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Warehouse Location Selection and Transportation Cost Control in Performance Network Optimization

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Abstract: Optimizing the performance network is crucial for the success of supply chain management, with key factors including warehouse location and transportation costs. This paper further explores the impact of these factors on performance network design and leverages geographic information analysis, big data, real-time traffic monitoring, and artificial intelligence algorithms to determine the optimal inventory location. By doing so, it effectively aligns inventory with demand, enhancing overall supply chain efficiency. At the same time, by effectively controlling freight costs to effectively control the cost of compliance, innovative solutions based on dynamic path planning, intelligent scheduling, real-time analysis and automatic regulation are proposed to improve logistics efficiency and reduce costs, and provide data-driven decision-making for the supply chain management.

Keywords: compliance network; warehouse location; transportation cost control; logistics optimization; intelligent scheduling

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1. Introduction

The optimization of performance network is crucial to the effective management of supply chain. Warehouse location selection and transportation cost control have a direct impact on logistics efficiency and operating cost. Reasonable storage location can improve the utilization rate of resources, while effective distribution methods can further improve the performance ability. Enterprises can optimize the location selection of warehouses and the design of transportation routes through advanced technologies such as GIS, big data analysis and AI, and quickly respond to the market. This paper mainly studies the implementation network structure, warehouse location data processing technology, intelligent transportation cost control strategy, and puts forward theoretical support and practical suggestions to promote the sustainable development of the industry.

2. Elements of the Implementation Network

2.1. Space Layout and Resource Matching of Warehouse Location

The selection of a warehouse location is a critical decision in the implementation of a performance network, directly impacting the efficiency of logistics operations and the overall stability of the supply chain. The scientific and reasonable use of inventory locations should fully consider the distribution degree of customer demand for materials, transportation and communication infrastructure, supply chain nodes, regional land prices, etc., so as to ensure the reasonable and effective use of logistics assets [1]. This is often through the geographic information system to process some relevant data, and to optimize the spatial layout, but also combined with the size of the regional population, consumption habits, market competitiveness of the advantages and disadvantages, to select an ideal warehouse location. Figure 1 shows the decision-making framework of warehouse location based on GIS:

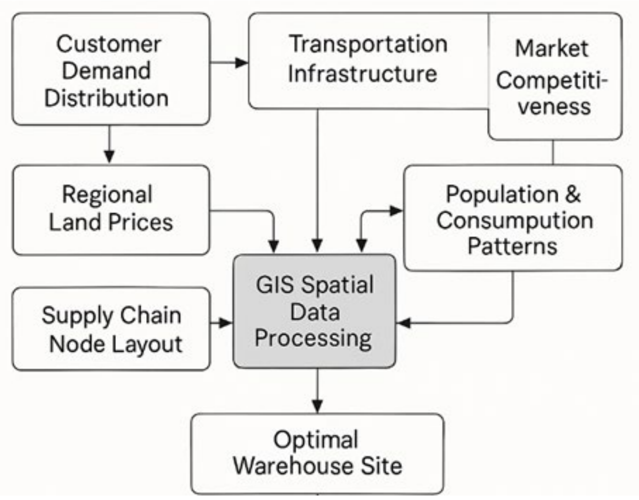

Figure 1. GIS-Based Warehouse Site Selection Decision Framework.

2.2. Architecture and Logistics Efficiency of Multi-Level Transport Network

The structural planning of the transport logistics network determines the logistics efficiency and the degree of order fulfillment. The existing delivery logistics network is usually composed of national transit stations, regional distribution stations and distribution terminals to ensure that the transit points to which goods flow can transport goods quickly and efficiently to the distribution terminals. To maximize the effectiveness of the transport network, its structure should be strategically designed and optimized based on factors such as goods flow, order attributes, and market demand. This approach ensures the shortest transportation routes and minimizes the number of transshipment stations, ultimately enhancing the overall efficiency of the logistics network [2].

2.3. Intelligent Order Forecasting Drives Warehousing and Distribution

Intelligent order prediction has a decisive impact on the realization of warehouse and distribution resource allocation, as well as the efficiency performance of the entire supply chain. Through the analysis and integration of historical sales data, seasonal rules, consumer behavior and market dynamics and other factors, using big data analysis, machine learning and artificial intelligence, intelligent order forecasting can effectively forecast the customer demand, help reduce the blindness of inventory management, reduce the risk of overstock and stockouts while minimizing unnecessary transportation costs [3]. With the development of technologies such as AI and cloud computing, intelligent order prediction will also benefit the warehousing and distribution process. Figure 2 below shows an example of an AI-driven automated 3D warehouse:

Figure 2. An Example Diagram of an Automated 3D Warehouse Driven by Artificial Intelligence.

3. Data-Driven Technology for Warehouse Location Selection in Performance Networks

3.1. Optimizing Storage Space Layout through Geographic Information Analysis

The accurate selection of a warehouse location is crucial for optimizing logistics efficiency and minimizing supply chain operating costs. GIS can provide quantitative basic data for warehouse regional planning and spatial data analysis to improve the selection of warehouse location, thus accelerating logistics response time. When determining the warehouse address, it is necessary to fully consider the market demand layout, transportation path, land constraints and supply chain operation links, and seek the optimal storage allocation scheme [4]. GIS can bring together data from other sources, such as satellite surveys, censuses, traffic flows, and business operations, to provide accurate spatial decision support. The main applications, data input and optimization functions of GIS in the field of inventory location are shown in Table 1 below:

Table 1. Core Application and Optimization Function of GIS in Warehouse Location.

GIS application	Data source	Effect	Optimization effect
Spatial data analysis	Satellite remote sensing, mapping data	Assess the terrain, infrastructure and land use of the target area	Select suitable location to avoid terrain restrictions
Heat map of market demand	Sales data, demographics, business activity data	Generate demand distribution heat maps to identify high demand areas	Ensure warehouse proximity to key markets and improve delivery timeliness
Traffic flow analysis	Road monitoring data, navigation systems, historical traffic flows	Monitor road flow, identify congested sections, and optimize warehouse and transportation hub connections	Reduce transportation time and cost, improve logistics stability
Competitor distribution	Enterprise registration information, industry data, logistics network	Evaluate competitors' storage networks and select strategic sites for differentiation	Improve market competitiveness and avoid excessive competition
Supply chain node optimization	Supplier data, production base location, terminal distribution point data	Optimize warehouse layout by integrating upstream and downstream nodes of supply chain	Shorten the supply chain path, reduce transit links, improve efficiency

Real-time environmental monitoring	Meteorological data, natural disaster monitoring system	Assess regional weather and disaster risks to ensure the stability of warehouse operations	Reduce the impact of climate and disasters on supply chains

As shown in Table 1, with the application of GIS technology, enterprises can achieve accurate inventory arrangement and market layout, reduce logistics processes, and shorten supply chain response time.

3.2. Big Data Analysis to Enhance Market Demand Matching

The ratio to meet market demand is an important part of network optimization, which is closely related to warehouse location selection and transportation planning. The use of big data can obtain valuable data and build models from a large number of market data, thereby improving the ability to predict customer demand, and then improve inventory management and distribution planning. This data can be obtained from previous transaction records, customer buying habits, comments on social networks, climate data, economic indicators, etc., to help companies accurately identify hot spots and rethink warehouse location choices and inventory arrangements [5]. Table 2 below lists the application of big data in market demand matching and the effect of optimizing performance:

Table 2. Application and Optimization of Big Data Analysis in Market Demand Matching.

Application scenario	Data source	Central role	Optimization effect
Demand forecasting	Historical sales data, social media trends, search engine keywords	Analyze the changing trend of market demand and improve the accuracy of demand forecasting	Improve order fulfillment rate, reduce stock shortages and slow sales
Regional consumption characteristics	Purchase records, demographics, payment data	Identify regional consumption preferences and identify high-demand markets	Make the warehouse location and demand highly match, improve the distribution time
Inventory optimization	Order flow data, inventory levels, return records	Forecast inventory consumption rate and optimize replenishment plan	Reduce inventory overhang and reduce operating costs
Supply chain dynamic adjustment	Logistics tracking data, weather information, market price fluctuations	Adapt your supply chain strategy to real-time market changes	Improve supply chain resilience and reduce the risk of supply chain disruption
Pricing optimization	Competitor pricing, market supply and demand, customer feedback data	Adjust commodity pricing strategies to improve market competitiveness	Increase sales and optimize profit margins
Precision marketing	User browsing data, social media interactions, customer preferences	Subdivide target customer group and develop personalized marketing plan	Increase conversion rate and enhance user loyalty

As shown in Table 2, big data analytics enhances the alignment of market demand, significantly improves supply chain flexibility, and enables real-time responsiveness to market fluctuations.

3.3. Real-Time Traffic Monitoring to Improve Logistics Scheduling Efficiency

Efficient logistics scheduling is a key factor to determine the quality of network transportation, and real-time traffic monitoring technology is a key tool to improve transportation routes, reduce delays and reduce logistics costs. By obtaining traffic flow information and using intelligent means to analyze and execute dynamic path planning, enterprises can learn about highway usage in real time and flexibly adjust their transportation strategies to improve the efficiency of the entire transportation network system. The data acquired includes GPS vehicle trackers, traffic cameras, routing apis, historical traffic data, weather forecasts and more, all of which help select and determine the most appropriate transport route. Table 3 shows the statistics of the application and optimization effect of real-time traffic monitoring on logistics scheduling:

Table 3. Application and Optimization of Real-Time Traffic Monitoring in Logistics Scheduling.

Application scenario	Data source	Central role	Optimization effect
Traffic flow analysis	GPS vehicle tracking, traffic cameras, intelligent transportation systems	Monitor road network flow, identify congested sections, and optimize logistics routes	Reduce shipping time and improve on-time delivery
Dynamic path optimization	Real-time navigation system, historical traffic data, weather data	Adjust the distribution route based on real-time road conditions to avoid traffic congestion	Reduce transportation costs and improve fleet operation efficiency
Transportation risk prediction	Accident reports, weather forecasts, historical traffic data	Give early warning of bad weather, traffic accidents and other emergencies, and adjust transportation plans	Reduce delays and improve logistics stability
Intelligent scheduling management	Vehicle networking data, order management system, cargo tracking system	Dispatch transport vehicles according to traffic conditions and optimize resource allocation	Improve vehicle utilization and reduce empty load rate
Accurate delivery time prediction	Historical driving data, road API, order fulfillment time records	Improve customer experience by estimating delivery times with real-time traffic conditions	Enhance customer satisfaction and improve service quality

As can be seen from Table 3, the application of intelligent traffic monitoring technology enables logistics companies to monitor and dispatch transport capacity resources more accurately, select more efficient routes in time, and reduce transportation delays caused by uncontrollable factors such as traffic accidents and fog during transportation.

3.4. Artificial Intelligence Calculation, Accurate Decision Warehouse Location

Choosing the right storage location will directly affect the efficiency of the entire distribution system, and this choice directly affects the rapid operation of the entire logistics, inventory management and transportation costs. The traditional selection method is based on the calculation of experience and basic data, which is difficult to cope with the increasingly complex market and constantly changing needs. However, artificial intelligence deep learning, optimal strategy and big data processing can promote the scientific and accurate selection of storage location. Its core goal is to make a more accurate location decision from the aspects of market demand, logistics costs, distribution of supply chain outlets and traffic conditions. The following Table 4 summarizes the application and optimization effect of artificial intelligence in warehouse location:

Table 4. Application and Optimization Function of Artificial Intelligence Calculation in Warehouse Location Selection.

Application scenario	Core technology	Central role	Optimization effect
Multidimensional data integration	Big data analytics, GIS, Internet of Things	Collect and integrate multi-source data such as market demand, traffic, land cost, etc	Form a global warehouse location analysis, improve the location accuracy
Intelligent location model	Machine learning, deep learning, reinforcement learning	The model is trained to evaluate different site selection schemes and select the optimal warehouse location	Improve computing efficiency and reduce site selection trial and error costs
Simulation optimization	Logistics network simulation, Monte Carlo simulation	Predict logistics performance under different location options and optimize supply chain network layout	Reduce operating costs and improve supply chain adaptability
Decision support system	Artificial intelligence decision algorithm, automated analysis platform	Combined with real-time market changes, provide dynamic location adjustment suggestions	Improve location flexibility and supply chain resilience
Inventory demand forecast	Time series analysis, neural networks	Forecast storage demand in each region and plan inventory allocation reasonably	Reduce the risk of overstock and out-of stock
Operating cost evaluation	Logistics cost model, route optimization algorithm	Calculate the cost of warehouse construction, maintenance and transportation, and provide the optimal cost plan	Reduce logistics costs and improve warehousing ROI

As can be seen in Table 4, with the help of artificial intelligence, the location of the warehouse will be more scientific and flexible, which can reduce the human errors and data limitations of traditional location selection methods. Through the continuous iteration and update of AI technology, changes in the market environment can be timely adjusted, so as to better realize the elasticity of the supply chain.

4. Intelligent Transportation Cost Management Strategy in the Performance Network

4.1. Dynamic Path Planning Minimizes Transportation Distance and Reduces Time-Related Costs

Dynamic route planning refers to the process of optimizing the actual route configuration for the purpose of reducing the transportation cost and improving the transportation efficiency on the basis of fulfilling the transportation contract. The optimization method of traditional route planning is to drive along the pre-set route, which fails to predict the sudden road conditions in advance, resulting in long delivery time, large fuel consumption and low transportation efficiency. The dynamic route optimization technology can integrate the information of road traffic condition, order priority, vehicle performance and delivery time window into the optimization calculation of dynamic route decision, and obtain the optimized transportation path, so as to minimize the transportation distance, optimize the transportation utility and maximize the economic benefit.

Dynamic path optimization is usually modeled as a vehicle path optimization problem, and its mathematical expression is as follows:

$$Z = \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij} \cdot x_{ij} + \alpha \sum_{k=1}^{m} C_k \quad (1)$$

Two basic parameters are defined in this model, the total freight Z and the freight d_{ij} between two nodes. If there is a line that can be connected, $d_{ij} = 1$ otherwise, $d_{ij} =$

0. The fixed operating cost C_k of each vehicle is defined, including various costs such as oil price, labor cost and maintenance, and its relative importance is σ, $0 \leq \sigma \leq 1$, and there are n distribution centers and m vehicles.

4.2. Intelligent Vehicle Scheduling to Optimize Capacity Allocation and Load Ratio

Intelligent fleet scheduling is crucial to improve the efficiency of the performance network and reduce logistics costs. The traditional dispatching scheme is mainly based on manual experience or unchanging rules, which is difficult to respond to the order demand and road environment in real time, resulting in resource waste and insufficient loading. By combining artificial intelligence and big data analytics, real-time capacity reallocation can be achieved to improve logistics efficiency. Ai-based scheduling system, through machine learning and deep learning algorithms, studies historical order data, traffic flow and vehicle conditions and other factors, can accurately predict future order demand and optimize its distribution plan. Using reinforcement learning, the scheduling strategy can be improved continuously to reduce the idle rate and improve the utilization rate of transport capacity.

4.3. Real-Time Data Analysis to Improve the Stability and Efficiency of the Transportation Process

The reliability and efficiency of the transportation process affects the fulfillment rate of orders as well as the overall transportation cost of goods. Traditional transportation management is based on pre-defined scheduling plans, and it is difficult to respond in a timely manner to random events such as traffic congestion, weather changes, vehicle breakdowns, etc., which can lead to delayed delivery and increased operating costs. Leveraging real-time data analysis, the Internet of Things (IoT), data processing, and artificial intelligence techniques, the transportation process is continuously monitored and adjusted to enhance reliability and efficiency. Through the application of machine learning and data mining, the system is capable of generating an optimal transportation model.

$$Z = \min \left(\sum_{i=1}^{n} T_i + \beta \sum_{j=1}^{m} C_j\right) \tag{2}$$

Where Z represents the transportation optimization objective, T_i represents the actual traveling time on the transport route i, C_j represents the traveling cost of the j vehicle (fuel cost + personnel cost + maintenance cost), β represents the cost weight, n represents the number of transport lines, and m represents the number of vehicles.

4.4. Automatic Control System, Improve the Logistics Network Coordination Ability

Logistics network key coordination and centralized control system, through the introduction of automated control means, effectively improve performance efficiency and reduce operating costs. Traditional logistics distribution relies on man-machine assisted operation, which makes the transportation route and storage scheduling can't be adjusted in time, resulting in unreasonable resource allocation, delivery lag and other problems. The automatic control system built by artificial intelligence, big data analysis and Internet technology is strengthened based on real-time data processing and intelligent decision-making, and has a comprehensive coordination ability for the logistics network system. Based on cloud computing and edge computing architecture, the system combines order flow, transportation routes, inventory dynamics and traffic conditions to achieve automated scheduling and optimization. According to historical data and the latest information, the artificial intelligence adjusts the storage layout inventory and the volume of booking orders, and at the same time make dynamic optimization adjustments to the transportation path to enhance the flexibility and response speed of the logistics line.

5. Conclusion

As the core of supply chain management, optimizing the performance network is crucial for enhancing operational efficiency. A key element of this optimization lies in the strategic selection of warehouse locations and the effective management of transportation capacity. These factors directly influence the overall efficiency of the supply chain network. This research focuses on intelligent allocation, dynamic path planning, and automatic regulation, all of which are supported by cutting-edge technologies such as artificial intelligence and big data analytics. By leveraging these technologies, the supply chain can improve collaboration among different stakeholders, optimize resource utilization, and ultimately reduce operating costs, leading to a more efficient and cost-effective supply chain operation.

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