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# Design and Implementation of Pet Logistics Service System based on the Internet of Things

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**Abstract.** It is well known that unlike other commodities, the pet transport needs a real-time monitoring of pet status. However, in fact, at present, we can't well do it. As a result, pet injuries, loss, deaths, these kinds of problem frequently crop up during transportation. At the same time, the high cost of domestic transport, and the traditional extensive transportation route management further hindered the development of pet Logistics. Our study tries to design and implementation a pet logistics service system on the internet of things. It is committed to improve the level of information pet logistics and create an efficient and secure service platform for pet logistics in china.

**Keywords:** Internet of things, Logistics service system, Pet logistics, IP-RFID.

## 1. Introduction

With the change of family structure and the development of living standard in our country, pet as a high level spiritual plays an important role in modem family.(White paper on Chinese pet industry in 2016)shows that in 2017, China's pet market size of about 150 billion, by 2020 is expected to break through 200.

At the same time, the increase of the phenomenon about job move, residence change, travel, pet sale and so on, pet logistics is coming. As an extension of pet services, pet logistics play a key role in the development of the pet market. However, it is disappointing that, there are many problems in our country about pet logistics: Pet cannot be guaranteed safety in transit, Low level of information service, High cost of logistics, Shirk responsibility and so on.

Almost all of the domestic literature recognizes that, in the country, the backward pet logistics information technology has seriously hindered the development of pet industry. (see [1], [2] and [3]). However, it is disappointing that, most of the domestic researches on pet logistics stay in the theoretical stage, the application and exploration of information technology is few.

Zhaoli Chen et al in 2017 [1] summarize the pet logistics research in recent years, and analysis of the current pet logistics operation mode. The focus is to use the chart method to comb the business process of logistics service providers, to find the problems in the operation mode of pet logistics. In the end, they put forward some innovative modes, such as, set up a special third-party pet logistics company, building “third party logistics + petummarize the problem in pet logistics, point out emphatically the level of pet logistics information need to be improved. They stress the lag of information technology will affect the quality of pet logistics in the future. Therefore, improving the level of pet logistics information will be a major direction for the future development of this industry. Chunyang Pan [2] point out some developed countries have already installed the necessary vital signs monitoring equipment for pets during their pet transportation, and then carried out remote real-time monitoring in different places. But, how to implement the equipment did not say. Based on above, we find that the domestic scholars' research about pet logistics into this information and technology problem is not sufficient enough.

In foreign countries, it is possible to apply advanced information technology to pet logistics. Hyung-Rim Choi et al [4] study a system that can use IP-RFID to monitor the location and environment of pet dogs during transportation. J. Park et al [5][6] design and implementation Ubiquitous Care System for pet using Web2.0. S. H. Hong et al [7] provide a U-Pet service System in smart environments.

The Internet of things (IoT), as an important means of future human intelligence, the development is getting more and more attention, and may become a new communication technology. The Internet of Things emerged in the early 2000s. [8]

It is a sensor technology, internet technology and communication technology as a whole to connect the objects between the network. Things to achieve the object to speak and communicate with the human.

The logistics information system based on the internet of things, the underlying hardware support of the IoT service uses a wireless sensor network to collect, upload, and receive commands from sensor nodes. The logistics information system then stores and processes data from sensors to track and monitor logistics in real time. [9] The realization of the connection between goods and goods, goods and transportation tools, goods and people has formed intelligent logistics.

The traditional logistics system only provides the location information through the order number. Facing the challenges of intelligent logistics, it cannot track the location and status of logistics (temperature, humidity, etc.) in real time to meet the needs of specific users. There is no visualization or route optimization during transportation. In this paper, the design and implementation of the pet logistics information system based on the Internet of things enables real-time tracking of pets, such as location and status, and provides more detailed pet information to pet owners, drivers and veterinarians.

We named the system "Chong Da", and the innovations of this system include the following points:

A. Comes with line planning function to help the driver find the optimal delivery path.

B. IP-RFID technology for the first time into the pet transportation system in Chain.

C. Independent development the online APP for Pet Logistics service System.

## 2. System Design

### 2.1 Route Optimization Model

The study tries to find the shortest distance go to the place of delivery, and the maximum profit of the return trip. Therefore, the problem can be divided into two parts:

1) Trip, the logistics business will transport pets to designated locations according to customer requirements. At this time, logistics should find a shortest path.

2) Return trip, the driver can choose a path that maximizes the return profit from a known location, based on the expected profit for each location.

Assuming that the trip is full load transportation and define the following notation:

Table 1. The description of notations.

| Notation | Description |
|---|---|
| Q | Vehicle load,Q>0 |
| P | Unit transport price of the trip |
| C | Unit transport cost of the trip |
| L | Transport distance of the trip ,L>0 |
| $R_0$ | Profit of the return trip |
| $L^*$ | Shortest path of the trip |
| $R_0^*$ | Maximum profit about return |
| G | Set of the delivery locations about the trip, $G=\{1,2,...,m\}$ |
| B | Set of the return from the places |
| i | To the location code |
| j | Return the location code |
| $D_{ij}$ | Distance from i to j |
| $P_{ij}$ | Price from i to j |
| $p^*$ | Optimal transportation price during trip |

If logistics is to be profitable in transit, the sum of profits from the round trip should be positive:

$$(P-C)QL+R_0 \geq 0(1)$$

we get

$$P \geq C-R_0/QL(2)$$

$$P^* = C-R_0^*/QL^*(3)$$

a. To the path selection, the mathematical model is as follows:

Equation (5) indicates that each place must be visited once. (6) shows that vehicle must access a place every time and the vehicle must proceed from the network. (7) means that if the vehicle from i to j, $x_{ij}=1$.otherwise, $x_{ij}=0$.

## 2.2 The Selection of Return

Return will be the m+1 as the starting point. Define the variable,

$$y_{i',j'} = \begin{cases} 1, \text{The vehicle starts at 0 and the i-th location is j} \\ 0, \text{ Otherwise} \end{cases} \quad i=1,2,\ldots,n \quad j=0,1,\ldots m,m+1 \quad n \leq m$$

The mathematical model is as follows:

$$\max \ z = \sum_{k=0}^{m}\sum_{l=0}^{m+1}\sum_{i'=0}^{n-1}(P_{kl}-C)QD_{kl}\,y_{i'k}\,y_{i'+1,l}(8)$$

$$st.\sum_{j=0}^{m} y_{ij} \leq 1, i=1,2,\ldots,n(9)$$

$$y_{l,m+l}=1(10)$$

$$\sum_{i=0}^{n} y_{ij} \leq 1, j=1,2,\ldots,m(11)$$

$$\sum_{i=0}^{n} y_{i,0}=1(12)$$

$$\sum_{K=0}^{m}\sum_{l=0}^{m+1} D_{kl}\,y_{ik}\,y_{i+1,l} \leq D, i=1,2,\ldots,n-1(13)$$

$$\sum_{k=i+0}^{n}\sum_{j=0}^{m} y_{ki} \leq 1-y_{i,0}, i=1,2,\ldots,n-1(13)$$

$$\sum_{k=i+0}^{n}\sum_{j=0}^{m} y_{ki} \leq 1-y_{i,0}, i=1,2,\ldots,n-1(14)$$

$$y_{ij}=0,1, i=1,2,\ldots,n, j=0,1,2\ldots,m,m+1$$

shows that vehicle most visit one at a time. (10) provisions of the first visit to the place must be m+1. (11) each pet shop is visited one times at most; (12) set that the place 0 must be visited one times. (13) is the distance constraint of the vehicle's return travel. (14) means once the place 0 has been visited, then the vehicle will no longer continue to visit others.

By calculating the cost of trip and return profit we can get, and then $p^*$.

## 2.3 IP-RFID Tehnology

The IP-RFID technology takes advantage of USN and RFID technology and combines it with the smallest IPv6 technology [5]. IP-RFID systems do not require a separate communication infrastructure because tags can provide information over the Internet. IP-RFID can transmit information about moving objects because it can transmit information anywhere the network is available.

The system can monitor the status of the pet in real time, have problems and take the necessary actions. For example, the sensor is first attached to the pet's neck and hind legs to monitor its body temperature and pulse. The transport box or container will be equipped with speakers and fans. There are sensors for measuring temperature and humidity, IP cameras for video transmission and speakers for voice transmission. Figure 1 is a system configuration of a pet safe transportation system.

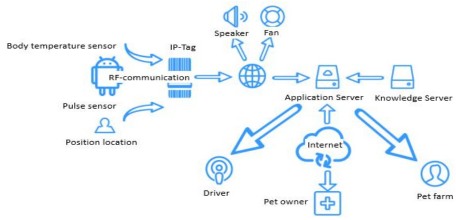



Fig. 1. The structure of the pet logistics service system

The operating procedures of the system include the pet security transportation system transaction function and two-way communication function content are:

1) the program helps the IP- Tag itself to solve the problem if it is changed by the simple temperature of the environment;

2) When the pet is seriously disturbed by changes in the environment, the program helps the pet owner to take two-way communication in real time;

3) After the pet is sick or injured, the procedure helps the driver to consult the veterinarian after taking direct action.

# 3. System Implementation and Discussion

## 3.1 Hypothesis and Data Analysis of Route Optimization Model

Assuming m=9, Q=1, C=30. The coordinate map of every places is shown in figure 1. Among them, 0 represent the starting point, and 9 represent at the end. Table 2 and 3 respectively, between the distance and profits.

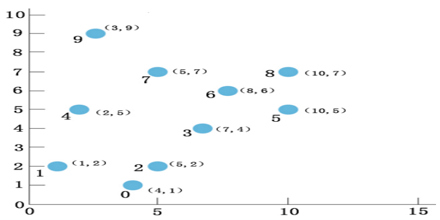



Fig. 2. The coordinate map of every places

Table 2. The distance between every place.

Unit: km

| Distance | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0. 00 | 3. 16 | 1. 41 | 4. 24 | 4. 47 | 7. 21 | 6. 40 | 6. 08 | 8. 49 | 8. 06 |
| 1 | 3. 16 | 0. 00 | 4. 00 | 6. 32 | 3. 16 | 9. 49 | 8. 06 | 6. 40 | 10. 3 | 7. 28 |
| 2 | 1. 41 | 4. 00 | 0. 00 | 2. 83 | 4. 24 | 5. 83 | 5. 00 | 5. 00 | 7. 07 | 7. 28 |
| 3 | 4. 24 | 6. 32 | 2. 83 | 0. 00 | 5. 10 | 3. 16 | 2. 24 | 3. 61 | 4. 24 | 6. 40 |
| 4 | 4. 47 | 3. 16 | 4. 24 | 5. 10 | 0. 00 | 8. 00 | 6. 08 | 3. 61 | 8. 25 | 4. 12 |
| 5 | 7. 21 | 9. 49 | 5. 83 | 3. 16 | 8. 00 | 0. 00 | 2. 24 | 5. 39 | 2. 00 | 8. 06 |
| 6 | 6. 40 | 8. 06 | 5. 00 | 2. 24 | 6. 08 | 2. 24 | 0. 00 | 3. 16 | 2. 24 | 5. 83 |
| 7 | 6. 08 | 6. 40 | 5. 00 | 3. 61 | 3. 61 | 5. 39 | 3. 16 | 0. 00 | 5. 00 | 2. 83 |
| 8 | 8. 49 | 10. 3 | 7. 07 | 4. 24 | 8. 25 | 2. 00 | 2. 24 | 5. 00 | 0. 00 | 7. 28 |
| 9 | 8. 06 | 7. 28 | 7. 28 | 6. 40 | 4. 12 | 8. 06 | 5. 83 | 2. 83 | 7. 28 | 0. 00 |

Table 3. Profits from transportation between every place

Unit: Hundres yuan

| Profit | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | −1 | 2 | 1 | 2 | 3 | 2 | 3 | 1 | 2 |
| 1 | 1 | 0 | 1 | 3 | 2 | 5 | 3 | 1 | −1 | −1 |
| 2 | 2 | 0 | 0 | 1 | −1 | 3 | −1 | 1 | 2 | 3 |
| 3 | 1 | 3 | 2 | 0 | −1 | 3 | 2 | 1 | 3 | 2 |
| 4 | −1 | 3 | 2 | 1 | 0 | 1 | 2 | −1 | 1 | 0 |
| 5 | 3 | −1 | 2 | 3 | 1 | 0 | 2 | 3 | 1 | −1 |
| 6 | 2 | 2 | −1 | 1 | 3 | 2 | 0 | 2 | 1 | 0 |
| 7 | 3 | 1 | 2 | 2 | 3 | 1 | −1 | 0 | 2 | 1 |
| 8 | 1 | 1 | 0 | 3 | 2 | −1 | 0 | 1 | 0 | 2 |
| 9 | 2 | 3 | 1 | −1 | 0 | 2 | 1 | −1 | 2 | 0 |

The result uses the Genetic Algorithm and MATLAB software to achieve. The test results are: The distance of the trip is 32.06, Encoded as (2, 1, 2, 1, 3, 1, 1, 1), converted to a path is (0,2,1,4,3,5,8,6,7,9), as shown in figure 3. The profit of the return trip is 89.65, The distance of return is 28.27,e encoded as(3,1,3,4,-1,-1,-1,-1)converted to a path is(0,3,1,4,6,9), because of the actual driving path and the required path is the opposite in the return trip. So, the end path is (9,6,4,1,3,0) see figure 4.

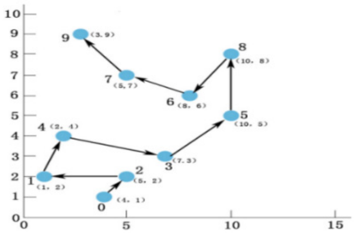


Fig. 3. To transport route

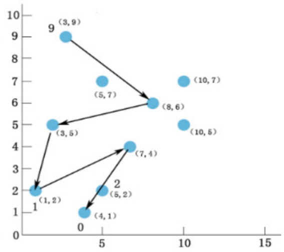


Fig. 4. Return routes

Ssubstituting the data into equation (3) yields:

$$P^{*} \geq 30 - \frac{89.65}{1 \times 32.06} \approx 27.2$$

From the above calculation we can see that $p^{*} < C$ , Because the driver in the return to find a better path, and get extra profits. So, we can reduce the transport price to the way and improve market competitiveness.

### 3.2 IP-RFID Technology

According to the contents of the above section, we can see the use of electronic tag service in systems can provide following services:

1) location information to provide services
2) status information to provide services
3) real-time status service services

Now we will show the pet logistics service system interface. Our system mainly includes four interfaces: pet tracking interface, transport interface, veterinary interface, driver interface.

#### 3.2.1. The Pet Tracking Interface

Through this interface we can track the pet to monitor the location of the pet where the state. While the data uploaded to the user phone APP, so that pet owners can monitor the service of pets. And the pet owner can use the web camera to take pictures of pets to obtain pet information, pets can also listen to the pet owner's voice through the speaker. see figure 5.

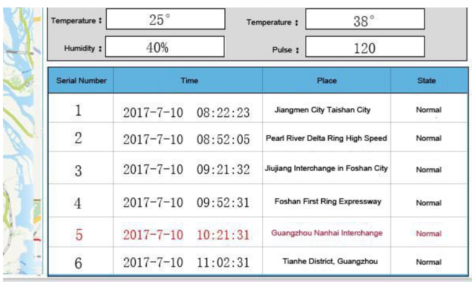
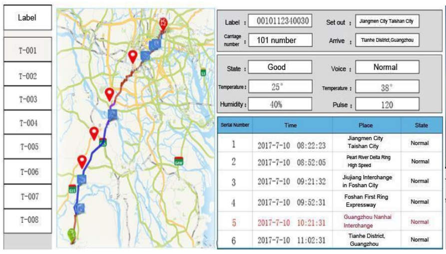



Fig. 5. The pet tracking interface

#### 3.2.2. The Transport Interfaces

It shows the current location and pet status, you can real-time understanding of the pet's state. The interface shows the status of the latest real-time information in order to understand the pet's state changes. For customers to record the pet data, electronic tags can be managed by the administrator. see figure 6.



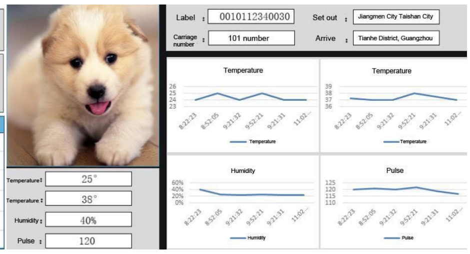



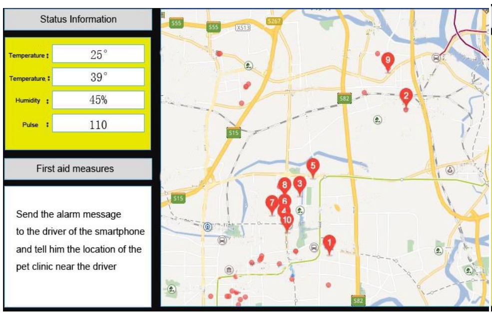

Fig. 6. The transport interface     Fig.7. The veterinary interface

### 3.2.3. The Veterinary Interface

It is the interface of the veterinarian, it mainly contains the pet status information, the veterinarian can see the camera by the network camera photos. Observe the pet's state, such as body temperature and pulse, are displayed by two data. see figure 7.

### 3.2.4. The Driver Interfaces

It is the driver interface; it shows the status of the pet. If there is a problem with the pet, the alert message is sent to the driver of the phone. It can also tell the driver about the location of the pet clinic nearby. In addition, the driver can be transported according to the planning route given by the system. see figure 8-9.



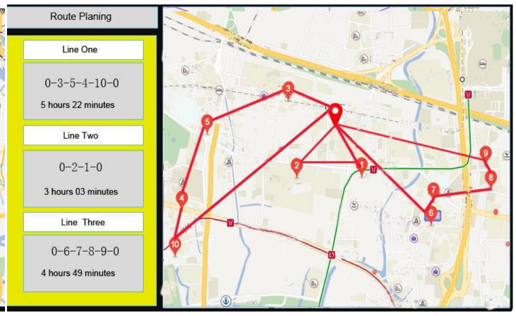




Fig. 8. The driver interface     Fig. 9. The Line planning chart

## 4. Summary

In this paper, introduce of path planning model , IP-RFID technology, and online APP, try to design a the first pet logistics service system——"Chong Da” in China. This system will help us solve the following pet logistics issues, see Table 4.

Table 4. The problem and solution situation about pet logistics

| Problem | Solution |
|---|---|
| The pet safety during transit | Use the “Chong Da”system, real-time monitoring of pet status, to ensure pet safety. |
| High cost of the pet transportation | Optimize the optimal transport path, through path optimization system. Using the pricing model to determine the optimal price. finally,improve the market competitiveness. |
| Backward trading patterns and low level of information service | Startn online trading and monitoring system about “Chong Da”APP,in which attract customers and provide better service. |
| Shirk responsibility | Our system commitment to real-time monitoring of pets in the whole process. So the responsibility is very clearly. If there is a problem with the pet, the veterinarian will receive the information and handle it at the same time. |

Of course, the article also has some problems, such as consider the issue of investment costs, the system not suitable for all businesses. On the other hand, in the air transport, the IP-Tag in the pet body will encounter problems because of airline control, and we unable to monitor pet status in real time. These issues will be the focus of future discussions.

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