Vehicle scheduling model of emergency logistics distribution based on internet of things

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Abstract: Considering that emergency logistics distribution has the timeliness, weak economy, and the traffic road condition and so on, based on reasonable assumptions, we effectively scheduled vehicles to maximise the demand for emergency logistics within the requested time. This paper proposes an emergency logistics vehicle scheduling model based on internet of things. Firstly, we built the model of emergency logistics distribution vehicle scheduling problem. Our research built a model of emergency logistics distribution vehicle scheduling by using the model of division time, and gave the interrelation of constraint condition. On this basis, this paper combined genetic algorithm and ant colony algorithm for the vehicle scheduling model design and parameter selection, which improved the efficiency of emergency logistics distribution. Simulation results show that the proposed model can effectively increase the transport efficiency and reduce transportation costs, and has strong practical value. It is suited for post-disaster emergency logistics distribution vehicle scheduling.

Keywords: internet of things; emergency logistics; vehicle scheduling model; simulation.


Biographical notes: Chang Qing received his Master’s degree in the Department of Computer and Information Engineering from Xinxiang University in 2007. He is currently a Lecturer of the Department of Computer and Information Engineering at Xinxiang University. His research interests include cloud computing, internet of things, information systems. His fund project is: Henan science and technology research project 142102310015.

1 Introduction

In recent years, the frequent occurrence of sudden disasters in China brings great influence on people’s lives, and gives people an extremely cruel memory at the same time. With the rapid development of modern society, social problems from all aspects of people’s lives and work have become increasingly prominent, resulting in the frequent occurrence of various sudden emergency and the expansion of the affected scope (Halldorsson and Mitra, 2016; Hung, 2015; Bao et al., 2015). Emergency logistics
is a special kind of logistics activities, which takes the providing emergency relief supplies in the treatment process of sudden natural disasters, public events and other sudden events and transferring the relief supplies to disaster areas and minimising the disaster losses in the shortest time as the purpose. Therefore, in the process of sudden disaster treatment, we need to set up an emergency logistics vehicle scheduling model to ensure the supplies of emergency materials in the treatment of sudden disasters (Lyu et al., 2015; Zhang et al., 2015). But most of the current relative researches expound on the establishment of emergency mechanism and the protection of emergency supplies, these researches are difficult to solve the problem of that the post disaster emergency logistics distribution vehicle scheduling time is long, the cost is much too high. Therefore, when emergency occurs, we set up emergency logistics system, and rapidly sent the relief supplies to the material demand point (Wang et al., 2016; Qiu and Wang, 2016; Ren and Tong, 2016), which directly affects the effectiveness of the rescue operations for whole emergent public event. However, the research of emergency logistics vehicle scheduling problem takes the network environment of internet of things as the premise. Through the internet of things, we carry out the remote overall deployment of distribution vehicles. Our search analyses characteristics of emergency logistics vehicle scheduling, builds a general emergency logistics vehicle scheduling model with non-full loads based on the internet of things using artificial immune algorithm to solve problems, and reasonably arranges scheduling operation of emergency supplies vehicles (Kaushik and Vidyarthi, 2016; Sajid and Raza, 2015; Wang et al., 2016). The cost of vehicle distribution is low and the efficiency is high. This is an important means to solve this problem, which has caused wide public concern of scholars and experts. This topic also becomes an important topic of industry research, and produces a lot of research findings (Tabyang and Benjaoran, 2016; Friese et al., 2015; Li et al., 2015).

Document proposes the improved heuristic model for emergency logistics vehicle scheduling. From finding the initial solution with weak feasibility of emergency logistics distribution vehicle scheduling, we improve it on the basis of maintaining the distribution vehicle scheduling solution characteristics, and enhance the feasibility of emergency logistics vehicle solutions. Then we continue to improve until a satisfactory solution is obtained. This model has the subjectivity of finding the initial solution of the emergency logistics distribution vehicle scheduling, which causes the satisfactory solution of emergency logistics distribution vehicle scheduling is not necessarily the most satisfactory solution. Document Teng et al. (2015), Mutlu et al. (2015) and Ya et al. (2015) sets the demand of supplies at affected sites as the fuzzy quantity, and considers the line problem of multiple emergency resource allocation points to multiple disaster points as the problem of the enormous vehicle at two-stage. So the emergency logistics distribution vehicle scheduling problem is completed. But this model operates complex, and will delay rescuing time in vehicle scheduling. Document Baker and Dan (2015), Zhao and Chen (2015) and Kumar et al. (2015) sets up emergency vehicle scheduling model for emergency logistics vehicle scheduling by thinking about the travel time random change and the randomness of location and type of the event not occurring and other uncertain factors, based on probability of occurrence of current event information and future events. But this model focuses on the future occurrence of event probability, and has uncertainty.
For above problems, this paper proposes an emergency logistics vehicle scheduling model based on internet of things. Firstly, we built the model of emergency logistics distribution vehicle scheduling problem. According to the characteristics of emergency logistics distribution, considering that emergency logistics distribution has the timeliness, weak economy, and the traffic road condition and so on, based on reasonable assumptions, we effectively scheduled vehicles to maximise the demand for emergency logistics within the requested time. We built a model of emergency logistics distribution vehicle scheduling by using the model of division time, and gave the interrelation of constraint condition in emergency logistics vehicle scheduling model. On this basis, this paper combined genetic algorithm and ant colony algorithm for the vehicle scheduling model design and parameter selection, which improved the efficiency of emergency logistics distribution. Simulation results show that the proposed model can effectively increase the transport efficiency and reduce transportation costs, and has strong practical value.

2 Emergency logistics distribution vehicle scheduling model based on internet of things

The biggest characteristic of emergency logistics is ‘urgency’, which emphasises the time benefit maximisation and disaster loss minimisation as the starting point and foothold. Compared with the general logistics, the emergency logistics has obvious differences in the target requirements and operating characteristics. Its specific performance are shown in Table 1.

![Figure 1](Schematic diagram of emergency logistics distribution vehicle scheduling based on internet of things)
Vehicle scheduling model of emergency logistics distribution

Table 1 General logistics and emergency logistics

<table>
<thead>
<tr>
<th>Item compared</th>
<th>General logistics</th>
<th>Emergency logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target requirements</td>
<td>The smallest loss and the greatest benefit</td>
<td>Time, efficiency, life</td>
</tr>
<tr>
<td>Use entities</td>
<td>Manufacturers and suppliers</td>
<td>Relief material reserve purchasing point</td>
</tr>
<tr>
<td></td>
<td>Wholesalers and retailers</td>
<td>Material transhipment point</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
<td>Disaster demand point</td>
</tr>
<tr>
<td>Operation characteristics</td>
<td>Routinisation</td>
<td>Temporary, emergency, sudden</td>
</tr>
<tr>
<td>Distribution mode</td>
<td>Reciprocating and itinerant</td>
<td>Unipolarity and reciprocating</td>
</tr>
</tbody>
</table>

The emergency logistics distribution vehicle scheduling based on the internet of things is shown in Figure 1.

In Figure 1, we can know that we use the amalgamation of GIS service and UI interface to collect the Geo-information data, then send them to EM service, dealing with the internet publishment, and judging the logistics information data, then sending the data to sensor network and delivery vehicle.

2.1 Emergency logistics distribution vehicle scheduling problem

The time of emergency logistics distribution directly influences the quality of post-disaster rescue. Reducing emergency logistics distribution time needs to optimise the emergency logistics distribution vehicle scheduling problem. With the characteristics of emergency logistics distribution and the multi-objective function of emergency logistics distribution vehicle scheduling, the model of emergency logistics distribution vehicle scheduling problem is established.

Figure 2 Sketch map of vehicle scheduling problem
Because it is the emergency logistics, it is necessary to consider the problem of time. For different loading points and unloading points, we arrange reasonable driving routes and send emergency materials to the unloading point within shortest time. The vehicle scheduling problem has different Figure 2.

**Table 2  Classification of vehicle scheduling problem**

<table>
<thead>
<tr>
<th>Division standard</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of distribution centres</td>
<td>Single distribution centre problem</td>
</tr>
<tr>
<td></td>
<td>Multi distribution centre problem</td>
</tr>
<tr>
<td>Vehicle type</td>
<td>Single-type vehicle problem</td>
</tr>
<tr>
<td></td>
<td>Multi-type vehicle problem</td>
</tr>
<tr>
<td>Vehicle loading condition</td>
<td>Full load problem</td>
</tr>
<tr>
<td></td>
<td>Non full load problem</td>
</tr>
<tr>
<td>Ownership of vehicle for parking lot</td>
<td>Open vehicle problem</td>
</tr>
<tr>
<td></td>
<td>Closed vehicle problem</td>
</tr>
<tr>
<td>Customer requirements for the pickup time</td>
<td>Time constrain</td>
</tr>
<tr>
<td></td>
<td>Without time constraints</td>
</tr>
<tr>
<td>Whether can determine the r attributes about customer, vehicle, transportation network</td>
<td>Static problem</td>
</tr>
<tr>
<td></td>
<td>Dynamic problem</td>
</tr>
<tr>
<td>Optimisation objective</td>
<td>Single objective problem</td>
</tr>
<tr>
<td></td>
<td>Multi-objective problem</td>
</tr>
<tr>
<td>Distribution task characteristics</td>
<td>Simple deliver goods problem</td>
</tr>
<tr>
<td></td>
<td>Simple pickup problem</td>
</tr>
<tr>
<td></td>
<td>Mixed problem about the pickup and deliver goods</td>
</tr>
</tbody>
</table>

Setting up a system with supply-demand relationship, there are a number of vehicles, disaster relief materials distribution centre, relief workers. This requires a reasonable arrangement of the route and departure time, according to the constraint conditions, supplying needs of relief personnel in time to achieve the optimal effect of objective function. The vehicle scheduling problem is shown in Figure 2.

Setting \( D = \{0, 1, \cdots, n\} \) indicates the sets of centre of relief supplies and the demand points. Among them, 0 represents the centre of relief supplies. The serial number of demand point is \( S(i = 1, 2, \cdots, n) \). \( K = \{1, 2, \cdots, m\} \) represents the sets of emergency logistics vehicle. \( Q \) represents maximum load-bearing capacity of emergency logistics vehicle. \( d_i \) represents the relief supplies demand at demand point \( i \). \( C_{ij} \) represents the transportation cost (such as the time, the distance, the cost, etc.) between demand points \( i \) and \( j \). \( x_{ijk}, y_{ik} \) represents the decision variable of the vehicle scheduling. Set as:

\[
x_{ijk} = \begin{cases} 
1 & \text{Vehicle } k \text{ travels from point } i \text{ to point } j \\
0 & \text{others} 
\end{cases} \tag{1}
\]

\[
y_{ik} = \begin{cases} 
1 & \text{Distribution of user by vehicle } k \\
0 & \text{others} 
\end{cases} \tag{2}
\]
The establishment of emergency logistics distribution vehicle scheduling digital model is to achieve the optimisation of the distribution vehicle scheduling. The objective function of the minimum transportation cost of emergency logistics distribution vehicles is expressed as formula (3).

\[
\min Z = \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{k} C_{ij} x_{ijk} \tag{3}
\]

Formula (4) indicates that the material weight distribution of each vehicle is not more than the maximum load capacity of the emergency logistics distribution vehicle.

\[
S_t \sum_{i=1}^{n} d_i y_{ik} \leq Q \quad \forall k \in R \tag{4}
\]

Formula (5) represents only one emergency logistics distribution vehicle at each demand point.

\[
\sum_{k=1}^{n} y_{ik} = 1 \quad \forall i \in R \tag{5}
\]

Formula (6) and (7) represent the number of distribution vehicles that arrived and left the demand point is identical.

\[
\sum_{i=0, i \in j}^{n} x_{ijk} = y_{ik} \quad \forall i \in D, \forall k \in D \tag{6}
\]

\[
\sum_{j=0, j \in i}^{n} x_{ijk} = y_{ik} \quad \forall i \in D, \forall k \in D \tag{7}
\]

\[
y_{ik}, x_{ijk} = \{0, 1, \cdots, n\} \quad \forall i, j \in D, \forall k \in R \tag{8}
\]

Formula (8) represents 0–1 constraint variable for distribution vehicles. Emergency logistics distribution vehicle routing problem is a multi-constraint and non-deterministic polynomial optimisation problem. Finding the optimal solution has been the focus of scholars and experts. So the emergency logistics distribution vehicle routing multi-objective should be optimised. The multi-objective problem can be expressed as:

\[
\min y = (f_1(x), f_2(x), \cdots, f_m(x)) \tag{9}
\]

\[
s.t. g_i(x) \leq 0, \quad i = 1, 2, \cdots, s
\]

\[
h_j(x) = 0, \quad j = 1, 2, \cdots, k
\]

Among them, \(m\) is the number of objective functions. \(g_i(x) \leq 0, \quad i = 1, 2, \cdots, s\) defines \(s\) inequality constraints. \(h_j(x) = 0, \quad j = 1, 2, \cdots, k\) defines inequality constraints.

With the development, initially we use the linear weighted method to transform into a single objective problem. Due to the efficiency is not high and the quality is not good, more and more multi-objective optimisation models have been proposed, and the application of Pareto model is more widely used.
Set $x_1$ and $x_2$ as the solutions of formula (3). If and only if the formula (10) is workable, we call $x_1$ the dominant Pareto compared with $x_2$. Remember it as $x_1 \succ x_2$, it can also be called $x_1$ dominate $x_2$.

$$f_i(x_1) \leq f_i(x_2) \quad \forall i = 1, 2, \ldots, m$$

$$f_i(x_1) \leq f_i(x_2) \quad \exists i = 1, 2, \ldots, m$$  \hspace{1cm} (10)

If and only if formula (11) is workable, $x$ is called the Pareto optimal solution, $x$ is not dominated by any other solution. So the model of emergency logistics distribution vehicle scheduling problem is structured.

$$-x^* \in X_f, x^* \succ x$$  \hspace{1cm} (11)

Emergency relief process in China: catastrophe happened – assessment report of disaster situation – launched contingency plan – the whole society will participate in disaster relief. The relief flow chart is shown in Figure 3.

**Figure 3** Emergency relief process

When the disaster comes, the emergency command system can quickly carry out disaster relief materials collection, acquisition, smooth relief work on the network platform only relying on intelligence and the use of internet of things networking technology. Emergency logistics distribution vehicle scheduling process in the internet of things
Vehicle scheduling model of emergency logistics distribution

The rapid information collection and processing analysis has an important impact on the developing of post-disaster relief work.

Figure 4  General view of the internet of things information system

2.2 Emergency logistics distribution vehicle scheduling model based on internet of things

The emergency logistics vehicle scheduling has timeliness and weak economic characteristics, with the influence of emergency logistics distribution vehicle road and other factors, by reasonable assumption, in the request time, the demand point of the material needs to get the greatest satisfaction. By dividing the constraint flow, we set up emergency logistics vehicle scheduling model. To achieve that all demand points are met with the greatest satisfaction in the requested time needs to meet the formula (3).

The constraint condition of emergency logistics distribution vehicle scheduling model includes emergency material flow constraints, vehicle flow constraints, emergency material flow and vehicle flow relevant constraint type. Set $T$ to represent the length of time of the distribution plan period; set $A$ to represent collection $A = \{a_1, a_2, \cdots, a_k\}$ of disaster relief materials; $X$ represents the collection $X = \{x_1, x_2, \cdots, x_m\}$ of demand point and transfer points; $G$ represents emergency supplies set; $R$ represents all emergency material demand point and supply point; $D_{ai}$ represents demand or supply of point $i$ for the material $a$ at time $t$ (positive represents the supply, negativity represents demand); $Z_{aij}$ represents number of $a$ materials transport on arc $(i, j)$ at time $t$; $d_{ai}$ represents the amount of material $a$ that is not satisfied at the point $i$ of emergency supplies at time $t$. The
logistics constraints of disaster relief goods can be expressed as formulas (12)–(14), and the expression of non-negativity restrictions is formula (15).

$$\sum_{q=1}^{i} \left[ -\sum_{j \in C} Z_{ajt,(q-t)} + \sum_{j \in C} Z_{alij} \right] - d_{ait} = \sum_{q=1}^{i} D_{alit}$$
\hspace{1cm} (\forall a \in A, i \in X, \in T) \tag{12}

$$\sum_{q=1}^{i} \left[ -\sum_{j \in C} Z_{ajt,(q-t)} + \sum_{j \in C} Z_{alij} \right] - d_{alit} \leq \sum_{q=1}^{i} D_{alij}$$
\hspace{1cm} (\forall a \in A, i \in G, t \in T) \tag{13}

$$Z_{a,B,t} + Z_{ajt,B,t} = 0 \quad (\forall a \in A, j \in R, t \in T) \tag{14}$$

$$Z_{ajt} \geq 0; \quad d_{alit} \geq 0 \tag{15}$$

Formula (12) represents emergency material flow constraints of the demand point and the transfer point. It indicates the relations between the amount of relief supplies receives by demand point and the unmet needs for their disaster relief supplies. Formula (13) represents emergency material flow constraint of disaster relief centre and represents the relationship between the amount of disaster relief materials sent to the demand point from the disaster relief centre and the stock balance of relief supplies centre. Formula (14) is a transit point for emergency material flow balance constraints. It indicates that the amount of emergency material entering the transfer point is equal to the amount of emergency material leaving this point.

Vehicle flow constraints include formulas (16)–(20) in the model. Formula (16) represents the restrictions of emergency logistics distribution vehicle routing, limiting the emergency logistics distribution vehicle routing, describing the routing that can be passed and the routing that cannot be passed. Formula (17) represents the constraint on the number of emergency logistics distribution vehicles, which limits the number of emergency material distribution vehicles in demand points. Formula (18) represents the balance constraints of emergency logistics distribution vehicle flow. Formula (19) indicates that the number of disaster relief material distribution vehicle through the arc \((i, j)\) cannot exceed the capacity of the road. Formula (20) represents the restricted function of the emergency logistics distribution vehicle, which indicates that the decision variables of the distribution vehicle flow are not negative, and they’re all integers.

$$Y_{ij} \leq t_{ij}K \quad (\forall [i, j] \in R, t \in T) \tag{16}$$

$$\sum_{q=1}^{i} Y_{R,iq} \leq \sum_{q=1}^{i} l_{iq} (\forall o \in R, m \in M, t \in T) \tag{17}$$

$$\sum_{q=1}^{i} \sum_{j \in C} Y_{j,(q-t)} - S_{a} = \sum_{q=1}^{i} \sum_{j \in C} Y_{jij}$$
\hspace{1cm} (\forall i \in R, t \in T) \tag{18}

$$Y_{ij} \leq \text{cap}_{ij} \quad (\forall [i, j] \subseteq C) \tag{19}$$
Among them, $N$ represents the maximum load of emergency logistics vehicle; $cap_{ij}$ represents the road capacity of load arc $(i, j)$; $l_i$ represents the number of available emergency logistics vehicle in emergency supplies point $i$ at time $t$. $Y_{ijt}$ represents the number (integer) of emergency logistics distribution vehicle running on the arc $(i, j)$ at time $t$. $S_i$ represents the number (integer) of emergency logistics distribution vehicle waiting on emergency supplies point $i$ at time $t$.

The correlation constraints of cargo logistics and vehicle flow are the formula (21), which indicates the relationship between emergency logistics and distribution vehicle flow.

$$Y_{ijt} N \geq 0 \text{And they're all integers: } S_i \geq 0 \text{And they're all integers}$$

$$Y_{ijt} \geq \sum_{a \in A} w_a Z_{a ij} (\forall \{i, j\} \subseteq C, t \in T)$$

Among them, $w_a$ represents the unit weight of a material. In above formula, the emergency logistics constraint indicates the conditions that should be met from the supply point to the demand point. Vehicle flow limits the relationship of vehicle operating, and reduces costs. In general, the model connects independent individuals into a whole through the association constraints expressing the relationship between the emergency supplies and the distribution vehicles. Considering ‘urgent’ in logistics is how to send the material to each demand point as quickly as possible. The interconnection constraint contacts the relationship between cargo flow and vehicle flow through the way of that the weight of the goods cannot exceed the maximum weight of the carrying vehicle. By this way, we combine the emergency logistics with the vehicle flow to establish the scheduling model of emergency logistics and distribution vehicles.

### 2.3 Genetic-ant colony combined algorithm for emergency logistics distribution vehicle scheduling

Combining genetic algorithm with ant colony algorithm is to carry out emergency logistics vehicle distribution scheduling. Due to the advantage of speediness, randomicity, genetic algorithm, global convergence, the genetic algorithm is suitable for searching the initial pheromone distribution of relevant issues, improving disadvantages of pheromone plaque deficiency and slow solution in the initial stage of ant colony algorithm.

#### 2.3.1 Genetic algorithm theory

Genetic algorithm is a global optimisation algorithm based on nature genetic and natural selection. It has the advantages of implicit parallelism, good global searching ability and strong robustness and flexibility. The main operations of genetic algorithm are selection, crossover and mutation. The core content is parameter coding, generation of initial population, design of fitness function, design of genetic operator and setting of control parameters.

The basic principle of genetic algorithm is closely related to its constituent elements, the main constituent elements are as following five points:
- Encoded mode: coding is the conversion method which transforms feasible solution of the emergency logistics distribution vehicle scheduling problem from its solution space to genetic algorithm can handle. Encoded mode is the primary problem of genetic algorithm.

- The generation of initial population: the genetic algorithm is a search group algorithm. It needs to prepare an initial group consisting of several individuals for genetic operations. Each individual is randomly generated, which indicates the initial solutions of the problem.

- Fitness function: generally, genetic algorithm does not need other external information in the search process, which only uses the fitness to evaluate individual advantages and disadvantages, and takes it as the basis for the implementation of genetic operations. Fitness function directly determines the quality of the solution set. If choosing improperly, it may result in local optimisation rather than global optimisation.

- Genetic operations: genetic operations mainly refers to the selection, crossover, mutation. The selection of relevant parameters of various processes of genetic operations affects the efficiency and results of genetic algorithms.

- Stop condition: in order to make the algorithm do not limit the operation, we need to set a stopping rules. The frequently-used stop standards are convergence criteria, time standards and accuracy standards. Setting the maximum number of iterations is to stop the algorithm operation.

**Figure 5** Basic flow chart of genetic algorithm
The basic flow of genetic algorithm is shown in Figure 5.

The genetic algorithm has strong applicability, versatility, good global optimisation, good augmentability and implicit parallelism. This algorithm is easy parallelism. But there are still many shortcomings in genetic algorithms, such as using the evaluation function heuristic in search, the process is too simple; the use of probability mechanism for iteration has the disadvantages of randomness. The search has blindness, easy precocity and other disadvantages.

2.3.2 Ant colony algorithm

Ant colony algorithm is an evolutionary algorithm inspired by the foraging mechanism of real ant colonies. It solves similar optimisation problems by simulating the foraging process of ants, and has Jiao Deqiang robustness, good distributed computing strategy and the advantage that easy to combine with other algorithms using in scientific research of various fields. Figure 6 is the basic flow chart of ant colony algorithm.

*Figure 6*  Basic flow chart of ant colony algorithm
Supposing there are $n$ disaster demand points, the set of them is $C$, $m$ represents the emergency supplies distribution vehicles, $d_{ij}$ ($i, j = 1, 2, \cdots, n$) shows the distance between affected demand point $i$ and $j$, $b_i(t)$ shows the number of emergency supplies distribution vehicles located in the affected demand point $i$ at time $t$, $m = \sum_{j=1}^{n} b_i(t)$. $\tau_i(t)$ represents the weight of emergency supplies in the path between the disaster demand point $i$ and $j$ at the time $t$. $\eta_{ij}$ shows the heuristic information from the affected demand point $i$ to the demand point $j$. In general, $\eta_{ij} = 1 / d_{ij}$. At time $t$, the probability of the vehicle from the disaster demand point $i$ to the demand point $j$ can be expressed as:

$$P_{ij}^k = \begin{cases} \frac{[\tau_i(t)]^\alpha [\eta_{ij}(t)]^\beta}{\sum_{j=\text{allowed}_k} [\tau_i(t)]^\alpha [\eta_{ij}(t)]^\beta}, & j \in \text{allowed}_k \\ 0, & \text{otherwise} \end{cases} \quad (22)$$

In above formula, $\text{allowed}_k$ shows a set of demand points which will drive of the emergency logistics distribution vehicles. $\alpha$ represents the material supplied in the automobile travel process. $\beta$ represents the expected value heuristic factor of emergency supplies:

$$\tau_{ij}(t+1) = (1 - \rho) \cdot \tau_{ij}(t) + \rho \cdot \Delta \tau_{ij}(t) \quad (23)$$

$$\Delta \tau_{ij}(t) = \sum_{k=1}^{m} \Delta \tau_{ij}^k(t) \quad (24)$$

Among them, $\rho$ represents to the transmitting material coefficient. $\Delta \tau_{ij}^k(t)$ represents the total number of material resources of vehicles $k$ left in the path $(i, j)$.

$$\Delta \tau_{ij}^k(t) = \begin{cases} \frac{Q}{d_{ij}}, & \text{if the } k\text{th vehicle pass}(i, j) \text{ between } t\text{and } t+1 \\ 0, & \text{otherwise} \end{cases} \quad (25)$$

Among them, $Q$ is the total amount of emergency supplies.

However, at the beginning, this algorithm has the information lack, resulting in the initial accumulation of information needs a long time. The algorithm is itself complex, needs the strong search time, and it is prone to stagnation.

### 2.3.3 Genetic-ant colony combined algorithm theory

Because the genetic algorithm and ant colony algorithm have their own advantages and disadvantages, how to make best use of the advantages and bypass the disadvantages and use their advantages to achieve the optimal scheduling of emergency logistics distribution is the key point to be considered. Therefore, the genetic-ant colony combined algorithm is proposed to overcome the weakness in the two algorithms.

In the initial collection of information, ant colony algorithm has the weakness of information lack, longer time spending and easy stagnation, and genetic algorithm has large-scale fast global search ability, but the utilisation rate of its feedback information is
not high with low resolution efficiency. For above reasons, firstly we use the large-scale rapid global search ability of genetic algorithm to gather information, then using the advantages of ant colony algorithm in information processing for information analysis and solution. Thus, the information gathering process after the combination is better than ant colony algorithm, and the information analysis and solution are better than genetic algorithm.

Simply, using genetic algorithm in the initial, we make full use of the advantages of the genetic algorithm for emergency relief material supply information collection; afterwards using ant colony algorithm to deal with and process the collected emergency relief supplies information is to improve the efficiency of solution. The specific process is shown in Figure 7.

Using the genetic-ant colony combined algorithm is helpful to improve the ability of collection and analysis of emergency relief supplies information of the information system of the internet of things, which lays the ground for the disaster relief work smoothly.

Figure 7 Flow chart of genetic ant colony algorithm
3 Experimental results and analysis

In order to prove the effectiveness of the genetic-ant colony algorithm for the emergency logistics distribution vehicle scheduling, using matlab 7.0 as the tool and P-4 as the platform, setting $\alpha, \beta, Q, \tau, \rho$, we carry out simulation experiment of emergency logistics distribution vehicle scheduling.

Supposing that a natural disaster area, its emergency logistics distribution includes a relief supplies centre, seven demand points (Figure 8). Setting the centre node of relief supplies to 0, supplies quantity demanded of demand points $i(i = 1, 2, \cdots, 7)$ is $g_i$, unloading time is $UT_i$, $LT_i$ represents the latest delivery time. Assuming that the carrying capacity of the truck is 8 tons, the average speed is 60 km/h. Vehicles cannot be overloaded and must deliver the goods to the point of demand within the specified time. The material demand at each demand point, the distance between disaster relief materials centre and the demand points, and the distance between each point of demand are in Tables 3 and 4. Requires a reasonable vehicle scheduling, to achieve the minimum operating costs. This requires a reasonable vehicle scheduling for achieving the least operating costs.

Figure 8 Location map of demand points and disaster relief centre

Table 3 Demand schedule of demand point

<table>
<thead>
<tr>
<th>Serial number of demand points</th>
<th>Quantity demanded/t</th>
<th>Unloading time/h</th>
<th>Time limit of shipment arrival/h</th>
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<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>0.2</td>
<td>[−, 5]</td>
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<td>7</td>
<td>2.5</td>
<td>0.5</td>
<td>[−, 5]</td>
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Table 4  Distance matrix

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<td>45</td>
<td>50</td>
<td>35</td>
<td>40</td>
<td>0</td>
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</tbody>
</table>

According to the experiment, we determine its optimal portfolio selection $\alpha = 1$, $\beta = 3$, $Q = 100$, $\tau(0) = 0.000001$, $\rho = 0.5$, by using genetic-ant colony combined algorithm to solve the above parameters. The operation result with running eight times is shown in Table 3. The emergency supplies distribution vehicle scheduling route is shown in Table 5.

Table 5  Results of genetic-ant colony algorithm with running eight times

<table>
<thead>
<tr>
<th>Run times</th>
<th>Total cost/(yuan/h)</th>
<th>Time/h</th>
<th>Cost/yuan</th>
<th>Number of vehicles</th>
<th>Final iterative-algebraic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>231.78</td>
<td>16.46</td>
<td>1,090.57</td>
<td>3</td>
<td>54</td>
</tr>
<tr>
<td>2</td>
<td>227.46</td>
<td>15.34</td>
<td>1,082.36</td>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>228.79</td>
<td>15.76</td>
<td>1,083.08</td>
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</tr>
<tr>
<td>4</td>
<td>236.48</td>
<td>17.59</td>
<td>1,106.72</td>
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<td>36</td>
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<tr>
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<td>240.65</td>
<td>18.07</td>
<td>1,114.33</td>
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<td>237.82</td>
<td>17.84</td>
<td>1,107.91</td>
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<td>51</td>
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<tr>
<td>7</td>
<td>235.91</td>
<td>17.38</td>
<td>1,105.37</td>
<td>3</td>
<td>16</td>
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<td>8</td>
<td>227.46</td>
<td>15.37</td>
<td>1,082.76</td>
<td>3</td>
<td>28</td>
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</tbody>
</table>

Table 6  Emergency logistics vehicle scheduling situation

<table>
<thead>
<tr>
<th>Vehicle number</th>
<th>Driving route</th>
<th>Time of arrive at each point/h</th>
<th>Goods amount/t</th>
<th>Mileage/km</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0-7-5-4-0</td>
<td>0-1.17-2.35-3.72-4.54</td>
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<td>0-1.75-2.82-4.27</td>
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<td>195</td>
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<tr>
<td>3</td>
<td>0-3-1-0</td>
<td>0-1.62-2.34-3.12</td>
<td>5.7</td>
<td>160</td>
</tr>
</tbody>
</table>

Using the traditional ant colony algorithm to solve the above problems, running eight times the results are expressed in Table 7, the cost of the genetic and ant colony algorithm which combined with the comparison results obtained in Figure 9 represents.
Table 7  Ant colony algorithm with running eight times

<table>
<thead>
<tr>
<th>Run times</th>
<th>Total cost/(yuan/h)</th>
<th>Time/h</th>
<th>Cost/yuan (yuan)</th>
<th>Number of vehicles</th>
<th>Final iterative-algebraic</th>
</tr>
</thead>
<tbody>
<tr>
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<td>242.89</td>
<td>17.57</td>
<td>1,101.32</td>
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<td>76</td>
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<td>3</td>
<td>248.28</td>
<td>18.16</td>
<td>1,106.76</td>
<td>3</td>
<td>37</td>
</tr>
<tr>
<td>4</td>
<td>237.91</td>
<td>16.59</td>
<td>1,120.45</td>
<td>3</td>
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<td>18.57</td>
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<td>251.38</td>
<td>19.38</td>
<td>1,120.17</td>
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<td>247.46</td>
<td>17.87</td>
<td>11,118.55</td>
<td>3</td>
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</tbody>
</table>

Figure 9  Comparison of optimisation results

From the chart, we can see that the genetic-ant colony combined algorithm on cost is lower than the traditional algorithm. The genetic-ant colony combined algorithm reduces the total cost. At the same time, this proves that the emergency logistics distribution vehicle scheduling model based on internet of things in this research under the premise of satisfying the emergency logistics time requirements considers emergency relief supplies information and reasonably arranges the driving route of disaster relief vehicles, saving the transportation cost of emergency logistics vehicles in great measure, and effectively enhances the efficiency of emergency logistics.

4 Conclusions

The disaster seriously affected the social stability and harmony. The emergency supplies for protecting life and the lives is the most urgent need in affected areas. This paper proposes an emergency logistics vehicle scheduling model based on internet of things. Firstly, we built the model of emergency logistics distribution vehicle scheduling problem. Our research built a model of emergency logistics distribution vehicle
scheduling by using the model of division time, and gave the interrelation of constraint condition. We combine the genetic algorithm with the ant colony algorithm reducing the distribution cost of vehicles, which improved the efficiency of emergency logistics distribution. and provides a reference to solve the emergency logistics distribution vehicle scheduling based on the internet of things, which has great value.

References


