Research on Green Logistics Energy-Saving and Emission-Reduction Vehicle Distribution System under Low Carbon Economy

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Abstract. Logistics is called "the source of the third profit", and it has attracted more and more attention from people, and it has increasingly become the basic industry of the national economy. Distribution is a special and comprehensive form of activity in the logistics system, which is a close combination of logistics and business flow. Distribution is the process of allocating goods at the distribution center or other logistics nodes according to the requirements of the customer and handing them to the customer in the most reasonable way. After the economic work conference of the 18th National Congress of the Communist Party of China, the government and enterprises put green and low carbon in a more important position, and industries such as urban construction and traditional manufacturing need to think about how to become greener, especially for the logistics and transportation industry. Based on this research background, the paper developed an intelligent vehicle scheduling system. Based on the summarization of a large number of applications at home and abroad, from the two aspects of the vehicle routing problem model and solution algorithm, the domestic and foreign research status of the vehicle routing problem is deeply analysed. According to different factors, the vehicle routing problem is based on the basic model and the derivative model. To classify and solve the current research hot issues-open vehicle routing problem and dynamic network vehicle routing problem. The system includes vehicle scheduling, management of carrier bills, electronic map display, basic information maintenance and other functions.

1. Introduction
As market competition intensifies, more and more companies begin to outsource logistics modules to specialized logistics service agencies. Logistics companies emerge as the times require. Through specialized logistics services, logistics companies can help reduce the logistics operations of cargo owners. Cost, profit from it. But the average profit level of China's logistics industry is only about 3%, logistics costs are mainly composed of transportation costs, storage costs and management costs, transportation costs account for the largest proportion.

As the government's requirements for environmental protection are getting higher and higher and the society's awareness of environmental protection is increasing, in the process of logistics distribution, in addition to considering the basic operation goals of on-time delivery, more and more companies are also Considering how to reduce environmental pressure and emission pollution,
academia began to pay attention to the issue of vehicle routing under emission control. Since emissions are related to the fuel combustion of automobiles, the general academic community has turned the vehicle routing problem with emission control as the target into the vehicle routing problem with minimum fuel consumption as the target. Such research has also received academic attention in recent years. The vehicle routing problem mainly studies vehicle route optimization in logistics distribution to reduce transportation costs. This problem is a well-known NP problem in the field of operations research and combinatorial optimization, and has applications in many fields such as flight scheduling and train formation. Vehicle routing problems can be divided into multiple models based on various constraints such as customers, roads, and vehicle types. Due to the complexity of NP problem solving, current vehicle routing problem solving methods mainly use various intelligent optimization algorithms [1].

2. Dynamic logistics distribution path model design

The mathematical model of the dynamic network vehicle routing problem can be expressed as follows: Assume that the distribution center can use at most \( K(k=1,2,\ldots,K) \) vehicles to transport and distribute \( L(i=1,2,\ldots,L) \) customers, and \( i=0 \) represents the warehouse. The load of each vehicle is \( b_k(k=1,2,\ldots,K) \), and the demand of each customer is \( d_i(i=1,2,\ldots,L) \). The time window of customer \( i \) is \([E_i,L_i]\), the time to start serving customer \( i \) is \( t_{i-} \), \( s_i \) which represents the service time of customer \( i \), \( w_i \) represents the waiting time in customer \( i \), and the running time of customer \( i \) to customer \( j \) in the time period \( m \) is \( c_{ij}^m \). \( M(m=1,2,\ldots,M) \) indicates the number of minutes in a day [2]. \( I \) represent an integer of infinity. The algorithm flow is shown in Figure 1. The goal of optimization is to minimize travel time and define the following variables:

\[
y_{ik} = \begin{cases} 1 & \text{Customer } i \text{ is delivered by vehicle } k \\ 0 & \text{other} \end{cases} \\
x_{ij}^m = \begin{cases} 1 & \text{The vehicle visits } j \text{ from } i \text{ in time period } m \\ 0 & \text{other} \end{cases}
\]

(1)

The objective function is to minimize travel time:

\[
\min Z = \sum_{i=1}^{L} \sum_{j=1}^{L} \sum_{m=1}^{M} (c_{ij}^m \times x_{ij}^m)
\]

(2)

Restrictions:

\[
\sum_{k=1}^{K} y_{ik} = 1 \quad \forall i \\
\sum_{i=1}^{L} x_{ij}^m = y_{ik} \quad \forall j,k \\
\sum_{j=1}^{L} x_{ij}^m = y_{ik} \quad \forall i,k \\
\sum_{i=1}^{L} d_i y_{i} \leq b_k \quad \forall k
\]

(3)

\[
\sum_{i,j:\{S\times S\}} x_{ij}^m \leq |S|-1 \quad S \subset \{1,2,\ldots,L\}, S \neq \emptyset \quad \forall k
\]

(4)

\[
t_j = \max \{E_j, t_{j-} + w_i + s_j + c_{ij}^m\}, t_j \leq L_j
\]
3. Realization of dynamic logistics distribution path system

3.1. System development platform
The software and hardware platforms of the distribution routing system are shown in Table 1 respectively. The system is developed using B/S architecture, with HTM L + DHTML + JavaScript as the front-end static page display tool, and ASP.Net as the dynamic page display tool; the background calls Java Web Service as the model library, algorithm library, and common tool implementation method; .Net Used to implement page control and business logic; the database uses Microsoft SQL Server 2005 as the database server; the web server uses IIS. In view of the fact that the mobile terminal software is developed using J2ME, it inherits the advantages of the Java language and has good portability. At the same time, about 78.6% of mobile phones worldwide support J2ME and 100% of smart phones support J2ME, which lays a good market foundation for the promotion of the platform.

Table 1. System development platform

| Hardware name       | Hardware conditions                      |
|---------------------|-----------------------------------------|
| server              | One web server and one data server       |
| CPU                 | Core i3, frequency: 2930MHz              |
| RAM                 | 2G                                      |
| hard disk           | 160G, SCSI hard disk                    |
| Network card        | 10/100M adaptive                        |
| Software Environment| Software conditions                     |
| Development structure| Based on B/S structure, MVC development model |
| operating system    | Windows 2003 Server                     |
| development tools   | Java, ASP.Net language                  |
| database            | MS SQL Server 2005                      |
| Web server          | IIS6.0                                  |
| Front page display  | ASP.NET + HTML + DHTML + JavaScript      |

3.2. The overall framework of the system
The B/S three-tier architecture is the mainstream architecture of database systems since the 1990s. A B/S three-tier architecture is used to build a logistics distribution system, which is composed of a customer browser (presentation layer), a web application (business logic layer), and a database server (data storage layer). The three-tier architecture of the logistics distribution system realizes the physical separation of customers, programs and data, has better portability and security, and is beneficial to the
expansion of the system. The logistics distribution vehicle scheduling platform is mainly used to verify the availability of dynamic path planning, including basic information management, distribution requirements management, and path planning modules. The core of the system is the path planning module, and the algorithm call is implemented in this module. Other modules provide operational data for the operation of the module. The overall framework of the system is shown in Figure 2 below.

![Figure 2. The structural framework of the system](image)

The core task of dynamic vehicle scheduling is to pre-plan the route according to the distribution requirements. When new scheduling needs occur, the planned route can be modified according to the actual driving status of the vehicle. The planning results are visually displayed in the form of a map.

3.2.1. **Presentation layer.** The presentation layer (customer browser) provides users with the system's interactive interface. The system uses HTML5, CSS3, JavaScript, and Flex language design to implement the front-end page of the logistics distribution system. Users can view geographic information (including spatial data and attribute data), vehicle information, logistics center information, and distribution route information in the database.

3.2.2. **Business logic layer.** The business logic layer (Web application) reads data from the data storage layer according to the user's request, processes and updates the data, and sends the processing result to the user. The business logic layer is composed of a map server and a business logic server. The map server is composed of AGS and Geo Server. The business logic server uses the MVC mode to implement system functions. Through the business logic layer, users can query and edit vehicle information, distribution center information, and logistics distribution route information, select distribution centres, and make optimal distribution path planning. The server in the business logic layer transmits the edited data to the data storage layer, and updates the data in the database.

3.2.3. **Data storage layer.** Data storage (database server) is used for data storage and management. The data of the system is divided into 3 categories: 1. Map and remote sensing image data; 2. Spatial data and attribute data; 3. General relational database data. The system uses SQL Server 2008 to build a complete database, with the help of the spatial database engine and ODBC interface to achieve effective management of geographic information and vehicles, logistics centres, and distribution route data in the database.

3.3. **System functions**

3.3.1. **Information management of distribution center.** Management and maintenance of distribution center information, you can view and update the distribution centre’s cargo information, infrastructure information, etc.
3.3.2. **Vehicle information management.** Manage and maintain vehicle information, view and update vehicle type, vehicle location, vehicle loading and other information.

3.3.3. **Intelligent selection of distribution center.** The customer's geographic location and their respective shipments are known or estimable, and the potential location of the facility is known. It can be found by minimizing transportation costs, distribution center construction costs, commodity warehouse storage costs, and processing costs. The optimal transportation path of the resource point and the distribution center, the distribution center and the user selects several distribution centers from the P candidate points to complete the solution of the location problem.

3.3.4. **Vehicle positioning.** The vehicle positioning function module uses GPS to accurately determine the real-time position, driving speed, and driving direction of the vehicle, and the dynamic positioning information of the vehicle is displayed on the display [3].

3.3.5. **Path optimization.** According to the principle of economic rationality, after obtaining the customer's delivery information, according to the distribution center that the distribution center module has generated, the ant colony algorithm is used to reasonably arrange the vehicle's driving route to minimize the total transportation distance, and display the calculated optimal route on the RS Satellite pictures and electronic maps.

3.3.6. **Data storage.** The basic data is stored in SQL Server 2008, a large-scale relational database system. SQL Server 2008 manages data such as vehicle information, distribution center information, and distribution route optimization results. In this system, Google Maps, a spatial data intermediate product, is used to effectively manage electronic maps and satellite image information.

3.4. **Database design**

According to the dynamic logistics path planning process and functional analysis, we design the database. The E-R model of the database expresses the relationship between business entities and entities. The model diagram is shown in Figure 3:

![Figure 3](image-url)
Based on the E-R model, SQL Server is selected as the relational database management system to store and access website basic information and transaction data according to the technical solution, and the logical model of the system database is designed.

4. Example analysis
In the daily distribution, the distribution center mainly designs the route based on the driver's experience, and improves and fine-tunes the original route. It is feasible in the case of fewer customer nodes, but when the number of nodes that need to be distributed increases, there will be certain unscientific. After the particle swarm optimization algorithm designed in this paper, the resulting Pareto solution set is shown in Figure 4. Among them, the ordinate represents the penalty for crossing the border, and the abscissa represents the fuel consumption target. Each point connected on the red line in the above figure is the Pareto solution set calculated by the algorithm in this paper. Each point represents a certain vehicle distribution path solution and its corresponding cross-border time penalty and fuel consumption. For example, the coordinates of point A (38.96, 42.14) indicate that the fuel consumption of its path scheme is 38.96 liters, and the cross-border time is 42.14. Because the coefficient of the penalty function used here is a linear function with a slope of 1 Therefore, the penalty for the cross-border time is 42.14, which means that the scheme is late for a total of 42.14 minutes in all client nodes. The coordinate of point B is (41.03, 0), that is, the path scheme is not late for all client nodes, so the penalty for time out of bounds is 0. As shown in Figure 4, none of the solutions in the Pareto solution set is superior to other points in both goals. For example, although the solution A can consume less fuel than the solution B, but the solution A brings out of bounds Time penalty is also higher, and vice versa. Therefore, this Pareto solution set provides a better set of solutions, and how to choose from it depends more on the management style and customer needs of the enterprise [4].

Figure 4. Pareto solution set for minimum fuel consumption and minimum cross-border time penalty

Y's original vehicle route plan is located at point C in Figure 4 with coordinates (74.98, 0). The position of point C in the figure is only the minimum fuel consumption and minimum cross-boundary time penalty Pareto solution in Figure 4 The purpose of the set is to make the relative position of C also shown in the figure. In fact, the position of C is more right in the figure. In other words, Y's original plan is actually not late on all nodes, but compared with the B plan in this article, it consumes much more fuel. The fuel consumption of Plan B calculated in this paper is 45.28% lower than the
original plan. It can be seen that the model and algorithm in this paper have a strong optimization effect on the original path without increasing the cross-border time. If a certain amount of time is allowed to cross the boundary, the fuel consumption savings will be higher. The comparison results of the above Pareto solution (from scheme B to scheme A) and the original scheme on the two goals are shown in the following table:

Table 2. The results of the algorithm in this paper reduce the fuel consumption and increase the late time of the original results

| % Reduction in fuel consumption | 45.30 | 45.80 | 46.20 | 47.10 | 47.40 | 47.60 | 47.70 | 48.00 |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Increased late time (minutes)  | 0     | 8.6   | 10.7  | 18.8  | 33.5  | 34.9  | 38.4  | 42.1  |

From Table 2, we can see that the Pareto solution calculated by the algorithm in this paper improves the fuel consumption target of the original scheme is quite amazing. All Pareto solutions can reduce fuel consumption by more than 45%, and can reduce fuel consumption by 45.3% without increasing any cross-border time. Then, with the increase in the number of allowable late minutes, the reduction in fuel consumption can reach more than 48%, which can also give managers a freedom of decision-making, allowing them to choose the above scheme according to the situation of enterprises and customers [5].

5. Conclusion
The future logistics management model must be more economical, environmentally friendly, and more efficient green logistics. China's logistics industry is still in a state of backward management concepts, low standardization and informatization, and poor coordination among departments. Green logistics is implemented There are still many problems in the process, such as lagging environmental protection concepts, imperfect profit distribution mechanism, relatively backward advanced technology, and low quality of employees. This paper designs the particle swarm optimization algorithm. The article uses the designed algorithm to solve a company's distribution plan for a certain day, and proposes a solution set of the distribution plan in this paper, and compares the solution set with the company's existing path and the path obtained with the shortest path as the target. To verify the effectiveness of the algorithm in reducing fuel consumption and improving punctuality.

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