Analysis and Design of Intelligent Logistics System Based on Internet of Things

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Abstract: Based on Internet of things, .NET software development technology and GIS technology, this paper analyzes and designs a system of intelligent distribution information with software engineering life cycle theory as the guide to solve the problem of high complexity and low efficiency of manual operation in logistics and distribution, improve the level of intelligent operation and then improve the operating efficiency. It analyzes the business requirements of the system, then designs its physical architecture, software architecture and system structure, and constructs the terminal node distribution dynamic model of transmission route, realizing the main function modules of the system and verifying the correctness and effectiveness of the system results through systematic and comprehensive tests.

Key words: *Logistics, Internet of Things, .NET, Intelligence*

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Informatization construction has brought great opportunities for enterprises to develop logistics distribution. Previously, it is difficult for the grass-roots employee to know the condition of delivery personnel and vehicles in real time. With the gradual development of informatization construction, enterprises can build logistics distribution information platform to plan routes reasonably, contact delivery personnel and master the distribution vehicles in real time, which can comprehensively enhance the distribution efficiency[1]. With the ability of enterprise logistics distribution center, how to apply modern technology to logistics management to optimize the logistics operation process, improve the efficiency, improve the management level, as well as reduce the logistics cost with scientific and standardized management methods has become an urgent issue for the enterprises now[2].

Now distribution intelligence has become a hot research topic in logistics industry. The latest research achievements include the integrated use of RFID and other IOT technologies, advanced intelligent geographic information and optimization of statistical techniques, based on which the Industrial Park Public intelligent logistics management service system with SHIP as the core has been developed [3]; "the cloud" server has been added into "jointed warehouse" intelligent operation mode[4], composed of the park combined warehouse module, distribution management module and market terminal ordering module; combined with the concept of supply chain management, the application and main functions of Internet of things packaging in the supply chain system of production, supply, transportation, warehousing, distribution operations and retail links have also been researched[5].

The above methods can greatly reduce the cost of distribution and operation time, improve the efficiency of distribution. In comparison with existing methods, the technology described in this paper provides a new idea for the traditional logistics, setting up an information system based on IOT, .NET software development technology and GIS technology. Through the construction of vehicle scheduling model, logistics distribution model, regional partition model, and optimizing distribution route, it fully meets customers' demands, improves the efficiency of logistics, reduces the logistics distribution cost, and enhances corporate profits as well as social benefits.

I. Requirement Analysis

This thesis analyzes the operation status quo of enterprise distribution to sum up the main problems existing in the distribution, and puts forward the construction of "three level distribution network" model, the combination of fixed route and dynamic route, the allocation of resources with "order type", and optimization direction of informatization distribution, which can be taken as the target and basis of requirement analysis. An important reason of designing distribution system is realizing the visualization of distribution part to make the delivery personnel and distribution

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management personnel able to monitor the total completion of the distribution task (including the total distribution amount, the distribution amount that has been completed and the remaining distribution amount)[6], so that the effective supervision on the work can be achieved; Through the integration of distribution system and command center, it provides the corresponding information source for the command center to monitor logistics distribution part, enhances the transparency of distribution, and realizes the standardization of the management of sales outlets. The logistics distribution system can realize the management of tobacco distribution information, the optimization of route, the optimization of vehicle scheduling, tracking and monitoring, etc[7].

Intelligent route planning is planning route of delivery vehicle and executing the distribution task, which includes route name, route number, vehicle number, customer number, geology, longitude, dimension, site name, longitude of the site, dimensions of the site, delivery order, etc. Nanchang tobacco logistics distribution system mainly uses the GPS technology, GIS technology and optimization decision of distribution route in designing intelligent route optimization function. Nanchang tobacco logistics distribution mainly sets out from distribution center to tobacco retail clients and uses GPS technology as well as GIS technology to collect the longitude and latitude information of the distribution center and the tobacco retail clients, which constitutes the basic data of Nanchang tobacco logistics distribution system. The optimization of intelligent route is an important part of Nanchang tobacco logistics distribution system based on GIS technology. It optimizes intelligently the distribution route of Nanchang tobacco company to shorten the distribution distance, increase the service life of vehicles, improve the efficiency of distribution, and reduce distribution cost[8], which is based on the data processing of E-map, the distribution route analysis and vehicle allocation technology[9].

The intelligent route optimization of logistics distribution considers characteristics of different groups and factors the influencing effect of logistics distribution. According to customers' order information, it optimizes decision support system (DSS) to establish the optimized intelligent subsystem by using GIS technology and distribution routes. It solves the network optimized mathematical model by using the heuristic algorithm, and intelligently optimizes the distribution route to send tobacco ordered by retail clients to clients accurately and promptly[10]. The business process of optimized intelligent system of logistics distribution with GIS technology is as shown in Figure 0.

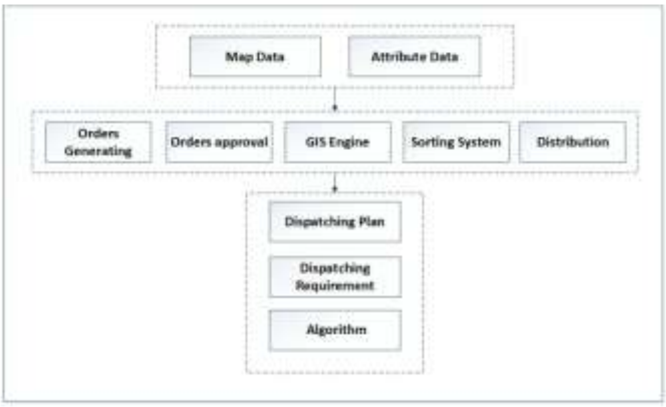

Figure0 The Business Process of the Intelligent Route Optimization

When the distribution is arriving in the terminal of clients, distribution center will remind clients of receiving commodity through RFID, SMS and other technical means. With the arrival of distribution vehicle, it will handover commodity by using RFID (electronic label is high frequency of 13.56 MHz) technology to confirm terminal clients' receiving commodity[11]. Information will be delivered to the logistics distribution center with usage of GPRS technology in real time after the handover of commodity. Specific process is shown in Figure 1.

Figure1 Delivery Process

A. *Use Case Analysis of the Platform*

This system's primary aim is to cut costs, improve efficiency, and enhance effectiveness of logistics and distribution center by optimizing the transit network's layout, tracking order delivery schedule and optimizing dispatching of vehicles according to the real-time information picked up from GIS, E-map and status of vehicles.

At the same time, the platform needs to be real-time, automatic and intelligent, collecting and transferring vehicles' status and both centralized / distributed synchronous display

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function; It can intelligently analyzes the operating data, judging the running status of vehicles, providing management, information searching, payment online, goods delivery and other integrated services for distribution, and dispatching center and retailers in different areas.

Summarizing the daily operation and maintenance business of the platform, we can get the corresponding use case diagram as shown in Figure 2.

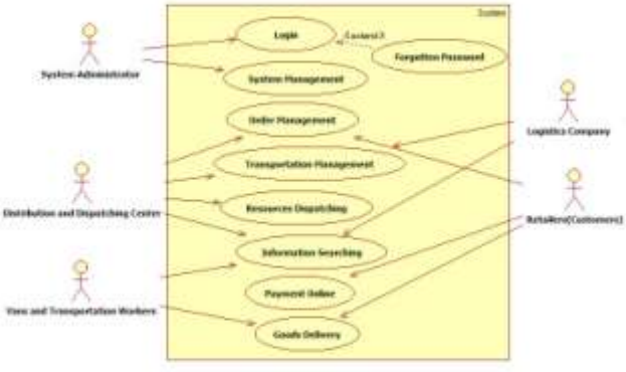

Figure2 Use Case of the Whole System

Use Case1: Order Management

Scope: Intelligent Logistical Distribution System
Level: User Goal
Primary Actor: Distribution and Dispatching Center and Retailers
Stakeholders and Interests:
-- Distribution and Dispatching Center: wish to check customers' orders and update status of orders for real - time tracking and feedback.
--Retailers: wish to order their requirements online and view its status.
Preconditions: Authorized users login in successfully and the unauthorized users are kept from the system.
Success Guarantee (or Post conditions): Retailers order successfully and the order can be checked and its status is updated in real time.
Main Success Scenario (or Basic Flow):
1. Retailer orders his/her requirements, and then submits.
2. Distribution and dispatching center checks the order's information
3. If order the retailer submits is correct, system generates record of the order and updates its status in real time.
Extensions (or Alternative Flows):
*a. Orders are modified.
1. Distribution and dispatching center checks the information modified and views the current status of the order.
2. If the goods in this order haven't been dispatched, distribution center can update the order and dispatch according to the modified order.
3. If dispatched, the goods should be returned back from the transit station and sent again.
*b. Orders are deleted.
1. Distribution and dispatching center checks the current status of the order.
2. If the goods in this order haven't been dispatched, distribution center can remove this order.
3. If dispatched, the goods should be returned back from the transit station.
Special Requirements: none
Technology and Data Variations List: none
Frequency of Occurrence: often.
Open Issues: none

Use Case2: Transportation Management

Scope: Intelligent Logistical Distribution System
Level: User Goal
Primary Actor: Distribution and Dispatching Center and Logistical company.
Stakeholders and Interests:
-- Distribution and Dispatching Center: wish to select the optimal route to transport goods.
--Logistical company: wish to manage vehicles in the transportation and dispatch vehicles as required.
Preconditions: Information picked up from GIS and E-Map is effective, vehicles are under control and authorized users login in successfully.
Success Guarantee (or Post conditions): Dynamic optimal route can be found and vehicles can be dispatched reasonably.
Main Success Scenario (or Basic Flow):
1. Distribution and dispatching center gets the geographical location of retailers.
2. System generates the optimal route by GIS technology and DDS.
3. Distribution and dispatching center gets the quantity of the goods to be transported.
4. Logistical company chooses the vehicle with proper capacity.
5. Distribution and dispatching center monitors the whole process of transportation.

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Extensions (or Alternative Flows):

*a. New transit station is added or some stations are deleted.

1．System recalculates the optimal route according to the dynamic information.

2．If the goods in this order haven't been dispatched, system can find the shortest route between vehicle's current position and the next station, and then update navigation.

Special Requirements: none

Technology and Data Variations List: none

Frequency of Occurrence: often.

Open Issues: none

III. SYSTEM DESIGN

A. *System Architecture Design*

These are the overall solutions of the system construction. The whole system consists of base layer, data layer, application layer and user layer. The system construction we study focuses on the application layer, which also covers three software application layer: platform construction, logistics applications, analysis and decision. System architecture is shown in Figure 3.

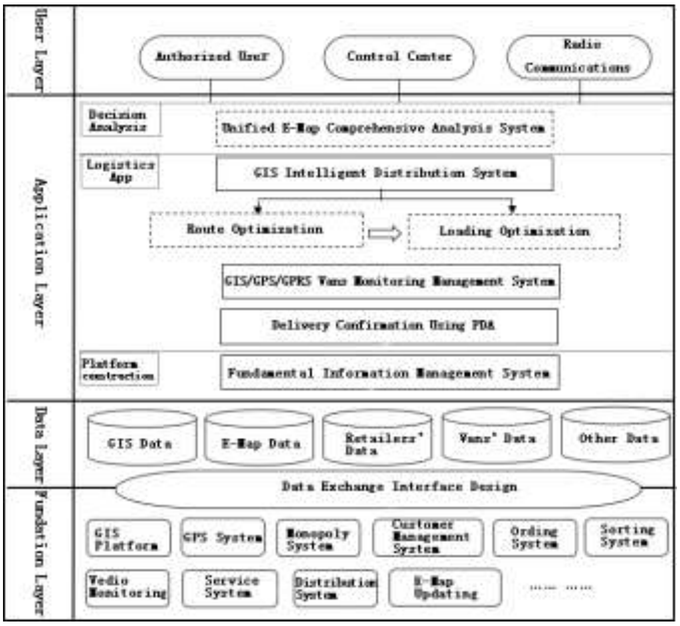

Figure 3 System Architecture Diagram

B. *System Structure Design*

We assume that the whole region can be divided into several small regions. Each region forms a small LAN. The RFID tags, the sensors, the converging point and the IP gateways do not interfere each other and work independently[27]. Topology diagram is shown in Figure 4.

Network topology is divided into three layers. The first layer is data acquisition layer, which through electronic RF technology and sensor technology collects and distributes cigarette and the vehicles information; the second layer is aggregation, which achieves regional full covered through built wireless sensing network in each regional of city, and provides a basic platform for data transformation with a collaboration node and multiple routing nodes that constitute each sensing network. Collaboration node is responsible for collecting received information of routing node, and each routing node directly receives first-hand information by sensor and RFID collection, while routing packets between nodes; the third layer is IP gateway, which provides wireless access, non-IP access gateway IP and connectivity to the Internet[25].

The servers of application layer include intermediate part servers, database servers, and distribution management server. Through its real-time processing of the data collected on the ground, they finally represent through the user interface visually[26].

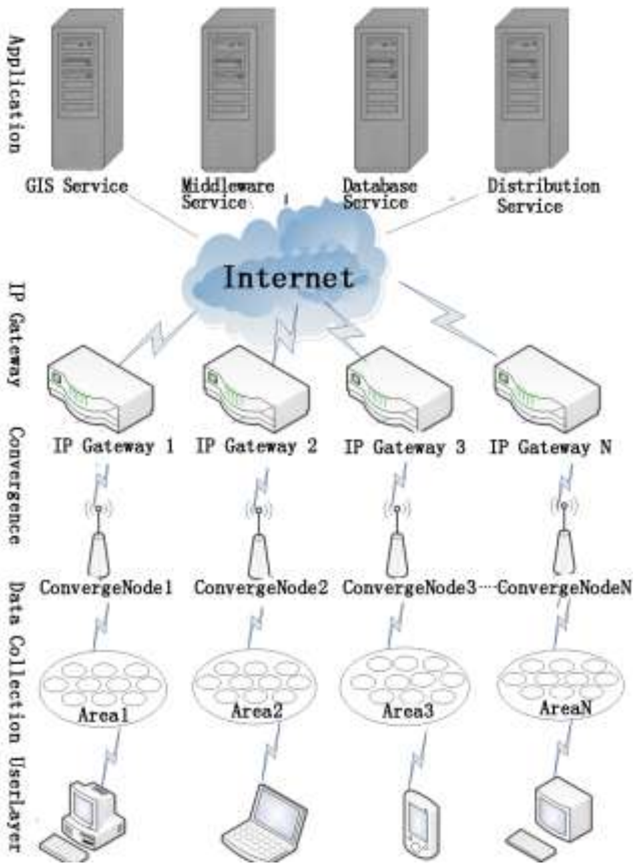

Figure4 The Topological Structure of the Network System Diagram

C. *Dynamic Route Model Design of Terminal Network Distribution*

Dynamic route terminal network distribution model

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solves the main problems that are the vehicle delivery from the transfer station to each terminal outlet, how to improve the use of the vehicle rate to make sure the distribution volume in a single network to a small amount (less than a car capacity) of cases, how to arrange car when performing multiple network distribution tasks, and how to arrange the route of the vehicle according to the order of the number of changes in order to meet the needs of the freight network and reach the lowest total cost while ensuring the timeliness of delivery[24].

- Variables Needed for the Model

Based on the above description of the problem, this model introduces the following variables:

i、j : i = {i | i = 1，2……n}，j = {j | j= 1，2……n}is the network included in a transfer station's delivery region, there are n radiation terminal web sites in total;

k: k={k | k=1，2……m}the equipped car in a delivery station, there are m cars in total;

d_{ij} : distance between web site i and web site j；

g_i : demand of each point

q :the limited capacity of each vehicle

y_{ki} : decision variable, $y_{ki}=1$ or 0，when $y_{ki}=1$, it means the goods of web site i have been delivered by car k; when $y_{ki}=0$, it means the goods of web site i are not delivered by car k.

x_{ijk} : decision variable, x_{ijk} =1or 0, when x_{ijk} =1, it means car k passed web site j after it passed web site i; when x_{ijk} =0, it means car k didn't pass web site j after it passed web site

- Model Building

Taking all factors into account, to minimize the distribution distance, vehicle routing model is derived as follows:

$$MinZ=\sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{m}d_{ij}x_{ijk} \quad (1)$$

According to the actual distribution operation, we set constraints as following:

$$\sum_{i=1}^{n}g_i y_{ki}\le q$$

$$\sum_{k=1}^{m}y_{ki}=1 \quad (2)$$

$$\sum_{i=1}^{n}x_{ijk}=y_{kj}$$

$$\sum_{j=1}^{n}x_{ijk}=y_{ki} \quad (3)$$

Meaning of the constraint includes:

(1) Ensure that vehicle load is less than the maximum loading capacity of the vehicle

(2) Ensure that each web site is only assigned to one route

IV. SYSTEM DEVELOPMENT TECHNOLOGY AND INTERFACE

A. Platform Development Technology

The key technology of system development platform, including .NET, GIS, Internet of things, and GPS technology, is the necessary basis of the whole distribution system, as it provides technical guarantee for the development of logistics distribution system from conception to realization[21].

Combined with its powerful functions and new technology, the system adopts .NET Framework 5.0, a new managed code programming model, for Windows to build application programs which can give users great experience. Moreover, it realizes seamless communication across technology boundaries and provides a software deployment and compiled code execution environment, while greatly improving the parallel computing ability of software operation[22].

The system realizes the high-speed operation of the server platform. At the same time, it also needs to realize the remote information collection and query via the mobile terminal. Therefore, we use the widespread Android mobile phone platform and application to establish the maintenance client[23]. The system adopts the new Eclipse 4.2 for development as a complete and mature open source software, which supports embedded Android compiler environment, the model of user interface framework based on lifting, and programming models for service.

B. System Interface

The following is the interface of two core parts, intelligent route planning system and vehicle video monitoring system.

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- Intelligent Route Planning System

To get intelligent route planning, first of all, the system sets the operation functions and parameters, including group number, starting point, end point, vehicle number, maximum load, and customer number, which leads to route segmentation automatically. Shown in Figure 7, Figure 8.

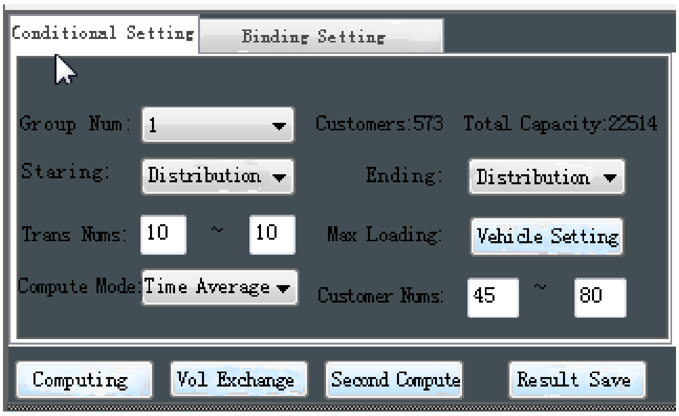

Figure 7 the Setting of the Route Segmentation Operation

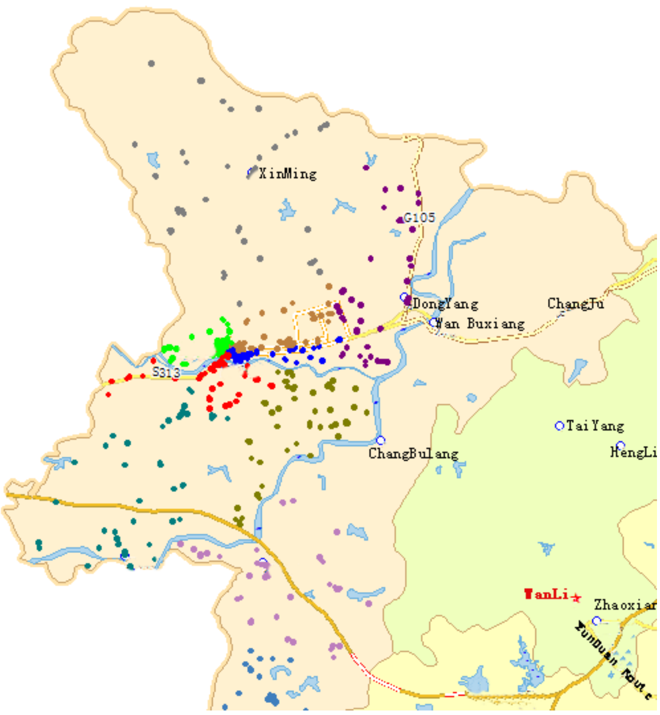

Figure 8 Route Segmentation Schema

Then, it makes polymerization of the routes belonging to the same group and distributes them into different directions on the map automatically .Shown in Figure 9, Figure 10.

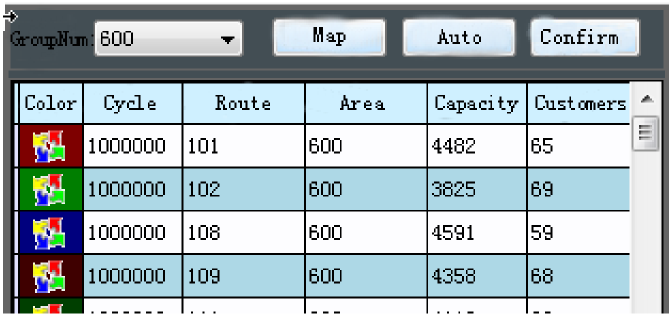

Figure 9 Routes Aggregation Operating System

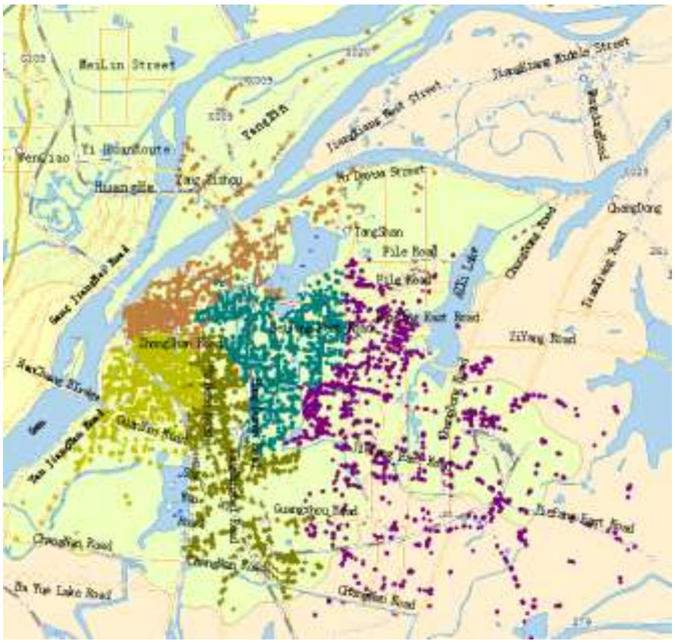

Figure10 Routes Polymerization Schema

- Vehicles Video Monitoring System

It also makes the realization of visualized real-time monitoring in the vehicle with the help of the vehicle mounted camera [12]. Shown in Figure 11.

Figure11 Visualized Real-time Monitoring

V. CONCLUSION

The logistics distribution system is designed on the basis of the full consideration of enterprise actual work procedures and operation characteristics. It makes a good use of the. NET platform, GIS technology, IOT technology, as well as GPRS and GPS technology, which cause that the system has plenty of advantages [13] [17] [18] [19]. In the aspect of system performance, we can see many highlights, such as the comprehensive functions, the pleasant interface design and the reasonable system structure. Taking the Nanchang City tobacco companies as an example, the index analysis and comparison before and after use are as shown in Table 1.

TABLE1 INDEX ANALYSIS AND COMPARISON OF DISTRIBUTION SYSTEM

Index	Before Use	After Use	Increased Proportion
Utilization Rate of Resources	*75%*	*95%*	*26.7%*
Accuracy Rate	*95%*	*99.5%*	*4.7％*
Working Time	*8.5Hour*	*5.7Hour*	*32.94%*
Average Cost	*￥1080*	*￥760*	*29.6%*

From the table above, we can find that this system improves the staff working efficiency and accuracy, while reduces the cost of distribution. In a word, Job burnout of staff is reduced and the convenience of clients is increased considerably[14] [15] [16] [20].

In terms of economic benefits, the platform saves the cost of the tobacco distribution business; the manager of distribution center can obtain real-time dynamic information distribution business to better scheduling.

In general, the use of this system not only improves the efficiency of enterprise logistics, but also makes an influential demonstration in the Internet industry.

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