Creative Economy
2024, VOL. 8, NO. 6, 40-44
DOI: 10.47297/wspceWSP2516-251907.20240806

Study of optimization algorithm in logistics network design

Keqi Zhu

Fuxin City High School, Fuxin Liaoning, 123000

ABSTRACT
Logistics network design is a key link in modern logistics management. The optimization of logistics network can not only improve logistics efficiency, but also significantly reduce logistics cost. This paper discusses the application of optimization algorithm in logistics network design, focuses on the combined optimization algorithm and the optimization method based on intelligent algorithm, and analyzes the application effect of these algorithms in the actual logistics network optimization through specific cases. The results show that the optimization algorithm has wide application prospect and important practical value in logistics network design.

KEYWORDS
logistics network design; combinatorial optimization algorithm; intelligent algorithm; logistics efficiency; logistics cost

1 Introduction

With the vigorous development of e-commerce and the deepening of globalization, the logistics industry plays a vital role in the modern economic system. As the core link of logistics management, logistics network design is directly related to logistics efficiency, cost and customer satisfaction. The traditional logistics network design often relies on empirical judgment, lack of scientific and systematic, it is difficult to meet the complex needs of modern logistics. Therefore, the introduction of the optimization algorithm, the scientific planning and optimization of the logistics network, has become an important means to improve the level of logistics management.

Optimization algorithm is a method to find the optimal solution or approximate the optimal solution through mathematical model and computer technology. In the logistics network design, the optimization algorithm can comprehensively consider various factors such as geographical location, transportation mode, storage facilities, customer needs and so on, to realize the optimized layout and efficient operation of the logistics network. This paper aims to explore the application of the optimization algorithm in the logistics network design, in order to provide a reference for the scientific management and sustainable development of the logistics industry.

2 Basic concepts and elements of logistics network design

2.1 Basic concepts of logistics network design

Logistics network design refers to the scientific planning and optimization of various nodes in the logistics system (such as warehouses, distribution centers, transportation centers, transportation vehicles, etc.) and connections (such as transportation lines, distribution paths, etc.), so as to achieve the goal of maximizing logistics efficiency, minimizing cost and improving customer satisfaction.

Logistics network design involves many aspects, including geographical location selection, node collaboration, transportation mode optimization, storage network layout, inventory management optimization and so on.

2.2 Elements of logistics network design

Geographic location: Geographic location is one of the key factors in logistics network design. Reasonable geographical location selection can reduce the transportation distance and time, and reduce the logistics cost. At the same time, the selection of geographical location also requires considering the distribution of suppliers, customer demand, transportation infrastructure and other factors.

Node collaboration: Each node in the logistics network needs to be closely coordinated to realize the smooth and efficient logistics process. Node collaboration includes collaboration between warehouse and distribution center, collaboration between transport vehicles, etc. Through node coordination, transportation routes and modes can be reasonably planned, and logistics efficiency can be improved.

Transportation mode: Transportation mode is another important element in logistics network design. According to the nature, quantity and transportation distance of the goods, choosing the appropriate transportation mode (such as road transportation, railway transportation, waterway transportation, etc.) can reduce the cost and improve the efficiency. At the same time, the optimization of the transportation mode also needs to consider the real-time information such as traffic congestion and traffic control.

Storage network layout: Storage network layout refers to the scientific planning and optimization of storage facilities such as warehouses and distribution centers. Reasonable storage network layout can reduce the time and cost of warehousing link and improve the logistics efficiency. The optimization of the storage network layout also needs to consider the storage demand of the goods, the capacity utilization of the warehouse, and the coordination between the warehouse and the distribution center.

Optimization of inventory management: Inventory management optimization is an important part of logistics network design. Through scientific inventory management method, can avoid inventory backlog and out of stock phenomenon, reduce inventory cost. The optimization of inventory management should also consider the factors such as real-time inventory monitoring, inventory prediction model and automatic replenishment strategy.

3 Application of optimization algorithm in logistics network design

3.1 Combined optimization algorithm

Combinatorial optimization algorithm is a kind of algorithm that combines several transportation or processes in the logistics network by constructing mathematical models, and determines the combination scheme according to specific goals, so as to achieve the purpose of optimizing the logistics network. Common combinatorial optimization algorithms include heuristic algorithm, greedy algorithm, backtracking algorithm and dynamic programming algorithm.

Heuristic algorithm: Heuristic algorithm is an algorithm based on experience and intuitive judgment, which simulates the process of human solving problems to find the optimal solution or approximate optimal solution. In logistics network design, heuristic algorithms can be used to solve complex path optimization problems. For example, in distribution path optimization, heuristic algorithms can quickly generate one or more optimal distribution paths based on the nature,

quantity and distribution of distribution points of goods.

Greedy algorithm: Greedy algorithm is an algorithm that gradually builds the optimal solution, step by step chooses the current optimal choice, so as to lead to the global optimal solution. In logistics network design, greedy algorithm can be used to solve the problem of storage facilities. For example, when selecting a warehouse, the greedy algorithm can gradually determine the optimal warehouse location according to the factors such as capacity utilization, transportation distance and cost.

Backtrack algorithm: Backtrack algorithm is an algorithm that finds the best solution by searching for all possible solutions. In the logistics network design, the backtracking algorithm can be used to solve the complex transportation mode optimization problems. For example, in multiple transport mode choices, the backtracking algorithm can traverse all possible combinations of transport modes according to factors such as the nature, quantity and transport distance of the cargo, so as to find the optimal combination of transport modes.

Dynamic programming algorithm: Dynamic programming algorithm is an algorithm that avoids repeated calculation by decomposed problems, and gradually solving and storing intermediate results. In the logistics network design, the dynamic programming algorithm can be used to solve the inventory management optimization problem. For example, in inventory management, dynamic planning algorithms can make optimal inventory plans based on factors such as historical sales data, inventory prediction model, and automatic replenishment strategy.

3.2 Optimization based on intelligent algorithm

The optimization based on intelligent algorithm refers to the use of modern computer and information technology, using biological evolution, artificial intelligence, neural network and other natural intelligent algorithms, to optimize the complex logistics network. Common optimization based on intelligent algorithm includes genetic algorithm, simulated annealing algorithm, ant colony algorithm and particle swarm algorithm.

Genetic algorithm: Genetic algorithm is an optimization algorithm that simulates the evolutionary process of living organisms and finds the optimal solution through selection, crossover and variation. In logistics network design, genetic algorithms can be used to solve complex path optimization and facility location problems. For example, in distribution path optimization, genetic algorithms can generate multiple candidate pathways according to the nature, quantity and distribution of distribution points, and continuously optimize the path through operations such as selection, crossover and variation.

Simulated annealing algorithm: Simulated annealing algorithm is an optimization algorithm based on the physical annealing process, which seeks for the optimal solution by simulating the process of slow cooling after metal heating. In the logistics network design, the simulated annealing algorithm can be used to solve the problem of transportation mode optimization. For example, in multiple transport mode choices, the simulated annealing algorithm can generate multiple candidate combinations of transport modes based on factors such as the nature, quantity and transport distance of the cargo, and continuously optimize the transport mode combinations by simulating the annealing process.

Ant colony algorithm: The ant colony algorithm is an optimization algorithm that simulates the foraging behavior of ants. It releases pheromone during the foraging process and cooperates with each other to find the optimal solution. In logistics network design, ant colony algorithm can be used to solve the complex path optimization and storage facilities. For example, in the distribution path optimization, the ant colony algorithm can simulate the movement process of ants on the distribution path according to the nature, quantity and distribution distribution of goods, and

continuously optimize the path through pheromone update.

Particle swarm algorithm: Particle swarm algorithm is an optimization algorithm that simulates the foraging behavior of birds. It finds the optimal solution by simulating the movement process of particles in the search space. In the logistics network design, the particle swarm algorithm can be used to solve the inventory management optimization problem. For example, in inventory management, the particle swarm algorithm can simulate the movement of particles in the inventory plan space based on factors such as historical sales data, inventory prediction model and automatic replenishment strategy, and optimize the inventory plan by constantly adjusting the position and speed of the particles.

4 Case analysis

4.1 The ORION system of the UPS

UPS is one of the largest logistics companies in the world, and its ORION (On-Road Integrated Optimization and Navigation) system is a typical case of logistics network design based on intelligent algorithm optimization. The ORION system uses optimization algorithms such as genetic algorithm and simulated anneal algorithm to optimize the distribution route, improve the distribution efficiency and reduce the cost. The ORION system determines the optimal delivery route by considering multiple factors, including road congestion, traffic conditions, delivery time windows, and delivery priorities. Using the ORION system, UPS is able to optimize its express delivery routes worldwide, thereby improving delivery efficiency and reducing costs. According to UPS, the ORION system can save companies millions of dollars a day.

4.2 JDs Smart Logistics system

JD is one of the largest e-commerce platforms in China, and its Smart Logistics system is a case of truck loading optimization based on intelligent algorithm optimization. Smart Logistics The system uses optimization algorithms such as genetic algorithm and simulated annealing algorithm to determine the optimal truck loading scheme. Smart Logistics The system can generate multiple candidate loading schemes according to different factors such as cargo volume, weight and destination, and continuously optimize the loading scheme through the optimization algorithm. By using the Smart Logistics system, JD can improve truck capacity utilization and transportation efficiency, thus reducing costs and improving customer satisfaction.

4.3 Cainiao intelligent warehouse optimization

Cainiao Intelligent Warehouse is a logistics technology company under Alibaba Group. It is committed to building a digital, intelligent and green modern logistics system. The algorithm optimization of Cainiao intelligent warehouse mainly focuses on the logistics links such as warehousing, sorting and delivery, and realizes automation, intelligence and optimization through intelligent algorithm and big data analysis. Cainiao intelligent warehouse adopts intelligent optimization methods, such as sorting, warehouse optimization, intelligent scheduling, intelligent prediction and intelligent operation, to improve logistics efficiency, accuracy and reliability. By optimizing the storage network layout and inventory management strategy, Cainiao intelligent warehouse can reduce the time and cost of the warehousing link and improve the logistics efficiency. At the same time, through intelligent scheduling and prediction algorithm, Cainiao intelligent warehouse can optimize the transportation path and distribution plan, and improve

customer satisfaction.

5 Conclusions and outlook

5.1 Conclusion

This paper discusses the application of optimization algorithm in logistics network design, focusing on combinatorial optimization algorithm and optimization method based on intelligent algorithm. Through the specific case analysis, this paper draws the following conclusions: The optimization algorithm has a wide application prospect and an important practical value in the logistics network design. By introducing the optimization algorithm, the logistics network can be scientifically planned and optimized to improve the logistics efficiency and reduce the cost. The combinatorial optimization algorithm and the optimization method based on the intelligent algorithm each have their own advantages and disadvantages, and the appropriate algorithm should be selected according to the specific problems and requirements. In practical applications, it can be weighed and selected based on the complexity of the problem, data scale and computational resources. Through the case analysis, it can be seen that the application of optimization algorithm in logistics network design has achieved remarkable results. For example, UPSs ORION system, JDs Smart Logistics system and the Cainiao intelligent warehouse optimization method all improve logistics efficiency and reduce costs.

5.2 Outlook

In the future, with the continuous development of information technology and artificial intelligence technology, the application of optimization algorithm in logistics network design will show the following trends: Improvement of efficient data processing capacity: With the increasing amount of data generated in the logistics network, the traditional computing methods have been unable to meet the demand. More efficient data processing algorithms and technologies need to be developed in the future to meet the needs for large-scale data processing and analysis. The popularization of intelligent logistics system: With the continuous development of artificial intelligence technology, intelligent logistics system will become an important trend in the field of logistics. Through automation, machine learning, expert system and other technologies, intelligent logistics system can realize real-time monitoring and optimization of logistics network, and improve logistics efficiency and service.

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