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The Application of Improved Set Coverage Model in Terminal Nodes Location: A Case Study of Joint Distribution in Wanzai County

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ABSTRACT

The rapid development of the Internet and e-commerce has brought great challenges to the terminal logistics distribution. Developing joint distribution is one of the effective ways to solve the bottleneck of terminal logistics distribution and realize the sharing of logistics resources. We investigated and got the status of joint distribution in Wanzai County, the overview of Wanzai delivery industry park, and the distribution status of terminal distribution outlets in Wanzai County. Taking a region of Wanzai County as an example, an improved set-coverage model was constructed to select the site of its terminal outlets, and using Java software to solve the feasible solution of the terminal network. Finally, taking into account the balance of the delivery volume of each outlet, the optimal solution for the site selection of the endpoint is selected based on the sum of squared deviations.

Keywords: terminal joint distribution, terminal outlets, location, set coverage

1. INTRODUCTION

Since the birth of express industry in 1970s and 1980s, with the rapid development of economy and e-commerce, express industry has been developing in a spurt, and has rapidly become a sunrise industry to promote China's economic development and employment growth. According to the monitoring data of Prospective Industry Research Institute, since May 2017, the average daily express volume in China has exceeded 100 million pieces. This marks the normalization of China's daily express volume into "the era of hundred million pieces". Also, the "Last-mile Delivery" service mode of China's e-commerce logistics is increasingly diversified, and has become an important component of urban community service and the citizens' livelihood (Zhi-lun, 2016).

However, due to the lagging development level of urban and rural distribution, the "Last-mile Delivery" problem has become a prominent contradiction in the entire supply chain in the development process of China's express industry. In the times of e-commerce where the goods and services are now being made available at our doorstep, there is a large section of population still deprived of basic services (Bajwa,2018). It seriously affects the development of efficient logistics and e-commerce, and the most effective way to improve the distribution efficiency is to develop joint distribution. Joint delivery adopts the distribution mode of "express company — joint delivery center — terminal outlet — customer". All express deliveries to the city are centralized and uniformly distributed to the terminal outlet. Customers can choose to deliver goods to the door or pick up the goods by themselves.

Compared with the traditional distribution mode of "express company — self-owned distribution center — customer", the co-distribution mode can not only effectively improve the delivery efficiency, reduce the cost, realize the sharing of social resources, but also effectively solve the difference in the time for customers to pick up goods, thus ensuring customer satisfaction. So, terminal joint distribution as an increased step in the process of delivery from warehouse/distribution center to end customer, it is integrated by multiple e-commerce or logistics enterprises which carry out terminal distribution through warehousing, distribution and other expansion businesses. In this way, joint organization and implementation of terminal distribution activities and integration of terminal distribution can improve the efficiency of utilization of terminal distribution resources, reduce the cost of operation, share benefits and achieve economies of scale. What's more, the location of joint distribution terminal is the key to optimize the "last mile". Some internet retailers, parcel express companies and other stakeholders have realized and put great investments on last-mile delivery network, especially on expanding delivery network at the scale of community (Zhi & Zuopeng, 2017). The central government and municipal authorities also have proposed the necessity of incorporating e-tailing logistics infrastructure to urban planning and promoting last-mile delivery network.

Foreign scholars have done little research on the model of terminal nodes location. Some scholars conducted detailed and objective analysis of terminal branches based on the statistics of daily operation and consumer behavior of express enterprises (Weltevreden, 2008; Weltevreden & Rotem-Mindali, 2009). But it mainly conducted qualitative research. A study put forward the method of constructing express terminal distribution network by comparing with the global mobile communication system network planning method (Journeau & Mercier, 2004). The problem of designing a parcel locker network as a solution to the Logistics Last Mile Problem: Choosing the optimal number, locations, and sizes of facilities can be expressed as a 0-1 integer linear program that maximizing the total profit (Deutsch & Golany, 2017).

Most of the subjects of location research are primary or secondary distribution centers, so it is necessary to use other location model for reference in the modeling of terminal nodes location. Relevant scholars adopted mixed integer programming model (Troncoso & Garrido, 2005; Jindal & Sangwan, 2014; Kratica, Dugošija & Saviæ, 2014), two-layer programming model (Zhu & Yu, 2014; Yan & Qin, 2016), analytic hierarchy process (Gao, Yoshimoto & Ohmori, 2011; Kabir & Sumi, 2014; Shu, Zhu & College, 2015), multi-objective site selection model (Sadigh, Naimi, Fallah, *et al.*, 2013; Sarker, Abbas, Dunstall, *et al.*, 2018), fuzzy clustering analysis method (Ren, Xing, Quan, *et al.*, 2010), set coverage model (Zhang, 2016; Auad & Batta, 2017; Dupont, Lauras & Yugma, 2017), maximum coverage model (Jing & Wang, 2013; Paulican & Ortega, 2013) and gradual coverage theory (Saydam, Rajagopalan, *et al.*, 2013; Chen, 2016) to optimize the location.

However, these models are mostly built for a single enterprise with a stable customer base and relatively stable distribution address and business volume. The service object of the express terminal network based on joint distribution is all the people in the city, and its distribution features such as "small batch, multi-frequency, strong timeliness, scattered locations, complicated customers and high service requirements". As the terminal network directly serves consumers and the demand is numerous and dispersed, the set coverage model is adopted in this paper to select the terminal nodes location. When establishing the terminal network, we should first divide the customer area and select the feasible terminal network. Then, in consideration of customer satisfaction, radiation range of facilities, service capacity, construction cost and other factors, choose the optimal terminal network.

2. DATE

Wanzai County is in Yichun City, Jiangxi Province, including Kangle Street as a first-class central city, Zhutan, Shuangqiao, Sanxing and Luocheng as four second-class central towns, and 12 third-class general towns such as Bailiang and Gaocheng. At present, every township in Wanzai County has a central station, most administrative villages have terminal nodes, mainly in the form of convenience stores, about 56. However, the distribution of its network outlets is very unreasonable. Taking the Lily Waterscape community in Kangle Town as an example, Yunda, Zhongtong and Yuantong Express have respectively set up terminal node inside or around the community, resulting in three terminal nodes in this area. Other express companies with smaller distribution volume have delivered directly. In the terminal joint distribution mode, the network should be optimized and integrated in this area. Additional, in a few more remote villages and towns, the number of outlets is relatively small, and additional outlets are needed.

In this paper, we analyzed the supply and demand situation of the terminal distribution network, The service radius of the node is analyzed to reflect the supply and demand situation. At present, a relatively representative standard is the National Standard for Standards of Postal Service Facilities formulated in Table 1, which can accurately reflect the relationship between population density and service radius.

Table 1: Comparison table of population density and service radius (postal service facilities planning national standard)

Urban population density (Man/km2)	500-1000	1000-5000	5000-10000	10000-150000	15000-20000	20000-250000	> 250000
Service radius (km)	2.01-3	1.01-2	0.81-1	0.71-0.8	0.61-0.7	0.51-0.6	0.5

According to the latest data, it is possible to calculate the demand for terminal nodes in each towns and villages, as shown in table 2. Taking Kangle Street as an example, it covers a total area of 18.1 square kilometers and has a total population of 121,000. From this, the population density is estimated to be about 3594.48 people per square kilometer. In contrast to table 1, the service radius of the terminal nodes of Kangle Street should be within the range of 1.01-2 km. At the same time, according to this standard, the number of terminal nodes in Kangle Street should be at least 2 and at most 6. In the actual establishment of terminal joint distribution network, the calculation results in Table 2 can be used as a reference basis, and the actual situation of the candidate network and the balance of business volume of the customer group covered by the network should be considered comprehensively.

Table 2: Calculation table of dot number

region	*The measure of area*	*population*	*Population density*	*Density standard range*	*Radius of service radius*	*Number of outlets should be set.*
unit	*Square kilometer*	*ten thousand people*	*Man / square kilometer*	*Man / square kilometer*	*kilometer*	*individual*
Kangle Street	18.1	65060	3594.48	1000-5000	1.01-2	2-6
Zhutan town	90.81	52460	577.69	500-1000	2.01-3	3-7
Hangmao town	137.36	47995	349.41	<500	>3	<5
Tanbu town	96.89	36546	377.19	<500	>3	<3
Shuangqiao town	132.36	32199	243.27	<500	>3	<5
Gaocun town	204.29	16631	81.41	<500	>3	<7
Luocheng town	155.41	21766	140.06	<500	>3	<5
Sanxing town	112.81	25214	223.51	<500	>3	<4
Efeng village	85.94	34197	397.92	<500	>3	<3
Mabu village	75.71	35772	472.49	<500	>3	<3
gaocheng village	116.77	30494	261.15	<500	>3	<4
Chixing village	77.74	11887	152.91	<500	>3	<3
Lingdong village	46.15	10705	231.96	<500	>3	<2
Baihsui village	59.28	9835	165.91	<500	>3	<2
Xianyuan village	148.84	16655	111.90	<500	>3	<5
Bailiang village	73.75	20056	271.95	<500	>3	<3
Jiaohu village	87.42	11397	130.37	<500	>3	<3

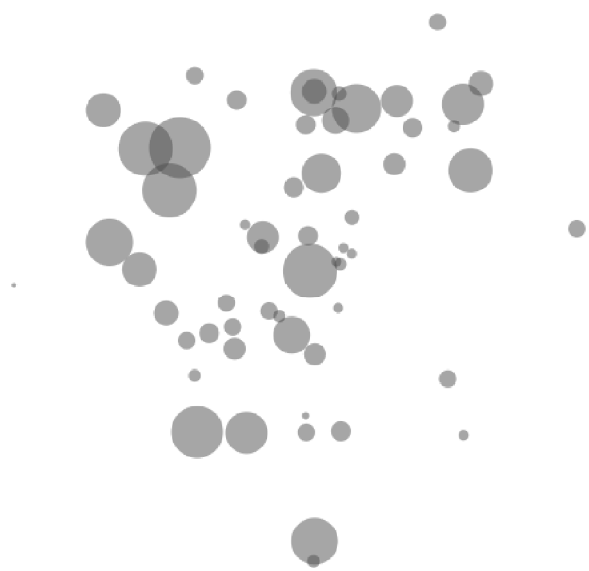
Due to the limited conditions, this paper chooses the central region of kangle town, wanzi county for the study of the layout of terminal distribution outlets. We obtained some information about the major education institutions, residential communities, medical institutions, large hotels, business centers and public institutions in this region by using Baidu Map Software. In detail, we used the coordinate picking function of Baidu Map Software, and obtained the longitude and latitude coordinates of 57 customer groups in the region. We converted the longitude and latitude coordinates into plane coordinates through the conversion formula of 111km/1 degree. At the same time, the daily average demand of each customer group is obtained by investigating, as shown in table 3. The distribution of customer groups is plotted using JAVA software, as shown in figure 1.

Table 3: Client information sheet

type	*number*	*Longitude and latitude coordinates*	*The x axis*	*The y axis*	*Daily demand (pieces)*
Education institutions	1	114.460823,28.113582	2251	2608	60
	2	114.448033,28.107066	832	1884	78
	3	114.4629,28.102235	2482	1348	66
	4	114.471056,28.091609	3387	169	31
	5	114.462349,28.129457	2421	4370	22
	6	114.471769,28.116663	3466	2950	28
	7	114.45419,28.120373	1515	3361	85
	8	114.46389,28.098513	2592	935	44
	9	114.450147,28.108966	1066	2095	56
	10	114.462424,28.128053	2429	4214	78
	11	114.468198,28.097127	3070	781	53
	12	114.480809,28.106118	4470	1779	28
	13	114.461955,28.106612	2377	1834	34
	14	114.462405,28.09645	2427	706	40
	15	114.455029,28.113455	1608	2594	33
Residents of the community	16	114.452973,28.100435	1380	1148	103
	17	114.450564,28.100516	1113	1157	89
	18	114.452244,28.103426	1299	1480	90
	19	114.462102,28.109082	2393	2108	88
	20	114.462357,28.096552	2422	717	76
	21	114.46426,28.120319	2633	3355	34
	22	114.465361,28.097664	2755	841	82
	23	114.461838,28.1204	2364	3364	31
	24	114.457645,28.120433	1899	3368	69
	25	114.474092,28.095917	3724	647	42
	26	114.468011,28.101593	3049	1277	38
	27	114.473364,28.102033	3643	1326	72
	28	114.47283,28.097367	3584	808	70
	29	114.45682,28.114544	1807	2714	36
	30	114.453447,28.113965	1433	2650	29
	31	114.454017,28.095353	1496	584	31
	32	114.461799,28.098817	2360	969	33
	33	114.459235,28.111922	2075	2423	29
	34	114.458708,28.107354	2017	1916	25
	35	114.456968,28.097061	1823	774	34
	36	114.447611,28.097796	785	855	57
	37	114.460956,28.103221	2266	1458	33
	38	114.459954,28.112266	2155	2462	21
	39	114.464147,28.096617	2620	724	26
A medical institution	40	114.454013,28.116442	1495	2925	22
	41	114.458797,28.106715	2026	1845	54
	42	114.462444,28.11494	2431	2758	39
	43	114.465049,28.105311	2720	1690	27
	44	114.456688,28.113028	1792	2546	29

contd. table 3

type	number	Longitude and latitude coordinates	The x axis	The y axis	Daily demand (pieces)
large hotel	45	114.472201,28.098925	3514	981	23
	46	114.465026,28.107859	2718	1972	17
	47	114.463958,28.108409	2599	2033	19
	48	114.464446,28.107464	2654	1929	17
	49	114.457547,28.105827	1888	1747	16
	50	114.46407,28.111699	2612	2399	19
Business center	51	114.4693,28.099038	3192	993	34
	52	114.464225,28.108581	2629	2052	22
	53	114.45623,28.111338	1742	2359	28
public institutions	54	114.45202,28.112063	1274	2439	41
	55	114.472869,28.120592	3588	3386	17
	56	114.461801,28.119243	2360	3236	12
	57	114.441335,28.110075	88	2218	8



Note: the circle distribution represents the location distribution, and the size of the circle represents the average daily demand.

Figure 1: Distribution of customer groups

In this region, there are 6 communities and 6 administrative village centers as the alternative points of the terminal joint distribution network. In the same way, we used Baidu Map Software to pick up its longitude and latitude coordinates, and converted them into plane coordinates, the information is shown in table 4.

Table 4: Terminal joint distribution point information table

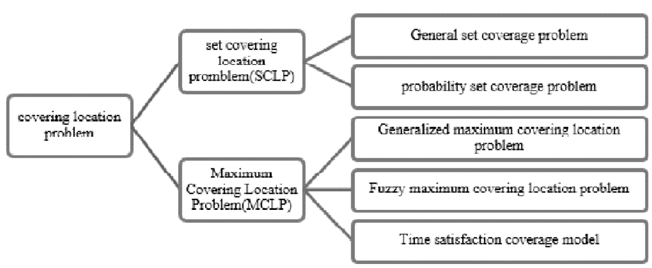
Alternative outlets	Longitude and latitude coordinates	number	The x axis	The y axis
West gate Residents' committees	114.450775,28.109441	1	1136	2148
East gate Residents' committees	114.460663,28.112396	2	2234	2476
South gate Residents' committees	114.45371,28.108598	3	1462	2054
North gate Residents' committees	114.46569,28.119644	4	2792	3280
Service before Residents' committees	114.455293,28.112949	5	1638	2537
Golden triangle Residents' committees	114.464288,28.097354	6	2636	806
Kangle village	114.462637,28.093678	7	2453	398
Yangle village	114.463864,28.103953	8	2589	1539
Lianxing village	114.46314,28.113132	9	2509	2558
Liquan village	114.460113,28.127252	10	2173	4125
Dongshen village	114.470583,28.116922	11	3335	2978
Shizibu village	114.478221,28.102931	12	4182	1425

3. MODEL

The last-mile logistics is the last link of distribution and the only link to contact with customers in the logistics. Its quality not only affects the economic benefit of enterprises and its competitiveness in the market, but also directly affects customer satisfaction. The location of terminal nodes will directly affect the distribution efficiency of the last-mile logistics, and the location of terminal nodes is very important to this link. However, in the process of management, resource allocation is often uneven. The main reasons are not only the existence of uncertain business, but also the unreasonable location of logistics facilities. We can adjust the location of the terminal node by restricting its workload so as to ensure the balance of the terminal node workload. Therefore, this paper proposes an improved set coverage model, which takes into account the constraints of traffic balance of terminal network, service radius, quantity of construction and non-repeated services. Also, relevant model algorithms are established to provide important technical support for decision makers.

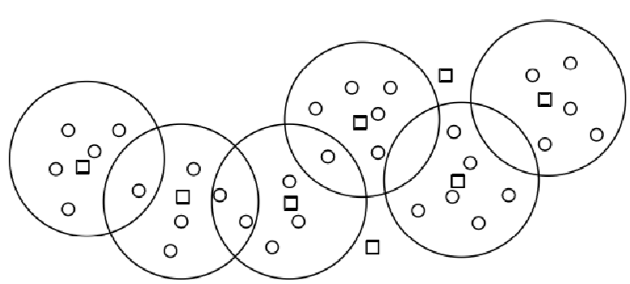
Covering location problem

According to the type of model parameters, the coverage location problem can be divided into two categories: deterministic and probabilistic location models. Further, according to its application method, the probabilistic model is divided into general probabilistic model and applied queuing theory model. Of course, it can be further subdivided according to the relationship between the models or the objective function. The most common classification is to classify coverage location problem into set coverage location problem and maximum coverage location problem.



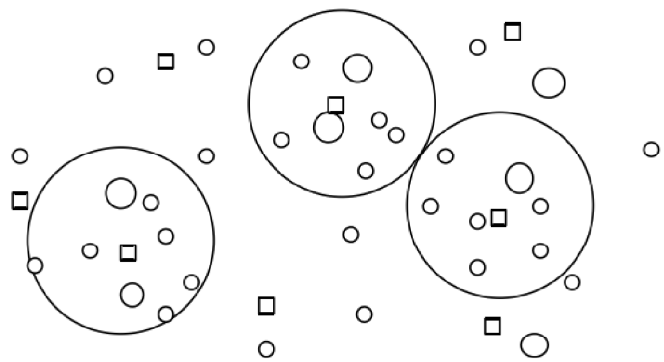
Picture 2: Covering location problem classification

The set coverage location problem is to covering all requirements with the least facilities, as shown in figure 3 (square represents distribution center, circle represents node). This requirement is usually represented by discrete objects (e.g., points, straight lines, polygons), and the selected facilities are fixed in a set of determined potential locations.



Picture 3: Set cover location model icon

The maximum coverage location problem is to cover as many points as possible with a fixed number of facilities, as shown in figure 4 (square represents distribution center, circle represents node).



Picture 4: Maximum coverage location model icon

Model establishment

Assuming that the standard of coverage radius is D, in order to ensure the balance of the total express traffic of the customers allocated within the coverage radius, it is necessary to reasonably restrain the amount of express traffic allocated to the facility. The lower limit is l and the upper limit is u. The goal of the model is to cover all the demand points in the area with the minimum number of facilities. The relevant assumptions of the model are as follows:

Hypothesis 1: the demand of customers is the average value of the historical express traffic;

Hypothesis 2: do not consider the influence of land rent, and the fixed cost of each terminal node is the same. In order to achieve the goal of minimum cost, it is necessary to establish a minimum number of end points to cover all customer demand points.

Hypothesis 3: there must be a road directly from the end point to the customer;

Hypothesis 4: the coverage radius is the same when the scale of all end-points is the same. If the radius is exceeded, the terminal node is considered not to meet the requirement of timeliness.

The goal of the improved set coverage model is to cover all requirement points with as few facilities as possible, namely, to cover all requirement points with the minimum number of terminal points, and the symbol is defined as follows:

i—Demand point index;

j—Alternative terminal node index;

I – I = $\{i \mid i = 1, 2, 3, ..., n\}$, A set of n requirement points in the target planning area;

$J – J = \{j \mid j = 1, 2, 3, ..., m\}$, A set of m alternative nodes in the target planning area;

d_{ij} —The distance from i to jÿ

D_j —The maximum distance that the demand point is allowed by the terminal node j service, that is, the coverage radius of the terminal node jÿ

w_i—The amount of express or the amount of demand at point iÿ

N(i) – N(i) = $\{j \mid d_{ij} \le D_j, \forall_j \in J\}$, The set of terminal node j that can cover demand point i;

$M_{(j)}$ – The set of requirement point i covered by terminal node j;

l — Assumed lower limit of work;

u — Assumed upper limit of workload;

$$x_{ij} \begin{cases} 1, \text{ Demand point } i \text{ is served by terminal point } j \\ 0, \text{ The demand point } I \text{ is not the end node} \end{cases};$$

$$y_j \begin{cases} 1, \text{ The terminal node is at } j \\ 0, \text{ The terminal node is not located in } j^{\circ} \end{cases}$$

The model is as follows:

$$\min Z = \sum_{i \in I} \sum_{j \in N_{(i)}} y_j \tag{3–1}$$

s.t.

$$\sum_{i \in I} \sum_{j \in N_{(i)}} x_{ij} = 1 \quad \forall i \in \mathrm{I}, \forall j \in J \tag{3–2}$$

$$l y_j \le \sum_{i \in M_{(j)}} w_i x_{ij} \le u y_j \tag{3–3}$$

$$\sum_{j \in N_{(i)}} y_j \ge 1 \quad \forall i \in I \tag{3–4}$$

$$x_{ij} \le y_j \quad \forall\ i \in \mathrm{I}, \forall j \in J \tag{3–5}$$

$$1 \le \sum_{i \in I} \sum_{j \in N_{(i)}} y_j \le P \tag{3–6}$$

$$x_{ij}, y_j \in \{0, 1\} \quad \forall\ i \in I, \forall\ j \in J \tag{3–7}$$

Type:

Formula (3-1) is the objective function of the set covering function, and the minimum number of end nodes to meet all customer needs;

Formula (3-2) represents each requirement point assigned to only one terminal node;

Formula (3-3) represents the limit of business volume of terminal branches. The total business volume of all demand points allocated to terminal node j cannot be lower than l and higher than u;

Formula (3-4) means that any demand point i shall be covered by the end node belonging to the $N_{(i)}$ set, namely $j \in N_{(i)}$;

Formula (3-5) represents that only the terminal node can be established at point j to serve point i;

Formula (3-6) represents upper and lower limit constraints on the number of terminal nodes;

Formula (3-7) denotes the binary constraint on x_{ij} and y_j, where and are variables.

4. RESULTS

According to table 2, we calculated the service radius of the terminal node in this example is 1000-2000 meters. So the service radius of the terminal node is selected in 1800 meters. The alternative point position and coverage range is drawn using JAVA software, as shown in figure 5.

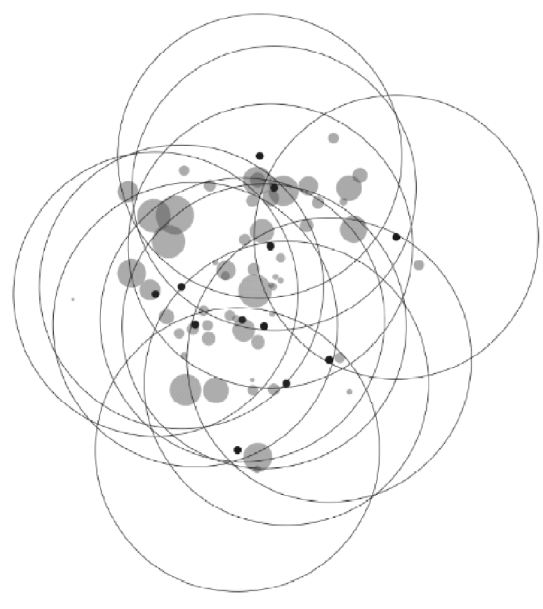


Figure 5: Alternative point position and coverage map

According to relevant data obtained from the survey, it is assumed that the size of each terminal node is the same, and the maximum delivery quantity is 1200 pieces. We obtained 10 feasible solution by using JAVA software programming, as shown in Table 3, and the corresponding images of each solution can be drawn, as shown in figure 6.

Table 3: Feasible solution

1	Selected delivery points	1,6,11	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	1	1,2,7,9,17,...,47,49,52,54,57		382
	6	3,4,8,11,14,...,25,28,39,45,51		420
	11	5,6,10,12,13,...,48,50,53,55,56		380
2	Selected delivery points	1,7,11	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	1	1,2,7,9,17,...,47,49,52,54,57		403
	7	3,4,8,11,14,...,25,28,39,45,51		372
	11	5,6,10,12,13,...,48,50,53,55,56		380
3	Selected delivery points	1,8,11	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	1	1,3,7,16,18,...,46,48,50,53,57		382
	8	2,4,8,9,11,...,43,45,49,51,54		420
	11	5,6,10,12,13,...,44,47,52,55,56		407
4	Selected delivery points	3,4,12	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	3	1,2,9,13,14,...,35,36,37,54,57		337
	4	5,6,7,10,15,...,49,50,53,55,56		356
	12	3,4,8,11,12,...,46,47,48,51,52		489
5	Selected delivery points	3,6,11	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	3	1,2,7,9,17,...,47,49,53,54,57		364
	6	3,4,8,11,14,...,39,43,45,48,51		419
	11	5,6,10,12,13,...,46,50,52,55,56		399
6	Selected delivery points	3,7,11	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	3	1,2,7,9,17,...,47,49,53,54,57		362
	7	3,4,8,11,14,...,36,43,45,48,51		421
	11	5,6,10,12,13,...,46,50,52,55,56		399
7	Selected delivery points	3,8,11	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	3	1,2,7,9,17,...,47,49,52,54,57		392
	8	2,4,8,9,11,...,40,45,48,51,54		379
	11	5,6,10,12,13,...,43,46,50,52,55		411
8	Selected delivery points	3,10,12	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	3	1,2,9,13,14,...,41,49,53,54,57		126
	10	5,6,7,10,15,...,42,44,50,55,56		567
	12	5,6,10,12,13,...,48,50,53,55,56		489
9	Selected delivery points	3,11,12	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	3	1,2,7,9,14,...,37,40,49,54,57		219
	11	5,6,10,12,13,...2,44,50,53,55,56		446
	12	3,4,8,11,22,...,46,47,48,51,52		517
10	Selected delivery points	5,7,11	Number of customers not covered	0
		Customer numbers corresponding to distribution points		Residual delivery capacity
	5	1,2,7,9,17,...,48,49,53,54,57		410
	7	3,4,8,11,14,...,31,36,39,45,51		332
	11	5,6,10,12,13,...,47,50,52,55,56		440

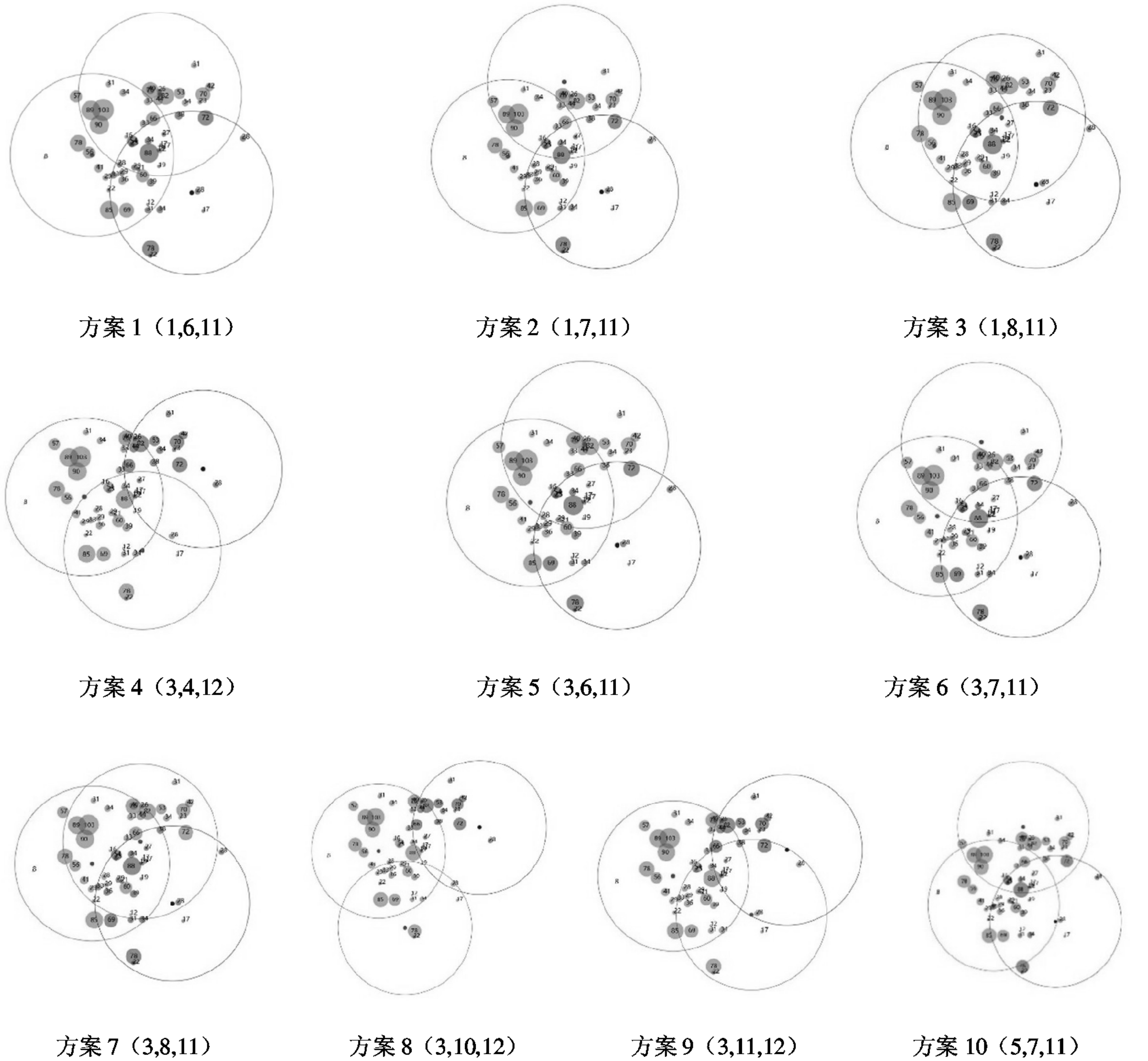


Figure 6: Corresponding images of scheme 1-10

Then, we used excel to calculate the deviation squared sum of the residual distribution capacity of terminal nodes in the feasible solution. The smaller the deviation squared sum, the more balanced the distribution of express traffic of distribution points. The solution with the smallest deviation squared sum is the most optimal. Take solution 1 as an example, set "=DEVSQ(B2:D2)" in the E2 cell and so on to get the result, as shown in figure 7.

Table 4: Calculation results of variance squared sum for each scheme

Solution	*Remaining distribution capacity of distribution points*			*Sum of squares of deviations*
1	382	420	380	1016
2	403	372	380	518
3	382	420	407	746
4	337	356	489	13718
5	364	419	399	1550
6	362	421	399	1778
7	392	379	411	518
8	126	567	489	110778
9	219	446	517	48458
10	410	332	440	6216

Among them, the deviation square sum of solution 2 and solution 7 is the smallest, which is 518. Therefore, the most optimal location solutions are 1, 7, 11 and 3, 8 and 11.

In this paper, we choose an area with a relatively high population density in wanzi county as an example, and built an improved set cover location model to find the most optimal location solution in this area. When choosing the location of terminal nodes in other regions, the parameters of the set coverage location model should be changed according to the actual situation of population density and express traffic in the region.

5. CONCLUSION AND PERSPECTIVE

Firstly, this paper elaborates the distribution status of express industry in China, relevant research on location problem and the theory of terminal joint distribution in detail. We investigated and analysed the current situation of terminal distribution in Wanzai county to meet the demand, and established a mathematical model for the location of terminal joint distribution network based on the improved set coverage model. The improved set coverage model not only ensures that all customer groups are covered by the minimum number of distribution networks, but also considers the size of each demand point and the distribution business capability of terminal nodes. Because there were many unknowns, we wrote codes through JAVA software programming to get the feasible solutions. Then taking the sum of squares of deviations of residual distribution capacity of each feasible distribution network as the basis of balancing distribution volume, we selected the most optimal solution of the feasible solution.

Due to the limitation of time and knowledge, there are still many deficiencies and parts to be further explored in this paper. Moreover, for express delivery, a rapidly developing new industry in the short term, both in terms of theoretical research and practical experience, it needs to be constantly developed and improved in order to make the terminal joint distribution network location problem to more mature research progress. The prospect part of this paper is illustrated from the following aspects:

(1) This paper only makes a detailed study on the layout of terminal joint distribution nodes (three-tier distribution points), but does not deal with the optimization of location and layout of upper-tier distribution points (such as first and second-tier distribution points).

(2) In the collection of relevant data, due to limited capacity, in some aspects (such as the size of the terminal distribution network, service radius, etc.) can only be obtained by calculating or field research, although accurate, but can not guarantee very representative data. If more accurate data can be obtained, the conclusion of the study The fruit will be closer to reality.

(3) In the case citation stage, only one area with high population density was selected because of the limited capacity, and the terminal network of express delivery in Guiyang was not laid out, so the final results are inevitably different from the actual situation.

(4) In this paper, JAVA programming is used to solve the improved set coverage terminal node location model, but no related algorithms (such as simulated annealing algorithm, genetic algorithm and ant colony algorithm) are used. It can be further discussed in future research.

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