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Research on adopting application in agricultural products supply Chain based on internet of things

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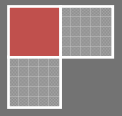
ABSTRACT

With the further deepening of the development economy, China's agriculture will face a huge crisis. Under the impact of global competition, our country agriculture showed a low level of industrialization, the low level of management, the value chain of low level and low degree of information technology. Organizational decentralization and shortcomings are lack of food quality and safety. China's agriculture is to survive in such a fierce competition environment, must to actively use advanced technology, management method and system to the effective integration of agricultural products supply chain. In this paper, through the supply chain of agricultural products in the internet of things technology, the overall framework for establishing network analysis technology application of business process of the supply chain of agricultural products in the application mode, to sort out the various links of production. In the supply chain of agricultural products processing, storage, transportation and sales; through the proposed strategy layer, the implementation of three layer and support layer network hierarchical structure of agricultural products supply chain management system, the management system of existing network system and agricultural products in the supply chain (ERP, MIS, CRM) to the organic integration, and the supply chain strategy and daily operation planning and supply chain management system together, so that the whole agricultural product supply chain has become a highly efficient, reasonable overall.

KEYWORDS

Internet of things; Agricultural means of production; Supply chain; TOE model.



INTRODUCTION

In the background of the global economic development, continuous integration of the global economy, the supply chain of agricultural products in China are confronted with the fierce competition of agricultural products[1]. For the enterprises, to survive in such a fierce competition environment down, we must constantly change, innovation, to improve the efficiency of enterprises using advanced technologies[2]; at the same time, in recent years, the safety problems of agricultural products emerge in an endless stream, the people are also getting to the safety problems of agricultural products is concerned, the Chinese government is also on the food safety issue of great concern, China's government is waging a campaign to system for food safety problems[3]. The adoption of the Internet of things technology effectively solves the above two problems. But there are many factors affect the adoption of technology of the Internet of things, such as cost, technical complexity and size of the organization, and so on, hence the need to identify these factors affecting the adoption of Internet of things technology[4,5].

In recent years, the business system of China has investigated tens of thousands of cases of fake cultural materials including many kilograms of substandard seeds and many kilograms of substandard fertilizer. These fake agricultural products will bring enormous loss to the farmers. In China, one of the important reasons why we cannot eliminate the problem of fake and shoddy agricultural products is that China has not established a reasonable sound agricultural supply chain[6]. Existing agricultural supply chain has disadvantages in decentralized management and lacks of convergence. So a safe, efficient, smooth and perfect operation of the network system of agricultural products cannot be established. It is the technology of internet of things that solves the above problem by providing a feasible and efficient solution[7]. In our current environment, the internet of things, with its real-time, accurate and shared characteristics, will bring great changes to the agricultural supply chain and provides a critical technology for establishing a smooth flow of agricultural logistics and supply chain information[8].

This paper focuses on foreign technology adoption theory and factors are summarized, it provides a theoretical basis for the Internet of things technology adoption. At the same time, the research of this paper enriches the theory of research adopted domestic technology. This paper presents the agricultural products supply chain management technology of Internet of things based on three layer framework (strategic layer, execution layer, support layer). In the agricultural information processing and application infrastructure, application of facility agriculture IOT is mainly embodied in the realization of intelligent agricultural production, management, decision-making, therefore on the agricultural production of the key link, need to focus on the applications of the Internet of things technology in crop growth data processing facilities, production of digital management, data sharing, user interface and service intelligent network, intelligent decision-making.

RELATED BASIC THEORY

Research status of agricultural products supply chain

The domestic and international research about the supply chain of agricultural products mainly focus on quality and safety, risk management, supply chain organization efficiency, information technology application (RFID tracing application), supply chain evaluation and so on several aspects[9]. Study on the supply chain of agricultural products in foreign countries is mainly the information management and the quality and safety aspects analysis, supply chain in the supply chain value. Development of Hofman[10] and points out the fishery supply chain cannot do without the information and communications technology, the overall competitiveness of the use of information and communication technology can greatly improve the fishery supply chain. Reardon and Farina pointed out that the use of advanced information technology to improve food safety, so that more competitive supply chain of aquatic products enterprises. Williamson pointed out that how to use modern information technology, Internet and information system in the agricultural products supply chain. Curieux-Belfond[11] pointed out that the professional standards of aquatic products processing is very

important to ensure the quality and safety of aquatic products, shall establish professional standards and continuous improvement.

The domestic research literature about agricultural products supply chain mainly concentrated in a few quality safety, risk management, organization efficiency etc. Han Limin and Deng Yunfeng pointed out that China's fishery industry there are farming, fishing, aquatic products processing three industry value chain. Jin Shufang and each part of the application of RFID technology to the aquatic product supply chain production, processing, storage, transportation, sales, and the need to solve the problem in the application described[8].

Internet of things theory

Now the internet of things is generally defined as a network, which connects everything with the internet by radio frequency identification (RFID), sensors, global positioning systems, laser scanners and other information sensing devices in accordance with the agreed protocol and exchange information in order to achieve intelligent identification, location tracking, monitoring and management.

The network can realize the automatic identification of objects and locate, track, monitor and trigger the corresponding event. It makes use of RFID technology for scanning and reading EPC tags on the items and achieves automatic identification of goods and information sharing. At present, the architecture of the Internet of things is divided into three layers: the sensing layer, network layer and application layer. System structure was shown in Figure 1 of the Internet of things.

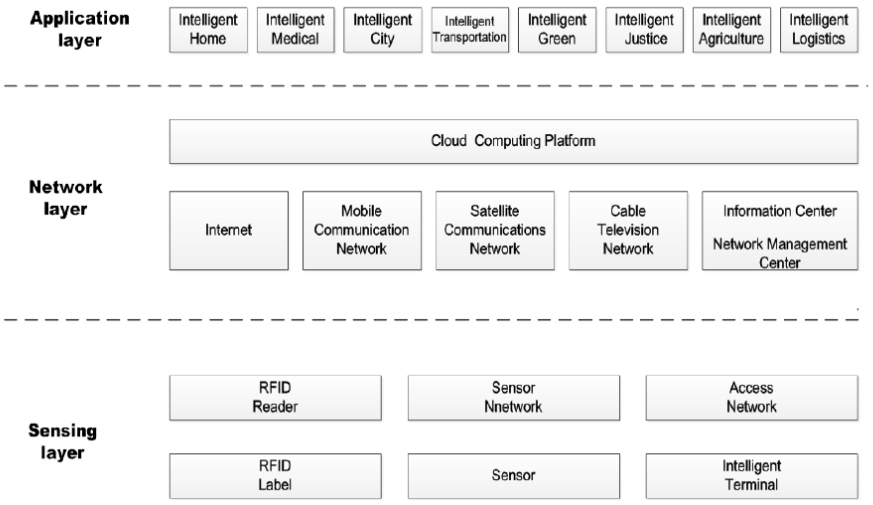


Figure 1: System structure of the three layers

The perceptual layer consists of data acquisition layer, self organizing sensor networks.

Acquisition sub layer integrated bar code, sensors, satellite positioning, RFID and multimedia information acquisition technology data acquisition, access to a variety of data information of all kinds of voice, video and other multimedia data, physical quantity, marking the physical world.

Self-organizing sensor network digital link coding, modulation, and demodulation technology based on data transmission, realize sensor and sensor nodes in the LAN between, networking, traffic management, routing technology based on self interaction, organization and coordination among the nodes.

Middleware includes embedded middleware, sensor network middleware, application in the sensing layer, in order to solve the problem of equipment management and data management, including configuration, calibration, fault detection and data conversion, such as loading. When the complete data collection, in order to effectively reduce the data redundancy, improve the quality of data, also need to

data fusion, compression, clustering, recognition and other information processing technology to the original coordinate sensing data processing based on.

In a unit of time, occurrence of foot data communication between n computers ($1 \leqq Y \leqq n/2$), source machine to the destination machine communication and participation are random, uniformly distributed in n;

From the moment of into the system of n, n machines as a poison, its number is Cl; a computer Di ($i \neq l$) virus conditions are: < Di, Dj>∈Ec, I (Di ∈ GY) I (Dj∈ GY); the computer once infected with the virus, the epidemic is poison machine. Let Xn be the number of infected computers, in the first n unit time in D {Xn, $n \geqq 1$} constitutes a discrete random process, in the Z units of time, the number of infected machines is E (Xi), it is not the number of exposure machine as (Z - E (Xi)). Foot data communication in the Z units of time and the n+1 units of time intervals, expected exposure machine mathematics source machine value:

$$\frac{Y}{Z}\,E(Xi) \tag{1}$$

Mathematical expectation of the number of non-toxic machine target values:

$$Y - \frac{Y}{Z}\,E(Xi) \tag{2}$$

According to the random assumption and propagation, new mathematical expectation for exposure machine is shown as follow:

$$\frac{Y}{Z}E(Xi)\left(1 - \frac{E(Xi)}{NZ}\right) \tag{3}$$

In the number of exposure machine is shown as follows:

$$E(Xi + 1) - E(Xi) = \frac{Y}{Z}E(Xi)\left(1 - \frac{E(Xi)}{Z}\right) \tag{4}$$

The number of units of time for exposure machine is shown:

$$\frac{E(Xi+1)-E(Xi)}{(i+1)-i} = \frac{Y}{Z}E(Xi)\left(1 - \frac{E(Xi)}{Z}\right) \tag{5}$$

Separation of variables, the solution and discrete time n, exposure to the computer number:

$$E(Xi) = \frac{Z}{\left[1+(Z-1)e^{\left(-\frac{iY}{Z}\right)}\right]} \tag{6}$$

The key technology of the internet of things

Formal due to RFID with these advantages, RFID has been applied to many fields, create great value for society. In recent years, as the Chinese government policy to promote, the application of RFID in the field of our country has been very extensive, RFID in the electronic ticket, highway automatic toll collection, railway automatic train identification, food safety, supply chain management and many other application fields have many mature case. The Radio Frequency Identification (RFID) is a non-contact automatic identification technology and obtains relevant data by automatically identifying the label on the objects. It is one of the most critical technologies in the technologies of internet of things.

Sensor technology is mainly responsible for the information collection of internet of things. It is the basis to achieve the perception of real-world, service and application. It is the sensor that exchanges

changes in the real world into quantitative data and sends these data to specified location through certain techniques. The technology of network communication includes a variety of wired and wireless transmission technology, switching technology, network technology and gateway technology, which is the basis of perceiving and communicating information between objects. The Cloud Computing is the products that combine traditional computer technology with network technology including grid computing, parallel computing, distributed computing, utility computing, virtualization, network storage, load balancing and other traditional computer technology and network technology. Sensor is based on accuracy and some rules to be measured into easy to identify the relationship between, a physical quantity measuring device and application.

The RFID system generally consists of three parts: tag, reader and antenna. The label by coupling components and chips, each label is the only electronic coding for recognition of objects; reader for reading the label information; main antenna for emitting radio frequency signals, in order to guarantee the communication quality inspection of the tag and reader.

Technology, organization, environment analysis framework (TOE)

Tornatzky is the critical theory of classical diffusion of innovation, factors that influence the diffusion of information technologies not only contains the characteristic elements of the technology itself (T), also contains the organization characteristic elements (O), environmental factor (E). The TOE framework is proposed, because of its wide applicability, many scholars at home and abroad based on TOE framework is studied, also studied the factors contained in this framework. The technical characteristics of the characteristics of technology itself, including technical compatibility, complexity, organizational factors include the size of the organization, high-level support, organizational culture, the environmental factors include external competition pressure, the government policy support. The TOE framework was shown in Figure 2.

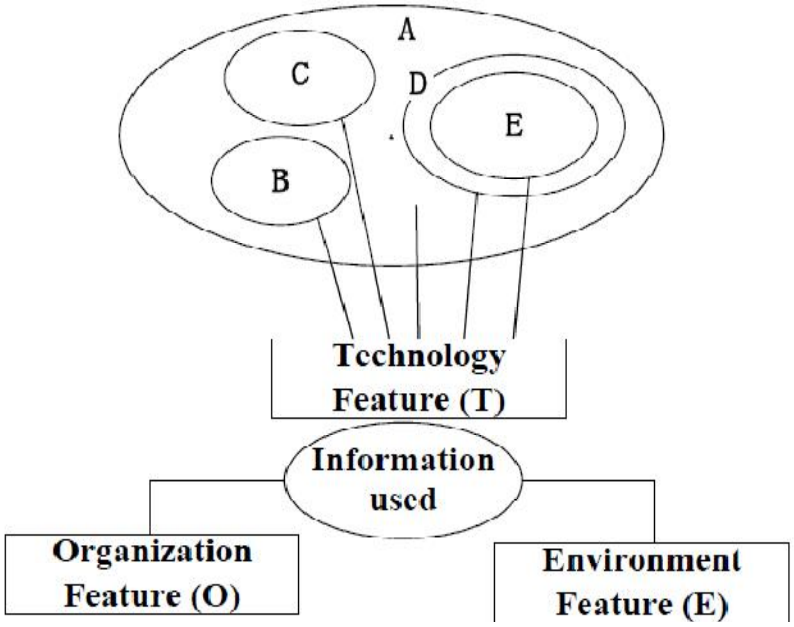


Figure 2: The TOE framework

ANALYSIS OF AGRICULTURAL SUPPLY CHAIN BASED ON THE INTERNET OF THINGS

The architecture system of the internet of things for agricultural supply chain

This paper argues that the system architecture of the Internet of Things for agricultural supply chain can also be divided into three layers including the layer of perception, the layer of network and the layer of application. It is shown in Figure 3.

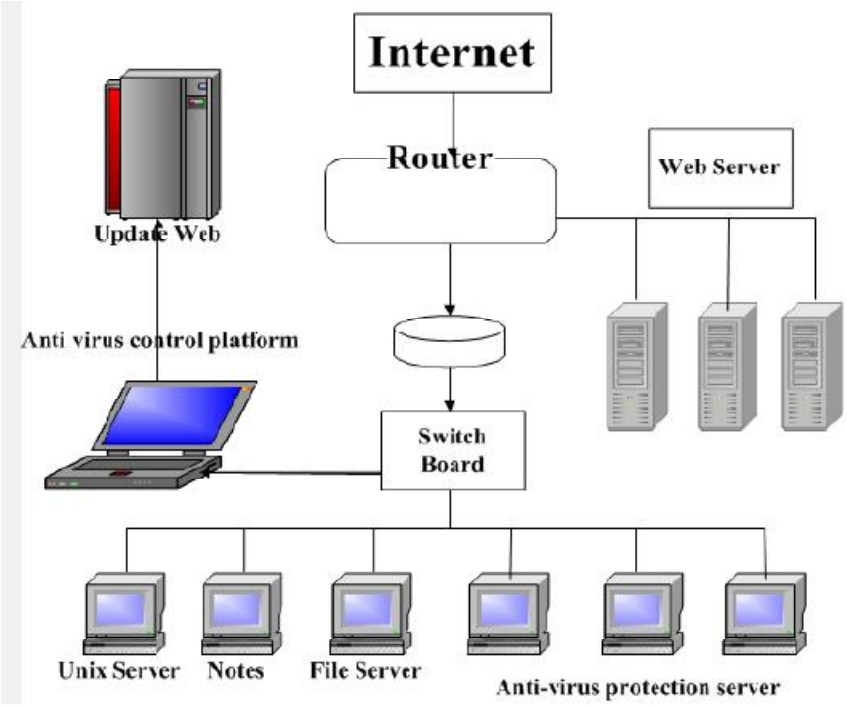


Figure 3: The architecture system of the internet of things for agricultural supply Chain

The layer of perception in the internet of things for agricultural supply chain contains the tag EPC, mobile reader RFID, sensor network and other sensing devices. In this layer, we should focus on solving the problem of perceiving and recognizing objects and collecting information. The main technology in this layer involves the technology of RFID, sensing, control and short-rang wireless communication. The information on tag EPC of agricultural products will be collected by RFID. Then it will be sent to the next layer, the layer of network.

The technology of the Internet of things is one of the RFID technologies can mark the object, making the object and the Internet, but the RFID/EPC tag is not able to obtain the temperature, oxygen concentration, humidity and other environmental information, can not meet the requirements of more information in the information age. The emergence of sensor technology to solve this problem, it can easily access to natural and production information in the field. The development of mature and electronic computer, information technology, remote sensing technology of sensor technology, the application field of the sensor has penetrated into every department of country economy and people's daily life.

Analysis of the internet of things for agricultural supply chain

In the traditional agricultural product supply chain, the data about the information of agricultural products is mainly collected by means of manual and bar code. This can easily result in delays, errors and lack of information of the internet of things for agricultural supply chain. And it will make logistics and information flow distorted in the transmission process. The application of the internet of things on agricultural supply chain can build a system that can control and trace the quality of agricultural products by combining agricultural supply chain with farmers' purchase. It is useful to establish a system that monitors and traces the quality of agricultural materials. The agricultural supply chain management based on the internet of things can process the logistics information of every aspect including the production, procurement, storage, transportation and sale. The system can sent exact number and right quality of agricultural products such as pesticides, fertilizers and seeds to appropriate places for meeting the needs of farmers in right price at the right time.

Industry experts believe that the Internet of things technology evolution is divided into information gathering, cooperative awareness and pan in the three stage polymerization. Application of

the angle from the Internet of things, the application of Internet of things technology will also be divided into three stages: the comprehensive development period the typical application demonstration period, growth period, scale. Chinese IOT is still in the typical application demonstration period, the Internet of things will take a long time to develop. The development model of IOT industry in China is: the initial government promotion, to apply for the pilot, and then gradually to the development of the market, public management and service to the enterprise, industry application market, and then to the individual household market. At present, the Internet of things technology and application in the back field have been mature, but failed in the logistics, retail and other fields has been a breakthrough may be due to the industrial chain is too long to, industrial organization is too complex, high transaction costs, the industry scale is difficult to reduce the problem of limited cost, so that the overall market growth is slow.

Analysis of the process in agricultural supply chain

(a) Production stage

Agricultural products are sent to the farmers mainly through production, transportation, storage, sales and other stages. In the production process of agricultural products, the entire items in product line including raw materials, products, semi-finished products and finished products should be identified and tracked to achieve a balanced and steady production. Each agricultural product is labeled with RFID tag encoded with the EPC. The EPC code contains the information of product such as product name, manufacturer, grade (classification), place of origin, net weight, batch number, production date, shelf life and so on. Storage management business process was shown in Figure 4.

From the processing plant products shipped after storage, RFID/EPC tag information in fixed locations RFID can be read into the wagon inside the product variety and quantity information. People can ordered these information, once found error, return the working personnel and processing factory communication; if shipment is correct, then classify products. Each batch of agricultural products will be stacked together and it is convenient for storing and linking goods.

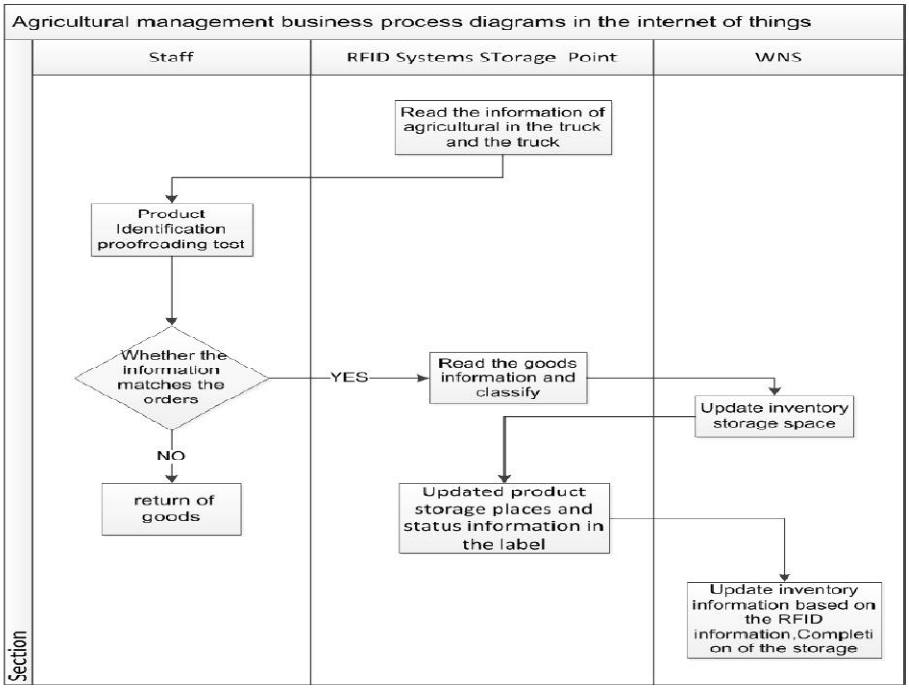


Figure 4: Storage management business process

(b) Transportation stage

In order to ensure the quality of aquatic products, reduce the loss of aquatic products, aquatic products must be in transport in low temperature environment, the temperature inside the car with the effective monitoring of the temperature sensor RFID/EPC tags, and transmitted to the management

system of distribution center. The following to distribution of aquatic products distribution center to the seller as an example to illustrate the distribution management business process. For the terminal vendors, through the Internet of things system can facilitate the view goods traffic condition through the ERP system vendors, to understand the transport of goods to what position. In the transportation stage of agricultural products, installing GPS positioning system on the vehicles enables the managers to know the location and state of the vehicles that transport the agricultural products and adjust driving direction timely in an emergency. At the same time, installing wireless data acquisition system on the vehicles can not only learn the basic information and quantity of the goods, but also detect and prevent the lost and stolen goods during the transportation.

The network structure of agricultural product supply chain management system of the Internet of things was shown in Figure 5.

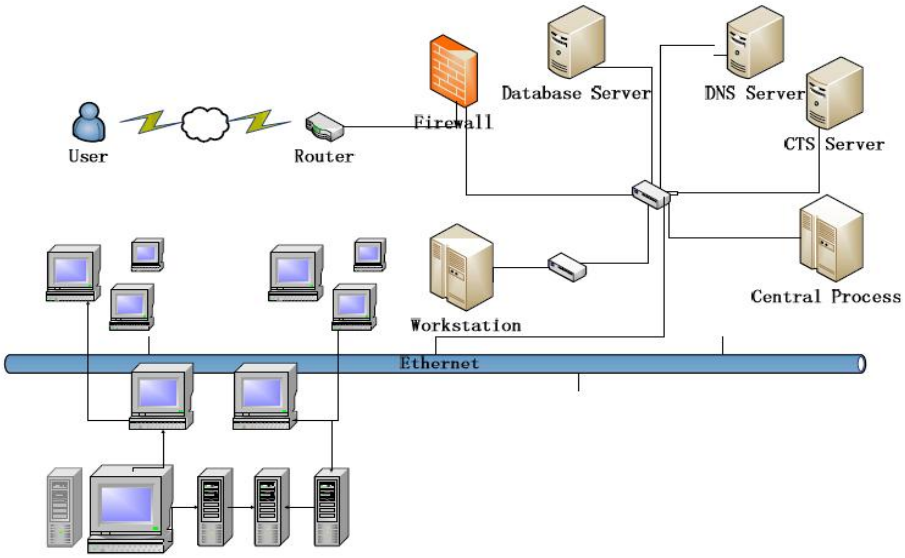


Figure 5: The network structure of agricultural product supply chain management system

(c) The system function design

Database about agricultural products should be established and set product code as its key information. It will not only help the enterprises improve storage utilization, reduce inventory and save costs, but also help the enterprises well aware of the business inventory and make a scientific and accurate decisions during ordering and production. Agricultural production management system infrastructure consisted environmental monitoring subsystem was shown in Figure 6, greenhouse facilities and digital management subsystem facility vegetable insect pest diagnosis subsystem.

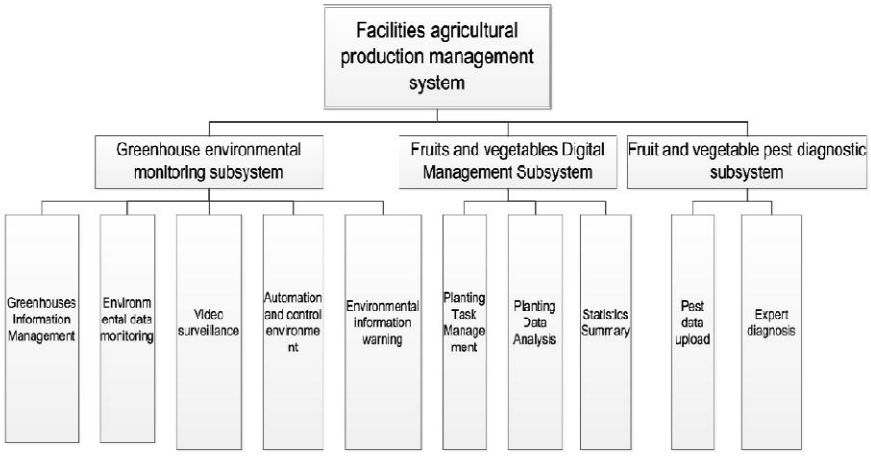


Figure 6: Agricultural production management system infrastructure

(d) Sale stage

The application of the internet of things in the stage of agricultural products' sale can be reflected in the statistics, security and validity monitoring forms. Farmers can determine whether the agricultural product is expired according to the production date EPC tags and then judge its quality. When the accident occurred in agricultural products, manufacturers, distributors, or farmers can find the final consumer by traceability system and find the places that occurred problems. This will help form a chain of efficient management and query.

THE ROLE OF THE INTERNET OF THINGS IN THE AGRICULTURAL SUPPLY CHAIN

Purify agricultural material market

The agricultural supply chain based on the technology of the internet of things is a chain of setting production, storage, distribution and retail in one to provide a traceable RFID carrier to confirm the authenticity of the agricultural products. Relevant information about agricultural products can be found from tag RFID. This will face the producers directly and eliminate the fake products completely. It will strengthen quality control and purify agricultural market by controlling the import and export channels. The Internet of things technology adopted model of this study was shown in Figure 7. Factors shown in the figure are classified according to the T-O-E model. Diagram '+' said positive influence factors on the Internet of things technology adoption, '-' said factors network reverse influence technology adoption.

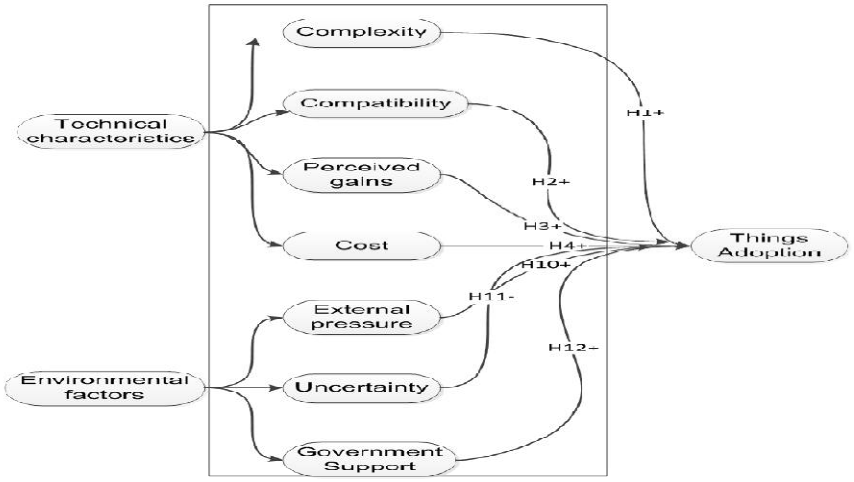


Figure 7: The Internet of things technology this study adopted model

Data analysis method

The agricultural supply chain based on the technology of the internet of things makes each step of the supply chain improve the transparency greatly. Tag RFID can automatically record the entire supply chain of agricultural products in the flow - from production to final farmers. It can not only greatly reduce the "bullwhip effect", inventory costs and labor costs in logistics center, but also improve inventory utilization. And then it will lower agricultural products price to give benefits to farmers and reduce their burdens.

The purpose of this study is to identify the key factors in the agricultural products supply chain effect of Internet of things technology adoption, and the analysis of the various factors on the impact of the Internet of things technology adoption. Therefore, in order to achieve these objectives, needs analysis of the data collected through the investigation, and the data were analyzed by statistical analysis method suitable. Analysis of the data involving many variables: variables (items), endogenous latent variables (adoption intention), exogenous latent variables (factors), so this research chose the structural equation modeling (SEM) as a data analysis method.

The observed variables can be measured directly variables, such as various items in this study is the observed variables. While the structural equation to directly measure the variable which is called

latent variables. Latent variables are constructed by observed variables. Latent variables can be divided into the exogenous latent variables and the endogenous latent variables. Changes in the exogenous latent variables of the model itself from outside variables, also is the causal relationship between changes of endogenous latent variables for; by interpreting model other internal variables, also is the causal relationship between fruit. In this study, the adoption intention as endogenous latent variables, the impact of various factors as exogenous latent variables. Structure parameter is the invariance of the causal relationship between the variables only constant.

The following general structure equation:

$$y = \Lambda_y + \varepsilon \quad x = \Lambda_x \xi + \delta \quad \eta = B\eta + \Gamma\xi \tag{7}$$

Serve the agriculture, rural areas and farmers better

The agricultural supply chain based on the technology of the internet of things can guarantee the supply of cultural materials and serve every link of agricultural production well. It will improve the efficiency of agricultural supplies and meet the needs of agricultural products by adopting advanced management concepts, management tools and distribution methods of agricultural products.

Business process analysis framework and network provides a good way for enterprises based on network, as the networking technology application in the agricultural supply chain provides a reference guide; adoption of agricultural enterprises of Internet of things technology. Analysis on Internet of things technology adoption drive factors, can make agricultural enterprises to understand what are the key factors affecting the adoption of Internet of things technology, can focus on these factors in the process of technology adoption, make things better, faster to implement in the agricultural products supply chain.

Test of goodness of fit

The agricultural supply chain based on the technology of the internet of things can promote the large-scale sales of agricultural products and make the services of agricultural technology standardization by using the way of modern logistics and marketing. This will improve the efficiency of the supply of agricultural enterprises and service level. At the same time it will enhance the competitiveness of China's agricultural enterprises. When monitor server receives the data stored in the database, it can choose to view the corresponding node temperature or humidity of the historical curve, as shown in Figure 8 for the T01 node temperature curve. Through the analysis of the temperature or the humidity curve, the user can summary agriculture monitoring field, temperature, and humidity change rule.

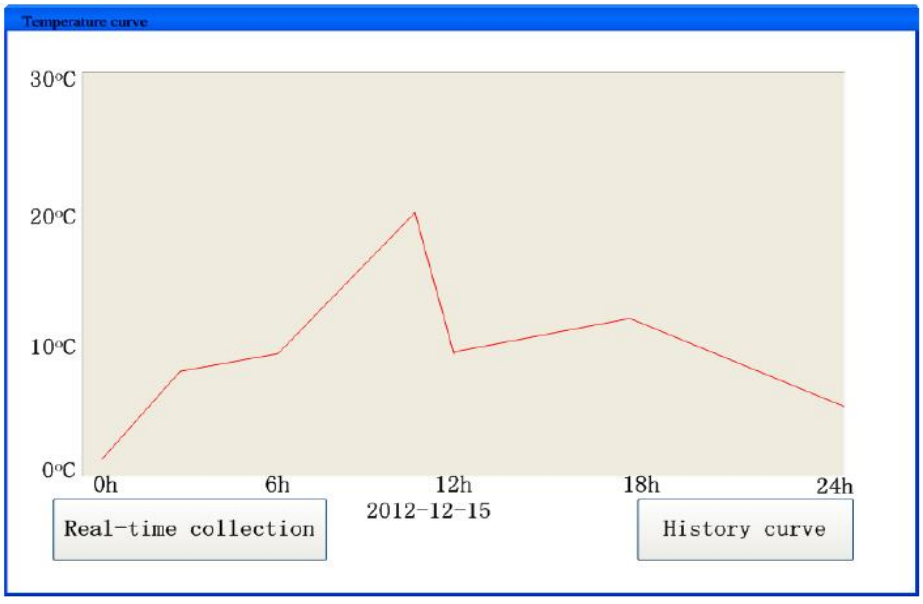


Figure 8: The temperature or the humidity curve

CONCLUSION

Through the significant path coefficient test found that in addition to the staff resistance and the uncertainty of these two factors are model refused outside, other factors are model support. In the numerous factors are supported, compatibility, perceived benefit, enterprise scale, top management support, inter enterprise supply chain trust each other, technical knowledge, the external pressure, the government support has significant positive influence on the adoption of the Internet of things technology, of which the greatest impact is the enterprise scale, the impact is the smallest external pressure; the complexity and cost the adoption of the Internet of things technology has significant and negative effects, which has a great impact on the cost of the adoption of the Internet of things technology.

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