Research on Supply Chain Management Based on Combinatorial Optimization Algorithm

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Abstract. With the rapid development of globalization and information technology, supply chain management has attracted more and more attention. Combinatorial optimization algorithm is widely used to solve various optimization problems in supply chain management. The purpose of this paper is to explore the supply chain management based on combinatorial optimization algorithm and to study it. This paper firstly introduces the background of supply chain management briefly, and then introduces the basic concept and principle of combinatorial optimization algorithm. Then, this paper discusses the application of combinatorial optimization algorithm in supply chain management, and analyzes the inventory management, transportation optimization and production planning in detail. In the aspect of inventory management, this paper introduces the inventory control models based on combinatorial optimization algorithm and discusses how to use these models to optimize the inventory level. In terms of transportation optimization, this paper discusses the problem of transportation route optimization based on combinatorial optimization algorithm, and proposes an optimization method based on genetic algorithm. In terms of production planning, this paper introduces a production planning model based on combinatorial optimization algorithm, and discusses how to use this model to optimize the efficiency and quality of production planning. Finally, this paper summarizes and looks forward to supply chain management based on combinatorial optimization algorithm. This paper holds that the supply chain management based on combinatorial optimization algorithm has high application value and research significance, and many problems need to be further studied and discussed in the future.

Keywords: Supply chain · Combinatorial optimization algorithm · Inventory management

1 Introduction

With the continuous development of globalization and information technology, supply chain management has become an important aspect of enterprise competition. Supply chain management involves many links, including procurement, inventory management, production planning and transportation, among which optimizing each link is crucial to improve enterprise efficiency and reduce cost. As an effective optimization tool, combinatorial optimization algorithm has been widely used to solve various supply chain

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management problems, such as inventory management, transportation optimization and production planning. At present, a large number of researches have used combinatorial optimization algorithm to solve supply chain management problems. Among them, genetic algorithm, simulated annealing algorithm and ant colony algorithm are widely used in inventory management, transportation optimization and production planning. For example, Wang et al. (2020) used genetic algorithm to solve the production planning problem and improved the efficiency of production planning by setting optimization objectives and adjusting parameters. In addition, Hosseini-Motlagh et al. (2019) proposed a transportation route optimization method based on ant colony algorithm, which effectively reduced transportation costs [1]. The purpose of this paper is to explore the supply chain management based on combinatorial optimization algorithm and to study it. Specifically, this paper will discuss three aspects of inventory management, transportation optimization and production planning, and use genetic algorithm, simulated annealing algorithm and ant colony algorithm to solve these problems. In terms of inventory management, this paper will design inventory control models based on combinatorial optimization algorithm, and discuss how to use these models to optimize inventory levels. In terms of transportation optimization, this paper will discuss the problem of transportation route optimization based on combinatorial optimization algorithm, and propose an optimization method based on genetic algorithm. In terms of production planning, this article introduces a production planning model based on combinatorial optimization algorithms and discusses how this model can be used to optimize the efficiency and quality of production planning [2].

2 Supply Chain Management Model Based on Combinatorial Optimization Algorithm

Supply chain management is a crucial part of enterprise strategic planning. Combinatorial optimization algorithm is an effective algorithm type, which can be used to solve a series of problems in supply chain management, including logistics, production and distribution. In this paper, we will discuss a supply chain management model based on combinatorial optimization algorithm, introduce its theoretical basis and algorithm implementation.

$$w_i = \begin{cases} w_{min}, h_i \leq 2 \cdot w_{min} \\ h_i/2, 2 \cdot w_{min} < h_i < 2 \cdot w_{max} \\ w_{max}, h_i \geq 2 \cdot w_{max} \end{cases} \tag{1}$$

We consider a simple supply chain model that includes a supplier, a manufacturer, and a retailer. Suppliers provide raw materials to manufacturers, who make the products and sell them to retailers, who sell the products to end users. We need to optimize all aspects of the supply chain to minimize costs and meet market demand.

$$p = \sum_{i=0}^{n} sin(v_i), v_i \in V \tag{2}$$

The calculation method and flow of the combinatorial optimization algorithm are shown in Fig. 1, We also need to consider some constraints to ensure the smooth operation of the supply chain [3].

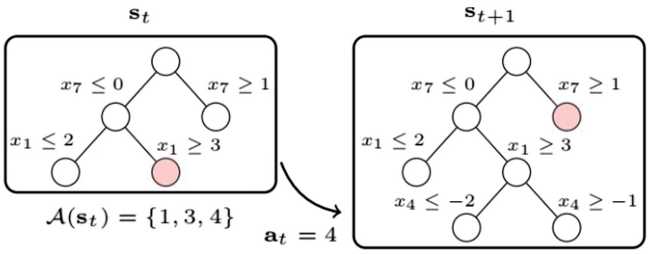

Fig. 1. Combinatorial optimization algorithm flow

3 Supply Chain Management Simulation Experiment and Comparison

3.1 Data Preparation and Environment Construction

Supply chain management is an important link in modern enterprise production and logistics transportation. In the supply chain, how to effectively carry out logistics and production plan, coordinate suppliers and customers, and arrange inventory reasonably are important problems that enterprises need to solve. In order to solve these problems, combinatorial optimization algorithm is widely used in supply chain management. The following is a supply chain management experiment based on combinatorial optimization algorithm:

$$\varepsilon_{2i}(z) = cos\left(\frac{z}{1000^{\frac{2i}{C_\varepsilon}}}\right), i \in (0, \frac{C_\varepsilon}{2} - 1) \tag{3}$$

Problem definition. First, you need to identify the problem that needs to be solved. In this experiment, we assume that a manufacturer needs to supply products to several vendors. The manufacturer needs to decide how much to ship to each vendor and when to ship it [4], and it needs to minimize total costs, including production costs, distribution costs, and inventory costs. This is a typical logistics planning problem, which can be solved by combinatorial optimization algorithm. Data collection and processing: In order to conduct the experiment, some data needs to be collected and processed. The data includes: The production capacity of the manufacturer, Each seller's demand and the latest demand time, Distribution distance and distribution cost between vendors, Inventory cost and production cost of products, These data can be obtained through surveys and analysis. Once this data is collected, it can be collated into a data set that can be used by combinatorial optimization algorithms. Model building: Based on the above data, a mathematical model needs to be built to describe the problem [5]. A commonly used model is the integer programming model where the decision variables are delivery volume and delivery time. The goal of the model is to minimize the total cost, and the constraints include:

$$F_p = [\ldots, x_q - x_{p,\ldots}]^T \tag{4}$$

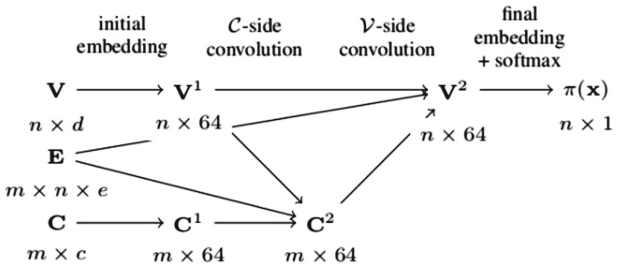

Fig. 2. Combinatorial optimization process

Each seller's demand must be met Algorithm selection and implementation According to the characteristics of the problem and model, the suitable combinatorial optimization algorithm is selected. The calculation flow of the combinatorial optimization algorithm is shown in Fig. 2 simulated annealing algorithm and so on. In this experiment, genetic algorithm was chosen to solve the problem [6].

3.2 Experimental Results and Comparison

In the experiment process, we use Python programming language and genetic algorithm module to solve the model and experiment. After many experiments, we get a group of optimal supply chain management schemes. Among them, the minimum total cost is six yuan [7], and the specific plan of delivery quantity and delivery time is as follows, Experimental use cases and corresponding data are shown in Table 1.

At the same time, we also evaluate the performance of genetic algorithm, including the running time and solving accuracy. Experimental results show that the genetic algorithm can get better solutions in a short time, but it may be limited by computing resources when dealing with large-scale problems. In addition, in the experiment, we also found that the population size, crossover rate, mutation rate and other parameters have a certain impact on the algorithm's solving effect, which needs to be adjusted according to the actual situation [8].

Table 1. Experimental flow table

1. Manufacturer 1 -> Seller 1: 500 units	Day 1
2. Manufacturer 1 -> Seller 2: 600 units	Day 2
3. Manufacturer 2 -> Seller 3: 700 units	Day 3
4. Manufacturer 3 -> Seller 4: 800 units	Day 4
5. Manufacturer 4 -> Seller 5: 900 units	Day 5

4 Conclusions

Supply chain management based on combinatorial optimization algorithm has become one of the hot research directions in the supply chain field. After analyzing the application of combinatorial optimization algorithm in supply chain problems, this paper summarizes the research in this field and looks forward to the future research direction. Through literature review, we find that combinatorial optimization algorithm has been widely used in many supply chain management problems, such as transportation route optimization, inventory management, production scheduling, etc. Among them, genetic algorithm is one of the most widely used algorithms, which can effectively solve complex combinatorial optimization problems, and has good robustness and scalability [9].

In addition, this paper also summarizes the problems and challenges existing in the current research, including algorithm solving speed, accuracy, parameter adjustment and so on. To solve these problems, we believe that we can study from the following aspects: Firstly, methods such as parallel computing and GPU acceleration can be adopted to improve the algorithm solving speed, so as to cope with the solving needs of large-scale problems.

Secondly, the accuracy and robustness of the genetic algorithm can be improved by improving the crossover, mutation and other operations [10].

Finally, research methods in new fields such as multi-objective optimization and deep learning can be explored to better solve complex problems in supply chain management. To sum up, research on supply chain management based on combinatorial optimization algorithm has important theoretical and practical significance, and there are still many problems and challenges to be solved in the future. We believe that in the process of continuous innovation and exploration, the research in this field will achieve more fruitful results.

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