Study of idle skipped Dynamic Frame Slotted ALOHA for RFID systems

Sanika.K.Wijayasekara[1],Chairat Phongphanphanee[1],Robithoh Annur[2],Suvit Nakpeerayuth[1] and Lunchakorn Wuttisittikulkij[1]
[1]Department of Electrical Engineering Chulalongkorn University,
1 Bangkok, Thailand
[2]Department of Computer and Communications Technology ,
Malaysia
E-mail : [1]wijayasekarasanika@gmail.com,[2] robithoh@utar.edu.my,[1](chai.p,nsuvit,wlunchak)@chula.ac.th

Abstract: The conventional dynamic frame slotted aloha algorithm (DFSA) adjusts the frame size according to the number of tags and continuously process until all the tags are identified. In this study we analyze the effect of skipping slots which are not carrying any information in order to enhance the performances of traditional DFSA. In addition, to compare the performances of idle skipped DFSA algorithm with conventional DFSA algorithm based on the mean number of slots require to identify all the tags. The mathematical analysis and simulation results show that the presented idle skipped DFSA algorithm is more effective when compared to the conventional DFSA algorithm.

Keywords—**DFSA**

1. Introduction

Currently RFID (Radio Frequency IDentification) gets more attention as an alternative to the bar code in almost every industry across the globe. As a result of the technology grown-up the prices drop and RFID becomes an inexpensive option for applications such as Healthcare, Aerospace, Banking and etc At the same time RFID has disadvantages and the main difficulty is degrading the system performance due to low tag identification efficiency which creates as a result of tag collisions. A RFID system has two main components called transponder and interrogator or reader [8]. Transponder is an object to be identified and in this work important to consider the objects as tags. A reader is a read or read/write device. In RFID, readers are capable enough to keep track and monitor the tagged objects through a shared wireless channel. Therefore, when the tags reply concurrently, the reader cannot identify the data of tags and this limitation called as collision which directly affect to the RFID system performance. To address this problem several anti-collision algorithms have been proposed. In literature, this divided as deterministic and probabilistic protocols. [1] Deterministic protocols follow tree based concepts which group the collided tags in to sub group and process recursively till all the tags are identified [7]. The probabilistic protocols based on ALOHA categorize in to pure ALOHA, slotted ALOHA and frame slotted ALOHA (FSA) [11]. In slotted ALOHA the time is divided into slots and corresponding tags can send the information at the beginning of the slot. In contrast frame slotted ALOHA group the same number of slots and creates frames [1].

Dynamic frame slotted ALOHA (DFSA) follows the similar concept of FSA with dynamic frame sizes. The frame sizes determine dynamically with respect to the information of remaining unidentified tags, number of collided slots and so on. DFSA algorithm has several versions depending on the methods changing the frame sizes. It has higher tag identification efficiency than ALOHA since it regulates the frame size according to the collided tags information. [2] In literature many experimental and mathematical analysis are carried out to evaluate the performance of DFSA. Recently, a new framed slotted ALOHA based anti-collision protocol has been proposed that yields better tag identification efficiency by receiving the information of the selected slots of each tags in advance[10]. In this study, we perform a mathematical analysis to show the significant improvement in DFSA where the idle slots are skipped. As a result, the DFSA with skipped idle method gives lowest mean Contention Resolution Interval (CRI) compare to conventional DFSA. Mean CRI indicates the average number of slots required to resolve the contention among tags which are collided initially. Further, we prove the proposed idea accuracy with aid of computer simulation.

This paper is structured as follows: Section 2 describes the related previous works. Section 3 describes the proposed analytical model and Section 4 results and discussions. We conclude our work in section 5.

2. Related work

The fundamental work of Frits C. Schout [2], determines the size of the frame dynamically based on collided, success and idle timeslots. In [6], a tag estimation method proposed by considering success,collission and idle situations. An optimal dynamic frame slotted Aloha algorithm presents in [3] and it follows a probabilistic approach according to the ratio of number of active tags in the current frame to the estimated total number of tags which remain to be identified in the system. Estimation of the number of unread tags is updated after end of each frame. [4] Moreover it had been illustrated and improved Dynamic Framed Slotted ALOHA (IDFSA) where the number of unread tags estimates at the beginning and adjusts the number of responding tags or the frame size to give the optimal system efficiency. A mathematical model is developed in [5] to estimate the time needed to discover all the tags with accurate tags prediction probability. [10] further had been recommend an idle slot skipping mechanism in RFID ALOHA system based on the ratio of selected slots to frame size. In this method the reader receives the information of the selected slots by tags in advance as a one sequence.

3. System Model

3.1 Algorithm

DFSA is the method of adjusting the next frame size by estimating the collided tags in the current frame. The algorithm indicated in [10] has significantly enhanced the tag identification efficiency by forming a frame where the idle slots can be skipped based on the information of the selected slots of each tags transmitted to the reader in advance. In our we modified the conventional DFSA algorithm by adding the idle skipped mechanism specified above.
Step 1: Reader broadcast the "Query (Q)" command by indicating the frame size as Q.
Step 2: After receiving Query command, each of the tags in readers interrogation zone send the selected slot information back to the reader as one sequence.
Step 3: Upon receiving the sequence of information, the reader forms a frame and calculates the ratio of number of selected slots to frame size.
Step 4: If the created frame contains collided slots, resolve it by forming a frame size equal to estimated the collided tags in the current frame.
Step 5: repeat step 3 and step3 until all the tags are identified

3.2 Analytical Model

In this work, we consider a RFID system where the users compete to access a shared channel and DFSA is the anti-collision algorithm in used. *M* and *N* indicate the frame size and the number of tags accessing the given frame respectively. *L(i)* specifys the mean CRI length for i number of collided tags, where *i* 1,2,3....
This mathematical model evaluates the CRI length of conventional DFSA and our study method of idle skipping concepts recusively as given bellow. In a given time a slot can be in three different states such as idle,success and collision. A given slot can be selected by no tags, only one tag and more than one tag and this represents the idle success and collision situations respectively in the system .
Lets consider an example where two tags A and B contend for a frame with size of two .The possible ways of selecting a slot by tags is given in Figure 1. According to DFSA algorithm the frame size is desided by the remaining number of slots in the system. Therfore, in our example the mean number of slots require to resolve the colllision of two tags with the framesize of two can be calculated as shown in Figure 2.
When consider the our study the idle slots do not take in to consideration and this is clearly clarify in Figure 4. Figure 3 and Figure 4 simplify the calculation of mean CRI length for traditional DFSA and idle slots skipped DFSA concepts in detail with respect to $N = M = \{2,3,4,5\}$ situations.

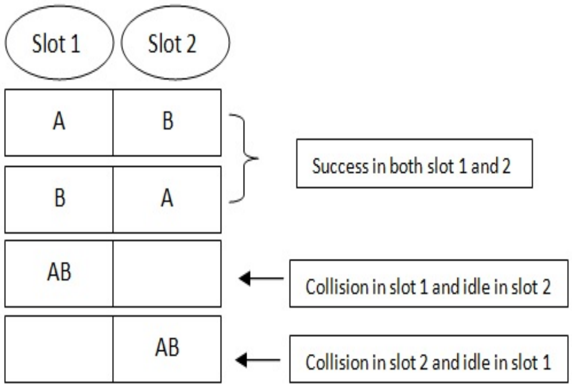

Figure 1. Example:Two slots and Two tags

$$N=2, M=2$$

$$L(2) = 2 + \frac{2}{4} \times L(2)$$

$$L(2) = 4$$

Figure 2. Example:Calculation

4. Performance Analysis

In section we compare the performance of both traditional and proposed idle skipped DFSA algorithms with respect to calculated and simulated mean CRI length. The processes of tags selecting the slots and reader identifying the tags are performed using MATLAB simulator . The initial frame size *M* is depend upon the remaining number of tags in the system. It is assumed that the remaining number of tags available reader's interrogation zone varies from 2 to 100.
For simulation purpose we assume the maximum frame size as 100 and for mathematical analysis it as 10. The CRI length (the average number of slots requires to identify all the collided tags) has been considered as the parameter to evaluate the performance of the said methods. As shown in Figure 5, Figure 6 the plots compare the calculated and simulated results of both traditional and proposed idle skipped DFSA algorithms.
It is obvious when there are more number of tags in the system it leads to higher amount of collision and require further number of slots to resolve it. Consequently, the mean CRI value increases when number of tags increase as depicted in Figure.5. The proposed idle skipped DFSA performs better than the conventional DFSA since, the idle slots are not being process and only success and collision been considered. The mathematically calculated values are strongly agree with the simulated values in both cases. In Figure 6 we compare only the simulations results where the number of tags range from 2 to 100. The proposed DFSA saves more number of slot in the whole range with respect to traditional method.

5. Conclusion

In this paper we focus on the process of idle skipping in DFSA algorithm to address one of its major week point of time waste in idle slots. In particular, the analytical and simulated results show 20% of higher efficiency and lower CRI values in our

$$N=3, M=3$$
$$L(3) = 3 + \frac{18}{27} \times L(2) + \frac{3}{27} \times L(3)$$
$$L(3) = 6.375$$

$$N=4, M=4$$
$$L(4) = 4 + \frac{4}{256} \times L(4) + \frac{48}{256} \times L(3) + \frac{36}{256} \times L(2) \times 2 + \frac{144}{256} \times L(2)$$
$$L(4) = 8.706$$

$$N=5, M=5$$
$$L(5) = 5 + \frac{5}{3125} \times L(5) + \frac{100}{3125} \times L(4) + \left(\frac{200}{3125} + \frac{600}{3125}\right) \times L(3) + \left(\frac{200}{3125} + \frac{900 \times 2}{3125} + \frac{1200}{3125}\right) \times L(2)$$
$$L(5) = 11.024$$

Figure 3. Calculation of Conventional DFSA

$$N=2, M=2$$
$$L(2) = \frac{2}{4} \times 2 + \frac{2}{4} \times 1 + \frac{2}{4} \times L(2)$$
$$L(2) = 3$$

$$N=3, M=3$$
$$L(3) = \frac{6}{27} \times 3 + \frac{18}{27} \times 2 + \frac{18}{27} \times L(2) + \frac{3}{27} \times 1 + \frac{3}{27} \times L(3)$$
$$L(3) = 4.625$$

$$N=4, M=4$$
$$L(4) = \frac{4}{256} \times 1 + \frac{4}{256} \times L(4) + \frac{48}{256} \times 2 + \frac{48}{256} \times L(3) + \frac{36}{256} \times L(2) \times 2 + \frac{36}{256} \times 2 + \frac{144}{256} \times L(2) + \frac{144}{256} \times 3 + \frac{24}{256} \times 4$$
$$L(4) = 6.23$$

$$N=5, M=5$$
$$L(5) = \frac{5}{3125} \times 1 + \frac{5}{3125} \times L(5) + \frac{100}{3125} \times 2 + \frac{100}{3125} \times L(4) + \frac{200}{3125} \times 2 + \frac{200}{3125} \times L(3) + \frac{200}{3125} \times L(2) + \frac{600}{3125} \times L(3) + \frac{600}{3125} \times 3 + \frac{900}{3125} \times L(2) \times 2 + \frac{900}{3125} \times 3 + \frac{1200}{3125} \times L(2) + \frac{1200}{3125} \times 4 + \frac{120}{3125} \times 5$$
$$L(5) = 7.829$$

Figure 4. Calculation of DFSA with idle skipped

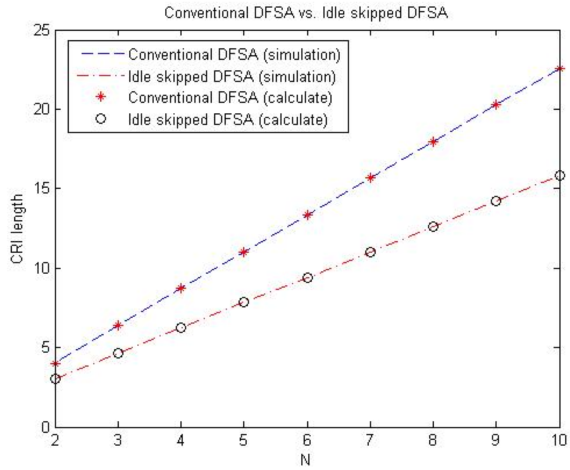

Figure 5. Comparison of simulated and mathematically calculated values of DFSA and idle skipped DFSA

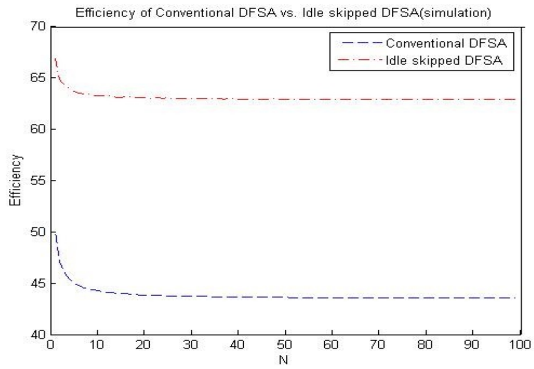

Figure 6. Comparison of simulated Efficiency between DFSA and idle skipped DFSA

study method than the conventional DFSA when number of tags increase. Therefore, idle skipped method can considerably improve the efficiency of DFSA when for higher number of tags. The possible extension related to this work is to originate a general formula to represent the recursive functionality of idle skipping mechanism.

6. References

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