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Research on the Dynamic Scenes' Ability to Adjust to the RFID Anti-Collision Calculation Method

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Abstract

Anti-collision calculation method is an important technique in the RFID system. On the basis of the research of RFID' s special decoding method and classic anti-collision method in a dynamic environment, using results of the ability of the reader to test the ability of the electronic tags to adjust itself to the blank time frames, controlling the reader's region of communication and allowing the reader to be at its highest efficiency and decoding rate, combined with the binary tree calculation method, the ability of the tags to adjust to the binary tree anti-collision method. When the tags are adjusting to the dynamic environment, at the same time, the tags that are interfering with the process can be removed, improving the stability of the RFID signal. The results shows that as compared to the calculation method used now, this calculation method effectively controls the happening of collisions, increasing the efficiency of the RFID system's reading of tags.

Keywords*: RFID anti-collision calculation method; binary tree; the ability to adjust*

1. Introduction

In the RFID system, anti-collision calculation method does research on how to prevent collisions from happening, reducing the time needed for the reader to decode and recognize the electronic tags to its minimum. Especially when the tags are under complex dynamic environments such as when the numbers of tags are large, multiplying or moving quickly, this prevents the collision of tags from affecting the reader's ability to decode them. It also assesses if all the readers can be combined together to ensure the accurate collection of statistics even if the numbers of tags are involved large and when the tags are moving at high speeds, the RFID system can further assess whether the reader is able to complete the decoding process of the tags (for example: when the cigarette leaves the storage pipeline, pieces of tobacco pellets are stacked at high speeds). During these circumstances, these considerations will then have to be taken into account. The anti-collision calculation method in the RFID system is usually with regards to static environments and can be classified into two different types [1], namely, the binary tree anti-collision calculation method and ALOHA anti-collision calculation method.

Binary tree anti-collision calculation method has many uses. When the numbers of tags are involved small, it can satisfy the decoding performance needed [2]. As the calculation method is being divided into the groups, the data received during each stage needs to be temporarily saved to create a binary tree, which is similar to a data structure. However, this process takes a very long time and it is not as safe. Assuming that the numbers of tags are N , and the numbers of iterations which needed to identify a tag is L , their relationship can be expressed as:

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$$L = \sum_{n=1}^{N} \log_2{}^{n} + 1 = \frac{N(N+1)}{2} (1 \le n \le N) \tag{1-1}$$

It can be seen that when the numbers of tags increases, the amount of iterations which need to identify a tag will also increase. Through this, optimization occurs and retreat binary search calculation method, dynamic binary search calculation method and pruning branches binary search calculation method etcetera are also produced. The retreat binary search calculation method and the numbers of tags share a linear relationship and from the system efficacy, it can be seen that there is a very big improvement in its functions. The dynamic binary search calculation method also showed a significant improvement in its stability and throughput [3]. Although the pruning branches binary search calculation method is complicated [4], but it saves a lot of time and it is very suitable when the numbers of tags are involved great.

The ALOHA calculation method is initially a calculation method [5] which is used in a wireless channel in the computer network. It has a simple design and the sending process need not be synchronized, possessing a lot of randomness. ALOHA time frame calculation method is also a kind of ALOHA calculation method, the only difference is that the time have been split into parts. As compared, the ALOHA calculation method's system efficacy is doubled, however, when the numbers of tags are large, their efficacies are reduced. Frame slotted ALOHA calculation method improved this situation. First, the time frames are being separated, with N numbers of time frames in each frame of a certain frame size [6]. However, the frame size is fixed. Hence even if the numbers of tags are larger or smaller than expected, the frame size cannot be changed. This will lead to either too much blank spaces within a time frame or collisions happening more often [7]. Although dynamic frame slotting ALOHA calculation method's frame size can be adjusted [8], it does not have a high system efficacy and its design is too complicated. Q calculation method on the other hand, belongs to a type named as heuristic calculation method [9]. It does not need to know the amount of time frames used up and can also adjust the frame size when needed. However, it will incur a great amount of operational costs [10].

In reality, the crucial point of performing the anti-collision calculation in a dynamic environment is removing disruption from the surrounding tags and preventing the tags from cross-disrupting each other. With regards to the active reader, by removing the stationary tags within the range of the reader, collecting many strong signal values to determine the stability of the operation data, tags with stable signals can be shielded, effectively reducing the numbers of tags to be decoded. From there, the complexity and time needed to handle the anti-collision method can be reduced, increasing the efficacy of identifying the tags.

2. Adaptive Strength of the Power Signal

2.1. Introduction of the Strength of the Signal

Firstly, many tags can be collected and passed through the RFID reader. The strength of their power signal can then be used as a base for the handling of statistics. When it is used in reality, the RSSI values can then be used to indicate the strength of the signal of the RF signal when it goes through the reader. Using the results received, a logarithmic-normal distribution of propagation loss model can be adapted, as shown in formula 2-1.

$$P(d) = P(d_0) - 10n\lg(d / d_0) - X_\sigma \tag{2-1}$$

In this formula, $P(d)$ is the signal strength received by the reader while $P(d_0)$ is the signal strength received by the reader at d0. Assuming that the initial strength emitted by the tags are the same, n is the scale factor for the loss and length of the path; X_σ is the Gaussian random numbers with an average value of 0, and it is also the attenuation for the signals passing through obstacles. Assuming that the tags can show an N signal strength as it passes through the RFID reader, using P to express, $\overline{p}$ represents the average signal strength as shown in formula 2-2.

$$P = \{p_1 + p_2 + ... + p_N\}, \overline{p} = \frac{p_1 + p_2 + ... + p_n}{N} \quad (2\text{-}2)$$

The variance, which is the stability of the signal strength, can be calculated as shown in formula 2-3.

$$S^2 = \frac{(p_1 - \overline{p})^2 + (p_2 - \overline{p})^2 + (p_3 - \overline{p})^2 ... + (p_n - \overline{p})^2}{N} \quad (2\text{-}3)$$

Through the calculation of the variance of the signal strength, its stability can be ascertained. As the tags that passes through the RFID reader is in movement, tags with the most stable signals are most probably stationary, which are known as distraction tags, can be set as threshold T. The signal variance lower than T will all have to be removed.

2.2. Operation of the Adaptive Power of the Reader

In the process of decoding the tags, as long as the transmission power of the reader is reduced making the range of each reader smaller and reducing the numbers of tags in the range of each reader, lowering down the frequency of collisions happening between the tags as a result, it can immediately get into the state of reading the data. The relationship of the reader's transmission power in its communication range is as shown in formula 2-4.

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \quad (2\text{-}4)$$

$P_r(d)$ in the formula above represents the power when receiving signals; P_t represents the sending power of the signals; G_t and G_r represents the gains in sending and receiving antennas respectively; L represents the loss of the system; λ represents the wavelength; while d represents the communication range of the reader.

A tag is kept in each reader and the strength of the electromagnetic force between the respective tags and the reader will give an idea about their respective distances, which can be used to setup an adjustable reader to reduce its transmission power, allowing the tags to accurately recognize the nearest tag.

When many tags start to enter the reader's detectable range, the reader will record the distance between the respective tags and itself through the strength of the electromagnetic force produced. These distances will then be arranged quickly in ascending order and the reader will start the recognition from the first tag. Its transmission power will also be adjusted according to the respective parameters of the tags so that the tags to enter the detectable range perfectly.

It will also be deduced if collisions are still happening at that point of time. If it does, it implies that distances between two tags and the readers are either very similar or exactly the same. During these circumstances, binary tree calculation method will be used for the recognition of tags instead. If collisions are not present, the tags will be decoded immediately and the tags in the region will be shielded after the recognition. With this, the reader will adjust its transmission power according to the parameter of each tag to be able to identify all the tags in the region. After all the tags in the region have been identified, the reader will go back to its original condition.

3. Design of the Adaptive Power Binary Tree Calculation Method

3.1. Calculation Method

This calculation method is based on the following presumed conditions:

(1) The reader is free to move; it can be added or taken away

(2) There is an active reader in every reader and it can adjust the power according to the parameter of the transmission

The calculation method is as shown in Figure 3-1:

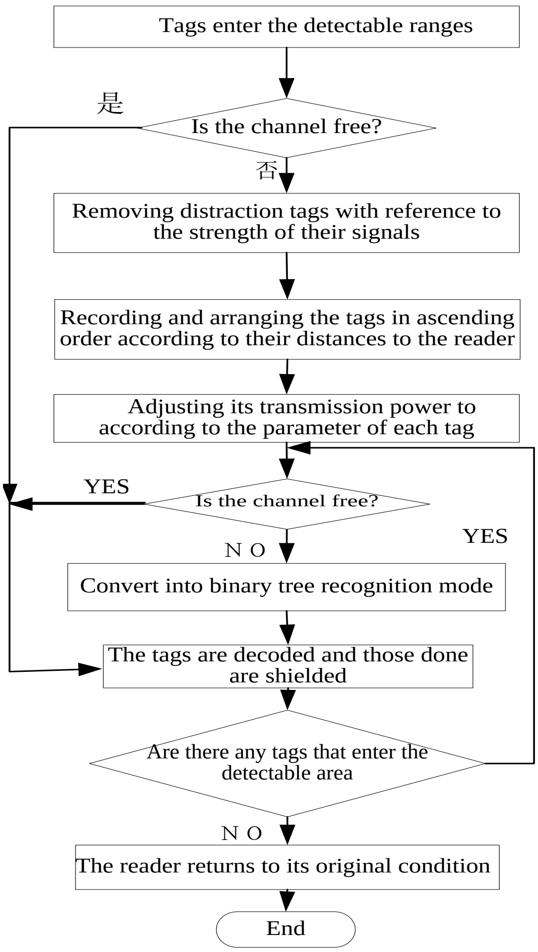

Figure 3-1. Steps to the Calculation Method

The steps are shown below:

1) Every time a tag is detected within the range of a reader, a data-listening channel is started to check if the statistics channel is free. If it is, the decoding process of the tag will then commence.

2) If the statistics channel is busy, distraction tags will then be deleted after reference to the signal strength of the tags. The reader will then record the distance between the reader and the different tags. They will then be arranged accordingly with reference to the results. The reader will then adjust the transmission power according to their respective parameters.

3) After the transmission power is adjusted, the statistics channel will then be deduced if it busy. If it free, decoding of tags and the transmission of statistics will then commence.

4) If the channel is still busy, it implies that collisions between tags have happened and it will be converted to commence with the binary tree calculation method recognition mode. After all the tags in the area have been decoded, the tags will then be screened.

5) The transmission power of the reader will then be adjusted to allow the commencement of the next round of recognition. Step 3) and 4) will also be repeated until all the tags identified. With this, the reader returns to its normal condition.

3.2. Adaptive Transmission Power of the Reader

Each reader has different functions, but they can all base on Manchester encryption to accurately detect the area where the collision occurred. To reach the targeted mark, when the tags are searching for time frames to exchange their statistics, the statistics will be sent to the end of the reader in a fixed method. When the reader receives it, it sends a command to the tags. After the tags receive them, the tags will randomly choose a value between the range 0~2Q-1, forming information bits of special format which have a length of 2Q bit lengths. Assuming that the starting value Q is 2 and there are 3 tags in the region, the tags will then produce 4bits of statistics which can be used to select their occupied slot number when the tags are going through the recognition process. If the tag chose number k time frame, number k bit's position will be set as 1, while others will be set as 0.3 tags will then produce 4 bits worth of statistics to be transmitted to the reader at the same time. After the reader receive the specific information that the tags are returning, they will be able to receive information of the occupancy of time slots and the description of colliding time frames is as shown in Figure3-2.

tag 1	0 1 0 0
tag 2	0 0 1 0
tag 3	0 0 1 0
reader detection	0 X X 0

Figure 3-2. Collisions that Happen in Time Frames

0 in 0XX0 represents the blank time frames, while X represents the successful time frames or time frames in which collision happens. With regards to the system functions of the reader, the largest amount of blank time frames that the system can take is represented as Mmax, the adjustment process of the transmission power, Pt, is as shown below:

1. When the tested amount of blank time frames in reality, M, is M>Mmax, the transmission power, Pt=, will then be adjusted to twice the its original value;
2. When M≦1/2Mmax, the transmission power, Pt, will then be adjusted to half its value;
3. When the value of M is retested, if M>Mmax, step 1 will be redone; however if M≦1/2Mmax, step 2 will be redone;
4. If the value of M remains unchanged or 1/2Mmax≦M≦Mmax; the transmission power will then be the value after it adjusts to the blank time frames, Pt.

After confirming the M value adjusted, and then using the formula, the number of tags present at a point of time, N, can be derived. It can then be combined with the formula in the binary tree calculation method, 2Q=N to get the new value Q. The reader resends the command to the tags in the region and when they receive it, they will then randomly choose a number from 0~2Q-1 and keep it in their respective computers.

4. Tests and Functions

In the RFID system, its throughput and efficiency is the main index in deducing the quality of the system. As the throughput and efficiency are closely related, only the recognition rate of the tags and the system efficacy is discussed here. The definition of the recognition rate of the tags is as shown formula 4-1 while the definition of the system efficacy is as shown in formula 4-2.

Recognition rate of the tags = total number of tags accurately recognize total number of tags (4-1)

System efficacy, η = total number of times a tag is accurately recognized total time used up (4-2)

With regards to the recognition rate of the tags, comparisons are made using two ways. The first is a filtration method which did not make use of the signal strength of the tags. The next makes use of the signal strength of the tags and the simulation results is as shown in Figure 4-1. It can be seen from the graph that, using the adaptive signal strength increases the recognition rate of the tags.

The system efficacy undergoes a MATLAB simulation experiment through the computer algorithms of the ALOHA calculation method, binary tree calculation method, power adaptive calculation method, and the suggested power adaptive binary tree anti-collision calculation method. The number of tags are between 50~500 and the simulation results can be seen in Figure 4-2.

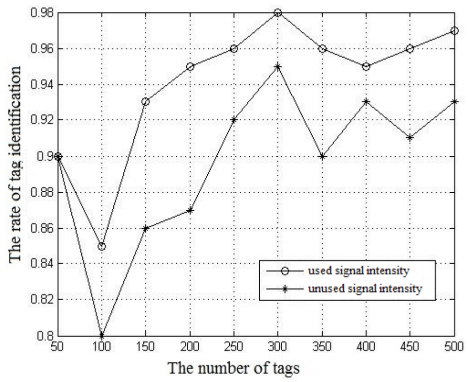

Figure 4-1. Recognition Rate of the Tags Under Disturbance

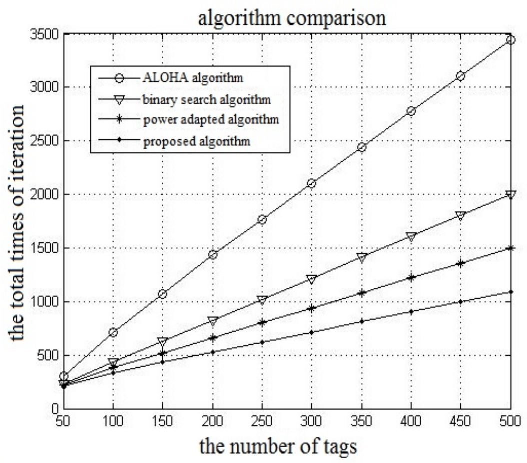

Figure 4-2. Comparison of the Systems' Efficiency

When the numbers of tags are the same, the recognition rate, as compared to the ALOHA calculation method, binary tree calculation method and the calculation method of its adaptive power, is higher by 6%, 20.3%, 6.7% respectively. Hence, it can be seen that the suggested calculation method is more efficient.

As compared to other classic calculation methods, the optimized calculation method does show an improvement in both the recognition rate of tags and the system efficacy. With the introduction of Manchester's encryption, the time taken for the estimation of the number of tags has been shortened, and fewer time frames are used up. As compared to the calculation method Q which requires repeated adjustments to find the suitable estimation, this optimized calculation method only needs once to derive that value. The calculation method not only simulates the reading of tags under a static environment, but also under a dynamic environment. Although there are movements of the tags, as the decoding rate of the reader is much faster than the movements of the tags, the tags can be completely decoded in time and it will not cause a thirst effect.

5. Conclusion

In the RFID system, anti-collision calculation method does research on how to prevent collisions from happening, reducing the time needed for the reader to decode and recognize the electronic tags to its minimum, combined with the binary tree calculation method, Design of the ability of the tags to adjust to the binary tree anti-collision method. When the tags are adjusting to the dynamic environment, at the same time, the tags that are interfering with the process can be removed, improving the stability of the RFID signal. As compared to other classic calculation methods, the optimized calculation method does show an improvement in both the recognition rate of tags and the system efficacy, this calculation method effectively controls the collisions from happening, increasing the efficiency of the RFID system's reading of tags, and it is also very practical. Hence, it is worth a more in depth research and more should know about it.

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