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# Research on Simulation and Optimization of Regional Express Cabinet Modeling based on Flexsim

**Kaixia Zhan [1], Qinghong Yan [1], Wei Chen [2]**

[1] School of Modern Posts, Chongqing University of Posts and Telecommunications, Chongqing, 400065, China
[2] Chongqing No.2 Foreign Language School, Chongqing, 400065, China

**Abstract:** In order to solve the problems of intelligent express cabinet quantity distribution and unreasonable grid configuration at the end of express delivery, improve customer satisfaction, and coordinate the investment cost and profitability of enterprises. Using the Flexsim software to simulate the distribution mode of regional express cabinets, set relevant parameters, analyze the utilization rate of intelligent express cabinets and the utilization rate of express cabinets, optimize the number of intelligent express cabinets and the configuration of the number of lattices, and enhance the corporate brand image.

**Keywords:** Intelligent Express Cabinet; Quantity Confirmed; Grid Configuration.

## 1. Research Background

The burgeoning development of e-commerce platform has promoted the high-speed growth of China's express delivery business volume. According to the official website of the State Post Bureau, China's express delivery business volume reached 83.36 billion pieces in 2020, an increase of 31.2% from the previous year. Business income has accumulated 879.54 billion yuan, an increase of 17.3% from the previous year. In January 2021, the business volume of the national express service enterprises reached 8.49 billion pieces, a year-on-year increase of 124.7%. business income reached 86.76 billion yuan, a year-on-year increase of 73.3%. This year, the postal express industry continues to maintain a trend of high growth. By February 7, 2021, China's 10 billionth piece of express mail was born. This achievement was reached in just 38 days, once again refreshing the record. It is expected that in 2021 the national express business volume will exceed 95 billion pieces.

Since the onset of the new corona epidemic, communities across China have implemented road traffic control to avoid large-scale contact among people. Online shopping has become the main mode of consumption, and with the significant increase in the volume of courier delivery, it has caused a certain level of pressure on delivery. Intelligent express cabinet mode, as one of the main business carriers of the contactless distribution mode, is drawing wide attention from the community.

Intelligent express cabinets, also known as self-service pickup cabinets, intelligent pickup cabinets, etc., is a self-service device that can be utilized in public places to complete the delivery and pickup of expresses through two-dimensional codes or digital passwords. It is a device based on the Internet of Things, capable of identifying, temporarily storing, monitoring and managing the express mail. The express cabinet together with the server constitutes an intelligent express terminal system. The server carries out integrated management of each express cabinet of the system and comprehensively analyzes and processes the information of the express mail's in-box, storage, and pick-up, etc. It integrates the technologies of the Internet of Things, intelligent identification, dynamic passwords, wireless communication, and property functions, and is thus capable of intelligent centralized access to express mail, designated location access, 24-hour access, remote monitoring and information dissemination and other functions.

The origins of intelligent express cabinets can be traced back to an intelligent parcel delivery terminal placed by the postal service in 2010. Subsequently, Jingdong joined the competition in August 2012, gradually laid intelligent express cabinets, and in December of the same year, Express Easy also entered the market. In November 2013, Suning set up cloud cabinets for the construction of its own logistics system. In February 2015, GLP, Yunda, Shentong, Zhongtong, and SF jointly set up the "Feng Nest" to formally join the competition in the market. In July 2017, Cainiao, China Post and Fosun Group financed to rename Express Easy to Zhongyou Express Easy, and in July 2018, Feng Nest wholly acquired CIMC e-stack. The data released by the State Post Bureau shows that between January and April 2020, the vast majority of parcels delivered by the national postal industry are switched to intelligent express cabinet delivery to accomplish. Currently, the number of intelligent express cabinets in China's major cities has reached 406,000 units, and the rate of express into the cabinet is expected to reach 15%.

Intelligent express cabinet mode is a kind of mode for receiving parcels that most of the current neighborhoods, office buildings and so on are equipped with. Typically, express cabinets are installed in areas with high traffic flow. The courier will put the contents into a box cabinet, at the same time, the service system of the express cabinet will automatically send a text message to the recipients, and the recipients can pick up the parcel in the express cabinet with a verification code in the text message at a convenient time. This mode can best meet the customer's need for time flexibility, while saving the waiting time of the courier, reducing communication links and improving distribution efficiency. However, in most cases problems of intelligent express cabinet like inactivity, fullness, remote location, lost pieces and other user dissatisfaction abound. Therefore, study of siting the facilities of intelligent express cabinets and the configuration of the number of compartments is of great significance for enterprises to improve user satisfaction.

## 2. Research Status in China and Abroad

Many foreign scholars have done detailed research on the planning and siting of express logistics network, Michael Wasner and Gunther Zapfel take the optimization of pickup and delivery of goods path and the optimization of long-distance trunk transportation path as a whole to implement the global system optimization, which means to determine the location of the hubs and nodes, the number of the range of services and paths at the same time. Alexandre Lafaye has analyzed the strategy and network structure of several express giants such as DHL, FedEx, TNT, UPS, etc. in the European market, and has concluded that the factors to be considered by each express courier in the location of the hubs are: the main influencing factor is the concentration of the market and the industry, and in addition, the time of sorting at hub airports as well as the geographic location will also affect the location of the hubs [1].

A part of foreign scholars has done some studies specifically for the problem of regional division of logistics network. Oliver. Fisher respectively uses the methods of network planning and nodal planning for elaboration in the study of logistics regional division problem, and for network planning he follows the method of traditional way of thinking, meanwhile for nodal planning, the problem is divided into three categories including generative distribution, consumptive distribution, and transportation transshipment distribution. GOLDEN and others have introduced a grid system used by Coca-Cola to divide large urban areas and regions into smaller areas or units. Cheong and others use a zip code-based customer regionalization integration method [1].

However, there are relatively less researches on express delivery mode in foreign countries, and the research literature on intelligent express cabinets is also relatively limited, which mainly focuses on the research of Collection and Delivery Point (CDP), attended CDP receiving box and unattended CDP shared receiving box. Xiaohao Xu and others point out that an unattended CDP is a smart receiving box or smart locker, which can be picked up by the customer at any time after the delivery by couriers, which significantly improves the efficiency of deliveries and is highly received by the customers. Ashu Kedia and others explore the acceptability of CDPs from the customer's point of view, and show that the main factors affecting the acceptability of CDPs are the density of network, the density of spatial location of CDPs, the number of CDPs in a given area, the proximity of the spatial location of the CDP to the consumer's home or office, safety and reliability of operation, and the operating time of the CDP [2].

Domestic researchers in China have also made a fairly detailed study on the planning and siting of express logistics network. Chen uses the gray comprehensive evaluation method for coarse siting of distribution centers, determines the optimal siting scheme based on the CFLP model for the siting of same-city express distribution centers and carries out the optimization of paths [3]. Huang and Guo Kun regard the siting of the express service outlets and the planning of the vehicle routes as a two-way logistics network optimization problem to establish a network optimization model and refine the discrete artificial bee colony algorithm [4].

Based on the demand of logistics enterprises and social demand, Wang quantifies the indicators affecting the distribution service of logistics enterprises from the perspective of consumers, and then establishes a generalized cost model and combines it with graph theory to study the regional division of distribution network for logistics enterprises [5]. Feng focuses on the hierarchical system of the logistics network system that has been formed in the central region of China, constructs the evaluation index system on logistics capacity, and uses the method of combining fuzzy clustering and factor analysis to classify the hierarchical development of the logistics network system in the central region [6].

Domestic research in China on intelligent express cabinets is mainly divided into three aspects: (1) In the aspect of satisfaction, Zhang, Yang have arrived the conclusion through researching and processing data that the factors affecting customer satisfaction are mainly reflected in the uneven distribution of the number of express cabinets. the unreasonable overtime charges. the untimely treatment of malfunctions by operation and maintenance personnel, etc., which can be achieved by rationally planning the number of placements, perfecting the relevant laws and regulations, and improving the technology to improve customer satisfaction [2]. (2) In the aspect of development strategy, Sun studies and analyzes the problems existing in the process of its development, and discusses some effective ways to improve the intelligent self-service courier system for better service to consumers [7]. Zhu, based on the analysis of the current problems of express terminal business in colleges and universities, proposes to build campus express service centers based on intelligent express cabinets, in order to integrate campus express terminal business and improve the level of campus express service [8]. Gao analyzes certain problems still existing in the use and development of express cabinets, particularly the legal issues arising from its use. And a certain reflection on the relevant laws has been made in order to effectively avoid these problems [9]. (3) In the aspect of empirical analysis and model testing, Ding Meng, based on the characteristics of university campus intelligent express cabinet site selection, set up university campus intelligent express cabinet site selection model with the minimum number of outlets and the number of fixed outlets respectively as the target [10]. Wang takes Zhuhai City as an example, analyzes the development of Zhuhai City express terminal delivery and the problems faced in the development of express cabinets, and puts forward specific countermeasures for jointly building an intelligent terminal delivery platform from the aspects of information technology and intelligent express cabinet intelligent postal construction [11].

## 3. Process Analysis

Intelligent express cabinet mainly includes two aspects including sending and picking-up: sending means that the consumer is to send the express parcel to the intelligent express cabinet, weighing, selecting the courier company, address of sending, and the size of the box grid. Then the system calculates the postage. The consumer then fills in the relevant information and pays the postage, obtains the sending code. The corresponding cabinet pops up and the consumer places the package in the box compartment. The cabinet compartment closure will notify the system, which subsequently informs the courier company. After that, the courier goes to the express cabinet to pick up the package, verifies identity, opens the box grid, affixes the express company's waybill, and closes the door after checking the

accuracy. Then the system sends a notice to the consumer that the express parcel has been shipped. And then the courier will transport the parcel to the regional network outlets for shipping operation which will then send it to the regional processing center. Picking-up means that the courier will get the corresponding express mail from regional outlets and then send it to the express cabinet, confirm his identity, record the express information, and select the size of the box compartment to be used for the express mail. After determination of the size of the box, the system will automatically pop up the corresponding available cabinet. The courier places the shipment into the box and then closes the door. The system immediately sends a message to the recipient. After receiving the SMS, the recipient picks up the shipment from the express cabinet at a free time. By entering the pickup code at the terminal, the corresponding box will pop up for picking up the shipment. If it is more than 24 hours, a certain storage fee will be charged. The system ends the delivery after receiving feedback from the express cabinet that the express has been extracted. If the system detects that the express has not been extracted in time, it will contact the customer by manual means to remind the customer to pick up the express. And if the maximum number of manual contacts is reached, the express will be treated as a withdrawal and be sent to its original delivery location.

# 4. Modeling Process

## 4.1. Problem Description

During the epidemic, in order to reduce the gathering of crowds, express delivery has become the main way for purchasing daily supplies. Therefore, how to carry out the contactless distribution in the "last kilometer" of logistics has become the main concern of the government and logistics enterprises. In this paper, Flexsim software is used to build a model to meet the needs of people for a safe and contactless business during the epidemic time, and the average daily volume of express delivery in the community is used to determine the number of intelligent express cabinets and the number of configurations of the grids.

(1) The community has a total of 500 households. There are two intelligent express cabinets, and the capacity of one group of express cabinets is 144, with the ratio of large compartments, medium compartments and small compartments set at 1:4:7. The height of large pieces is 30 cm, the height of medium pieces is 20 cm, and the height of small pieces is 10 cm.

(2) The location of the intelligent express cabinet is reasonable to ensure both the convenience for users to its location, as well as the efficiency and safety of the courier delivery.

(3) this community has only SF, China post and Yunda, each courier company delivers two times a day, send pieces by a collection in the evening, and the amount of pieces delivered each time is relatively average.

## 4.2. General Layout of the Model

The daily volume of the community approximately for SF to pick up are 100 pieces, for Yunda are 150 pieces, for China Post are 80 pieces, which are divided into large, medium and small pieces separately placed in the corresponding intelligent express cabinet box grid. The proportion of pieces returned accounts for 2%. the daily mail pieces are about 55 pieces, and the initial stock of the intelligent express cabinet is 5%, as shown in Figure 1.

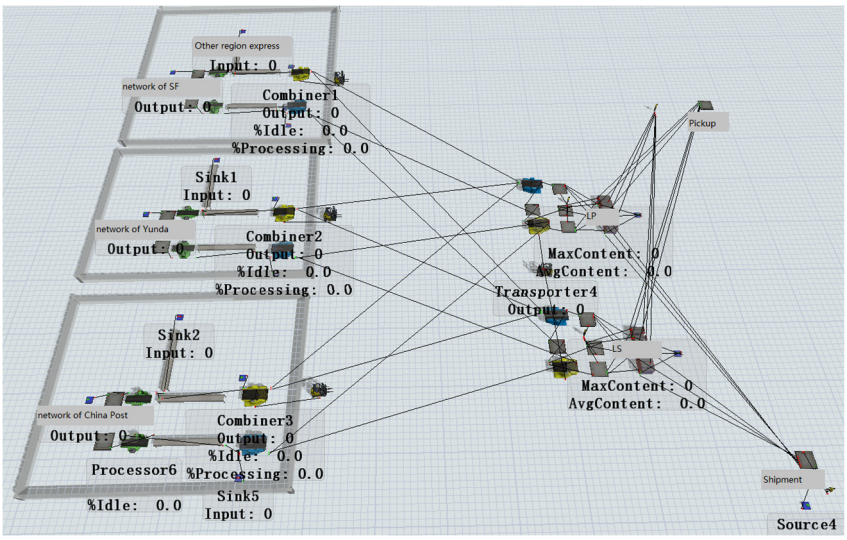


**Figure 1.** General layout of the model

# 5. Simulation Result Analysis and Optimization

## 5.1. Analysis of Results of Simulation Output

(1) A pile up of items was generated in the express queue area, as shown in Figure 2.

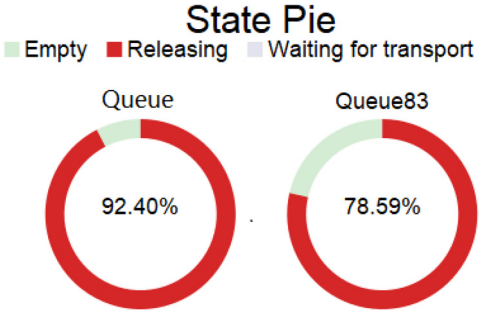


**Figure 2.** State pie of queue

(2) There is a large proportion of unevenness in the state of large, medium, and small compartment pickups, as shown in the Figure 3.

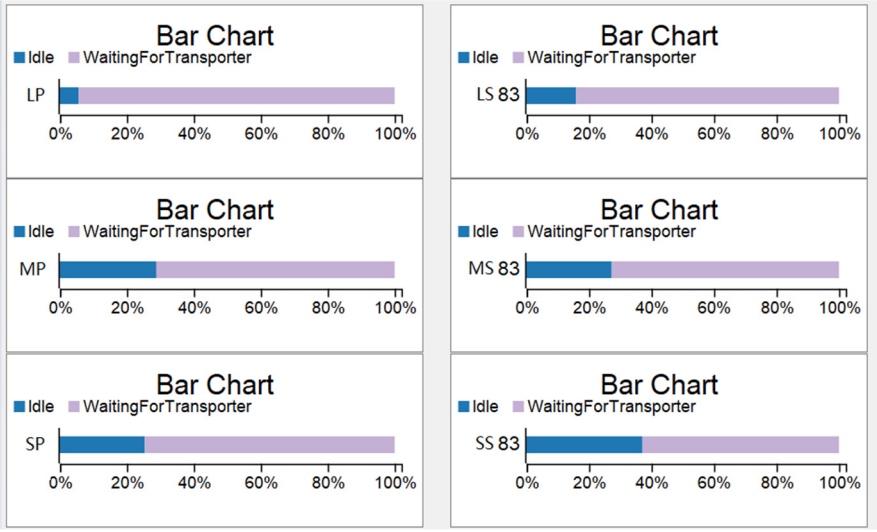


**Figure 3.** Charts of rack utilization

## 5.2. Optimization of Simulation System

Optimization of the model is done based on the problems that come out of the analysis of operation:

(1) As the average daily arrivals in this community are greater than the capacity of the intelligent express cabinet, it is necessary to increase the number of express cabinets, or increase the scale of the size of the intelligent express cabinet to enhance the capacity of the intelligent express cabinet. In this case, the option of upgrading the intelligent express cabinet capacity is selected. The capacity of each intelligent express cabinet is upgraded to 210 compartments, in which the ratio of large, medium and small box compartments remains unchanged.

The proportion of queues for goods in the pickup express queue area decreased from 92.4% to 78.93%, and the proportion of queues for goods in the shipment express queue area decreased from 78.59% to 67.59%.

The idle rate of the rack corresponding to large, medium and small pickups have been reduced by nearly one-third. While the idle rate of large shipping rack has nearly 50% reduction, the idle rate of medium-sized shipping rack, on the contrary, increased by about 16%, at the same time, the idle rate of small-sized shipping rack decreased by about 10%.

(2) On the basis of the change in capacity, the ratio of the number of large, medium and small cells is modified to 1:3:3.

The proportion of queues for goods in the pickup express queue area decreased from 92.4% to 71.71%, and the proportion of queues for goods in the shipment express queue area decreased dramatically from 78.59% to 28.39%.

The idle rate for the rack corresponding to large, medium and small pickups has dropped by an astonishing 60%. And the idle rate of large shipping rack has nearly two-thirds of the reduction. the idle rate of medium-sized shipping rack, although still failed to decline, but barely remained unchanged, without rising. at the same time, the idle rate of small shipping rack significantly reduced by about one-fifth.

# 6. Conclusion

Through the Flexsim software simulation of the community intelligent express cabinet operation process simulation and optimization, it can be seen that the 2 intelligent express cabinet capacity is not enough. It is necessary to increase the number of intelligent express cabinets or expand the capacity of express cabinets to solve the situation of grid fullness. In addition, there are a number of problems with the grid configuration ratio of 1:4:7, which needs to be optimized and adjusted to 1:3:3. Naturally, in order to better enhance customer satisfaction, there is also a need to solve the problem of overtime charges for intelligent express cabinets, the problem of security and safety of the express, related legal issues, the layout of express cabinets and coordination of the problem of the optimization of distribution paths under the distribution mode of express cabinets. At the same time, enterprises can expand value-added services to better promote the utilization rate of express cabinets, improve the frequency of customer use to increase operating income, extend the crowd of users, improve convenience, and establish a business image.

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