adaptation of the ViPS reference architecture to support the learning process in the secondary school. Its architecture is discussed in detail. This is followed by a description of the School Diary module, which is implemented as a multi-agent system and Blockchain. Blockchain oracle (BO) is used to record the grades from the Data Module of the electronic school register (DMSD) in the blockchain. The development of a model system that manages and coordinates documents with factory numbering is presented, where Blockchain technology is also used.

The **third chapter** presents the application of Blockchain technology in multi-agent system and adaptation of ViPS in agriculture. A concept for using the personal assistant-blockchain model to solve problems related to intelligent agriculture is proposed - the implementation of a validator of new seed samples in the National GeneBank (GeneBank Validator) and a store for selling or exchanging seed samples and their use in actual production (GeneBank Store). The Validator of new seed samples has been developed as a separate blockchain channel GeneBank Validator. This channel is being developed as a closed system implemented as a Blockchain using the Hyperledger Fabric Blockchain, which aims to verify and validate each new plant variety. The GeneBank store is built as a consortium blockchain, and it itself consists of three different communication channels: a seed exchange channel, a donation channel, and a sale channel. Each individual channel has a different logic for operation, which requires the creation of different smart contracts - a smart contract in the donation channel between the genebank and a botanical garden is presented (Fig.

27). The GeneBank store is built as a multi-agent system - the smart Blockchain agents Oracle, PAClient and PAGen, and the communication between them are presented.

The **fourth chapter**, "Ideas and Future Plans," discusses two models for applying Blockchain technology in supply chains. A supply chain model linked to the National General Bank is described. The model has been implemented using Blockchain technology, looking at the process from receiving the seed from the National Genebank to its implementation. A model for synchronization of Blockchain for wine production and distribution with Personal Tourist Guide is considered. In the implementation of this service, blockchain synchronization is used to guarantee the origin of the wine bottle with a Personal Tourist Guide of the consumer.

The conclusion of the dissertation includes a summary of the results and related developments and publications presented in the table on page 112.

## **7. Contributions and significance of the work for science and practice**

The main contributions of the dissertation are of scientific and scientifically applied nature.

Four main results (p. 112) are defined in the dissertation work, which correspond to the set tasks (p. 111):

1. A general concept for blockchain-based information synchronization and interaction with personal assistants within a cyber-physical multi-agent system is established.

2. Concrete models have been created for the application of the developed concept in the adaptation of the reference ViPS architecture in the fields of education and smart agriculture.

3. Prototypes have been created to test the application of the developed models.

Each of the three results, corresponds to the development described in Chapters 2 and 3, so I accept the PhD student's claim of achieving the stated aim and additional objective of the thesis defined on page 8.

I believe that the reached results correspond to the normative requirement that they represent an "original contribution to science" (Art. 27(1) of the Rules for the Implementation of the Act for the Development of the Academic Staff in the Republic of Bulgaria).

## **8. Evaluation of the dissertation publications**

The author has submitted a list of 4 papers which are in proceedings of international conferences and reviewed journals. Three of the papers are in English and one in Bulgarian. Two of the publications numbered 1, 2 from the list of publications are refereed in Scopus. This satisfies the minimum national requirements of the Regulations for the Implementation of the Law on the Development of Academic Staff of the Republic of Bulgaria for a minimum of 30 points in indicator group G, where the PhD student has 36 points. The table on page 112 shows that the results have been reflected in the four publications on the thesis, which I am convinced of. The PhD student's publications are co-authored.

The PhD student has also participated in the project KP-06H36/2 of 13.12.2019 - Fundamental research 2019-2022 at the Scientific Research Fund, BG PLANTNET "Establishment of a national genebank information network - plant genetic resources" - funded by the Scientific Research Fund at the Ministry of Education and Science.

### **9. Personal participation of the doctoral student**

I have no doubts about the personal contribution of Irina Krasimirova Krasteva in the conducted dissertation research and in obtaining the relevant scientific-applied and applied results.

I have not found any plagiarism in the developments and results related to the dissertation work.

### **10. Abstract**

The abstract is in accordance with the requirements in Bulgarian and English, in the amount of 32 pages, meets the requirements for accurate, complete and concise coverage of the dissertation.

### **11. Critical remarks, recommendations and questions**

There are some incorrect citations in the bibliography of the thesis - ISBN or ISSN numbers of some of the publications are missing.

I have some questions for the doctoral candidate that are not discussed in the dissertation:

1. What is the expected speed of transactions in the Blockchain network for the "Electronic School Diary" and what steps could be taken to ensure the scalability and efficiency of the system as the number of users increases?
2. Why did you choose Hyperledger Fabric and what criteria did you consider when choosing the Blockchain platform for the implementation of the prototypes?

3. In relation to the model of a system that manages and coordinates documents with fabric numbering, if the system is extended ( considering that each school is a node in the system) in the future, how would you ensure scalability and easy extension of the Blockchain network?

I would recommend the Ph.D. student to focus their efforts on one of the application areas of Blockchain technology and continue their research on the dissertation topic.

Despite the comments made, which do not affect the quality of the presented dissertation work, I must note that the topic of the dissertation is current, and the achieved results deserve high praise. The doctoral student has shown in-depth knowledge of the field and the ability for independent scientific research in her work.

## **12. Personal impressions**

I know Irina Krasteva from her work as an assistant professor and PhD student in the Department of Computer Systems. My personal impressions are that she is extremely responsible, works easily in a team and does her job as an assistant with great diligence and honesty.

## **CONCLUSION**

The dissertation contains **scientific-applied and applied results**, which represent an original contribution to science and meet all the requirements of the Act for the Development of the Academic Staff in the Republic of Bulgaria, the Rules for the Implementation of the Act for the Development of the Academic Staff in the Republic of Bulgaria (ADASRB), and the relevant Rules of the University of Plovdiv “Paisii Hilendarski”. The presented materials and dissertation results fully correspond to the minimum national requirements in the Rules for the implementation of the ADASRB.

Due to the above, I confidently give my **positive** assessment of the conducted research, presented by the above-reviewed dissertation work, abstract, achieved results, and contributions, and I propose to the honorable scientific jury to award the educational and scientific degree “doctor” to Irina Krasimirova Krasteva in field of higher education: 4. Natural sciences, Mathematics, and Informatics, professional field: 4.6. Informatics and Computer Science, doctoral program: Informatics.

05.02.2024

Plovdiv

Reviewer: .....

Prof. Asya Stoyanova-Doycheva, PhD