A logistics production-distribution scheme based on intelligent computing

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Abstract

How to improve the overall level of the supply chain of the logistics industry has become the focus of enterprises and scholars. Firstly, production-distribution model is investigated, including the object function and constraint conditions. Then the optimized production-distribution scheme based on genetic harmony algorithm is proposed. At last, the experiment results show that the proposed scheme can solve the problem of the production-distribution and can achieve the goal of minimizing cost.

Keywords: logistics production-distribution; genetic algorithm; harmony algorithm, cost.

Introduction

Competition of the logistics industry is growing in the world today, how to improve the overall level of the supply chain has become the focus of enterprises and scholars [1]. Traditional researches for stages have been relatively mature, and the effect to improve the overall level of the supply chain is not obvious, which can not fundamentally solve the problem [2]. The improvement of the overall level of the supply chain problems already are turning to research of coordinating stages of the supply chain [3, 4].

Enterprise supply chain optimization can reduce cost and improve enterprise efficiency, improve customer satisfaction and enhance the competitiveness of enterprises [5,6]. In the research of production-distribution network, there is a workshop, which can produce a variety of products, the workshop has no inventory, and the products are shipped to the distribution centers. There is more than one customer, and customer demand for products is diversified, and each customer can get products from multiple distribution centers. The purpose of this paper is to make the transportation cost, distribution cost and storage cost minimum. How many products are produced, how the products are stored into multiple distribution centers, and how the distribution centers deliver products to the customer are investigated. A genetic algorithm to optimize the total cost and service level for just-in-time distribution in a supply chain was proposed by Zanjirani, Farahan[7]. Analysis of closed loop supply chain using genetic algorithm and particle swarm optimization is proposed by Kannan, G[8]. Multiobjective optimization of production, distribution and capacity planning of global supply chains in the process industry was proposed by Liu, S [9]. Optimal supply chain redesign method using genetic algorithm was proposed by Naraharisetti, P.K [10]. Genetic algorithm optimization of an integrated aggregate production-distribution plan in supply chains was proposed by Fahimnia, B [11]. A genetic algorithm approach for multi-objective optimazation of supply chain networks was proposed by Altiparmak,F[12]. A simulation approach for production-distribution planning with consideration given to replenishment policies was proposed by Lim [13]. A steady-state genetic algorithm for multi-product supply chain network design was proposed by Altiparmak[14]. Performance characteristics of stochastic integrated production-distribution systems were given by Pyke, D.F [15]. Optimal production-distribution planning in supply chain management using a hybrid simulation-analytic approach was given by Young Hae[16]. An approach using particle swarm optimization and bottleneck heuristic to solve hybrid flow shop scheduling problem was proposed by Liao[17]. An effective hybrid DE-based algorithm for multi-objective flow shop scheduling with limited buffers was proposed by Qian B [18]. An effective hybrid discrete differential evolution algorithm for the flowshop scheduling with intermediate buffers was proposed by Pan Q. K[19]. Minimizing the total flow time in a flow shop with blocking by using hybrid harmony search algorithm was proposed by Wang L [20]. The paper is organized as follows. In the next section, model of production-distribution is proposed. In Section 3, production-distribution scheme based on genetic harmony is proposed. In Section 4, in order to test the performance of proposed algorithm, experiment is carried out. Finally, some conclusions are given in section 5.

2 Model of production-distribution

In this production-distribution network, there is a fixed workshop and there are multiple fixed distribution centers and multiple clients. Workshop production capacity can satisfy the needs of all customers, workshop has no inventory, and its products are stored in each distribution center.

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Workshop has its fixed cost and production cost, and production of different products has different unit production cost. Each distribution center has the maximum capacity, and its stored products cannot exceed the maximum capacity. Different products have the same storage cost in the same distribution center. Unit transportation cost from the workshop to each distribution center is different, and the transport capacity is infinite, meaning the production of the workshop can be shipped to distribution center. There are multiple customers, each customer demand for product is diversity, and can be supplied by multiple distribution centers. Transportation cost from each distribution center to each customer is different, and transport capacity is infinite. Production-distribution schematic diagram is shown in figure 1.

I represents product, D represents distribution center, L represents client, C_i^P represents unit production cost of product $I_i, i=1,2,\dots,n$, n represents the type of product, and Q_i^P represents the number of product I_i. $D_k^{\max}$ represents the maximum capacity of distribution center D_k, $k=1,2,\dots,m$, m represents the number of distribution center. D_{ki}^P represents the number of product I_i stored in the distribution center D_k. C_k^T represents shipping cost of workshop transporting unit product I to distribution center D_k. Q_{li}^P represents demand of product I_i to client L_l, $l=1,2,\dots,o$ and o represents the number of client. C_{kl}^T represents shipping cost of unit product from distribution center D_k to client L_l. C_k^P represents storage cost of distribution center D_k to product I. Q_{kli}^P represents distribution quantity of distribution center D_k to product I_i of client L_l. The constraint condition is as follows.

$$Q_i^P = \sum_k D_{ki}^p \tag{1}$$

$$\sum_i D_{ki}^P \le D_k^{\max} \tag{2}$$

$$Q_i^P \le \sum_l Q_{li}^P \tag{3}$$

$$\sum_l Q_{kli}^P \le D_{ki}^P \tag{4}$$

$$\sum_k Q_{kli}^P = Q_{li}^P \tag{5}$$

$$D_{ki}^P \ge 0, \forall k, i \tag{6}$$

$$Q_{kli}^P \ge 0, \forall k, l, i \tag{7}$$

In the above constraints, formula 1 means that all products of workshop are stored in each distribution center. Formula 2 means the number of products stored in the distribution center should be less than or equal to its maximum capacity. The production cost is $\sum_i C_i^P \cdot Q_i^P$, the storage cost is $\sum_k (C_k^P \cdot \sum_i D_{ki}^P)$.

The transportation cost is

$\sum_k (C_k^T \cdot \sum_i D_{ki}^P) + \sum_{kl} (C_{kl}^T \cdot \sum_i Q_{kli}^P)$.

The target function is

$$z = \min \sum_i C_i^P \cdot Q_i^P + \sum_k (C_k^P \cdot \sum_i D_{ki}^P) + \sum_k (C_k^T \cdot \sum_i D_{ki}^P) + \sum_{kl} (C_{kl}^T \cdot \sum_i Q_{kli}^P) \tag{8}$$

3 Distribution scheme based on genetic harmony algorithm

Harmony algorithm refers to three main parameters, which are harmony memory considering-HMCR, pitch adjusting rate-PAR, and bandwidth-BW. Firstly, certain number of initial harmony x is produced and is stored in the harmony memory, and then a new harmony is generated randomly from harmony memory. If the New Harmony is better than the worst harmony in the memory, the New Harmony is stored in the memory and the worst harmony is deleted from the memory. Here an improved scheme combing genetic algorithm is proposed. After selection, cross, and mutation operation of genetic algorithm, a new population is produced and the best initial solution is taken as initial solution of genetic harmony memory and then the basic harmony algorithm is carried out. The process of the algorithm is shown in figure2.

Step1. Initialize harmony memory.

(a)Initialize population. The optimized parameters are encoded with natural number.

(b)Choose two individuals x_1 and x_2 which have the higher fitness value.

(c)Carry out cross operation.

$b_1 = ux_2 + (1-u)x_1$

$b_2 = ux_1 + (1-u)x_2$

u represents crossover probability factor and x represents the harmony in the harmony population.

(d)Carry out mutation operation. b_1 and b_2 are used to replace the corresponding bit of the individual.

(e)Calculate the new individual fitness value.

$$F = \frac{1}{z}$$

(f)The newly generated population is stored in the harmony memory to be as solution vector of initial harmony memory.

Step2. The New Harmony is generated and the new solution X^{new} is generated by HMCR and PAR. $X^{new} = X^{new} + 2 \cdot w \cdot rand - w$.

w represents bandwidth and $rand$ represents a random number between 0 and 1.

Step3. Update the memory. The worst solution is replaced.

Step4. Determine whether it achieves the maximum iteration number to stop the algorithm. Otherwise, turn to step 2 to go on.

4 Numerical examples

The parameters of proposed algorithm include HMS, HMCR, PAR, bw, NI, population scale GS, cross probability PM, mutation probability PC and iteration number NG. GS=[40,90], PC=[0.02,0.52], PW=[0.35, 0.95], NG=[50,150], HMCR=[0.63,0.99], PAR=[0.01,0.73], bw=[0.01, 0.73], NI=[50,150]. For each experiment sample, 20 simulations are carried out. The testing function is

$$f(x) = \sum_{i=1}^{n} [x_i^2 - 10\cos(2\pi x_i) + 10]$$

$-5.12 \le x_i \le 5.12$.

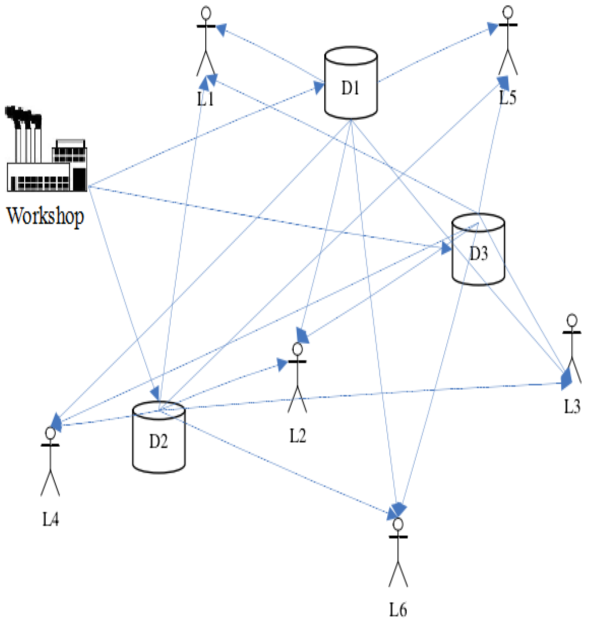

FIGURE 1 Production-Distribution schematic diagram

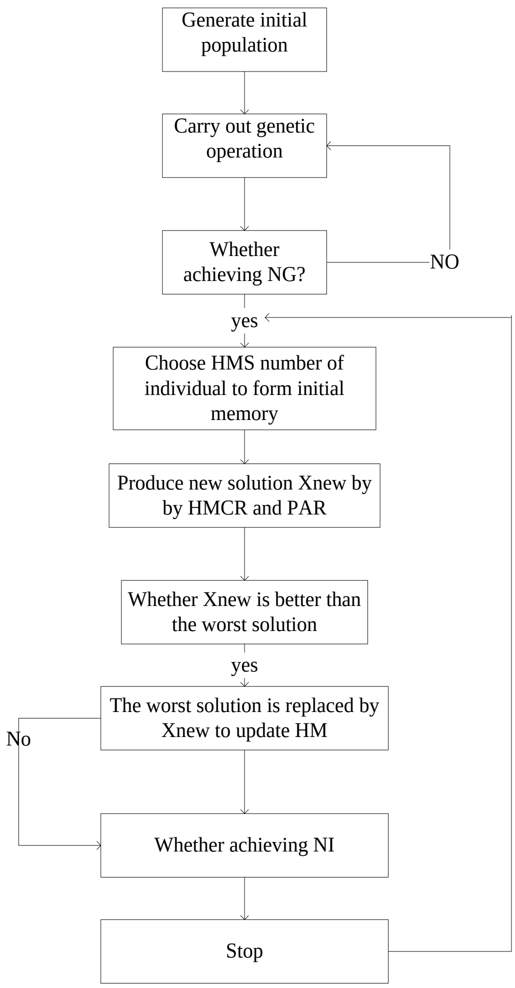

FIGURE 2 The process of the proposed algorithm

The horizontal recommended table is shown in table 1 and calculation result of the sample is shown in table 2.

TABEL 1.The horizontal recommended table

	1	2	3	4	5	6	7	8
1	1	2	3	4	5	7	9	10
2	2	4	6	8	10	3	7	9
3	3	6	9	1	4	10	5	8
4	4	8	1	5	9	6	3	7
5	5	10	4	9	3	2	1	6
6	6	1	7	2	8	9	10	5
7	7	3	10	6	2	5	8	4
8	8	5	2	10	7	1	6	3
9	9	7	5	3	1	8	4	2
10	10	9	8	7	6	4	2	1

TABLE2. Calculation result of the sample

	Optimal value	Standard deviation
1	167.896	10.7685
2	124.639	13.9835
3	59.8456	6.7863
4	184.985	9.3998
5	41.2376	3.0867
6	36.4528	3.0762
7	5.2946	1.3688
8	2.9856	1.0241
9	1.0023	0.0023
10	2.5658	1.1923

From table 2, it can be seen the result of sample 9 is the best. So the optimal parameters of sample 9 are selected, which is GS=65,pc=0.25, PM=0.02, NG=110, HMCR=0.8, PAR=0.05, bw=0.03, NI=50. To test and verify the efficiency of the above model, experiments are carried out using practical example. The production-distribution includes a workshop, three products, three distribution centers and six customers. Workshop production capacity is infinite, which can meet the demands of the six customers. Products of the workshop are shipped to the distribution centers, and then customer required products are distributed to the appropriate customer by the distribution center. Transport capacity from the workshop to distribution centers and transport capacity from each distribution center to the customer is assumed unlimited, but the unit transportation cost is not the same. Each customer can be distributed products by the three distribution centers. The production cost of product I_1 is 0.7 yuan, the production cost of product I_2 is 0.8 yuan and the production cost of product I_3 is 0.6 yuan. The maximum capacity of distribution center D_1 is 200, the maximum capacity of distribution center D_2 is 250 and the maximum capacity of distribution center D_3 is 300. The storage cost of unit product in the distribution center is 0.03, 0.02 and 0.04 respectively. Transport cost of unit production when workshop shipping unit product to each distribution center is 0.02, 0.01 and 0.05 respectively. The number of products of workshop shipping to distribution center is shown in figure 3.

The cost of distribution center shipping unit product to each customer is shown in table 1 and customer demand for various products is shown in table 2. The number of products of workshop shipping to distribution center is shown in table 3. The number of products of distribution center shipping I_1 to customer is shown in table 4, the number of products of distribution center shipping I_2 to customer is shown in table 5 and the number of products of distribution center shipping I_3 to customer is shown in table 6.

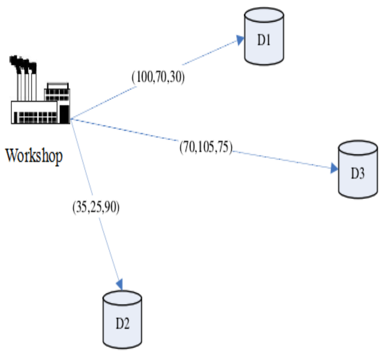

FIGURE 3The number of products of workshop shipping to distribution center

TABLE 1 The cost of distribution center shipping unit product to each customer

Customer/distribution center	D_1	D_2	D_3
L_1	0.04	0.04	0.02
L_2	0.03	0.02	0.03
L_3	0.03	0.03	0.03
L_4	0.02	0.04	0.02
L_5	0.01	0.01	0.01
L_6	0.03	0.06	0.02

TABLE2. Customer demand for various products

Production/customer	L_1	L_2	L_3
I_1	35	30	40
I_2	20	15	30
I_3	50	20	35
sum	105	65	105

TABLE 2 Customer demand for various products

Production/customer	L_4	L_5	L_6	sum
I_1	20	35	45	205
I_2	45	60	30	200
I_3	30	20	40	195
sum	95	115	115	

TABLE 3 The number of products of workshop shipping to distribution center

Product/distribution center	D_1	D_2	D_3	sum
I_1	100	70	35	205
I_2	70	105	25	200
I_3	30	75	90	195
sum	200	250	150	

TABLE 4 The number of products of distribution center shipping I_1 to customer

Customer/distribution center	D_1	D_2	D_3	sum
L_1	0	0	30	30
L_2	0	30	0	30
L_3	30	5	5	40
L_4	20	0	0	20
L_5	0	35	0	35
L_6	50	0	0	50
sum	100	70	35	

TABLE 5 The number of products of distribution center shipping I_2 to customer

Customer/distribution center	D_1	D_2	D_3	sum
L_1	0	0	30	30
L_2	0	30	0	30
L_3	30	5	5	40
L_4	20	0	0	20
L_5	0	35	0	35
L_6	50	0	0	50
sum	100	70	35	

TABLE 6 The number of products of distribution center shipping I_3 to customer

Customer/distribution center	D_1	D_2	D_3	sum
L_1	0	0	50	50
L_2	5	20	0	25
L_3	0	40	0	40
L_4	20	0	0	20
L_5	0	20	0	20
L_6	0	0	40	40
sum	25	80	90	

5 Conclusions

This paper studies production-distribution in the logistics industry. The workshop production capacity is infinite and transport capacity is unlimited. A theoretical model to solve the problem is proposed. The experiment results show that the proposed scheme can solve the problem of the production-distribution, based on the optimal solution of production, transportation and distribution. It also can achieve the goal of minimizing cost.

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