Research on the Route Optimization of Express Companies in Shenbei Area

——Taking ZTO Express as an Example

Jun Zhao
School of Economic and Management
Shenyang Aerospace University
Shenyang, China

Li Qiqi
School of Economic and Management
Shenyang Aerospace University
Shenyang, China

Abstract—Along with China's economic globalization, the promotion of enterprises informatization and e-commerce are rapidly emerging. As a result the express industry shines out in the logistics industry and development of social economy. The soc-called accelerator for economic development is infiltrated into people's daily life at a tremendous speed, and people all depend on the express industry. However, with such a big opportunity, the express industry also faces a development bottleneck, for example high distribution cost, lack of goods, and professional talents, etc.

Keywords- Express Distribution; Shortest Path; Path Optimization; SWOT Analysis; Scanning Method

I. INTRODUCTION

The rapid development of the popularity of internet and development of economy has brought along with the development of e-commerce, express industry and expansion of express team. What's more, with the quick development of market economy, and emerging of e-commerce and information sharing, express industry has become an integral part of people's daily life

Even though the industry starts later, its development is fast. According to incomplete statistics, the annual growth rate of express industry remains a 31% or above increase, three times comparing to the average increase of GDP of the same period, so express industry is the fastest growing industry in recent years. In addition, the business volume has increased to 32% from 2003 to 2012, which is 2.3 times, 1,13 times, and 3,5 times comparing to the national economic growth of the same period with a 34% increase from 2003 to 2005, 21% from 2005 to 2009 and above 46% from 2009 to 2012.

TABLE I. Statistical graph of express business volume from 2003 to 2012 (Unit: one hundred million)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Business volume (one hundred million)	4.8	6.6	9.0	10.6	12.0	15.1	18.6	23.4	36.7	56.9

Data source: National Bureau of Statistics of China, China statistical yearbook

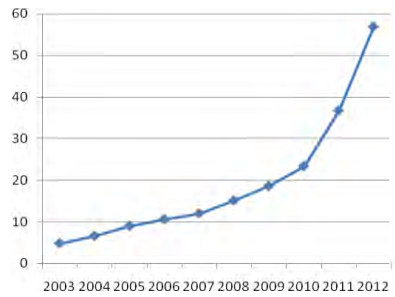

Figure1. LINE CHART FOR THE EXPRESS VOLUME FROM 1003 TO 2012 (UNIT: ONE HUNDRED MILLION)

Business volume (one hundred million)

The express industry has become a new service industry to promote the development of national economy and upgrading of an industrial structure. The informationization society and universal access to internet have ignited the development of e-commerce and online purchasing, which also become an important impetus to promote the express industry. In addition, the express business volume has also expanded rapidly, and the business volume depending on the internet retailing occupies more than half of the total business volume. Statistics show that the business volume depends on e-commerce in 2008 occupying three-sevenths of the annual business volume; and express revenues which are driven by online shopping are RMB 19.27 billion Yuan; Three years later, the express revenues based on online shopping remain a 25.8% increase rate, which has reached to RMB 44.23 billion Yuan in 2012. Online shopping has become an impetus for express business. However, the rapid development of e-commerce has brought both challenges and opportunities for Chinese express industry. According to the situation from 2005 until now, the overall development trend of the express's business volume is in accordance with the development of e-commerce

II. THE ROUTE OPTIMIZATION OF SHENBEI'S EXPRESS DELIVERY

A. *Brief explanation on Shenbei's express delivery*

Even though the express distribution in Shenbei has developed quickly in recent years, it is still at an early age comparing to other regions, which will inevitably face some problems during the development. Shenbei new district is a newly established area, and many delivery systems are not mature with a lack of management talents and technology talents in terms of professional distribution. Besides, the route cannot meet the requirements of current needs with an immature express information chain, which have caused disorder delivery, high cost and low efficiency..

B. *The establishment of delivery mode*

This matter is about the delivery route with the same start and ending points, namely express enterprises always ask the transport vehicles to go back to the starting point after the completion of the delivery. The Coincidence matter of the starting and ending point is the so-called 'Traveling Salesman Problem'. There is a network system constructed by n nodes {v1,v2…….vn}, the distance between the node is already known, and the shortest route remains to be found out.

1)Basic conditions: There are M transport vehicles with some cargo load parking in the same place (or logistics center) P, they have to provide goods to N customers, and the location of the parking place and customer of v1, v2……vn haven been know. Suppose that the ability to drive can meet current requirements.

2)Modules of Objectives: Determine the number K of required transport vehicles, and arrange these cars to run in the same loopback with the optimized path to ensure the overall transport distance S is the shortest.

3)Constraint conditions:

The number of required transport vehicles cannot exceed the number provided by the distribution center;

The required cargo load will never exceed the deadweight;

Every customer's needs should be satisfied with one transport vehicle to deliver;

All vehicles have to go back to the starting point after the completion.

$$\min \quad z = \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}x_{ij} \tag{1}$$

Suppose the number of customers of each vehicle is U, is the shortest between i and j; introduce (i≠j) between 0 to 1, =1 shows the distance between i to j, which means the vehicle is running in the path and if =0, the vehicle is not running in the path, the objective function shows as follow:

$$\min \quad z = \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}x_{ij} \tag{2}$$

$$\sum_{j=1}^{n} x_{ij} = 1, \quad i = 1,2,\Lambda\ ,n\ ,\ j \neq i \tag{3}$$

The constraint condition has to be satisfied: Visit to the city only for one time. Starting from the city i to (other cities), showing as follow:

$$\sum_{j=1}^{n} x_{ij} = 1, \quad i = 1,2,\Lambda\ ,n\ ,\ j \neq i \tag{4}$$

$$\sum_{i=1}^{n} x_{ij} = 1, \quad j = 1,2,\Lambda\ ,n\ ,\ i \neq j \tag{5}$$

Starting from a certain city to j only for one time, showing as follow:

$$\sum_{i=1}^{n} x_{ij} = 1, \quad j = 1,2,\Lambda\ ,n\ ,\ i \neq j \tag{6}$$

Above modes are same to those of assignment problems, which are necessary conditions for TSP not sufficient conditions. And sufficient constraint conditions should be added to avoid subsidiary circuit. Add variable quantity u, i=1,2,….n, (it can adopt integral number, for example, the u is 2 from the starting city to the ending city, and so on)

Additional restraint conditions: $u_i - u_j + nx_{ij} \le n-1, i=1,\ldots,n,\ j=2,\ldots,n$, and $i \ne j$

$$\min \quad z = \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}x_{ij} \tag{7}$$

The basic mathematical model for optimized delivery route is:

$$\begin{cases} \sum_{i=1}^{n} x_{ij} = 1, \quad j = 1,2,\Lambda\ ,n\ , i \ne j \\ \sum_{j=1}^{n} x_{ij} = 1, \quad i = 1,2,\Lambda\ ,n\ , j \ne i \\ u_i - u_j + nx_{ij} \le n-1, \quad i = 1,\Lambda\ ,n, j = 2,\Lambda\ ,n, i \ne j \\ x_{ij} = 0\ ,1 \quad , \quad i, j = 1,2,\Lambda\ ,n\ , u_i \ge 0\ , i = 1,2,\Lambda\ ,n \end{cases}$$

Among which refers to the distance between i to j.

x_{ij} refers to the road section from i to j. and 0-1 is a variable quantity.

The objective function refers to the shortest route to deliver all of the goods.

The constraint condition 1 means that there is only one route to the distribution point, which is among different distribution points.

Similarly, the constraint condition 2 also means that there is only one route to the distribution point, which is among different distribution points.

The constraint condition 3 means that the range of u which is limited by ! is solved with the accelerator model to ensure that the additional constraint will not exclude the optimized solution of TSP to prevent the problem of subsidiary delivery circuit.

C. *Algorithm Analysis and Solution Method Review*

This paper has adopted the following research methods during the course of the study:

1. Scanning method: The Vehicle Routing Problem, VRP which was put forward by Gillett and Miller, which firstly divides group and then arrange the delivery route. This route adopts polar coordinates to represent the location of demand points, and choose one of them as the starting point with zero degree toward a clockwise or anticlockwise direction and divide regions based on capacity of transportation vehicle. And then with the exchange method proposed by Lin and Kernighan, the demand points can be orderly sorted to construct delivery route. This method can be divided into two stages:

The first stage: Represent the location of demanding points with polar coordinates, and choose one of them as the starting points and divide groups based on vehicle capacity and then carry out customer scanning toward the clockwise or anticlockwise direction.

The second stage shall solve the customer route based on the Traveling Salesman Problem algorithm, which is going to combine the overall distribution delivery sites with the delivery volume through the years so as to choose the proper delivery sites. Regard the distribution center as the starting point and carry out scanning based on the anticlockwise direction and divide the delivery regions according to the vehicle capacity, which can reduce the number of vehicles and at the same time develop work efficiency.

2. Set up mathematical model. Set up a mathematical model with number form 0-1 based on constraint conditions and given data and solve the problem with lingo procedure to find out the shortest route, which is the optimal path.

D. *Model data description and hypothesis*

This paper adopts 17 demand points of ZTO express in Shenbei area to calculate the distance between each point with Baidu Measurement tools and also estimate the everyday volume based on actual research, concrete demand points show as follows:

○1ZTO express center ○2Shenyang Guaipo ○3Xinchengzi District ○4Shifo ○5Xinglongtai ○6Hunagjia ○7New castle ○8Nnatai ○9Yinjia ○10Liaoning University ○11Shenyang Normal University ○12Hushitai ○13Qignshui ○14Splendor mountain ○15Puhe ○16Qipan Mountain ○17Cuigongbao village ○18Zhangjiawo

According to investigations, everyday express volume of each delivery site is shown in the table 2:

TABLE II. Express volume of each demand point in Shenbei area (unit: items)

①	②	③	④	⑤	⑥	⑦	⑧	⑨
0	40	40	45	55	30	60	25	70
⑩	⑪	⑫	⑬	⑭	⑭	⑯	⑰	⑱
80	100	70	30	45	45	50	30	25

The capacity cargo load of each vehicle is 300 items. Carry out scanning toward the anticlockwise direction of each point, and the result is shown as follow, which can be divided into three delivery sites:

A 区：50＋40＋45＋55＋30+60+25＝295
B 区：70＋80＋100＝250
C 区：70＋30＋45＋45＋50+35+25＝300

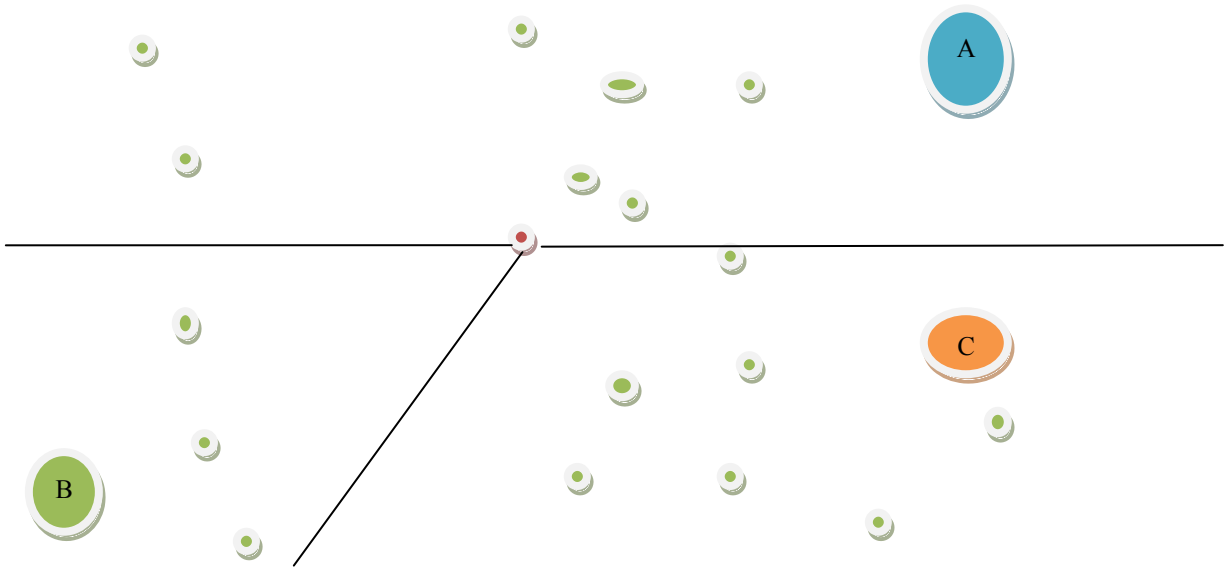

Figure2. Route of distribution scanning

A district includes 8 delivery site: ZTO express center, Sheyang Guaipo, Xinchengzi District, Shifo, Huangjiaxi, New castle, Nantai while B district includes 4 sites which are ZTO express center, Yinjin, Liaoning University, Shenyang Normal University; C district has 8 sites, which are ZTO express center, Hushitai, Qingshui, Splendor mountain, Puhe, Qipan mountain, Cuigonbao Village, Zhangjiawo. All is shown in the figure 2.

According to research, the distance between these three districts shows in the following table

TABLE III. Distance between the delivery sites of A district (Unit: Kilo meters)

Distance/ kilo meters	①	②	③	④	⑤	⑥	⑦	⑧
①	0	8	0.8	17	14	7.7	2.3	4
②	8	0	7	23.5	22	11	8.4	6
③	0.8	7	0	17.5	14.5	7	2.1	3
④	17	23.5	17.5	0	7	13	17	18.1
⑤	14	22	14.5	7	0	7	13	16.4
⑥	7.7	11	7	13	7	0	5.6	6.5
⑦	2.3	8.4	2.1	17	13	5.6	0	2.5
⑧	4	6	3	18.1	16.4	6.5	2.5	0

Among which ○1ZTO express center ○2Shengyang Guaipo ○3Xinchengzi District ○4Shifo ○5Xinglongtao ○6Huangjiaxi ○7New castle ○8Nantai

TABLE IV. Distance between the delivery sites of B district (Unit: Kilo meters)

Distance/kilo meters	①	②	③	④
①	0	13.5	17	18
②	13.5	0	10.5	13
③	17	10.5	0	3
④	18	13	3	0

Among which ○1ZTO express center ○2Yinji ○3Liaoning University ○4Shenyang Normal University

TABLE V. Distance between the delivery sites of C district (Unit: Kilo meters)

Distance/ kilo meters	①	②	③	④	⑤	⑥	⑦	⑧
①	0	11.5	7	8.5	12	16	5.6	19.1
②	11.5	0	12	10	6.8	10.5	6.8	17.9
③	7	12	0	2	8	10	6	10.4
④	8.5	10	2	0	6	8	5.5	9.3
⑤	12	6.8	8	6	0	4	6.8	11.1
⑥	16	10.5	10	8	4	0	10.6	8.9
⑦	5.6	6.8	6	5.5	6.8	10.6	0	14.8
⑧	19.1	17.9	10.4	9.3	11.1	8.9	14.8	0

Among which ○1ZTO express center ○2Hushitai ○3Qingshui ○4Splendor mountain ○5Puhe ○6Qipan mountain ○7Cuigongbao village ○8Zhangjiawo

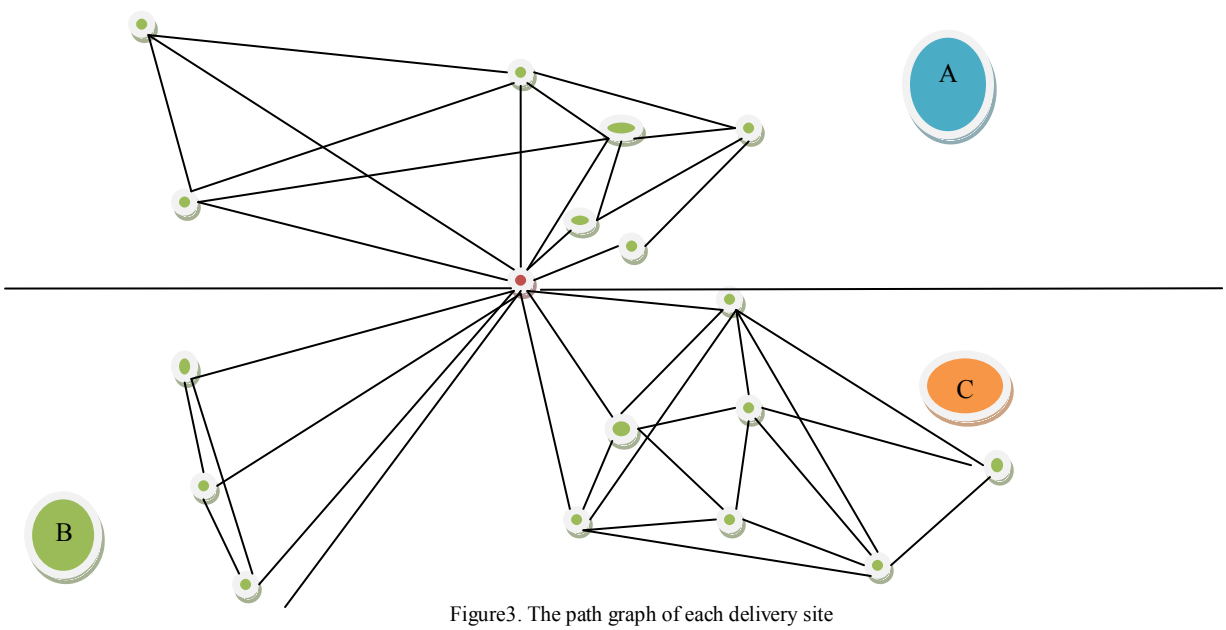

Figure3. The path graph of each delivery site

E. Model solution and calculation

Calculate the model with Lingo and the result show as follows:

Objective value: 54.10000
The running result of A district is shown as follows: Objective bound: 54.10000
The running result of B district is shown as follows:
Objective value: 45.00000
Objective bound: 45.00000
The running result of C district is shown as follows:
Objective value: 50.40000
Objective bound: 50.40000

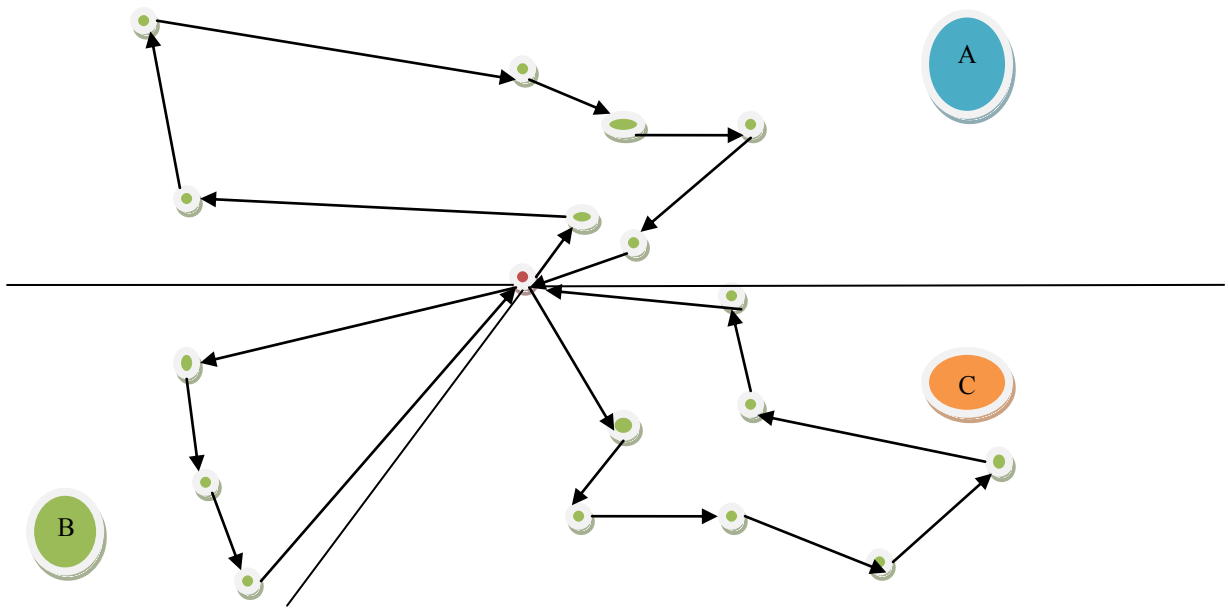

Figure 4. The shortest routine of each district

As figure 6 shows: The Shenbei Area is divided into three districts with the scanning method, and the optimal path is shown in the figure.

The optimal path of A district is :1—7—5—4—6—8—2—3—1, the overall distance is 54.1 kilo meters. The optimal path of A district is starting from the express center, the first station is Xinchengbao, second Xinglongtai, third Shifo, fourth Huangjiaxi, and so on , then the vehicle shall go to Nantai, Shengyang Guaipo, Xinchengzi District and go back to the starting point.

The optimal path of B district is 1—4—3—2—1, the overall distance is 45 kilo meters. The optimal path of B district is starting from the express center, the fists station is Shenyang Normal University, and then Laoning University, Yinjia village and finally go back to the starting point.

The optimal path of C district is 1—3—4—8—6—5—2—7—1, and the overall distance is 50.4 kilo meters. The optimal path of C district is starting from the express center, the first station is Qingshui, then Splendor mountain, Zhangjiawo, Qipan Mountain, and Puhe, Hushitai, Cuigongbao village and finally go back to the starting point.

The above optimal route is helpful to decrease the cost in terms of labor and materials, and also develop delivery efficiency and enhance enterprise competitiveness.

III. CONCLUSION

With the rapid development of Shenbei area, people begin to flock into this city and the potential market depending on university district has been expanded. To satisfy these needs, express enterprises have established delivery centers in this area.

The most subsidiary system of logistics system is the transportation system, and the transportation fee shall occupy 60% of the total logistics fee. So the decrease of logistics cost shall being with the decrease of transportation cost. The final part of the whole logistics process is the delivery sector, which is an extension of the transportation management system and customers shall focus on the distribution effect.

Therefore, express delivery is very important while judging from the perspective of service quality and cost saving. Concerning above matters, this paper aims to come up with the following suggestions to optimize the delivery route.

1 Focus on the decrease of delivery cost, chose proper delivery route. Because of the borderless nature of internet, the demand is diverse and uncertain and scattered demand will increase the cost of the delivery center. So it has to focus on the decrease of delivery cost and timeliness of delivery route.

2 Improve the quality of employee, strengthen the construction of team, promote the service quality, broad exchanges and cooperation, and joint development of China and foreign logistics enterprises.

3 Perfect the management system, enhance the

capacity to execute, strengthen the construction and management of internal delivery center. Integrate logistics resources to construct a professional and social-oriented company; organize and coordinate related duties; integrate partners who have mutual callings with independent economy interests become one system to serve customers so as to achieve overall benefits.

4 Increase input on the informationization and automation equipment, decrease labor cost. China's express industry starts late with comparatively low development degree, and a huge gap comparing to those foreign giant logistics enterprises. In addition, the industry mainly depends on manual operation. Express enterprises have to adopt information technology and equipment, such as management information system, enterprise resource planning, radio frequency identification, automatic tracking technology, etc.

5 Optimize the transportation route, decrease related cost; encourage large manufacturing enterprises to invest and develop logistics enterprises or cooperate with the third-party logistics enterprises to perfect the delivery system.

6 Perfect the system of encouragements and penalties. It is a necessity for a company to conduct strict discipline with clear encouragements and penalties so as to arouse the initiative of employees and enhance work efficiency; Conduct the regulations and rules of company based on fair competition and management to strengthen the work flow and clear the job responsibilities. Enterprises have to make a encouragements and penalties system according to the associated work between departments and the work flow. Only through this, can their initiative be promoted to enhance work efficiency, and competitiveness with same cost.

7 Fully arouse the initiative of employees, develop enterprising spirit, provide new ideas, plans to companies; choose local people as employees, have a deep understanding of local customs so as to make company culture feet on the ground to further expand the market.

REFERENCES

[1] Fu Hongxiang Department of Human Resources and Social Security of Zhejiang Province Search for the Optimal Route Optimize Management mode[N] China Pharmaceutical News

[2] Jiang Yan, Guan Xue, Research on the Optimal Route of Express Delivery[J]. Logistics technology,2008,03:39-41

[3] Ji Tong Analysis on the Influencing Factors of Express Development[D] Nanjing University of Posts and Telecommunications, 2012

[4] Yan Yuting Research on the Division of Express Distribution Area Based on the Improved FCM Algorithm[D] Dalian Maritime University,2012.

[5] Zeng Linguo: Study on Optimization of logistics distribution route under electronic commerce environment. Hubei University of Technology, China.Proceedings of 2010 Third International Conference on Education Technology and Training [6] Wen Yingjie E-commerce Era Rapid Development of Express Industry BUSINESSPEOPIE,2009,22:139

[7] Li Yuanchen, Liu Weiqun, Analysis on the Optimal Path Based on Dijkstra

[8] Clive Thomas, Kevin Campbell, Gail Hines, Michael Racer. Airbus Packing at Federal Express. Interfaces [J], Vol.28, No.4(Jul.-Aug, 1998) : 21-30.

[9] CLARKE G, WRIGHT J W. Scheduling of vehicles from a central depot to a number ofdelivery points [J]. Operations Research, 1964, 12(4): 568–581.

[10] . Koehler. City Logistics In Kassel [J].City Logistics,1999, 1:261-271.