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COMPUTER MODELING AND ANALYSIS OF LOGISTIC PROCESSES BASED ON PETRI NETS

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Abstract

The presented study addresses the practical aspects of simulating complex logistics processes by leveraging the mathematical foundation of Petri nets. A review of existing software tools and relevant academic literature reveals a distinct gap between formal Petri net theory and real-world logistics operational planning. To bridge this gap, this work outlines the architectural design, implementation, and evaluation of a custom web-based platform that unifies graphical editing, discrete-event simulation, structural and behavioral analysis, and cartographic visualization on the digital map. The proposed application follows a classic three-tier architecture (Client–Server–Database). The backend is developed using Python and the FastAPI framework, featuring synchronous HTTP handling, robust data validation via Pydantic schemas, and automated OpenAPI documentation. The frontend relies on React.js using a modular component structure, incorporating the ReactFlow library to provide an interactive graphical interface for constructing Petri net models. Asynchronous data exchange between client and server is handled via RESTful APIs using JSON payload formats. The utility of the developed system is demonstrated through specialized case studies, confirming its ability to support the complete lifecycle of logistics modeling—from formal net synthesis to route visualization on digital maps. In particular, it is discussed the cases: (1) simulation of simple logistic chain "Closed supply cycle (warehouse supply and replenishment process)" demonstrating the facility to create (edit) user's Petri net using the tools of interactive editor, to provide a user with visualized simulation to inspect the built

net, and to obtain the results of the net analysis, (2) modeling of logistic process "Resources delivery via a node of the limited capacity" focused on the facilities to user's work with templates for typical logistic tasks; (3) simulation of "Logistics complex of delivery and drift from final destinations" that demonstrates the opportunities for a user to work with the net templates and to provide them with the net analysis results along with suggestions on the net improvements. A comparative feature-based evaluation against existing tools demonstrates that the proposed web solution successfully addresses current software limitations. The practical value of the platform lies in its ready-to-use, zero-installation deployment model, making it equally adaptable for civilian distribution networks (such as food supply and pharmaceuticals) and defense-related supply chain logistics.

Keywords:
Petri Nets, Petri Nets Analysis, Logistic Processes Simulation, Software for Computer Modeling