

Research to Improve Vehicle Scheduling Efficiency in the Supply Chain on the Strategies: Automotive Logistics & Distribution Centers

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Abstract: The growing popularity of online shopping in China has promoted the logistics and transport industry. Automobile is the most frequently used, most efficient, and most convenient means in medium- and short-distance road transport. China Federation of Logistics and Purchasing pointed out by the statistics that road transport freight by automobile accounts for about 80% of the total freight of logistics systems nationwide, while showing a rising trend. By applying technology in management of vehicles for logistics and distribution, this paper built a mathematical model for vehicle management from economic, technical, and management perspectives, using economic and rational vehicle configuration and minimal operating costs to ensure completion of deliveries, thereby improving the efficiency of automobile transport and logistics industry.

Introduction

With the rapid development of e-commerce and third-party logistics, logistics and distribution systems have increasingly become a bottleneck in the development of the logistics industry. Currently, most of China's logistics and distribution centers (such as logistics and distribution in e-commerce, large supermarket chains, etc.) mainly apply empirical manual scheduling formula for the scheduling of operating vehicles, thus resulting in the low effective utilization of business transport resources, lack of scientific and accuracy in scheduling decision-making, too high operating costs and inability to provide customers with high quality services. Therefore, it is an important issue to study logistics optimization and establish vehicle scheduling and routing systems that meet customer demand based on scientific location of logistics and distribution centers so as to enhance the level of service of the logistics industry.

In China due to the lagged behind operation and management modes, most of the logistics enterprises have such problem as large investment, low equipment utilization and poor earnings, and because of low automation and low level of informationization, some companies are still in the state of manual work and empirical management, which has not meet the society's growing demands for logistics and distribution, and there is an urgent need to adopt modern and scientific ways to guide, organize and manage the production. Thus, it is of important practical significance to develop a computer-aided distribution, production and vehicle management system for management of vehicles for logistics and distribution. Cargo consolidation, loading and delivery process is the core of the operation of a logistics and distribution system. Optimization of a logistics and distribution system mainly refers to scheduling optimization of distribution vehicles and rationalization of transportation, including consolidation route optimization, optimization of cargo loading and delivery routes, as well as optimization of the integration of cargo consolidation, loading and delivery. Vehicle scheduling optimization and rationalization of transportation is a key link in the optimization of logistics and distribution systems and also an integral part of e-commerce activities in logistics and distribution systems.

Research Theories and Model

Faced with the expansion of distribution area and the increase in distribution points, it has been difficult for this artificial mode of operation to achieve immediate vehicle scheduling optimization, so there is an urgent need to use the computer to optimize the vehicle scheduling. Vehicle scheduling and routing for a distribution center belongs to the issue of vehicle scheduling that can be defined as optimization and design of a vehicle scheduling solution for transport vehicles from one or more facilities to multiple geographically dispersed customer sites, while meeting a series of constraints. The premise is that the facility locations, customer locations and road conditions have been known, whereupon a vehicle scheduling program is developed to meet the objective function.

According to the VRP (vehicle routing problem) model, a distribution centers vehicle scheduling and routing problem can be described as follows: under the premise that the distribution centers location, customer locations, customer demand, roads and other factors have been known, for m vehicles and n customers points, the allocation of vehicles (assigning each vehicle the customer points it is responsible for) and the routing of each vehicle is determined, minimizing the operating costs while meeting the following assumptions:

(1) All vehicles routes start and end at the distribution center, so that the route forms a closed loop between the distribution center and customer points, where each customer point is served by only one vehicle (but a vehicle can serve multiple customer points);

(2) Each customer point has a non-negative demand of goods, but the total demand for goods of all customer points each vehicle is responsible for does not exceed the maximum loading capacity of the vehicle;

(3) For any customer point, the vehicle is required to arrive at a given time, or if the conditions are not met, the penalty function will be introduced;

(4) Each vehicles total running time on the route (with the distribution center as the starting and ending point) does not exceed a given limit.

The scheduling module implements real-time scheduling by automatic processing and human intervention based on the actual flow of traffic, delivery routes, and vehicle allocation: First, the scheduling room determines cargo, time requirements, etc. for each route to complete based on the data on flow of traffic of various categories of goods sent from the distribution center and generates shipment planning and scheduling orders, and then according to shipment planning and scheduling commands implements scheduling combined with current vehicles, staffing and situation, including determination of vehicles for various route and shifts, drivers, guards, commodity list for distribution, purpose, a variety of information on recipients, and so on for delivery staff and recipients to view and sign. Distribution management personnel monitor, inspect, and evaluate of distribution processes and results based on records returned from GPS or distribution operating personnel and this is the content of distribution work management.

The basic design ideas and principles of a delivery vehicle management system are as follows:

(1) Under the premise of sound physical management, implement full-process management of vehicle life cycles starting from vehicle selection to scrap. Apply views and methods of systems engineering in management of vehicle purchase, use, repair and maintenance, and scrap, and improve the functioning of all aspects of the whole process.

(2) Based on technology management, transport is an important part of distribution, but not the only part, so we can not put aside other aspects and consider economy alone. Vehicle management should first ensure synergy with other jobs to complete delivery according to the right quality and right quantity, while considering lowering production costs under this premise as far as possible. Thus, the basis of vehicle management is to ensure that vehicles and equipment are always in the best condition, staff in the optimal configuration, so as to achieve vehicle availability at any time and minimal costs, and so that the time, volume of transport, and reliability of distribution meet the requirements.

(3) Economic management of vehicles is mainly strict management and control of the entire production costs of companies, so that the calculation on the people, vehicles, departments and routes measured by mileage and time (day, month, quarter, and year) is based on production capacity.

Transportation is an intermediate link of logistics, and its economy depends on the ratio of the volume of distribution to transportation costs, and transportation costs management focuses on management of daily consumption and repair and maintenance, because the two aspects occupy the most important part of the entire transport costs, and these costs show great randomness, increasing difficulty in management, such as fuel, tires, materials and working hours in repair and maintenance operations; assessment of personnel and departments combined with production status (volume of distribution) also provides basis for decision-making on staff arrangements, vehicle and equipment configuration, identification of distribution costs and pricing.

(4) Vehicles ultimately serve deliveries, while producing consumption in the production, so vehicle management should not be separated from distribution and transport, but vehicle scheduling, staffing, etc. should be regarded as content of management, and production herein mainly refers to transport operations.

(5) Emphasize information management. Distribution requires and constantly produces large amounts of information, and this information should be continuously transferred between various departments and between the higher and lower levels. Each administrative department should not only keep abreast of various types of information every day, such as merchandise, vehicle, etc., but also calculate, analyze, and fill in the various reports on the production status on a regular basis, therefore, it is necessary to use computer and network technology to manage and share information, which saves a lot of manpower and material resources for statistics, filling and transmitting various reports and data, while providing a basis for business decision-making.

This paper used mixed integer programming approach for transport scheduling, which built a model for vehicle scheduling to achieve optimum efficiency. Assuming C for minimum cost, the objective function is as below.

$$c = \min\left(\sum_{i,j,k} (O_{ijk} t_{ij} u) + \sum_{i=1}^n P_i(t_i)\right)$$

In view of the actual situation, the constraints are as follows.

$$\sum_{k=1}^m x_{ik} = \begin{cases} m, i = 0 \\ 1, i = 1, \dots, n \end{cases}$$

$$\sum_{i=1}^n l_i x_{ik} \leq L_k, \forall k \in K,$$

$$\sum_{i=1}^n O_{ijk} = \sum_{j=1}^n O_{ijk}, \forall k \in K$$

$$S_0^k + \sum \sum O_{ijk} (t_{ij} + s_i) \leq S_R^k, \forall i, j \in G_0, k \in K$$

$$t_i + s_i + t_{ij} - M(1 - O_{ijk}) \leq t_j, \forall i, j \in G_0, k \in K$$

Wherein, u is operating costs for per unit of time, including the cost of vehicles and personnel costs; $P_i(t_i)$ is the penalty function, meaning the penalty cost corresponding to the vehicle arriving at customer i at time t that fails to meet customer requirements;

K is the set of all vehicles $K = \{1, \dots, m\}$; G_k is the set of customers served by vehicle k ; G_0 refers to all nodes consisting of the distribution center and customer points $G \cup \{0\}$, where $\{0\}$ represents the distribution center; t_i is the time the vehicle arrives at customer i ; t_{ij} is the travelling time

(constant) of the vehicle from customer i to customer j ; l_i is the demand of customer i (constant); L_k is the maximum loading capacity of vehicle k (constant, depending on the model); S_i is the duration of stay of the vehicle at customer i (constant); S_0^k is the departure time of vehicle k ; S_R^k is the time vehicle k is required to return (constant); M is a very large positive number (constant).

If vehicle k serves customer i , then x_{ik} is 1, or 0 otherwise, namely $x_{ij} = \{0,1\}$, $\forall i \in G_0$. This variable indicates the vehicle allocation scheme, which can be represented by Boolean Matrix; if vehicle k travels to customer j via customer i , O_{ijk} is 1 or 0 otherwise, namely $O_{ijk} = \{0,1\}$, $\forall i \in G_0, k \in K$. This variable represents the vehicle routing.

Constraint 1) Ensure that every customer is served and that each vehicle departs from the distribution center and returns to the distribution center;

Constraint 2) The total load of each vehicle does not exceed the maximum load;

Constraint 3) For customer point j served by vehicle k , there must be the other customer point i (including the distribution center) served by vehicle k , so that vehicle k runs from customer point i to customer point j ; for customer point i , the other customer point j exists to be served by vehicle k , so that vehicle k runs from customer point j to customer point i , and so on;

Constraint 4) Ensure that the total time consumed by each vehicle each route does not exceed a pre-set value;

Constraint 5) Determine the time limit the vehicle arrives at a customer point to meet customer requirements for time.

Conclusion

This paper analyzed scheduling and management of vehicles for distribution in the context of supply chain, which is an application of the supply chain in the logistics and distribution technology, so research in this regard has a high theoretical and practical significance; at the same time, this paper studied methods to optimize scheduling of vehicles for logistics and distribution and found that scientific management of vehicle scheduling could improve the efficiency of automotive transportation and logistics industry.

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