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The application analysis of genetic algorithm in integrated reverse logistics supply chain network design

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ABSTRACT

According to clients' needs and the limit of existing infrastructure skill, the total cost to the principle of minimum, insure both of forward logistics and reverse logistics. Fix the topological structure and then do the supply chain network design. People can use Priority coding genetic algorithm to get optimal solution of the supply chain network designing model. According to the basic principles of genetic algorithms, dividing the process of supply chain logistics activities into four parts, use not niced coding method to code the four parts. The purpose is to make this algorithm fast and accurate. When we determine the initial population can use Greedy heuristic algorithm, then do genetic manipulation to make it produce offspring and insure both of the cross operator and mutation operator at the same time. After designing the model and algorithm, make one area's Supply chain network design for example to test the correctness of the model and algorithm. The design process clear that the total number , location and feature of the factory and railway freight station which are need to be established. And in terms of calculation time we also compared with other algorithms. The results show that this genetic algorithm can obtain the optimal supply chain network design solution and use the shortest time.

KEYWORDS

Genetic algorithm; Reverse logistics; Priority coding; Supply chain strategy design.

INTRODUCTION

The supply chain of logistics industry contains two aspects, one is enterprises produce and reproduce products will be sent to the customer directly from the manufacturer. This is forward logistics. The other one is enterprises recall the no used products from customers, this is reverse logistics[1]. This study concentrates logistics supply chain on the basis of relevant research achievements, then stresses the importance of reverse logistics to the supply chain network design, built a model based on genetic algorithms coded priority. According to the genetic algorithm to obtain the optimal solution. Insure factories capable of manufacturing and remanufacturing and the number and location of distribution centers which have capability of both sending and recovery and the transmission network between products in different facilities[2]. Finally proving the correctness of the model and algorithm through diffset.

OPTIMIZATION MODEL

Basic assumptions

1. The number of customers, market demand for products and recalled no used products are predicted in advance.
2. The required number of factories and highest limit number of product distribution are predicted in advance.
3. The materials consumption of remaking products will not be considered.
4. Rebuilding of plants and the place of product distribution are predicted in advance. The Annual manufacturing capacity,the cost of consumption and operating process of production cost of plants and place of product distribution are predicted in advance.
5. The topology of the logistics supply chain production is known.

Define variables

Define l for product categories,The l = {1, 2}, when l = 1, refers to the original ones. When l = 2, refers to the remanufacturing of products.

Define the following cost parameters : $g_i$is factory i construction cost and operation cost,$v_{li}$is poduct l unit production costs, $o_j$is construction of distribution center, $s_j$is distribution center unit operating expenses, t_{kj} is the the unit transportation cost of customer K to distribution center j, r_{ji} is the transportation cost of distribution center j to factory I, $c_{kjl}$is product 1's unit cost of transportation from j to K. ajil is 1'sunit cost of transportation from i to j.

Define the following parameters: I is factory set of candidate address , J is warehouse address candidate set, K is collection of customer group. $w_j$is J's turnover. D_i is I's annual production capacity. n_l is construction of distribution center, m_l is 1's occupied rate.

Define the following cost parameters : x_{il} is i to 1 output, d_{kl} is K's quantity demanded, b_{kj} is recovery from K to j , h_{ji} is reforger from j to i, f_{ijl} is 1's volume, q_{kjl} is 1's volume from j to K.

Define the following 0-1 variables : l_j is j=1 , o therwise for 0 , P_i is i=1, otherwise for 0, y_{kj} is j=1, otherwise for 0.

Model building

The final destination of construction of integrated reverse logistics supply chain model is to achieve the logistics chain process costs arising reaches a minimum. And then make the profits of logistics enterprises maximized. Generally, the logistics supply chain, especially the cost of the chain contains the cost of plant construction, the cost of enterprises produced goods, the cost of recalled products, the cost of construction of logistics enterprise distribution field, operating the shipping department, the cost of reproducting carry back to the plants and the cost of products carry to customers[3].

$$\min C = \sum_i g_i p_i + \sum_l \sum_i v_{li} x_{li} + \sum_j o_j z_j + \sum_k \sum_j \sum_l s_j d_{kl} y_{kj} + \sum_j \sum_k b_{kj} t_{kj} + \sum_j \sum_i h_{ji} r_{ji} + \sum_k \sum_j \sum_l c_{kjl} q_{kjl} + \sum_i \sum_j \sum_l a_{jil} f_{ijl}$$

s.t.

$$\sum_k \sum_j n_l y_{kj} (d_{kl} + b_{kj}) \le W_j z_j \quad \forall j \tag{1}$$

$$\sum_j z_j \le |J| \tag{2}$$

$$q_{kjl} = d_{kl} y_{kj} \quad \forall j,k,l \tag{3}$$

$$\sum_i f_{ijl} = \sum_k q_{kjl} \quad \forall j,l \tag{4}$$

$$\sum_l m_l x_{li} \le D_i p_i \quad \forall i \tag{5}$$

$$\sum_j f_{ijl} \le x_{li} \quad \forall i,l \tag{6}$$

$$\sum_i p_i \le |I| \tag{7}$$

$$h_{ji} \le b_{kj} y_{kj} \quad \forall i,k \tag{8}$$

$$z_j = \{0,1\}, p_i = \{0,1\}, y_{kj} = \{0,1\}, x_{li} \ge 0, q_{kjl} \ge 0 \quad \forall i,j,k \tag{9}$$

$$l = \{1,2\} \tag{10}$$

The above constraint is : formula (1) is capacity constraint to distribution department, formula (2) is maximum limits of constraints of distribution site, formula (3) and (4) is balance punishment, formula (5) is the constraint of enterprise workshop production and manufacturing capacity, formula (6) is balance punishment of enterprise delivery amount of product with the customer actual amount received product,formula (7) is the constraint of establish enterprise workshop maximum limits,formula (8) is the constraint of the distribution center to factory remanufacturing should be no greater than the number of waste products recycling waste products to the customer, formula (9) is the constraint of all the variables,formula (10) is the constraint of product type.

ALGORITHM

The model is the conventional programming model,involves only mixed integer,is a NP problem. Therefore the priority-based encoding genetic algorithm can be used to solve.

Coding method

The algorithm is based on priority coding genetic algorithm. So the first thing to process of the supply chain logistics activities can be divided into four stages and then coding. The first stage is the product from the factory to the distribution center,The second stage is the product from the distribution center to customers,also belong to the distribution center of conventional forward delivery. The third stage is the waste products from the customer to the recycling process of distribution center,belong to the distribution center of reverse distribution. The fourth stage is waste products from the distribution center to the factory for remanufacturing recycling process. Also belong to the distribution center of reverse distribution[4]. The four phases can form a random initial chromosomes. A figure as shown in Figure 1 below.

1 2 123 1 2 123	1 2 3 123 1 2 3 1 2 3	1 2 3 1 2 3	1 2 3 12
[104| 256][93| 187]	[6128| 147][2109| 5311]	[423| 165]	[425| 31]

Figure 1 : Dyed style

Ength of chromosome

Command$|L|$is number for the product,$|K|$ for source points, $|J|$ for number of nodes,the length of chromosomes is $|L|(|K|+|J|)$.

Factory, distribution center set up largest number respectively are 2 and 3,the number of customer is 3. Because 1 and 2 a phase consists of logistics include the original ones and the remanufacturing. So $|L|=2$. Third and fourth phases only consider the recycling of waste products. So $|L|=1$. The four stages of gene length respectively are 2×(2+3)=10 ; 2×(3+3)=12 ; 1× (3+3)=6 ; 1×(2+3)=5.

The chromosome and the corresponding positions of numerical encoding and decoding

Chromosomes lined with many genes,every gene location corresponding to a certain activity. The priority of value is the location of the activity, the higher the value, on behalf of the higher is a choice. A numerical first produced by a particular function. This value represents the total number of activities throughout the supply chain,that is equal to $(|K|+|J|)$ sequence of positive integer. This sequence constitutes reference standard of supply chain activities search path[5]. Every time to generate different paths,can produce a different sequence of priority as a referenceand ensure the diversity of population. It is advantageous to get the optimal solution. Chromosomes section as shown in figure 1. The first stage of the chromosomes of each position is an integer from 1 to 10,in each position of the second stage of an integer from 1 to 12. The third stage of each position is an integer from 1 to 6. The fourth stage of each position is an integer from 1 to 5.

As shown in figure 1 chromosome code is divided into four stages which is divided into four stages to decode. In phase 1 and 2,first select a G value,let G=argmax $\{v(t),\ t\in|K|+|J|\}$, and then let l*=[G/(|K|+|J|)]. So you can choice the products. When l*=1, that is the information of the original product. When l*=2, that is obtained by remanufacturing product information. Then iterate in turn. For the third and fourth phases, due to the recycling of waste products also contains the information, so you can direct access to related product information. In each iteration process, should follow the principle of greed. make distribution of the location of the high priority to the highest priority to meet the needs of the terminal node. And so on, until meet all the requirements. This completes the network design and allocation and recovery plan.

Genetic manipulation

The population initialization

The selection of the initial group of 20 chromosomes as the research object. In order to speed up the convergence of the algorithm,first to use a greedy heuristic algorithm, implemented contains 6 chromosomes of the initial population feasible solutions,as described below.

(1)According to the forward logistics and reverse logistics distribution of the principle of minimum total customer to specific distribution center.

(2)According to the distribution center operation and distribution principle of the lowest total cost allocation of customers to a specific distribution center.

(3)According to the distribution center operation and the increasing order of distribution costs, random collocation with the customers. In the end customer requirements are fully satisfied.

(4)According to the capacity of the distribution center from high to low arrangement,random collocation with the customers, In the end customer requirements are fully satisfied.

(5)According to the unit operating costs from low to high alignment, random collocation with the customers. In the end customer requirements are fully satisfied.

(6)According to the construction of the unit cost from low to high alignment, random collocation with the customers. In the end customer requirements are fully satisfied.

The remaining 14 chromosomes randomly generated the implementation of the scheme.

Choice

With the objective function of the minimum difference between pairwise comparison. Finally selected as the target function are the smallest two chromosomes as the parent. The difference between the smallest chromosome as the first parent. The other chromosomes as the second parents,parents choose after hybridization to get the next generatio[6].

Cross

Because of the different parts of the supply chain length are different,needs to be implemented with the help of a binary mask cross hybridization. According to the figure 1. The length of the chromosome in different parts. Making corresponding length binary mask which is the length of 10, 12, 6, and 5 of the four binary mask[7]. When binary mask values of 0,selecting the first parent chromosomes corresponding genes to their children. When the binary mask value is 1,the relevant genetic selection second parent chromosomes to future generations. The purpose of the operation is to get the best of ability, the best of ability will be the best genes to their children. To improve the competitive advantage of offspring.

Variation

Because in the different stages of the supply chain, there are two types of coding structure,the change of the method is divided into two types[8]. First, set the mutation rate of 0.5,it can determine mutation. This step operation can also use a binary mask. Then according to the variation pattern of generalized commutative passed to their children.

Diffset

When planning for railway freight station in somewhere,The number of railway freight station needs to be insured. And which of these need to have the function of the recycling of waste products[9].

Suppose you want to build factories candidate address number is 2, railway freight station candidate address number is 3,the number of customers is 3. The original product and remanufacturing product and recycle waste products's space is 1. The construction cost for the factory P1 and P2 are 210 and 230. Factory P1 original and remanufacturing product unit production costs for the 2 and 4,factory P2 original and remanufacturing product unit production costs for the 3and 5. Three railway freight station are DC1, DC2 and DC3. The three fixed construction cost in the order 390, 410 and 370. Operating costs per unit time is in turn 7, 6, and 8. Factory P1 original products and the ability to create products for 85 and 70. factory P2 original products and the ability to create products for 80 and 75. Client C1, C2 and C3 of original requirement for 18, 22, and 16. For remanufacturing product requirements followed by 6, 4, and 10, the number of waste products to deal with for 6, 7 and 5 in turn. In the supply chain there are several constants see the TABLE 1 to TABLE 4 below.

TABLE l : From the factory to the railway freight station, the original unit remanufacturing product distribution costs

Factory	Railway freight station					
	DC1		DC2		DC3	
	Primary products	Further products	Primary products	Further products	Primary products	Further products
P1	7	5	5	4	6	3
P2	8	9	4	6	10	12

TABLE 2: From the railway freight station to the customer the original ones, remanufacturing product unit distribution costs

Railway freight station	Customer					
	C1		C2		C3	
	Primary products	Further products	Primary products	Further products	Primary products	Further products
DC1	10	9	5	4	8	5
DC2	8	6	9	5	3	4
DC3	5	3	3	2	6	6

TABLE 3: From the customer to the railway freight station unit transportation cost for old products

customer	railway freight station		
	DC1	DC2	DC3
C1	8	9	6
C2	1	3	4
C3	8	4	2

TABLE 4: From the railway freight station to the factory waste products of the unit transportation cost

railway freight station	Factory	
	P1	P2

DC1	5	11
DC2	3	7
DC3	6	9

Using genetic algorithm, after 10 generations is concluded that the optimization solution of the chromosome is shown in Figure 2.

$$\left|\begin{array}{l} 1\ \ 2\ \ 123\ \ 1\ 2\ \ 123 \\ [9\ 5|\ 246][103|\ 187] \end{array}\right|\left|\begin{array}{l} 1\ \ 2\ \ 3\ \ 123\ \ 1\ 2\ 3\ \ \ 1\ 2\ 3 \\ [4118|\ \ 517][2129|\ \ 6300] \end{array}\right|\left|\begin{array}{l} 1\ 2\ 3\ \ 1\ 2\ 3 \\ [532|\ \ 164] \end{array}\right|\left|\begin{array}{l} 1\ 2\ 3\ \ 12 \\ [254|\ 31] \end{array}\right|$$

Figure 2 : The chromosome of the optimal solution

According to the decoding genetic algorithm to get the optimal solution for supply chain network design :we need to build two factories in the supply chain network design. The factory two candidate address have P1 and P2,therefore, both position need to build the factory. P1 needs to increase the function of remanufacturing. Recycling of waste products is only in P1 processing again. After the remanufacturing product can be shipped again. With the aid of railway freight transportation process to transit to the transportation of the goods. there need to build two on the way. In providing DC3, DC1 and DC2 three candidate address in transit DC2 and DC3 construction is more appropriate. In order to accelerate the speed of the reverse logistics,DC2 and DC3 requires integrated recovery function. Throughout the supply chain to the normal operation will take at least total cost is 3695.

The design of the integrated reverse logistics chain are mainly based on genetic algorithm. Generally speaking,Genetic algorithm are include : Simulated annealing algorithm, Lagrange innovation algorithm and multiple inheritance of hybrid algorithm ect. In order to further implement the genetic algorithm in the logistics chain is highly effective,The combination of advanced language programming on the genetic algorithms to assess[10]. Randomly selected from more than 20 quality good example,and then see the computer as a platform for testing again. To obtain the best design center of the processor's average speed is : Hybrid genetic algorithm needs 118.22 s,Lagrange heuristic algorithm needs 99.71 s,Simulated annealing algorithm needs 79.16 s. But according to this research priority coding genetic algorithm only needs 61.83 s. Therefore, this study proposed the priority-based encoding genetic algorithm (ga) in the supply chain network design is suitable for solving the problem and can save a lot of computation time.

CONCLUSION

According to the actual capacity of facilities and the actual needs of customers,innovative this study proposes a new mathematical model. The mathematical model based on a comprehensive consideration on the basis of forward and reverse logistics,and with the minimum total cost for the fundamental goal setting. This research constructs the mathematical model of belongs to the NP problems. On the genetic algorithm selection priority coding way,and to all logistics activities in the supply chain was divided into a number of different stage in turn to solve. The use of genetic algorithm in the integration of reverse logistics in supply chain network design saves a lot of time and energy. In the stage of the supply chain for increased and product quantity increases in a short period of time,problem will become more trouble. But genetic algorithm has a strong applicability, and can also be used in complex situations

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