Application of Improved RFID Anti-collision Algorithm in Cylinder Inflation System

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Abstract. An improved design of an inflatable system based on RFID smart cylinder and an improved algorithm for preventing the collision of multiple electronic tags during the recognition process are solved. The continuous filling of the unmarked and discarded cylinders is solved, and the cross charging of the cylinders is solved. And customer churn and other issues. Through the RFID radio frequency identification technology and GPRS wireless communication technology to achieve the inflatable terminal can be real-time upload the cylinder of RFID coding and filling information to the database server. In this paper, a new improved algorithm is proposed, which is based on the binary tree search algorithm, which improves the number of collisions and transmission faults of the reader in the recognition process. Information. The system has carried out the filling test, the real-time monitoring and testing of the cylinder data and the historical data query test. The test results show that the system can control the continuous filling of the non-seized and discarded cylinders and the cross filling of the cylinder to realize the accurate and fast of the network transmission, to meet the requirements of the safety management of the barrel of things.

Keywords: RFID · Algorithm · GPRS · Database · Objects of Internet styling

1 Introduction

With the fine management of liquefied petroleum gas companies and the state to improve the management of liquefied petroleum gas, cylinder safety management has always been a very headache for managers. Cylinder safety management is mainly reflected in: whether the control is not seized, scrapped cylinders continue to fill; can control the cross-filling cylinder; can control the loss of scrap cylinders; can control the loss of customers and other phenomena [1–3]. In order to solve the above problems, to achieve the safety management of the Internet of things, the system depends mainly processing. On the cylinder on the smart angle valve device, the smart angle valve embedded with RFID smart chip and limit control device. RFID smart chip so that each cylinder has a unique RFID code, that is, ID information. The inflatable gun is equipped with an RFID identification device and a control inflator. The identification device is composed of a reader and an STM32 controller. The control device on the intelligent angle valve can only be opened after the reader and the identification. And

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then open the inflatable operation. When the cylinder inflated after the end of the filling information (cylinder inspection, filling, release, validity, specifications, cylinder code) through the GPRS wireless communication module uploaded to the database server, easy to monitor the center for statistical, query and other data applications. The inflatable system is through the RFID technology to control the cylinder is not seized, scrap cylinders continue to fill and cylinder filling, to eliminate expired, not seized, dangerous cylinders are used again, through the cylinder RFID coding means for each cylinder to wear a Helmet, so that people's lives and property from the threat [4–6]. But the core problem of the system is the reader in the identification of cylinder ID, there will be RFID tag collision phenomenon, resulting in the reader can not correctly identify any one of the label information, reducing the reader's recognition efficiency and read and write Speed, seriously affecting the normal operation of the system.

There are two kinds of anti-collision algorithms in RFID system. ALOHA-based uncertainty algorithm and deterministic algorithm based on binary tree (BT, binary tree). ALOHA algorithm is a random algorithm, its operation is simple but random, low throughput, there will be a label in a very long time can not be identified, that is, "label hunger" phenomenon. The binary tree algorithm is a deterministic algorithm. The algorithm does not have the phenomenon of "label hunger and thirst", its recognition rate is high, and the advantages of throughput are applied in the RFID system, but the algorithm is relatively complex and the recognition time is long. In the improved binary tree algorithm, Fikenzeller proposed a binary search algorithm [7], the advantage lies in the idea of simple thinking, but there are many requests and return the amount of data larger shortcomings. On this basis, Zhang Hang proposed a return binary search algorithm [8], the advantages of the algorithm can be ordered to read and reduce the number of requests, the disadvantage is that the amount of data returned to the label is still large. The dynamic binary search algorithm proposed by Hsuei has improved the first two algorithms, and the problem of reducing the number of requests but the large amount of data returned by the tag still exists [9]. In this case, Bingcai proposed based on the stack storage anti-collision algorithm, which reduces the amount of data returned by the label has improved, but the number of requests for the reader did not change a lot [10]. Above the binary search algorithm still exists too many times the number of reader requests and the amount of data returned by the label is too large and so on [11–13].

In this paper, based on the binary search algorithm, an improved algorithm based on stack is proposed, which can reduce the number of times of reader/writer while ensuring the redundancy of data redundancy, and effectively solve the problem that many cylinders are embedded in the filling process RFID tag collision problem.

2 System Solutions

2.1 System Composition

With pneumatic system based on RFID intelligence cylinder design mainly consists of four parts, respectively, inflatable terminal layer, data layer, data processing layer and application management. The system structure diagram is shown in Fig. 1.

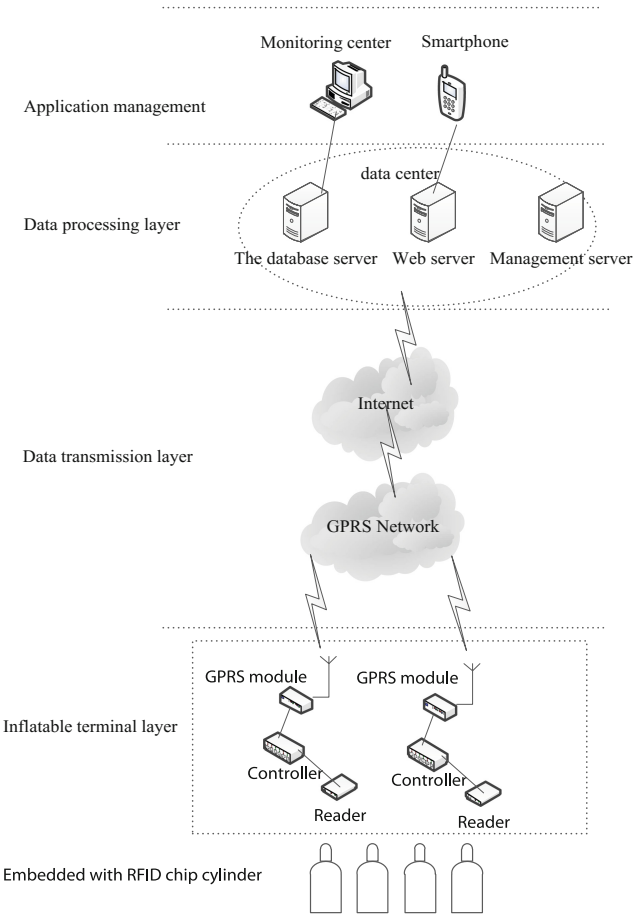


Fig. 1. The overall structure of the inflatable system

(1) Inflatable terminal layer

Before filling operation, first by identifying the device within the cylinder RFID chips on ID information verification, if the verification through, start control pneumatic device, the intelligent Angle on the cylinder valve limit device filling valve opened, the air gun to the cylinder air. If not, the buzzer alerts the alarm and indicates which identity information is not passed on the LCD. Fill in the filling and then upload the cylinder's filling information to the database via GPRS module.

(2) Data transfer layer

The data transmission layer is located between the inflatable terminal layer and the data processing layer, which is used to carry out the downstream transmission of the cylinder information and control information. In order to meet the requirement of data collection and transmission, the GPRS network is used to transmit data.

(3) Data processing layer
The data processing layer receives the data message from the inflatable terminal layer and interprets, classifies, and stores the packets. This layer consists primarily of database servers, Web servers, and administrative servers.
(4) Application management
Application management consists mainly of monitoring center and user center, the monitoring center and the server adopt the C/S structure, and the user and the server are the B/S structure. The monitoring center can access the database server, Web server, and management database over the Internet, and check the filling information of the cylinder in real time. Users can also check the filling information of a cylinder by using a smartphone login account.

2.2 System Functional Requirements

(1) Validation
First identification equipment within the cylinder RFID chips on ID information for validation: whether the current cylinders for XXX, determine whether the cylinder using time has been to scrap (discard time < system time + 30), the cylinder testing time is due (detection time < system time + 30), the bottle filling number is consistent with the filling data information within the machine, the cylinder is in accordance with the provisions. All of these conditions must be met, and the identification device will activate the charging device, turn on the inflatable valve and inflate the inflatable gun.
(2) Run the detection function
In the process of aeration, the controller to start the module of infrared measuring temperature and pressure measuring modules, read every 0.5 s a temperature and pressure in a cylinder, and then compared with set of reference temperature and pressure, your LCD screen time display cylinders, temperature and pressure parameters. If the temperature or pressure inside the cylinder to rise to limit value, an alarm signal, the controller immediately signal intelligent Angle valve shut down, the end of the cylinder filling operation.
(3) Query function
Administrators monitor the data and view historical data in real time, and generate data reports that facilitate the analysis, statistics, and application of data.

3 Algorithm Principle

Role of read and write in the RFID system, if there are multiple electronic label, the same time there can be multiple tags for energy and send information to the read/write device that will interfere with each other, causing the cylinder embedded RFID encoding can't correct recognition. In this adopted a stack-based RFID binary tree anti-collision algorithm, the principle of which is to read and write device using the detected conflict into the stack to the current request sequence, when the conflict a greater than 1, through the stack decide next time to read and write device sends the request instructions, avoid the request each time from the base of the tree in the process of identification is insufficient [14, 15]. The algorithm can reduce query times and improve recognition efficiency.

3.1 Basic Binary Search Algorithm Principle

The algorithm requires that each tag have unique ID information, and the information is encoded in Manchester to quickly locate the location of the data conflict location. In this code, the increase along the encoding logic "0" indicates the descent along the encoding logic "1". In the process of receiving data, there is no jump in the state level, and the data bit is in conflict. For example, it identifies the collision process by bit, as shown in Fig. 2.

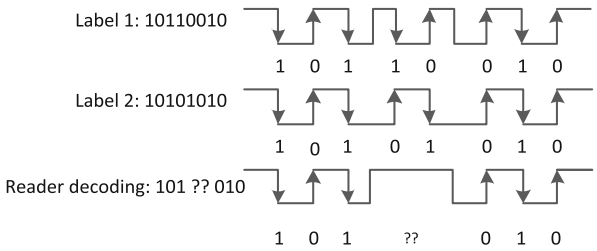


Fig. 2. The Manchester code identifies the conflict bits

3.2 Introduction

(1) Request(ID) Request: abbreviated R(ID), within the read-write scope, the label of all the active status is received and the ID information is returned. For example, the R(11111111) directive, which removes the tag outside of the silent state, returns its own ID information from the tag.
(2) Rw-data read-write Data: the reader reads and writes to the selected TAB.
(3) Push (data) into the stack: Push data into the stack.
(4) Pop () the stack instruction: the sequence of the previous entry stack.
(5) Select the ID tag.
(6) UnSelect(ID) to select: the selected tag causes it to enter the silent state and does not respond to any instruction from the reader.

3.3 Algorithm Process

The whole improved anti-conflict algorithm's ideas and processes, as shown in Fig. 3.

Assume that there are four tags in the scope of the writer's scope, whose ID information is encoded in eight bits, and its tag ID information is shown in Table 1.

Table 1. The tag ID number

The tag	ID number
Tag 1	(highest) 10111001 (lowest)
Tag 2	(highest) 10011000 (lowest)
Tag 3	(highest) 11011001 (lowest)
Tag 4	(highest) 11011000 (lowest)

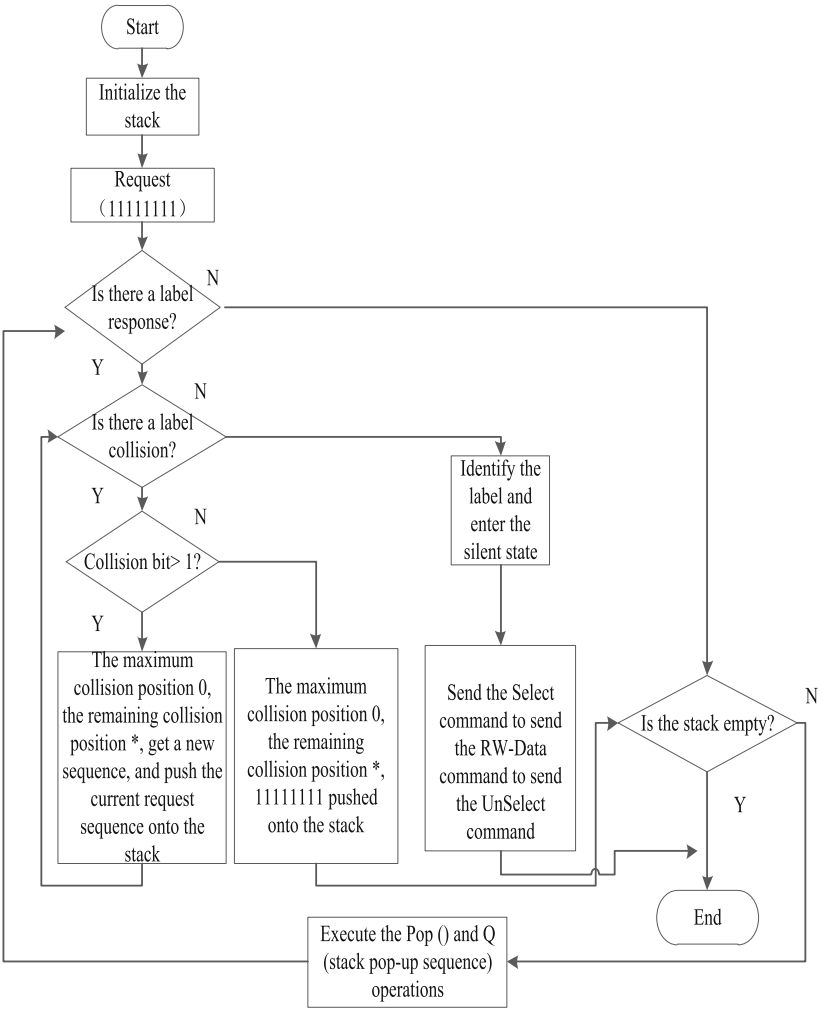


Fig. 3. The framework of the conflict prevention algorithm

Use these four labels to specify the process:

a. The reader sends the R(11111111) instruction, and the status tag returns its own ID. Label at 0, 5 and 6 clashed, received 1xx1100x serial number is 1, according to the rules of algorithm, when conflict digit is greater than 1, the sequence of read/write device receives the highest conflict location to 0 and the rest of the conflict to *, 10*1100*, get the next new send sequence onto the stack, and then sends the current sequence that Push(11111111).
b. Send R(10*1100*) instruction, received the command of all labels, comparing their ID number and request serial number, its scope is at the highest level to the highest * bits of data between bits. Within this range, the same data to a tag to make reply

and return with * a corresponding data, namely the tag 1 and 2 is selected, and the tag 1 and 2 data returned 11, 00 respectively, the conflict is still greater than one, then the current sequence onto the stack, which Push(10*1100*), according to the highest position 0 conflict rules, get the next sends the request sequences of R (1001100 *).

c. Send R(1001100*) instruction, only 2 tags TAB is selected and no conflict occurs, read and write device sends the Select(10011000) instructions and RW - Data command, read the label 2 Data, at the end of the operation, send UnSelect (10011000) instruction will be set to silent mode. Because no conflict has occurred, it is possible to determine whether the stack is empty. When the stack is not empty, the stack instruction Pop() is called, and the stack sequence pops up, and the next request sequence, R(10*1100*) is sent.
d. Send R(10*1100*) instruction, 1 is selected, the tag Data returned 11 and there is no conflict, and then to read and write device sends the Select(10111001) instructions and RW - Data operation, upon the completion of the read and write, send UnSelect (10111001) order will tag 2 set of silent state. Because no conflict has occurred, it is possible to determine whether the stack is empty. When the stack is not empty, the stack instruction Pop () is called, and the next request sequence, R(11111111), is sent.
e. Send the R(11111111) instruction, tag 3 and tag 4, and only one conflict occurs, and the reader receives a new sequence of 1101100x. The highest conflict location 0 and the remaining conflicts are *, and the next time the sequence is R(11011000) and Push(11111111).
f. Send R(11011000), the only label 4 response, Select(11011000) to be selected and corresponding RW-Data instructions after the completion of the operation, send UnSelect(11011000) order will tag 4 set of silent state. View the stack not empty, and send the next instruction R(11111111).
g. To send R(11111111), because the tag 1, tag 2, and tag 3 are blocked, only the tag 3 response, the read-writer, reads and writes to it, and the recognition process is over.

3.4 Analysis

In the VC++ simulation platform, the process of transceiver and electronic tags is implemented, and the read-write process is simulated by a large amount of data. Label bits digit, which represeanted by $K = 8$, $K = 16$, $K = 32$ three conditions, the basic dynamic binary, backward binary binary, and improved algorithm to identify the total number of read and write, transfer the total digits are simulated, the simulation results as shown in Figs. 4, 5, 6, 7, 8 and 9.

Figure 4 through Fig. 6: (1) when the tag number is certain, the total number of reads and reads increases as the number of tags increases; (2) the label number, tag number are at the same time, the basic dynamic binary algorithm to identify the total number of binary and almost unanimously, the improved algorithm based on stack and backward binary total number. So the stack based improvement algorithm and the backward binary are better than the basic binary and dynamic binary algorithm.

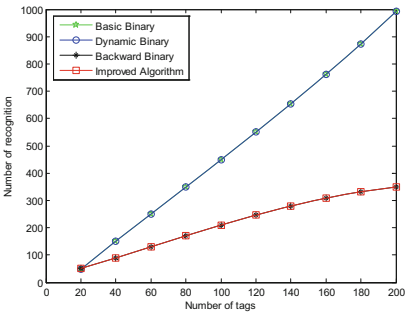


Fig. 4. $K = 8$

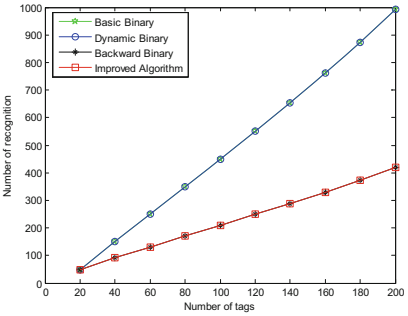


Fig. 5. $K = 16$

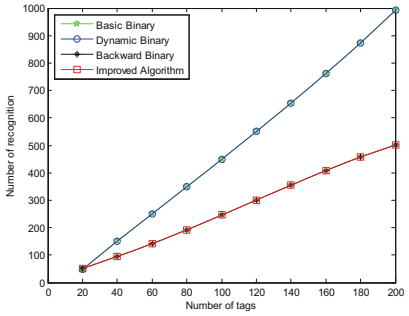


Fig. 6. $K = 32$

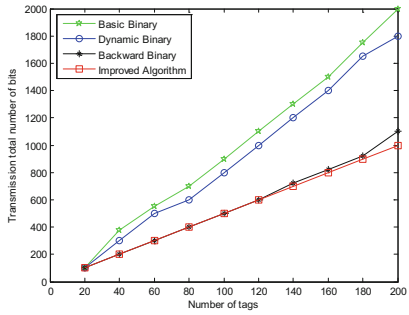


Fig. 7. $K = 8$

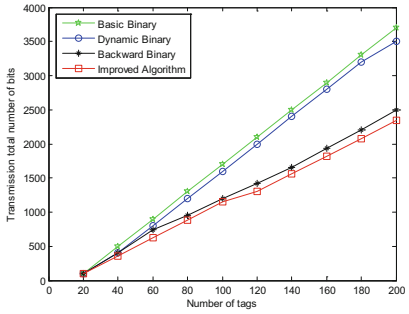


Fig. 8. $K = 16$

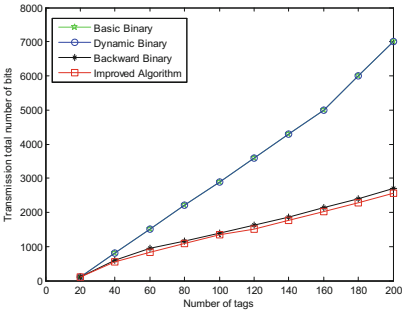


Fig. 9. $K = 32$

From Figs. 7, 8 and 9: (1) The total number of transmissions increases as the number of tabs increases, as the number of tags increases. (2) When the number of tags is certain, the number of total digits transferred by the four algorithms increases as the number of tabs increases. (3) When the number of tabs and the number of tags is identical, the total number of bits of the stack based improvement algorithm is the smallest.

By Figs. 4, 5, 6, 7, 8 and 9, it is so easy to get: (1) under the same conditions, the improved algorithm and backward binary algorithm based on stack in the identification of the total number of almost the same, but the improved algorithm in the data transmission is far less than backward binary algorithm. So according to the total number of identification number and transmission of the simulation result shows that the improved algorithm is superior to the basic binary, dynamic binary, backward binary algorithm.

4 Monitoring System Design and Testing

4.1 Monitoring System Design

The monitoring center consists of the upper machine software and the database. The top machine software was written in the Visual Studio 2010 development environment with the c# language, using SQL Server 2008 as a database, and its application interface was implemented using ADO through the OLE.db technology. The entire monitoring system structure diagram is shown in Fig. 10.

The monitoring system is established by GPRS communication module, cylinder information management module, user information management module and cylinder information. GPRS communication module is responsible for RFID read-write device collecting information in accordance with the agreement of cylinders packing backwardness to monitor and control system, monitoring system based on protocol analysis data, in every field in the database table. The information about the cylinder

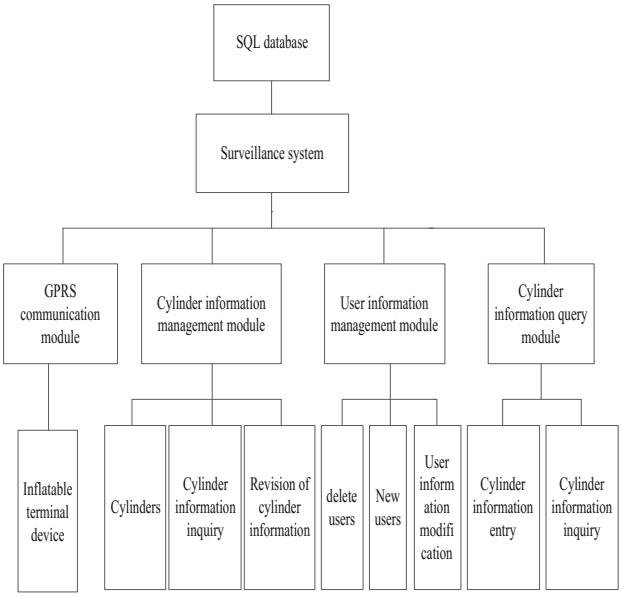


Fig. 10. Monitors the architecture diagram

information in the database includes the information such as the RFID number of the steel bottle, the time information for filling, the time of scrap, the charge record, the filling station number of the cylinder, etc.

4.2 Monitor System Real-Time Data Test

The previous real-time monitoring interface is shown in Fig. 11. Interface display basic information refilling station, shows the number of cylinders filling and filling, query the total gas filling gun number, and the data in the form of real time curve display. Adjust the amount of charge and fill the total amount of gas in real time according to the requirement.

You can query the full history of the filling and display the user's detailed cylinder information, as well as the historical data for a certain period of time. Its historical data query interface is shown in Fig. 12.

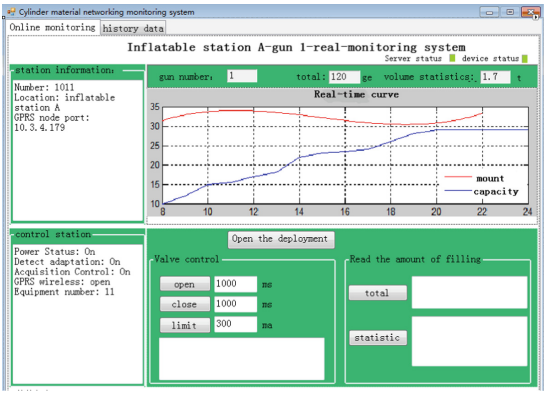
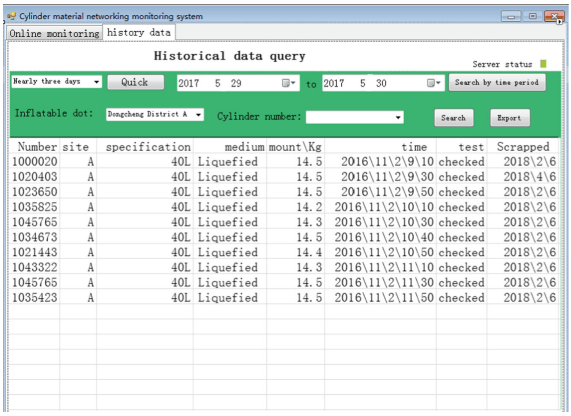


Fig. 11. The top machine interface of the monitoring center



Number	site	specification	medium	mount\Kg	time	test	Scrapped
1000020	A	40L	Liquefied	14.5	2016\11\2\9\10	checked	2018\2\6
1020403	A	40L	Liquefied	14.5	2016\11\2\9\30	checked	2018\4\6
1023650	A	40L	Liquefied	14.5	2016\11\2\9\50	checked	2018\2\6
1035825	A	40L	Liquefied	14.2	2016\11\2\10\10	checked	2018\2\6
1045765	A	40L	Liquefied	14.3	2016\11\2\10\30	checked	2018\2\6
1034673	A	40L	Liquefied	14.5	2016\11\2\10\40	checked	2018\2\6
1021443	A	40L	Liquefied	14.4	2016\11\2\10\50	checked	2018\2\6
1043322	A	40L	Liquefied	14.3	2016\11\2\11\10	checked	2018\2\6
1045765	A	40L	Liquefied	14.5	2016\11\2\11\30	checked	2018\2\6
1035423	A	40L	Liquefied	14.5	2016\11\2\11\50	checked	2018\2\6

Fig. 12. Historical data query interface

5 Conclusion

An improved algorithm designed to prevent multiple electronic tags from colliding in the identification process is designed based on RFID. According to the result of simulation shows that the improved algorithm is superior to the binary tree search algorithm, decrease the number of collisions and consult for the recognition process of the cylinder, and the cylinder data information upload real-time test, the test results show that the system can realize the cylinder accurately and fast network transmission of information, the administrator can query the cylinder filling data real-time information and historical data, and meet the requirements of the cylinder iot security management.

References

1. Shijie, X.: Design and implementation of the RFID based cylinder management system. Xiamen University (2007)
2. Rong, H.: Application of radio frequency identification technology in cylinder safety traceability. China Autom. Ident. Technol. **02**, 72–74 (2013)
3. Chao, Z., Shouyuan, C., Zengzhen, S., Jian, L., Lijuan, L., Lin, L.: Development of logistics tracking system based on RFID, GPS and GPRS. Electron. Des. Eng. **05**, 147–149 (2015)
4. Jin, T., Yahui, W., Xuemei, F., Shujun, Z., Donghui, C.: Fresh agricultural products cold chain logistics status monitoring information system. J. Jilin Univ. (Eng. Sci.) **06**, 1707–1711 (2015)
5. Lin, L.: Design and implementation of IT - based network operation and maintenance management system. Huazhong Normal University (2012)
6. Jedda, A., Khair, M.G., Hussein, T.M.: Decentralized RFID coverage algorithms using writeable tags. Comput. Netw. **07**, 257–261 (2016)
7. Finkenzeller, K.: Radio Frequency Identification Technology. Electronic Industry Press, Beijing (2006)
8. Hang, Z., Minghao, T., Hui, C.: Improved backplane binary anti-collision algorithm. Comput. Eng. Appl. **25**, 208–211 (2011)
9. Chuiyi, X., Yigang, H., Bing, L., Gefeng, F.: Improvement of dynamic binary tree search algorithm. Comput. Eng. (02), 260–262+265 (2015)
10. Bingcai, C., Dongsheng, X., Guochang, G., Lili, G.: An RFID anti-collision algorithm based on stack storage. Comput. Appl. (06), 1483–1486 (2009)
11. Xue, W., Zhihong, Q., Zhengchao, H., Yiman, L.: Research on RFID anti-collision algorithm based on binary tree. J. Commun. **06**, 49–57 (2014)
12. Bo, F., Jintao, L., Weimin, Z., Ping, Z., Zhenhua, D.: A new anti-collision algorithm for RFID tag identification. J. Autom. **06**, 632–638 (2008)
13. Duroc, Y., Vera, G.A., Martin, J.G.: Modified RSSI technique for the localization of passive UHFRFID tags in LOS channels. Int. J. Microwave Wirel. Technol. **55**, 27–32 (2013)
14. Zhenya, C., Tai, J.: An Ethernet-based anti-trailing elevator access control system. Comput. Eng. Appl. **22**, 232–237 (2016)
15. Hsu, C.-H., Chen, Y.-M., Kang, H.-J.: Performance-effective and low-complexity redundant reader detection in wireless RFID networks. EURASIP J. Wirel. Commun. Netw. **1**, 12–16 (2008)