Key Problems of Fruit and Vegetable Cold Chain Logistics

Warehousing Management System

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Abstract

With the promulgation and implementation of the new version of SQMFV (Quality Management Standard for Fruit and Vegetable Production), the cold chain management of fruits and vegetables has once again become a hot topic in the fruit and vegetable logistics industry. The so-called fresh fruit and vegetable cold chain management is a management method for temperature-sensitive fruits and vegetables, especially fruits and vegetables that require storage and transportation in the environment of 0~13°C, in the circulation of fruits and vegetables. The promulgation of this regulation gives a detailed answer and explanation on the unclear management requirements of the cold chain of fruits and vegetables in the industry, and the unclear definition of responsibility. It accelerates the standardization, integrates the management of cold chain of fruits and vegetables, and the quality of fruit and vegetable production with SQMFV. Management norms) and European and American countries have taken the initiative to promote the integration. However, at present, China's fruit and vegetable cold chain market has a wide coverage, numerous participants, and complex links. It is unrealistic to solve all the problems of fruit and vegetable cold chain management by relying on the effective effect of one regulation, and the relevant policies of China's fruit and vegetable cold chain operation management. There is still room for further optimization in the regulations. In this context, this paper builds an intelligent cold chain logistics system based on the Internet of Things cloud computing by vigorously developing the cold chain logistics of fruits and vegetables combined with new technologies, and study the zero-stock warehouse and three-dimensional warehouse of a fruit and vegetable distribution center. The object is to optimize the key problems involved in its warehouse operation process and management system to improve the control ability of the cold chain logistics and improve the circulation efficiency.

Key words: Fresh Fruits and Vegetables, Cold Chain Logistics, Logistics Warehouse.

1. Introduction

With the development of economic globalization and information technology, the role of modern logistics in economic development has become increasingly prominent [1, 2]. The development of modern logistics can improve circulation efficiency and effectively reduce logistics costs, thereby enhancing the competitiveness of enterprises [3]. Therefore, modern logistics is called the “third profit source” of the enterprise. With the intensification of competition in the logistics industry, there will be two major development trends in the logistics industry in the future: First, the number of third-party logistics companies has increased rapidly [4]. According to a survey conducted by the American Mercer consultants and the China Federation of Logistics and Purchasing, the turnover of real third-party logistics companies in 2017 was 70 billion Yuan, but at a rate of 15% per year. According to statistics, in 2018, it is close to 80 billion Yuan, and in 2019 it is close to 100 billion Yuan. The logistics outsourcing of industrial and circulation enterprises has increased significantly, and about 60% of enterprises choose some or most of logistics outsourcing. Second, the intensified competition in the logistics market will lead to an accelerated division of labor, and the specialization of demand will bring about market segmentation. Logistics enterprises will develop in a more specialized and more efficient direction, thus gradually forming a situation in which product lines and product lines, supply chains and supply chains compete.
The emergence of the cold chain logistics industry is the birth of modern logistics in the direction of specialization [5-7]. Fruit and vegetable cold chain logistics belongs to the fine series and scarce parts of today's logistics industry [8]. He refers to the use of modern technology equipment and information technology to provide customers with refrigeration, refrigeration, warehousing, transportation, distribution, packaging, processing, multimodal transport and other value-added services. Its service target is mainly catering, retail industry and so on which have special requirements for temperature control. At present, a complete set of complete fruit and vegetable cold chain systems, such as production, processing, distribution, warehousing, distribution, and after-sales, have been formed in developed countries in Europe and America [9]. At present, China's fruit and vegetable cold chain logistics has many problems such as uneven regional development, inadequate supporting policies and standards, high cost, lack of scale and professional operation, and lack of professional management talents. At this stage, rebuilding the integrity system of fruit and vegetable cold chain is the primary responsibility of practitioners. In the future, “professional”, “fine”, “integration” and “integrity” will become the key words for the development of fruit and vegetable cold chain industry [10-13].

The basis of fruit and vegetable cold chain logistics is cold chain logistics. Different definitions are given to different countries and different scholars of cold chain logistics. The research on cold chain logistics in foreign countries is relatively mature, and the theoretical rules and regulations have been formed. The representative definition of cold chain logistics can be defined by the Japanese National Pharmacy and the US Food and Drug Administration. Domestic reference can be made to Wang Zhitai and “Logistics Terminology” for the introduction of cold chain logistics. Different definitions of cold chain logistics have in common: throughout the whole process, low temperature processing, and quality assurance [14-17]. In view of the development of China's fruit and vegetable cold chain, Zhang Hao and other scholars analyzed the advantages and disadvantages of radio frequency identification technology for the characteristics and requirements of vegetable cold chain logistics system, focusing on the research, production, processing, storage and transportation of radio frequency identification technology in vegetables. The application of cold chain in sales and other links has proposed the application design of radio frequency identification technology in the production system, storage system, transportation system and sales system of vegetable cold chain logistics [18]. Based on the analysis of the problems existing in the cold chain logistics of vegetables, Liu Min et al. discussed the quality and safety of all aspects of the vegetable supply chain based on HACCP system management, and pointed out the shortcomings of the HACCP management system. At the same time, a series of optimization methods for HACCP management system of vegetable cold chain logistics were proposed [19]. Chen Sumin and others established a safety early warning indicator system for agricultural products cold chain logistics based on fuzzy hierarchy method. According to the source and nature of the hazard generated in the cold chain logistics of agricultural products, and the relevant norms that the agricultural products are in the process of circulation, this paper analyzes the three aspects of internal factors, environmental factors and logistics factors to find out the actual situation. The indicator set and the fuzzy analytic hierarchy process are used to determine the weight of the early warning indicator [20].

Due to the lack of cold chain logistics industry standards, China's cold chain logistics has the phenomenon of “high requirements, no standards” and faces the double test of safety and development. At the “2018 Pan-Pearl River Delta Cold Chain System Construction Conference” held in April 2018, the cold chain companies from the fields of medicine, food, technical equipment and other fields discussed the development of industry standards to improve the safety of temperature control products. It’s about sex and reliability. The standards related to quality control, environmental temperature and cleanliness monitoring, cold chain transportation temperature control, sanitary management and packaging technology in the cold chain logistics industry will be led by the state, and the industry will be gradually established and improved. In terms of informationization, advanced logistics technology is combined with information system and network interaction platform to implement real-time monitoring of the entire supply chain process of temperature control products, to understand accurate market dynamics through information technology, and to master temperature control products in the process of circulation. The quantity, location and other information to provide a reliable basis for decision-making, maximize management and logistics efficiency. It is also possible to implement quality traceability, clarify powers and responsibilities, and avoid disputes. The advanced information technologies currently involved include management information systems, warehouse management systems, enterprise resource plans, information dissemination systems and search engines.

This paper builds an intelligent cold chain logistics system based on the Internet of Things cloud computing by vigorously developing the cold chain logistics of fruits and vegetables combined with new technologies, and take the zero cargo warehouses and the three-dimensional warehouse of a fruit and vegetable distribution center as the research object, and its storage operation process. And optimize the key issues involved in the management system to improve the control and control of cold chain logistics and improve circulation efficiency.
2. Internet of Things and Cloud Computing

2.1. Internet of Things Technology

The definition of IOT technology is: through information recognition devices such as radio frequency identification (RFID), infrared sensors, global positioning systems, laser scanners, etc., to connect any item with the Internet according to the agreed agreement, and exchange information and communication, a network technology that enables intelligent identification, location, tracking, monitoring, and management. The core and foundation of “Internet of Things technology” is still “Internet technology”, which is a network technology that extends and expands on the basis of Internet technology. Its client extends and extends to any item and item for information exchange and communication.

(1) Definition of Internet of Things technology

The Internet of Things refers to Ubiquitous devices and facilities, including sensors with “intrinsic intelligence”, mobile terminals, industrial systems, CNC systems, and home intelligence devices, video surveillance systems, etc., and “external enable” (Enabled), such as RFID-attached assets (Assets), individuals and vehicles carrying wireless terminals, etc. “smart parts or animals” or “smart dust” (Mote), interoperability (M2M), application integration (Grand Integration), and cloud-based SaaS operation through various wireless and wired long-distance and short-range communication networks. In the network (Intranet), private network (Extranet), and Internet (Internet) environment, the use of appropriate information security mechanisms to provide secure, controllable or even personalized real-time online monitoring, location and traceability, alarm linkage, scheduling command, Plan management, remote control, security, remote maintenance, online upgrade, statistical reports, decision support, leadership desktop (centralized display C The management and service functions such as cockpit Dashboard realize the integration of “management, control, and battalion” of “all things”, “efficient, energy-saving, safe, and environmentally friendly”.

(2) Key technologies

First, sensor technology, which is also a key technology in computer applications, everyone knows that most computers have processed digital signals so far. Since the computer has been required, the sensor needs to convert the analog signal into a digital signal computer.

Second, the RFID tag is also a sensor technology. RFID technology is a comprehensive technology that integrates radio frequency technology and embedded technology. RFID has broad application prospects in automatic identification and item logistics management.

Third, embedded system technology: is a complex technology that integrates computer hardware and software, sensor technology, integrated circuit technology, and electronic application technology. After decades of evolution, smart terminal products characterized by embedded systems can be seen everywhere; from small MP3s to aerospace satellite systems. Embedded systems are changing people’s lives and driving industrial production and the development of the defense industry. If the Internet of Things is a simple metaphor for the human body, the sensor is equivalent to the human eye, nose, skin and other senses, the network is the nervous system used to transmit information, the embedded system is the human brain, and the information is classified after receiving the information. Deal with. This example is a very vivid description of the location and role of sensors and embedded systems in the Internet of Things.

(3) Architecture

The typical architecture of the Internet of Things is divided into three layers, from bottom to top, the sensing layer, the network layer and the application layer. The core ability of the IOT to realize the comprehensive awareness of the Internet of Things is a key part of the key technologies, standardization and industrialization in the Internet of Things. The key is to have more accurate and comprehensive sensing capabilities, and to solve low power consumption and miniaturization. Low cost issues. The network layer mainly uses the widely covered mobile communication network as the infrastructure. It is the most standardized part of the Internet of Things, and the most mature and mature part of the industrialization. The key is to optimize and transform the characteristics of the Internet of Things application to form a system-aware network. The application layer provides a wealth of applications, combining IOT technology with industry information needs to achieve a wide range of intelligent application solutions. The key lies in industry convergence, information resource development and utilization, low-cost high-quality solutions, and information security. Safeguard and development of an effective business model, The Internet of Things system is mainly composed of an operation support system, a sensor network system, a business application system, and a wireless communication network system.

Through the sensor network, the required information can be collected. In practice, the customer can use RFID readers and related sensors to collect the data information they need. When the gateway terminal is aggregated, it can be smoothed by the wireless network. Transfer to the specified application system. In addition, the sensor can also use ZigBee and Bluetooth technology to achieve effective communication with the sensor gateway.
The business application system mainly provides necessary application services, including smart home services, card services, water quality monitoring services, etc., and the objects served are not only individual users, but also industrial users or home users. In the Internet of Things system, there are usually multiple communication interfaces, and the communication interface is not standardized. However, in terms of IOT applications, the relevant laws and regulations are not perfect, which is not conducive to the security development of the Internet of Things.

The use of sensor gateways can achieve the convergence of information, and at the same time, communication network technology can be used to make information can be transmitted over long distances and smoothly reach the specified application system.

2.2. Cloud Computing Technology

Cloud computing consists of a series of resources that can be dynamically upgraded and virtualized. These resources are shared by all cloud computing users and can be easily accessed through the network. Users do not need to master the cloud computing technology, and only need to rent according to the needs of individuals or groups, Cloud computing resources.

(1) The technical principle of cloud computing

In a typical cloud computing mode, users access the network through the terminal to make demands on the “cloud”; the “cloud” organizes resources after accepting the request, and provides services for the “end” through the network. The functions of the user terminal can be greatly simplified, and many complicated calculations and processing procedures will be transferred to the “cloud” behind the terminal to complete. The application required by the user does not need to run on the user's personal computer, mobile phone and other terminal devices, but runs on a large-scale server cluster of the Internet; the data processed by the user does not need to be stored locally, but stored in the Internet, on the data center. Enterprises that provide cloud computing services are responsible for the management and maintenance of these data centers and servers, and provide users with sufficient computing power and sufficient storage space. Anytime, anywhere, users can access the cloud as long as they can connect to the Internet for on-demand use.

(2) Key technologies of cloud computing

Cloud computing is the result of the development of processor technology, virtualization technology, distributed storage technology, broadband Internet technology and automated management technology. From a technical perspective, the realization of the basic functions of cloud computing depends on two key factors, one is the storage capacity of data, and the other is distributed computing power. Therefore, the “cloud” in cloud computing can be subdivided into “storage cloud” and “computation cloud”, that is, “cloud computing = storage cloud + computation cloud.”

Storage cloud: a large-scale distributed storage system;
Compute Cloud: Resource Virtualization + Parallel Computing
The role of parallel computing is to first split large computing tasks and then distribute them to the nodes in the cloud for distributed parallel computing. Finally, the results will be collected and unified, such as sorting and merging.

The main meaning of virtualization is to do more with less resource. Introducing virtualization technology into the computing cloud is to enable more parallel computing to be run on fewer servers, and to quickly and optimally configure the resources used in cloud computing.

(3) Characteristics of cloud computing

First, the cloud computing system provides services, and the implementation mechanism of the service is transparent to the user. The user does not need to understand the specific mechanism of the cloud computing to obtain the required services.

Second, reliability is provided in a redundant manner. The cloud computing system provides data processing services to users by a large number of commercial computer components. As the number of computers increases, the probability of a system error increases dramatically. With the support of dedicated hardware reliability components, software is used, namely data redundancy and distributed storage to ensure data reliability.

Third, high availability, by integrating mass storage and high-performance computing capabilities, the cloud can provide a certain level of satisfaction with the quality of service. The cloud computing system can automatically detect the failed node and exclude the failed node without affecting the normal operation of the system.

Fourth, high-level programming models, cloud computing systems provide a high-level programming model. With simple learning, users can write their own cloud computing programs and execute them on the “cloud” system to meet their own needs. Cloud computing systems now mainly use the Map-Reduce model.

Fifth, economics, the formation of a fleet of large commercial machines is much less expensive than a supercomputer of the same performance.
3. Design of Cold Chain Warehouse Management System Based on Internet of Things

3.1. The Overall Architecture of the Information Acquisition System Based on the Internet of Things

For the AS/RS of a fruit and vegetable distribution center, the RFID and WSN information collection technology of the Internet of Things is used to automatically collect information such as items and environment, and provide basic data support for WMS optimization scheduling and information management functions. From the perspective of the application of the entire Internet of Things in the cold chain storage of a fruit and vegetable distribution center, it can be divided into the following three parts: real-time collection of warehousing information (information of goods and environment), convergence and transmission of warehousing information, and warehousing information. Storage and application, its IOT system architecture is shown in Figure 1:

![System architecture diagram](image)

Figure 1. System architecture diagram

(1) The theory of EPC coding, RFID technology and WSN sensor system are mainly used for automatic collection of fruit, vegetable and environment information in cold storage. Before the purchased goods are stored in the warehouse, the basic information of the goods is coded according to EPC coding rules. After that, the data can be stored in the RFID tag by intelligent reader and attached to the fruit and vegetable pallet (each pallet stores the same batch of fruits and vegetables), which provides data support for the information management of the warehousing system. According to the storage order, when the fruits and vegetables are stored in the warehouse, the RFID intelligent reader at the warehouse storage desk reads the tray label information. The principle is shown in Figure 2. The RFID middleware manages the EPC codes read and transmitted from the reader through the Savant system, organizes and manages the information flow hierarchically by using the distributed structure, and then gives the Savant system the object name parsing service (ONS) of EPCIS. The EPC codes stored in the traditional positioning and labeling system correspond to the system IP which contains the basic information of fruits and vegetables. Then the corresponding entries in the Product Marked Language (PML) server can be found. Thus, the basic data information of fruits and vegetables can be visualized and managed through the interface between the reader and the computer. At the same time, WSN sensor system collects temperature and humidity information in the cold storage through a large number of sensors, and transmits it to the warehouse management system through fieldbus. It realizes dynamic monitoring and warning of environmental information, avoids environmental failure of fruits and vegetables, and ensures the quality and safety of fruits and vegetables.

(2) Cold chain storage information is mainly collected and transmitted through wired or wireless communication network technology. The existing wired transmission network includes controller LAN, fieldbus, TCP/IP and so on. RS-484 fieldbus is used in the storage of fruit and vegetable distribution center. The commonly used wireless transmission network includes ZigBee short-range wireless networking technology, GPRS, Wi-Fi and so on.

(3) Automatic collection and storage of cold chain storage information, for the warehouse management system designed in this paper, to provide basic data support for dispatch management system and information management system (query, early warning, etc.).

Aiming at AS/RS of cold chain warehouse core, based on the above information collection based on the Internet of Things, we can get the flow chart of the joint entry and exit operation of goods: the scheduling system first assigns and optimizes the entry and exit tasks according to the entry and exit tasks, and then sends them to the control layer for execution. All fruits and vegetables must go through the outlet/storage desk before they can go out/into storage. In the process of storage of fruits and vegetables through the conveying system, the information of fruits and vegetables should be read through the automatic identification system (RFID
technology, consisting of electronic tags attached to the tray, intelligent reader and computer), then the read data should be transmitted to WMS. After the information processing is processed by the intelligent optimization algorithm of WMS background, a specific roadway stacker is assigned for storage, and then the fruits and vegetables waiting for storage are transported to WMS. At last, the roadway stacker is used to assign AS/RS cargo location automatically according to the pre-programmed cargo allocation in the Warehouse Control System (WCS) and complete the task of warehousing operation. Usually, the process of out warehousing fruits and vegetables is similar to that of in warehousing, so the process of out warehousing is no longer described in detail.

![Figure 2. Principle of information acquisition system](image)

3.2. Demand Analysis

The system-oriented automatic three-dimensional refrigerator of a fruit and vegetable distribution center not only includes low-temperature storage of fruits and vegetables, but also includes upstream purchasing and downstream sales to break the revenue limitation of a single storage business. Aiming at the low-temperature storage of business agents, the optimization of scheduling control for AS/RS cold storage is studied based on intelligent algorithms such as multi-agent, improved Hungarian algorithm, polychromatic set and discrete particle swarm optimization. On this basis, an automatic information acquisition system based on the Internet of Things (RFID and WSN) is constructed to realize more automation, intelligence and informationization of AS/RS in inventory operations such as receipt, storage, inventory and discharge, which greatly improves the operation efficiency of AS/RS, reduces operation time, and improves the circulation efficiency of low-temperature food in the cold storage, thereby further improving the results. The whole circulation efficiency of the vegetable cold chain is realized, and the real-time monitoring and warning analysis of the temperature of the cold storage are realized. The temperature of the refrigeration system is automatically controlled to reduce the loss of the articles. In addition, the fruit and vegetable distribution center also attaches great importance to the procurement and sales business. With information technology as the carrier, the information management of enterprise's purchasing, storage and sales links is realized so as to avoid errors in the actual operation of the system as far as possible, and to significantly reduce blind purchasing, reduce storage costs, improve circulation efficiency, pay attention to market demand, reduce capital occupation and improve market sensitivity, so as to enable enterprises to rationally arrange purchasing, storage and sales. Each key step is to enhance the competitiveness of enterprises in the market. To solve these problems, fruit and vegetable enterprises put forward higher requirements for WMS based on automatic collection of goods and environmental information, integrated warehouse dispatching and inventory information management. According to the actual demand survey of distribution center, WMS is required to have the following functions.

1. The operation interface is beautiful, convenient and flexible;
2. In addition to the menu bar and toolbar, navigation buttons can also be used to achieve rapid operation of some functions of the system;
3. Providing manual and automatic collection, input, analysis and early warning of goods, environment and other information based on the Internet of Things;
4. Assignment of AS/RS and spare warehouse operations, and optimization of AS/RS cargo location allocation;
5. Strong information management of purchase, sale and inventory, including basic information, procurement, in-store management, sales and returns, etc.
6. Providing statistical analysis function for information such as purchasing, inventory, sales, etc.
(7) Queries of single condition, combination condition and fuzzy condition can be realized.
(8) Providing functions authorized for multiple users, but allocating relatively limited functions according to permissions;

Based on the above requirements, the logistics management system of cold chain warehouse is designed to achieve the established objectives.

4. Implementation of Key Functions of the System

4.1. Key Function Module Implementation

Because there are many modules of fruit and vegetable cold chain logistics information system, here we only introduce the quality control module of transportation delivery quality management and in-transit goods quality control in fruit and vegetable cold chain logistics process. In the quality management of fruit and vegetable cold chain logistics transportation, the system can query, input, delete and modify the information of transportation, goods, real-time temperature, destination, etc. The interface of the system is shown in Fig. 3, Fig. 4 and Fig. 5.

![Figure 3. Transport delivery query interface](image1)

![Figure 4. Input, modify, delete interface](image2)

The system can also monitor the quality of fruit and vegetable cold chain goods during transportation. The monitoring mainly focuses on the temperature, location and packaging intact rate of fruit and vegetable cold chain goods. According to the temperature information collected from the database, the system can automatically generate the static temperature monitoring line chart with the time point as the horizontal axis and the temperature as the longitudinal axis. The system implementation interface is shown in Fig. 5. At the same time, the fruit and vegetable cold chain logistics quality management information system plans to achieve temperature early warning/alarm, as well as dynamic monitoring. The function of early warning/alarm is that when the temperature point in the temperature broken line chart exceeds (or is on the verge of) the specified temperature limit, the system will automatically alarm, and display the shipping order number of the defective goods and the information of the relevant person in charge, so as to prevent or deal with the quality hazard in
time; dynamic monitoring, that is, relying on the wireless temperature monitoring equipment to collect and transmit the temperature information to the database in real time, and then through the place of the information system. Real-time monitoring of goods temperature can be realized by generating dynamic temperature monitoring charts.

![Diagram of temperature monitoring system](image)

**Figure 5.** Interface Diagram for Quality Monitoring of In-transit Goods in Fruit and Vegetable Cold Chain Logistics

5. Conclusions

1. Based on the analysis of the current fruit and vegetable cold chain logistics system, the intelligent cold chain logistics system based on cloud computing is constructed by combining new technologies such as EPC Internet of Things, cloud computing and cold chain logistics. Combining with the diversified cold chain logistics service demand of the recipients, the modular construction of the intelligent cold chain logistics system is carried out, and its core is explored, and the feasibility of the intelligent fruit and vegetable cold chain logistics system is demonstrated.

2. Aiming at the whole process of cold chain logistics of low-temperature fruits and vegetables, integrating Internet of Things, cloud computing and other technologies, and facing different related objects, an intelligent cold chain logistics system based on cloud computing is constructed. Through collecting the data information of products and environment in the whole cold chain, the information of each link is automatically tracked, identified, dynamically analyzed and predicted, and the abnormal information which may lead to the quality and safety problems of low-temperature fruits and vegetables is predicted and warned. Through the public information platform, an effective way to monitor, query and trace the quality of low-temperature fruits and vegetables is provided. Now the whole process of cold chain control of low-temperature fruits and vegetables, improve the logistics efficiency and quality of low-temperature fruits and vegetables. Thus, the intelligent cold chain logistics system based on cloud computing can solve the shortcomings of the current cold chain logistics system, promote the automation and informatization of the whole cold chain of low-temperature fruits and vegetables, and greatly promote the development of modern cold chain logistics.

3. Compared with other identification technologies in China, the RFID system has obvious technical advantages, such as non-contact automatic identification of target objects, long-distance identification of high-speed moving target objects, bidirectional communication of dynamic information management, higher level of intelligence and stronger environmental adaptability. In the management of fruit and vegetable cold chain logistics, people pay more and more attention to the real-time collection and transmission of fruit and vegetable information. For some valuable fruits and vegetables, cold chain logistics pursues real-time comprehensive monitoring. In the process of cold-chain fruit and vegetable circulation, the use of RFID technology can not only realize the real-time upload of temperature data in each link of logistics, the temperature label loaded on the target object combined with GPRS and other means, but also realize the real-time monitoring of the target fruit and vegetable and the continuous record of the environmental temperature of the cold-chain fruit and vegetable in the logistics information management platform.

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