REVIEW

by Prof. Dr. Irina A. Radeva – IICT - BAS

of a dissertation for obtaining the educational and scientific degree

"Doctor"

in professional field 4.6. "Informatics and Computer Sciences"

doctoral program "Informatics"

on the topic **"Modelling and Optimization of Communication Strategies In Information Process Management"**

by **Gergana Petkova Mateeva**

By Order No. 265/31.10.2025 of the Director of IICT-BAS, Corresponding Member D.Sc. Svetozar Margenov, based on Art. 4, Para. 2 of the Act on the Development of Academic Staff in the Republic of Bulgaria and the decision of the Scientific Council of IICT (Protocol No. 8/29.10.2025) in connection with the procedure for obtaining the educational and scientific degree "Doctor" in professional field 4.6. "Informatics and Computer Sciences" doctoral program "Informatics" by Gergana Petkova Mateeva with a dissertation on the topic "Modelling and Optimization of Communication Strategies in Information Process Management", I have been appointed as a member of the Scientific Jury.

In evaluating the dissertation, the conditions of the Act on the Development of Academic Staff in the Republic of Bulgaria (ADASRB), RAADASRB (Decree No. 26 of February 13, 2019) and the Regulations for the Specific Conditions at IICT - BAS for applying the law are decisive and therefore will be accurately presented:

1. According to Art. 27 (1) of RAADASRB "the dissertation must contain scientific or applied scientific results that represent an original contribution to science. The dissertation must show that the candidate possesses in-depth theoretical knowledge in the relevant specialty and capabilities for independent scientific research".
2. According to Art. 27 (2) of RAADASRB "the dissertation must be presented in a form and volume corresponding to the specific requirements of the primary unit. The dissertation must contain: title page; introduction; exposition; conclusion - summary of the obtained results with a declaration of originality; bibliography".

According to RAADASRB, the minimum number of points by indicator groups for "Doctor" are:

Indicator Group	Content	Number of Points
A	Indicator 1	50
G	Sum of indicators 5 to 10	72

The scientific supervisor of the dissertation is Prof. Dr. Tatyana Atanasova.

The dissertation is 135 pages in volume, with 47 figures, 9 tables, a bibliography of 137 sources and includes:

- Abbreviations used in the dissertation (5-6);
- Dictionary of key terms used in the dissertation (7-13)
- Introduction (14);
- Chapter 1. "Contemporary Trends in Developing Communication Strategies for Information Process Management" (16-59);
- Chapter 2. "Methods for Heuristic Optimization of Communication Strategies in Information Process Management" (60-91);
- Chapter 3. "Models for Communication Strategies in Information Process Management in Digital Environments: Technical and Architectural Aspects" (91-117);
- Conclusion and summary of obtained results (117-118);
- Directions for future research (119);
- Publications on the dissertation topic (120);
- Noted citations (121-123);
- Declaration of originality of results (125);
- Bibliography (126-135).

The formulated purpose (p. 59) of the dissertation is: "To develop models and methods for optimizing communication strategies in information process management."

For this purpose, the following tasks are defined:

1. To develop heuristic methods for optimizing communication strategies in information process management in digital environments.
2. To propose a modification of genetic algorithms for optimizing communication strategies in information process management.
3. To propose a method for improving the efficiency of genetic algorithms for information process management purposes.

4. To develop models that allow effective implementation and application of the developed heuristic methods on heterogeneous mobile and IoT devices in distributed digital environments with limited resources.
5. To propose an approach for evaluating the effect of applying the developed models and methods for optimizing communication strategies for managing information flows in distributed digital environments."

RELEVANCE OF THE TOPIC AND APPROPRIATENESS OF THE STATED GOALS AND TASKS

The dissertation addresses a relevant problem that lies at the intersection of distributed computing, IoT systems, and mobile devices with limited resources. The topic is timely, considering the proliferation of IoT devices, the growing importance of edge computing, and the need for intelligent distributed systems and cyber-physical systems. The focus on communication strategies in information process management responds to real practical challenges, where organizations increasingly rely on distributed digital infrastructures that require intensive data flow and rapid decision-making processes. The integration of heuristic optimization methods with practical architectural solutions bridges the gap between theoretical algorithm development and real implementation constraints, aligning with current research directions in Edge AI, federated learning, and distributed intelligent systems.

The main goal of the dissertation is appropriate and well-formulated. It is broad enough to encompass multiple research contributions while remaining focused on a specific area, indicating theoretical development and practical orientation. The four tasks are well-defined and logically structured. The coherence between the topic, goal, and tasks demonstrates consistency and clear research focus. The scope is appropriate for a doctoral dissertation.

RESEARCH METHOD

The dissertation employs an approach that combines theoretical development, algorithm design, experimental validation, and practical application.

The study analyses existing communication models, theoretical frameworks, and contemporary trends to identify gaps in current approaches to optimizing communication strategy in distributed environments with limited resources. Heuristic techniques are developed through modification of genetic algorithms, with the DNA-inspired modification introducing chromosome pairs with inverted bits, while the adaptive approximation uses Lagrange polynomial curves to reduce computational complexity.

The proposed algorithms are validated through controlled experiments with benchmark optimization functions, comparing standard GA with modified versions in multiple test scenarios, and quantitatively measuring performance through MAE and RMSE metrics for financial time series forecasting and game optimization applications.

The practical framework deploys algorithms on mobile and IoT devices and uses client-server architecture with Android OS API, Content Providers for modular data management, external libraries, and local SQLite storage. The framework is validated through implementation of a CPS/IoT system for intelligent farm monitoring, SWOT analysis to evaluate system performance in the production environment. To identify relative advantages and design trade-offs, the study compares different approaches including communication models, architectural models, and algorithm performance.

CHARACTERISTICS AND EVALUATION OF THE DISSERTATION

Chapter 1 is the theoretical foundation of the research. It examines information processes in digital environments and presents communication models - from linear (unidirectional sender-receiver) and interactive (with feedback) to transactional (simultaneous co-creation).

The chapter explores theoretical frameworks, including the Shannon-Weaver model, models based on autonomous software agents, hierarchical and decentralized structures, game theory approaches, and simulation techniques.

Five core components of contemporary communication strategies are identified: ICT integration providing infrastructure and tools, strategic message planning and management, organizational process integration across functions, human factors and cultural context, and monitoring/evaluation/adaptation mechanisms.

The chapter analyses the role of ICT in decision-making and knowledge management processes, then presents implementation challenges: complex organizational structures, decentralized data sharing, communication control issues, dynamic requirements, and technological integration barriers. Contemporary trends reviewed include AI-driven automation, cloud-based collaboration platforms, IoT and Edge Computing integration, blockchain and cybersecurity, adaptive and context-aware systems, and emerging technologies such as quantum communication, 5G/6G networks, and holographic interfaces. The chapter concludes with formulating the dissertation's research objectives.

Chapter 2 presents three developments for optimizing communication strategies using heuristic techniques.

The first is a DNA-inspired genetic algorithm (GA) modification where chromosomes exist as twin pairs with inverted bits, with each pair sharing the same fitness value to improve search space exploration and maintain population diversity. This modification is implemented using the openGA library in C/C++ and tested on benchmark optimization functions.

The second development introduces adaptive fitness function approximation using Lagrange polynomials with a self-adjusting pool of best solutions that adjusts based on time. When approximate solutions appear better, they are verified against the original fitness function, and the pool is dynamically updated by adding new best solutions and removing worst ones. Three experiments compare standard GA with GA with approximate fitness function in the context of game optimization for slot machine symbol arrangement RTP.

The third component investigates random number generation and scaling, comparing Mersenne Twister (PRNG) with TrueRNG v3 (TRNG) through statistical measures including entropy, chi-square distribution, Monte Carlo Pi estimation, and serial correlation. Demonstrated applications include financial time series forecasting through sinusoidal function series with linear components and distributed computing on mobile devices, with evaluation metrics using MAE and RMSE.

Chapter 3 describes the architectural framework for implementing heuristic methods in distributed systems with limited resources. Android Content Providers are proposed as a modular mechanism for data management in mobile distributed computing, implementing a client-server architecture with HTTP/JSON RESTful communication, where the server manages the global population and mobile clients perform local computations.

Technical implementation uses Android OS API, including Services for background operations, LiveWallpaper for visualization, and Widgets for user interaction, along with external Java libraries (Encog for neural networks, MOEA Framework for optimization, JSON-java and HttpClient for communication) and local SQLite storage. The chapter examines CPS/IoT challenges: data heterogeneity, noise, lack of standardization, and scalability limitations.

Cloud-Based IoT using AWS infrastructure for automated scaling and analysis is proposed. SWOT analysis identifies the system's strengths, weaknesses, opportunities, and threats.

Four architectural models are compared: client-server (centralized management), peer-to-peer (decentralized), event-based publish-subscribe (asynchronous messaging), and layered architecture (task separation).

Communication optimization techniques include adaptive models, energy-efficient routing, data aggregation, and "island model" for distributed GA, where each device maintains a local population with minimal synchronization.

The framework is validated through a CPS/IoT farm monitoring system. Future directions discussed include integration with federated learning, multi-agent systems with game theory-based negotiations, and the impact of 5G/6G networks and quantum communication.

RESULTS IN THE DISSERTATION

The results obtained in the dissertation can be systematized as follows:

1. Methods for improving genetic algorithm efficiency in networked environments:
   - genetic algorithm (GA) modification that improves search space exploration and maintains population diversity in complex optimization problems.
   - adaptive method for approximating computationally expensive fitness functions (Lagrange polynomial technique for approximating time-consuming fitness functions).
2. Architectural model for deploying computationally intensive optimization algorithms (such as GA) on heterogeneous mobile and IoT devices with limited resources, through asynchronous communication protocols and modular and buffered data management.
3. Validated implementation for intelligent monitoring and data processing in smart livestock farming, which uses:
   - quantitative performance indicators for evaluation through standard metrics such as Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) to assess forecast accuracy and optimization algorithm efficiency;
   - SWOT analysis to contextualize system strengths and weaknesses and validate design decisions against key challenges such as data quality, interoperability, and resource constraints.

I accept that the obtained and presented results cover the scope of the stated goal and tasks. All stages of preliminary research, analysis, preparation, development, and experiments are correctly documented and describe the scope of possible theoretical and practical applications. The results presented in the dissertation have potential for further development.

The abstracts are in Bulgarian and English, 45 and 48 pages respectively, and present the dissertation work.

PUBLICATIONS ON THE DISSERTATION TOPIC

7 publications are presented on the dissertation topic: all in proceedings of international conferences indexed in Scopus; co-authored, in English. One publication is in Web of Science (No. 1). Gergana Mateeva is first author on 6 publications (Nos. 1, 2, 3, 4, 6, and 7).

Gergana Mateeva's scientometric indicators in Group G exceed the minimum specific requirements of IICT - BAS for obtaining the educational and scientific degree "Doctor": with minimum requirements of 30 points, 72 points have been achieved.

In the presented list of noted citations, there are 22 citations of 2 publications (Nos. 4 and 5), of which 21 citations are of the publication "Dineva K., Atanasova T., Petrov P., Parvanov D., Mateeva G., Kostadinov G. Towards CPS/IoT System for Livestock Smart Farm Monitoring. 2021 International Conference Automatics and Informatics (ICAI), IEEE, 2021, ISSN:978-1-6654-2661-9, DOI:10.1109/ICAI52893.2021.9639460, 252-255

The conditions of RAADASRB and The Regulations for the specific conditions of IICT-BAS are fulfilled.

Gergana Mateeva has participated in two projects: National Science Program "Intelligent Livestock Farming" and "Research on Methods and Technologies for Digitalization of Education".

REMARKS AND QUESTIONS

1. The term "communication strategy" is used in the title and goals of the dissertation, but no definition is provided that links organizational communication (Chapter 1) with algorithmic optimization (Chapters 2-3). How is "communication strategy" formally defined within this dissertation?
2. The dissertation describes the framework for optimizing communication strategies as "holistic hybrid" and as "hybrid" with a "holistic approach", but does not give a clear definition of these terms. What specifically makes the proposed framework "holistic" and what makes it "hybrid"?
3. In the dissertation it states "A new technique has been developed using Lagrange polynomials to approximate time-consuming objective functions. This method significantly reduces computational and communication traffic, making GA application feasible on resource-constrained devices where direct evaluation would be prohibitive. The adaptive nature of the approximation set represents a self-optimizing mechanism within the algorithm itself." (p. 90); "The adaptive nature of

the approximation set represents a self-optimizing mechanism within the algorithm itself." (p. 118). What criteria define a "self-optimizing mechanism" for the approximation method?

CONCLUSION

The dissertation contains applied scientific results that represent an original contribution to science and **meet all requirements of ADASRB, RAADASRB, and the Regulations for the specific conditions at IICT - BAS.**

Based on the above, **I confidently give my positive assessment of the presented dissertation, abstract, and achieved results, and propose to the esteemed scientific jury to award the educational and scientific degree "Doctor" to Gergana Petkova Mateeva in the field of higher education 4. Natural Sciences, Mathematics and Informatics, professional field 4.6 "Informatics and Computer Sciences", doctoral program "Informatics".**

20.11.2025

R ...

НА ОСНОВАНИЕ
ЗЗЛД