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Simulation on probabilistic anti collision protocols of RFID using variable delay

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Abstract— *In RFID System, it is important to avoid tag collision for identifying tag faster. In this paper, we proposed concept of variable delay for tag estimation & identification. The scheme is based on the Multi-level dynamic framed ALOHA protocol. Simulation results indicate that the time delay is added to each tag for avoiding collision. The main advantage of this is the delay is in microseconds which will not create problem of more time consumption.*

Keywords—RFID, anti collision, Tag identification, variable time delay.

I. INTRODUCTION

The Radio Frequency Identification (RFID) system is a new emerging technology to identify a label which is attached to a product. Ease of Use with the advent of digital era in 21st century, information based remote network management and mobile business needs of the community, radio frequency identification technology in the intelligent management system will play a huge role. RFID technology is becoming a new economic growth point widespread in the global, research and development of RFID. Radio frequency identification (RFID) is a kind of non-contacted automatic identification technique, which can be used to automatically identify the targets by radio frequency signal. Currently, RFID technology is used in different systems such as: transportation, distribution, retail and consumer packaging, security and access control, monitoring and sensing, library system, defense and military, health care, and baggage and passenger tracing at the airports [1].

RFID systems consist of a reading device called a reader, and one or more tags. The reader is typically a powerful device with ample memory and computational resources. They range from dumb passive tags, which respond only at reader commands, to smart active tags, which have an on-board micro-controller, transceiver, memory, and power supply [2]. The passive tags are cheaper and active tags are expensive. Due to the low cost, passive tags are the popular choices for large scale deployment. In an RFID system, when numerous tags are present at the same time in the interrogation zone of a single reader, the system requires an anti-collision algorithm to read tags' ID or data from individual tags. If the tags are detected in the identification range of the reader, the reader exchanges the information through the process of the commands and response. Based on the detected information, the tags randomly select the particular slot in the frame, load the identification and transmit it to the reader. Each transmitted identification in each time slot can be recognized by reading it in the reader.

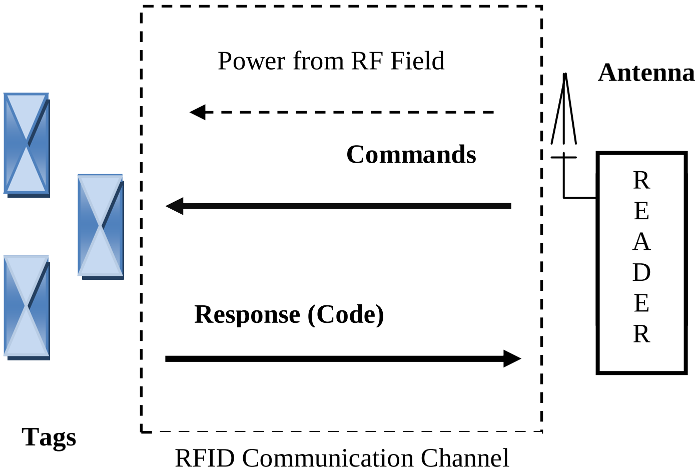

Fig.1:RFID Communication Model

Collision due to simultaneous tag responses is one of the key issues in RFID systems [3]. It results in wastage of bandwidth, energy, and increases identification delays. To minimize collisions, RFID readers must use an anti-collision protocol. There are two types of RFID collision problems, a reader collision problem and a tag identification problem. The reader collision problem is caused by two adjacent readers intersecting their interrogation zones so that neither reader is able to communication with any tags located in this intersection. The tag identification problem is caused by collisions in situations where more than one tag responds to a single reader's query.

This paper is survey of the probabilistic anti-collision protocols, and provided anti-collision protocols in detail to reduce the identification delays. Such reviews are important for building RFID system in interrogative zones – e.g. reading tagged items in shopping malls as customer passes an automated checkout.

The RFID collision problems are divided into tag collisions and reader collisions [4]. The tag collision problems are subdivided into active tag collisions and passive tag collisions, as a rule, passive tag collision problems are more complicated than the latter .The tag collisions occur in the case where more than one tag reflect back a signal at the same time.. Since low-functional passive tags cannot figure out neighboring tags or detect collisions, it is of great significance to develop a tag anti-collision protocol improving the identification ability of RFID systems.

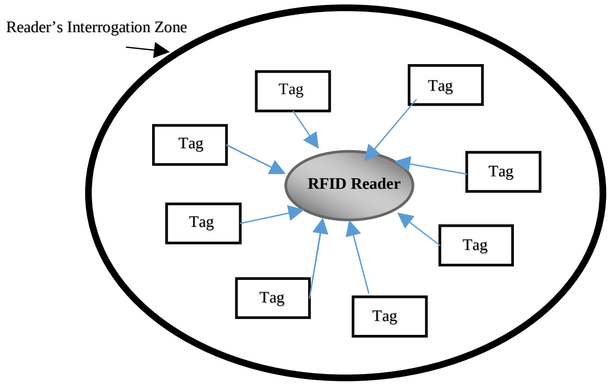

Fig.2: Tag collision problem in RFID [2]

II. ANTI-COLLISION PROTOCOL

The tags identification problem is associated with how to efficiently develop an anti-collision protocol in RFID tags. It can be defined as to identify multiple objects reliably without significant delay by utilizing minimal transmission power and computation. Anti-collision protocols that address this problem cannot be directly applied to the tag identification problem due to various constraints.

Anti-collision protocols are critical to the performance of RFID systems. Figure 1 shows eight tags and a reader. Without an anti-collision protocol, the replies from these tags would collide and thereby prolong their identification. Also, collisions cause bandwidth and energy wastage.

Collision protocols can be classified into two categories: 1) Probabilistic Protocols which are the ALOHA based Protocols and 2) Deterministic Protocols which are the Tree based Protocols. We provide a brief discussion on probabilistic Protocols to reduce RFID tag collisions problem.

Numerous multi-access/anti-collision procedures have been developed with the objective of separating the individual participant signals from one another.

III. PROBLEM DEFINITION

In this paper, we how to improve the readability of low-cost passive RFID systems and its identification speed using the present memory less tag anti-collision protocols. Focusing on characteristic, both prefix overhead and iteration overhead are reduced by the time divided responses depending on whether the collided bit is '0' or '1'. We demonstrate via simulation results that the proposed Multilevel frame slotted based RFID tag anti-collision protocols achieve considerably better performance than the tree based RFID tag anti-collision protocols. Besides, the proposed algorithms require less time consumption for tag identification than the conventional schemes.

IV. RELATED WORK

Basic Frame Slotted Aloha (BFSA):

BFSA is developed from Pure-ALOHA. It divides the response time into consecutive time periods; each time periods called a Slot, a number of slots formed a Frame. Tag's response must complete in the time span of a slot. The

situation of multiple labels 'share' the same slot is regarded as a slot collision; those tags will select a slot to respond in the next frame. In this algorithm, the number of slot in each frame is fixed; it limits the efficiency of the algorithm, but is

twice of pure ALOHA algorithm [13].

A. Dynamic Frame Slotted Aloha (DFSA):

DFSA algorithm changes the frame size for efficient tag identification. To determine the frame size, it uses the information such as the number of slots used to identify the tag and the number of the slots collided and so on. So DFSA algorithm can solve partially the problem of BFSA that is inefficient to identify the tag [11][13].

DFSA algorithm can identify the tag efficiently because the reader regulates the frame size according to the number of tags. But, the frame size change alone cannot reduce sufficiently the tag collision when there are a number of tag because it cannot increase the frame size indefinitely. When the number of tags is small, then it can identify all the tag without too much collision. However, if the number of tags is large, it needs exponentially increasing number of slots to identify the tags because it always starts with the initial minimum frame size after identifying a tag, regardless how many tags are unread [11].

Throughput of dynamic frame slotted aloha is 42.6%. Moreover, there is a spike at the beginning of both subplots because when there is only one tag in the area, the probability for a tag to collide in practice is equal to zero and the reader always read this tag and so S=1. After some tags are added, throughput falls very quickly to its final value.

B. Multilevel frame Slotted Aloha (MFSA):

MFSA slotted ALOHA algorithm, an improved slotted ALOHA anti-collision algorithm, it identifies collided tags in the sub-frame by force, reduces the consumption of the main frame, increases system efficiency. Slotted ALOHA algorithm for multi-level is: tag can be identified both in main frame and sub-frame. The length of the main frame is much larger than sub-frame's length. Frame length need to be pre-set through experience.

When the collisions occurred in the main frame, the main frame counter should be stopped immediately and system should record the collision point and transfer to the sub-frame processing. It can't return to the main frame of a recent collision point until all collide tags be recognized. The algorithm requires that tags are able to generate random number for main frame and sub-frame. As sub-frame is short enough, tag random number generator which adds few bits can meet the requirements.

The efficiency of algorithm: BFSA, DFSA and MFSA are simulated under the same conditions. The number of tag is set about 1~300 and simulating result will be averaged 100 times.

We use formula (2) to calculate the system efficiency.

$$\eta = \frac{\text{Number of identified tags}}{\text{Number of consumed slots}} = \frac{N_{TAG}}{N_{SLOT}} \times 100\%$$

V. PROPOSED WORK

A. TAG ESTIMATION

In RFID system, L and n are assumed to be, respectively, the frame size and the number of tags. In practice, it is reasonable to assume that is not known and has to be estimated based on the observed read results. For an observed read result C={c_0,c_1, c_k} (where c_0, c_1 & c_k and are the number of the empty time slot, successful time slot, and collision time slot), there have been many methods to estimate tag number in RFID system.

Collision ratio mechanism assumes that the slot collision ratio is equal to the expectation slot collision probability:

$$C_{ratio} = \frac{c_k}{c_k+c_1+c_0},$$

$$P_c = 1-\left(1-\frac{1}{L}\right)^n - \left(\frac{n}{L}\right)\left(1-\frac{1}{L}\right)^{n-1},$$

Where, P_c is the expectation of the slot collision probability. By letting C_{ratio} be equal to P_c, the number of tags n can be obtained. This mechanism ignores the difference between the real collision ratio and the expectation of the slot collision probability and also has larger error of tags estimation [17].

The probability that r tags appear in a time slot can be computed as in the following equation:

$$P(r)=\binom{n}{r}\left(\frac{1}{L}\right)^r\left(1-\frac{1}{L}\right)^{n-r}$$

Let $p(0)$ be the probability that the time slot is an empty time slot, that is, no tag to choose this time slot, let $p(1)$ be the probability that the time slot is a successful time slot, that is, one of tags to choose this time slot, and let $p(k)$ be the probability that the time slot is a collision time slot, that is, tags in tags to choose this time slot. So,

$$p(0)=\left(1-\frac{1}{L}\right)^n,$$

$$p(1)=\left(\frac{n}{L}\right)\left(1-\frac{1}{L}\right)^{n-1},$$

$$p(k)=1 - p(0) - p(1)$$
$$=1-\left(1-\frac{1}{L}\right)^n-\left(\frac{n}{L}\right)\left(1-\frac{1}{L}\right)^{n-1}$$

In a frame, the average values of empty time slots, successful time slots, and collision time slots can be represented as

$$s_0(L,n) = L\left(1-\frac{1}{L}\right)^n,$$

$$s_1(L,n) = \frac{n}{L}\left(1-\frac{1}{L}\right)^{n-1},$$

$$s_k(L,n) = L\left(1-\left(1-\frac{1}{L}\right)^n - \left(\frac{n}{L}\right)\left(1-\frac{1}{L}\right)^{n-1}\right)$$

Actually, $s_0(L,n)$, $s_1(L,n)$ and $s_k(L,n)$, are respectively, the expectation values of empty time slots, successful time slots, and collision time slots, and the expectations are relevant to the length of frame and the number of tags. We denote the estimation function by

$$\xi(L,C) = min_{\bar{n}\,\epsilon\Phi}|S(n)-C|,$$

where,

$S(n) = [S_0(L,n), S_1(L,n), S_K(L,n)]^T$,

$C = [c_0, c_1, c_k]^T$,

$\Phi = \{n|\ c_1 + 2c_k \le n \le N\}$ and N is the maximum number of tags in the system. We can get the estimation number of tags, that is,, by using the EM(expectation maximization) algorithm [18] as follows:

$$\hat{n}= \arg\ \xi(L,C) = \arg min_{\bar{n}\,\epsilon\Phi}|S(n)-C|$$

B. TAG IDENTIFICATION TIME DELAY

In terms of the tag identification time delay, which is the elapsed time for a reader to identify all tags in the interrogation zone. The tag identification time delay Td is defined to be [19, 20]

$$T_d = (n_c + n_{nc}) \times t_{id} + n_{cmd} \times t_m + n_{np} \times t_a$$

The notations used are shown as follows:

n_c : The number of cases with tag collisions;

n_{nc} : The number of cases with no tag collisions;
n_{cmd} : The number of commands sent by the reader;
n_{np} : The number of cases of no tag response;
t_{id} : The elapsed time for a tag to transmit its ID;
t_m : The elapsed time for the reader to transmit a command;
t_a : The elapsed time for a reader to be aware of null response.

The mechanisms that reduce data transmission between the tags and the reader help to save the identification time.

VI. SIMULATION FLOW CHART

An overview of the simulator created to calculate the time required to identify RFID tags with the Frame Slotted Aloha protocol when interference is present. Tags will pick a slot randomly and respond to the reader's query.

More than one tag responding using the same slot will result in a collision at the RFID reader end. Collided tags need to be read again until the total number of tags is identified. Each anti-collided tag interference is compared with the user-entered probability of interference, and the tags are taken as successfully read if the anti-collided tag interference is greater than the user-entered probability of interference. If not, those anti-collided tags need to be read again.

The simulator is run until the total number of RFID tags is identified. Figure below displays the flow chart of the proposed simulator [16].

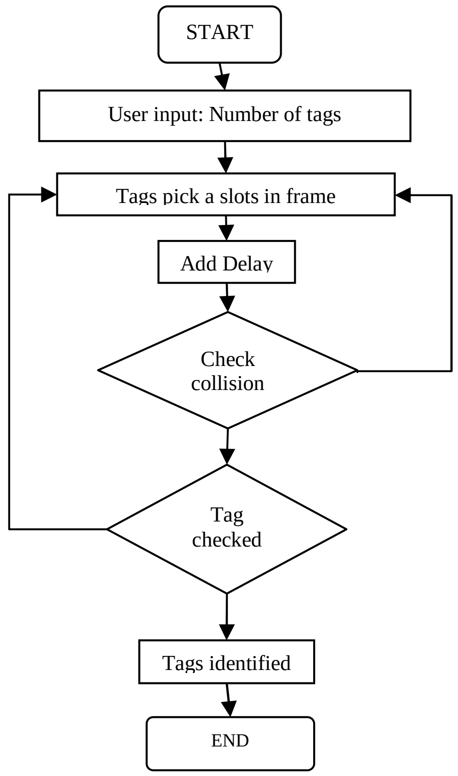

Fig.3: Flowchart of simulation

VII. RESULT

The result shows that the time delay added for each tag to avoid collision. We develop java code to simulate the problem. We have added time delay to each of the tags. Some of having same time delay, some having different. With the proportion of the tag frequency & the variable time delay the collision can be avoided.

The results of the successive tags can be shown in graph as below :

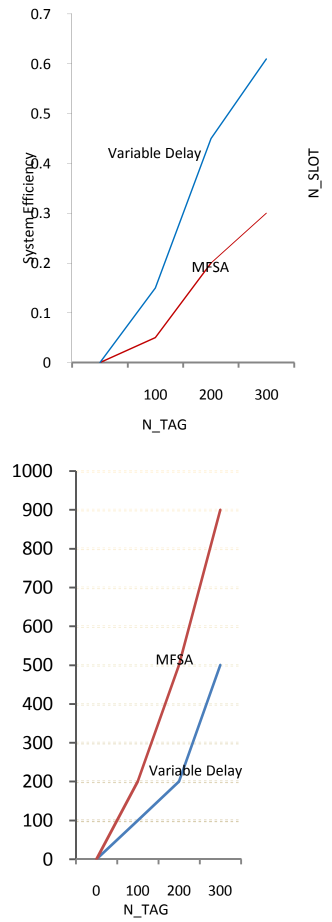

Fig.4:System efficiency comparison

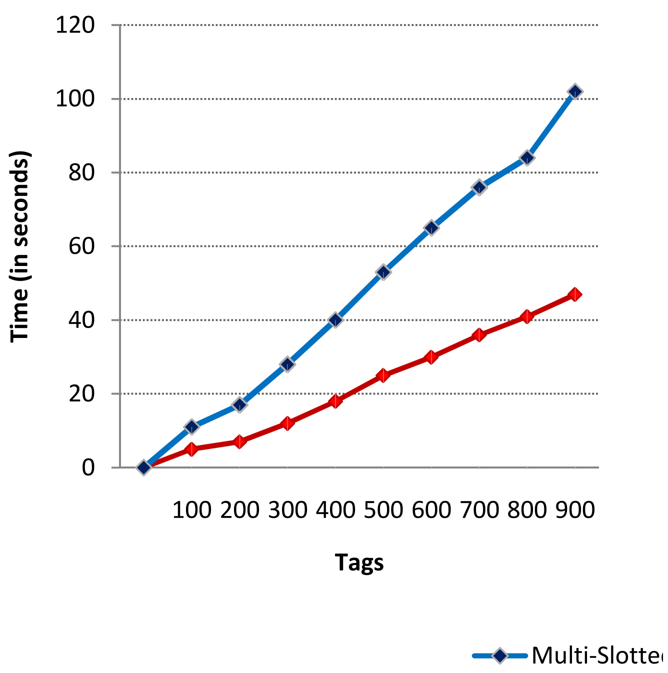

Fig.5:Plot of time delay

VIII. CONCLUSION

The authors analyzed multi-tags access problem in radiofrequency identification from the view of interaction between frame size and tag number, and proposed a new concept called variable delay with help of multi-level framed slot ALOHA anti-collision. Firstly, we surveyed the existing algorithms for anti-collision of tags. Then, we proposed a new anti-collision algorithm based on multilevel slotted aloha to improve the efficiency of tags.

The results of the experiment show that it has better performance than BFS DFS, in efficiency of the tags. Simulation results show that the system efficiency has been increased by about 30% compared with the original algorithm.

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