

The Distribution Network Planning Using Geographic Information System (GIS)

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ABSTRACT

To improve the customer service level, tobacco companies in China use the strategy of direct delivery. But this strategy has a great influence on the local company's operation cost. In this paper, a distribution planning of the local company is made to decrease the operation cost.

The distribution planning includes the location and choice of the distributed centers and the transferring points. In this problem, the Greedy Dropping Heuristic Algorithm is used twice to decide the distributed centers and transferring points. After the transferring points are set, the Vehicle Routing of each transferring points is presented. The savings algorithm is used in this process.

To analyze the complicated data, as well as to make the decisions, GIS (Geography Information System) technology is used, which turns to be a great help.

Key words: logistics, distribution, inventory, vehicle routing problem

1. INTRODUCTION

To improve the customer service level, tobacco companies in China use the strategy of direct delivery, delivering tobacco from local company directly to their customers, i.e., different retailers. But this strategy has a great influence on the local company's operation cost, which includes the labor cost of delivery workers, the cost of delivery vehicles and the inventory cost. All the cost mentioned above adding up will be a great number. For example, for a local company studied, the delivery cost counts up to about 7 million RMB, while the inventory cost is as much as 35 million RMB. So in this paper, a distribution planning of the local company will be made to decrease the operation cost.

The project is divided into two parts; the first is to determine how many distribution centers will be used. Now in their system, there are 42 distribution centers, including 11 bigger one belonging to 11 sale divisions and 31 smaller one dispersed in different towns in convenience for the distribution of tobacco. Considering the position and scale of all the 42 distribution centers, as well as the traffic conditions, several candidate schemes consisting of different distribution centers are put forward. After the first phase work, the main nodes of the distribution network are determined.

Based on the above structure, the second one is to determine the route planning for every demand point, i.e., the basic node in the network consisting of certain number of retailers. Considering the laws and the working load of the workers, the working time of worker is set to about 6 hours. The truckload is supposed to be big enough at first. Then using some heuristics of Vehicle Routing Problem, the route planning for every

demand point is decided. According to the total demand of all the demand points in the same route, the truck load of the vehicle and which kind of vehicle to use are decided at last.

To analyze the complicated data, GIS (Geography Information System) technology was used. The correct and ample geography information is needed in the system. So the preparation of the geography information is the first and most important step. Then all the nodes of the distribution network are presented in GIS, including the attributes of the nodes. Thus we can see clearly the distributing of the customers and the traffic conditions of them. It will be a great help for the decision that how many distribution centers should be used. When the routes computed out is displayed in GIS, we can see clearly which route is unreasonable in the scheme and thus correct it.

2. GIS TECHNOLOGY AND ITS USE IN LOGISTICS

In the beginning of the evolution of the vehicle routing systems, routes were designed manually with the aid of paper maps that provide the locations of the customers. From the early 1980s the development of computer technology gave birth to the systems for analyzing and displaying spatially or geographically related data. In the 1990s, the rapid growth of GIS gives us the hope of good use in logistics. However the most prevalent GIS software can only deal with and display the data that is formatted. While in the real life, the dimension of the location and routing problems are quite large. To design routing more efficiently, it is necessary to develop decision support systems that incorporate effective methods and spatial techniques.

A GIS is a system that can support the capture, management, analysis and display of spatially referenced data. The storing and management of the vast data using database technology is the key to the problem. With the aid of GIS and accurate digital maps, users can browse, locate customers automatically and compute out the shortest distance between customers.

The main purpose of using GIS technology in logistics is using a graphical and text display to assist the user to get good and implantable solutions to such problems as vehicle routing problem. Bodin (1994) brought forward the areas of the visualization in Routing and Scheduling Problems. The first is the preparing and validating data, which includes creating and editing data, displaying attribute information, zooming, network connectivity, network planarity and address matching. The second is the finding, displaying, and changing a solution. The third are some future directions, including the solution of the clutter problem and visualization in three dimensions.

In our opinion, the preparation and validation of the data is really a kind of plenty and tiring work. Certainly it is the most important step as the basis of the ultimate schemes.

3. THE LOCATION AND CHOICE OF THE DISTRIBUTION CENTER

In our problem, the local company consists of 11 divisions. Every division is responsible for the inventory of tobacco, collecting the demand information of every customer, sorting and delivering the tobacco to every customer. Every division has its own distribution planning. At the end of every month, they order according to their own inventory of the time. To ensure enough tobacco of all kinds to sell, every division keeps a large inventory for at least one month. Every day except for Saturday, the workers visit the customers by telephone for their demand, and delivery to them the next day. The sorting of tobacco consists of two steps. Every morning before delivery, the tobacco demanded of the route is sorted out first and loaded onto the vehicle. Then when the customer is reached, the tobacco demanded of the customer is sorted out finally. All the sorting work is made by hand.

From the definition of the distribution flow above we can see that the distribution itself is a time-consuming job. In some area, the distribution time of each customer is as many as 5 minutes. Moreover, a full-time worker is needed to sort the tobacco on the way. To improve the efficiency of the distribution, modern distribution centers are required to be built, where the distribution work is done specially. But the location of the distribution centers becomes the key problem.

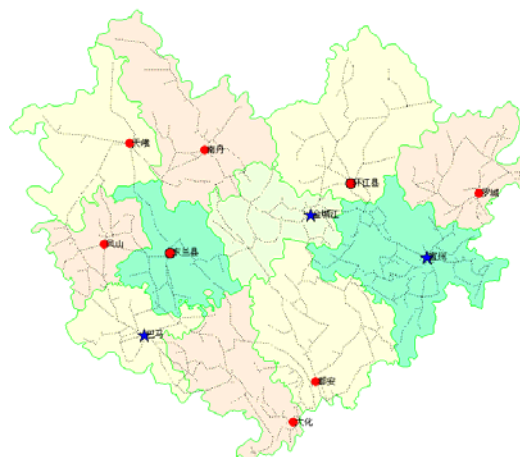


Figure 1 The candidate distribution centers

In figure 1, the eleven candidate distribution centers considering the transportation conditions are listed out. Then using the Greedy Dropping Heuristic Algorithm the candidate schemes involving 5, 4, and 3 distribution centers are acquired. In the computation, the Dijkstra Algorithm is used to compute the shortest distance between the customers and the candidate distribution centers. At the same time the frequency of each customer is considered in the computation of the cost. Considering the total amount of the tobacco dealt with each year and other conditions, the scheme consists of 3 distribution centers is adopted. The blue points in figure 1 representing the 3 distribution centers are presented.

4. THE SET OF POINTS FOR TRANSFERRING TOBACCO

Because of the broad area covered by the local company, most of the customers can not be reached if distributed directly from the distribution centers. While the inventory level should be kept as low as possible, the scheme involving transferring points are adopted. Thus every transferring point only keeps the inventory of one day, which is quite small.

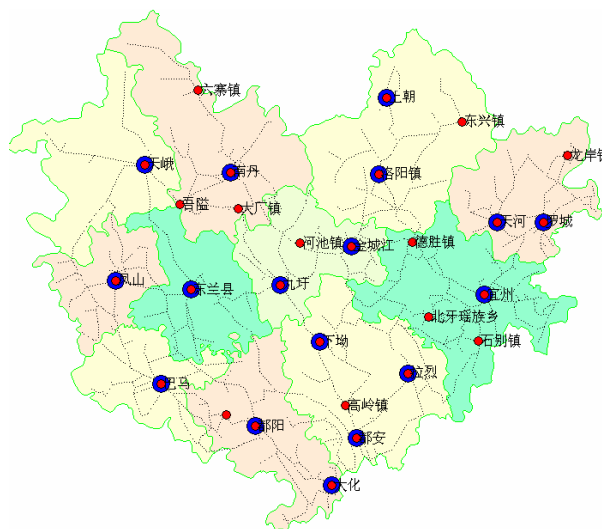


Figure 2 The candidate transferring points of tobacco

Considering the present conditions of the local company, 28 towns that have warehouse of themselves are regarded as the candidate transferring points, which are presented in figure 2. Also the Greedy Dropping Heuristic Algorithm is used to derive the optimal choice of the transferring points, while a constraint is added: When the candidate transferring point is removed and the customers belong to it are re-distributed, if there exists more than one customer whose distance to the transferring point is more than one and a half hours' traveling time, the transferring point should not be removed.

As the result 18 transferring points are selected to transfer tobacco to the customers. Then the 18 transferring points are distributed to the 3 distribution centers, which are presented in figure 3.

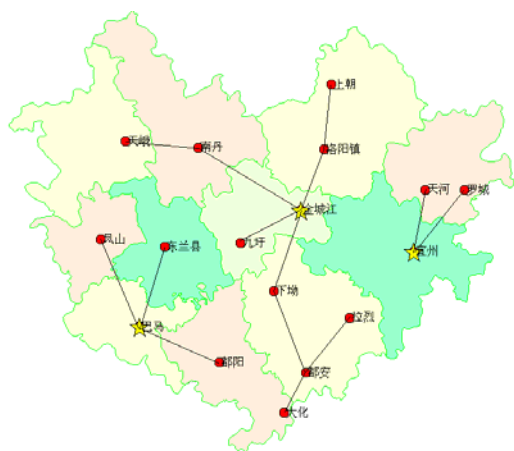


Figure 3 The scheme of 3 distribution centers and 18 transferring points

5. THE VEHICLE ROUTING OF EACH TRANSFERRING POINTS

For each transferring point, the customers belong to it should be distributed from it and in the end return to it as the depot. In the real problem, the importance of choosing proper algorithm and modifying the routing according to the actual conditions are equal. In the solution of this problem, the Savings Algorithm presented by Clarke and Wright in 1964 is used. While in this algorithm, the truckload constraint and the time constraint are considered at the same time.

Then the results of the vehicle routing are presented in the geographical information system. With the aid of the experience of the workers and the local transportation

conditions etc., the routing schemes are modified. Figure 4 presents an example of the vehicle routing of one transferring points.

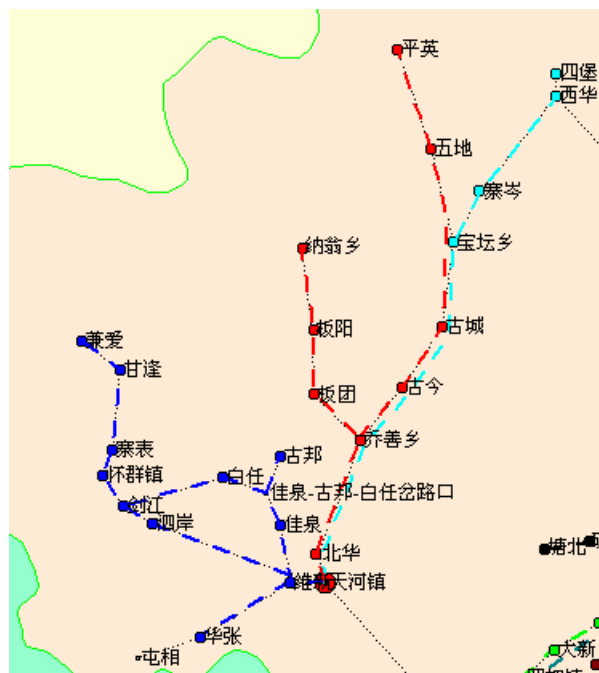


Figure 4 One example of the vehicle routing

6. CONCLUSIONS

From the above we can see that whenever the choice and location of the distribution centers or the choice of the transferring points or the vehicle routing of each transferring problem, the GIS technology is a great help in all the decisions. From complex and dull various data to the simple and sensed view of the map, the human can take part in the decisions directly.

Finally, the distribution plan comes to be successful, which decrease the local company's operation cost by 10% or so.

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