Proceedings of 2012 4th International Conference on Machine Learning and Computing
IPCSIT vol. 25 (2012) © (2012) IACSIT Press, Singapore

Auto Components Inbound Logistics Network Optimization Based on Mixed Taboo Search and Genetic Algorithm

Yingjie Shi + and Dong Wang

[1] School of Software, Shanghai Jiao Tong University

Abstract. It proposes a solution to the problem of auto component inbound logistics network optimization associated with distribution routing optimization and logistics network location. A genetic algorithm combined with taboo search algorithm and the relevant adaptive operator updating method is adopted to solve this problem. The optimized solution is verified with optimizing and analyzing in the actual project cases. Computing results show that the model is scientific and effective.

Keywords: Auto components inbound logistics, Logistics network optimization, Mixed Taboo Search and Genetic Algorithm

1. Introduction

With increasingly heating competition and shrinking profit margins in domestic and international market, the auto logistics industry faces a dilemma that to reduce operating costs and to improve service. Thus, auto components inbound logistics becomes the key link. Whilst the research is rather weak in our country, how to make auto components inbound logistics effective and stable is a problem to be solved.

2. Auto Components Inbound Logistics Network Optimization Model

Inbound Logistics is to collect auto components from vendors, and then deliver to plants on time according to needs of plants (Vehicle Operation). Dhaenens-Flipo proposed the problem of one or more facilities to optimize manufacturing and distribution as a whole[1]; Melkote and Daskin proposed the problem simultaneously optimizing location and transportation network[2]; Goetschalckx[3] proposed the mathematical model simultaneously optimizing international transport, manufacturing and distribution as a whole. Auto components inbound logistics involves Vehicle Operation, Distribution Center and Supplier. The network topology is illustrated in Figure 1.

+ Corresponding author. Tel.: + 86-21-34205077; fax: +86-21-34205077.
E-mail address: shiyingjie.career@gmail.com.

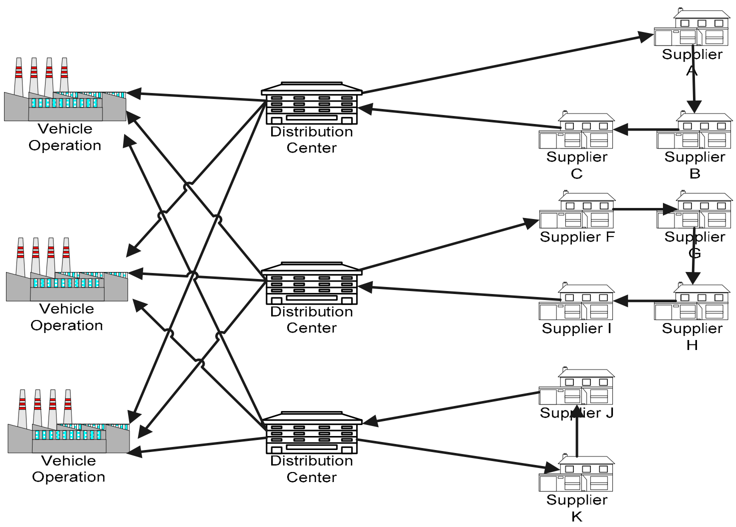

Fig. 1: Auto components inbound logistics network topology.

- Vehicle Operation-Distribution Center Carriage Cost

In this process, carriage cost is defined as a uniform price in the whole country by the enterprise at the present. The expression is as follow:

$$\sum_{v=1}^{V}\sum_{d=1}^{D}[l_{vd}^{R}\cdot p_{vd}^{R}\cdot Vo_{vd}] \quad (1)$$

$$Vo_{vd}=\left(\sum_{d=1}^{D} D_{vd}\right)(d=1,2,...,D) \quad (2)$$

l_{vd}^{R} distance from Vehicle Operation(v) to Distribution Center(d);
p_{vd}^{R} transport rate from Vehicle Operation(v) to Distribution Center(d);
Vo_{vd} transport total volume from Vehicle Operation(v) to Distribution Center(d);
D_{vd} demand from Vehicle Operation(v) to Distribution Center(d);

- Distribution Center-Supplier Carriage Cost

The speeds on urban and suburban road must be different. We adopt average speed to facilitate users to establish model. The expression is as follow:

$$\sum_{d=1}^{D}\sum_{s=1}^{S}\eta^{R}\cdot\chi_{ds}\cdot[l_{ds}^{R}\cdot p_{ds}^{R}\cdot\sum_{v=1}^{V}Vo_{dsv}^{R}] \quad (3)$$

$$Vo_{dsv}^{R}=\sum_{s=1}^{S}D_{dv}\cdot\beta_{d}(s=1,2,...,S) \quad (4)$$

χ_{ds} 0-1 variable, is there a connection between Distribution Center(d) and Supplier(s);
l_{ds}^{R} distance from Distribution Center(d) to Supplier(s);
P_{ds}^{R} transport rate from Distribution Center(d) to Supplier(s);
Vo_{dsv}^{R} transport total volume from Distribution Center(d) to Supplier(s);
D_{vs} demand from Distribution Center(d) to Supplier(s);
β_{d} proportion factor of demand to storage of Distribution Center(d);
η^{R} proportion of road transport, usually 1;

- Vehicle Operation-Supplier Carriage Cost

Some far away suppliers are not suitable for batch scheduling and highway transportation. These suppliers need to be delivered into assemble line.

$$\sum_{v=1}^{V}\sum_{s=1}^{S}\eta^{R}\cdot\chi_{vs}\cdot[l_{vs}^{R}\cdot p_{vs}^{R}\cdot\sum_{v=1}^{V}Vo_{sv}^{R}]+\sum_{v=1}^{V}\sum_{s=1}^{S}\eta^{T}\cdot\chi_{vs}\cdot[l_{vs}^{T}\cdot p_{vs}^{T}\cdot\sum_{v=1}^{V}Vo_{sv}^{T}] \quad (5)$$

χ_{ds} 0-1 variable, is there a connection between Vehicle Operation (v) and Supplier(s);
l_{vs}^{R} road distance from Vehicle Operation(v) to Supplier(s);
l_{vs}^{T} rail distance from Vehicle Operation(v) to Supplier(s);
p_{vs}^{R} road transport rate from Vehicle Operation(v) to Supplier(s);
p_{vs}^{T} rail transport rate from Vehicle Operation(v) to Supplier(s);
Vo_{sv}^{R} road transport total volume from Vehicle Operation(v) to Supplier(s);
Vo_{sv}^{T} rail transport total volume from Vehicle Operation(v) to Supplier(s);
η^{R} proportion of road transport;
η^{T} proportion of road transport;
$\eta^{R}+\eta^{T}=1$;

- Supplier-Supplier Transport Cost

The vehicle routine consists of one distribution center and several suppliers. So we need to calculate the cost between suppliers.

$$\sum_{d=1}^{D}\sum_{s=1}^{S}\sum_{s=1}^{S}\chi_{ss}^{d}\cdot l_{ss}^{R}\cdot p_{ss}^{R}\cdot Vo_{sd} \quad (6)$$

χ_{ss}^{d} 0-1 variable, is there a connection between Supplier(s) and Supplier(s) or not, superscripts 'R' indicate pass Distribution Centre(d);

l_{ss}^{R} road distance from Supplier(s) to Supplier(s);

p_{ss}^{R} road transport rate from Supplier(s) to Supplier(s);

Vo_{sd} road transport total volume from Supplier(s) to Supplier(s);

The expression of total cost of transportation is as follow:

$$\begin{aligned}T \quad = \quad & \sum_{v=1}^{V}\sum_{d=1}^{D}[l_{vd}^{R}\cdot p_{vd}^{R}\cdot Vo_{vd}] \\ & +\sum_{d=1}^{D}\sum_{s=1}^{S}\eta^{R}\cdot\chi_{ds}\cdot[l_{ds}^{R}\cdot p_{ds}^{R}\cdot\sum_{v=1}^{V}Vo_{dsv}^{R}] \\ & +\sum_{v=1}^{V}\sum_{s=1}^{S}\eta^{R}\cdot\chi_{vs}\cdot[l_{vs}^{R}\cdot p_{vs}^{R}\cdot\sum_{v=1}^{V}Vo_{sv}^{R}] \\ & +\sum_{v=1}^{V}\sum_{s=1}^{S}\eta^{T}\cdot\chi_{vs}\cdot[l_{vs}^{T}\cdot p_{vs}^{T}\cdot\sum_{v=1}^{V}Vo_{sv}^{T}] \\ & +\sum_{d=1}^{D}\sum_{s=1}^{S}\sum_{s=1}^{S}\chi_{ss}^{d}\cdot l_{ss}^{R}\cdot p_{ss}^{R}\cdot Vo_{sd}\end{aligned} \quad (7)$$

We can get the reasonable parameters in a mature statistical method. The expression is as follow:

$$S=\sum_{v=1}^{V}\sum_{d=1}^{D}K_{d}\cdot\varphi_{d}\cdot\chi_{d} \quad (8)$$

$$K_{d}=D_{ds}\times\gamma_{d},\quad D_{ds}=[\sum_{s=1}^{S}\chi_{ds}\cdot Vo_{sv}]\cdot\beta_{d} \quad (9)$$

K_{d} building area of Distribution Center (d);

φ_d building rate of Distribution Center (d);

χ_d 0-1 variable, Distribution Center (d) is enable or not;

D_{ds} demand of Distribution Center (d);

γ_d storage factor of Distribution Center (d);

β_d proportion factor of demand to storage of Distribution Center (d);

Vo_{sv} demand from Supplier to Distribution Center (d);

- Service Cost Analysis

The point is the analysis of suppliers' milk-run response time. This model is designed for static data calculation, so we need to change the response time into service radius-the maximum distance that the vehicle can reach. The suppliers which are not in the service radius have an extra cost. The cost rate is ρ. The expression is as follow:

$$P = \rho \sum_{d=1}^{D} \sum_{s=1}^{S} \chi_d^D \cdot \chi_{ds}^{DS} \cdot q_{ds} \cdot (l_{ds} - D_s^r) \sum_{v=1}^{V} R_{sv} \ . \tag{10}$$

ρ service penalty rate;

q_{ds} 0-1 variable, Supplier (s) is in the service scope of Distribution Center (d) or not;

D_s^{γ} coverage radius of Distribution Center (d);

χ_d 0-1 variable, Distribution Center (d) is enable or not;

χ_{ds}^{DS} 0-1 variable, is there a connection between Distribution Center (d) and Supplier(s) or not;

Based on the above, the whole network model is as follow:

$$Min \quad m \quad = \quad T + S + P \ . \tag{11}$$

ST.

$$Vo_{vd} = \left(\sum_{d=1}^{D} D_{vd} \right) (d = 1, 2, ..., D) \ . \tag{12}$$

$$Vo_{dsv}^R = \sum_{s=1}^{S} D_{dv} \cdot \beta_d (s = 1, 2, ..., S) \ . \tag{13}$$

$$\sum_{s=1}^{S} \chi_{sd}^{SD} = 1 \ ; \ \sum_{s=1}^{S} \chi_{vs} = 1 \ . \tag{14}$$

3. Algorithm Design of Auto Components Inbound Logistics Network Optimization

The inbound logistics network optimization is a typical NP-Hard problem, which cannot be resolved in a routine method. GA[4] is an available method in network optimization, while taboo search algorithm is practicable in VRP. It brings out a new hybrid method which combined GA with Taboo Search Algorithm, to simplify bi-iterative complexity and settle the local convergence of GA.

3.1. Algorithm Frame of Hybrid Taboo Search and GA

The Figure 2 is an algorithm frame of the mixed Taboo Search and Genetic Algorithm.

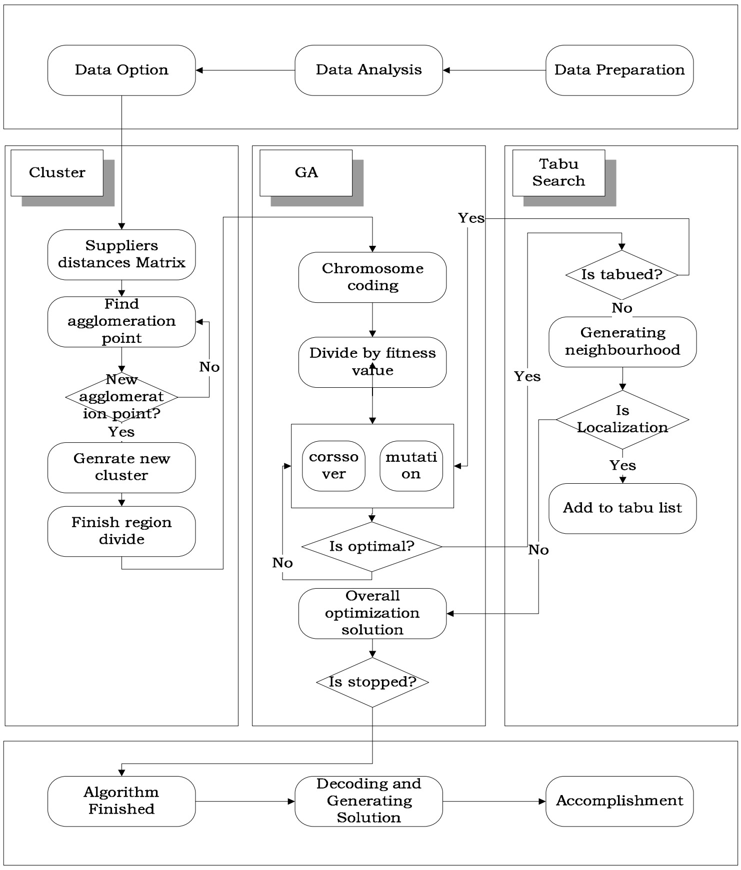

Fig. 2: Algorithm frame of the mixed Taboo Search and Genetic Algorithm.

3.2. Optimal Design Steps of Mixed Taboo Search and GA

- Unification coding of chromosome.

We use L natural numbers' permutation to express the transport vehicles' permutation, which makes up a chromosome. Every chromosome contains not only the suppliers' delivery routine but also the delivery order and the quantity of the vehicles. The first number of the chromosome means the vehicle number in the distribution center. In this way we can plan all the suppliers, and decide which supplier belongs to the distribution center.

- Population regeneration.

Crossover operator is designed to control the velocity of new individuals' generation. It is only used in the transport vehicles permutation and suppliers' permutation. The transport vehicles permutation is performed by routine crossover including single point and multi-point crossover. As to the suppliers' permutation, we use match-crossover operator.

Mutation operator is designed to control some chromosomes to make the genetic variants, which enhances the searching ability of the algorithm. We adopt single-point and multi-point mutation in transport vehicles permutation, and only single-point in suppliers' permutation.

- Algorithm criteria for the termination.

Algorithm criteria for the termination use taboo search algorithm as reference. It avoids traps into local optima. We use taboo list to store the local optima and find the optimized solution.

4. Example and Results Analysis

A 3PL company needs to set up distribution centers in eastern China. It has 227 suppliers and 4 original DCs. The alternatives are Shanghai, Ningbo, Nanjing, Suzhou, Hangzhou, Wuxi, and Jiaxing. We set services radius as 150km. Compared with standard GA, the results are presented in Table 1. Obviously, the number of DC is reduced. The cost of transportation, storage and service also reduce by 5%.

Table. 1: Comparison diagram of optimized results.

Optimal solution	DC amount	Iterations	DC address	Cost
Before optimizing	4	-	Shanghai, Suzhou, Jiaxing, Fuzhou	196933427.49
After optimizing	3	500	Nanjing, Shanghai, Suzhou	186710339.82
After typical GA	4	1000	Nanjing, Shanghai, Hangzhou, Ningbo	190392446.93

5. Summaries

The model and method brought forward in this article to solve the problem of auto components inbound logistics provide a rational solution to third party auto components logistics companies. An improved algorithm named hybrid TSGA has been presented. Meanwhile, it applies Simulated Annealing algorithm to improve crossover operation and mutation operation. The algorithm is validated by actual project.

6. References

[1] Dhaenens-Flipo C. Spatial decomposition for a multi-facility production and distribution problem [J]. International Journal of Production Economics, 2000, 64(1/2/3), 177-186.

[2] Melkote S, Daskin M S, An integrated model of facility location and transportation network design [J]. Transportation Research Part A, 2001, 35(6), 515-538.

[3] Geotschalckx M, Vidal C J. Dogan K. Modeling and design of global logistics systems: a review of integrated strategic and tactical models and design algorithms [J]. European Journal of Operational Research, 2002, 143(1), 1-18.

[4] Jianxing Zhou, Ying Piao, Zhisong Cao. Design and Optimization of Inlet Performance Based on Hybrid Genetic Algorithm [J]. Computer Engineering, 2008-12.