A Fast Anticollision Algorithm with Early Adjustment of Frame Length for the EPCglobal UHF Class-1 Generation-2 RFID Standard

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Abstract

This paper develops a fast algorithm to identify a large number of tags in a short period of time duration in RFID systems. The main goal of the proposed algorithm is to meet the requirement in supply chain management. In this paper, we derive mathematical model to analyze the tag identify process. Based on the analysis, we can decide the optimal frame length and when the current read round is early ended. We find that the optimal frame length should be set to 1.72 times of the number of tags when the ratio between collision-slot duration and empty-slot duration is 4. Through the use of early adjustment of frame length, the RFID interrogator examines the fitness of frame lemgth only at three time slots in each read round. The primary advantage of our algorithm is the ability to achieve a good compromise between throughput performance and computation complexity.

Keywords: RFID, tag identification, logistic management, read efficiency, Anti-collision algorithm

1. Introduction

For managing a large amount of objects and identifying their IDs, the radio frequency identification (RFID) technology operating on ultra-high frequency (UHF) band is increasingly being used especially in logistic management. To meet the requirement of reading a dense population of objects, the EPCglobal developed an air interface, named UHF Class-1 Generation-2 or ISO 18000-6 Type C [1].

The algorithms for identifying multiple tags in RFID systems have been widely studied in the literature [2-6]. The EPCglobal UHF Class-1 Generation-2 specifies an algorithm based on dynamic frame slotted ALOHA (DFSA) to solve the RFID anticollision problem. The author in [4] indicated that the read performance of DFSA depends mainly on the accuracy of backlog estimate and frame length setting. For the DFSA algorithm, a maximum throughput of 36.8% can be achieved only if the frame length is set to the number of tags. One of the most interesting procedures is how to dynamically adjust frame length to achieve maximum throughput when a big difference exists between frame length and tag quantity.

2. Proposed Algorithm

This paper proposes a simple and efficient anticollision algorithm for the EPCglobal Cass-1 Generation-2 protocol and describes clear rules for early adjustment mechanism of frame length. This mechanism allows the interrogator to early end the current read round at any time slot and enter into a new round with a new frame length. Hence, the interrogator will examine whether the current frame length requires adjustment or not and how to adjust it if necessary. To achieve a good compromise between computation complexity and throughput performance, the proposed algorithm examines the fitness of frame length at only the three quartiles in each read round, i.e. at the $L/4^{th}$, $L/2^{th}$, and $(3/4)L^{th}$ slots. The procedures of the proposed method is shown in Fig. 1.

A key performce of anticollision algorithm is normalized throughput,

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$$U = S \cdot T_S / (S \cdot T_S + C \cdot T_C + E \cdot T_E) \quad (1)$$

S, C, and E are the numbers of successful, collision, and empty slots. The time intervals of the successful, collision, and empty slots are T_S, T_C, and T_E, respectively.

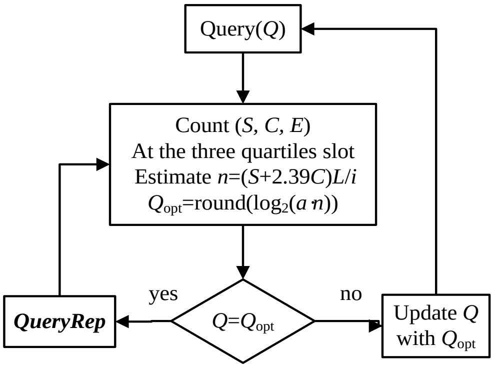

Fig. 1 Proposed anti-collision procedures

At the three time slots, the interrogator counts the number of singly occupied slots Si, the number of collision slots Ci, and the number of empty slots Ei. Note that i is equal to L/4, L/2, or (3/4) L here. The tag quantity to be read at the beginning of the round can be estimated by [6].

$$\hat{n} = (S_i + 2.39 \cdot C_i) \cdot L / i \quad (2)$$

Given tag quantity n, we attempt to determine an optimal frame length L_{opt} to maximize the throughput in (1). Taking the derivative of U with respect to L and setting the derivative to zero lead to an optimal frame length.

$$L_{opt} = a \cdot n \quad (3)$$

In Eq. (3), a is a coefficient. Table 1 lists the coefficients for different values of TC/TE.

Table 1 Coefficients between L_{opt} and n

T_C/T_E	a ($L_{opt}=a \times n$)
1	1
2	1.30
3	1.53
4	1.72
5	1.89
6	2.05
7	2.19
8	2.32
9	2.44

After computing the optimal frame length, the interrogator should check whether the current frame length is appropriate or not. The frame length must be a power of 2 due to the UHF Class-1 Generation-2 standard. Hence, the optimal Q value can be obtained by:

$$Q_{opt} = \text{round}(\log_2 L_{opt}) \quad (4)$$

3. Simulation Results

The read performance of the proposed algorithm and the reference schemes was examined by carrying out computer simulations based on the Monte Carlo technique.

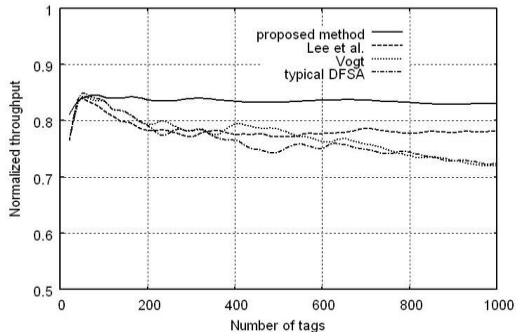

Fig. 2 Comparison of throughput performance for anticollision algorithms

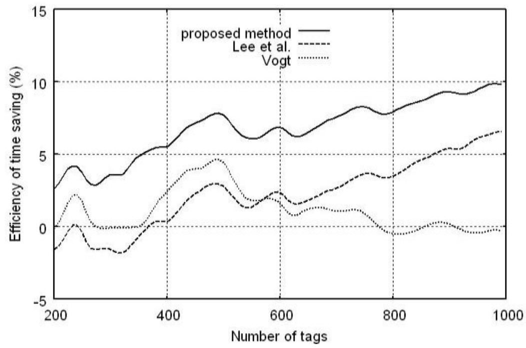

Fig. 3 Time-saving efficiency

The throughput performance of the proposed algorithm is presented in Fig. 2. As mentioned before, our method uses early adjustment mechanism for frame length and performs at most three examinations in each read round for the fitness of frame length. It can be found that our method has better throughput performance as compared with the other schemes. Particularly, for a large number of tags, i.e. 1000, the proposed algorithm can achieve up to 10% throughput improvement as compared with the typical DFSA. Another advantage of the proposed method is the stability. When the number of tags is increased, the proposed method can keep the throughput stable.

Fig. 3 presents the time-saving efficiency for different algorithms. It can be observed from Fig. 3 that our algorithm can obtain 5-10 % time-saving efficiency as the tag quantity is greater than 200.

4. Conclusions

This paper proposes an efficient RFID anticollision algorithm to improve the read performance for the EPCglobal UHF Class-1 Generation-2 standard. The results show that the proposed algorithm can achieve up to 400 tags/s read speed. For a large number of tags, i.e. 1000, the proposed algorithm can achieve up to 10% throughput improvement as compared with the typical DFSA. We believe that this advantage comes from the early adjustment mechanism for frame length. Another advantage of the proposed method is the stability. When the number of tags is increased, the proposed method can keep the throughput stable.

Acknowledgement

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