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Discussing On RFID Tag Conflict Problem

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Abstract

This paper introduces the basic concept, development process, key technology of RFID and related theory. And in view of the key technology of RFID, anti collision algorithm is analyzed. Tag collision algorithm is to solve the reading and writing implement effective communications within the scope of multiple tags at the same time, speaking, reading and writing for communication problems. Under the condition of keep a certain complexity and cost, minimize the search time, improve the efficiency of recognition, is the direction and trend of algorithms. Through the comparison of several kinds of algorithm for collision, clear the necessity of the collision algorithm is improved. The author select dynamic frame ALOHA algorithm, introduces in detail the improved algorithm, and apply it to the system, to improve the recognition efficiency.

Keywords: *wireless channel; label; reader; anti-collision algorithm; Discussing on RFID tag conflict problem*

1. Introduction

Radio frequency identification technology uses radio frequency signal through space coupling (alternating magnetic field or electromagnetic field) to achieve non-contact transmission of information through the transmission of information to the purpose of automatic recognition. First appeared in twentieth Century 80 years, compared with other technologies, the obvious advantage is electronic tag and reader can complete recognition without contact. Due to the miniaturization of RFID chip and the high performance chip, location and transportation situation of RFID tags can not only help managers track objects in different fields, but also be attached to real time information report on the tag, such as temperature and pressure.

According to the application purpose and different application environment, the components of the RFID system will be different, But basically consists of three parts: the electronic tag, reader, antenna [1, 3].

Electronic tag (or tag, transponder) is composed of a coupling element and a chip, the built-in antenna chip storage of electronic data of a certain format, as identification information for identifying items, is the real data carrier frequency identification system. The built-in antenna for communication and RF antenna. The antenna is a device for transmitting, receiving data transmission between tag and reader.

The reader is an equipment which be used to read or read / write electronic tag information, the main task is to control the RF module to transmit and receive signals read tags, tag response, object identification information on the tag is decoded, the object identity information and other relevant information transmission on the tag to the host for processing.

The selection of operating frequency, the antenna design, collision algorithm research are the key problems of RFID technology [4]. The current RFID working across multiple frequency band, low frequency (125 ~ 134 KHZ), high frequency (13.553 ~ 13.567 MHz),

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ultra high frequency (400 ~ 1000 MHz), microwave (2.45 GHz) and so on [6], It not only affects the performance and the size of label, also affect the price of tags and readers.According to the working frequency band antenna can be divided into shortwave antenna, ultrashort wave antenna, microwave antenna, etc.; According to the direction can be divided into the omni-directional antenna, directional antenna, etc.; According to the shape can be divided into linear antenna, planar antenna, etc. Collision algorithm mainly include the ALOHA algorithm and the binary search algorithm. ALOHA algorithm is simple, easy to implement, but the recognition efficiency is poor; Binary search algorithm need to special encoding of the data, is a bit complicated, and easy to leak information.

According to the implementation way, RFID can be divided into two categories - active RFID and passive RFID. Passive RFID electronic tag has no battery, the power supply in accordance with the work required by converting sent by readers and electromagnetic wave, so the reader's transmission power generally is bigger. Passive RFID electronic tag has no battery, the power supply in accordance with the work required by converting sent by readers and electromagnetic wave, so the reader's transmission power generally is bigger. In contrast, active RFID electronic tag to have battery, can provide all the power of the device working, thus the corresponding reader transmitted power requirement is not high, and increase effective reading distance than the former. Active RFID has many characteristics, such as low transmission power, long communication distance, large amount of data, high reliability and good compatibility, Compared with the passive RFID, has obvious advantages in technology. Because of this, it is widely applied to the toll roads, ports, shipping management, *etc*.

With the constant progress of science and technology, the social information degree is increasing day by day, the work efficiency and the requirement of the degree of automation is becoming more and more important Combining the RFID technology and communication technology, and combining the computer technology and the Internet, can achieve the global range tracking and information sharing of the item. Applied to logistics, manufacturing and public information services and other industries, can greatly improve the efficiency of management and operation, reduce the cost. With the constant improvement of related technologies, the development and maturity, the RFID industry will become a new high technology industry group, and become the new bright spot of the national economic growth.

But now, there are still many factors restrict the RFID technology popularization, which mainly has the following several aspects:

(1) RFID standard is not unified, with poor compatibility between different standards, it is difficult to realize materials information sharing. That makes the whole industry can't in-depth technology research and production, thus restricting the development of the industry.

(2) The RFID technology application faced with the threat of information security. Unique identifier in the RFID tags, namely the Electronic Product Code (Electronic Product Code, EPC) are easy to copy, RFID basic authentication mechanism exists serious security hidden danger and defects.

(3) RFID tag cost is still relatively high, difficult to implement on a large scale applications. The current price for the lowest $0.15, the highest $100 or more. From the view point of cost accounting, RFID is too expensive.

(4) At present, the anti collision mechanism in the RFID standards of efficiency is low. In the process of multiple target identification, when the target's movement speed is faster or target exceeds a certain number, the system of anti collision algorithm efficiency is especially important. Especially in the design of active electronic tags, the collision mechanism is a hotspot of research. The solution of these problems will pave the way for the popularity of the RFID technology further development.

2. Description and Solution of RFID Tag Conflict Problem

2.1. The Conflict Problem Description

Along with the increase of reader communication distance, the recognition area also increases, which may result in multiple tags At the same time in the reader identifies scope. As the reader with all tags share the same radio channel, when two or more tags send identification signal to the reader at the same time, signal will overlap, which leads to the reader cannot be performed analytically. This problem is known as the tag signal conflict (or conflict) ,in order to solve the conflict, It is necessary to set up relevant command and operation process. These commands of operating process are called anti-collision algorithm (or anti collision algorithm).

Generally speaking, there are four types of conflict resolution in a wireless network,namely spatial division multiple access (SDMA), code division multiple access (CDMA),frequency division multiple access (FDMA) and time division multiple access (TDMA),Considering the communication form of the RFID system, system complexity and cost, time division multiple access (TDMA) is anti collision algorithm for a class of the most practical application value. This method is all the tags in the unified command reader, in different time slices are sending identification signal, in order to ensure the tag signal without mutual interference.

The existing time division multiple access collision algorithm is divided into two kinds: one kind is the Anti collision algorithm based on binary tree , an other is a algorithm which based on ALOHA mechanism.

2.2 Anti Collision Algorithm based on Binary Tree

Anti collision algorithm based on the binary tree is:According to the recursive way of working, dividing the conflict of tag sets into two subsets , until only one tag in the set.Anti collision algorithm based on binary tree is one of the common algorithm.

Anti collision algorithm based on binary tree is a stateless protocol, which does not need to maintain any state inside the tag, the tag can only compare an identifier with prefix reader broadcast. Keep a binary prefix inside the reader, the initial values for each is 0 .At the beginning of each time slot, the reader broadcasts the binary prefix, Electronic tags will own the identifiers top comparing with time binary prefix, if the same, send the identifiers immediately . If the reader detects the conflicts, then at the back of the original binary prefix in the next query add 0 or 1,Cyclic query, until all tags are identified. The essence of the whole recognition process is to build a two fork tree according to the identification signal tag, the two fork tree known as query two fork tree, as shown in Figure 1.

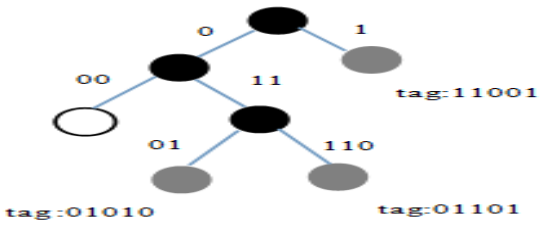

Figure 1. Binary Tree Search Algorithm

2.3. Anti Collision Algorithm based on ALOHA

2.3.1. The Pure ALOHA Algorithm: Multiple access mode of pure ALOHA algorithm used is a kind of random time division multiple access, or random multiple access. When any one of radio identification tag received the command from reader , immediately sends its symbol to the reader with a fixed length packets, in the process of sending data, if there are other tags also sending identifier, the signal they occur between the superposition leads to conflict or Part of the conflict. When receiving signal, the reader will check whether there is a conflict. If there is no conflict, reader correct identification tag identifier and send a confirmation message; if there is a conflict, the reader sends confirmation after the conflict, the tag will independent to wait a long time to send a signal at random, and until success.

Pure ALOHA method is only for read-only reader, as long as there is a packet, the packet can be sent to the reader from the tag.. This type of tag is usually only a few data(serial number) is transmitted to the reader, and in the cycle, a cycle of these data continuously sent to the reader, data transmission time is only a small part of the repetition time, resulting in a long intermittent in transmission between.

Between the repetition time each tag the difference is very small, so there is a certain rob ability, two tabs can their data set in different time periods, so that the packet transmission will not conflict with each other.

This method is simple, easy to implement, but the channel utilization rate is only 18.4%[4], performance is very not ideal. As shown in Figure 2.

Figure 2. Pure ALOHA Algorithm in Information Time Division Multiple Access Diagram

If G is the average number of packets exchanged, T is the observation time, the amount G of the packets exchanged by the average packet transmission time τ is calculated, see formula (1), n is the number of the label system, 1~n is observed the number of packets transmitted by the time tag T n; relatio $G = \sum_{1}^{n} \frac{\tau_n}{T} r_n$ t S represents a transport packet error, the average throughput S of the tr... and the exchange of data packets between the amount, see equation (2). When G = 0.5, the maximum value of S was 18.4%, see dashed lines shown below.

(1)

$$S=G*e(-2G) \quad (2)$$

2.3.2. Slotted ALOHA Algorithm based on Frame: To this problem, some people put forward a improved scheme, namely slotted ALOHA algorithm (S-ALOHA).The pure ALOHA algorithm's time is divided into several time slots, each slot is equal to or greater than the tag identifier of the time, and each tag can only be in the beginning of the time slot time sending identifier. The S-ALOHA protocol to send time synchronization by

RFID system, the reader through beginning of the time slot synchronous control command to realize time slot. Because the system time synchronization, utilization rate of channel is 36.8%[5],it is two times as pure ALOHA as shown in Equation, showing that the figure indicated by solid lines.

Basis on S-ALOHA, a plurality of slots organized as a frame, reader according to the frame as a unit for identification, which is based on frame slotted ALOHA (FSA). It is a time division multiple access mode, which can improve the throughput rate of the ALOHA method. The slot length determined by the system clock, the control unit must be with the clock synchronization. For RFID system, the transmission of data packets in the tag can only synchronization slots within the set, must be on all the tags simultaneously by a reader control. Using a slotted ALOHA, to transmit data packets begin always synchronous time slot, so compared with the ALOHA method simply, conflict may arise time only half as much, so that when the ALOHA method of S throughput rate:

$$S=G*e(-G) \quad (3)$$

By the equation above, exchange data packets in G=1 throughput rate of S was 36.8%.Therefore, because of this simple improvement, the channel utilization rate has doubled. As with pure ALOHA, after the conflict, the tag is still a random time delay dispersion retransmission. Slotted ALHOA system throughput rate of S in the exchange of data packet G approximately reaches the maximum value 1. If there are many tags in the range of reader, as existing slot, with the addition to tag, so throughput quickly close to 0. In the worst case, after several search may also sequence number has not been found, because not only tags can be alone in a time slot and successfully sent. Therefore, to get enough number of time slots, this approach can reduce the performance of the anti-collision algorithm. As shown in Figure 4. The throughput rate is S:

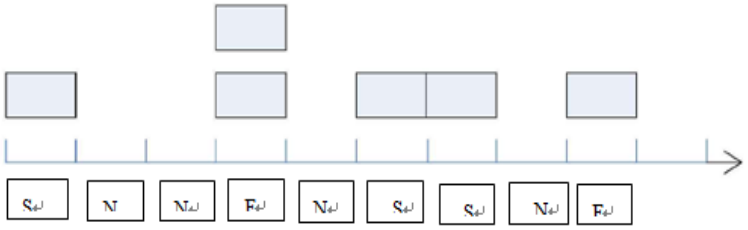

Figure 4. Time Slot ALOHA Algorithm Information Frame TDMA Diagram

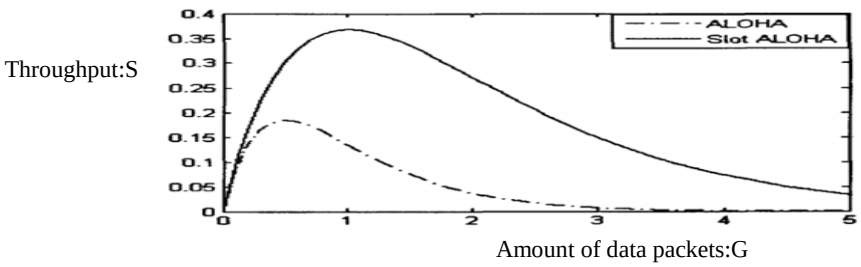

Figure 5. Time Slot ALOHA Algorithm Information Frame TDMA Diagram

2.3.3. Dynamic Frame Slotted ALOHA Algorithm: Dynamic frame slot slot ALOHA (Dynamic Framed Slotted ALOHA) referred to as the DFSA algorithm, the algorithm to improve the recognition rate by changing the tag of the time slots of a frame size. In order to determine the frame size, number of time slots are used to tag and conflicting slot number information. This algorithm is the use of the number of empty slots, slot number

only one tag transmission conflict slot and slot to adjust the frame size, the conflict of the slot size specific limit, reader increase the frame size. If the conflict probability is less than a certain limit, the reader can reduce the frame size. Because the reader to read cycle, the frame size is set to a minimum, so when the tag number not much, read and write without the frame size increase a lot can effectively identify tag. When the tag number, the reader todecrease conflict must adjust the frame size. The DFSA algorithm can solve BFSA algorithm has the problem of low efficiency of recognition. In the DFSA algorithm, the time slot number N of each frame are dynamically generated. Thus it can be seen that the algorithm is simple, easy to realize, and can fully adapt to the dynamic changes in the number of tags, very suitable for use in RFID technology.

In order to obtain the maximum system throughput, the number of time slots in a frameof a DFSA algorithm need statistics at the end this intra tag reading success, idle and collision, and then according to the various estimation algorithm to estimate the number of tags, to determine the number of slots matching, even if the frame slot to send the next length is equal to the estimated tags the number of. There are many ways to tage stimation, for example:

Minimum prediction[5]: the conflict happens in a time slot, at least 2 more tags at the same time, can predict the number of tags collision of at least 2*ak.

Schout[2] assumes that the tag selection slot with Poisson distribution prediction of -1Schout, when the system reaches the maximum throughput, the collision of a time slot rate of C tags=0.4180, so the number of tags in a time slot collision is 2.39, which can predict the number of tags are not identified 2.39*ak.

Vogt [5]: it is by comparing the actual success, idle, the number of slots and the theory of conflict Power, conflict free, slot number results for minimum error to predict unknown tag number, *i.e.*,:

$$\varepsilon = \min_{N} \left| \begin{pmatrix} c0 \\ c1 \\ ck \end{pmatrix} - \begin{pmatrix} a0 \\ a1 \\ ak \end{pmatrix} \right| \tag{4}$$

Among them, C1, CK, C0 value of actual measured success, idle time slot, conflict. 2*[C1+2*CK... In the tag number N (C1+2*CK)] to find the minimum e values, the corresponding N value is the prediction of the number of tags. As shown in Figure 5.

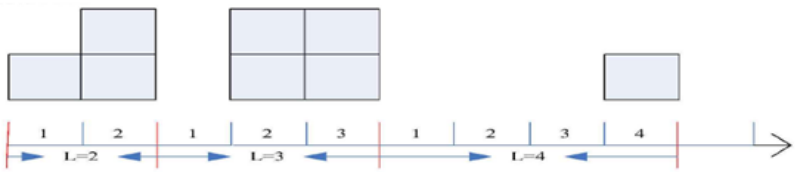

Figure 6. Schematic Diagram of Dynamic Frame Slotted ALOHA Algorithm

2.3.4 Packet Frame Slot Algorithm: When the number of labels is too large, we can not indefinitely increase the number of slots of the frame. Therefore, it was suggested that the grouping frame slot ALOHA (Group Framed Slotted Aloha, GFSA) algorithm [16]. The purpose of grouping is to limit the number of tags response, making the number of labels involved in identifying the number of cycles to match the frame slot. In GFSA algorithm, if the estimated number of tags to be identified exceeds the maximum number of frames that can match the range of slots, in order to ensure each set of tags to be identified with the maximum number of slots to match the frame, should be grouped. Assuming the probability of a single tag in the same time slot appears, the probability r label appears within the same time slot according to the Principle of the binomial distribution:

$$B_{n,\frac{1}{N}}(r) = C_n^r \left(\frac{1}{N}\right)\left(1-\frac{1}{N}\right)^{n-1} \tag{5}$$

2.3.5 Adaptive Information Frame: Slot algorithm:According to the analysis, in order to obtain high throughput rate, first of all need to predict the possible number of labels. However, when the number of labels change range is very large, To directly predict the number of labels and set the best time slot frame length is more complicated in the design of the actual circuit system, and will bring additional power consumption. In order to simplify the design of the actual circuit, method is usually used in setting the power index information frame length tag number prediction based adaptive information, such as the use of frame slotted Q-Algorithm settings for the [28] solution in the new EPC Gen2 standard. When there is too much conflict time slots of a frame, a reader ahead of the end of the frame, will send a new large frame, when appeared idle slot more than one frame ahead of the end of the frame, the reader, will send a new small frame. Specific implementation plan as described below, the identification process begins with reader sends the Query command. Command contains time slot parameters Q. Label will choose a random number as a slot counter value from 0 ~ 2 ^ Q 1 range. When the slot counter value is equal to 0, labels will make a reply. If the label is read/write device successfully, then exit the recognition system. Read/write device by sending commands to tags slot counter value minus 1, if the slot counter value is 0 (the previous time slot collision), it is referred to the maximum (7 FFFH). When reading and writing device need to change the time slot number, will send change time slot parameters command, make originally the Q value of plus or minus 1, then the label will produce counter value. Time slot number of the adaptive process is by sending a Query Adjust command implementation. Identification of a read/write device according to several time slot (rather than a cycle), to increase or decrease time slot parameter Q, can reflect the dynamic changes of the tag number in a timely and effective manner.

3. The Improved Dynamic Frame Time Slot Algorithm

From the study of the RFID tag collision, when the frame time slot equals the number of tag number, the system throughput will reach the maximum value. In the whole dynamic frame slot collision algorithm process, the accurate tag estimation is a very important link, it directly decides the whole recognition efficiency of the algorithm. Therefore, we must first study to estimate the label.

3.1. Estimate is Derived

Based on traditional tag collision probability estimation algorithm is as follows: first, assume that the frame time slot size and the label number N and M, because the probability of label distribution in each time slot is the same, namely 1/N, so it can be found in each time slot is deduced the probability of t a label as follows:

$$\mathbf{G} = \mathbf{N} C_M^t (\frac{1}{N})^t (1 - \frac{1}{N})^{M-t} \tag{6}$$

We can deduce the exist in the N 2 G 2 slots, where each time slot contains t a label, including the value of G launched by type:

$$\mathbf{P}(X = t) = C_M^t (\frac{1}{N})^t (1 - \frac{1}{N})^{M-t} \tag{7}$$

Suppose respectively have S, I and C time slots (I + S + C = N), S means that there are s time slots, there is only one label success to send data, I means that there are c time slots no label to send data, C means, there are C time slots, respectively, there are two or more than two tags to send data, namely the collision happened in each time slot. Can be derived:

$$\mathbf{G} = \mathbf{N} C_M^t (\frac{1}{N})^t (1 - \frac{1}{N})^{M-t} \tag{8}$$

When the initial frame timeslot number equals the tag number, the system throughput will reach the maximum value. But in practical application, due to the reader for the initial frame slot size set for some discrete values, commonly as 4,8,16,32,64,128,256, *etc*.

So can according to the actual situation, set up the frame time slot optimal initial value L, and make it as far as possible close to estimate M label quantity.

According to the formula, we learn that in the frame time slot number for the above mentioned fixed value, the tag number of the throughput graph, as shown in figure 6.

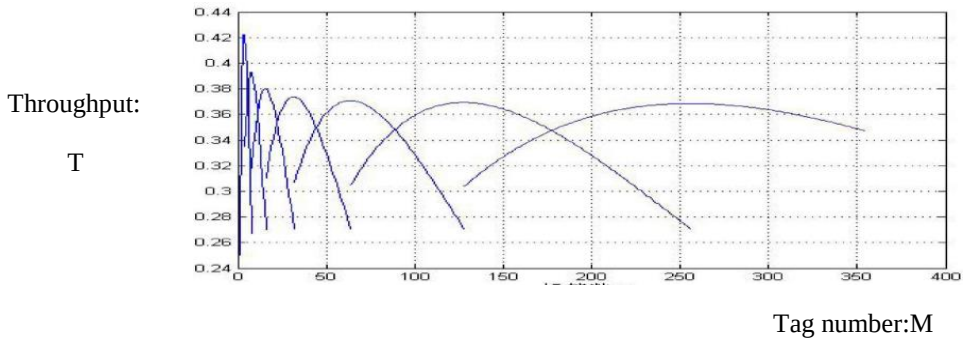

Figure 6. In the N Value under Different Conditions, the System Throughput

Dynamic frame time slot judgment methods are mostly based on collision time slot number and the number of idle time slot, thus to change the next frame time slot number,

When there is too much conflict in a frame time slot, will increase the frame length; When there is too much free time slots in a frame, will reduce the length of the frame.

Such a decision will be the first kind of error in statistical (left), namely, although more than a hollow frame time slot or time slot collision, but the number of successful identification tag has been able to meet the minimum recognition rate, but also change the length of the frame.

For example: when the frame time slot number is 128, tag number in the range 89-177, select the frame time slot number can make the system throughput is greater than 0.348 (successful timeslot number greater than 44), in this case, the maximum rate of idle time slot is 0.498 (64) is the maximum number of idle time slot, slot collision rate maximum is 0.402 (51) collision is the maximum number of time slots.

According to the above judgment method, the length of the frame will change in the following two cases: the free time slot number greater than 64, reduce frame time slot number; Collision time slot number greater than 51, increase the frame time slot number.

In his free time slot number greater than 64 and successful time slot number greater than 44 or collision time slot number greater than 51 and successful time slot number greater than 44 in both cases, frame time slot number will also change.

When the system throughput rate > = 0.347, you can keep the frame length; When the system rate < 0.347, according to the formulas for calculating label after estimating, find matching frame length value.

Specifically, the algorithm for time in multiples of 4 to this place, as long as successful identification labels of these moments of statistical number greater than 0.347 | | 4 * I * when the integer (I = 1, 2, 3... take an integer), can continue to monitor the following time slot, until the end of the frame, do tag number estimation. If less than the integer value of the above, directly out of the frame, and then do the tag number estimation.

4. Conclusion

Comparison of two kinds of anti-collision algorithm, it is not difficult to find, ALOHA algorithm is relatively simple, easy to implement, but the recognition efficiency is poor; binary search algorithm requires a special coding, the data is more complex, and is easy to leak information. In current RFID standard anti-collision mechanism low efficiency. In the process of multi object recognition and, if the target moves faster or more than a certain amount, it is anti collision algorithm efficiency system is particularly important. Especially in the design of active tag, anti-collision mechanism is studied, the solution of these problems will spread to the further development of RFID technology to pave the way.

We can make conclusions: Determine the frame time slot, should be the first to correctly identify time slot number whether meet minimum identification efficiency, rather than to judge the empty slot number or collision time slot number; Should be in a frame for the position of the integer times of 4 be treated early; In the grouping algorithm, the experiment adopted the ID partitioning method

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