Research on Scheduling Emergency Supplies Featuring Hierarchical Linkage Based on Genetic Algorithm

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Abstract. This paper presents the hierarchical linkage scheduling emergency supplies problem. A mathematical description is provided and a model of the hierarchical scheduling emergency supplies with multiple supplies and multiple vehicles is formed in order to acquire the shortest scheduling time and the lowest cost. For this problem, we give a two-stage scheduling case of supplies in this paper. This case consists of a primary transportation system including primary storage, secondary storage and primary road network(normal road and highway), and the secondary system which includes secondary storage, disaster point and secondary road network(normal road). In order to facilitate the expression, we named primary first-stage and secondary second-stage. After that, we define the hybrid of shortest scheduling time and cost as the objective function in this two-stage system. An improved genetic algorithm is applied to calculate this case. Thus, we can obtain the scheduling plan after implementing a global linkage approach.

1. Introduction

The problem of emergency supplies scheduling is complex and meaningful, scholars at home and abroad have studied and made some progress. Stephan Hassold et al.[1] study public transport vehicle scheduling featuring multiple vehicle types and propose a new methodology based on a minimum-cost network flow model. Swong Jae Park[2] adopts genetic algorithms to calculate bus network scheduling and give us a new idea. Salhi and Nagy[3] focus on the distance and give a dispatch method at the function of the least distance. The papers[4][5] attempt to adapt different genetic algorithms to analyze VSP(Vehicle Scheduling Problem) and give a new conception about hierarchical dispatch. After that, Beraldide et al.[6] propose a two-stage stochastic method to solve the vehicle dispatch problem considering two-stage transportation and many kinds of vehicles. Arun Kummar[7] think the problem of supplies scheduling can be divided into two stage and give ant colony optimization to calculate it. And Mawbey W T et al.[8] give a new static solution to solve two-stage emergency vehicle.

The above articles about vehicle scheduling and two-stage scheduling focus on the change. That's to say, during the vehicles scheduling, if the condition of vehicles or supplies is changed, we have to recalculate the problem and they regard the previous condition as the first-stage and the other as the second-stage. However, in reality, here exists a common problem that we have to transport supplies through transfer station. We define this kind of supplies scheduling problem as hierarchical supplies scheduling. In this case, the supplies distribution network is hierarchical, we can regard it as multiple distribution networks connected in series and their tasks are correlative. During the hierarchical scheduling, vehicles in both two stages start transportation tasks at the meantime and run in parallel state. When all the tasks of transportation have been finished, we think the entire system's tasks have been finished. Under tins condition, with the aim of the shortest time and the lowest cost, we therefore propose a idea of global linkage.

In this article, we proposed a model about the two-stage scheduling problem. Considering the different stage's interaction, two kinds of vehicles, multiple supplies, multiple route and multiple objective functions, we make the first-stage and second-stage scheduling plan according to the relationship of supply and demand; and then we regard the two stage scheduling plan as a entirety, which is produced by iteration based on the improved genetic algorithm[9], and then the optimal solution in the fitness of overall plan as a selection criterion is obtained.

2. The mathematical model of two-stage scheduling case

2.1 The model of hierarchical scheduling emergency supplies

There are two-stage transportation system and two-stage scheduling task, and the vehicles and road network form the transportation system. The vehicles in different stages can only finish tasks in their own stages. Therefore we describe this model as figure 1.

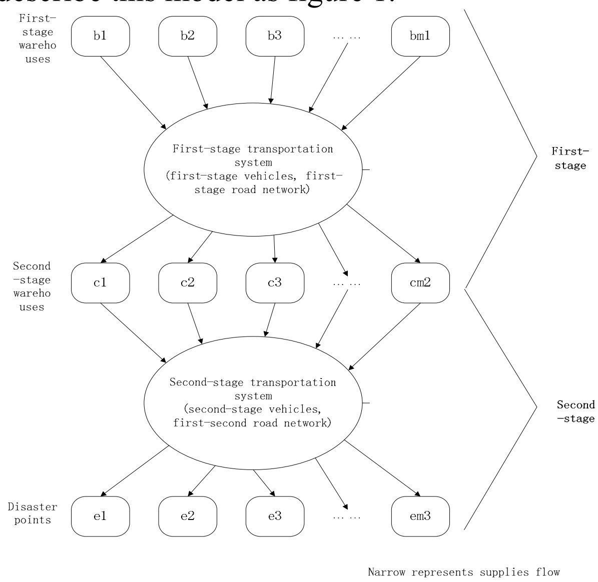

Fig.1 Hierarchical scheduling emergency supplies model

2.2 The optimal model of scheduling plan

2.2.1 The conditions of the hypothesis

We suppose:

1) The storage of different supplies in both first and second stage warehouses must feed the demands of all the disaster points.
2) We consider the laytime of all different vehicles.
3) A vehicle can only be fully loaded with one kind of supplies, and we don't consider combined shipment.
4) We don't consider the change of vehicles, that's to say, we don't care about the increase and decrease of the vehicles.

Parameter codes and its meaning:

W:Emergency supplies set. W={1,2,…k,…,p}, and the element of the set W represent different kinds of supplies.

Pi:The set of nodes in scheduling system. Pi={pi1,pi2,…,piMi}, and P1,P2,P3 represent respectively first-stage warehouse points set, second-stage warehouse points set, and disaster points set. Besides, Mi represent the number of i type nodes.

Zi:The nodes' information. Zi={zi1,zi2,…,zim}, and Z1,Z2,Z3 represent respectively the information of first-stage warehouse points, second-stage warehouse points, and disaster points. Zij(j=1,2,…,m) represents the information of j-th node in i type nodes, and the information of zij should include supplies' kinds(w)(w=1,2,…,p), and its corresponding amount of storages or demands(cijw), that's to say, zij={(1,cij1), (2,cij2),…,(p,cijp)}. If the value of Cijw is negative, we make it represent demands, else, we make it represent storages.

Rφ:The set of scheduling transportation vehicles in φ-th stage, Rφ={rφ1,rφ2,...,rφg}(φ∈{1,2}). The element of Rφ, rφk (k=1,2,...,g), represents the k-th kind of vehicles' information in its stage, including shipment(dφk), speed(vφk), amount(nφk), that's to say , rφk ={ dφk,, vφk , nφk }.

X1:The matrix of distance(normal road) between first-stage warehouses and second-stage warehouse.

$$X_1 = \begin{bmatrix} q_{1,1} & q_{1,2} & \dots & q_{1,M_2} \\ q_{2,1} & q_{2,2} & \dots & q_{2,M_2} \\ \dots & \dots & \dots & \dots \\ q_{M_1,1} & q_{M_1,2} & \dots & q_{M_1,M_2} \end{bmatrix} \quad (1)$$

X1’:The matrix of distance(highway) between first-stage warehouses and second-stage warehouse.

$$X_1' = \begin{bmatrix} q_{1,1}' & q_{1,2}' & \dots & q_{1,M_2}' \\ q_{2,1}' & q_{2,2}' & \dots & q_{2,M_2}' \\ \dots & \dots & \dots & \dots \\ q_{M_1,1}' & q_{M_1,2}' & \dots & q_{M_1,M_2}' \end{bmatrix} \quad (2)$$

X2:The matrix of distance(normal road) between second-stage warehouses and disaster points.

$$X_2 = \begin{bmatrix} l_{1,1} & l_{1,2} & \dots & l_{1,M_3} \\ l_{2,1} & l_{2,2} & \dots & l_{2,M_3} \\ \dots & \dots & \dots & \dots \\ l_{M_2,1} & l_{n,2} & \dots & l_{M_2,M_3} \end{bmatrix} \quad (3)$$

μ:A complete transportation task of a certain kind of vehicles in first-stage scheduling system is μ, and it includes the starting points of first-stage warehouses, the kinds of carrying supplies, the destination points of second-stage warehouses, that’s to say, μ=(bi，k，cj)(i=1,2,...,m; k=1,2,...,p; j=1,2,...,n).

τ:A complete transportation task of a certain kind of vehicles in second-stage scheduling system is τ, and it includes the starting points of second-stage warehouses, the kinds of carrying supplies, the destination points of disaster, that’s to say, τ=(ci，k，ej)(i=1,2,...,n; k=1,2,...,p; j=1,2,...,a).

U:The final scheduling plan is U which contains first-stage and second-stage scheduling plan, that’s to say, U={Ψ1, Ψ2}.

Ψφ:The φ-th stage scheduling plan is Ψφ, and it includes all vehicles’ driving route in φ-th stage. Besides, pφ represents the number of vehicles which are included in this stage plan. That’s to say, Ψφ={ψφ1, ψφ2,..., ψφp}, and in which, ψφg (g=1,2,...,p) represent the g-th vehicle’s scheduling plan in φ-th stage scheduling system, including a series of transportation plans and the information of this vehicle. We use {μφ1, μφ2,...,μφx;rφg} to represent the scheduling plan of g-th vehicle, and the information of this vehicle is rφg. In which, the x represent this vehicle finish x times tasks of loading-transportation-unloading.

Tφg:The total time of g-th vehicle after finishing all tasks in φ-th stage is Tφg, we define it as:

$$t_{\varphi g} = \sum_{n=1}^{K} X_{\varphi}(f_{\varphi g}(n))(f_{\varphi g}(n+1)) / v_{\varphi g} + \frac{K+1}{2}(t_{load,\varphi g} + t_{unload,\varphi g}) + t_{wait,g} \quad (4)$$

In which, (K+1)/2 is the amount of this vehicle’s tasks, that’s to say, it represent the times of loading in warehouses and unloading in destinations. Xφ(m)(n) represents the distance between m and n in φ-th stage system. {fφg(n)} represents the nodes column when vehicle expressed as rφg finish tasks expressed as ψφg. tload,φg, tunload,φg respectively represent the loading time and unloading time of this vehicle. twait,g represents the possible waiting time in second-stage warehouse when two stages are in linkage run, and that can be explain that when the vehicle expressed as r2g has arrived the second-warehouse, the warehouse had been empty, therefore this vehicle have to wait till the upper stage scheduling vehicle finish its tasks. Of course, there doesn’t exist waiting time in first-stage, and we define the value as 0 in first-stage system.

Tφ:The set of time when vehicle in φ-th stage system finish their own tasks, that can be expressed as Tφ={tφ1,tφ2,...,tφp}. In which, p represents the amount of vehicles in φ-th stage system, we define the finishing time of φ-th stage as Tφs = sup Tφ.

Nijw: Ψφ——>N(Natural Numbers), The value of Nijw(ψφg) represents the calculated scheduling plan expressed as Ψφ∈U. That can be describe that the number of Pij when g-th vehicle, which carries supply named w, runs from i-type node to j-type node or the times that this truck ships w-type supply out from pij. When the value of i is 3, it presents the number that this truck ships w-type supply to disaster points and when the value of it is 1, it presents the number that this truck ships w-type supply from this stage warehouse.

2.2.2 Solution form

$$U = \{\Psi_1, \Psi_2\} \qquad (5)$$

2.2.3 Objective function

$$\min\{\sup(T_1 \cup T_2) + Cost * 0.001\},$$

In which, $Cost = \sum_{i=1}^{10} T_{1i} * Capacity + \sum_{n=1}^{14} T_{2n} * Capacity$. (6)

2.2.4 Constraint conditions

$$\sum_g N_{3jw}(\psi_{2g}) \cdot d_{2g} + c_{3jw} \geq 0,$$

$$c_{1jw} - \sum_g N_{1jw}(\psi_{1g}) \cdot d_{1g} \geq 0 \quad \forall m \in [1, p]; \ \forall j \in [1, M_j] \qquad (7)$$

3. Case of two stage scheduling problem

3.1 Initial conditions

In the first-stage scheduling system, the first-stage warehouses are b1,b2 and first-stage demand points(the second-stage warehouse) are c1,c2,c3,c4. We suppose there are two kinds of road here, and they are highway and normal road. The route network is shown as figure 2 and the distance is shown as table 1 and in which, "∞" represents there is no road between two points, "+" represents highway and "-" represents normal road. There are two kinds of vehicle in the first-stage scheduling system, they are large trucks numbered 1-4 and small trucks numbered 5-10. The large trucks have the speed of 60km/h(75km/h in highway) and the capacity of 15t. Besides, the small trucks have the speed of 70km/h(85km/h in highway) and the capacity of 10t.

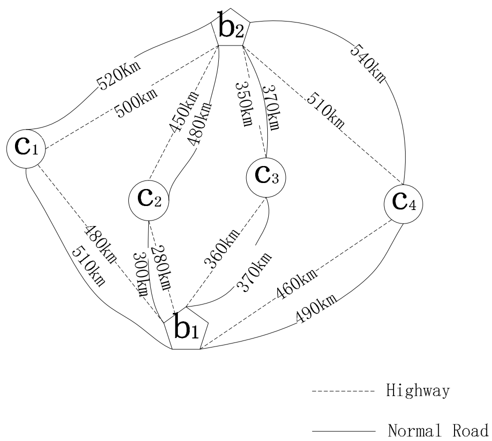

Fig.2 Route relationship between the first-stage warehouses and the second warehouses

Table 1 The distance between the first-stage warehouses and the second-stage warehouses(/km)

	c1	*c2*	*c3*	*c4*
b1	510(-)/480(+)	300(-)/280(+)	370(-)/360(+)	490(-)/460(+)
b2	520(-)/500(+)	480(-)/450(+)	370(-)/350(+)	540(-)/510(+)

In the second-stage scheduling system, the disaster points are e1,e2,e3,e4,e5,e6 and there is only one kind of road and that's normal road. The route relationship between disaster points and the second-stage warehouses is shown as figure 3 and the distance is shown as table 2. There are two kinds of vehicle in the second-stage scheduling system, they are large trucks numbered 1-4 and small trucks numbered 5-14. The large trucks have the speed of 60km/h and the capacity of 10t. Besides, the small trucks have the speed of 70km/h and the capacity of 5t.

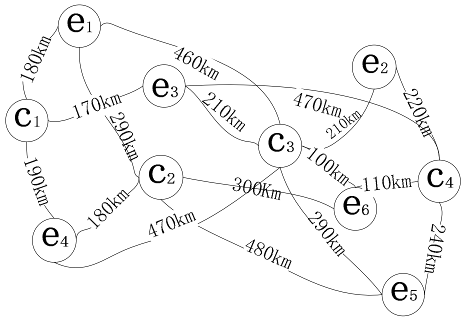

Fig.3 Route relationship between the second-stage warehouse and disaster points

Table 2 The distance between the second-stage warehouses and disaster points (/km)

	e1	*e2*	*e3*	*e4*	*e5*	*e6*
c1	180	∞	170	190	∞	∞
c2	290	∞	∞	180	∞	300
c3	460	210	210	∞	290	100
c4	∞	220	470	∞	240	110

The route network of the whole system is shown as figure 4.

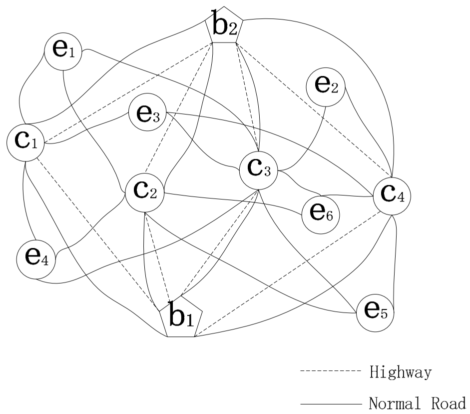

Fig.4 The route network of the whole system

There are three kinds of supplies marked 1,2,3 and they are medicine, food and living goods. The storage of these three kinds of supplies in warehouses and the demands of these three kinds of supplies in disaster points are respectively shown in table 3 and table 4.

Table 3 The storage of the first-stage warehouses and demand of the second-stage warehouses

	b1	*b2*	*c1*	c2	*c3*	*c4*
Medicine/t	250	300	55	30	35	25
Food/t	400	350	40	35	35	30
Living goods/t	350	200	25	40	45	55

Table 4 The demand of the disaster points

	e1	*e2*	*e3*	*e4*	*e5*	*e6*
Medicine/t	25	35	30	25	20	15
Food/t	50	55	45	35	50	30
Living goods/t	45	40	50	40	45	20

We consider the laytime and we suppose the large trucks need 40min to load and 20min to unload and the small ones need 20min to load and 10 min to unload.

3.2 Solving target

We get the scheduling plan based on the minimum value of objective function considering both time and cost.

4. The process of solving the case using genetic algorithm

4.1 Parameter encoding

In one scheduling plan, scheduling tasks of all vehicles in the first-stage system compose one first-stage chromosome and scheduling tasks of all vehicles in the second-stage system compose one second-stage chromosome. In chromosome, all tasks of any one vehicle is defined as a gene and the part of tasks is defined as gene sequence and the one time scheduling task of the truck is defined as a gene unit.

We define code and symbol as follows in our research"

"b1,b2" represent two first-stage warehouses;

"c1,c2,c3,c4" represent four second-stage warehouses;

"e1,e2,e3,e4,e5,e6" represent six disaster points;

"1,2,3" represent three kinds of supplies: medicine, food and living goods;

μi=(pij,k,pi+1,l) represents gene sequence, and in which, p i j represents starting point, k represents the kind of supplies, pi + 1,l represents arriving point. For example, μ1 = μ = (bi , k, cj) , μ2=τ=(ci, k, ej) respectively represent the first-stage and second-stage one time transportation task.

Ψ1={ψ1,1, ψ1,2,..., ψ1,10} represents a first-stage chromosome, that's a set of all vehicles' tasks in the first-stage system.

Ψ2={ψ2,1, ψ2,2,..., ψ1,14} represents a second-stage chromosome, that's a set of all vehicles' tasks in the second-stage system.

U={Ψ1，Ψ2} represents a chromosome pair, and it's a set of the whole system's scheduling plan.

4.2 Initialing population

After the population is initialed according to population size as we set before, it generates chromosomes, which are the corresponding number compared to first-stage and second-stage scheduling tasks, and then we pair the chromosomes. The experience has shown that 50 is a good population size, so we choose 50 as our initial size in this article.

4.3 Genetic operator

4.3.1 Basic genetic operator

This operator can do the basic functions of GA—crossing the same kind of chromosomes.

4.3.2 Auxiliary genetic operator

This operator can amend the chromosomes according the supply and demand, and the specific circumstances can be divided into 3: demand>supply; demand<supply; shipment>storage.

4.3.3 Minimizing waiting time operation

First of all, it remains to be judged that whether the waiting time in the second-stage chromosome when vehicles arriving in warehouses exists or not. And if it does, we adapt the method of amending disaster's replenishment in the second-stage chromosomes, amending the first-stage chromosomes, or changing supply's kind of waiting vehicle in order to minimizing waiting time.

4.3.4 Amending operation after minimizing waiting time

1)We amend the second-stage disaster's replenishment in second-stage chromosomes generated before to make the second-stage scheduling plan meet the constraint of supply and demand.

2)We amend gene sequence units in first-stage chromosomes generated before to make the first-stage scheduling plan meet the constraint of supply and demand.

3)We amend the scheduling plan in which the second-stage vehicles' waiting time is longer when arriving in the second-stage warehouses to reduce vehicles' waiting time and accelerate convergence.

4.4 Objective function

In this article, we take the hybrid of finishing time and cost of scheduling plan as our objective function value. The specific description is as follows, and the parameters are as previously defined in mathematical model.

$$
\begin{aligned}
f(U) &= \max_{\forall\varphi\in\{1,2\},\forall g\in\{1,2\ldots p_\varphi\}} (t_{\varphi g}) + Cost*0.001 \\
&= [\max_{\forall\varphi\in\{1,2\},\forall g\in\{1,2\ldots p_\varphi\}} \{\sum_{n=1}^{K} X_\varphi(f_{\varphi g}(n))(f_{\varphi g}(n+1))/v_{\varphi g} \\
&+ \frac{K+1}{2}(t_{load\varphi g} + t_{unload\varphi g})\} + t_{waitg}] + Cost*0.001
\end{aligned} \quad (8)
$$

4.5 Fitness evaluation

In this article, the smaller the objective function value is, the higher the corresponding fitness evaluation and the more excellent the scheduling plan will be.

4.6 The process of linkage solving method

At first, we pair the first-stage and second-stage chromosomes, and then chose 50 chromosome pairs to form a population, that's to say, a chromosome pair means a complete scheduling plan including all two stage. Next, we use GA which can perform operations of crossing, mutation and amending, accord to the optimal criterion of chromosome pairs' fitness. Foe detailed, we make the first-stage and second-stage chromosomes in the chromosome pairs perform operations of crossing, mutation and amending with the optimal chromosome pair in this generation, and then it generates a new chromosome pair. After that, we make them and the optimal pair in previous generation form a new population and we repeat iteration until the value of the objective function is stable, that's to say, reaching convergence. At last, we can get the optimal chromosome pair and the corresponding scheduling plan is the global optimization solution.

4.7 Program flow chart

The program flow chart is shown as figure 5.

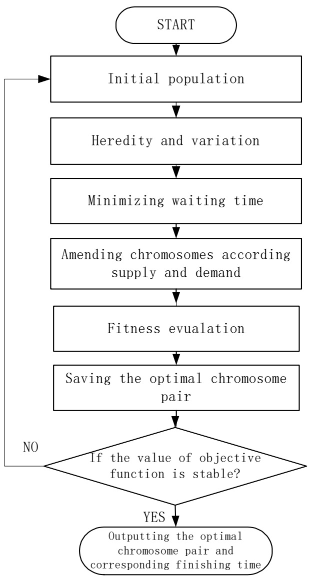

Fig.5 Program flow chart

5. Solving case and analysis

5.1 Process analysis

We save the finishing time of the first-stage and second-stage scheduling plan which are values of objective function after GA 's calculating and its corresponding iterations. By the method of global linkage, the finishing time of the first-stage and second-stage scheduling plan is becoming stable synchronously. In this case, when the iterations is a certain number, the value is stable, and this finishing time's corresponding chromosome pair is the global optimal solution.

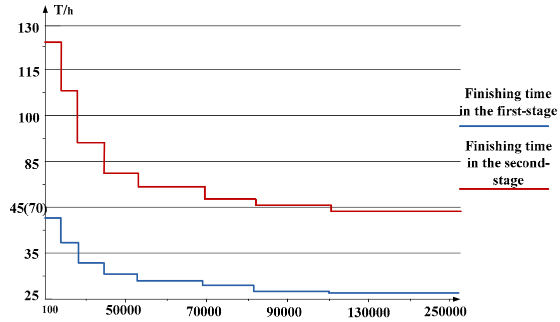

Fig.6 relationship between two-stage finishing time and iterations

From figure 6, we can see that the finishing time decreases rapidly at first, and then it's rate is becoming slowly. When iterations is about 200000, the two-stage finishing time is stable, and we can get the finial scheduling plan form the chromosome pair.

Table 5 Relationship between the first-stage scheduling plan and iterations

Iterations	1000	50000	100000	150000	200000
T1s/h	40.1	30.5	26.6	26.6	26.6
Cost	4958.2	3457.21	2342.65	2342.65	2342.65

From table 5, we can see that when iterations is about 100000, the first-stage finishing time is 26.6h, the cost is 2342.65 and the number is table.

Table 6 Relationship between the second-stage scheduling plan and iterations

Iterations	100	50000	100000	150000	200000
T2s/h	122.23	80.58	66.5	66.5	66.5
Cost	1324.5	6578.2	4350.52	4350.52	4350.52

From table 6, we can see that when iterations is about 100000, the second-stage finishing time is 66.5h, the cost is 4350.52 and the number is table.

We can get the optimal objective function value from the data above, and the value is 73.19.

5.2 Scheduling plan

The finial scheduling plan is shown as table 7 and table 8. In table 7, the large trucks in first-stage number 1~4 and the small trucks in first-stage number 5~10. Then in table 8the large trucks in second-stage number 1~4 and the small trucks in second-stage number 5~14.

Table 7 Scheduling plan in the first-stage scheduling system

g	ψ_1	t_{1g}/h	*cost*
1	(b21(-)c4(+))(b12(+)c2)	18.87	257.4
2	*(b12(+)c4(+))*(b22(+)c3)	17.47	254.4
3	(b21(+)c2(+))(b12(+)c3(-))(b23(+)c3)	25.34	367.5
4	(b21(-)c3(+))(b13(+)c3(+))(b23(-)c3)	26.60	349.8
5	(b22(-)c4(-))(b12(-)c2)	19.00	155.0
6	(b11(+)c3(+))(b23(-)c4)	16.07	148.6
7	(b21(+)c3(+))(b23(-)c2(+))(b12(-)c2)	22.67	197.9
8	(b22(+)c1(+))(b22(+)c3(+))(b12(-)c2)	24.40	219.3
9	(b13(-)c1(+))(b22(-)c2)	20.03	170.8
10	(b23(+)c2(+))(b23(-)c3(-))(b22(-)c3)	26.45	222.1
	Finishing time of the first-stage system T_1s/h	26.60	
	Cost of the first-stage system	2342.65	

Table 8 Scheduling plan in the second-stage scheduling system

g	ψ_2	t_{2g}/h	*cost*
1	(c22(-)e4(-))(c23(-)e3(-))(c22(-)e3(-))(c42(-)e2(-))(c23(-)e3(-))(c22(-)e4(-))(c31(-)e2(-))(c32(-)e5(-))(c42(-)e5)	63.0	455.0
2	(c43(-)e2(-))(c31(-)e6(-))(c31(-)e5(-))(c11(-)e1(-))(c22(-)e6(-))(c33(-)e4(-))(c22(-)e1(-))(c12(-)e5)	66.5	520.8
3	(c33(-)e2(-))(c33(-)e4(-))(c33(-)e5(-))(c33(-)e5(-))(c21(-)e4(-))(c21(-)e4(-))(c23(-)e5(-))(c32(-)e2)	64.8	495.0
4	(c43(-)e1(-))(c41(-)e2(-))(c32(-)e6(-))(c31(-)e4(-))(c22(-)e1(-))(c12(-)e2(-))(c33(-)e4)	61.7	493.3
5	(c33(-)e3(-))(c31(-)e1(-))(c31(-)e1(-))(c41(-)e2(-))(c23(-)e1(-))(c33(-)e4)	59.7	215.4
6	(c43(-)e6(-))(c31(-)e1(-))(c43(-)e2(-))(c32(-)e5(-))(c23(-)e1(-))(c13(-)e1(-))(c32(-)e3(-))(c42(-)e2)	63.3	229.0
7	(c21(-)e6(-))(c41(-)e2(-))(c32(-)e1(-))(c41(-)e3(-))(c13(-)e1(-))(c43(-)e4(-))(c32(-)e3)	62.4	244.3
8	(c13(-)e5(-))(c23(-)e6(-))(c12(-)e1(-))(c42(-)e6(-))(c22(-)e2(-))(c32(-)e3(-))(c33(-)e3)	65.1	244.3
9	(c21(-)e3(-))(c12(-)e1(-))(c33(-)e6(-))(c33(-)e3(-))(c13(-)e5(-))(c12(-)e2(-))(c42(-)e2(-))(c32(-)e3)	61.4	235.7
10	(c42(-)e1(-))(c31(-)e3(-))(c41(-)e5(-))(c21(-)e3(-))(c22(-)e3(-))(c22(-)e4(-))(c23(-)e2(-))(c13(-)e3)	65.9	244.7
11	(c21(-)e3(-))(c43(-)e1(-))(c21(-)e2(-))(c42(-)e1(-))(c22(-)e4(·))(c43(-)e3)	63.1	247.9
12	(c12(-)e2(-))(c23(-)e2(-))(c43(-)e5(-))(c13(-)e2(-))(c43(-)e3(·))(c12(-)e3)	64.1	253.6
13	(c41(-)e2(-))(c31(-)e3(-))(c43(-)e5(-))(c32(-)e5(-))(c31(-)e5(·))(c23(-)e1(-))(c32(-)e5(-))(c22(-)e3)	65.4	233.2
14	(c32(-)e6(-))(c42(-)e1(-))(c33(-)e6(-))(c32(-)e4(-))(c32(-)e5(·))(c42(-)e1(-))(c43(-)e1)	60.3	240.0
	Finishing time of the first-stage system T_2s/h	66.5	
	Cost of the second-stage system	4350.52	

5.3 Result analysis

From tale 7 and 8, we can see that finishing time of the first-stage scheduling plan is 26.6h and the second-stage is 66.5h. We verify our plan which can strictly feed the relationship of demand and supply, that's to say, no matter which kinds of supplies the shipments of the first-stage warehouse is less than its storage and the supply of disaster points can feed its demand. In two-stage scheduling plan , we can see that all vehicles' running time is similar, that's so say, our plan is reasonable. From figure 5, we can see the two-stage finishing time is stable synchronously, that means our plan meet the idea of global linkage.

6. Conclusion

This paper, facing the problem of scheduling emergency supplies, provides with a solving method of global linkage based on GA with the aim of getting the minimum value of objective function. We take the hybrid of cost and finishing time as our function and consider multiple kinds of supplies and vehicles. Through solving two-stage case we supposed above, we acquire a good method to analyze the two-stage scheduling problem of multiple kinds of supplies and vehicles. We adapt a method of two-stage linkage to solving hierarchical scheduling problem. Specific process is as follows. Firstly, we consider the two-stage chromosomes at the meantime and make them generate together and secondly we can get the optimal solution with the overall perspective. Compared with method of hierarchical independence[10], this method is relatively complex but we can use it to analyze the scheduling problem when the storage in second-stage warehouse is different.

This paper gives a specific process to solve the two-stage scheduling case. Hopefully, more stages would be handled by expanding the methods listed in this paper.

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