Study on Emergency Drug Inventory Models based on Internet+

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Abstract. Emergency drug inventory is a key problem for emergencymanagement.Inthis study, an emergency drug inventory model is proposed, which is based on Internet. A genetic algorithm is developed to obtain the optimal solution of the proposed model. An example is included to illustrate the result of the model.

Introduction

In the progress of science and technology, medical level is also increasing. There are many nature disastershave been happened in recent years, which have caused great harms to people's life and wealth. So it is urgent to establish an emergency drug reserve system. We should also consider the special nature and waste of emergency drug.

SantosoWibowo and HepuDeng[1] presented multicriteria analysis for evaluating and selecting Suppliers under uncertainty. Jiuh-BilingSheu[2] included the core framework of emergency logistics.Byung Do Chung [3] studies the distributional robust chance-constrained approach based on dynamic traffic assignment under uncertainty.

YumeiBao and Guixiang[4] Chen proposed the problem and corresponding strategies in emergency preserve. Zijun[5] Wang discussed the mechanism of emergency material reserve. LinduZhao[6][7] presented the emergency network construction based on crisis resource management.Longfei Wang[8] proposes a time-space network model to address the emergency logistics planning problem.

Save lives is the most important, so the hospital must do the preparation of emergency drug reservation in the emergency event. This paper presents the models to minimize the cost of emergency drug while satisfy the sum demand.

Notations and assumptions

To establish the mathematical model, the following notations and assumptions are used.

Notations

T time of supply
N vendor's number
M hospital's number
U demand for U unit emergency drug
Y hospital reserve quota
Q_k the maximum supply of vendor k
C_y the storage cost of hospital y
C_{ky} the cost per unit of transportation
t_{ky} the time of transportation
C the sum of cost
N_{ki} the amount of vendors
N_i the amount of vendors whose supply time is smaller than T
a the expand scale of T
N_{ai} the sum of vendors whose supply time is not greater than $a \times T$

Assumptions

The adopted assumptions are as follows:

1. In time T, N vendors supply emergency drug to M hospitals.
2. thevendors'vehicles all can satisfy the demand for transportation, each vehicle can carry W unit drug

Cooperative Reserve Model

The model of emergency drug reserve is based on Internet+. It is a cooperative reserve model, which satisfies the amount demand and reduces the cost of reservation. There are two subsystems in this model. One is composed of hospitals; the other is composed of drug suppliers. This system is optimized based on Internet, which can get the lowest cost of storage and supply drug. The model is depicted in Figure 1. This model is composed of cooperative center and the collective drug suppliers and several hospitals. The cooperative center is in charge of information collection and command send.

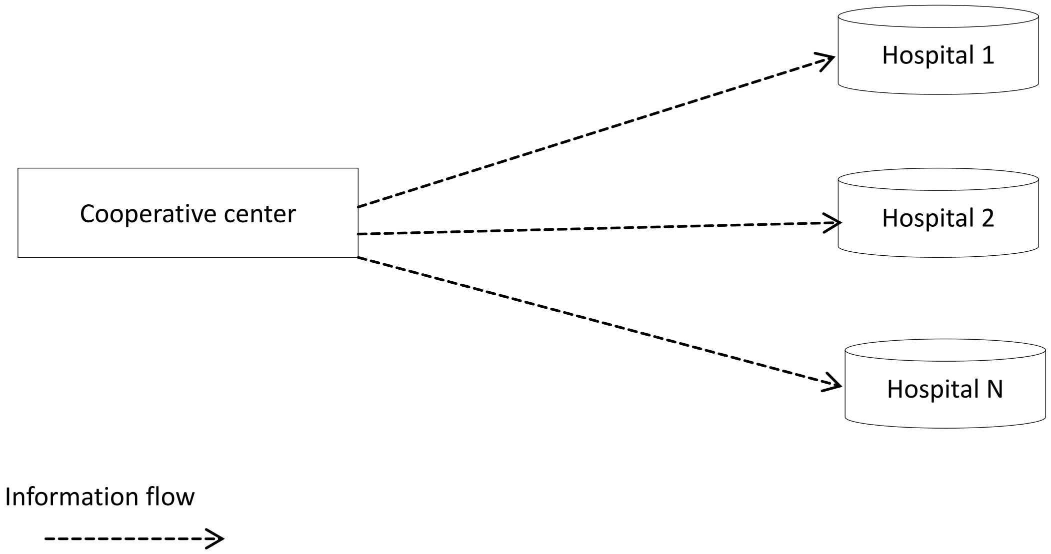

Fig1. Storage Model

Problem description

The cooperative center will be faced with these circumstances.

(1) Pick up the drug suppliers which can be satisfied with supply time, when the sum of maximum supply is greater or equal to demand for hospitals then it can be optimized.

(2) When the sum of maximum supply is smaller than demand for hospitals, the cooperative center will expand a scale of supply time , the optimize the new suppliers.

(3) If the maximum supply is still smaller than demand for hospitals after expanding a scale of supply time, then we should adopt some incentive measures to increase the supply volume.

The proposed model

The objective function can be described as follows.

$$\min C = \delta_1 (\sum_{k=1}^{N_i} Q_k - U) \times (\sum_{y=1}^{M} \sum_{k=1}^{N_i} \mathrm{int}(\frac{Q_{ky}}{w}) + \delta(\frac{Q_{ky}}{w})) \times C_{ky}) +$$

$$\delta_1(U - \sum_{k=1}^{N_i} Q_k) \times \delta_1(\sum_{k=1}^{N_{ai}} Q_k - U) \times (\sum_{y=1}^{M} \sum_{k=1}^{N_{ai}} Q_{ky} \times C_y + \sum_{y=1}^{M} \sum_{k=1}^{N_{ai}} \mathrm{int}(\frac{Q_{ky}}{w}) + \delta(\frac{Q_{ky}}{w})) \times C_{ky})$$

$$\mathrm{k} = 1,2, \dots, \mathrm{N}, \mathrm{y} = 1,2, \dots., \mathrm{M},$$

$$\mathrm{s.t.} \sum_{k=1}^{N_{ki}} Q_{ky} = Z_y, \sum_{y=1}^{M} Q_{ky} \le Q_k, \sum_{y=1}^{M} Z_y = U; \delta(x) = \begin{cases} 1 & x \text{ is not integer} \\ 0 & x \text{ is integer} \end{cases}$$

$$\delta_1(x) = \begin{cases} 1 & \text{while } x > 0 \\ 0 & \text{while } x \le 0 \end{cases}$$

The solving method

Step1: according$\mathrm{t_k} \le \mathrm{T}$, determine the set of suppliers and the element number $\mathrm{N_i}$;

Step2: $\mathrm{G} = \sum_{k=1}^{N_i} \mathrm{Q_k} - \mathrm{U}$, count the value of G and judge the process of algorithm according to to G;

(1) if $\mathrm{G} \ge 0$,determine the set of suppliers, jump to step6;

(2) if $\mathrm{G} < 0$, then jump to step 3;

step 3: input the expand scale of time a ,determine the set of suppliers and element number $\mathrm{N_{ai}}$ which satisfy the condition of $\mathrm{t_k} \le \mathrm{a} \times \mathrm{T}$, then jump to step 4;

step 4: set $\mathrm{G_1} = \sum_{k=1}^{N_{ai}} \mathrm{Q_k} - \mathrm{U}$, count the value of $\mathrm{G_1}$, then judge the process of algorithm according to the result.

(1) if $\mathrm{G_1} \ge 0$, determine the set of suppliers who satisfy the condition of $\mathrm{t_k} \le \mathrm{a} \times \mathrm{T}$, then jump to step 6;

(2) if $\mathrm{G_1} < 0$, jump to step 5;

step 5: According to the actual situation, we will adopt some incentive measures to increase the supply volume.

Step 6: adopt genetic algorithm, count the sum of cost which satisfy the minus sum cost of storage and transportation, then jump to step 7;

Step 7: done.

The genetic algorithm as follows:

1.Initial Population

T chromosomes POP1..POPSIZE=$(\mathrm{Q_{1T}}, \mathrm{Q_{2T}}, \dots, \mathrm{Q_{LT}})$ are randomly generated by random integer, which satisfy $\sum_{k=1}^{L} \mathrm{Q_{kt}} = \mathrm{M}$, according constraint condition ,determine the feasible region $\mathrm{Q_{kt}} \in [0, \mathrm{Q_k}]$,$\sum_{k=1}^{L} \mathrm{Q_{kt}} = \mathrm{M}$, the generation of generator as follows:

The first generator :$\mathrm{Q_{1T}} \in [0, \min(\mathrm{Q_1}, \mathrm{M})]$;

The second generator: $\mathrm{Q_{2T}} \in [0, \min(\mathrm{Q_1}, \mathrm{M} - \mathrm{Q_{1T}})]$;

……

The L-1 generator:$\mathrm{Q_{L-1T}} \in [0, \min(\mathrm{Q_{L-1}}, \mathrm{A_{L-1T}}, \mathrm{M} - \sum_{k=1}^{L-2} \mathrm{Q_{kT}})]$;

The L generator: $\mathrm{Q_{LT=\sum_{k=1}^{L-1} Q_{kT}}}$

2. Fitness Function

The fitness function is by definition the measure of how well a candidate solution solves the problem. It is important to distinguish between fitness function and objective function that are used in genetic algorithms. The fitness function, which may be defined as the sum of all objective function value and the penalty for constraint violation, ban be calculated for each chromosome. Where f=C.

3.Selection

The selection process follows the evaluation of the fitness function. Fitness proportionate selection is also known as roulette wheel selection. The selection is a procedure in which chromosomes are selected POPSIZE times for reproduction.

4.Crossover

Crossover is a recombination technique used for creation of one or more offspring form the parents selected by means of exchange of the genetic material. According the rate P_c, determine the sum of crossover $n = \text{POPSIZE} \times P_c$ until the crossover number is n.

5.Mutation

Mutation is an operator that allows reappearing of the genetic material, that otherwise might be lost from the population using crossover alone. Mutation is a mechanism that ensures the algorithm is not stuck in local minima. The number of mutations is determined by choice and is often not more than several percepts from the number of variables in the population:

$nn = \text{POPSIZE} \times P_m$, where P_m is the mutation rate.

Example and discussion

According to the CDC forecast there will be 4 hospitals demand for 100 unit emergency drug. There are 5 suppliers, the information of hospital as Table 1, the suppliers and hospital as Table 2 or Table 3.

Table 1 Hospital Table

Hospital	A	B	C	D
Q_k	30	34	28	30
C_k	20	30	40	30

Table 2 Supply Time of vendors

Supplier / Hospital	a	b	c	d	e
A	4	2	4	5	6
B	5	3	3	4	3
C	3	4	3	7	2
D	5	6	5	2	4

Table3 Transportation price of vendors

Supplier / Hospital	a	b	c	d	e
A	300	200	300	450	600
B	400	200	400	350	400
C	300	350	400	550	300
D	400	400	260	300	200
Maxium supply	17	15	18	8	9

To minimize the transportation and storage cost, the amount of each vendor supply for hospital should be got from the cooperative model. From data, it can be included that the supply capacity of vendors is greater than the sum demand of hospital, so we can optimize by genetic algorithm, the optimize result as Table 4.

Table 4 Optimize result

Supplier / Hospital	A	B	C	D	E	Planned reserves
A	17	8	5	0	0	30
B	0	7	0	0	0	7
C	0	0	0	0	0	0
D	0	0	13	8	9	30
Total cost	18890					

The parameters in genetic algorithm, POPSIZE=50，P_c=0.3,P_m =0.1.It is no difficult to verify that the total cost is smaller than any scheme without optimization.

In this study, a cooperative model based on Internet is proposed. The quantity of reserves is optimized by using the mathematical model. It satisfies the economy and emergency in drug reserve.

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