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Enhancement of Operational Efficiency of Postal Logistics Through Integration of Courier Mobile Applications with A Centralized Logistics Platform

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Abstract

The study focuses on the analysis of improving the operational efficiency of postal logistics through integration of mobile applications for courier services with a unified centralized platform. The aim of the work is to systematize existing approaches and assess the impact of such technological synchronization on key last-mile logistics indicators. As a methodological basis, a systematic review of scientific publications was applied, supplemented by analysis of thematic case studies and statistical data from authoritative industry reports. The results obtained indicate that combining courier mobile interfaces that provide real-time information transmission with powerful predictive analytics tools and route optimization algorithms on a centralized platform leads to reduced delivery time, decreased operational costs, more efficient utilization of vehicle fleets and increased customer satisfaction. The scientific novelty of the study lies in the description of a comprehensive model for evaluating the synergistic effect of implementing integrated IT solutions in the operational activities of postal logistics. The conclusions presented may be useful to logistics operators' executives, IT infrastructure specialists in the delivery sector and researchers engaged in supply chain optimization.

Keywords

postal logistics, operational efficiency, last mile, mobile applications, centralized logistics platform, route optimization, digital transformation, supply chain management, logistics KPIs, predictive analytics

Introduction

The modern economic landscape is experiencing a rapid expansion of e-commerce volumes, creating unprecedented strain on traditional postal and courier networks. According to expert estimates, by 2026 the global e-commerce market will reach approximately 8.1 trillion USD, which necessitates not so much a quantitative increase in the capacities of logistics operators as a qualitative reorganization of all key processes [1]. Under these conditions, enhancing operational efficiency acquires not merely the status of a competitive advantage but becomes the principal requirement for business sustainability and development. The relevance of this research is determined by the need for innovative approaches capable of reducing costs, minimizing delivery times and improving the level of customer service. One of the promising directions is the digital transformation of logistics operations through the integration of courier mobile technologies with centralized management platforms [10, 11, 12].

Despite extensive interest among researchers in various aspects of logistics digitalization, there remains a lack of analysis of the synergistic effect arising from the combination of courier mobile applications and a unified logistics platform within postal services. Existing studies, as a rule, either examine in detail the technological component of mobile solutions or focus on routing algorithms within platforms, thereby overlooking the overall effect of their interaction on key operational metrics.

The aim of this work is the systematization of existing approaches and the assessment of the impact of such technological synchronization on the key indicators of last-mile logistics.

The scientific novelty of the research lies in the description of a comprehensive model for assessing the synergistic effect of introducing integrated IT solutions into the operational activities of postal logistics.

The author's hypothesis assumes that the seamless integration of a courier mobile application as a source of primary real-time data with an analytical and optimization platform makes it possible to achieve a nonlinear increase in operational efficiency compared to the separate use of these technologies. This effect is achieved through the formation of a closed management loop data-analysis-optimal decision-execution-new data, which fundamentally enhances the adaptability and proactivity of the entire system.

Materials and Methods

In scientific research aimed at improving the operational efficiency of postal logistics through the integration of couriers' mobile applications with a centralized platform, five semantic groups of sources can be distinguished.

1. Strategic and sustainable models in logistics. Heikkinen H. [2] examines how managers of retail and logistics providers conceptualize sustainability principles in last-mile delivery, relying on qualitative interview analysis and the sensemaking theory concept to explain decision-making mechanisms in delivery sustainability. Mukhuty S., Upadhyay A., Rothwell H. [3] propose a conceptual model of strategically sustainable enterprise development under Industry 4.0 conditions, emphasizing the role of human-resource management practices in ensuring social responsibility and the long-term viability of supply chains. Ivanov D. [4] develops the idea of integrating flexibility, resilience and environmental friendliness into a single viable supply-chain model, using simulation experiments and lessons from the COVID-19 pandemic to formalize three component performance indicators.

2. Digital platforms and multi-agent systems. Liu S., Hennequin S., Roy D. [8] describe the architecture of a corporate logistics-services platform based on a multi-agent mechanism and blockchain technologies, demonstrating how a decentralized ledger can increase transparency and trust among supply-chain participants. Alnaggar A., Gzara F., Bookbinder J. H. [7] review existing crowdsourced-delivery platforms, classify business models and academic approaches to organizing folk logistics, and focus attention on quality and safety risks of such services. Alaei S., Durán-Micco J., Macharis C. [6] propose an agent-oriented simulation model for real-time reconfiguration of synchromodal transport, showing how flexible switching between transport modes can optimize costs and delivery time.

3. Routing optimization and machine learning. Giuffrida N. et al. [9] systematize optimization and machine-learning methods for last-mile problems, considering both classical heuristic and exact algorithms and modern approaches based on deep neural networks, and identify key efficiency metrics and limitations of each class of methods.

4. Customer-oriented approach and service quality. Aljohani K. [5], in an empirical study, analyzes the impact of last-mile delivery quality on the overall online-retail experience, using structural modeling methods to identify direct and indirect effects of speed, accuracy and tracking convenience on consumer satisfaction.

5. Industry reports and market prospects. The Morgan Stanley report 2025 Midyear Outlooks forecasts macroeconomic trends and the influence of global financial factors on the logistics sector, highlighting the growing demand for digitalization and process automation in delivery [1]. Gartner, in Market Guide for Vehicle Routing and Scheduling, describes the category of routing-optimization solutions, compares the functional capabilities of leading vendors and provides recommendations for selecting software to reduce operating costs and improve service level [10]. The PGS Logistics publication The Future of Logistics: What to Expect in 2024 and Beyond focuses on the introduction of autonomous vehicles, digital twins and advanced analytics platforms by 2024 [11]. The StartUs Insights report Explore the Last Mile Delivery Report 2024 presents a compendium of innovations, start-ups and technological trends in the last-mile segment, including tracking solutions, drone delivery and eco-friendly packaging [12].

Thus, the literature demonstrates a contradiction between the decentralized crowdsourcing approach [7] and corporate blockchain-based platforms [8], as well as between the focus on environmental sustainability [3, 4] and the tasks of increasing delivery speed and reliability [5, 9]. Despite a rich variety of conceptual and simulation models, the publications pay insufficient attention to practical aspects of integrating couriers' mobile applications in particular, issues of usability, cross-platform compatibility and data-transfer security. Weakly covered are questions of the economic efficiency of implementing such systems and the influence of the human factor (couriers' motivation and training) on achieving operational efficiency when mobile solutions are used.

Results and Discussion

The synergy of courier mobile applications and a unified logistics platform forms an integrated digital ecosystem operating on the principles of a closed cyber-physical loop. As a result, the traditional linear delivery process management scheme is transformed into a dynamic, data-driven, adaptive model. In this context, the central importance lies not so much in the software solutions themselves as in their ability to provide seamless, bidirectional information exchange in real time.

At the conceptual level, the architecture of such an integrated system can be represented as a modular structure **(Figure 1).**

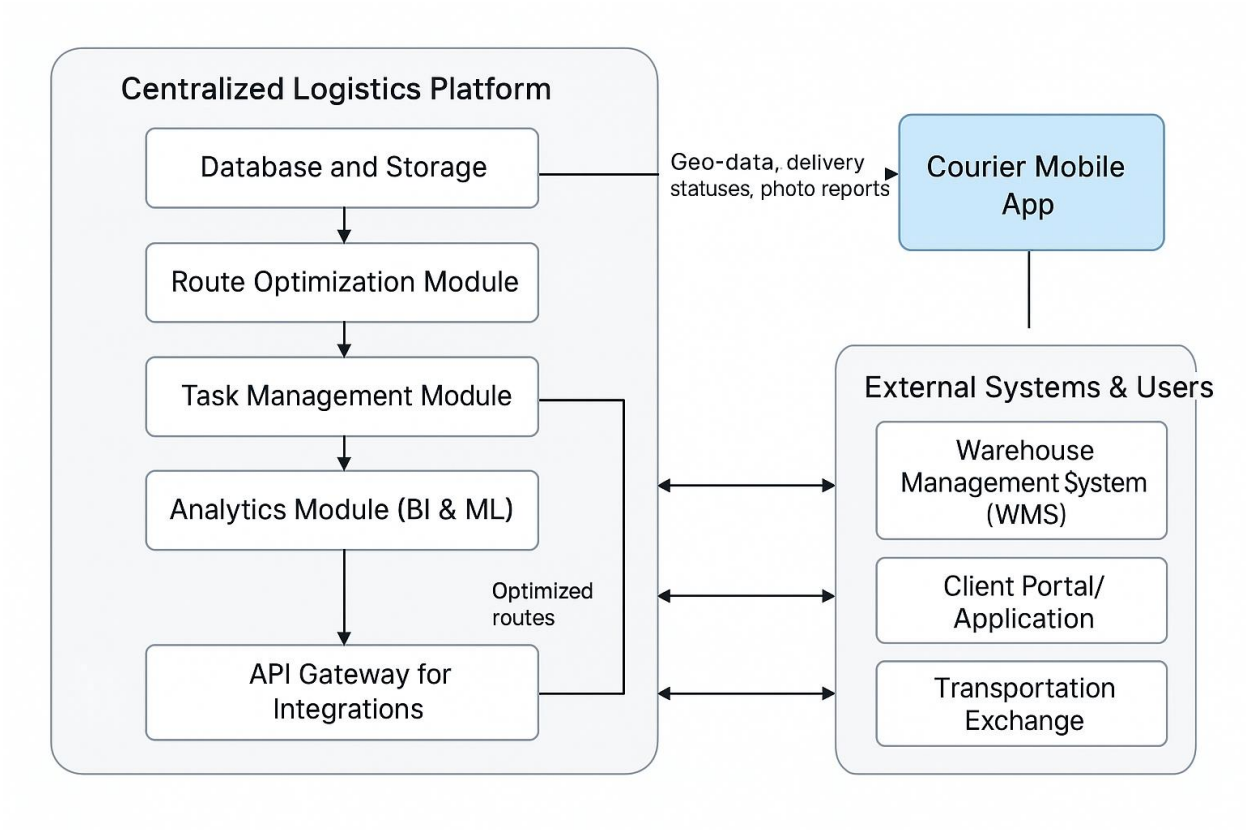

Fig. 1. Conceptual architecture of the integrated logistics platform (compiled by the author based on the analysis of [2, 3, 7, 9]).

From the presented figure it is evident that the courier application transforms from a simple positioning tool into the primary source of raw data – including geographic coordinates, travel speed, order fulfillment statuses, photographic confirmations and barcode scan results. Via an API gateway this incoming real-time information is continuously transmitted to the central platform. On its basis, the optimization module, operating variations of the travelling salesman problem with time windows (VRPTW) and dynamic factors (traffic congestion, new orders), promptly recalculates routes. The task management system then synchronously updates route sheets and transmits the adjusted assignments back to the courier's mobile application. In parallel, the analytics unit, applying machine learning methods, analyses the accumulated data in order to identify patterns, accurately forecast delivery times and strategically redistribute workload among couriers in subsequent planning [4, 5].

The practical advantages of implementing the described solution are reflected in key performance indicators (KPI). Table 1 presents a comparison of the basic processes before integration and after its implementation.

Table 1. *Comparison of operational processes in traditional and integrated postal logistics models (compiled by the author based on the analysis of [5, 6, 8]).*

Parameter	Traditional model (without integration)	Integrated model
Route planning	Static, on the eve of the delivery day, based on approximate data.	Dynamic, real-time. Algorithm accounts for traffic congestion, new orders, and prioritization.
Task assignment	Manual distribution by zones, without considering the courier's current load.	Automatic, based on the courier's location, current load, and skills.
Customer communication	Limited (courier call 15–30 minutes before). Broad time windows (from 9 to 18).	Proactive (SMS/push notifications on status, ETA), ability to track the courier on a map.
Delivery confirmation	Paper waybills, manual data entry into the system upon return to base.	Instantaneous: photo confirmation, electronic signature, QR-code scanning via the application.
Exception handling	Slow response. Dispatcher learns of failed delivery with delay.	Instant notification to the platform of issues (address not found, customer absent).
Performance analysis	Ex post, based on incomplete data. Difficulty identifying bottlenecks.	Continuous data collection for each courier and order. BI dashboards with real-time KPIs.

Quantitative evidence of the aforementioned improvements is contained in a number of industry case studies and analytical reports. The implementation of comprehensive platforms ensures the achievement of the following results:

1. Substantial reduction in average delivery duration and overall length of routing chains. The use of dynamic optimization logic makes it possible to decrease the total mileage of the vehicle fleet by 15–25 % [11], which directly impacts the reduction of fuel costs and equipment wear.

2. Reduction of operational cost per parcel. This multifactor indicator reflects the overall effectiveness of optimization measures in terms of fuel savings, reduction of courier labor costs per delivery, and decrease in the frequency of redelivery attempts. According to research data, the introduction of algorithms for precise estimation of estimated time of arrival (ETA) and improvement of communication protocols with the client lead to an increase in [12]. This shift makes it possible to minimize costs associated with additional dispatches, storage, and handling of returned shipments.

3. Optimization of resource utilization and increase in labor efficiency are achieved through the automation of planning and reporting processes, which significantly frees up time for both dispatchers and couriers. This liberation enables couriers to process a greater number of orders within the same shift. In addition, the platform provides flexible load management mechanisms for example, the engagement of additional couriers via a crowdsourcing model during peak activity periods which increases the overall throughput capacity of the system without increasing permanent costs.

Below in table 2 the main aspects of the use of mobile applications by couriers within a centralized logistics platform will be reflected: advantages, disadvantages and future development trends.

Table 2. *Key aspects of mobile application usage by couriers within a centralized logistics platform: advantages, disadvantages and future development trends (compiled by the author based on the analysis of [3, 7, 8]).*

Aspect	Advantages	Disadvantages	Future trends
Operational efficiency	• Accelerated transmission of tasks and real-time feedback • Dynamic redistribution of orders based on geolocation and courier workload • Reduction of idle time and empty runs through algorithmic routing	• Dependence on a stable internet connection • Requirement for high-precision GPS, vulnerable to urban canyon effects • Integration challenges in offline mode (data loss upon connection loss)	• Implementation of hybrid routing algorithms (online + offline) • Utilization of 5G and edge computing to minimize latency • Self-learning optimization systems based on machine learning and big data
Technological integration	• Centralized end-to-end API for interaction with ERP/WMS/CRM • Automatic updating of status and inventory information • Support for microservices architecture and containerization	• High complexity of maintaining multiple mobile client versions • Risk of API contract breakage upon third-party system updates • Need for round-the-clock monitoring of services and CI/CD pipelines	• Transition to event-driven architectures using Kafka/AMQP • Widespread adoption of serverless solutions to reduce infrastructure costs • Standardization of industry protocols (e.g. OpenAPI, GS1)
Data management and analytics	• Collection of operational telemetry data (speed, stops, route) • Capability for end-to-end KPI analytics (delivery time, % of tasks completed) • Predictive planning based on historical data	• Large volumes of raw data require complex ETL processes • Need to ensure data quality and consistency • Delays in analytical reports when storage throughput is exceeded	• Integration of real-time BI dashboards for dispatchers• Application of ML/AI models to predict peak loads and idle times • Expansion of IoT capabilities for additional telemetry (temperature, vibration)
User experience (UX/UI)	• Intuitive interface increases courier onboarding speed	• Limited screen size and in-motion input complicate display of complex scenarios• Risk of information overload	• AR overlays for indoor navigation and parcel scanning

	• Voice prompts and chatbots for hands-free operation • Personalization of notifications and routes	from notifications and multiple statuses • Variations in couriers' levels of digital literacy	• Flexible interfaces with adaptive design systems • Implementation of voice interfaces (LAI) and real-time machine translation
Security and reliability	• Encryption of transmission channel (TLS), secure storage for tokens • Biometric authentication (fingerprint, FaceID) • Centralized MFA and RBAC access management	• Vulnerabilities in third-party libraries and supply-chain risks • Increased certification requirements (GDPR, ISO/IEC 27001) • Frequent security updates may cause incompatibilities and failures	• Use of decentralized PKI systems based on blockchain • Automated anomaly detection and self-healing systems • Next-generation biometric sensors (ocular, heart-rate monitoring)
Scalability and flexibility	• Horizontal scaling of backend services • Containerization (Docker/Kubernetes) simplifies deployment • Modular mobile code (feature flags, plug-in architecture)	• Growth of technical debt as functionality expands • Complexity of CI/CD with multiple feature flags and platforms (iOS, Android) • Dependence on couriers' OS and device versions	• Adoption of mobile-as-a-backend (MaaB) architecture • Low-code/no-code platforms to accelerate development • Automatic A/B testing of new modules in production
Economic efficiency	• Reduction of operating expenses through dispatch automation • Decrease in penalties for delays due to precise tracking • Optimization of fuel and depreciation costs	• High initial investments in development and maintenance • Need for personnel training and technical support • Cost of licenses for third-party SDKs and services (maps, notifications)	• Transition to a Logistics-as-a-Service subscription mode I• Expansion of partner service ecosystem within the platform • Use of open-source solutions to reduce licensing costs
Socio-ethical aspects	• Increased transparency of working conditions • Opportunity for feedback and evaluation of courier performance	• Risk of courier stalking through constant tracking • Algorithmic pressure on speed and KPI "race"	• Development of ethical codes for AI/ML application in logistics • Implementation of fairness-by-design algorithms

	• Reduction of dispatcher–courier conflict through clear algorithms	• Potential discrimination in order distribution based on historical statistics	• Involvement of trade unions and legislation in regulating digital labor control
Regulatory-legal aspects	• Centralized compliance control and certification • Ability to rapidly adapt to new regulations (e.g. environmental, location restrictions)	• Diversity of local legal requirements for data storage and transmission • Need for legal audit of each update • Potential platform liability for couriers' traffic violations	• Automated GDPR/CCPA compliance via built-in controls • Integration with e-ID and government registries for verification • Increased requirements for green logistics and CO_2 emissions reporting

In the analysis of the achieved results, the key factor lies not merely in the straightforward implementation of software, but in the comprehensive review and adaptation of operational procedures. As a result, a synergistic effect emerges: high-precision data supplied by couriers enhances the performance of the platform's algorithms, while tasks intelligently generated by the platform contribute to an increase in the productivity of the couriers themselves. It is precisely the closed loop Data → Analytics → Action (Data-Analytics-Action Loop) that functions as the core around which the automation effect is consolidated.

The hypothesis of nonlinear efficiency growth is confirmed by empirical results. A reduction in mileage directly decreases fuel expenses, while an increase in the First Attempt Delivery Rate eliminates costs associated with repeat logistical operations (additional mileage, courier labor, warehouse processing), which collectively yields an efficiency improvement of more than 25 %. At the same time, the implementation process is associated with certain challenges: the need for substantial initial investments, difficulties integrating with legacy IT systems of postal operators, potential personnel resistance to change, and the requirement to ensure the security of transmitted data. Nevertheless, long-term benefits in the form of direct cost reductions and reinforced competitive positions generally outweigh these initial obstacles.

Conclusion

The analysis conducted provided a systematization of the impact of integrating courier mobile applications with a unified logistics platform on operational performance in postal logistics. It was found that this integration constitutes not so much a technical improvement as a strategic transition to a new adaptive last-mile organization model based on data processing and management.

The conclusion of the study confirms the hypothesis put forward regarding the manifestation of a significant synergistic effect. Continuous real-time information exchange between couriers' mobile devices and the platform's analytical core forms a closed control loop ensuring nonlinear efficiency gains. According to the analysis results the comprehensive implementation of the integrated solution can lead to a reduction of operational delivery costs achieved through decreased mileage increased share of successful first-attempt deliveries and optimization of personnel labor inputs.

The objective of the study systematization and assessment of the impact of integration was achieved by identifying key optimization directions and quantitatively validating them based on current empirical data.

The scientific novelty of the research lies in the development of a comprehensive evaluation model demonstrating the incorrectness of separate analyses of mobile applications and platforms. Only their joint functioning within a unified digital ecosystem generates maximal synergistic return.

In the practical aspect the obtained results may serve as a basis for managers of postal and logistics organizations when substantiating investments in digitalization and formulating a roadmap for the implementation of integrated delivery management systems. Prospects for further research are associated with the development of more complex predictive models that take into account the specifics of various types of shipments and geographic zones as well as the study of the socio-economic consequences of such transformation including changes in personnel qualification requirements and the emergence of new logistics services.

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