ISSN 2522-3488 Vol. 8, Issue 5: 28-33, DOI: 10.25236/IJNDES.2024.080505

Design and Implementation of an Intelligent Unmanned Community Delivery System

Changhao Meng

School of Mathematics and Physics, Shanghai University of Engineering Science, Shanghai, 201620, China

Abstract: *Logistics cost reduction and efficiency still need to deepen; some areas of the short board are more prominent, and other issues need to be resolved. In fact, community logistics is a major problem. In view of the current situation of community logistics, this paper designs and realizes the intelligent unmanned community distribution system, taking advantage of database theory and software engineering theory to build the system, aiming to solve the current distribution of community logistics, which is too dependent on manual labor, has poor customer experience, low distribution efficiency, and high costs for logistics enterprises. The system mainly includes a logistics transportation system, a logistics information system, pipeline design, and logistics accessories. This paper proposes a new reference system for the community logistics field and empowers the community to enter into a smart community.*

Keywords: *unmanned; community delivery; database realization*

1. Introduction

Based on the current community logistics and distribution research, which mainly focuses on the optimization of self-pickup points and national census data, the optimization of collection services and other distribution systems that require more manual inputs, as well as the reality of community logistics. Moreover, along with the increasing aging of China, the issue of how to spend old age happily has become a hot topic in society. From the customer demand point of view, self-pickup points, due to distance, size, and number of factors, are easy to lead to courier leakage, wrong pickup, and other phenomena occurring frequently. Therefore, customers need a way to save time and prevent the accumulation of community distribution.

Further, there is an elite group of elderly people in the customer group. Some scholars have pointed out that the overall level of community services for the elderly is relatively low and cannot meet the needs of the elderly in old age. Many aspects are still to be improved, such as the quality of logistics services, which is not high; the logistics and distribution system is complex; and the degree of informationization of logistics is low. Therefore, the elderly need a simple information logistics communication bridge, timely and convenient logistics distribution, and high-quality service.

From the courier's point of view, at the present stage, the community's unterminated delivery staff often encounter a mismatch between the delivery staff and customer's time. Currently, most of the unterminated logistics operation modes match the courier's time to the customer's time, but they ignore the efficiency and cost of matching the courier's time to the customer's time. Therefore, for the courier group, they need a community logistics system that can directly deliver the courier on time or indirectly deliver the courier to better fulfill the delivery task[1].

From the perspective of logistics manufacturers, they are currently facing a high turnover rate of distribution staff, fixed inputs, and high labor costs. On the one hand, there is a significant gap between the efficiency of new and old employees. On the other hand, with the development of economic globalization and the needs of China's market economy, the cost of manpower will continue to increase. Therefore, manufacturers need a distribution system to replace part of the labor in order to achieve the purpose of cost and efficiency [2].

In view of the above problems and practical needs, this study proposes an intelligent unmanned community system. The main operation process is as follows: the courier puts the courier into the interface outside the community, and then naturally enters the pipeline through gravity, and then is transported to the vicinity of the building by the pipeline. At the bottom of the building, it is transported upwards, vertically transported according to the floor, and stored in batches in the storage cabinets of the

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corresponding portals on the corresponding floors. The user opens the locker with a predetermined password, and the user picks up the delivery items. (Due to limited capacity, when the storage locker capacity is exceeded, the excess items are temporarily stored at the bottom of the building, waiting for the items to be taken out, and then transported upward when the locker door is closed).

Based on the current situation in China, the future fertility rate will be lower and lower. The population is also generally showing a downward trend, so it is inevitable that the labor force will be short. This model can greatly improve the efficiency of courier work, as well as the possibility of express pile-up. Therefore, this model is also used to replace the newcomer station, freeing up the labor force. In other words, one worker can do more work, which can largely alleviate the labor shortage problem that is likely to occur in the future. At the same time, the system allows the elderly to take a shorter route to get express delivery, improving their quality of life, strengthening social security, and meeting the needs of the elderly.

1.1. Functional Requirements Analysis

Based on the preliminary business research and the decomposition of the requirements analysis report, the user's core needs are fully considered, and a use case diagram is produced as shown in Figure 1.

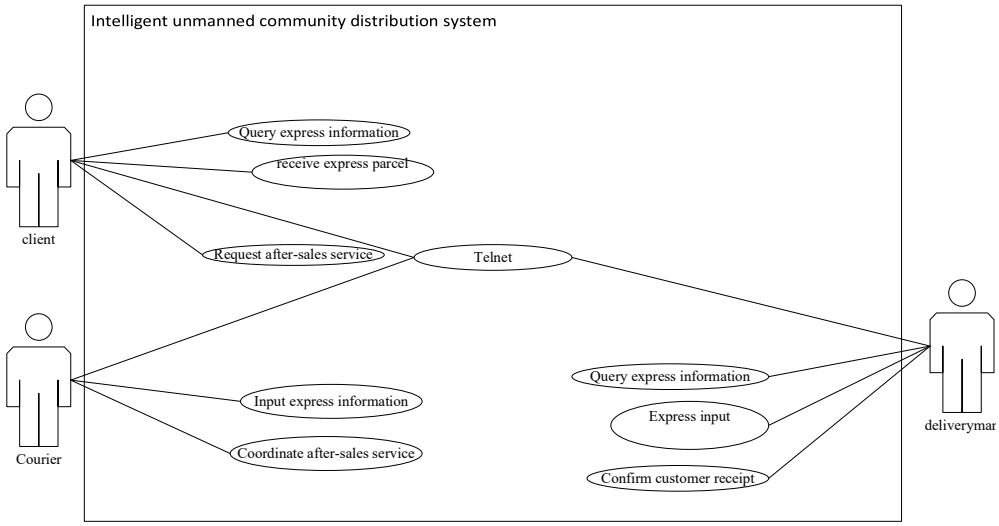

Figure 1: Use case diagram.

1.2. Feasibility Analysis

1.2.1. Technical Feasibility Analysis

The intelligent unmanned community backbone system designed and implemented in this article will be implemented using the currently popular software development environment, Java-related technologies. Specifically, it is based on the mature Struts2 framework with fully verified stability and uses the MySQL database as the system's data storage and access tools. In terms of data reception and transmission, due to the small volume of express delivery information, we use LoRaWAN to connect to the cloud platform to achieve data transmission. In order to prevent user express data from being lost, the system will adopt a distributed backup strategy [3].

1.2.2. Economic Feasibility Analysis

After a number of research and interviews, it was found that today, courier loss, courier mistakenly taking, courier dirtiness, and even courier poisoning and other issues are still common. The mode of operation can be very effective in avoiding these problems in the community link, making people's lives more beautiful and convenient. At the same time, the model can greatly reduce the workload of couriers, as well as the possibility of courier accumulation. Therefore, this mode is also used to replace the bird station and become a new community logistics model, in order to realize profit.

We can market the model to real estate developers to sell the system and use the express pipeline transportation system in new communities. This would increase the price of the building by making it easier for the people of the community to access public services. The actual construction costs can be

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counted as value-added coverage when purchasing a home, so that users can enjoy lifelong service and residents can actually experience the "home to get the express" online shopping experience, truly achieving a win-win situation for all three parties. At the same time, the logistics system receives a certain degree of praise and promotion for the building that has been constructed to build the system. The system directly transacts with the local community logistics company or community group logistics company, and ultimately, the social logistics company is responsible for the construction of the system [4].

1.2.3. Operational Feasibility Analysis

The system is primarily categorized into four components: logistics and transportation, pipeline design, pneumatic transportation, and information systems. The information system oversees the management of both logistics and pneumatic transport operations.

The introduction to the system is as follows: in contrast to traditional logistics transportation methods, our propulsion system's transport mechanism employs a permanent magnet synchronous traction motor that enables trains to maintain straight or curved trajectories. Our pipeline express transportation principle involves utilizing chassis and bearing plates made from permanent magnetic materials; by elevating the expressway based on magnetic levitation principles, we harness the magnetic effects generated by motors concealed within the pipe walls for energy efficiency through a "magnetism generates electricity; electricity generates magnetism" cycle. Additionally, solar panels are installed atop residential buildings and connected to internal wiring of these motors to ensure minimal energy consumption during emergencies.

Unlike conventional pusher launches, our courier launch utilizes gas propulsion. This system vertically transports couriers to designated floor heights where they are propelled into storage boxes via gas flow, completing the entire logistics process efficiently. Compared with traditional robotic arm mechanisms for pushing items out, gas propulsion offers more flexible routing options while effectively mitigating damage risks associated with couriers; it allows for precise control over push distances and significantly reduces maintenance requirements.

The logistics framework incorporates high-performance green concrete for constructing efficient pipelines. This concrete exhibits exceptional strength characteristics—earthquake resistance, wind resistance—and can endure substantial pressure levels ensuring uninterrupted express transport under various weather conditions. Both interior and exterior surfaces of pipes can be polished and painted to address wear issues inside the pipes as well as rainwater corrosion outside while enhancing aesthetic appeal. A lightweight heat-insulating and sound-absorbing stone-like paint is applied externally for aesthetic enhancement along with sound insulation, thermal insulation, and waterproofing properties; internally coated polyurethane foam fabric minimizes wear on pipe interiors while providing additional soundproofing and waterproofing benefits.

2. System Design

2.1. System Design Principles

The community logistics system serves as a crucial link in the operation and development of communities. In designing and implementing an intelligent unmanned community distribution system, it is essential to enhance the application of information technology to ensure optimal design outcomes. This paper will explore the intelligent unmanned community distribution system through the lens of information technology, elucidating its role and design principles while addressing potential challenges that may arise during the overall system design.

In developing this system, five core principles must be adhered to: First, embracing green development; the design process should consider environmental impacts and resource efficiency to promote long-term ecological balance and sustainable resource utilization. Second, flexibility and adaptability; the system must accommodate changing environmental conditions and user requirements, including factors such as climate change and population growth. Third, user-friendliness and compatibility; both the interface and operational processes should be straightforward and intuitive to facilitate ease of management for all users. Fourth, data-driven decision-making; decisions should rely on data analysis to optimize distribution operations effectively. Finally, security and reliability; it is imperative that data integrity and physical security are ensured throughout the design process to prevent data breaches or systemic failures [5].

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2.2. System Functional Architecture Design

Intelligent unmanned community delivery system is mainly composed of courier information module, courier delivery module and reverse logistics module. The courier information module includes the system's login, status, rights, security management and courier information management. Express delivery module mainly includes express delivery time, delivery location, delivery mode, delivery feedback and other aspects of management. Reverse logistics module mainly includes courier recovery, courier valuation, payment of compensation, notification of recovery and other functions. As shown in Figure 2 below

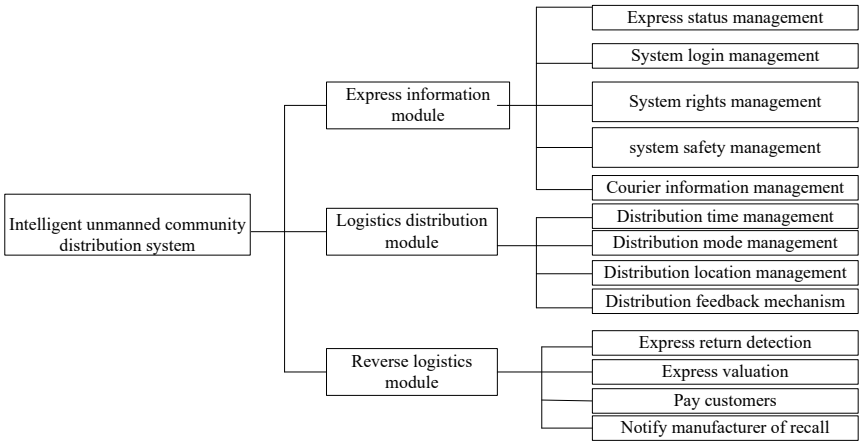

Figure 2: Functional structure diagram

2.3. Database Design

The ER diagram primarily encompasses several entities, including after-sales service, express delivery, couriers, express delivery information, customers, and logistics manufacturers. Each courier is associated with multiple after-sales services; a single customer typically receives numerous couriers; each courier possesses various pieces of courier information; and each piece of courier information is generally linked to one specific customer. A courier facilitates the delivery of multiple express items while acquiring diverse express delivery information in the process. Logistics manufacturers maintain independent contact details along with their after-sales attitudes and manufacturer registration numbers, as illustrated in Figure 3 below.

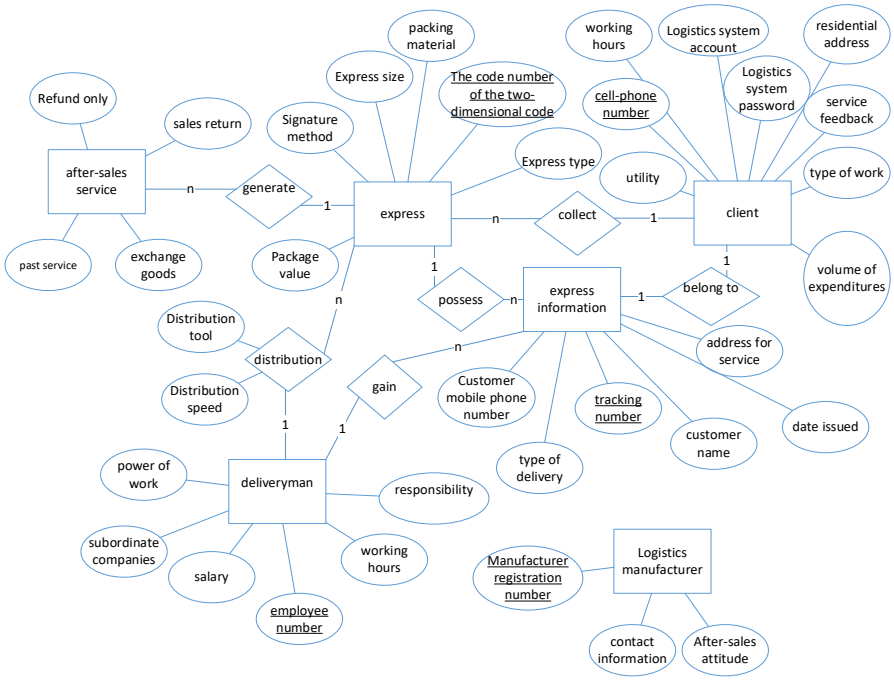

Figure 3: ER diagram

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The courier entity has the code number of the QR code, the packaging material, the size of the courier, the method of signing, the value of the package, the type of courier, the means of delivery, the speed of delivery, and the employee number as shown in the Table 1 Express information table and Table 2 User information table below.

Table 1: Express information sheet

name	field	data type	primary key	is empty	remark
The code number of the QR code	The code number of the QR code	Varchar (255)	True	False	
Packaging materials	Packaging materials	Varchar (255)	False	False	
Express size	Courier size	Varchar (255)	False	False	
the manner in which it was signed	delivery	Varchar (255)	False	False	
packaging value	Packaging value	Varchar (255)	False	False	
type of courier	Type of courier	Varchar (255)	False	False	
Distribution tools	Delivery Tools	Varchar (255)	False	False	
Distribution speed	Shipping speed	Varchar (255)	False	False	
Employee number	Employee number	Varchar (255)	False	False	foreign key

Table 2: User information table

name	field	data type	primary key	is empty	remark
Cell phone number	Mobile phone number	Varchar (255)	True	False	
Working hours	working hours	Varchar (255)	False	False	
The account number of the logistics system	The account number of the logistics system	Varchar (255)	False	False	
The password for the logistics system	The password of the logistics system	Varchar (255)	False	False	
service feedback	Service Feedback	Varchar (255)	False	False	
type of work	Type of work	Varchar (255)	False	False	
Residential address	Residential address	Varchar (255)	False	False	
Effectiveness	utility	Varchar (255)	False	False	
Expenditures	Amount of expenditure	Varchar (255)	False	False	

2.4. System Realization

In the realization of the function, through software design and other ways to realize an information system, its ability is to respond to the courier operation status, courier information, but also in unusual circumstances by the courier to add or modify part of the information. At the same time, it is connected to the back-end network on the one hand to do supervisor courier work, on the one hand to avoid accidents.

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As shown in Figure 4 below

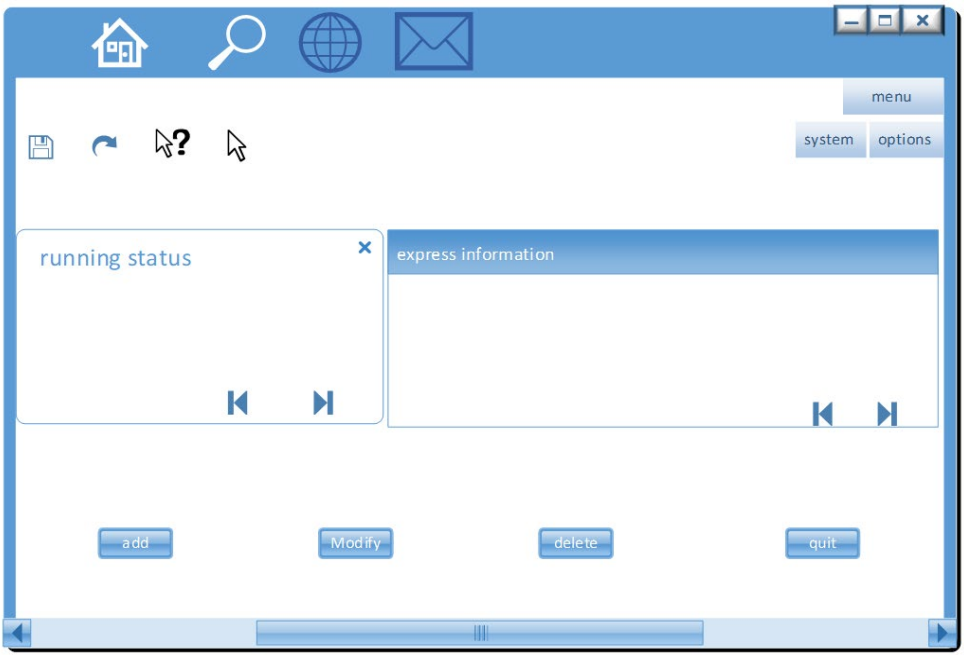

Figure 4: Interface diagram

3. Conclusion

For the community distribution system, this paper creatively puts forward intelligent unmanned community distribution system to solve the current community logistics distribution is overly dependent on manual labor, so that the courier pay does not match; customer experience is poor, can not be out of the house or not out of the building to receive the courier; distribution efficiency is low, the customer's time and the courier time can not be accurately matched; logistics enterprises cost-effective and poor and other issues.

At present, this paper is only in the stage of theoretical proposal and database design in information system. In the next research, we need to gradually improve the information system and the Internet of Things or software engineering to form a complete intelligent unmanned community distribution system.

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