Research on Intelligent Scheduling Optimization of Non-Full-Load Logistics Vehicle Based on the Monitor Image

Rui Li¹ and Haiying Chen²

¹ Software College, Nanyang Institute of Technology, Nanyang 473000, China
² College of Humanities and Arts, Xianning Vocational Technical College, Xianning, China

Abstract. The traditional logistics vehicle scheduling method only estimates the total scheduling of batch vehicles, without considering the capacity limit of single logistics vehicle. It causes the problem of waste in vehicle transportation. Therefore, a vehicle scheduling method based on monitoring image under time constraints is proposed, using the time displayed in the monitoring image to constrain, the dynamic scheduling model is established by setting up the time window scheduling model to schedule the vehicle tasks within the time window conditions. According to the images obtained from the monitoring, combined with the need to divide several stages under the time constraints, the vehicles to ensure the logistics transportation can be scheduled according to the actual situation, make a highly optimal decision, achieve the maximum vehicle load rate, and ensure the smooth implementation of the dynamic strategy of the non full load logistics vehicle scheduling under the time constraints. Finally, the simulation test results show that the proposed method can improve the efficiency and rationality of logistics vehicle scheduling, the algorithm is stable and reliable, and has strong practicability.

Keywords: Integration of collection and delivery · Vehicle scheduling · Dynamic scheduling · Time window

1 Introduction

Non full load logistics vehicle scheduling is an important part of vehicle scheduling. The reasonable optimization of non full load logistics vehicle scheduling can improve the vehicle full load rate, which has great economic benefits and social value. It is widely valued by experts and scholars in related fields, and has made some progress [1]. In the traditional method of non full load logistics vehicle scheduling, the non full load logistics vehicle scheduling based on non-linear transformation path selection algorithm is mainly used, these non full load logistics vehicle scheduling methods only consider the distance and transportation speed in the process of cargo transportation, the implementation process is relatively simple, but the capacity limit of single transport vehicle is considered in the actual logistics vehicle scheduling process [2].
The overall capacity of the bulk vehicle is estimated and scheduled, resulting in a non-full-load waste in the transportation of the vehicle.

Aiming at the problems of traditional methods, a method of vehicle scheduling based on monitoring image is proposed, through the establishment of time window scheduling model and optimization of the model, time window constraints are obtained under the premise of image monitoring, and tasks are scheduled based on this condition. According to the needs of the division of a number of time constraints under the stage, in any stage of logistics transport vehicles can be scheduled according to the actual situation, make a high degree of optimal decision, to achieve the maximum vehicle load ratio. The simulation results show that the non full load logistics vehicle scheduling method can improve the efficiency and rationality of logistics vehicle scheduling, the algorithm is stable and reliable, and has strong practicability.

2 Non-Full Load Logistics Vehicle Scheduling Algorithm

Cargo collection and distribution are two important parts of logistics system [3], which play an important role in the whole logistics system, and vehicle scheduling information computing is also more and more important. The competition of logistics center urges users to pay attention to their own internal and also to strengthen the speed of software facilities, i.e. goods dispatching, so as to make rapid response to market demand. Only in the case of reasonable cost reduction, can we have a foothold in the fierce competition [4].

In the scheduling of non full load logistics vehicles, once the cargo transportation is required to arrive in a relatively tight time, the scheduling system shall be started to determine the logistics vehicle scheduling according to the current cargo and special needs [5]. Combined with the total vehicle capacity, the vehicle scheduling model of non full load logistics is established, to complete the vehicle scheduling problem constrained by the time window of non full load logistics vehicle scheduling, that is to say, the customer has time requirements for the distribution task, and the distribution activity should be carried out between the earliest time at and the latest time QT (AT < t < QT) [6]. Time window is obtained by monitoring image, and time window is constrained. The problem of time window can be divided into hard time window and soft time window. For the hard time window problem, the vehicle must be delivered within the time window [AT, QT], while the customer does not accept the delivery outside the time window, that is, the solution obtained is infeasible. For the soft time window problem, if the vehicle arrives earlier than at, it needs to wait until at to deliver. At this time, it needs to bear a certain cost loss. If it arrives later than QT, it needs to bear a certain penalty cost. If it arrives too early or too late, the customer will not accept delivery, that is, it becomes a hard time window problem again. At this time, it needs an infinite penalty cost expressed by Q. The penalty cost can be expressed as follows:
\[ f(t) = \begin{cases} 
Q \rightarrow +\infty, & t \leq e \\
v(AT - t), & 0 < AT \leq t \leq QT \\
k(t - QT), & P \leq t \leq QT \\
A \rightarrow +\infty, & t \geq r 
\end{cases} \]  

\[ (1) \]

Among them, \( f(t) \) is the penalty cost caused by the time window constraint, \( e \) is the earliest acceptable waiting time, \( K \) is the cost coefficient generated when waiting; \( R \) is the latest acceptable time, \( V \) is the penalty cost coefficient to be borne by delayed delivery; \( P \) is the infinite penalty cost. Logistics distribution path optimization problem can be described as: a distribution center needs multiple vehicles to deliver goods to multiple customers in this area. The location of customers and distribution centers is determined, and each customer’s demand for goods is determined \[7\]. Each distribution center has a variety of models, each model load is determined, and the maximum driving distance is determined. Each vehicle can serve multiple customers. Each customer can only have one vehicle to provide service. The vehicle starts from the distribution center and returns to the original distribution center after completing the distribution task. The distribution center shall deliver the goods to the customer within the time specified by the customer \[8\]. It is required to reasonably schedule vehicles to arrange the distribution path so that the objective function, i.e. the minimum distribution cost, can be optimized. The basic constraints of the problem are as follows:

1. There are multiple distribution centers, each of which has a variety of models;
2. The distribution center type is different, the weight is different, and the maximum travel distance is different;
3. The distribution center is known to the customer’s distribution needs and locations;
4. The actual demand per customer does not exceed the maximum load of each model, and the total distance of a distribution mission is not greater than the maximum distance of a distribution vehicle;
5. Each vehicle is only scheduled once, and each customer can only have one vehicle for distribution, and the vehicle will return to the original distribution center from the distribution center;
6. The customer requires that the goods be delivered within a certain amount of time, taking into account the time window constraints.

From the above time window constraints, the mathematical model of multi-unloaded logistics vehicle distribution scheduling can be obtained as follows:

\[ \min G = \sum_{i=1}^{I} \sum_{j} f(t) + \sum_{i=1}^{I} X_{abcd}(Y + S) \leq P \]

\[ (2) \]

Among them, \( X \) is the distribution center set, \( I \) is each distribution center, \( a \) is the customer set, \( B \) is the vehicle set, \( C \) is the customer demand, \( D \) is the maximum load capacity of the vehicle in the distribution center, \( S \) is the distance from the distribution center to the customer, and \( Y \) is the transportation cost per unit mileage of goods.
3 The Design of the Vehicle Scheduling Model for Non-Full-Load Logistics

3.1 Design of the Non-Full-Load Logistics Vehicle Scheduling Process

The non full load logistics vehicle scheduling algorithm based on the monitoring image is divided into two stages. In the first stage, the adaptive genetic algorithm is applied to obtain the elite population as the initial solution, and in the second stage, the tabu search algorithm is applied to re optimize the initial solution to obtain the final solution to take account of customer satisfaction, while avoiding the “shock” phenomenon of scheduling [9, 10]. Considering the actual situation, the dispatching center will not dispatch vehicles far away from the dynamic demand point for service, so before searching all current paths, first select the candidate route set according to the location of the new demand point, using the buffer analysis function of GIS, combined with the demand of the customer point, so as to reduce the search time of logistics vehicle path [11, 12]. At the same time, through comprehensive consideration of customer satisfaction, vehicle driving distance, vehicle waiting time and other factors, the Logistics comprehensive cost increase caused by the addition of new customers is worth to be optimized. Combined with the above ideas, the non full load logistics vehicle scheduling process under the constraints of time window is designed, as shown in Fig. 1.

Fig. 1. Vehicle scheduling flow under time window constraint
3.2 Optimization of Vehicle Scheduling for Non-Full Load Logistics Based on Shortest Path

In the process of logistics and distribution, a traffic network structure is composed of each city point connected by roads. In the process of transportation, the shortest path problem is the minimum path from the logistics and distribution center to each city point. In general, the weight of the shortest path is represented by the distance between the source point and the target point, vehicle travel time and cost. In order to solve the shortest path problem in logistics network, it is necessary to find the lowest transportation cost, the shortest driving time and the shortest driving distance from the distribution center to the target point.

The input contains a weighted digraph \( g \) and a source vertex \( s \) in \( G \). \( V \) is the set of all vertices in \( G \). Every edge in a graph is an ordered pair of elements formed by two vertices. \((U, V)\) indicates that there is a path from vertex \( u \) to \( v \). With the set of all edges of \( E \), \( w(U, V) \) is the nonnegative cost value from vertex \( u \) to vertex \( v \). The cost of an edge can be thought of as the distance between two vertices. The cost value of a path between any two points is the sum of the cost values of all sides of the path. We know that there are vertices \( s \) and \( T \) in \( V \), and find the lowest cost path from \( s \) to \( t \). The driving cost between two points is equal to the driving time plus the distance between two points plus the driving cost. The distance between two customer points in the traffic network is known, and the driving time of vehicles can be roughly estimated. However, the amount of vehicle driving can only be determined according to the actual situation and experience. With the weight between two points, the problem is transformed into the shortest path problem. Therefore, the traffic network structure with weight is designed as shown in Fig. 2:

![Traffic network](image)

**Fig. 2.** Traffic network

Using the above network to carry out vehicle traffic, on the way of vehicle delivery, the dispatching center receives the demand from new customers. The dispatching
center records the customer information, goods information and service time require-
ments of the new demand according to the principle of first come first serve. According
to the interval time and the situation of new customers, judge whether to conduct
dynamic scheduling, as shown in Fig. 3. The judgment of scheduling time is to avoid
two kinds of situations: too long delay and too short delay. Too long delay will lead to
untimely customer service and affect the customer service level of logistics enterprises;
too short delay will lead to scheduling “oscillation”, that is to say, too frequent
scheduling scheme changes will affect the implementation effect of the scheduling
scheme. The time interval threshold and new customer threshold are set by the dis-
patching center personnel according to their experience. In this paper, the threshold of
scheduling time is 30 min, and the threshold of new customers is 5.

4 Experimental Results and Analysis

In order to verify the effectiveness of the algorithm, it is assumed that there are three
types of non full load logistics vehicles under the time constraints obtained from the
monitoring image, a total of 300 vehicles, including 100 vehicles of a, B and C, each
with a full load time of 10 min and a cost of 20 tons. The vehicle attributes of each
vehicle (including load, fuel consumption, freight, etc.) are shown in Table 1. The simulation environment of this paper is: Windows 7 operating system, using the simulation software MATLAB 7.0, combined with the method of random data generation. In order to facilitate the comparative analysis of data, three kinds of transportation tasks with the same vehicle distribution are simulated, and the scheduling time, stability and scheduling frequency are taken as the basis to evaluate the effectiveness of this method (Table 2).

Table 1. Dispatching logistics vehicle attribute

| Models | Load | Load No | Load Additional | Speed |
|--------|------|---------|-----------------|-------|
| A      | 8    | 32      | 0.94            | 0.22  | 80    |
| B      | 14   | 46      | 0.81            | 0.16  | 86    |
| C      | 20   | 60      | 0.93            | 0.14  | 70    |

Table 2. Dispatching logistics vehicle task data

| Task | Weight/kg | Volume | Time/min | A | B | C |
|------|-----------|--------|----------|---|---|---|
| A    | 460       | 200    | 24       | 50| 40| 35|
| B    | 420       | 280    | 24       | 50| 40| 35|
| C    | 400       | 360    | 24       | 50| 40| 35|

Due to the complex application environment of the non full load logistics vehicle scheduling method, the logistics vehicle scheduling time is tested first. The purpose of this paper is to test the effectiveness of this method in scheduling efficiency compared with traditional methods, and the results are shown in Fig. 4.

Fig. 4. Comparison and test results of dispatching efficiency of non-full-load vehicles
From the analysis of Fig. 4, it can be seen that there is not much difference between the two methods in the process of clustering under the condition of the same cargo volume and the same scheduling volume. However, with the continuous increase of the number of scheduled cargo, the method in this paper is used for the non full load logistics vehicle scheduling. The required scheduling time is far less than that of traditional methods, so we can see that, with the passage of time, the scheduling results of this algorithm are much higher than that of traditional algorithms. The purpose of the comparison is to test the stability of the two methods under the condition of large cargo volume. A total of 400000 tons of logistics resources are set for scheduling, and tested by cbkal software. The results are shown in the Fig. 5.

![Fig. 5. Comparative Test results of Stability of vehicle scheduling methods for non-full load Logistics](image)

Analyzing the experimental data in the Fig. 5, we find that under the same scheduling time, the stability rate of this method is obviously higher than that of the traditional method when scheduling non full load logistics vehicles. With the extension of scheduling time, its advantages are more obvious. On the whole level, the average scheduling stability of the non full load vehicle scheduling optimization method with time window can reach more than 50%. However, the average scheduling stability of the traditional method is about 13%, which proves that the stability of this method is much higher than that of the traditional method, and the scheduling results are stable and reliable.

5 Conclusions

In order to solve the problem of vehicle scheduling in logistics distribution, the time window algorithm is used to optimize the logistics distribution system, and the vehicle scheduling optimization algorithm under the constraints of time window is established,
and the comparison and analysis of the non full load logistics vehicle scheduling situation is carried out, and a new model is established to realize the optimal design of non full load logistics vehicle scheduling. Finally, through the square array experiment, it is proved that the vehicle scheduling optimization method with time window is of high value.

References

1. Yang, G.: Research on optimization method of vehicle scheduling for non-full load logistics. Comput. Simul. 34(03), 147–150 (2017)
2. Zheng, Z., Long, J.Y., Gao, X.Q.: Production scheduling problems of steelmaking-continuous casting process in dynamic production environment. J. Iron Steel Res. (Int.) 24 (6), 586–594 (2017)
3. Gili, S., Marra, W.G., D’Ascenzo, F., et al.: Comparative safety and efficacy of statins for primary prevention in human immunodeficiency virus-positive patients: a systematic review and meta-analysis. Eur. Heart J. 37(48), 3600–3610 (2016)
4. Pan, C., Zhang, J., Qin, W.: Real-time OHT dispatching mechanism for the interbay automated material handling system with shortcuts and bypasses. Chin. J. Mech. Eng. 30(3), 663–675 (2017)
5. Chamana, M., Chowdhury, B.H., Jahanbakhsh, F.: Distributed control of voltage regulating devices in the presence of high PV penetration to mitigate ramp-rate issues. IEEE Trans. Smart Grid 77(99), 1 (2016)
6. Yu, Y.L., Li, W., Sheng, D.R., et al.: A hybrid short-term load forecasting method based on improved ensemble empirical mode decomposition and back propagation neural network. J. Zhejiang Universitycience A 17(2), 101–114 (2016)
7. Chen, L., Ming, Y.E., Jiang, Y.E., et al.: Study on ecological operation and influence of power generation of Longtan-Yantan cascade reservoirs on Hongshui River. J. Hydroel. Eng. 35(2), 45–53 (2016)
8. Niu, W., Feng, Z., Cheng, C., et al.: Parallel multi-objective optimal operation of cascaded hydropower system. J. Hydraulic Eng. 48(01), 104–112 (2017)
9. Sediqi, M.M., et al.: An optimization approach for unit commitment of a power system integrated with renewable energy sources: a case study of Afghanistan. Energy Power Eng. Engl. Vers. 8, 528–536 (2017)
10. Tao, D., Lin, Z., Wang, B.: Load feedback-based resource scheduling and dynamic migration-based data locality for virtual hadoop clusters in OpenStack-based clouds. Tsinghua Sci. Technol. 22(2), 149–159 (2017)
11. Shi, J., Lee, W.-J., Liu, X.: Generation scheduling optimization of wind-energy storage system based on wind power output fluctuation features. IEEE Trans. Ind. Appl. 16(99), 1–7 (2017)
12. Gutiérrez-Mena, J.T., Gutiérrez, C.A., Luna-Rivera, J.M., et al.: A novel geometrical model for non-stationary MIMO vehicle-to-vehicle channels. IETE Tech. Rev. 7, 1–12 (2017)