Adaptive Slot-Count Selection Algorithm based on Tag Replies in EPCglobal Gen-2 RFID System

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ABSTRACT

EPCglobal proposed a Q-algorithm, which is used for selecting a slot-count in the next query round. However, it is impossible to allocate an optimized slot-count because the original Q-algorithm did not define an optimized weight C value. In this paper, we propose an adaptive Q-algorithm, in which we differentiate the weight values with respect to collision and empty slots. The weight values are defined with the identification time as well as the collision probability.

키워드

RFID system, anti-collision algorithm, slot-count selection algorithm, EPCglobal Class-1 Gen-2

Ⅰ. INTRODUCTION

In EPCglobal Class-1 Gen-2 RFID system, Q-algorithm determines the slot-count without conducting the tag number estimation scheme [1]. In Q-algorithm, when the result of tag's reply in a slot is idle, the reader subtracts a weight C from the slot-count. When a collision occurs, a weight C is added to the slot-count[2]. The standard suggests that the reader typically uses small values of C when the slot-count is large and larger values of C when the slot-count is small. If an inappropriate weight is selected, there may be a lot of idle or collided slots. As a result, the frame size will not converge to the optimal point quickly during the query round. This will reduce the identification speed and slot efficiency. Therefore, in this paper, we propose an adaptive Q-algorithm, which differentiates the parameter Q between in collision case and idle case.

Ⅱ. RESEARCH MOTIVATION

In Q-algorithm, if the value of weight C is relatively large, the frame size can converge to the optimal point very quickly. However, the oscillation of frame size will occur near the optimal point. On the other hand, if the weight C is small, the convergence to the optimal frame size will be very slow, but the frame size rarely changes after converging to the optimal point. Therefore, it is expected that the weight C must be differentiated according to the tag's reply. In the proposed algorithm, we apply new weights named C_c and C_i, which mean the weight for collision and idle slot, respectively.

The slot duration in Gen-2 RFID system is different according to the tag's reply. Let T_c and T_i denote the duration of collision and idle slot, respectively. T_c and T_i can be written as following:

$$T_c = T_1 + RN16 + T_2 \quad (1)$$

$$T_i = T_1 + T_3 \quad (2)$$

The values for T_1, T_2, T_3, and RN16 are defined in [1]. If we assume that TR_{rate} is 125Kbps, the duration of collision slot is about 4.3 times longer than that of idle slot. Therefore, the identification time of Gen RFID system could be improved if we adjust the value of weight C in a way to increase the number of idle slots while relatively decreasing the number of collision slots.

We also apply the probabilistic approaches. Let P_c and P_i denote the probabilities that a slot is collision and idle, respectively. Let's assume that a frame consists of N slots and there are n tags within the identification range of reader. If we assume that the tag selects one of N slots with the equal probability, P_c and P_i can be defined as follows [3].

$$P_c = \lim_{n\to\infty}\left[1-\left(1-\frac{1}{N}\right)^n\left(1+\frac{1}{N}\right)^n\right] \quad (3)$$
$$= \left(1-\frac{2}{e}\right)$$

$$P_i = \lim_{n\to\infty}\left(1-\frac{1}{N}\right)^n \quad (4)$$
$$= \frac{1}{e}$$

From the above equations, because T_c is longer than T_i and P_i is higher than P_c, the value of weight C must be applied differently according to the slot status.

Ⅲ. ADAPTIVE Q-ALGORITHM

Because T_c is longer than T_i, it is necessary for the frame size to be increased as soon as possible when the slot has a collided reply. Also, when the slot has no reply, the frame size should be decreased slowly because P_i is greater than P_c. The operation of adaptive Q-algorithm is as follows in according to the tag's reply:

1) when the tag's reply is successful,

$$C_i = 0.1$$
$$C_c = \frac{T_c}{T_i} \cdot \frac{P_c}{P_i} \cdot C_i$$

2) when the tag's reply is collision,

$$C_i = 0.1$$
$$C_c = (1+P_c) \cdot C_c$$

3) when the tag's reply is idle,

$$C_i = (1+P_i) \cdot C_i$$
$$C_c = \frac{T_c}{T_i} \cdot \frac{P_c}{P_i} \cdot C_i$$

The basic operation of adaptive Q-algorithm is very similar to the original one. The only difference is the differentiation of weight C between in collision cases and idle cases. We can see that it is easy for the reader to obtain T_c and T_i. And we can use P_c and P_i as constant values. Therefore, the proposed adaptive Q-algorithm does not impose any change on tags while a little bit overhead at the reader.

IV. SIMULATION RESULTS

The performances of adaptive Q-algorithm are compared with the original Gen-2 Q-algorithm with C=0.3 and the scheme proposed by Daneshmand [2]. The typical values of simulation parameters are listed in [1].

In order to observe how the slot durations and probabilities have influences over the slot status, the collision ratio according to the number of tags is shown in Fig. 1. In the adaptive Q-algorithm, we considered the idle probability of slot as well as the collision probability when calculating the value of parameter C_c and C_i. Therefore, as shown in Fig. 1, the collision ratio of adaptive Q-algorithm is 42% and 65% less than Daneshmand's and Gen-2 algorithm, respectively.

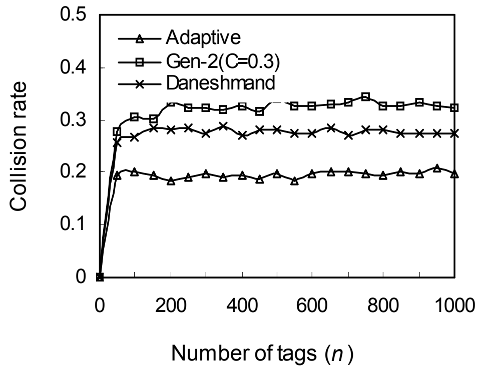

Fig.1. Comparison of collision ratio.

Fig. 2 and Fig. 3 show the total identification time and identification speed, respectively. As shown in the figures, the adaptive Q-algorithm outperforms Daneshmand's algorithm and Gen-2 by around 2% and 4.5%, respectively. In general, because the duration of collision slot is longer than idle slot, the fewer number of collisions is, the faster the reader will identify all tags. Therefore, as shown in Fig. 2, the total identification time of adaptive Q-algorithm is shorter than Daneshmand's algorithm and Gen-2 because the collision ratio of adaptive Q-algorithm is less than those algorithms.

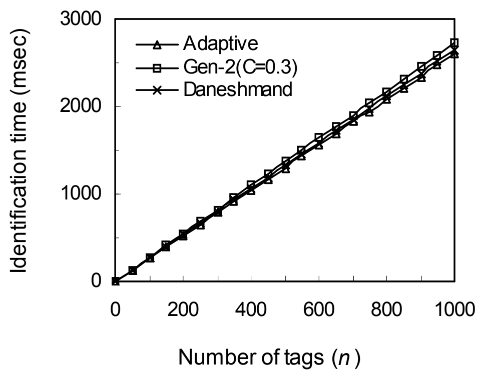

Fig.2. Total identification time.

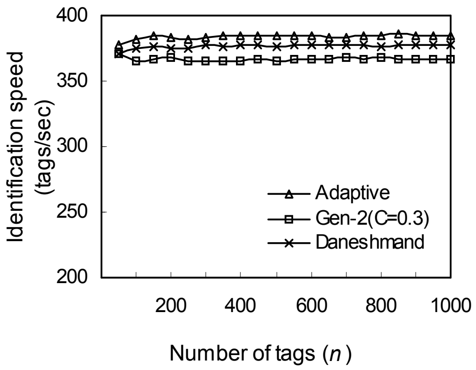

Fig.3. Identification speed.

V. CONSLUSIONS

It has been found that the adaptive Q-algorithm gives a good performance compared with other algorithms. Especially, the number of collided slots is 42% and 65% less than Daneshmand's algorithm and original Gen-2, respectively.

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