Research on Anti-collision algorithm of Multi-RFID tags in intelligent clinical monitoring system

Helin Zhang¹, Yiqun Huang¹, Qingmei Chen¹ and Kang Zhang¹

¹Jiangxi University of Traditional Chinese Medicine, Nanchang, China

Abstract. In view of the collision problem of multi Rfid Tags in recognition, the long recognition time of Deterministic algorithm and the low efficiency of the random algorithm are easily hungry and thirsty; In this paper, an improved anti-collision Algorithm (DFSA-CT) is proposed based on the design of dynamic environment. Compared with other collision algorithms, this algorithm has obvious advantages in time slot number and recognition efficiency. Finally, experimental simulation is used to analyze the algorithm and its superiority is verified.

1. Introduction

With the rapid development of the Internet of things, RFID technology has been applied in the field of clinical monitoring system. Because of the multi-label characteristic of clinical monitoring system and the dynamic application scenario, the problem of multi-label collision becomes the key problem to be solved. Thus the multi-RFID tag anti-collision Algorithm put forward higher requirements.

At present, the research on multi-RFID tag anti-collision Algorithms mainly includes deterministic anti-collision algorithm based on tree, random anti-collision Algorithm based on ALOHA and hybrid anti-collision Algorithm based on both. Tree-based anti-collision Algorithms include binary query tree (QT) algorithm, binary search (BS) Algorithm, Collision Tree Algorithm (CT) and so on. The recognition rate of these algorithms can reach 100%, and the most typical deterministic algorithm is binary query tree algorithm Aloha anti-collision Algorithm, which was proposed by Norman Abramson in the 1970s, is a widely used algorithm. In this algorithm, the label can send data in any time slot. Once the collision occurs, the label can send data in another time slot at random until all labels are identified successfully.

Combined with the characteristics of the clinical monitoring system, the multi RFID tag Deterministic algorithm identification efficiency is low and the random algorithm is prone to hunger and thirst, in this paper, an improved anti-collision Algorithm based on the capture effect in dynamic environment is proposed. Compared with other collision algorithms, this algorithm has obvious advantages in slot number, recognition efficiency and communication complexity. The Algorithm is analyzed by experimental simulation, and its superiority is verified.

2. Design of recognition process based on Hybrid Algorithm (DFSA-CT)

Considering the randomness of the algorithm with the advantages of simple and fast but there is a problem of label hunger. This can result in some tags may not be recognized by the reader in a short time, seriously affecting the reliability of recognition. The Deterministic algorithm, on the other hand,
allows all tags to be identified. However, the identification process will waste a lot of time slots, in the case of tag density is more obvious, a great impact on the efficiency of identification. Especially when the application environment is a dynamic environment, the identification efficiency of the traditional random and deterministic algorithms will be reduced, and there may be a large number of tags in the flow process is not recognized.

In this paper, we combine dynamic frame Slot Algorithm with collision tree algorithm to design an efficient recognition Algorithm (DFSA-CT) for dynamic environment. In each slot of the frame, the reader will detect the collision of the tags. If the collision occurs, the collision tags in the slot will be identified by the collision Tree Algorithm. This ensures that all tags will be identified and avoids label starvation. Compared with the traditional collision Tree Algorithm, this algorithm reduces the recognition time of traversing binary tree and reduces the communication between reader and tag. Therefore, the algorithm has the advantages of improving the recognition efficiency and reliability, and reducing the communication between reader and tag in the process of recognition.

The identification process of Hybrid Algorithm (DFSA-CT) is divided into two stages. In the first stage, the reader uses the dynamic frame time-slot Algorithm to identify the tags in the range. In the second stage, the collision time slot is processed by the collision tree (CT) Algorithm, and the collision information is checked by the packet parity method, the collision time slot that satisfies the check condition is the successful time slot. The loop grouping that does not meet the check condition is finally identified successfully.

Under the dynamic environment of Clinical Monitoring, the number of tags to be recognized in the range of readers is dynamic. Since the number of new arrivals is random, we assume that the rate of new arrivals is $\lambda (0 \leq \lambda < 1)$. When $\lambda = 0$, the identified environment is static.

The time interval between consecutive the $i$ frame and the $i+1$ frame is short, and its tag arrival rate $\lambda_i$ and $\lambda_{i+1}$ are regarded as continuous change. The experimental results show that the stability of the system is good when the initial state $\lambda_0$ is set to 36.8%. If the number of collision slots in the frame is $S_c$, the number of successful slots is $S_s$, and the number of tags recognized by the CT Algorithm is $S_1$, the total number of tags is $N$ recognized in this frame can be calculated by using the tag number calculation algorithm:

$$n = S_s + S_1$$

The new tag arrival rate is:

$$\lambda_{i+1} \approx \lambda_i = \frac{n_{i+1}}{n_i}$$

In the recognition process of CT Algorithm of collision tree, we use group parity check method to check the pre-set parity bit and collision information. Because it is parity check, when the collision number does not exceed 2 bits, the tag in the slot will be successfully identified; when the Collision Bit exceeds 2 bits, the reader will set the highest collision bit to 0 and 1, respectively, after combining the information bits that have not collided, two New Query prefixes are generated to round-trip the tags and then they are validated until they are successful.

The specific identification process of the Hybrid Collision Avoidance Algorithm (DFSA-CT) is as follows:

First, the reader is initialized. For the frame length $L_i$, the initial state $i = 0$. The new label arrival rate $\lambda_0$, the slot counting position is initially set $S = 0$; the successful slot counter $S_s = 0$, the collision slot counter $S_c = 0$, the idle slot counter $S_e = 0$, the collision tree CT algorithm identifies the tag counter as $S_1$. Second, Issue a query instruction, select the tag of the timeslot $S$ to communicate with the reader and determine the status of the timeslot .Successfully identified and
assignment $S = S + 1, S_s = S_s + 1$ back to step 2. Unlabeled response, assignment $S = S + 1, S_s = S_s + 1$ returns to step. If a collision occurs, the assignment $S_c = S_c + 1$ performs the next step. Thirdly, the reader judges the collision position and validates the collision information by using the character of the check information position. Fourth, determine if there are any unrecognized slots. Fifth, determine if there are any unrecognized tags.

The Algorithm Flowchart looks like this:

![Algorithm Flowchart](image)

**Figure 1.** The process of algorithm.

### 3. Analysis of DFSA-CT anti-collision algorithm

Whether an anti-collision Algorithm in RFID system is advanced or not depends on the following indexes: Query Times, system identification efficiency, transmission information, transmission delay, system stability and so on. We analyze the hybrid algorithm in terms of the number of time slots and the efficiency of system identification.

#### 3.1. Total time slot analysis

The hybrid anti-collision Algorithm is based on the random algorithm to identify the label within the recognition range. Then, when the collision time slot is encountered, the collision tree CT algorithm is
used to deal with the problem. Therefore, the total timeslot of this algorithm should include the total time slots in two processes.

In the Algorithm, the frame length is $L$, the number of tags to be identified is $N$, the number of successful timeslots is $S_s$, the number of idle timeslots is $S_e$, the number of collision timeslots is $S_c$, the collision, recognition, and idle probabilities are $P_c, P_r, P_e$ respectively, then:

$$P_s = C_N^1 \frac{1}{L} \left(1 - \frac{1}{L}\right)^{N-1} = \frac{N}{L} \left(1 - \frac{1}{L}\right)^{N-1}$$

$$P_e = C_N^0 \left(\frac{1}{L}\right)^0 \left(1 - \frac{1}{L}\right)^N = \left(1 - \frac{1}{L}\right)^N$$

$$P_c = 1 - P_s - P_e$$

The number of successful timeslots is $S_s$, the number of idle timeslots is $S_e$, and the number of collision timeslots is $S_c$

$$S_s = LP_s = N \left(1 - \frac{1}{L}\right)^{N-1}$$

$$S_e = LP_e = L \left(1 - \frac{1}{L}\right)^N$$

$$S_c = 1 - S_s - S_e$$

When the number of collision tags is $n$, the average number of collision tree CT Algorithm Identification tags in each collision timeslot is:

$$S_1 = 1.5 \frac{n}{S_c} - 1$$

The tags in all the collision slots are identified by the collision tree CT Algorithm. The total number of timeslots is:

$$S_2 = S_p S_c = 1.5n - S_c$$

The total number of timeslots in the DFSA-CT Hybrid Algorithm is:

$$S = L + S_2 - S_c = 2L \left(1 - \frac{1}{L}\right)^N + 1.5N + \frac{N}{2} \left(1 - \frac{1}{L}\right)^{N-1} - L$$

Figure 2 is a comparison chart of the relationship between the total number of timeslots and the number of tags of the three algorithms. It can be seen that when the number of tags in the range is the same, the total number of timeslots of the randomicity algorithm is the most, and the total number of timeslots of the hybrid algorithm is only about 50%, which is obviously better than other algorithms.
Figure 2. Comparison of the relationship between the total number of slots and the number of tags in different algorithms.

3.2. Identification efficiency analysis

The identification efficiency of the DFSA-CT anti-collision Algorithm $M$ is defined as the ratio of the number of tags $N$ to be identified in a range to the total number of timeslots $S$ identified, namely:

$$M = \frac{N}{S} = \frac{N}{2L(1-\frac{N}{L})^3 + 1.5N + \frac{N(N-1)}{2}(1-\frac{N}{L})^{N-1} - L}$$

Figure 3. Comparison of recognition efficiency of different algorithms.

As can be seen from the graph, the recognition efficiency of the Hybrid Algorithm (DFSA-CT) is more than 70% with the increase of tag number, which is more than double that of the other two algorithms.

In the DFSA-CT Algorithm, the reader active query frequency is few, the overall traffic is low. The algorithm uses queries to avoid multiple responses or even missing tags in the DFSA Algorithm when it encounters a collision time slot.

In addition, compared to CT and DFSA algorithms in communication complexity, the average amount of data transmitted to identify a single tag increases with the number of tags: the DFSA-CT Algorithm is about 123 bits per tag, and the DFSA Algorithm is about 205 bits per tag, the CT
Algorithm requires more than 270 bits. The DFSA-CT Algorithm is superior to the other two algorithms,

4. Conclusions
In this paper, a hybrid DFSA-CT Algorithm suitable for dynamic environment is proposed by combining the advantages of the random DFSA algorithm and the deterministic collision tree CT algorithm. The Algorithm first identifies the time slot through the DFSA, and then uses the CT Algorithm of the collision tree to check the information bit after processing the collision. The length of the next frame is adjusted dynamically according to the recognition condition and the tag arrival rate, so that the frame length is approximately equal to the tag number. By analyzing and comparing the performance parameters of different algorithms, such as the number of query slots and the efficiency of recognition, the experiment shows that the hybrid DFSA-CT Algorithm is better than other algorithms. In dynamic environment, this algorithm has relatively high recognition efficiency and avoids the problem occurrence in label starvation to a great extent.

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References
[1] Pan Yuanyuan. Application of Internet of things technology in medical care system [J]. Journal of clinical practice hospital, 2011,8 (2): 196-198
[2] Wang Hong, Wu Fei, Zhang zxi. Design and implementation of wireless nursing information system based on RFID [J]. Hospital digitization, 2009,30 (2): 56-57
[3] Liu Qiang, Cui Li, Chen Haiming. Key technologies and applications of Internet of things [J]. Computer science, 2010,37 (6): 1-10
[4] Li Jing, Zhang Hong, Wang Zhiqi, et al. Construction of digital surround intelligent hospital using RFID technology [J]. China Medical equipment, 2009,24 (7): 44-46
[5] S.L.Ting, S.K. Kwok, Albert H.C, etal. Enhancing the Information Transmission for Pharmaceutical Supply Chain Based on Radio Frequency Identification (RFID) and Internet of Things[C]//Proceedings of 2010 International Conference of Supply Chain Management and Information Systems(SCMIS-2010),2010:1-5.
[6] Pilar Manzanares-Lopez, Juan Pedro Munoz-Gea, Josemaria Malgosa-Sanahuja etal. An efficient distributed discovery service for EPCglobal network in nested package scenarios [J]. Journal of Network and Computer Applications, 2011,(34): 925-937.