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A random multi-objective model on integrated logistics*

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Abstract. Four classical reverse logistics network structures are presented. In the reuse reverse logistics network, the quantity of recycled products, the requirement of the "new" products, and the time request are uncertain, according to theory of uncertain program, and base on the analysis of the construction of reuse reverse logistics network, we try to integrate the forward logistics network and reverse logistics network to set up a closed loop logistics network. An EVMOP (Expected Value Multi-objective Programming) model is established, the model describes the reuse reverse logistics as production, distribution, consumption, collection, transportation, recycle, disposal, reuse. The solution scheme was pursued by the hybrid genetic algorithm. An application to Chinese beer industry is given as an illustration.

Keywords: EVMOP, hybrid genetic algorithm, integrated logistics

1 Introduction

Reverse logistics was first brought up in 1981, Lambert and Stock considered that the reverse logistics is the reverse flow different from the normal product shipment channel[15]. In the early time of the 1990s, the two papers about reverse logistics from American GLM (Council of Logistics Management) are the start of the research on reverse logistics, the first is the research by Stock, he put forward the relativity between reverse logistics and business and society[16]. One year later, Kopicki researched the practical operations and rules, brought out the point of reusing and recycling[9]. In 1999, Roger and Tibber-Lembke collected the examples on reverse logistics, this two scholar did large-scale and long-term survey, and published the work "Going Backwards: reverse logistics trends and practices"[12]. After 2000, many papers on optimal management of reverse logistics were come forth[2, 4, 5, 10, 11, 13, 14, 17].

We summarize the main former research works as follow: Mirchandani and Francis (1989) used traditional location model to design reverse logistics distribution network[14]. Thierry (1995) researched the construction of reverse logistics decided by the different instance of recycling and reusing[4]. Fleischmann and Jacqueline (1997) integrated the forward and reverse logistics[10]. Marin and Pelegrin (1998) analyzed the MILP model and proposed the Lagrangian decomposition[5]. Fleischmann and Krikkle (2000) designed a network with considering the high complexity, multi objective[11]. Harold Krikkle (2001) designed the rules of the construction of close-loop reverse logistics system[17]. Min Hokey (2004) built up a single objective, non-linear MILP model of two level network[2].

Besides, some scholars built reverse logistics models special for some certain goods, such as solid waste[3], carpet[1], hazardous materials[17] and so on. In short, the relevant literature and fruit are all achieved by the European and the USs scholars. The study of reverse logistics is still developing and the study of network about reverse logistics is more lagged.

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Section 2 of this paper presents four classic reverse logistics networks; In section 3, we specially researches one of the networks-recycling reverse logistic network, and we build a EVMOP for integrating the forward logistics network and reverse logistics; Section 4 shows the hybrid genetic algorithm which could solve this model. In the last section, we apply the model to Chinese beer industry.

2 Summary of reverse logistics networks

Reverse logistics is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. Therefore reverse logistics includes not only processing used products and processing returned merchandise due to damage, seasonal inventory, restock, recalls, and excess inventory but also reusable containers and returned packages.

2.1 The functions of reverse logistics system

Specific activities covered by different reverse logistics system may not be the same, but they generally include the following five functions, as shown in Fig. 1:

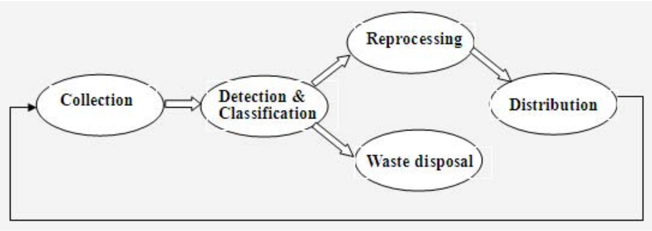


Fig. 1: Functions of reverse logistics network

Collection: Through paid or unpaid ways, collect scrap items that scattered around and transport to the reprocessing place.

Detection and classification: Test the quality of recycling products to determine the appropriate treatment options, and classified accordingly.

Reprocessing: Deal with the recycling products or their components to re-acquire value. The steps may include cleaning, replacement components and reassembled. Wherein, the ways to deal with mainly include re-using, re-manufacturing and recycling.

Waste disposal: Destruct those waste products and components which can no longer use for economic or technical reasons.

Redistribution: Sell the recycled products that after reprocessed to the market. The steps may include the sale, transport and storage. This process is similar to forward distribution.

Some of the above functions can be provided by independent facilities, such as remanufacturing; and other functions like collection, classification and redistribution can be provided either by independent facilities or by the general treatment facilities, such as recycling centers.

2.2 Different types of reverse logistics networks

There are different reverse logistics networks structures according to different kinds of reverse goods, such as reuse, remanufacturing, recycling and commercial return.

(1) Reuse reverse logistics network

Many re-usable packaging and containers are widely used in the food and chemical industries, such as glass bottles, plastic bottles, cans, boxes and pallets. The programming of the reverse logistics network of reusing packaging could include the designs of custody, the positioning of collection facilities, the number and scale of the cost of distribution and transportation. The following Fig. 2 describes this reverse logistics network.

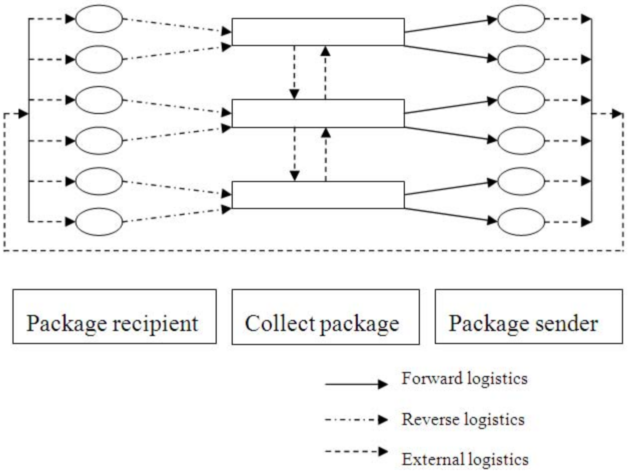


Fig. 2: The structure of reuse reverse logistics network

(2) Remanufacturing reverse logistics network

Typical remanufacturing goods include the precious parts of cars, planes, tools, copiers and computer parts. First, people collect the goods which has been used, through the detection and separation, remanufacture them for the new products, and finally sale them. The construction of the network is shown in Fig. 3. The programming of remanufacturing reverse logistics network involves the position and the size of remanufacturing facilities, and the calculation of the minimize cost of recycling goods flow. In the process of calculation and decision-making, the costs of investment, transport, handling and inventory must be considered.

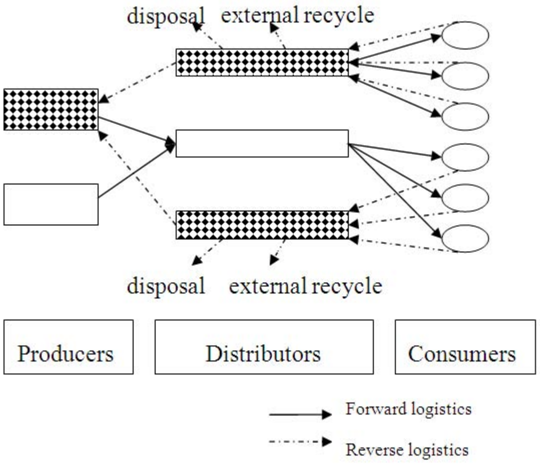


Fig. 3: The structure of remanufacturing reverse logistics network

(3) Recycling reverse logistics network

Typical recycling goods include paper, glass, metal, carpet, plastic and so on. The construction of this reverse logistics network is shown in Fig. 4. In this system, the prices of goods which are collected are generally low, and the specialized equipments that could handle these goods are very expensive. Thus recycling places are always relatively focused, and handling capacity is great. In the programming of this network, position of recycling places, design of capacity and economic analysis are very important.

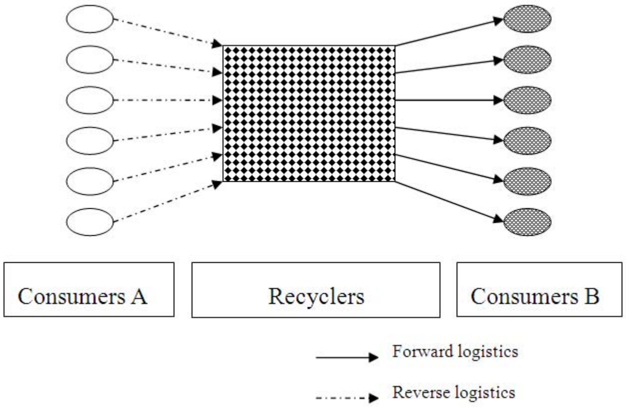


Fig. 4: The structure of recycling reverse logistics network

(4) Commercial return reverse logistics network

Commercial returns occur from the retail sector to the manufacturing sector. For example, excess inventory, the returns according to the contract, the goods that sent wrong, damaged goods. If the returns are of good quality, they will be sent to the normal business inventory, sale them once again; for the goods of poor quality, they will be callback. Fig. 5 is the structure of this reverse logistics network. The programming of this reverse logistics network include including the process design and the contract management.

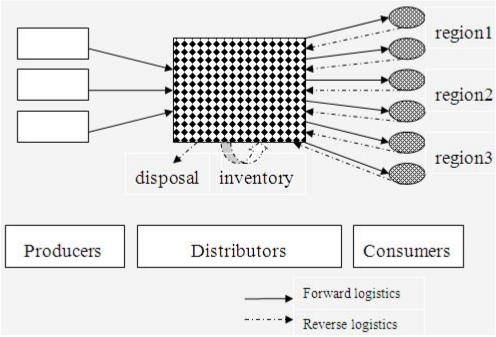


Fig. 5: The structure of commercial return reverse logistics network

3 Modeling for uncertain reuse reverse logistics network

In the following text of this paper, we built up a model only for the reuse reverse logistics network.

3.1 Conceptual model

The target of reuse reverse logistics network is the items which could be re-used after simple treatment, the items mainly include package containers and auxiliary materials such as trays.

There are three main establishments in reuse reverse logistics network:

- Collectors: have the responsibility of recycling packages that scattered around.

- Recyclers or expanded distributors: receive the items from collectors, and their work concentrate on detecting, cleaning, processing to recovery the items as the state which undifferentiated form the state of new items, and then these items will be delivered to enterprises again.
- Disposal places: process the waste items that could no longer be used.

There are producers, distributors and main wholesalers in forward logistics. So reuse reverse logistics network is constructed by collectors/wholesalers, recycling centers/ distribution centers, final disposal places and manufacturing plants and the transport routes among them, this network calls reuse reverse logistics network. The following Fig. 6 can describe this network.

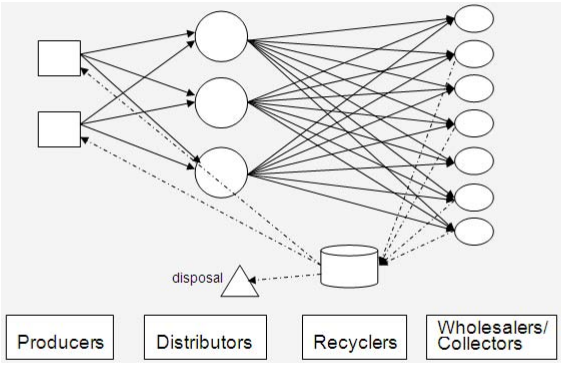


Fig. 6: The conceptual model of reuse reverse logistics network

3.2 Assumptions

We will build a model on the following assumption that:

(1) We only consider a kind of product in a period, and every periods are the same;
(2) The quantity of recycling products from collectors and the demand from the wholesalers are independent random variables, and the distribution function could be obtained;
(3) We will locate recyclers from some places that already known;
(4) The distributors also can take the work of recycling;
(5) The wholesalers sell products and meanwhile collect the used packages;
(6) The abilities of producers and distributors are big enough.

3.3 Notation

Model symbols are defined as follows:

Indices:
i: the location of producers ($i = 1, 2, \cdots, I$).
j: the location of distributors ($j = 1, 2, \cdots, J$).
k: the location of collectors/wholesalers ($k = 1, 2, \cdots, K$).
t: the alternative of recyclers ($t = 1, 2, \cdots, T$).

Variables:

x_{ij}^{PD}: the quantity of products from producer i to distributor j;
x_{jk}^{DC}: the quantity of products from distributor j to wholesaler k;
x_{kt}^{CR}: the quantity of packages from collector k to recycler t;
x_{kj}^{CD}: the quantity of packages from collector k to distributor j;
x_{ti}^{RP}: the quantity of packages from recycler t to producer i;
x_{ji}^{DP}: the quantity of packages from distributor j to producer i;
x_i: the quantity of new packages bought by producer i;
y_i^R: 0-1 variable, whether the alternative recycler t will be chosen or not, 0 denotes we do not choose, 1 denotes we choose it;
y_j^D: 0-1 variable, whether the distributor j will be expended or not, 0 denotes we don't expend, 1 denotes we expend it;
y_{jk}^{DC}: 0-1 variable, whether the distributor j will send products to wholesaler k, 0 denotes don't send, 1 denotes send;

Random parameters:

D_k: the demand of wholesaler k, it is random parameter;
R_k: the quantity of the recycling packages collected by collector k, it is random parameter;
T_t^R: the time of recycler t processing unit package;
T_j^D: the time of expended distributor j processing unit package;
T_k^{Lim}: the time limit of wholesaler k;

Certain parameters:

C_{ab}: the unit transport cost from a to b(a and b could denote producer, distributor, recycling center or wholesaler);
T_{ab}: the unit transport time from a to b;
F_t^R: the fixed cost of building a recycler t;
F_j^D: the fixed cost of expending a distributor j;
V_t^R: the variable cost of recycler t processing unit package;
V_j^D: the variable cost of expended distributor j processing unit package;
Q_t^R: the capacity of recycler t processing packages;
Q_j^D: the capacity of expended distributor j processing packages;
α_t^R: the discard proportion after recycler t processing packages;
α_j^D: the discard proportion after expended distributor j processing packages;
N^R: the ceiling number of recyclers;
N^D: the ceiling number of expended distributors;
U_k^l: the unit default cost when the demand of wholesaler k are not meted;
U_k^e: the processing cost when the supply to wholesaler k are excessive;
U_k^T: the default cost when the time limit of wholesaler k are not satisfied;
U^P: the disposal cost of unit un-useable package;
P_i: the variable cost of producer i buying unit package;

3.4 Mathematic model

We build the following mathematical model according the conceptual model.

In company, the first objective will be considered is surely the economic thing, that is, the first objective is to minimize the total costs. After analysis, we think that there are 6 parts should be included in the this objective, as following:

$$\left[\sum_{i\in I}\sum_{j\in J} x_{ij}^{PD}C_{ij} + \sum_{j\in J}\sum_{k\in K} x_{jk}^{DC}C_{jk} + \sum_{k\in K}\sum_{t\in T} x_{kt}^{CR}C_{kt} + \sum_{t\in T}\sum_{i\in I} x_{ti}^{RP}C_{ti} + \sum_{k\in K}\sum_{j\in J} x_{kj}^{CD}C_{kj} + \sum_{j\in J}\sum_{i\in I} x_{ji}^{DP}C_{ji}\right]_1 .$$

The first part of objective is the total transportation cost;

$$\left[\sum_{t\in T} y_t^R F_t^R + \sum_{j\in J} y_j^D F_j^D\right]_2 .$$

The second part is the total fixed cost of building recycling centers and expending the distribution centers;

$$\left[\sum_{k\in K}\sum_{t\in T} x_{kt}^{CR} V_t^R + \sum_{k\in K}\sum_{j\in J} x_{kj}^{CD} V_j^D\right]_3 .$$

The third part is the total variable cost of processing packages;

$$\left[\sum_{i\in I} x_i P_i\right]_4 .$$

The fourth part is the cost of buying new packages;

$$\left[\sum_{k\in K} U_k^l \max(D_k - \sum_{j\in J} x_{jk}^{DC}, 0) + \sum_{k\in K} U_k^e \max(D_k - \sum_{j\in J} x_{jk}^{DC}, 0)\right]_5 .$$

The fifth part is the cost when there exists imbalance between supply and demand, when the supply is less than the demand, there will occur default costs, or when the supply is more than demand, the redundant products will be processed and it will cost.

$$\left[\sum_{k\in K}\sum_{t\in T} x_{kt}^{CR} \alpha_t^R U^P + \sum_{k\in K}\sum_{j\in J} x_{kj}^{CD} \alpha_j^D U^P\right]_6 .$$

The sixth part is the cost of disposing the un-useable packages.

Also we know that to minimize the total costs is not the only objective of a company. In the commercial environment of this period, customer is the center, good relationship with customer is very important to the company, too. So when we design a logistics network, we need to consider the efficiency of distribution and recycle, that is, we should shorten the time of distribution and recycle, that is, the second objective is to minimize the total time.

According to the above notion, we should add the following seventh part to the first objective:

$$\left[U_k^T \max(0, T_{jk} y_{jk}^{DC} - T_k^{Lim})\right]_7 .$$

The seventh part means that when the time limit of wholesaler are not satisfied, it will occur this costs.

Also, from the above notion, we could obtain the second objective of minimizing the total time:

$$\begin{aligned}\text{TotalTime} = {} & \sum_{k\in K}\sum_{t\in T} T_{kt} y_t^R + \sum_{t\in T}(T_t^R \sum_{k\in K} x_{kt}^{CR}) + \sum_{i\in I}\sum_{t\in T} T_{it} y_t^R + \sum_{k\in K}\sum_{j\in J} T_{kj} y_j^D \\ & + \sum_{j\in J}(T_j^D \sum_{k\in K} x_{kj}^{CD}) + \sum_{i\in I}\sum_{j\in J} T_{ij} y_t^R .\end{aligned}$$

Now we can obtain the objectives function as shown in (1) and 2:

$$\begin{aligned}\min C = & \left[\sum_{i\in I}\sum_{j\in J} x_{ij}^{PD} C_{ij} + \sum_{j\in J}\sum_{k\in K} x_{jk}^{DC} C_{jk} + \sum_{k\in K}\sum_{t\in T} x_{kt}^{CR} C_{kt} + \sum_{t\in T}\sum_{i\in I} x_{ti}^{RP} C_{ti}\right. \\ & \left. + \sum_{k\in K}\sum_{j\in J} x_{kj}^{CD} C_{kj} + \sum_{j\in J}\sum_{i\in I} x_{ji}^{DP} C_{ji}\right]_1 \\ & + \left[\sum_{t\in T} y_t^R F_t^R + \sum_{j\in J} y_j^D F_j^D\right]_2 + \left[\sum_{k\in K}\sum_{t\in T} x_{kt}^{CR} V_t^R + \sum_{k\in K}\sum_{j\in J} x_{kj}^{CD} V_j^D\right]_3 \\ & + \left[\sum_{i\in I} x_i P_i\right]_4 + \left[\sum_{k\in K} U_k^l \max(D_k - \sum_{j\in J} x_{jk}^{DC}, 0) + \sum_{k\in K} U_k^e \max(D_k - \sum_{j\in J} x_{jk}^{DC}, 0)\right]_5 \\ & + \left[\sum_{k\in K}\sum_{t\in T} x_{kt}^{CR} \alpha_t^R U^P + \sum_{k\in K}\sum_{j\in J} x_{kj}^{CD} \alpha_j^D U^P\right]_6 + \left[U_k^T \max(0, T_{jk} y_{jk}^{DC} - T_k^{Lim})\right]_7,\end{aligned} \tag{1}$$

$$\begin{aligned}\min T = & \sum_{k\in K}\sum_{t\in T} T_{kt} y_t^R + \sum_{t\in T}(T_t^R \sum_{k\in K} x_{kt}^{CR}) + \sum_{i\in I}\sum_{t\in T} T_{it} y_t^R + \sum_{k\in K}\sum_{j\in J} T_{kj} y_j^D \\ & + \sum_{j\in J}(T_j^D \sum_{k\in K} x_{kj}^{CD}) + \sum_{i\in I}\sum_{j\in J} T_{ij} y_t^R.\end{aligned} \tag{2}$$

This objective subjects to the following constraints:
Balance constraints:

$$\sum_{t\in T} x_{kt}^{CR} + \sum_{j\in J} x_{kj}^{CD} = R_k,\ k\in K, \tag{3}$$

$$(1-\alpha_t^R)\sum_{k\in K} x_{kt}^{CR} = \sum_{i\in I} x_{ti}^{RP},\ t\in T, \tag{4}$$

$$(1-\alpha_j^D)\sum_{k\in K} x_{kj}^{CD} = \sum_{i\in I} x_{ji}^{DP},\ t\in T, \tag{5}$$

$$\sum_{t\in T} x_{ti}^{RP} + \sum_{j\in J} x_{ji}^{DP} + x_i = \sum_{j\in J} x_{ij}^{PD},\ i\in I, \tag{6}$$

$$\sum_{i\in I} x_{ij}^{PD} = \sum_{j\in J} x_{jk}^{DC},\ j\in J, \tag{7}$$

$$x_{jk}^{DC} = y_{jk}^{DC} x_{jk}^{DC},\ j\in J. \tag{8}$$

Capacity constraints:

$$\sum_{k\in K} x_{kt}^{CR} \le y_t^R Q_t^R,\ t\in T, \tag{9}$$

$$\sum_{k\in K} x_{kj}^{CD} \le y_j^D Q_j^D,\ j\in J. \tag{10}$$

Number constraints:

$$\sum_{t\in T} y_t^R \le N^R, \tag{11}$$

$$\sum_{j\in J} y_j^D \le N^D. \tag{12}$$

Logical constraints:

$$x_{ij}^{PD}, x_{jk}^{DC}, x_{kt}^{CR}, x_{kj}^{CD}, x_{ti}^{RP}, x_{ji}^{DP}, x_i \geq 0,\ i \in I, j \in J, k \in K, t \in T, \tag{13}$$

$$y_t^R, y_j^D - \{0,1\},\ t \in T, j \in J. \tag{14}$$

3.5 Model transformation

Because there are random parameters in the above model, in order to solve it, we should use expected value operator to transform the above model to a certain EVMOP.

We change the fifth part and the seventh part by adding four constraints (18)-(21).

$$\min E(C) \tag{15}$$

$$\min E(T) \tag{16}$$

Subject to:

$$\sum_{t\in T} x_{kt}^{CR} + \sum_{j\in J} x_{kj}^{CD} = E(R_k),\ k \in K, \tag{17}$$

$$e_k^- = E(D_k - \sum_{j\in J} x_{kj}^{CD}),\ k \in K, \tag{18}$$

$$e_k^+ = E(\sum_{j\in J} x_{kj}^{CD} - D_k),\ k \in K, \tag{19}$$

$$t_k^- = E(T_{jk} y_{jk}^{DC} - T_k^{Lim}),\ k \in K, \tag{20}$$

$$e_k^-, e_k^+, t_k^- \geq 0. \tag{21}$$

Besides, the other constrains are as the same as the above model.

4 Algorithm

The model we proposed is actually a two-objective linear model, and both of them are needed to optimization. These two objective are un-comparable, and there exists inconsistency between them. When we built recycling centers near the collectors, we can make the transportation time lesser, but the number of recycling centers more; contrariwise, we reduce the numbers of recycling centers, it will reduce the fixed cost of building the recycling centers, but the transportation time will arise. So the Pareto solutions will be used.

4.1 Adaptive-weight evaluation procedure genetic algorithm

In this paper, we adopted the adaptive-weight genetic algorithm proposed by Gen and Cheng (2000)[6] to deal with the multi-objective model. The algorithm utilizes some useful information from current population to readjust weights in order to obtain a search pressure towards to positive ideal point. For the examined solutions at each generation, we define two extreme points: the maximum extreme point z^+ and the minimum extreme point z^- in the criteria space as the follows:

$$z^+ = \{z_1^{\max}, z_2^{\max}, \cdots, z_q^{\max}\},$$
$$z^- = \{z_1^{\min}, z_2^{\min}, \cdots, z_q^{\min}\},$$

where $z_k^{\max}$ and $z_k^{\min}$ are the maximal value and minimal value for objective in the current population. Let P denote the set of current population.

For a given individual x, the maximal value and minimal value for each objective are defined as the follows:

$$z_k^{\max} = \max\{f_k(x|x \in P), k = 1, 2, \cdots, q\},$$
$$z_k^{\min} = \max\{f_k(x|x \in P), k = 1, 2, \cdots, q\}.$$

The hyper parallelogram defined by the two extreme points is a minimal hyper parallelogram containing all current solutions. The two extreme points renewed at each generation. The maximum extreme point will gradually approximate to the positive ideal point. The adaptive weight for objective is calculated by the following equation:

$$w_k = \frac{1}{z_k^{\max} - z_k^{\min}}$$

For a given individual x, the weighted-sum objective function is given by the following equation:

$$z(x) = \sum_{k=1}^{q} w_k(f_k(x) - z_k^{\min}) = \sum_{k=1}^{q} \frac{f - z_k^{\min}}{z_k^{\max} - z_k^{\min}}$$

As the extreme points are renewed at each generation, the weights are renewed accordingly.

4.2 Hybrid genetic algorithm

Genetic Algorithm was created by Professor John and Holland in American Michigan University and the basic idea of the algorithm came from the theory of evolution in biology of Darwin, the species selection theory of Weizmann and the gene theory of Mendol [7, 8]. In genetic algorithm the solutions of objective problem are encoded to "chromosome", we put the chromosome population under the "circumstances" of the problem. According to the "survival of the fittest" principle, through genetic operator, such as selection, crossover and mutation, a new chromosome population is generated, Select chromosome population suitable to environment, reproductive and evolution, finally a high degree fitness of chromosomes are obtained, that is the approximate optimal solution of the problem.

Because there are random parameters in the above model, so we obtain the value of objective through stochastic simulation, so we embed the stochastic simulation into the genetic algorithm, which forms the hybrid algorithm.

The hybrid genetic algorithm include the following steps:

Step 1. Initialize pop-size chromosomes, $v_k = (y^R, y^D), k = 1, 2, \cdots, pop\_size$, because the variables are 0-1 variables, so we use binary encoding;

Step 2. For every chromosomes v_k, we calculate the values of objective $Z(v_k), T(v_k)$ by stochastic simulation;

Step 3. Use the Adaptive-weight evaluation procedure[17] to obtain the evaluation value of every chromosome v_k;

Step 4. Select chromosomes for a new population by roulette wheel selection;

Step 5. Update these new chromosomes v_k by crossover operator. Here we use two-point crossover and the crossover rate is P_c;

Step 6. Update these new chromosomes by mutation operator. Here we use single point mutation and the mutation rate is P_m;

Step 7. Repeat step 2 to 6 until the completion of the cycle of a given number;

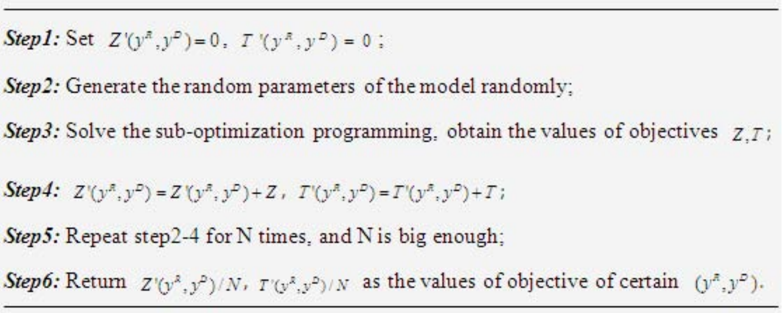
Step 8. Return the best v_k^*, (Z^*, T^*) as the best location and best value of objectives for this reverse logistics network.

Wherein the above algorithm the simulation procedure is as shown in Fig. 7:

5 Case study

Suppose LanMa beer co. has 2 production plants in XianYang, 3 distribution centers, and they are with responsibility for three sections of Shanxi (GuanZhong, ShanBei and ShanNan) respectively, there are 5 main wholesalers, and they are located in WeiNan, ShangLuo, HanZhong, AnKang and YanAn.

Now This company want to built up reverse logistics through establishing recycling centers or expending the existing distribution centers, and integrate the forward logistics and reverse logistics to a loop logistics network which have the abilities of production, distribution, recycle and reuse. So we can use this model to help the company to program.



Step1: Set $Z'(y^R,y^D)=0$, $T'(y^R,y^D)=0$;

Step2: Generate the random parameters of the model randomly;

Step3: Solve the sub-optimization programming, obtain the values of objectives Z,T;

Step4: $Z'(y^R,y^D)=Z'(y^R,y^D)+Z$, $T'(y^R,y^D)=T'(y^R,y^D)+T$;

Step5: Repeat step2-4 for N times, and N is big enough;

Step6: Return $Z'(y^R,y^D)/N$, $T'(y^R,y^D)/N$ as the values of objective of certain (y^R,y^D).

Fig. 7: Simulation procedure

At present, according to survey results, there are four options which can be used to establish recycling center, and all of the three existing distribution centers could be expended. The alternative option places are ZhouZhi, PuCheng, ZhaShui and HuaXian. The largest processing capacities of these 4 places are 20000, 23000, 15000, and 27000, the fixed construction costs are 12.5, 16.5, 10 and 19.5(*10000RMB). We suppose the discard proportions are all 0.2, they want to build 3 recycling centers at most. We also could expend the 3 distribution centers to process the recycled packages, the expending costs are 6.6, 5.4 and 7(*10000RMB), their capacities are 11000, 9000, and 12000, the discard proportions are all 0.2, They request that we can expend 2 at most. The price of new bottle is 0.7(RMB). The other data are as follows.

Table 1: Recycling/demand distribution and default/excessive processing cost

Wholesalers	WeiNan	ShangLuo	HanZhong	AnKang	YanAn
R_k	$U(8000,10000)$	$U(6000,7000)$	$U(12000,14000)$	$U(10000,11000)$	$U(16000,18000)$
D_k	$N(11000,100^2)$	$N(7500,50^2)$	$N(15000,100^2)$	$N(12000,100^2)$	$N(19000,100^2)$
U_l	1.2	1	1.1	1	1.5
U_e	1.8	1.9	1.6	1.3	1.5
U_T	3000	3500	4000	3000	4500

Table 2: Transport cost, time(h) from collectors to recyclers

	WeiNan	ShangLuo	HanZhong	AnKang	YanAn
ZhouZhi	0.1,2.2	0.12,3.8	0.1,4.2	0.05,2.7	0.12,2.9
PuCheng	0.13,2.9	0.15,3	0.06,4	0.11,4.5	0.08,3.3
ZhaShui	0.11,3.5	0.15,4.5	0.08,2.5	0.13,5	0.2,2.9
HuaXian	0.12,2.8	0.1,3.2	0.19,4.5	0.1,4	0.11,3

Table 3: Transport cost, time(h) from collectors to distributors

	WeiNan	ShangLuo	HanZhong	AnKang	YanAn
GuanZhong	0.08,3.5	0.15,4	0.06,2.5	0.12,2	0.1,4.5
ShanBei	0.1,2.5	0.08,2	0.1,4.5	0.12,3.5	0.08,5
ShanNan	0.11,4	0.1,2.5	0.08,3	0.13,3.5	0.11,3

Table 4: Transport cost, time(h) from distributors to wholesalers

	WeiNan	ShangLuo	HanZhong	AnKang	YanAn
GuanZhong	0.23,3.5	0.31,4	0.15,2.5	0.17,2	0.3,4.5
ShanBei	0.17,2.5	0.2,2	0.15,4.5	0.18,3.5	0.27,5
ShanNan	0.13,4	0.25,2.5	0.22,3	0.18,3.5	0.26,3

Table 5: Transport cost from distributors to producers

	GuanZhong	ShanBei	ShanNan
Plant1	0.1	0.08	0.15
Plant2	0.15	0.2	0.08

Table 6: Transport cost and time(h) from producers to distributors

	GuanZhong	ShanBei	ShanNan
Plant1	0.3,2.5	0.25,1	0.35,2
Plant2	0.35,2	0.4,2.5	0.2,1.5

Table 7: Transport cost and time(h) from recyclers to producers

	ZhouZhi	PuCheng	ZhaShui	HuaXian
Plant1	0.17,1.5	0.13,2	0.12,2.5	0.15,1.5
Plant2	0.1,2.5	0.16,1	0.11,2	0.08,2.5

Table 8: Processing cost, time(s) and disposal cost of recyclers

	ZhouZhi	PuCheng	ZhaShui	HuaXian
V^R	0.25,3	0.2,2.5	0.23,3.5	0.18,2
U^P	0.2	0.15	0.18	0.13

Table 9: Processing cost, time(s) and disposal cost of distributors

	GuanZhong	ShanBei	ShanNan
V^D	0.28,5	0.22,6	0.25,4
U^P	0.2	0.15	0.18

We use the above hybrid genetic algorithm to solve this problem, the corresponding parameters are 100 genetic generation iteration, population of every generation is 10, crossover rate 0.3, the mutation rate 0.2, the parameter in evaluation function is 0.05.

The optimal value of the objective function is $Z^* = 456253$(RMB), $T^* = 2200.3$(hour) and the value of 0-1 decision variables are in Table 10.

Table 10: Location decision

ZhouZhi	PuCheng	ZhaShui	HuaXian	GuanZhong	ShanBei	ShanNan
0	1	1	0	1	1	0

After solving the model, we offer the best choice for LanMa beer co., that is: establish the recycling center in PuCheng and ZhaShui, and expend the GuanZhong and ShanBei distribution center. And this can be shown as the following Fig. 8:

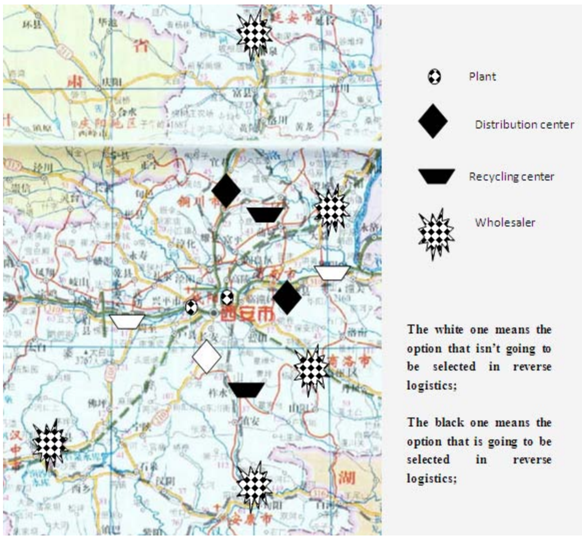


Fig. 8: Final decision

6 Conclusion

In this paper, we set up a closed loop logistics network by integrating the traditional forward logistics network and reverse logistics network, especially we research the reuse reverse logistics network on the uncertain environment, the demand of consumers, the packages recycled from collectors and the time request are regarded as random parameters. We build a multi-objective random reuse reverse logistics network model from the perspective of manufacturing enterprises, then we use hybrid intelligent algorithm to solve the model, at last, in order to show effectiveness of this model we apply the model to help a Chinese beer co. to set up its logistics network and we obtain satisfied results.

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