Research on Location of Underground Logistics Nodes in Xiong County, Xiong'an New Area

Zhang Qian, Zhang Panli

***Abstract*— Traffic congestion is one of the "difficulties" encountered by major cities in the world. The construction of ground transportation facilities is limited, the roads cannot be increased without limit, and the traffic demand is still increasing rapidly. Therefore, it is imperative to "overall planning the development of ground and underground space". "Underground logistics system" is being paid more and more attention by more and more developed countries. In view of the problem of traffic congestion, this article takes the Xiong county district of Xiong'an New Area as a case where traffic is congested as an example to carry out the location selection of underground logistics nodes in the region. Firstly, through the analysis of the traffic congestion index in each region of Xiong county in Xiong'an New Area and the data of the locations of the central points in the region, the Stannaby point by point was calculated using a simulated plant growth algorithm to determine the number of primary nodes and their locations. Then use area coverage to determine the number and location of secondary nodes. Thereby completing the location of the nodes of the region.**

***Index Terms*— simulated plant growth algorithm, traffic congestion index, underground logistics node**

I. INTRODUCTION

Traffic congestion is one of the "difficulties" encountered by major cities in the world. TomTom, the Dutch navigation provider, released the world's most congested cities in 2015. In the top thirty, mainland China occupied ten of them. According to the data released by China's Ministry of Communications in 2014, the economic losses caused by traffic congestion in China account for 20% of the disposable income of urban residents, which is equivalent to an annual loss of 5 to 8% of gross domestic product (GDP). Residents of 15 big cities consume 2.88 billion more minutes a day than the developed countries in Europe. A large number of studies have shown that "stop-go" traffic causes crude oil consumption to account for 20% of the world's total consumption. Data released at the 2015 annual meeting of urban transport planning shows that in terms of oil consumption in China, transportation oil consumption accounts for 54% of total consumption, and Traffic energy consumption accounts for more than 10% of the total energy consumption of the entire society, which has increased year by year. High energy consumption also means high pollution and high emissions. This series of problems has seriously affected the quality of life of the people living in the city and threatened the safety of the living environment. There is an urgent need for effective measures to improve this situation. Therefore, the demand for the development of underground logistics system in China is imminent.

The underground logistics system converts ground cargo to the underground and uses pipelines or tunnels for transportation. It can effectively reduce ground vehicles to reduce congestion and reduce the exhaust emissions of trucks. It is more environmentally friendly and energy-saving and saves land; at the same time, the underground transportation path is short, fast, and barrier-free, which can greatly improve the efficiency of urban freight transport and contribute to the sustainable development of the city. A complete underground logistics network is composed of a logistics center outside the city, logistics lines, logistics nodes, customers, and special vehicles. The logistics node is the key to the entire underground logistics network. Its location determines the layout and scale of the entire logistics network, directly affects the construction cost of the entire logistics system and the service level to customers.

Jiang Yang et al. used the set coverage model to analyze the location problem of urban underground logistics nodes; Xie Li used a bi-level planning model to study the location of ULS nodes, aiming to meet all customer needs with the lowest logistics costs and the least logistics nodes. Yan Wentao et al. studied the location of underground logistics nodes based on a bi-level planning model and established an upper-level planning model from the perspective of decision makers and a lower-level planning model from the customer's point of view. The solution of the model is analyzed by the reaction function, and the fmincon function in MATLAB is used. Huang Oulong et al. analyzed the relationship between the functional areas on the internal design of the node, and proposed a method of planar layout in the system. Klose et al. proposed nine basic site selection models, including a capacity-constrained site selection model, a dynamic site selection model, a simple site selection model, and a location change model for demand changes, etc. The objective function is almost always the minimum for transportation costs and fixed site investment costs.

Research scholars have basically started from the interests of logistics planning departments or companies, establish mathematical models and solve them in hypothetical examples, and do not do deep research based on actual regions. This article takes the Xiong'an New Area as an example to study the location of underground logistics nodes in Xiong county, which is more important and has the most traffic in this area. Use the traffic congestion index of the region and the cargo volume data of the center points of each region to determine the number and location of the primary nodes of underground logistics by simulated plant growth algorithm. At last the number and position of secondary nodes are determined by the area covering method.

II. THE ESTABLISHMENT AND SOLUTION OF THE MODEL

A. *Location of underground logistics nodes*

The problem of location selection of underground logistics nodes is a key part of the entire logistics network planning, and its location plays a decisive role in the layout and scale of the entire logistics network. Considering the principle of the lowest cost, the location and construction of logistics nodes is crucial.

The location of the underground logistics node in Xiong county, Xiong'an New Area, needs to consider the primary nodes and the secondary nodes, of which only the primary nodes can connect across regions, and the secondary nodes and non-local first-level nodes can only communicate through the primary node in this area. The range of channels that can be selected includes a 10-ton two-way two-track, two-way four-track channel, and a 5-ton two-way two-track channel and two-way four-track channel. Different nodes and different channels have different construction costs. The choice of designing and constructing underground logistics nodes not only has to meet regional transportation needs, but also has a certain degree of stability, and the lowest operating costs. Traffic congestion index is based on road traffic cases, a comprehensive reflection of the road network in some cities set or clear conceptual congestion index value, which is equivalent to the congestion digitized. By consulting relevant data, it is known that the traffic congestion index can be divided into five levels, as shown in Table 1.

B. *Traffic Congestion Index*

Traffic congestion index is based on road traffic cases, a comprehensive reflection of the road network in some cities set or clear conceptual congestion index value, which is equivalent to the congestion digitized. By consulting related materials, it is known that the traffic congestion index can be divided into five levels, as shown in Table 1.

Source: "Traffic Impact Assessment for Construction Projects"

It can be seen from the table that the congestion can be classified as "0-2 unblocked", "2-4 basic flow", "4-6 mild congestion", "6-8 moderate congestion", and "8-10 severe congestion" "five levels. Among them, the higher the value, the more serious the traffic jam.

Table 1 Congestion Level Table

Service Level	Congestion Index	Operational Status
One level	0-2	Unblocked
The second level	2-4	Basic Flow
Three levels	4-6	Mild Congestion
Four levels	6-8	Moderate Congestion
Five Levels	8-10	Severe Congestion

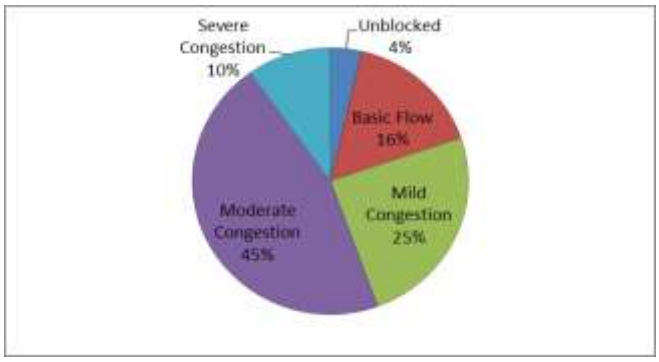

Fig.1. Traffic congestion index

Through the congestion level rating table, the congestion level of the traffic freight area in Xiong county, Xiong'an New Area was classified, and the data in the traffic freight area of Xiong county in Xiong'an New Area was analyzed and the traffic shown in Fig.1. was obtained.

As can be seen from the above figure, most of Xiong county in Xiong'an New Area is moderately congested, accounting for 45%. Severe congestion accounts for 10%. Choosing the number and location of nodes and building a reasonable underground logistics network are critical to reducing traffic congestion.

C. *Model Assumptions*

(1) Do not consider human factors.
(2) The known data is correct.
(3) For the convenience of study, the cargo discussed is not classified.
(4) The vehicles participating in the underground logistics and transportation process have the same type, the same capacity, and the same vehicle condition.
(5) The quantity and location of logistics requirements for each node in the logistics line are known.
(6) Each customer must accept the delivery service.
(7) The volume of goods in the distribution center meets the customer's demand.
(8) The service scope of the node is 4 kilometers.

D. *Simulated Plant Growth Algorithm*

The simulated plant growth algorithm establishes the dynamic mechanism of growth of stems, branches, and withering mechanisms based on the plant growth-to-photodynamic growth mechanism. The plant's entire growing space is regarded as a feasible region of the solution, and the light source is treated as a global optimal solution. The phototropism determines the mechanism of dynamic growth, according to the theory of morphological concentration in botany, a dynamic model for the rapid growth of light source in different light intensity environment was established according to the global optimal method. The probabilistic growth model for simulated plant phototropism was analyzed. M denotes the length of the stem,

The stem has K initial growth points $S_M = (S_{M1}, S_{M2}, ..., S_{MK})$, and the morphological concentration of each growth point is $P_M = (P_{M1}, P_{M2}, ..., P_{MK})$; the stem unit length is m (m <

Table 2 Traffic volume of all-day traffic in all regions of Xiong County

ZONE	100	101	102	103	104	105	106	107	108	...
100	0	0	0	0	0	0	0	0	0	...
101	0	0	1.603	0.423	0.304	0.543	0.362	2.177	2.015	...
102	0	1.247	0	0.32	0.668	2.201	1.486	14.065	1.24	...
103	0	0.529	0.515	0	0.697	0.372	0.17	0.669	0.209	...
104	0	0.443	1.252	0.813	0	0.34	0.158	1.677	0.321	...
105	0	0.792	4.127	0.434	0.34	0	0.475	5.173	1.354	...
106	0	0.528	2.785	0.198	0.158	0.475	0	3.828	0.304	...
107	0	1.058	8.79	0.26	0.559	1.724	1.276	0	0.888	...
108	0	2.015	1.595	0.167	0.22	0.929	0.208	1.826	0	...
109	0	0.596	0.204	0.085	0.17	0.681	0.256	0.273	0.341	...
110	0	0.702	4.197	0.338	0.305	1.553	0.942	10.355	0.617	...
111	0	0.239	0.601	0.091	0.091	0.239	0.156	1.095	0.181	...
112	0	1.001	2.037	0.174	0.232	1.452	0.521	2.524	0.592	...
113	0	0.429	1.712	0.19	0.225	0.53	0.361	2.194	0.642	...
114	0	0.166	0.114	0.279	0.573	0.096	0.543	0.219	0.172	...
115	0	0.185	0.724	0.616	0.704	0.123	0.114	0.99	0.114	...
116	0	1.475	4.081	0.542	0.573	1.279	1.122	6.576	1.122	...
117	0	2.347	4.109	0.335	0.572	1.539	0.733	5.444	3.125	...
...	...	...	...	...	...	...	...	...	...	...

n) .The number of above growing points is q, which means $S_m = \left(S_{m1}, S_{m2}, ..., S_{mq}\right)$ that the concentration of morphine is $P_m = \left(P_{m1}, P_{m2}, ...P_{mq}\right)$, and the formula for the concentration of morphine in stems and branches is:

$$P_{Mi} = \frac{f\left(x_0\right) - f\left(S_{Mi}\right)}{\sum_{i=1}^{k}\left(f\left(x_0\right) - f\left(S_{Mi}\right)\right) + \sum_{j=1}^{q}\left(f\left(x_0\right) - f\left(S_{mj}\right)\right)} \quad (2\text{-}1)$$

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Where x_0 is the initial feasible solution and $f\left(*\right)$ is the objective function. The relative positions of the growth points and the roots in the above two formulas and the environment of the position determine the morphine concentration at this point，which is consistent with the production mechanism of the morphine concentration in real plant cells. The above two formulas can be drawn:

$$\sum_{i=1}^{k} P_{Mi} + \sum_{j=1}^{q} P_{mj} = 1 \quad (2\text{-}3)$$

After the morphine concentration is determined, there are k+q growth points on the stem and branch, that is $\left(x_1, x_2, ..., x_{(k+q)}\right)$, the corresponding morphine concentration is $\left(p_1, p_2, ..., p_{(k+q)}\right)$，respectively, and a random generated number (between [0, 1]) corresponds to the growth point in the state space. As a new growth point for the next growing branch. The values of k and q change with the growth of new shoots. After the new shoots are grown, the growth points that have just grown new shoots will be removed from the growth set, and the growth points contained in the newly grown shoots will be add to the growing set and repeat this step until no new shoots have grown.

Given nodes $P: a_1, a_{2,} \cdots, a_m$, find a minimum network to connect them. For this problem, the test database STEILIB is published internationally, which $L_S(X)/L_M(X)$ is Steinerby. For a given set of nodes, this paper uses a

simulated plant growth algorithm, through the calculation of the traffic data of all-day traffic in the Xiong County, some of the data are shown in Table 2:

The first row of data and the first column of data in the table represent the various districts of Xiong County, and the other data represent the Traffic volume of all-day traffic from the vertical area to the horizontal area.

The calculation results of $L_S(X)/L_M(X)$ =0.7194, and then the first-level node can be calculated by simulated plant growth model, and the first-level node is set as S. Three primary nodes are calculated, as shown in Fig.2. :

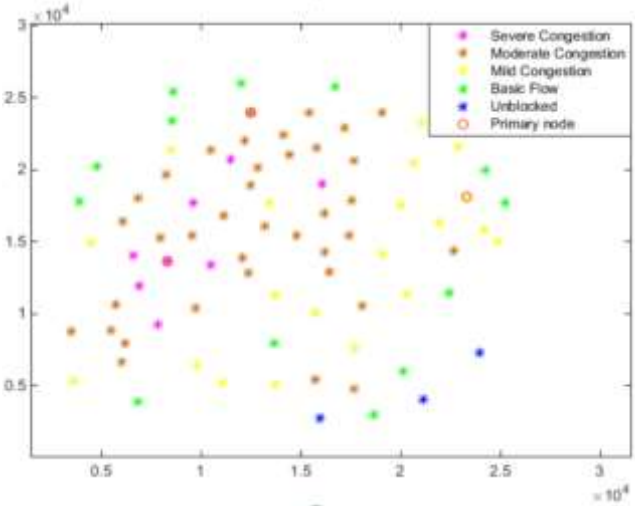

Fig.2 · The primary nodes

The primary nodes are: 123 (12512.1 23976.56); 137 (8307.89 13654.38); 173 (23320.02 18108.56).

Table 3 Indicators of the primary nodes

The Primary node	X center distance (m)	Y center distance (m)	Actual freight (tons)	Transfer rate
S_1	12512.1	23976.56	2894	72.35%
S_2	8307.89	13654.38	2657	66.425%
S_3	23320.02	18108.56	3016	75.4%

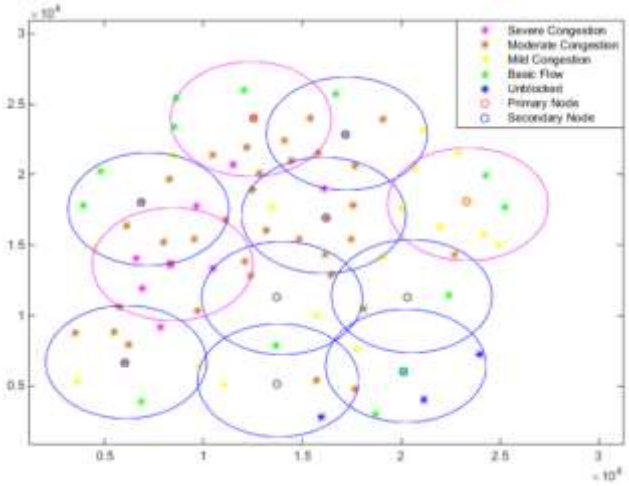

Fig.3. the primary and secondary nodes overlays

The actual cargo volume and transshipment rate were obtained from the OD data of all-day cargo and the location and area of the center points in each region. The results obtained are shown in Table 3:

Using the above indicators of the first-level nodes, and then using area coverage, determining the location and specific number of the secondary nodes. Fig.3. shows the primary and Secondary nodes overlays:

The central positions of the secondary nodes are respectively 107 (6013.43 6620.54); 111 (6846.6 18008.9); 132 (17198.45 22867.98); 142 (13699.08 11304.68); 147 (13721 5126.34); 154 (20127.04 6008.23); 159 (20317.2 11320.89); 164(16198.08 16932.51). The determination of the location of the node can in turn provide data for future route planning studies.

III. Conclusion

The urban underground logistics system is a kind of green logistics system adapting to sustainable development. It can achieve automatic, fast, safe and reliable non-interfering goods transportation, and can effectively alleviate urban traffic congestion, improve the urban ecological environment, improve the city logistics efficiency and service level, thereby improving the quality of urban life.

In recent years, research on urban underground logistics systems has progressed very rapidly. Even a few areas have entered the stage of implementation of the project, but China's research in this area has only just begun. In this paper, according to the traffic congestion Index and traffic volume, the location of the underground logistics nodes in Xiong county, Xiong'an New Area is studied. Finally, the number and location of the primary and secondary nodes were determined by the simulated plant growth algorithm. The results show that the proposed model and algorithm are practical. In addition, the model constructed in this paper mainly considers the internal factors such as costs and other factors closely related to the logistics system, but without considering the geological conditions, human environment, noise pollution and other external conditions. Therefore, based on scientific analysis of internal conditions, at the same time, considering the influence of external conditions and making reasonable decisions is the direction of future research.

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