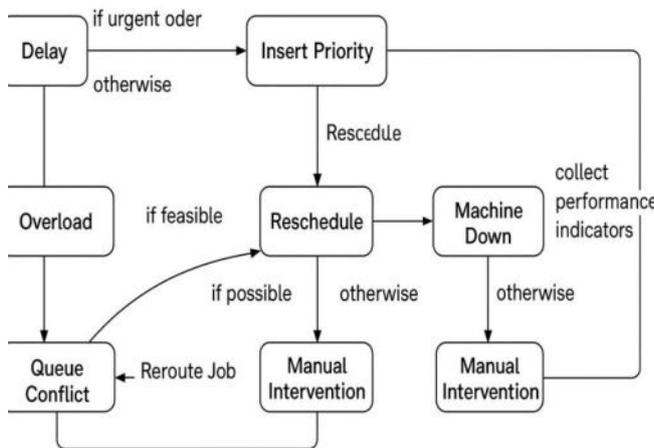# PRODUCTION SCENARIOS MODELING IN OPERATIONAL PRINTING BASED ON DIGITAL TWINS

Neroda T. V.
Institute of Printing Art and Media Technologies
in Lviv Polytechnic National University, Lviv

The principal characteristics of the operational printing market segment include substantial variability in print runs, substrates, and technological operations required for the production of time-sensitive outputs. This diversity hinders the standardization of production flows. The emergence of numerous production scenarios is driven by fluctuations in order structures, equipment workload, and resource availability constraints. These factors impose stringent requirements on the flexibility of production processes and necessitate adaptive control mechanisms that respond dynamically to the current operational context at each production unit. The capability to analyze system behavior under variable conditions without costly intervention in real-world operations is ensured by production scenario modeling based on digital twins. Within the infrastructure of operational printing, this approach enables consideration of the specific characteristics of each order, facilitates rapid assessment of the impact of external and internal factors on the production cycle, and supports the timely formulation of alternative response strategies. The use of digital twins enhances the validity of management decisions, reduces the risk of downtime, and supports the adaptation of production to non-standard situations by accounting for the current state of resources and technical workload. A classical digital twin incorporates forecasting or adaptation mechanisms based on historical data or real-time metrics, enabling not only modeling of scenarios but also the optimization of system behavior in real time [1].

Consequently, the system constantly analyzes the state of the production environment (delays, overloads, queue conflicts, equipment status). This data is mapped to the corresponding input vertex of the map – a typical production situation. The digital twin algorithm evaluates it according to the criterion of feasibility (e.g., minimum downtime, maximum resource saved). Thus, a digital twin for operational printing can be represented as a combination of a simulation multi-agent model with a modular structure and data from production logs, visualized as a scenario-oriented behavior map.

References (translated):
1. Neroda T. Predictive maintenance algorithms stratification for the machinery fleet in operational printing. Automation and computer-integrated technologies in industry and education, Vol. 13, 2024.