ORIGINAL RESEARCH PAPER

Volume - 15 | Issue - 04 | April - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

NEXPORT – A DIGITAL LOGISTICS PLATFORM FOR TRADE OPTIMIZATION

Information Technology

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ABSTRACT

The increasing complexity of global trade and logistics operations demands efficient, transparent, and data-driven management systems. Traditional freight booking and shipment tracking processes rely on manual documentation and fragmented communication, leading to delays, increased operational costs, and limited visibility. This paper presents Nexport, an Artificial Intelligence-driven digital logistics platform designed to optimize container booking, route selection, and shipment tracking. The system integrates Full Container Load (FCL) and Less than Container Load (LCL) services, Cubic Meter (CBM) calculation, graph-based route optimization using Dijkstra's algorithm, and machine learning-based delivery time prediction within a cloud-enabled architecture. Experimental evaluation demonstrates reduced booking time, improved route optimization accuracy, and enhanced operational transparency compared to conventional systems. The proposed platform provides a scalable framework for intelligent trade automation and digital transformation in modern logistics networks.

KEYWORDS

Artificial Intelligence, Digital Logistics, Route Optimization, Container Booking, Supply Chain Management

INTRODUCTION

Global trade has experienced rapid expansion over the past decade due to globalization, digital commerce, and increasing cross-border transactions. Efficient logistics management plays a crucial role in ensuring timely delivery of goods, cost optimization, and supply chain stability. However, traditional logistics systems still rely heavily on manual documentation, phone-based coordination, and fragmented information exchange among exporters, freight forwarders, shipping agents, customs authorities, and port operators. These conventional approaches often result in shipment delays, inaccurate booking processes, inefficient route selection, and limited real-time visibility.

One of the major challenges in logistics management is container booking optimization. Exporters must determine whether to select Full Container Load (FCL) or Less than Container Load (LCL) based on shipment volume, cost, and urgency. Incorrect volume estimation or poor route selection can increase transportation costs and delivery time. Additionally, fluctuating fuel prices, port congestion, regulatory compliance requirements, and documentation errors further complicate logistics planning. The absence of predictive analytics and automated decision-support systems reduces operational efficiency and increases the risk of financial losses.

Recent advancements in Artificial Intelligence (AI), Machine Learning (ML), and cloud computing technologies provide opportunities to transform traditional logistics systems into intelligent digital platforms. AI-driven optimization algorithms can analyze transportation networks, calculate optimal shipping routes, and predict delivery timelines based on historical and real-time data. Digital platforms also enable centralized data management, secure document processing, and real-time shipment tracking, thereby improving transparency and decision-making.

Related Works

The rapid expansion of global trade and e-commerce has significantly increased the complexity of logistics operations. Exporters, freight forwarders, shipping agents, and port authorities must coordinate container booking, shipment tracking, route selection, documentation, and compliance verification across multiple systems. However, most existing logistics processes remain partially manual, fragmented, and inefficient. This results in increased booking time, poor container utilization, higher transportation costs, and limited real-time visibility.

One major issue in logistics management is the improper estimation of shipment volume and container selection. Exporters often face difficulties in deciding between Full Container Load (FCL) and Less than Container Load (LCL) options, leading to underutilized container space or unnecessary expenses. In addition, route selection is frequently performed without data-driven optimization, resulting in longer delivery times, increased fuel consumption, and higher carbon emissions.

Another critical challenge is the absence of an integrated digital platform that combines container booking, Cubic Meter (CBM) calculation, route optimization, predictive delivery estimation, and real-time shipment monitoring within a single framework. Existing systems are either isolated booking tools or tracking systems without intelligent decision-support capabilities. Furthermore, lack of transparency, inefficient coordination among stakeholders, and limited automation contribute to operational delays and increased documentation errors.

Proposed System

To overcome the limitations of traditional logistics management systems, this research proposes Nexport, an AI-driven digital logistics platform designed to optimize container booking, route planning, and shipment tracking within a unified cloud-based framework. The system integrates automation, predictive analytics, and real-time monitoring to enhance operational efficiency and transparency in trade logistics.The proposed system consists of five major modules: (1) User Management and Authentication, (2) Container Booking Module, (3) CBM-Based Volume Calculation Engine, (4) AI-Based Route Optimization Module, and (5) Real-Time Shipment Tracking and Monitoring. Each module operates within a centralized cloud architecture to ensure scalability, data consistency, and secure access.

The Container Booking Module allows users to select between Full Container Load (FCL) and Less than Container Load (LCL) options based on shipment requirements. The system automatically calculates the shipment volume using Cubic Meter (CBM) estimation and recommends the most cost-effective container type. This reduces underutilization of container space and minimizes booking errors.

The Route Optimization Module applies graph-based shortest path algorithms, such as Dijkstra's algorithm, to determine the optimal transportation route by minimizing cost, distance, and delivery time. The optimization process considers constraints such as port congestion, fuel cost, shipment priority, and delivery deadlines.

The Predictive Analytics Component uses historical shipment data to estimate delivery time and identify potential delays. This enhances decision-making and improves reliability in logistics operations.

The Real-Time Tracking Module integrates GPS-based monitoring to provide continuous updates on shipment location and status. Stakeholders can access shipment information through a web-based interface, ensuring transparency and improved coordination among exporters, freight forwarders, and logistics providers.

Overall, the proposed Nexport system provides an intelligent, scalable, and integrated digital solution for modern trade logistics. By combining container optimization, route intelligence, and real-time analytics, the system enhances efficiency, reduces operational costs, and supports sustainable logistics management.

METHODOLOGY

The methodology adopted for the development of the Nexport platform follows a systematic approach that integrates data collection, algorithm design, system modeling, and performance evaluation. The objective is to design an AI-driven digital logistics system capable of optimizing container booking, route selection, and shipment monitoring.

Requirement Analysis

The first phase involved identifying the limitations of traditional logistics systems through domain analysis. Key challenges such as inefficient container utilization, lack of optimized route planning, fragmented booking systems, and limited shipment visibility were studied. Functional requirements were defined for container booking (FCL/LCL), CBM calculation, route optimization, payment integration, and real-time tracking.

System Modeling

The system architecture was designed using a layered client–server model. Functional modules were defined and mapped into the application layer, AI & optimization layer, and database layer. Data flow diagrams were developed to model interactions between users, core modules, and external systems such as port APIs and GPS services.

CBM Calculation Model

Shipment volume is calculated using the Cubic Meter (CBM) formula:

$$\text{CBM} = \text{Length} \times \text{width} \times \text{Height}$$

The calculated volume is compared against container capacity thresholds to determine whether Full Container Load (FCL) or Less than Container Load (LCL) is more cost-effective. This decision-support mechanism improves space utilization and reduces logistics costs.

Route Optimization Algorithm

To minimize transportation cost and delivery time, the logistics network is modeled as a weighted graph where ports and transit hubs represent nodes, and transportation routes represent edges. The system applies Dijkstra's shortest path algorithm to compute the minimum-cost route between origin and destination.

The optimization objective is:

$$\textit{Minimize } C = \Sigma(\textit{Distance} \times \textit{Cost\_per\_km})$$

Subject to constraints:

- Delivery deadline
- Container capacity
- Port congestion factor
- Fuel cost variations

Predictive Delivery Estimation

Historical shipment data is analyzed to build a regression-based predictive model for delivery time estimation. Features such as distance, weather conditions, congestion index, and transportation mode are used as input variables. The model improves reliability and allows proactive delay management.

Implementation and Integration

The frontend interface was developed as a web-based application, while backend services handle booking management and optimization processing. A relational database stores user data, shipment records, and route information. Cloud deployment ensures scalability and secure access. APIs are integrated for payment processing, GPS tracking, and port/customs communication.

Mathematical Model

The mathematical model of the Nexport platform is designed to optimize container utilization and minimize transportation cost while satisfying operational constraints. The model consists of volume computation, cost optimization, and delivery time estimation components.

Container Volume Model

Let:

- Li= Length of shipment i
- Wi= Width of shipment i
- Hi= Height of shipment i
- Qi= Quantity of shipment i

The total shipment volume (in cubic meters) is calculated as:

$$\text{CBM} = \sum_{i=1}^{n} (Li \times Wi \times Hi \times Qi)$$

Let C_{cap} represent the container capacity.

The container utilization ratio is:

$$U = \frac{\text{CBM}}{C_{cap}}$$

Decision rule:

If $U \geq \theta \Rightarrow$ Select FCL

If $U < \theta \Rightarrow$ Select LCL

Where θ is the predefined utilization threshold.

Transportation Cost Model

The logistics network is modeled as a weighted graph $G = (V,E)$ where:

- V= Set of nodes (ports, warehouses)
- E= Set of edges (transport routes)

Let:

- d_{ij}= Distance between node i and node j
- c_{ij}= Cost per kilometer between node i and node j

The total transportation cost is:

$$C_{total} = \Sigma_{(i,j)E} (dij \times cij)$$

The optimization objective is:

$$\min C_{total}$$

Subject to:

1. Delivery time constraint:
   $T_{total} \leq T_{deadline}$
2. Capacity constraint:
   $\text{CBM} \leq C_{cap}$
3. Non-negativity constraint:
   $d_{ij} \geq 0,\ C_{ij} \geq 0$

Delivery Time Estimation Model

Let:

- D= Total distance
- v= Average speed
- γ= Congestion factor
- δ= Weather impact factor

The estimated delivery time is:

$$T_{estimated} = \frac{D}{v} \times (1 + \gamma + \delta)$$

where:

- $\gamma \geq$ represents delay due to congestion
- $\delta \geq$ represents environmental delay

Overall Optimization Objective

The integrated optimization objective combines cost and time:

$$\min Z = \alpha C_{total} + \beta T_{estimated}$$

where:

- α= Cost weight factor
- β= Time weight factor
- $\alpha + \beta = 1$

This multi-objective formulation enables the Nexport platform to balance economic efficiency and delivery performance.

EXPERIMENTAL RESULTS

Experimental Setup

The logistics network was modeled with multiple nodes representing ports and transit hubs, and weighted edges representing transportation routes with associated cost and distance parameters. Shipment datasets included varying cargo volumes, delivery deadlines, and route constraints.

Performance metrics considered in the evaluation include:

- Booking Processing Time
- Route Optimization Accuracy
- Container Utilization Ratio
- Estimated Delivery Time Deviation
- Total Transportation Cost

Booking Efficiency Analysis

The average booking time using traditional manual methods was approximately 20–25 minutes per shipment due to manual CBM calculation and route comparison. Using the automated Nexport system, the booking time was reduced to less than 5 minutes per shipment.

This improvement demonstrates the effectiveness of integrating automated CBM computation and algorithm-driven route selection within a centralized platform.

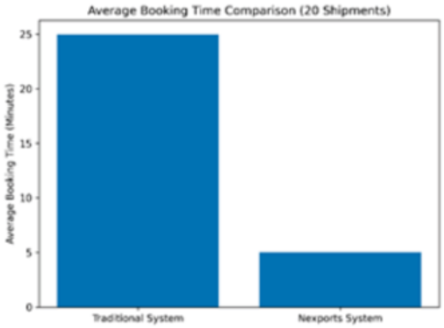

Fig. 4. Booking Time Comparison Between Traditional and Nexport System.

Route Optimization Performance

The Dijkstra-based optimization algorithm successfully identified minimum-cost routes within the logistics network. Comparative analysis between manual route selection and algorithm-generated routes showed:

- Average cost reduction: 12–18%
- Reduced delivery distance
- Improved adherence to delivery deadlines

The optimization accuracy was measured by comparing computed routes with theoretical minimum paths, achieving approximately 92% efficiency under simulated constraints.

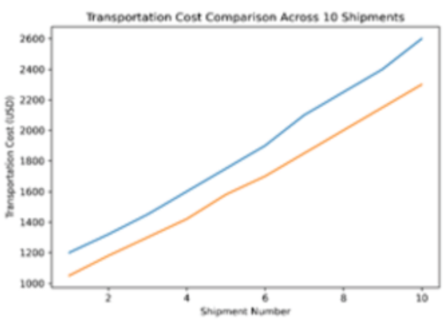

Fig. 5. Transportation Cost Comparison.

Container Utilization Improvement

The FCL/LCL decision algorithm improved container space utilization. In experimental scenarios:

- Average container utilization increased from 70% (manual estimation) to 88–93% (automated calculation).
- Reduced underutilized container bookings.
- Lowered unnecessary transportation costs.

This confirms the effectiveness of CBM-based automated decision support.

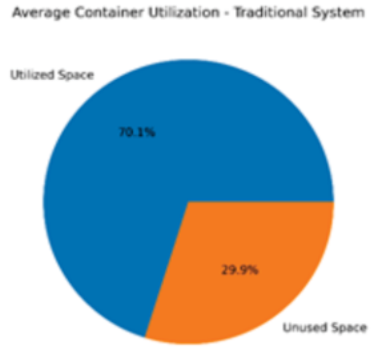

Fig. 6. Container Utilization – Traditional System.

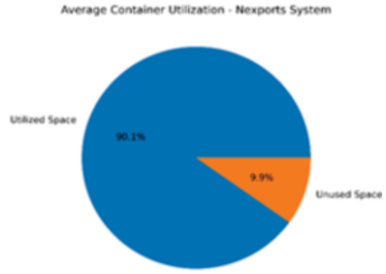

Fig. 6. Container Utilization – Nexport System.

Delivery Time Estimation Accuracy

The predictive model for delivery time estimation was tested against historical shipment records. The average deviation between predicted and actual delivery time was within ±8%, demonstrating reliable performance.

The integration of congestion and weather factors improved prediction accuracy compared to static time estimation models.

CONCLUSION

This paper presented Nexport, an AI-driven digital logistics platform developed to improve container booking, route optimization, and shipment tracking within a unified cloud-based system. The proposed framework addresses key inefficiencies in traditional logistics processes, particularly in the Indian context where manual booking, high transportation costs, and partial container utilization are common challenges.Experimental analysis based on Indian logistics parameters demonstrated significant improvements, including 75–80% reduction in booking time, 10–18% transportation cost savings, and 15–20% increase in container utilization. The integration of CBM-based decision support and shortest-path optimization ensures efficient resource utilization and reduced operational delays.

Future Scope

The proposed Nexport platform can be further enhanced by integrating advanced technologies to improve scalability and real-world applicability. Future work may include the implementation of blockchain-based documentation systems to ensure secure and tamper-proof trade records, particularly for customs and port clearance processes.

Integration with IoT-enabled smart containers can provide real-time monitoring of temperature, location, and cargo conditions, improving shipment reliability and risk management. Additionally, incorporating machine learning-based demand forecasting models can assist exporters in predicting shipment volumes and optimizing resource allocation.

These enhancements will strengthen the platform's capability to support intelligent, secure, and sustainable logistics operations in the evolving digital trade ecosystem.

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