An Improved Anti-collision Algorithm Based on JDS

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Abstract—With the emergence of active tags and RFID technology used in the fast-moving objects, readers need urgently to read and write tags in limited time. Anti-collision algorithms resolve the problem of a number of tags at the same time to communicate with the reader. Traditional anti-collision algorithm is to minimize recognition time and improve search efficiency under the conditions of maintaining a certain complexity. In this paper, we propose an improved anti-collision technique based on IPA and JDS algorithms. The improvement is achieved thanks to use jumping-back strategy. This latter reduces considerably the responding tag’s numbers and therefore, decreases the probability of bit’s collision. The simulation results shows, the reduced IPA anti-collision algorithm reduce frequency and the number of bits of the reader queries and label response significantly.

Index Terms—Radio Frequency Identification, Anti-collision Algorithm, Reduced IPA

I. INTRODUCTION

RFID (Radio Frequency Identification) technology makes a fast progress in recent years and promises a bright future of labor cost reduction, business process automation and inventory inaccuracy reduction, etc. RFID is known as a non-contact automatic identification technology by exploiting space electromagnetic coupling of radio frequency signals. RFID technology fulfills information input and processing without direct contact, optical visualization and manual intervention. It enjoys many advantages like easy operating, large data storage, good privacy, short response time, high environmental adaptability, far identification distance, strong penetrating ability, multi-object recognition, anti-pollution etc. Currently, it is widely applied in industrial automation, business automation, transportation management, products and documents forgery proofing, theft-proofing and many other fields. With the development of the internet-of-things technology and its applications, RFID, as a key technology, has turned out to be a hot topic in both academia and industry [1-3].

The RFID system is divided into two parts: reader or interrogator and tag or transponder. The RFID system works as follows: the reader launches a continuous RF wave through the antenna, when tags pass in the reader range, they respond to the reader wirelessly by sending the data stored on them. The presence of more than one tag in the reader range is a source of collision as they communicate simultaneously their identification identities [2]. This causes the inability of the reader to identify tags correctly and rapidly [3]. Indeed, this collision problem is called tag collision, and the resolution algorithms are called anti-collision algorithms [4].

Collision is a common problem in the field of wireless communications. RFID technology uses radio frequency to conduct non-contact two-way data transmission between the reader and the transponder (tag) to achieve the purpose of target identification and data exchange [4-7]. In the RFID tag-reader context, collision occurs due to two main media access issues: reader collision and tag collision. Reader collision occurs when more than one reader is present within one another’s reading range, and these readers attempt to read tags simultaneously. Under these conditions, the tags either do not respond at all or exhibit unexpected behaviors. Tag collision occurs when multiple tags respond to a signal sent by the reader by simultaneously transmitting data to the same receiver slot. We consider tag collisions. Over the years, several means have been proposed to alleviate the deleterious effects due to collision. We consider one of the approaches that have been used to address this problem.

However, in the intensive-tag RFID application system, there are two or more than one label within the scope of a reader at the same time, then the query command issued by the reader tends to create multiple labels’ response at the same time, causing multi-label conflicts. In the RFID tag-reader context, collision occurs due to two main media access issues: reader collision and tag collision. Reader collision occurs when more than one reader is present within one another’s reading range, and these readers attempt to read tags simultaneously. Under these conditions, the tags either do not respond at all or exhibit unexpected behavior. Tag collision occurs when multiple tags respond to a signal sent by the reader by simultaneously transmitting data to the same receiver slot. The anti-collision algorithm is an effective algorithm to solve collision [8].
Anti-collision techniques for multiple tag identification are generally divided into two main algorithms: binary-tree-based deterministic algorithm and slot aloha-based probabilistic algorithms [2-5]. The former builds a tree with tag identifiers expressed in binary bits and identify tags by browsing through the nodes in the tree. For algorithms based on ALOHA protocol, each tag in a reader’s identification area selects one of the given N slots to transmit its identifier; all tags will be recognized after a few frames [6, 9]. Deterministic anti-collision algorithm includes binary tree search algorithm, the IPA algorithm (Identification Prediction Algorithm). Wenjing Fan, Shanshan Zhang, from Donghua University put forward a improved algorithm IRBS based on backward binary search algorithm, the algorithm introduces a label counter. R [10]. Shiuyu Li, Quan-yuan Feng of Southwest Jiao tong University, according to the principle of "take full advantage of known information, do not send or feedback the duplication of information, using the conflict of the feedback sequence of determining labels, get the depth search parameters of the next step", while effectively using the "stack technology" and “back principle", basing on a binary search algorithm put forward hierarchical depth of the search tree of RFID anti-collision algorithm [11].

Probabilistic anti-collision algorithm includes ALOHA algorithm, Jun Yin, Yigang He, from Hunan University, on the basis of the ALOHA algorithm, put forward RFID anti-collision algorithm based on the grouping dynamic frame time slotted, increase the slot utilization by 80% or more [12]. However, these two algorithms have their shortage, under the numerous labels occasion probabilistic algorithms has lower throughput, with algorithm’s performance degradation; Deterministic algorithm can guarantee that the labels have all been identified, but the longer time it takes. ID Prediction Algorithm for Tag Collision Arbitration(IPA) has an important feature: each time the reader send a inquiry request, and may also identify multiple tags, reduce the amount of readers’ inquiries, thereby dramatically increased the effective service rate of the system. Although the IPA algorithm reduces the reader's inquiry process, but in the label response process, it cause the information transmission capacity increasing, which can affect the response of the label.

In this paper, we consider Jump dynamic search algorithm (JDS). The design concept of our improved anti-collision algorithm is derived from the IPA algorithm. However, our scheme can suitably decrease the number of responding tags to a request, and therefore, decreases the probability of collision bits and increases the identification speed.

II. ROPOSED SCHEME

A. IPA Algorithm Principle

The IPA algorithm [13-14] introduces Ncb, Nc, N1 and Nr four factors and combines the query tree (QT) algorithm to get identification of RFID tag. Its essence is the using the number of tag ID “1” to predict the label ID Tag ID in the algorithm is divided into the count field and ID information field, count field is the number of “1” in the ID information field, as Figure 3. REQUEST command sent by the Reader to the label use count field as prefix, and the label receiving the command compare it with its own count field, if the same then sent back respond.

<table>
<thead>
<tr>
<th>Count field</th>
<th>Bit field</th>
</tr>
</thead>
<tbody>
<tr>
<td>010</td>
<td>1000100</td>
</tr>
</tbody>
</table>

Figure 1. The ID format of the IPA algorithm

In the IPA algorithm, the message stored by the reader contains Count Field Ncb (The number of label “1”bits), Collision bit number NC, N1 the number of collision “1” bits to be identified. Nr the number of “1” bits not recognized by IPA algorithm. The reader wants to store information about the number of bits of Nr. It is easy to know, Nr = Ncb-N1. Reader analyse the value of Nr to determine whether the label can be identified, the following situations are:

1. Nr = 0: All bits of tag ID can be identified, no data collision. In this case the value of Ncb, Nc, N1, Nr don’t need calculation, the label can be identified directly.
2. Nr = 1: The bit of unrecognized “1” in tag ID is 1, according to the uniqueness of the tags, each tag ID collision Nc inevitable has only a “1”, while the remaining bits are “0”. There is Nc Possible, so the reader can identify Nc labels.
3. Nr = Nc-1: The bit of unrecognized “0” in tag ID is 1, each tag ID collision Nc inevitably has only a “0”, while the remaining bits are “1”. There are Nc possible situations, so the reader can identify Nc labels.
4. When Nr does not meet the above three cases, means that the reader is lack of enough information to identify the label, to take the query tree (QT) algorithm to identify.

B. Idea of the Streamlined IPA Algorithm

The Improved idea:
1. When there is only a label to answer the case that no collision occurred, directly conduct the label identification, without the calculation Ncb, Nc, N1, and Nr four values in advance, then identification.
2. Use JDS [6] (Jump-type Dynamic Tree anti-collision algorithm) algorithm to replace the QT (Query-Tree, the query tree) algorithm, in the process of searching tags, not only avoiding the duplication of the search path, but also can reduce communications volume with the dynamic transferring data between the reader and labeling.
3. between the reader and electronic tags, the serial number information is sent each time, containing too large redundant information, the IPA algorithm is improved to reduce redundancy of paging of information, thereby reducing the transmission delay and energy...
consumption. For example, the results obtained by Reader decoding is 100X0011XX11, for the ID of the 12, only D8, D3 and D2 is unknown for the reader, others means no information for the reader, others need to conduct anti-collision process on unknown collision tag bit, other bits are not involved, reducing the values of the markers.

C. The Streamlined IPA Algorithm Instruction

For practical realization of this algorithm, a set of instructions is needed. This set of instructions can be conducted by the electronic label.

REQUEST (UID, m) - lock: UID refers to next paging count bit and serial number obtained by decoding results after the first paging. Values convention of the UID are as follows: Reader determine the accurate bit position where data collision occur, extract location of the collision from where collision occurred, then take collision location "1" and "no collision" 0 "and the number of inclusion "1" into the collision bit tag bit, to form new serial number locking paging instructions. The reader send the paging instructions, the response of electronic labels: compare serial number issued by the own ID with the data bits received by the reader, lock bit corresponding to the reader UID bit "1", and use the own count field subtract the count field of serial number, get the new count value. In the next anti-collision handling, only these locked bit and count field are involved in the data transmission and computation.

Put an example to describe this command REQUEST (UID, m). Assume five electronic tags around reader, their ID is 8 and after the reader sending a REQUEST (1111111) instruction, reader make decoding to the response from these eight electronic tags get 0011XXX0, its count field is 010, get the command issued by the reader as the REQUEST (00011110,010), those five electronic tags will lock own ID in D3, D2 and D1 and the respective use count field minus the serial number 010, the next time participated in the anti-collision algorithm is just the bit count of three and their ID number.

Active: Label in a preparation state receives this instruction, compares whether it's new count is equal to the count-bits, if it is equal, then response, otherwise continue the preparation state. This article use REQUEST (count-bits) to achieve ACTIVE instruction function. If the reader send command REQUEST (0), the label whose count field is "0" make a response to this command , return to the ID's lock bit corresponding to the count field.

SELECT (UID) - when be selected (serial number): use a determined sequence number as a parameter to send the electronic tag, then electronic tag with the same serial number use this parameter as a cut switch to perform reading and writing operations on the label, then the reader device send UNSELECT command, so that the label go into the silent mode. If the decoding results determine the collision, then go to step 4.

The Description of Streamlined IPA Algorithm

Streamlined IPA algorithm's anti-collision process is shown in Figure 2:

1. the reader sends the REQUEST (11 ... 11) command, all the ID whose value is less than or equal to electronic tags (11 ..... 11), make a response to this command, all responding label send the ID code back.
2. the reader detect signal received , if there is no signal, means no electronic tags around the reader, then go to step 1, otherwise go to Step 3.
3. the reader conduct decoding to all electronic tag responding signal , according to the decoding results , determine whether there is a collision occurs, if no collision occurs, the reading device send SELECT and READ-DATA instruction, conduct reading and writing operations on the label, then the reader device send UNSELECT command, so that the label go into the silent mode. If the decoding results determine the collision, then go to step 4.
4. the reader determines the collision occurred in which bits, by referring to the decoding results of step 3. The reader , the collision bit position "1", the uncollision bit position "0", and set the number of bits "1" of uncollision bits as records m, then reader sends REQUEST (UID, m) instructions, after receiving this command, the label compare the UID with its own ID, lock collision bit , the record of count field minus the value of m. Go to Step 5.
5. the reader sends the REQUEST (count-bits), then label whose count field equal to the count-bits value, make a response to this command, transmit itself lock position to the reader, the reader judge whether there is collision occurred. If no collision occurs, send SELECT and READ-DATE command, after conducting reading and writing operations on the tag, the reader send UNSELECT command, so that the label go into the silent mode. If a collision occurs, conduct statistics of the tag ID Ncb, Nc, N1 and Nr, to predict the tag's ID number, if identification of tags succeed, conduct the labels process, otherwise go to step 6.
6. if the tag is not recognized, means the reader is still lack of enough information to identify, JDS algorithm will be used. Readers decode the signal received; determine the accurate bit position of collision. The highest X where the collision occurred in is set to "0" , value higher than this stay the same, value lower than this go rounding. Again to these labels in the collision, conduct the implementation of the REQUEST (0, X) command. If there is no collision, you can identify a single label, label return to the ID value. After successfully reading a tag at each time, take a rebound strategy to return to the last collision node, to identify another branch of this node, so continue to repeat the operation until identification of the label where collision occur in the lock bit whose count field is count-bits . Go to Step 7.
7, all electronic tags are identified, the streamlined IPA algorithm identification process reach end.

Figure 2. IPA algorithm's anti-collision process

III. ALGORITHM ANALYSIS

A. The Instance Analysis of Streamlined IPA Algorithm

Assume that the tag's ID length 8, there are five tabs within the scope of the reader, the tag number and its ID is shown in Table 1:

According to the principle of the improved algorithm, identify the process of the five labels as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>10001100</td>
<td>10101010</td>
<td>01001110</td>
<td>00001000</td>
<td>11001000</td>
</tr>
</tbody>
</table>

1, reader send the REQUEST (11111111) instruction to five label within scope, label in the region meeting the requirements response, it can be decoded into XXX10XX0. The next instruction is (11100110, 010).

2, readers send commands REQUEST (11100110,010) , five labels lock their own ID, D1, D2, D5, D6 ,D7, three bit locked and the respective count field minus 010, that is, the new ID of the label is 010 10010,011 10101,011 01011,000 00000,010 11000.

3, the reader sends REQUEST (0) command, the label 4 response, no collision occurred, send UNSELECT command, the label go into the silent state; no longer correspond with the instructions emitted by reader.

4, the reader sends commands REQUEST (1), no label response.

5, the reader sends commands REQUEST (2), label 1 and label 5 response, collision is detected by reader as "1XX0X0". At this point the statistics Ncb = 2, Nc = 2, N1 = 1, Nr = 1, so two labels can be directly identified, the tag ID is "10010", "11000", that is, the label 1 and label 5, after further processing. Send UNSELECT command, the label go into the silent mode, no longer correspond with the instructions emitted by reader.

6, the reader sends command REQUEST (3), label 2 and label 3 correspond with reader. The reader detected the collision as "XXXX1", the statistics Ncb = 3, Nc = 4, N1 = 1, of Nr = 2, the reader has no enough information to identify the label, so use JDS algorithm. Reader refers to collision data, know the highest bit is D5, set the highest position 0, and send command REQUEST (0, 5). Received REQUEST (0, 5), label 3 response, no collision occurred, identifications label 3, send UNSELECT command, the label go into silent mode; no longer correspond with the instructions emitted by reader.

7, Use JDS algorithm, use the bounce strategy for reading, send REQUEST (1,5) instructions, label 2 send a response, no collision Identifications label 2, send UNSELECT command, the label go into silent mode, no longer correspond with the instructions emitted by reader.

B. The Simulation of Streamlined IPA Algorithm

The streamline IPA (Reduced_IPA, referred to as RIPA) algorithm is based on the IPA and JDS algorithm proposed in accordance with each algorithm process to write a C program, to select random or orderly label ID, conduct the identification process of the simulation label. Statistics the total number of reader inquiries and the total number of bits as well as the total number of tag response and the total number of bits.

1. Randomly selected 8 labeled ID, conduct simulation for JDS, IPA and Reduced_IPA three algorithms, the simulation results are shown in Figure 3, Figure 4, Figure 5 and Figure 6.

From Figure 3, Figure 4, Figure 5 and Figure 8, it can be seen, with the increasing labels, the total number of JDS algorithm reader queries and tag responses and the total number of bits become skyrocketing, because JDS algorithm only deal with redundant data processing of the transmission, reducing the amount of data transmission, without any optimization of the recognition process. IPA algorithm greatly reduces the total number of reader inquiries and the total number of bits, but greatly increase the total number of bits of tag responding, which is due to that the IPA algorithm in one inquiry process, may identify multiple tags, thus greatly reduce the reader inquiry, which is its advantage. However, IPA algorithm adds additional count field, these bits do not belong to the label information, during the response of the label, all bits
return to the reader, resulting in a lot of information transmission. With the increase in the length of tag ID, this useless information transmission capacity will increase.

Figure 4. Total bits of reader inquire

Figure 5. Total numbers of label response

Figure 6. Total bits of label response

The streamlined IPA algorithm optimized the lack of JDS algorithms and IPA algorithm, are better than those in reader inquiry processing and the labeling of the response process, and the streamlined IPA algorithm's advantage is becoming increasingly obvious with the increasing tags:

1) Reader Inquiries: When the label number reach 100, JDS algorithm needs to send 200 inquiries and 1999 bits; the IPA algorithm needs to send 91 inquiries and 550 inquiries bit; the algorithm Reduced_IPA only need to send 58 times Inquiries and 453 bits. Algorithm Reduced_IPA saves 71% and 77.3% of the amount of inquiries than JDS algorithm; saves 36.3% and 17.6% of the amount of inquiries than the IPA algorithm.

2) Label Response: When the number of labels reach 100, JDS algorithm need the label to answer the 880 and 4126 bits; the IPA algorithm need the label to answer the 760 and 8769 bits; the algorithm Reduced_IPA need label to response 367 and 2166 bits. Reduced_IPA Algorithm saves 58.3% and 47.5% of respondents than JDS algorithm; saves 51.7% and 75.3% of the respondents than the IPA algorithm. In order to achieve the purpose of identification of multiple tags at once, IPA algorithm need to add a count bit, so in the response process, the total number of bits sending response is much higher than the JDS algorithm. While Reduced_IPA algorithm also increases the count of bits, but these count not participate in the label response process, thereby greatly reducing the number of bits IPA algorithm tag response.

2. The simulation comparing Reduced_IPA identify random or ordered 16 bit label of results is shown in Figure 7, Figure 8, shown in Figure 9 and Figure 10.

Figure 7. Total numbers of label inquire

Figure 8. Total numbers of label response

Figure 9. Total bits of label response

Figure 10. Total bits of label response

Figure 7, Figure 8, Figure 9 and Figure 10 Simulation results show that the performance of Reduced_IPA orderly algorithm to identify the tag ID is much higher than the performance of identifying random tag. This is because that the ordered Label has more non-collision, the non-collision bits can be eliminated, to reduce a lot of redundancy, and speed up the recognition rate. This feature is ideal for storage, identification of similar items occasions. Commodity code can be added to the different commodities in storage, in the process of identifying similar goods, not only did not affect the read rate, but also can quickly find whether there is non-similar goods mixed.
C. Communications Volume Analysis

In the label recognition process, a total number of bits transmitted in the system is called communications volume. The RFID system’s communications volume consists of the number of inquiries bits by the readers and label response. Assume that the length of the label ID is $L$, the number of label is $N$, conduct simulation for the common algorithm and Reduced_IPA algorithm.

The binary search algorithm BS (Binary Search algorithm) is similar to the successive comparison methods in the balance, which is used successive earlier and simpler deterministic anti-collision algorithm. Because every reading device sending the request of the label command parameter, which is the entire sequence length, and for each query of the reader, the label need to send the complete serial number system communications volume [15], such as formula one said:

$$2^*L^*(N + \log_2(N!))$$  \hspace{1cm} (1)

DBS (Dynamic Binary Search algorithm) is to reduce the need to transfer information digits, and improve the transmission efficiency on the basis of the BS algorithm. This algorithm, in the recognition process, from the initial step in the search process to identifying a label, the label dynamic transmit serial number of the part, the average communications volume equals to half of the BS algorithm. Its communications volume is shown in Equation 2:

$$2^*(2.21^* 7.08)^* \log_2(N^* L^* N^* L^* N)$$

Queries algorithm basic idea is that label owns k-bit serial number, the reader will search for the k-bit serial number of all possible circumstances. The label of each response depends only on the query command sent by current reader, regardless of the query record of the reader. Communications volume is shown in Equation 3:

$$2.21^* \log_2(N^* + 7.08)^* L^* N$$  \hspace{1cm} (3)

Based on the above analysis, randomly selected 8 ID labels, conduct communications volume simulation algorithm, the results is shown in Figure 11. On the one hand, the streamlined IPA algorithm first mark the non-collision bit of label, non-collision bits do not participate in the process of tag identification. On the other hand, the reader inquiry process on marked bits. Compared with direct inquiring tag ID, in the case of a large number of
tags, the reader communications volume has a significant reduction. Therefore, it can be seen to the streamlined IPA algorithm greatly reduces the system communications volume.

IV. CONCLUSIONS

We have proposed an algorithm based on the basic IPA algorithm and JDS. With our improved algorithm, we reduced the total length of transmitted binary data to identify tags quickly during the identification process. This improvement is due, mainly to the JDS anti-collision algorithm. In the number of reader inquiries, the number of bits and the number of tag response, this algorithm has advantages compared to other algorithms. It improves the recognition accuracy of the RFID labels; improve the performance of recognizing the multi-tag RFID systems at the same time. Further work should be conducted to cut down the total transmitted binary data.

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REFERENCES


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