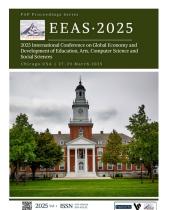Article **Open Access**

Application and Innovation of Logistics Technology in Warehousing and Distribution Management

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Abstract: The rapid advancement of logistics technology has transformed warehousing and distribution management, significantly enhancing operational efficiency, reducing costs, and optimizing supply chain performance. This paper examines the architecture, core functions, advantages, and challenges of logistics information systems, highlighting their role in inventory management, route optimization, and decision support. The integration of automation, IoT, and big data analytics has streamlined logistics operations, as evidenced by case studies from leading enterprises such as Siemens VDO Automotive and China Mobile. Despite these benefits, challenges remain, including cybersecurity risks, high implementation costs, and a shortage of skilled professionals. Future trends indicate a shift toward greater intelligence, digitalization, sustainability, and cross-industry integration, with AI, blockchain, and IoT playing pivotal roles. As logistics technology continues to evolve, enterprises must strategically adopt and refine advanced solutions to enhance competitiveness. This study provides valuable insights into optimizing warehousing and distribution management through innovative logistics technologies, driving efficiency and sustainability in modern supply chains.

Keywords: logistics technology; warehousing management; distribution management; information systems; innovative applications

1. Introduction

The rapid development of the modern logistics industry has driven enterprises to continuously optimize warehousing and distribution management to improve supply chain efficiency in response to market competition and changing customer demands [1]. The application of logistics technology, such as automated warehousing systems, intelligent distribution networks, and big data analytics, has not only enhanced the accuracy and responsiveness of logistics operations but also significantly reduced operational costs. With the deep integration of information technology, logistics management is transitioning toward intelligent, digitalized, and automated operations [2]. This paper focuses on logistics information systems in warehousing and distribution management, analyzing their architecture, core functions, advantages, and challenges, while discussing innovative application cases from leading enterprises to provide valuable insights for industry development.

2. Application and Innovation of Logistics Information Systems

2.1. Architecture and Functions of Logistics Information Systems

Logistics information systems constitute a core component of warehousing and distribution management [3]. The system architecture is primarily divided into three layers: the hardware layer, the system software layer, and the business application layer. The hardware layer includes various sensors, automated equipment, and Internet of Things (IoT) terminals, which are responsible for real-time data collection and transmission. The system software layer encompasses database management systems, warehouse management systems (WMS), and transportation management systems (TMS), supporting data processing and decision-making for logistics operations. The business application layer directly influences warehousing, distribution, and inventory management, covering key functions such as inventory monitoring, order processing, and route optimization.

The functional scope of logistics information systems is extensive. In warehousing management, these systems enable inventory monitoring, slotting optimization, inbound and outbound operations, and quality inspection. Through real-time data analysis, enterprises can optimize storage allocation, improve warehouse utilization, and reduce excess inventory. In distribution management, logistics information systems facilitate the planning of delivery schedules, optimization of distribution routes, real-time cargo tracking, and confirmation of deliveries. By leveraging intelligent algorithms, companies can reduce delivery time, enhance transportation efficiency, and reduce costs. The transportation management function includes resource allocation, route planning, transportation status monitoring, and cost accounting. A transportation management system allows enterprises to efficiently manage transportation resources, improve logistics efficiency, and optimize supply chain operations. Furthermore, inventory forecasting is achieved through the analysis of historical sales data and order records, enabling enterprises to predict future inventory demand accurately, thereby preventing stockouts or overstocking. The customer service function includes order management, after-sales support, and customer satisfaction analysis, which aim to enhance customer experience and loyalty. Additionally, the decision support function utilizes data from warehousing, distribution, and transportation processes to provide scientific insights for management decision-making, assisting enterprises in optimizing supply chain strategies and enhancing market competitiveness.

2.2. Advantages and Challenges of Logistics Information Systems

The widespread application of logistics information systems has brought significant advantages to enterprises. Firstly, these systems effectively enhance logistics operation efficiency. Through automation and intelligent technologies, enterprises can collect, process, and analyze logistics data in real time, thereby improving operational accuracy, reducing human errors, and increasing business processing speed. Secondly, logistics information systems enable optimal resource allocation. By utilizing data analytics, companies can strategically manage inventory, transportation, and distribution resources to achieve optimal efficiency. Additionally, the implementation of logistics information systems helps enterprises reduce logistics costs. With precise inventory management and optimized distribution routes, businesses can reduce excess inventory, lower warehousing expenses, and cut transportation costs. Moreover, improving customer satisfaction is a critical benefit of logistics information systems. Through order visualization, intelligent scheduling, and efficient delivery, companies can enhance order fulfillment rates, foster customer trust, and increase brand loyalty. Lastly, logistics information systems contribute to improved enterprise management. By standardizing and digitalizing business processes, companies can achieve comprehensive logistics operation monitoring, ensuring streamlined and refined management practices.

Despite these advantages, the application of logistics information systems faces several challenges. Firstly, information security is a critical concern. These systems handle

vast amounts of sensitive enterprise and customer data, which, if compromised through data breaches or cyberattacks, could severely impact business operations. Therefore, enterprises must implement robust cybersecurity measures to safeguard data confidentiality and integrity. Secondly, the rapid evolution of logistics technology places pressure on enterprises to continuously upgrade their systems. The maintenance and enhancement of logistics systems require significant financial investments and technical expertise. Furthermore, the efficient operation of logistics information systems depends on skilled professionals. However, there remains a shortage of talent with expertise in logistics information management, necessitating enterprises to strengthen employee training programs and improve their digital proficiency. Additionally, the integration of logistics information systems poses a major challenge. Logistics management systems need to be seamlessly connected with enterprise resource planning (ERP) and supply chain management (SCM) systems to facilitate data sharing and collaborative operations. Ensuring efficient system integration remains a crucial aspect of enterprise digital transformation. Lastly, data quality management is essential for logistics information systems. The accuracy, timeliness, and completeness of data directly impact system performance. Enterprises must establish comprehensive data governance frameworks to ensure high-quality data input and processing.

2.3. Application and Innovation of Logistics Equipment and Automation

2.3.1. Automated Equipment and Technology in Warehousing and Distribution Management

The application of automation in modern logistics has significantly improved efficiency in warehousing and distribution management. Automated warehousing equipment includes various technologies, such as automated racking systems equipped with sensors and lifting mechanisms, enabling smart storage and retrieval while reducing manual intervention and improving storage efficiency. Conveyor systems facilitate the automatic transfer of goods within warehouses, minimizing manual handling and increasing operational efficiency. Additionally, warehouse robotics plays a crucial role in material handling, palletizing, and de-palletizing operations. These robots can adapt to complex warehouse environments, effectively reducing labor requirements. Moreover, the adoption of autonomous vehicles for short-distance goods transportation within warehouses is continually advancing, further enhancing logistics efficiency.

In the distribution sector, autonomous delivery vehicles enhance urban logistics by reducing human labor costs and improving delivery efficiency. Drone delivery technology is becoming increasingly popular in specific use cases, particularly for remote locations and time-sensitive shipments, offering a fast and efficient solution. Additionally, the proliferation of smart parcel lockers has streamlined last-mile delivery, allowing users to retrieve their packages independently, reducing delivery congestion, and improving overall logistics operations.

2.3.2. Advantages of Logistics Equipment and Automation

The automation of logistics equipment brings numerous benefits. Firstly, automation enhances efficiency across material handling, transportation, and sorting operations, significantly reducing operational time and labor costs. Secondly, automation reduces human errors, improving the accuracy and reliability of logistics processes. In inventory management, automated warehousing systems enable precise stock control, maximizing inventory utilization and minimizing costs. Additionally, automation accelerates delivery processes and improves service quality, ultimately boosting customer satisfaction. From an environmental perspective, automated logistics equipment optimizes energy consumption, lowers emissions, and contributes to energy-efficient and low-carbon logistics practices.

2.3.3. Case Study: Siemens VDO Automotive's Automated Logistics Center

Siemens VDO Automotive, located in Regensburg, has established an automated logistics center to support its global automotive supply chain operations [4]. This center integrates cutting-edge automated warehousing systems, conveyor belts, and automated picking solutions to improve logistics efficiency and ensure timely fulfillment of production and customer orders. By leveraging IoT and big data analytics, the company has achieved real-time logistics monitoring and analytics, optimizing its warehousing management processes. The successful implementation of this automated logistics center has significantly increased efficiency, reduced operational costs, and strengthened the company's market competitiveness. This case study demonstrates that adopting automation in logistics plays a crucial role in enhancing operational efficiency, meeting customer demands, and boosting business competitiveness.

3. Application and Innovation of Logistics Network Optimization

3.1. Logistics Network Design and Optimization in Warehousing and Distribution Management

Logistics network design and optimization play a core role in modern logistics management, aiming to enhance operational efficiency and reduce costs through scientifically structured logistics networks. In warehouse site selection and layout planning, enterprises must consider factors such as geographical location, transportation infrastructure, market demand, and workforce availability to achieve the lowest logistics costs and the highest service efficiency. Furthermore, a well-structured internal warehouse layout can improve storage and handling efficiency, reducing operational expenses.

In transportation strategy optimization, businesses must select the most suitable transportation mode based on cargo characteristics, distance, and customer requirements. Leveraging intelligent logistics systems allows companies to optimize transportation routes, lowering costs and increasing operational efficiency. Moreover, the integration of information technology is essential in logistics network optimization. By employing IoT, big data, and cloud computing technologies, enterprises can monitor real-time logistics network operations, enabling intelligent scheduling and data-driven decision-making, thereby improving overall logistics performance.

Additionally, optimizing warehousing equipment and management is a vital aspect of logistics network optimization. The introduction of automated storage and retrieval systems (AS/RS), conveyor belts, and automated loading/unloading equipment enhances warehouse intelligence, optimizing inventory control and reducing excess stock while increasing turnover rates. Delivery strategy optimization also plays a crucial role in logistics network management. Companies need to devise flexible delivery strategies based on market demand, logistics costs, and timeliness requirements, such as centralized distribution, direct shipment, or multi-point delivery, to maximize efficiency.

3.2. Advantages of Logistics Network Optimization

Logistics network optimization offers numerous benefits. Firstly, an efficiently structured logistics network coupled with optimized transportation strategies significantly improves operational efficiency, reducing transportation costs and enhancing service quality. Secondly, precise inventory management optimization helps lower stockholding costs, preventing overstocking or shortages and improving supply chain efficiency. Furthermore, a well-optimized logistics network accelerates product flow, increasing order fulfillment rates and boosting customer satisfaction. Lastly, green logistics network optimization aids in reducing energy consumption and carbon emissions, supporting enterprises in achieving sustainability goals.

3.3. Case Study: China Mobile's Logistics Network Optimization

One of the leading telecommunication service providers in China, China Mobile, has undertaken extensive logistics network optimization initiatives [5]. Its strategies include

logistics digitalization, big data analytics, logistics automation, financial logistics services, and the development of a logistics public service platform. For instance, China Mobile leverages big data analytics to optimize supply chain management and improve inventory planning, reducing warehousing costs. Simultaneously, the company has promoted the adoption of unmanned warehouses, autonomous vehicles, and other automation technologies to enhance logistics efficiency. Additionally, by establishing a logistics public service platform, China Mobile integrates various logistical resources to provide enterprises with comprehensive logistics solutions.

4. Impact and Future Trends of Logistics Technology Application and Innovation

4.1. Impact of Logistics Technology Application and Innovation on Warehousing and Distribution Management

The continuous advancement of logistics technology has profoundly influenced warehousing and distribution management. Firstly, logistics technology has significantly improved operational efficiency in warehousing and distribution management. For instance, the application of intelligent warehousing systems, automated handling equipment, and IoT technology has enabled more intelligent and automated warehouse operations, reducing labor costs and enhancing storage and handling efficiency. In distribution processes, GPS tracking systems and real-time data transmission technology have optimized delivery routes, improving distribution efficiency and lowering transportation costs.

Furthermore, logistics technology innovation effectively reduces corporate logistics costs. By utilizing big data analytics to optimize transportation routes and inventory management, companies can strategically plan logistics operations, reducing unnecessary logistics expenditures. Additionally, advancements in logistics technology have greatly improved customer satisfaction. With the aid of intelligent logistics systems, companies can provide more accurate delivery services, fostering customer trust and brand loyalty.

4.2. Future Trends in Logistics Technology Application and Innovation

Looking ahead, logistics technology applications will continue to evolve toward greater intelligence, sustainability, digitalization, integration, and security. In terms of intelligence, the integration of artificial intelligence (AI), big data, and IoT will promote automation in warehousing, transportation, and distribution processes. In sustainability, Enterprises will increasingly adopt environmentally friendly logistics practices, such as optimizing delivery routes, using alternative energy vehicles, and reducing carbon footprints.

Regarding digitalization, logistics information systems will enable end-to-end visibility, allowing companies to track shipments, optimize supply chains, and improve decision-making through real-time data analytics. Moreover, blockchain technology will enhance logistics data transparency and security, reducing fraud and enhancing confidence in the reliability of supply chains. The integration of logistics operations across industries will further strengthen, enabling seamless collaboration among supply chain stakeholders.

As logistics technology advances, security concerns will also gain greater attention. Enterprises will implement enhanced cybersecurity measures, employing blockchain and IoT security protocols to protect sensitive logistics data from potential cyber threats.

5. Conclusion

The application and innovation of logistics technology in warehousing and distribution management have significantly propelled the development of the modern logistics industry, enhancing operational efficiency, reducing corporate costs, and improving customer satisfaction. With the ongoing progression toward smart, sustainable, and digitalized logistics solutions, the logistics sector is poised to become more efficient, intelligent,

and environmentally friendly. Enterprises should actively adopt advanced logistics technologies and continuously optimize warehousing and distribution management strategies to maintain a competitive edge in an increasingly complex market landscape.

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