

# The Method of Configuring Railway Logistics Agent Business Service Scheme Based on NSGA-II

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**Abstract:** Modular design is an important means of railway logistics service scheme design. First, the railway logistics process is divided into 19 modules, and each module contains a number of module instances. Secondly, the objective function is the minimum service time, the lowest service cost and the highest quality of service. The constraint conditions are module selection constraints, goods type constraints, maximum cost and maximum time. Then we establish optimization model of railway logistics service scheme configuration. Finally, the NSGA-II method is used to solve the model, and the optimal set of Pareto solutions is obtained. The Hybrid Fuzzy TOPSIS method is used to evaluate the scheme, and the optimal scheme is selected. The results show that the method is effective and reasonable. The method provides a basis for solving the problem of railway logistics agent business service scheme allocation.

## 1.Introduction

In order to adapt to the demand of the market, and improve the railway logistics service ability, China Railway carried out the agent business of the railway logistics faced on the logistics service demand of the production and processing enterprises<sup>1</sup>. The design of railway logistics service scheme in China is mainly based on artificial experience, which is low efficiency and lack of scientific basis. In order to meet the differential demand of railway logistics and reduce the cost of service plan design, we need to use some general modules to realize the modular design of railway logistics service. Therefore, it is of great practical significance to study the scientific and reasonable allocation method of railway logistics service scheme.

Liu Qigang<sup>2</sup> divides the logistics into 11 processes. It puts forward the mechanism of railway logistics service configuration of "logistics link-service measures-parameter attributes", and adopts the multi attribute decision particle calculation method to select the scheme. Finally, the shortest interval between the whole process operation is optimized and the multi ring service is constructed; Wang Danzhu<sup>3</sup> divides the railway logistics process into a modular division, and using the CSP method to get the optimal solution for the scheme configuration. Fei Chang<sup>4</sup> considers the logical relationship of logistics service in logistics business and the joint relationship between service providers, and constructs the logistics Web service combination model by using the QoS attribute demand of the customer in the railway logistics service as the penalty function of the target function of the combined service. Some scholars have made a thorough study of the modular design of the entity product, which has a good reference for the modular design of the service scheme<sup>5-7</sup>.

This paper uses the NSGA-II method to optimize the existing modules, and obtains the Pareto optimal solution set of the railway logistics service scheme configuration model. The optimal scheme



is evaluated by using the Hybrid Fuzzy TOPSIS evaluation method to evaluate the optimal scheme set. Finally, the logistics service of Xiamen to Chengdu is taken as an example to verify the effectiveness and feasibility of the method.

## 2. Configuration model of railway logistics service scheme

### 2.1 Problem description

As shown in Figure 1, the railway logistics service process can be divided into 19 modules. Each module consists of multiple module instances, which constitute the module instance library, and the diversity and complexity of the scheme are formed by the combination of different modules.

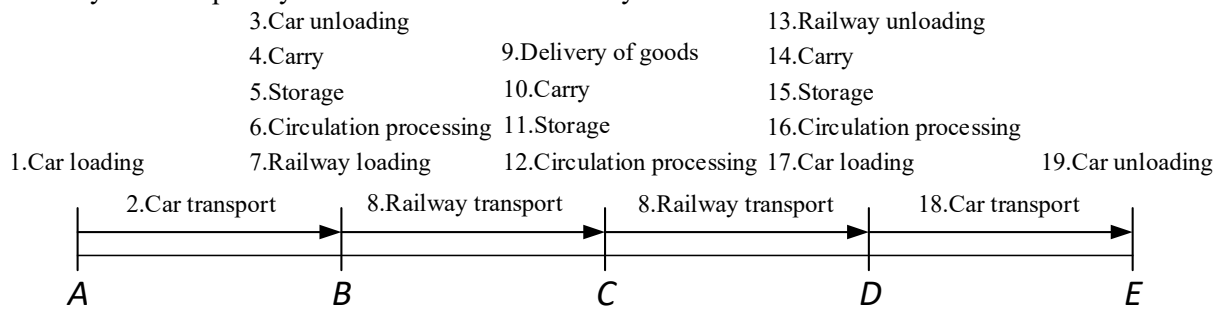


Figure 1 Railway logistics service module partition diagram

The service function characteristics of the railway logistics service are finally realized by the module instance. Each module instance will have different effects on the quality of service. Suppose that the module is represented by  $M_x(x=1,2,\dots,m)$ ,  $m$  is the number of modules,  $M_{xy}(x=1,2,\dots,m; y=1,2,\dots,u_x)$  represents the  $y$  instance of the  $x$  module,  $u_x$  is the number of module instances corresponding to the  $x$  module, and the module instance collection can be represented as  $M=[M_{xy}](x=1,2,\dots,m; y=1,2,\dots,u_x)$ . The two element decision variables  $\epsilon_x$  and  $\epsilon_{xy}$  represent the selection identification of modules and module instances respectively. If  $\epsilon_x=1$ , the module  $M_x$  is selected, if  $\epsilon_x=0$ , the module  $M_x$  is not selected; the identification of  $\epsilon_{xy}$  is the same. The configuration process of the railway logistics service scheme is as follows: The selected module  $I_z(z=1,2,\dots,n, n \leq m)$  is determined in the  $m$  module, and then a module instance  $I_{zv_z}(v_z \leq u_z)$  is selected under each selected module to form a railway logistics service scheme. The service scheme instance has  $n$  module instances, which can be shown as  $S=(I_{01v_{01}}, I_{02v_{02}}, \dots, I_{zv_z}, \dots, I_{nv_n})$ ,  $S$  is configuration, and  $I_{zv_z}$  is the  $v_z$  module instance of the  $z$  module.

### 2.2 Model construction

The model of railway logistics service scheme configuration is a multi-objective optimization model. The optimization targets are maximization of quality, minimum of time and minimization of cost. The configuration model of railway logistics service scheme is constructed as follows:

$$\max Q_s = \sum_{x=1}^m \sum_{y=1}^{u_x} (\epsilon_{xy} Q_{xy}) \quad (1)$$

$$\min T_s = \sum_{x=1}^m \sum_{y=1}^{u_x} (\epsilon_{xy} T_{xy}) \quad (2)$$

$$\min C_s = \sum_{x=1}^m \sum_{y=1}^{u_x} (\epsilon_{xy} C_{xy}) \quad (3)$$

$$\text{s.t.} \quad \sum_{y=1}^{u_x} \epsilon_{xy} C_{xy} \leq C_t \quad (4)$$

$$\sum_{y=1}^{u_x} \epsilon_{xy} T_{xy} \leq T_t \quad (5)$$

$$\sum_{y=1}^{u_x} \epsilon_{xy} M_{xy}(P) = P_t \quad (6)$$

$$\sum_{y=1}^{u_x} \epsilon_{xy} = \epsilon_x \quad (7)$$

In the formula,  $Q_s$  represents the total quality,  $T_s$  represents the total time, and the  $C_s$  represents the total cost.  $Q_{xy}$ ,  $T_{xy}$ , and  $C_{xy}$  are the quality of attributes, time properties, and cost attributes of the  $y$  module instance of the  $x$  module, and  $\epsilon_{xy}$  is the identification of the module instance selection. Type (4) is the maximum cost constraint,  $C_t$  is the maximum cost that the customer can bear; type (5) is the maximum time constraint, and  $T_t$  is the maximum time that the customer can bear; type (6) is a kind of goods constraint,  $P_t$  is the category number of the goods,  $M_{xy}(P)$  is the Category attribute of the module instance  $M_{xy}$ ; type (7) is the selection identification constraint for the module configuration, refers to the selected module, and only one module instance is selected.

### 3. Non-dominated sorting genetic algorithm II (NSGA-II) solution

The genetic manipulation of the initial population  $P_t$  is carried out, and the progeny population  $Q_t$  is obtained. The population  $P_t$  is merged with the population  $Q_t$ , and then the operation of the non-dominated sorting and crowding distance sorting is carried out. The optimal individual is selected to form a new population  $P_{t+1}$ , and the final condition is repeated until the termination condition is set up. The steps are shown in Figure 2.

Step1: Randomly generated the parent population  $P_t$  of the initial population size of  $N$ , and then a new progeny population  $P_t$  was obtained by crossover and mutation operation to the initial population  $Q_t$ , and the size of the population was also  $N$ , we let  $t=0$ .

Step2: Combined with population  $P_t$  and population  $Q_t$  to get a new population  $R_t$  with a population size of  $2N$ , and the target function was used as the fitness function. The non-dominated sorting of the population  $R_t$  was carried out, and the non-dominated set  $Z_1, Z_2, \dots$  was obtained.

Step3: we calculate the crowding degree  $i_d$  among all individuals, and select a new parent population  $i_d$ , then we get the non-dominated level  $rank_i$  and the individual crowding degree  $P_{t+1}$  of the individual.

Step4: Repeats the above operation until the termination condition is set up, otherwise  $t=t+1$  and back to Step2.

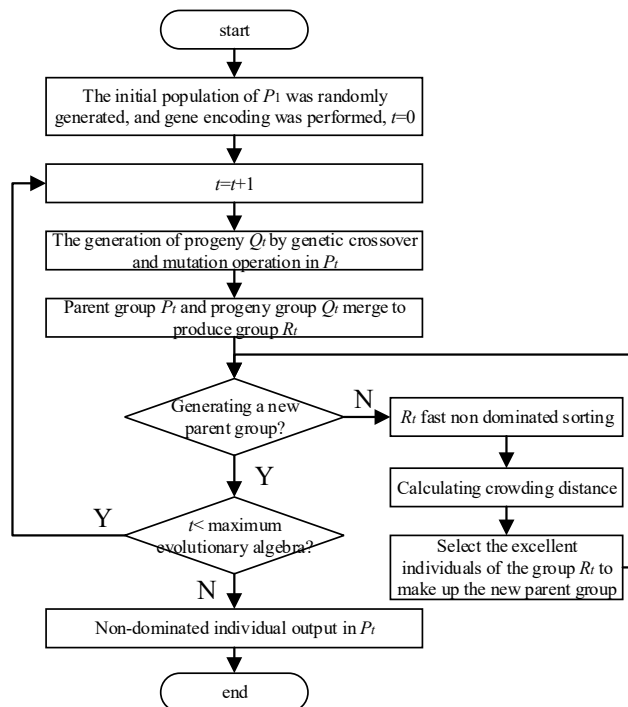


Figure 2 NSGA-II solution flow chart

(1) Fast non-dominated sorting. The specific steps of the fast non-dominated sorting of the population  $Q_t$  by the NSGA-II algorithm are as follows.

1) For each individual  $i$  in the population  $R$ , there are two parameters  $n_i$  and  $S_i$ ,  $n_i$  is the number of individuals that dominate the  $i$ , and  $S_i$  is the individual set dominated by  $i$ .

2) Find out all the individuals of the  $n_i=0$ , and save them into the current non dominated set  $Z_1$ .

3) For each individual  $j$  in the current non-dominated set  $Z_1$ , traversing the individual set  $S_j$  that it dominates, the  $n_t$  of each individual  $t$  in the set  $S_j$  is reduced by 1, that is, the number of individuals who dominate the individual  $t$  is reduced by 1, and if  $n_t - 1 = 0$ , the individual  $t$  is stored in another set  $H$ .

4) Taking  $Z_1$  as a set of first class non-dominated individuals, all individuals in  $Z_1$  are optimal. All individuals within the set are given the same non-dominant sequence  $rank_1$ . With the set  $H$  as the current set, the above classification operation is repeated, and the corresponding non-dominant sequence is given, until all the corresponding non-dominant sequences are given.

(2) Calculation of crowding degree. The crowding degree represents the density of the surrounding individuals at the given point  $i$  in the population. With  $i_d$ , the minimum Euclidean distance can be expressed with the  $i$  point to the surrounding point. The detailed calculation steps are as follows.

1) The crowding degree  $i_d$  of each point is set to 0.

2) Calculating the crowding degree of other individuals in the population  $i_d = \min \sqrt{\sum_{k=1}^m (f_k^i - f_k^j)^2}$ .

$i_d$  represents the crowding degree of the  $i$  point;  $f_k^i$  represents the function value of the  $k$  point  $i$  objective function; and  $f_k^j$  represents the function value of the  $k$  objective function of the  $j$  point; and  $m$  is the number of target functions.

3) Each individual  $i$  in the population has two attributes of non-dominated sequence  $rank_i$  and crowding degree  $i_d$ . The crowding degree comparison operator can be defined: the individual  $i$  is compared with another individual  $j$ , and the individual  $i$  wins as long as one of the following conditions is set up.

1. If the non-innervation layer of individual  $i$  is superior to individual  $j$ , that is  $rank_i < rank_j$ ;

2. If two individuals in the population have the same grade, and the crowding distance of the individual  $i$  is greater than that of the individual  $j$ , that is  $rank_i = rank_j$ , and  $i_d > j_d$ .

(3) Elite selection strategy. The elite selection strategy is to prevent the loss of the outstanding individuals during the evolution of the population.

First, it is necessary to combine the progeny  $t$  of the  $Q_t$  generation with the parent population  $P_t$  to form a new species group  $R_t$  with a population size of  $2N$ . Then, the population  $R_t$  is sorted by non-domination, and a series of non-dominated sets  $Z_i$  are obtained and the crowding degree of each individual is calculated. If the  $Z_1$  is put into the new parent population  $P_{t+1}$ , if the size of the population  $P_{t+1}$  is less than  $N$ , then continue to add the next level of non-dominating set  $P_{t+1}$  to  $Z_2$ , until the population is added to the non-dominating set  $Z_n$ , the size of the population is beyond  $N$ , and the crowding degree comparison operator is used for each individual in the  $Z_n$  to take the former  $\{num(Z_n) - (num(P_{t+1}) - N)\}$  individual, so that the size of the population  $P_{t+1}$  reaches  $N$ , then produce a new progeny population  $Q_{t+1}$ .

## 4.Example

### 4.1 The basic situation of the example

A beverage enterprise needs to complete the "door to door" process from Xiamen to Chengdu by railway. The total weight of the goods is 30 tons, and the distance from the enterprise to the originating Dongfu station is 20 kilometers, and the distance from the Chengxiang station to the enterprise distribution point is 40 kilometers. The running time of the X316 express train from Dongfu to Chengxiang is 22.6 hours. The running time of the X8742 fast train is 27 hours, and the time of the 81106 freight train is 38 hours.

Customer requirements: 1.The goods category is packed beverage  $P_z = 4$ , the total weight is 30 tons; 2.The customer requires the Car loading, Car transport, Car unloading, Railway loading, Railway transport, Railway unloading, Car loading, Car transport and Car unloading, the module selection identification is  $\epsilon=(1,1,1,0,0,0,1,1,0,0,0,0,1,0,0,0,1,1,1)$ ; 3. The total time is no more than 72 hours, the price is no more than 24000 yuan, and the quality is high. The parameters of each module instance is shown in Table 1.

Table 1 The parameter value of module instance

Module	Module instance	Service cost (yuan/t)	Service time (h)	Service quality	Type of goods
Car loading M01	M0101	12	2	0.542	1,2,3,4
	M0102	15	2	0.542	1,2,3,4
	...	...	...	...	...
...	M0112	18	4	0.532	1-7
	...	...	...	...	...
	M1901	13	1	0.542	1,2,3,4
Car unloading M19	...	...	...	...	...
	M1912	16	3.5	0.532	1-7

### 4.2 Example solution

MATLAB R2011a programming is used to optimize the model of the model based on NSGA-II algorithm. The parameters are set as follows: The number of target functions is 3, the number of decision variables is 156, the population size is 30, the evolutionary algebra is 100, the cross probability is 0.9, the mutation probability is 0.1, and the calculation results are calculated as shown in Figure 3.

Since the three objective functions are not completely consistent, the solution that can make the three objective functions achieve the best at the same time does not exist. We can get a set of Pareto solutions configured for a series of service schemes, as shown in Table 2. In these optimal solution sets, the customer can select the appropriate alternatives according to the preferences of each target.

It can be seen from the above table that we can't find one best solution to all the goals at the same time. Each scheme has its own advantages and disadvantages. The scheme 1 has the lowest cost, but the time is the longest, the quality is the worst; the program 3 has the shortest time and the best quality, but the cost is the highest; program 2 is moderate, the objective function is between two other schemes.

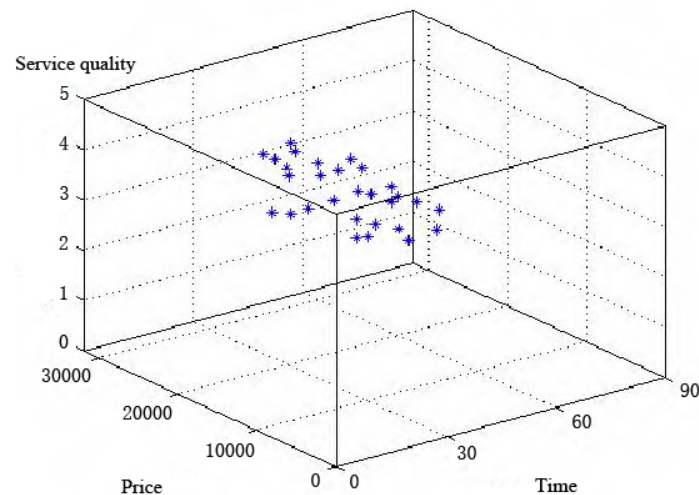


Figure 3 The distribution of Pareto solution set

Table 2 Optimal solution set of railway logistics service scheme

Sequence number	Module instance	Cost (yuan)	Time (h)	Quality
1	Single set forklift loading M0101	18882	53.5	2.872
	Single van transport M0203			
	Single set forklift unloading M0301			
	Railway single set forklift loading M0701			
	81106 train transport M0806			
	Railway single set forklift unloading M1301			
	Single set forklift loading M1701			
	Single van transport M1803			
	Single set forklift unloading M1901			
	Single set forklift loading M0101			
2	Single van transport M0203	20996.1	42.5	3.019
	Single set forklift unloading M0301			
	Railway single set forklift loading M0701			
	X8742 fast train transport M0805			
	Railway single set forklift unloading M1301			
	Single set forklift loading M1701			
	Single van transport M1803			
	Single set forklift unloading M1901			
	Single set forklift loading M0101			
	Single van transport M0203			
3	Single set forklift unloading M0301	23110.2	38.1	3.068
	Railway single set forklift loading M0701			
	X316 express train transport M0804			
	Railway single set forklift unloading M1301			
	Single set forklift loading M1701			
	Single van transport M1803			
	Single set forklift unloading M1901			

#### 4.3 Project selection

The evaluation method of Hybrid Fuzzy TOPSIS<sup>8</sup> is used to evaluate the solution set of railway



logistics service scheme. The evaluation values of each objective function are represented by interval number, triangular fuzzy number and intuitionistic fuzzy number respectively. The solution process is detailed in document [8]. This article only lists the initial evaluation matrices and the final evaluation results, as shown in Table 3.

Scheme 2 is the best scheme. The total cost of the scheme is 20996.1 yuan, the total time is 42.5 hours and the total quality is 3.091. The process of railway logistics is as follows:

Single set forklift loading M0101: A single forklift truck is used to carry out the loading operation. The unit cost is 12 yuan per ton and the total loading time is 2 hours.

Single van transport M0203: A single van is used for transportation, with a unit cost of 33 yuan per ton, and the total transportation time is 3 hours.

Single set forklift unloading M0301: A single forklift truck is used to carry out the unloading operation. The unit cost is 15 yuan per ton and the total loading time is 1.5 hours.

Railway single set forklift loading M0701: A single forklift truck is used for railway loading operation. The unit cost is 10.8 yuan per ton and the total loading time is 2 hours.

X8742 fast train transport M0805: Fast freight train transportation, the unit cost is 529.47 yuan per ton, the total transportation time is 27 hours.

Railway single set forklift unloading M1301: A single forklift truck is used for the railway unloading operation. The unit cost is 14.6 yuan per ton and the total unloading time is 1 hours.

Single set forklift loading M1701: A single forklift truck is used to load the car. The unit cost is 12 yuan per ton and the total installation time is 1.5 hours.

Single van transport M1803: A single van is used for transportation, with a unit cost of 60 yuan per ton, and the total transportation time is 3.5 hours.

Single set forklift unloading M1901: A single forklift truck is used to carry out the unloading operation. The unit cost is 13 yuan per ton and the total loading time is 1 hour.

Table 3 Service scheme evaluation initial matrix

Sequence number	Expert number	Cost	Time	Quality	Comprehensive closeness degree	Sort
A1	1	[90,95]	(0.4,0.5,0.6)	<0.5,0.3>	2.443	2
	2	[90,95]	(0.6,0.7,0.8)	<0.5,0.4>		
	3	[85,90]	(0.4,0.5,0.6)	<0.6,0.3>		
	4	[90,95]	(0.6,0.7,0.8)	<0.7,0.3>		
A2	1	[80,85]	(0.6,0.7,0.8)	<0.4,0.5>	2.858	1
	2	[75,80]	(0.8,0.9,1)	<0.4,0.5>		
	3	[75,80]	(0.6,0.7,0.8)	<0.5,0.5>		
	4	[85,90]	(0.8,0.9,1)	<0.7,0.1>		
A3	1	[70,75]	(0.8,0.9,1)	<0.3,0.6>	1.825	3
	2	[60,65]	(0.8,0.9,1)	<0.4,0.4>		
	3	[65,70]	(0.8,0.9,1)	<0.4,0.6>		
	4	[75,80]	(0.8,0.9,1)	<0.6,0.3>		

## 5. Conclusion

Through the determination of the link of the railway logistics module, the module case base is set up, and the NSGA-II method is used to select and configure the railway logistics module, and the optimal scheme is obtained. From the results, it can be seen that the railway logistics service scheme configuration method can configure the reasonable service plan according to the customers' demand, which provides reference for railway department to realize the railway logistics service scheme configuration oriented to the agent business.

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