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Research Article
Research on Vegetable Traceability System Based on Internet of Things and its Application

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Abstract: In order to improve the vegetables tracing efficiency and reduce vegetables tracking and monitoring cost, analyzed existing vegetable production, testing, location, track and sales process through the investigation of one vegetable enterprise, the vegetable traceability system scheme by RFID and Internet technology is designed. Emphasis on an analysis of the RFID system, middleware and applications such as mobile phone or wireless PDA of internet of things The final analysis of the network in the Internet based on the vegetable enterprise vegetable traceability system integrated approach. The system provides the details about vegetable information for the consumers and a good operation platform for vegetable production management and vegetable quality safety monitoring. Application results show that the warehouse has a significant effect in improving the tracing efficiency and reducing the tracking and monitoring cost.

Keywords: Anti-collision algorithm, internet of things, RFID, vegetable traceability

INTRODUCTION

As a new internet of things information network, to realize supply chain of goods automation track and trace provides basic platform. It is significant in logistics supply chain of goods and track traceability for realizing efficient logistics management and business operation.

With the development of internet of things, its technology has been widely applied to all aspects of agricultural production (Calmels *et al.*, 2006) at present most vegetable production enterprises have been under the banner of green vegetables, but consumer can't see vegetables is really green food. With the internet of things that consumers can install the machine in the kitchen, send the vegetables needed information to manufacturers, manufacturers will send home the freshest vegetables; vegetables to the home, consumers can check online barcode on the packaging of vegetables, you can understand the tree of vegetables from seed to harvest the entire process.

Meanwhile, after application of the internet of things technology can provide online ordering green vegetables, which can be timely delivered to consumers of green vegetables to ensure food freshness, while enabling consumers to the internet through the product barcode information, understanding purchased the whole process of vegetable production, to ensure that the green and organic are not adulterated, so that consumers buy the rest assured.

Application of traceability system based on internet of things, food products are labeled for each two-dimensional code, no matter where vegetables sold to consumers can be found in vegetable sources, fertilizer and drug use, so that consumers clearly consumption. Vegetable production enterprise in real-time monitoring of air museum vegetable production and land temperature, humidity and air pressure, carbon dioxide concentration and planting closely related data. Moreover, inside hall when ventilation, vegetables when water, such as how to open shade net after many needs management personnel to complete work and now things are installed sensors and the network, these tasks can be automated by the installation of the network by the appropriate setting to complete.

Combination of the related research, based on the vegetable traceability system scheme by RFID and Internet technology for the application of the background puts forward a kind of RFID system, middleware and applications Therefore; this paper studied the following questions:

- Internet of things working process
- Design of RFID middleware
- RFID anti-collision algorithm
- RFID data collection filtering algorithm

This study is partially based on the Vegetable Traceability System based on Internet of things (VTS) as an example and supported by the Science and Technology Research and Development Program of Shaanxi Province in 2012 #2012K12-03-08.

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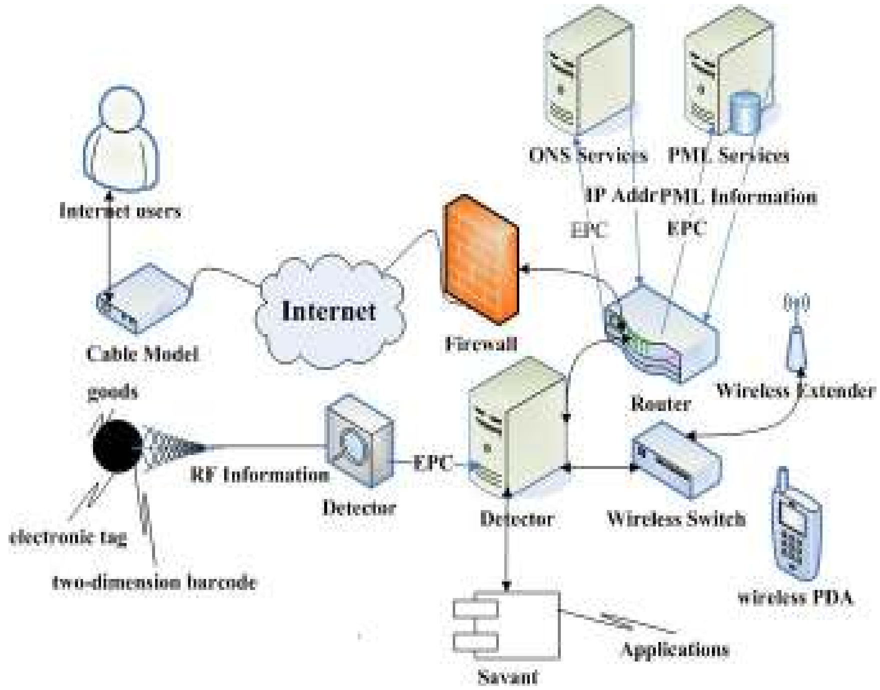

Fig. 1: The system architecture of things

EXISTING RESEARCH RESULTS

In the internet of things related techniques, domestic currently in wireless sensor network software made corresponding breakthrough on the operating system based on foreign to develop their own middleware software (Brock *et al.*, 2001). Such as the Nanjing University of Posts and Telecommunications research center for development of wireless sensor networks based on mobile agent middleware platform for wireless sensor networks, shingling technology development of wireless sensor network development kits. Domestic research institutions in the theoretical research, such as network protocols for wireless sensor networks, algorithms, architecture, etc., put forward a number of innovative ideas and theories. In this field, Nanjing University of posts and telecommunications, Tsinghua University (Sarma *et al.*, 2004), Beijing University of Posts and so made some relevant theoretical research results.

In other countries, many American universities in the wireless sensor network have carried out a lot of work. Such as the University of California, Los Angeles, CENS (Center for Embedded Networked Sensing) Laboratory, WINS (Wireless Integrated Network Sensors) Laboratory and IRL (Internet Research Lab) and so on., (Prabhu and Xiaoyong, 2005).

This study reference some vegetables enterprise's actual production processes, from home and abroad to the traceability system related research, through research based on internet of things vegetables traceability system scheme, the original traceability system based on Web vegetables processing scheme must be improved and in practical projects application and achieved good effect.

WHAT IS THE INTERNET OF THINGS

Definition of internet of things: Internet of Things (The Internet of things) is defined as: The Radio Frequency Identification (RFID), infrared sensors (Law *et al*., 2000) global positioning systems, laser scanners and other information sensing device, according to the agreement agreed to anything connected to the Internet, the information exchange and communication, in order to achieve intelligent identify, locate, track, monitor and manage a network.

Internet of things working process: The basic workflow of things from the four components, namely the information acquisition system (RFID system), PML Information Server, the product Name Server (ONS) and application management system (Gan and Fu-E, 2006). Internet of Things architecture shown in Fig. 1. Their functions are as follows:

- **Information collection system:** Information collection system consists of RFID tag (tag), two-dimensional code reader (Reader) and data exchange and management system software, the main finished products identification and EPC (Electronic Product Code) code collection and processing (Roy *et al.*, 2004).
- **Object Name Service (ONS):** Object name server ONS (Object Name Service) main function is to implement the various information collection points

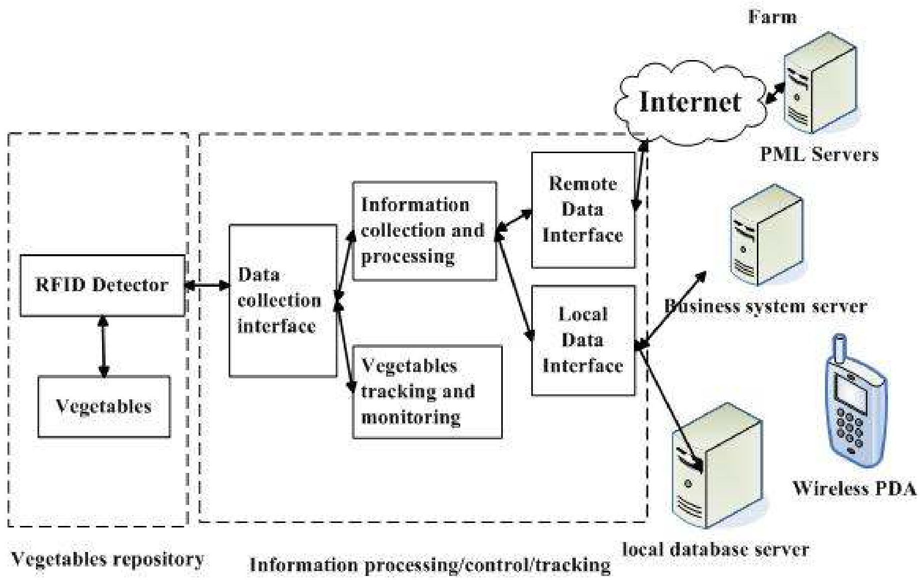

Fig. 2: Vegetable traceability system structures

and PML association between the information servers to achieve RFID EPC codes from the items to the product mapping between PML descriptions (Jb *et al*., 2008).

- **Physical markup language:** PML (Physical Markup Language, physical description language) information server data definition rules created and maintained by the user, the user according to predetermined rules to encode the items and use XML more information on the item description. In the Internet of Things, PML server is mainly used for in their common model provides for objects original information, so as to define the rules of other server access.
- **Business management system:** Business management system by accessing information collection software got the EPC information and through the PML ONS find items, which can be in the form of Web users to the Internet, such as information search, tracking and other functions, users can also real-time via cell phone or wireless PDA understanding of the status of items.

DESIGN OF VEGETABLE TRACEABILITY SYSTEM BASED ON INTERNET OF THINGS

System architecture design: Vegetable traceability system based on Internet of things using radio frequency identification and two-dimensional code technology and each of them are labeled on vegetables, two-dimensional code, no matter where vegetables sold to consumers can be found in vegetable sources. Vegetable traceability system based on Internet of things structure is shown in Fig. 2. It mainly consists of vegetables and recognition, information processing/control/tracking, PML server, the local database server, business systems, composed of five modules. Their roles are as follows:

- **Vegetable identification:** The core of vegetables identification system is the coding and identification. Since each vegetables barcode has a unique coding, no matter where vegetables sold, just enter the number of vegetables to can vegetables, tracking and monitoring. Therefore, the traceability system based on RFID or two dimensional barcode label adopts the EPC code as vegetables identification tag codes, the only by chip and Antenna composition, each tag has a unique electronic product code.
  EPC Code (Electronic Product Code) is Auto-ID research center for each physical target d can be assigned a unique identification code, its included a series of numbers can represent vegetables category and vegetables ID, production date and producer etc. information. With the transfer or change in the sales of vegetables, these data can be updated in real time. Usually, EPC code can be made of silicon chips into electronic tag, with vegetables being identified to be the information-processing software to identify, transfer and check.
- **Information processing/ control/ tracking:** Information processing/control/tracking module is the core of the system function module, it through the data collection interface, information processing, vegetables tracking and monitoring interfaces to interact with other functional modules, enabling automatic processing of vegetables.
- **PML server:** PML server consists of vegetable production manufacturer to create and maintain

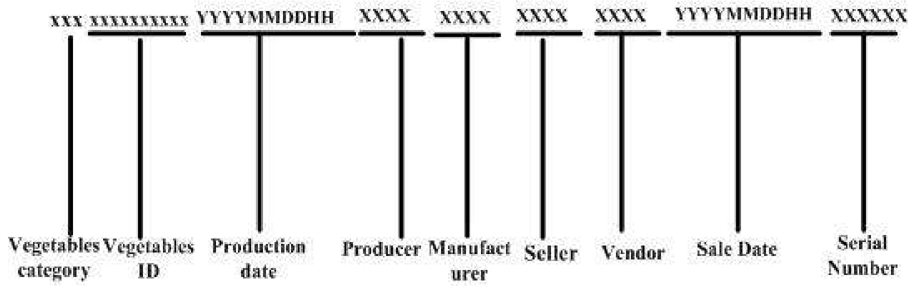

Fig. 3: RFID tag encoded form

server and it with XML-based, provide detailed information, such as vegetable category and ID and place of production information and allows the EPC code of vegetables information inquiries.

- **Local database server:** Local database server is mainly used for storing data acquisition and processing interface obtains vegetables message, in order to query and maintenance of business systems. For example, the user can through phone or wireless PDA or Web client anytime inquires the current state of the vegetables.

System developing platform: The system uses Internet environment, the use of B/S model for development. system server operation system chooses Linux, the main technology used for the Java EE and Java programming language, database system used Oracle11g.

IMPLEMENTATION OF VEGETABLES TRACEABILITY SYSTEM

The key technology of system implementation: To ensure the integrity of the vegetable processing, every vegetable has the unique coding. Coding by vegetables category 3-bit code and 10-bit vegetables ID code, 10-bit the date of production code, 4-bit producer code, 4-bit manufacturer code, 4-bit sale code, 10-bit sales date code, 4-bit sales enterprise code and 6-bit serial number composition. Before selling the vegetables for an RFID tag affixed vegetables. RFID tag encoding components is shown in Fig. 3.

Design of RFID middleware: According to previous research methods and the Savant label ID that the definition of middleware, RFID middleware function modules should contain the following several functional modules: Reader interface module, the logical drive mapping module, RFID data filtering module, the business rules, filter modules, equipment management and configuration module, the upper service interface module. And, Reader interface for middleware and RFID reader data communications, mainly to have access to RFID data and device management module to issue commands reader. Equipment management configuration module is used to adjust the working status of RFID read-write device, configure the appropriate interface parameters such as Reader, logical

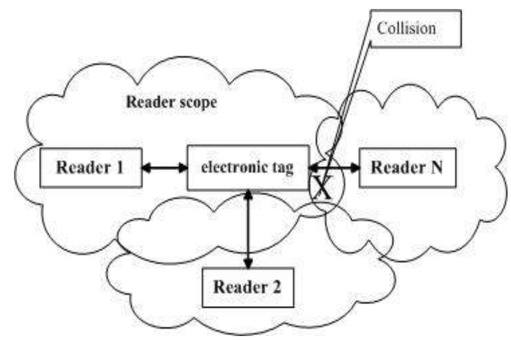

Fig. 4: Reader anti-collision model

reader will be more physical mapping module reader for the reader or multiple antennas into a logical map reader.

RFID anti-collision algorithm: In most applications, the range in the memory reader to be identified in a number of labels, radio frequency identification system is an advantage in a very short period of time to identify multiple tags. From reader to tag communications, also received multiple tags with a reader to send the data stream, the role of the reader multiple tags simultaneously within the range of data to send it, this form is known as multi-access. In order to prevent multiple tags data reader interference in the receiver can not accurately read, must be anti-collision algorithm to resolve them. Reader anti-collision model method is shown in Fig. 4.

Suppose in a RFID system, identification tag reader in the EPC k-bit collision occurred, the algorithm searches in the range of k tags, the EPC bits are determined except collision bits. Suppose that there exists a label, it's not within the scope of the search, then the EPC will collide with other labels in addition to a bit outside of one or a few bit different, so in other bits will also appear on the collision, which contradicts the known collision, so the theorem. The overall search algorithm requires the number of T slots:

$$T = T_c + T_r + T_e \quad (1)$$

Which, T_C, T_r, T_e, represent the collision, readable and the number of free slots. And the total number of time slots is different from the depth of the slot number i correspond to the sum, that is:

$$T(k) = \sum_{i=0}^{k} T(N,i) \tag{2}$$

$$T_c(k) = \sum_{i=0}^{k} T_c(N,i) \tag{3}$$

$$T_e(k) = \sum_{i=0}^{k} T_e(N,i) \tag{4}$$

where,

k : The maximum search depth
N : On behalf of all within the reader the role of number of tags to be identified
T (N, i) : That the depth search algorithm i on the number of required slots

For i search depth, most can determine 2^i buttress. The EPC tags length is n and the total number of labels is N for the RFID systems, estimates of the number of idle slots:

$$T_e(N,i) = 2^i(1-\frac{1}{2^i})^N \tag{5}$$

Readable slot number is:

$$T_r(N,i) = \frac{N}{2^i}(1-\frac{1}{2^i})^{N-1} \tag{6}$$

Number of collision slots:

$$T_c(k) = \sum_{i=0}^{k} 2^i \left[1 - \left(1-\frac{1}{2^i}\right)^N - \frac{N}{2^i}\left(1-\frac{1}{2^i}\right)^{N-1} \right] \tag{7}$$

As the number of segments chosen by the algorithm is based on the number of collisions bits decision, a bit not the probability of collision is 2^{N-1}, so the number of segments to meet the binomial distribution:

$$p(k) = C_n^{n-k}\left(1-\frac{1}{2^{N-1}}\right)^k \left(\frac{1}{2^{N-1}}\right)^{n-k} \tag{8}$$

To (6) into (8), the algorithm can get the number of collisions:

$$T_c = \sum_{k=1}^{n} T_c(k)\,p(k) = \sum_{k=1}^{n}\ \sum_{i=0}^{k} 2^i \left[1 - \left(1-\frac{1}{2^i}\right)^N - \frac{1}{2^i}\left(1-\frac{1}{2^i}\right)^{N-1} \right] C_n^{n-k}\left(1-\frac{1}{2^{N-1}}\right)^k \left(\frac{1}{2^{N-1}}\right)^{n-k} \tag{9}$$

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RFID data collection filtering algorithm: RFID data collected is very large, in practical applications, depending on the configuration, each reader can be reported per second to a few dozens, ranging from electronic tag data, such as repeated several times with an electronic scanning label, but only a small part of the user meaningful, non-repetitive data, so after a lot of data to redundancy, etc. If you do not deal directly uploaded to the whole RFID system will bring great burden. Therefore, RFID filtering the data collected.

Designed RFID data collection Filter can be divided into the following categories:

- **Establishing a list of categories of data collection events:** New tag for each data in real-time detection, if it is a new scanning electronic tag, is added to the appropriate list, if the tag already exists in the list, only updates the corresponding time the label state data, not the new tag data records, remove duplicate data in order to achieve the purpose.
- **Data collection event code categories:** change in state code, custom tag appear status code for 0, tag state disappear coding for 1. Then add the timer mechanism of effective inside time the same timer labels on state of jumping in the state, thus ignore definition and the time dimension 2 aspects of data to heavy and chemical.

All these algorithms can eliminate redundant data, reducing the load on the upper system. But in practical applications, in addition to the redundancy of the RFID data outside the filtering of data there are other needs. In response to these problems, the design under different scenarios in the adaptability and effectiveness of the filtering algorithm.

Experimental platform using RS232 interface of single antenna literacy device, the reader reporting cycle for the 1s, the number of tags each time the report was 5. Implementation of algorithm adopts Java language, through a serial port for Java serial communication.

The first is to build an RTagReadEvent tag class that contains the key parameters and methods are as follows:

```
public void run ( ) {
while (currentvalue>0) {
if (currentvalue> = tagmax&&! detecedStauts) {
// Tag on the trigger record
……
detecedStauts = true;
}
```

```
else if (currentvalue< = tagmin&&detected Status) {
// Trigger disappear tag records
     detected Stauts = false;
  }
  Current value - - ;
```

When the main program the of filter module detects a new tab, it will create a new Read Tag class object of R Tag Read Event and initial values of each key field, while the internal timer to start the thread object, the role of the timer thread on the label of each reporting period to check the weight value and trigger appropriate action. Check the label each time the weight will current value minus 1, in order to achieve the report when the label is not the gradual decrease of its weight. Current value reduced power value of 0, the timer thread to stop and then you can destroy the object.

When the main module of filtering algorithm found already exist in the label report, the label current value value object cohorts:

```
newReadTag. currentvalue + = valueStep;
    if (newReadTag. currentvalue> = newReadTag. tagmax) {
    newReadTag. currentvalue = newReadTag. tagmax;
     }
```

Algorithm which is defined value Step accumulated weights. Current value if the weight has reached the threshold Read Tag max, will it remain at that value, to prevent the cycle through a number of tags reported weight is too high, impact subsequent judgments.

Implementation of vegetables traceability system: Application of RFID anti-collision algorithm was simulated RFID reader, which reader anti-collision detection algorithm simulation results shown in Fig. 5.

The following data acquisition filter algorithm on the simulated test that set value Step = 5, tag max = 8, tagmin = 0, when the tag into the reader range, after a period of about 8s tag filtering module trigger action occurs, set label reader a short time out of range, the analog signal interference and fluctuations and the other label from within the reader move through the reader were not triggered by the extra labels appear and disappear operation, the reader scans the tag data shown in Fig. 6.

They appear in Fig. 6 cycles set the encoding of RFID tags 1, does not appear in the code is 0, so that, for each baggage tag and its events can be recorded as a binary string of order 01. For purposes of Fig. 6, tag1 can encoded as 01001011, said tag reader through the range; tag2 can be encoded as 11011000, said the label left the reader range; tag3 can be encoded as 00000011, said tag reader to enter and remain in the range.

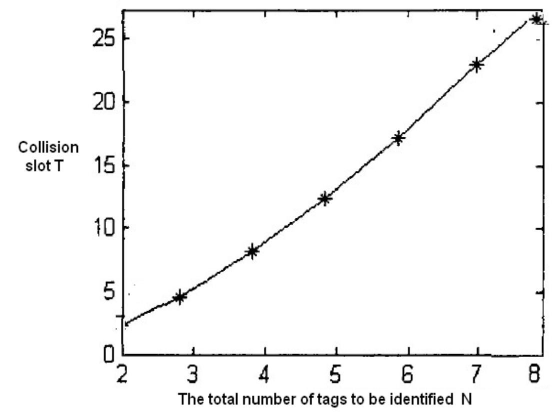

Fig. 5: Simulation results of collision detection algorithm

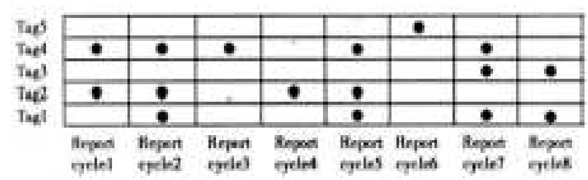

Fig. 6: Reader scans the tag data algorithm

CONCLUSION

This study proposed vegetable traceability system based on Internet of things, which has a high degree of automation features. The program is currently developing the vegetable traceability system has been installed in the domestic use of a vegetable business; the future will continue to improve based on user feedback.

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