O P I N I O N

by Prof. Dr. Irina Aleksandrovna Radeva – Institute of Information and Communication Technologies – BAS

on a dissertation for the award of the educational and scientific degree "Doctor"

Higher education area: **4. Natural Sciences, Mathematics and Informatics**

Professional field: **4.6. Informatics and Computer Sciences**

Doctoral programme: **Informatics**

Author: **Laska Delkova Kostadinova-Tsankova**

Topic: **Modelling of an Intelligent Supply Chain in Smart Agriculture Systems**

Scientific supervisor: **Assoc. Prof. Dr. Emil Hristov Doychev**

1. General Presentation of the Procedure and the Doctoral Candidate

By Order No. RD-22-692/30.03.2026 of the Rector of Plovdiv University "Paisii Hilendarski" Prof. Dr. Rumen Mladenov, in connection with the open procedure for the defence of a dissertation on "Modelling of an Intelligent Supply Chain in Smart Agriculture Systems" for the award of the educational and scientific degree "Doctor" in higher education area 4. Natural Sciences, Mathematics and Informatics, professional field 4.6. Informatics and Computer Sciences, doctoral programme Informatics, by Laska Delkova Kostadinova-Tsankova – part-time doctoral candidate at the Department of "Computer Systems" with scientific supervisor Assoc. Prof. Dr. Emil Hristov Doychev, report No. RD-21-656/30.03.2026 by Prof. Dr. Angel Atanasov Golev – Dean of the Faculty of Mathematics and Informatics, and in accordance with Art. 4 of the LDASRB, Art. 2 (2), Art. 30 (3) of the RILDASRB and Art. 37 (1) of the RDASPU, I have been appointed as a member of the scientific jury.

As a member of the scientific jury, a complete set of documents has been received: dissertation, abstract in Bulgarian, abstract in English, curriculum vitae, list and full-text copies of publications, declaration of originality, statement of compliance with the minimum national requirements, minutes of the preliminary discussion at the Department of "Computer Systems" from 13.03.2026, opinion of the scientific supervisor, accompanying administrative documents. The submitted documentation complies with the requirements of Art. 36 (1) of the RDASPU, and the composition of the scientific jury – with Art. 31 (1) of the RILDASRB and Art. 9 (1) of the LDASRB.

The doctoral candidate Laska Delkova Kostadinova-Tsankova has graduated from Plovdiv University "Paisii Hilendarski" with the degree of "Master" in computer technologies with the professional qualification of informatician-economist (1994–1999) and with the degree of "Master"

in macroeconomics with the specialization "organization and technology of accounting" (1999–2002). She also holds a Master's degree in Finance and Accounting, Financial Audit, from Varna Free University "Chernorizets Hrabar", Varna (2018–2020). Since 2022 she has been a part-time doctoral candidate at the Department of "Computer Systems" of the FMI at PU "Paisii Hilendarski". Her professional experience covers more than twenty years of accounting and consulting practice, including as manager of "ZOP Consulting" Ltd. – a company specialised in public procurement. This combination of engineering, economic and expert-practical qualification provides the doctoral candidate's unique perspective on the topic of the dissertation.

2. Relevance of the Topic

The topic of the dissertation is unquestionably relevant in the context of the digital transformation of the public sector and the growing need for integrated risk management in supply chains serving strategic public institutions – kindergartens, schools, hospitals and social-service establishments. The research is set within the current problem framework of the pandemic, geopolitical and inflationary shocks that have, in recent years, exposed the vulnerability of classical linear logistics chains. In this sense, the work addresses a topic of high public significance and is consistent with contemporary scientific and applied efforts towards building adaptive, transparent and knowledge-based logistics systems in the public sector.

3. Familiarity with the Problem

The dissertation demonstrates an in-depth familiarity with the problem area in three dimensions. In theoretical-analytical terms, Chapter One presents classical and contemporary definitions of "supply chain", the main models (continuous flow, fast chain, agile and hybrid model), the typology of risks and vulnerabilities, as well as real examples from leading companies – Nestlé, Walmart, Kaufland, Amazon, McDonald's, Starbucks and Tesla. Basic concepts of intelligent supply chains, such as Direct-to-Consumer and On-Demand Supply, are also considered.

The bibliography contains 234 titles from the fields of informatics, computer sciences and economics, which demonstrates the interdisciplinary character of the research and a command of a wide theoretical context. Both classical works of Christopher, Chopra and Hayes and contemporary sources from McKinsey, Gartner, IEEE and Springer are included.

In practical-applied terms, the doctoral candidate brings into the research her own professional experience as manager of a consulting company in the field of public procurement. This practical knowledge is evident in the choice of a concrete object – a supplier company of food products for kindergartens in the Municipality of Plovdiv – and in the detailed modelling of the actual logistics processes, regulatory constraints and procedural specifics of public deliveries.

4. Research Methodology

In the introduction of the dissertation (p. 13), the author formulates the main goal as follows: "The main goal of the present dissertation is to develop a model of an intelligent supply

chain. A prototype implementation of the model is to be integrated into the existing ZEMELA platform, achieving integration between the platform and the logistics system of a supplier company of food products carrying out deliveries to childcare establishments on the territory of the Municipality of Plovdiv."

To achieve the goal, the following tasks are formulated (p. 13): "1. Analysis of contemporary supply chains and their integration into platforms for smart agriculture. 2. Development of a model and architecture of the system. 3. Prototype implementation."

An approach for the execution of these tasks is presented in the section "Research Methodology" (pp. 14–15) in eight consecutive steps – critical analysis of the specialized literature, identification of the object and formulation of the research questions, systematization and assessment of the existing platforms, decomposition of the problem, development of a new version of the event model, design of an architecture for integration with the ZEMELA platform, development of a reference architecture and prototype of a personal assistant, demonstration of the applicability.

The goal of the dissertation is formulated specifically and binds together three components – a theoretical model of an intelligent supply chain, a prototype implementation of this model, and its integration into an existing smart-agriculture platform. The tasks set are derived from the goal and cover the main stages of the development: analytical review, modelling and architecture, prototype implementation and validation. The adopted methodology corresponds to the requirements of Art. 27 (1) of the RILDASRB regarding the scientific-applied character of the dissertation.

5. Characteristics and Assessment of the Dissertation and the Contributions

The dissertation is 212 pages in volume and includes: introduction, five chapters, conclusion, main results of the dissertation, tabular presentation of the relations between results, goals, tasks and publications, full list of the author's publications, list of publications cited in the dissertation, full list of projects, observed citations, acknowledgements, bibliography, declaration of originality, 64 figures and 19 tables. The structure complies with the requirements of Art. 27 (2) of the RILDASRB.

Chapter One is an analytical review establishing the theoretical basis of the research. Chapter Two is composed of two main parts – research methodology and conceptual framework. In the methodology, the author works on a real object – a supplier company of food products for kindergartens in the Municipality of Plovdiv – and uses SWOT analysis, mapping of the logistics flows and key performance indicators. In the conceptual framework, a model of integrated supply chain performance measurement (ISCPM) is introduced.

Chapter Three is substantive for the dissertation and contains the event machines developed by the author, based on Mealy and Moore finite-state automata, as well as an event machine based on the STRIPS concept. Scenarios are demonstrated for avoiding duplication of orders, managing combined deliveries and permuting the sequence of order execution.

Chapter Four presents the technological basis of the development. The integration of Flex Expert System into the LPA software package, the connection with Prolog, the architecture, functionalities and applications of Flex are described, as well as its advantages and limitations for the development of rule-based systems. However, a comparative analysis is missing here, establishing the choice of precisely this environment for the development of expert systems. Such a comparison would have strengthened the argumentation for the choice of technological platform.

Chapter Five presents the implemented prototype – architecture, event machine with rules for forward and backward chaining, knowledge base, user interface, use of templates, and sample sessions for generating delivery schedules of food products to kindergartens. The implementation demonstrates the operability of both inference methods over the same input data and confirms the practical applicability of the developed approach. It deserves to be noted that, in the demonstration sessions (pp. 179–181), forward chaining and backward chaining over the same factual base generate an identical delivery schedule. This confirms the functional correctness of the machine but leaves open the question of scenarios in which the parallel implementation of the two approaches would have added value. This observation does not diminish the contribution but outlines a direction for more in-depth discussion.

The formulated goal and tasks have been fulfilled in accordance with the scope of the dissertation. The event model developed in Chapter Three and the technological basis described in Chapter Four cover the first and second tasks. The prototype implemented in Chapter Five, integrated into the ZEMELA platform, fulfils the third task and demonstrates the applicability of the approach to a real scenario of public deliveries of food products.

It is appropriate to note that the three tasks formulated in the introduction have a relatively high degree of abstraction and do not fully reflect the actual scope of the work performed. In the section "Research Methodology", the tasks are unfolded into eight operational steps, while in the summary table on pp. 185–188 the author systematizes a total of nine scientific and applied contributions. This discrepancy requires more attention when tracing the relations "task – step – contribution – chapter – publication". A positive assessment is precisely deserved by the author's effort to provide such a table, which makes this reverse check possible.

An advantage of the system proposed by the author is the choice of a hybrid architecture in which an event-driven model, on the basis of Mealy and Moore finite-state automata and the STRIPS concept, is combined with an expert-system model, based on production rules and logical inference. In this architecture, the two approaches are supplemented with a template mechanism, which improves the readability of the knowledge, and with bidirectional inference – forward chaining and backward chaining – over a common factual base. Such a configuration provides two different perspectives on the same logistics scenario – a generative one (from facts to schedule) and a goal-oriented one (from query to justification).

The assessment of the dissertation requires noting an internal tension between the theoretical framework and the prototype implementation. The thesis of the dissertation (p. 12)

places risk management as a foundational principle, and Chapter 1 examines extensively the risks, vulnerabilities and disruptions in supply chains (sections 3.1–3.7, pp. 53–69). In the prototype of the system (Chapter 5, pp. 162–182), however, risk events do not find direct reflection in the event machine. This discrepancy is a prerequisite for future further development of the dissertation.

The research work has been carried out within the framework of the author's participation in project BG05M2OP001-1.001-0003 "Centre of Excellence in Informatics and ICT" at Plovdiv University "Paisii Hilendarski", as well as in project KP-06-M62/2 "Modelling of Knowledge in the Field of Bulgarian Folklore" at the National Science Fund. This indicates the research environment in which the proposed solutions have been formed and developed and confirms the continuity with the long-standing efforts of the Department of "Computer Systems" in building the ZEMELA platform.

On the basis of the results declared by the author and the analysis of the dissertation, I accept the following contributions, grouped in two directions.

Scientific-applied contributions

1. Systematic analysis and classification of the models and approaches for supply-chain management, with identification of the main factors that influence the efficiency of the logistics processes in public deliveries of food products to childcare establishments.

2. Conceptual model and architecture of an intelligent supply chain as an extension of the ZEMELA platform, tailored to the specifics of public procurement.

3. Approach for integration of the event model into a smart-agriculture platform, which supports the applicability of artificial intelligence, logical inference and adaptive behaviour in a real logistics environment.

4. Approach for integration of heterogeneous information sources, by means of ontologies and information-extraction methods, supporting the architecture of the ZEMELA platform.

Applied contributions

1. Architecture of a prototype supply-chain management system, based on event models and a knowledge base, with event machines built on Mealy and Moore automata and the STRIPS concept.

2. Prototype implementation and test scenarios for generating a delivery schedule of food products to kindergartens, with forward and backward chaining over a common factual base.

The contributions listed are realistic, correspond to the scope of the dissertation, and meet the requirements for the award of the educational and scientific degree "Doctor".

6. Assessment of the Publications and the Personal Contribution of the Doctoral Candidate

In the dissertation, a "Full List of Publications" with ten authored titles is presented, and in the "List of Publications Cited in the Dissertation" two of them are indicated – publications Nos. 8 and 9 according to the numbering of the full list:

– Kostadinova-Tsankova, L., Stoyanov, S., Tabakova-Komsalova, V., Stoyanov, I., Stoyanova-Doycheva, A., Wassilew, K. "Intelligent Supply Chain Management, Emphasizing the Public Procurement Requirements for Supplying Food to Kindergartens". International Conference Automatics and Informatics 2025 (ICAI'25), Varna, Bulgaria, IEEE, Scopus, https://ieeexplore.ieee.org/document/11324961.

– Malinov, P., Kostadinova-Tsankova, L., Madanska, S., Stoyanov, I., Doychev, E., Wassilew, K. "Cross-Platform Integration of Ontologies and Information Extraction for Plant Genetic Resources for the Bulgarian National GeneBank". International Conference Automatics and Informatics 2025 (ICAI'25), Varna, Bulgaria, IEEE, Scopus, https://ieeexplore.ieee.org/document/11324786.

Both publications are in English, in co-authorship. In publication No. 8 the doctoral candidate is the first author, and in publication No. 9 she is the second author of a six-member authorial team. The publications are in the proceedings of the International Conference Automatics and Informatics 2025 (ICAI'25), indexed in Scopus and accessible in IEEE Xplore.

Publication No. 8 presents the intelligent system for the management of deliveries to kindergartens and the expert system as a component of the ZEMELA platform – directly related to the main results of the dissertation. Publication No. 9 presents the approach for integration of ontologies and information extraction – a methodological instrument used in the architecture of the ZEMELA platform, also directly related to the dissertation.

A separate section "Publications on the Dissertation" is not provided. The reviewer is expected to derive indirectly that the two cited publications correspond precisely to the publications on the dissertation.

In the dissertation, the section "Observed Citations" is presented, in which one citation of publication No. 3 from the full list is indicated.

The personal contribution of the doctoral candidate in the publications and in the dissertation is unquestionable. According to the submitted statement, the author meets the minimum national requirements for the award of the educational and scientific degree "Doctor" in area 4. Natural Sciences, Mathematics and Informatics – Group A (50 points for the dissertation) and Group D (36 points for two publications indexed in Scopus, against 30 required points), totalling 86 points.

7. Abstract

The abstracts in Bulgarian (32 pages) and in English (30 pages) adequately present the content of the dissertation and comply with the requirements of Art. 36 (1) item 7 of the RDASPU. The structure follows the chapters of the dissertation, the main formulations of the goal, tasks and contributions are synchronised, and the main illustrations and results are reproduced in reduced form. The English abstract corresponds in content to the Bulgarian one and ensures accessibility for an international scientific audience.

8. Recommendations for Future Use of the Dissertation Contributions and Results

The dissertation contributions and results have potential for practical application in the public sector. The developed event-expert architecture may serve as a reference platform for the management of public deliveries not only in the sector of food products to kindergartens but also in adjacent areas – pharmaceutical and medical deliveries in hospital establishments, deliveries of teaching aids in the school network, deliveries to social-service establishments and municipal institutions.

The future directions in the conclusion of the dissertation (p. 184) outline a wide spectrum of areas – machine learning and predictive analytics, cloud and microservice architecture, blockchain technologies for transparency and traceability, expansion of the application domain, simulation modelling, and the establishment of a national platform for intelligent management of public deliveries. As priority directions which would ensure the most rapid transition of the prototype to operation with real operational data, the following may be recommended: (a) integration with the actual logistics and accounting system of the supplier company in the Municipality of Plovdiv; (b) validation of the event machine with a standard operational volume of requests; (c) the inclusion of a specialised module for the processing of risk events, operating over the existing event machine; (d) integration with external sources such as the CAIS-EPP and the Public Procurement Register, which would raise the prototype to the level of a pilot production system.

These directions naturally extend the developed architecture and do not require restructuring of the main theoretical solutions, which is an additional argument in favour of the stability and applicability of the adopted conceptual choices.

C O N C L U S I O N

The dissertation contains scientific-applied results which constitute an original contribution to science and meet all the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB), the Regulations for its Implementation, the corresponding Regulations of Plovdiv University "Paisii Hilendarski" and the additional faculty requirements of the FMI under the RDAS of PU.

The doctoral candidate **Laska Delkova Kostadinova-Tsankova** possesses theoretical knowledge and professional skills in professional field 4.6. Informatics and Computer Sciences, demonstrating qualities and capabilities for independently conducting scientific research.

On the grounds set out above, I give my positive assessment of the presented dissertation, abstract and achieved results, and I propose to the honourable scientific jury to award the educational and scientific degree "Doctor" to Laska Delkova Kostadinova-Tsankova in higher education area 4. Natural Sciences, Mathematics and Informatics, professional field 4.6. Informatics and Computer Sciences, doctoral programme "Informatics".

27.05.2026

Signed: _____

Prof. Dr. Irina Radeva