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Research on the Use of RFID Technology in Cigarette Production

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Abstract

With regard to the cigarette manufacturing's demand for modern management, to protect the integrity and reliability of the cigarette production processing data, the proposed RFID application in cigarette production system, building on the basis of RFID security controlled digital information system platform, the system covers the entire process of cigarette production and can realize the control and management of cigarette production and optimize the improvement on the basis of binary ALOHA anti-collision algorithm. It can also improve RFID's recognition accuracy to achieve the basic information for cigarette products in the process of digitization accuracy.

***Keywords**: cigarette manufacturing; RFID; anti-collision algorithm*

1. Introduction

To satisfy the need to clearly suggest the "cigarette level" for the "twelve-five" project in the tobacco industry, an internet of items have been set up as the important carrier and embody of reflecting the gradually changing operational direction. It can effectively solve the current problem of the construction of information during the cigarette production process, building a safe and controllable digital basic information alternating system [1] which has become an indispensable content for cigarette manufacturing enterprises.

Although cigarette production enterprises have the support of the better equipped Internet structure [2], however the basic digital information is still not complete. The network of cigarette products can provide us with the website for sharing of information, allowing the information of the production facility of production, personnel management, asset management and other basic information to be entered into the digital interactive systems, perfecting the basic digital information. Other than this, the research and development of cigarette products and the production plants needed for production, the demand for transport links as well as the consumer's need for information can also receive support from the digital information systems. In tobacco processing and materials supply, the entry of the basic statistics of the construction specifications is made possible through the network of cigarette products, satisfying the need for the digitalizing of the cigarette production process [3].

The technology used in the network [4] of cigarette products is an improving technology that initially bases on radio frequency identification (RFID) [5]. It uses radio frequency to achieve a contactless technology, and it also achieved the purpose of identification and exchange of data, realizing the management of information technology and this technology can also go through encryption security to keep the system more secure [6]. Its recognition process does not require any human interference, hence widely used in industries like manufacturing. The RFID electronic tags are also able to make use of the Internet to fulfill the automated recognition and the interconnection and sharing of

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product information, continuing to improve the whole production line and the management standard of the production operators.

With the introduction of radio frequency identification (RFID), the productivity and management standard of the cigarette production process can be efficiently improved. Through the traces that RFID leaves in the cigarette production, RFID tags' information can be collected and we can then follow through the whole cigarette production process [7]. This can not only improve its productivity, but also reduce the intensity of labour, step up on better management of the system and track the source of the cigarette product in time. It will also provide an accurate liability scheme, creating an effective tracking system. This way, the quality of the cigarette products can be assured and follow-ups of the after sales services can also be done, helping to improve the quality of the cigarette product comprehensively, increasing the competitiveness of the product.

In recent years, the creation of an informationized cigarette production process has already been completely equipped with the desired conditions for this process to reach its best outcome. The cigarette production process uses modern information as its theory to build and improve their own information management system and preparations to build a network of cigarette products are underway. With the improvements in the technological standard and productivity of cigarette production companies in the country, it is highly impossible to reduce the budget spent during the production process. Hence, many companies set their sights on increasing the productivity of their company, trying to improve their automated management of their products and lowering down their labour intensity, hoping to use these advantages to try and achieve a greater share of the market [8].

2. Setting Up of the Computing Platform

2.1. The Structure of the Whole Computing Platform

The cigarette production process mostly makes use of RFID technology to manage many systems that performs different tasks, to collect the information of the cigarette factories, equipment and workers so that they can be saved into the database. Workers can then get hold of information of a product, if it is still available in stock and they are also able to know the progress of a product in each round of production. At the same time, when a fault happens in a cigarette product, two-way tracking can be done on the product. The structure of the system whereby the cigarette production process helps to manage different tasks is as shown in Figure 2-1.

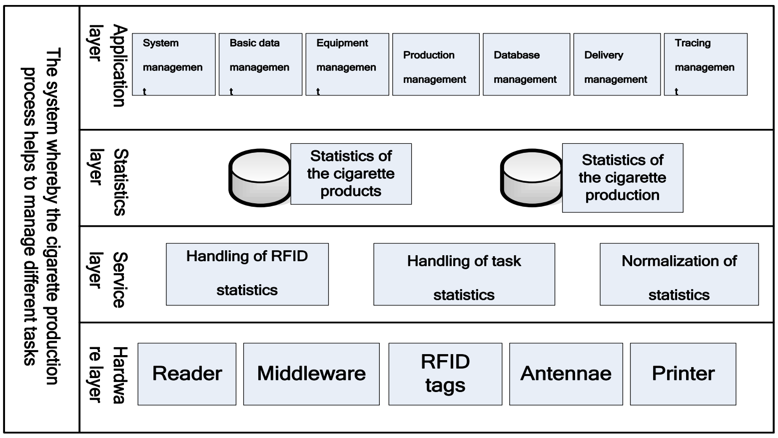

Figure 2-1. The Structure of the System

The hardware layer in the system contains RFID reader, RFID middleware, RFID tags, antennas, and printer. The RFID reader also contains RFID handheld terminal and RFID permanent reader. The service layer also contains three models, namely, the handling of RFID statistics, handling of task statistics and the normalization of statistics. The handling of RFID statistic' model contains the statistics for a cigarette product, the protection of the basic information of the cigarette product and the handling of the production business information. It is also responsible for the normalization performed on the data collection terminal so that the data will be consistent with the back-end database storage requirements. Statistics layer contains statistics of the cigarette products and statistics of the cigarette production. The product and business data are stored in the corporate database.

The application layer can fulfill the management of systems of many different tasks, namely, system management, basic data management, equipment management, production management, database management, delivery management and tracing management etcetera. Other than that, by using the system to share and exchange information, this will improve the information sharing and docking system. This is also another aspect that is worth a more in-depth research.

Among them, the electronic labeling systems, electronic tag data acquisition systems and database management systems constitute the main part of the cigarette production system based on the network of cigarette products. The RFID system is indispensable in this cigarette production system and the RFID data acquisition system is the basis of the management and means of obtaining the digital information and the back-end statistics database system is the turning point for the whole system.

2.2. Design of the Functions of the Cigarette Production Process

The function of the cigarette production process is as shown in Figure 2-2.

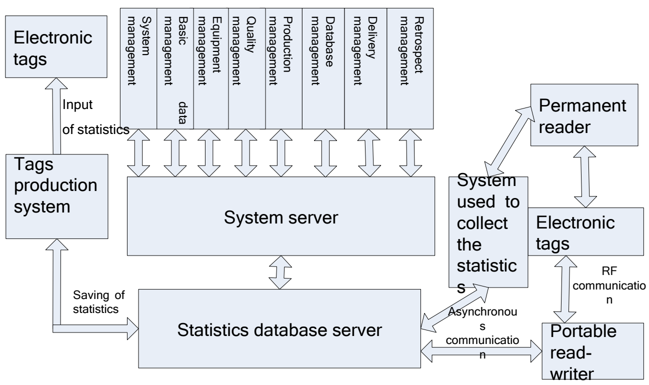

Figure 2-2. The Basic Functions of the System

RFID designated printer and RFID production software makes up the electronic tabs production system. It is mainly responsible for entering information and printing them out, like how electronic tabs are named in the system, the time taken for the production of tags etcetera. This system is the prerequisite for the system of realizing many other tasks as it is the only system that allows the combination of bar code technology and RFID technology in the cigarette production process. Label Maker DLL function is the main core of the system, the information collected will then be transferred to the back-end statistics database management system and be used as interface functions for the production of electronic tags.

RFID designated reader, RFID portable read-writer and electronic tags makes up the base for the system of data collation. This system mainly makes use of the communication between the reader and the electronic tags to obtain the specific information in the electronic tags and make use of the serial port or asynchronous communication to be transmitted to the statistics database system at the back-end, completing the saving of the information of the initial product.

The statistics database server and application software makes up the statistics database management system at the back-end, and it is the safekeeping and handling centre. This system is responsible for the communication with the read-writer, obtaining specific information of the electronic tabs in the process. This information is then saved, processed and displayed. In them, RFID technology in cigarette production manages many task systems, including management of systems, management of basic information, management of equipment, management of quality, production management, database management, delivery management, retrospect management, and the tallying of analysis models etcetera, fulfilling the basic functions of many task systems in the cigarette production.

These eight major models not only fulfill the need for the function needed for the basic information of the cigarettes to be digitalized, but also combine the database management, retrospect management and the tallying of analysis models together to fulfill the need for the cigarette production's daily management to be informationized and it is useful to allow the system to fully utilize the information collected at the back end system. All the major function models are although independent in terms of their physical structure, they are still linked to one another in terms of their logical structure.

3. RFID Anti-Collision Processes in Cigarette Production

3.1. Binary Tree ALOHA Anti-Collision Calculation Method Theory

When the tags choose a similar value, they will cause collisions to occur when the reader is decoding them, preventing the reader doing so as per normal. With regard to the collided tags, according to aloha calculation method, it will normally be transferred to another time frame. This means that they will have to choose another value. With a greater number of tags, the possibility of collisions happening will be higher. To reduce the probability, the collided tags will go through immediate processing as shown in Figure 3-1.

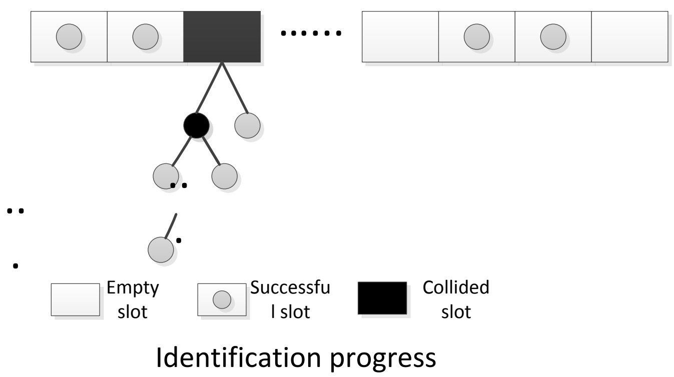

Figure 3-1. Collided Tags Processing Graph

From Figure 3-1, it can be seen that when the tags collide into each other, a new time frame is immediately created so that the tags can be handled efficiently. Especially when the calculation method is used in a dynamic method, due to the free moving tags, if the tags cannot be immediately processed, they may leave the decoding area before the problem is solved, causing a thirst effect.

Assuming that if the tags are not immediately processed, but through a first come first serve basis, the tags that arrived first will be immediately processed, but the others will be placed into the second round of decoding.

3.2. The Choice and Confirmation of Estimation

3.2.1. Choosing the Best Estimation

When the estimation is closest to the actual number of tags, the system efficiency is then the highest. In theory, it is assumed that the amount of blank time frames, time frames in which collision happens, and the amount of successful time frames are the same, however, in reality, the amount of time frames under these situations are often different.

Blank time frames only contain Query command, if there is no response from the tags, the blank time frames will then end earlier and the tags will then be brought to the time frames in which collision occurs. In there, other than the Query command, it also contains the transmission for RN16 database. The tags stay in the successful time frames for the longest period of time. Once it is reserved for the RN16 database, a successful tag will need to transmit the EPC ID number into the end of the reader. Hence, to represent the amount of time the tags stay in each time frame; formula $T_0 < T_c < T_S$ is created T_0, T_c and T_S represents the amount of time the tags stay in the blank time frames, time frames in which collision happens and the successful time frames respectively. To standardize the time, formulas $T_0 = \alpha T_s$ and $T_c = \beta T_s$ have been set. Once the amount of tags is ascertained, (accurate or estimated value), it will then go through a setup to maximize the system efficacy. The system efficacy is as defined in formula 3-1.

$$\eta_{eff} = \frac{\alpha_s T_s}{\alpha_0 T_0 + \alpha_s T_s + \alpha_c T_c} \tag{3-1}$$

In this formula, a_0, a_s and a_c represents the expected number of tags in the blank time frames, successful time frame and time frames in which collision occurs. The eventual expected value can then be calculated and brought forward to formula 3-2.

$$\eta_{eff} = \frac{N(1-\frac{1}{L})^{N-1}}{(\alpha-\beta)(1-\frac{1}{L})^N + \beta L + (1-\beta)(1-\frac{1}{L})^{N-1} N} \tag{3-2}$$

System efficacy, η_{eff} then goes through differentiation, and let the differentiated value equate to 0 so that formula 3-3 can be derived.

$$\frac{\eta_{eff}}{\partial L} = 0 \tag{3-3}$$

Formula 2-4 can also be derived.

$$\beta(1-\frac{N}{L}) = (\beta-\alpha)(1-\frac{1}{L})^N \tag{3-4}$$

Hence, to maximize the system efficacy, frame size L and the tag base N should satisfy formula, under special circumstances, when $T_0 = T_c = T_S$, for example $\alpha = \beta$, L will then equate to N. When the time the tags stay in each circumstance is the same, the system efficacy is then the highest and this is the best frame size.

3.2.2. The Confirmation of the Frame Size

The frame size of the time frames will affect the handling rate of the colliding tags. When collision happens in a certain time frame, it means that there are at least two tags colliding into each other in that time frame. However, what should be the reasonable frame size for each frame. Hence, it is introduced into its position to preserve its condition in the previous time frame.

To measure the frame size of the time frame more accurately, let us assume that when collision happens in a time frame, the size of the time frame is 3, and the tags which are about to collide will choose a value in (0, 2) and all the unread tags will then have 1 added to their values. If the tags were present in the blank or successful time frame previously, their frame size will then be set as 2. The tags which are colliding with each other will then choose a value in (0, 1).

3.3. Binary Tree ALOHA Anti-Collision Calculation Method Setup

The specific method of calculation is as shown in Figure 3-2:

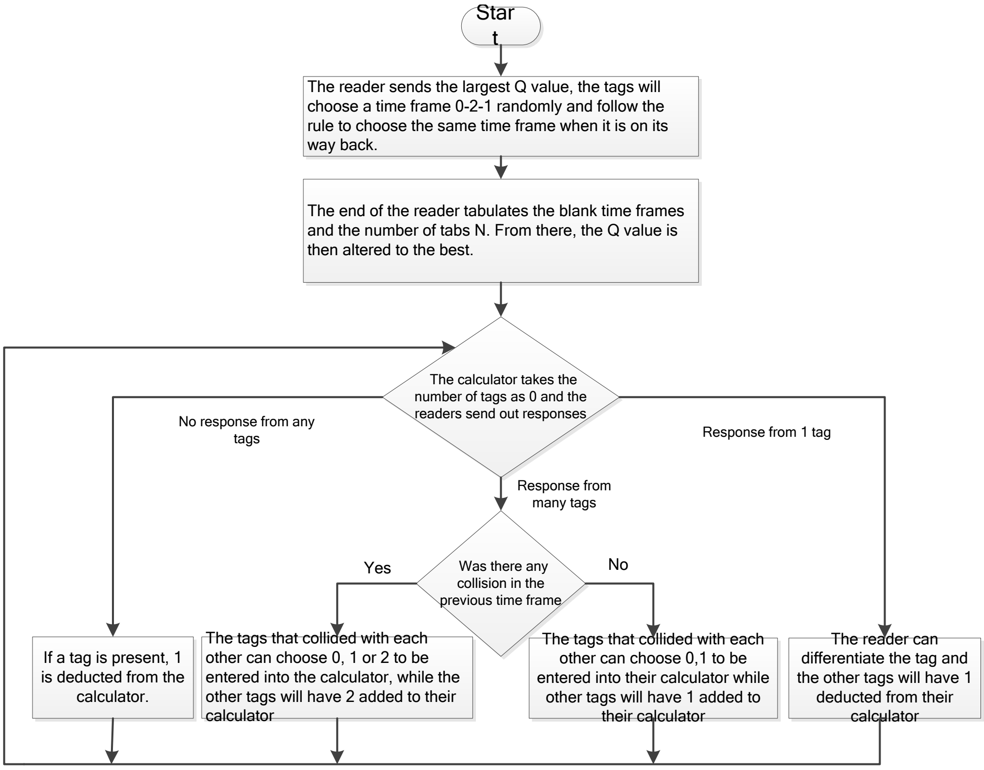

Figure 3-2. Flow Chart of the Calculation Method

3.4. Simulation and Analysis

Simulation of the calculation method is done in MATLAB. To better explain the feasibility of this calculation method, let us assume that the tags are taken from a range of [0, 1000] and the simulation has been repeated 500 times to get the average result. For a better comparison, the stimulation uses Vogt, Scoute, lower-bound that bases on a dynamic time frame as a comparison with Q calculation method and it also defines the system efficacy η, η= successful time intervals/total time intervals used up。The collision rate is also defined as CR, CR= amount of time frame where collision happens C/total amount of time frame D, reflecting the estimation of the communication energy used up between the tags and the reader. In this simulation the mean consideration is done under desirable conditions. From the formula, it can be seen that η and CR are proportional.

1, Comparison of time frame:

First, a comparison of the depletion of the number of tags is done to help us understand how much time frame will be depleted after finishing a task. It also reflects the calculation method's capability to reduce the time used. Assuming that the number of tags are taken from of ranges of (10, 1000) and simulations under groups of tags of 1000 and 100 are done, as shown in Figure 3-3 and Figure 3-4.

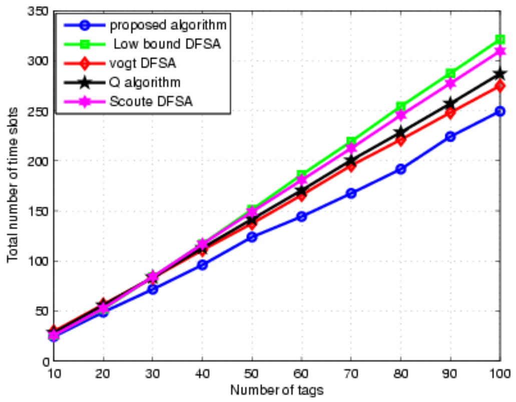

Figure 3-3. Comparison of the Time Frames Used Up and the Numbers of Tags (N_{max} =1000)

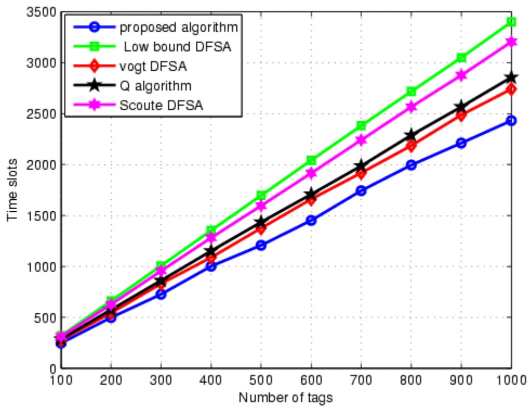

Figure 3-4. Comparison of the Time Frames Used Up and the Numbers of Tags (N_{max} =100)

From this it can be seen that when the numbers are smaller, the suggested calculation method has an obvious advantage as compared to the other calculation methods commonly used. After reading 100 tags, this suggested calculation only takes up 250 time frames while others will take up more than 250 time frames to read this 100 tags. Hence, this calculation method is superior in its efficiency of reading the tags. When the numbers of tags are bigger, it can be observed this calculation method is also superior. With these two figures, it can be known that this suggested method is indeed better as compared to the other calculation methods.

2, The comparison of system efficacy

When the time of the differences which tags staying in the three different environments, they are considered, the defined system efficacy will also be different. Here, let us assume that the time the tags stay in the three different environments are the same. The system efficacy will then be defined as the time taken to read the tags successfully/the total time taken. Similarly, for a better comparison, the ranges of the tags are also compared under two different environments as shown in Figure 3-5 and 3-6.

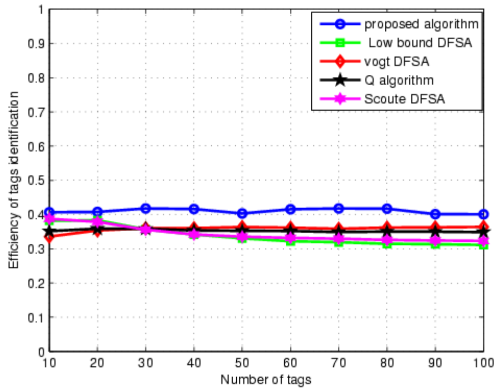

Figure 3-5. System Efficacy (N_{max} =100)

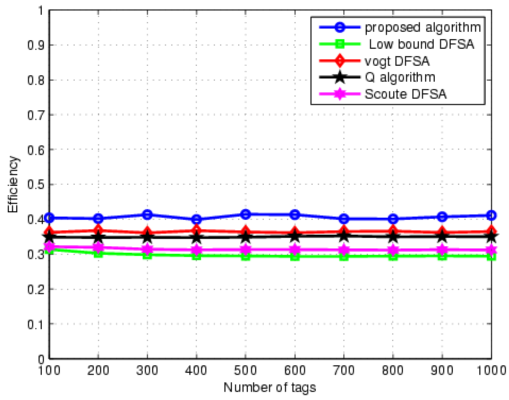

Figure 3-6. System Efficacy (N_{max} =1000)

From the figures, it can be observed that when the numbers of tags are smaller, the suggested calculation method will derive a system efficacy of more than 0.4. However, in other calculation methods, the system efficacy calculated is many percentiles lower. When the numbers of tags are bigger and the same system efficacy is compared, it can be seen that the suggested calculated method is still superior as compared to their other calculation methods. Comparing these two simulations, we are able to know that the suggested calculation method will improve the system efficacy.

3, Comparison of the collision rate

With regards to the dynamic Aloha frame time slot and calculation method Q， the tags that collide against each other may mix with the other frame which contains unknown tags, fighting for time frames with them, greatly increasing the probability of collisions happening and the amount of collisions is proportional to the amount of energy used up by the system. In the newest RFID reading system, as the time taken for reading the blank time frames takes up less than 10% of the time taken to read the time frames. Hence, especially if the consideration is based on the using of time frames, the collision rate is a very good way of reflecting the system's positive and negative features. The definition of collision rate is as shown below

$$CR = C / n$$

CR represents the collision rate, C represents the number of intervals between the collisions, while n represents the total number of tags present. It reflected the estimation of the energy consumption for the communication between the tags and the reader. In this simulation, the mean consideration is done under desirable conditions. Through the graphs, we can know that η and CR are proportional .It is as shown in Figure 3-7 and 3-8.

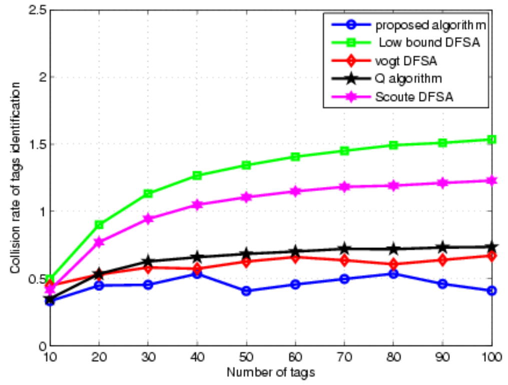

Figure3-7. The Comparison of the Collision of the Tags (N_{max} =1000)

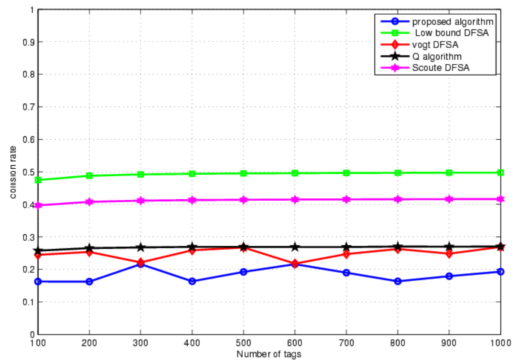

Figure 3-8. The Comparison of the Collision of the Tags (N_{max} =1000)

From the figures, we can know that our method of calculation as compared to the classic calculation method reduces the frequency of collision, implying that the energy consumption is decreased. Regarding this suggested calculation method, three factors, namely, collision rate, and system efficiency has been compared with the previous and it can be seen that there is really an improvement.

4. Functions and Innovation

4.1. The Functions and Analysis of the Collision Calculation Method Used in Cigarette Production

The environment of the tags is placed in during cigarette production can be either static or dynamic. With regard to the research for the collision scene, it is normally static and the movement of the tags is not considered. However in reality, the tags are moving in a certain period of time and it will leave some operational traces. Binary tree ALOHA anti-collision calculation method can be used both in a static and dynamic environment. At the speed of transmission in the cigarette production, it results in the reader's speed being much faster than the movement of tags. Hence, we need not worry about an overly large amount of unread tags after the reader decodes the tags that entered earlier. While reading the tags that have already been allocated time frames, the newly arrived tags will not cause any disturbance to the reader. After all the allocated tags have been read, the newly arrived tags can then be allocated and read as well. This will prevent the thirst effect of the tags from happening. This first come first serve system will also make it a very fair way of reading the tags. The simulation below assumes that the tags are continuously moving and the largest number of tags, 2000 means that 2000 tags have been read.

Through the comparison with the simulation of calculation method Q, it can be observed that this calculation method can satisfy the reading of tags under the dynamic environment very well and it is also achieves a higher system efficiency of about 8 percent as compared with the previous calculation method Q.

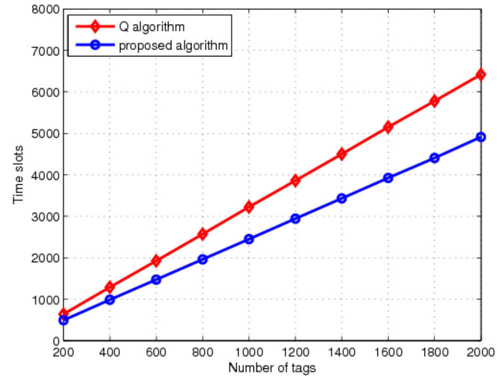

Figure 4-1. Comparison of the Time Frames Used Up under a Dynamic Environment

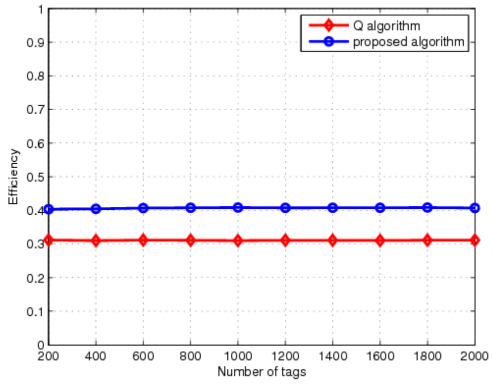

Figure 4-2. Comparison of the System Efficiency under a Dynamic Environment

Figure 4-1 and Figure 4-2 shows the results of a system simulation under a dynamic environment and the comparisons with the previous calculation method Q made in terms of the time frames used up and the system efficiency. It can be observed that the efficacy of the system is still above 0.4. This shows that the suggested calculation method can be used under a dynamic environment.

As compared with other classic calculation methods based on the Aloha anti-collision calculation method, the suggested calculation method is superior in its functions and prevention of time delays. With the introduction of the Manchester encryption, the estimation of the amount of tags becomes more efficient and it also uses up less time intervals. As compared with the previous calculation method Q which requires a lot of adjustments to find the correct estimation, using this calculation method, it can be found with just one try. This calculation method not only does simulation of reading the labels under a static environment, but also under a dynamic environment. Although there are movements of the tags in and out of the system, as the speed of the reading of tags is much faster than their movement, the tags can be deciphered successfully and a thirst effect of the labels would not happen.

4.2. Conclusion and Innovation

In the cigarette production system, the use of RFID allows the whole process to receive all the statistics needed to complete the process, reliably received assurance, and acts as a statistics base for the digital business management and cigarette retrospective. To accustom to the different circumstances where the cigarette will be in, increase RFID reader's decoding speed、efficiency and recognition rate, binary tree ALOHA anti-collision calculation method has been set up and it is innovative in these following ways.

(1)By adding more special bits and using them in the time frame to choose their situation so that the amount of tags can be estimated more efficiently.

(2)By opening up time frames so that the tags that collided with each other can be efficiently handled, effectively reduced the thirst effect.

(3)The choice of the frame size of the time frames is based on the introduction of the bits that are in a memory status. This way, its condition in the previous time frame can be recorded. If it collides with other tags in any time frame, it can be checked if that tag was in a collided condition previously. This will affect the frame size designed for it.

(4)The scenes researched presently are assuming that the tags are in a static condition and there is no movement of tags. However, in reality, the tags will move with the items. This proposed calculation method can also be used for a dynamic environment.

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