A New Multi Tree Query Based Protocol for Reducing Tag Collision in RFID Systems

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ABSTRACT

One of the important challenges in RFID[1] systems is reducing time of identifying tag readers. This problem is happened when tag reader asks tags for information and confront with several answers, concurrently. Most of techniques for confronting with collision are based on multiple access method based on time division. Thus, main protocols on confronting with collision are divided into two basic deterministic and non-deterministic protocols. We evaluate some available protocol and compare them and then present a model based on multi groups tree combination, which in this method, tags are divided into groups based on size frames, and each group consist a tree. In fact, we break a large binary tree into the several smaller trees to reduce the number of collisions. Our simulation result shows that multi query tree outperforms some tree based tag anti-collision protocols when the number of tags is increased.

Keywords*:* Tag Anti-collision protocols, RFID, multi query tree, Tree based

1. Introduction

Radio frequency identification systems are those systems which identify tags using radio frequencies in less radio wave range than wireless networks. Two main constituent parts of these systems are tags and readers (interrogator). Tags have an ID which is labeled on different objects. For example, these systems have been used in a production cycle system for recording arrival and discharge of objects. As mentioned above, this problem is occurred when several tags answer to interrogator request, concurrently and create collision [1]. As shown in Figure.1, tag collision in RFID systems happens when multiple tags are energized by the RFID tag reader simultaneously, and reflect their respective signals back to the reader at the same time.

For solving this problem, collision avoiding techniques have used in wireless networks, which among them time division and frequency division have used more Frequent [2]. Time division technique for RFID systems are categorized into two deterministic and non-deterministic, which deterministic methods are for Aloha based protocol and non-deterministic methods are for tree-based protocols.

1.1. Deterministic Methods

Deterministic methods which are based on Aloha protocol, act based on dividing time into smaller intervals. In these protocols, as data is send as frame, each frame is divided into slots, and each tag send its information on beginning of one of slots, randomly. Send is continuous until al, tags would be identified.

[1] - Radio Frequency Identification

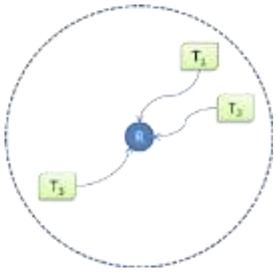

Fig.1. *how collision happens*

As it is possible that two or more tags choose one slot for sending information, concurrently, Aloha based technique which is called pure Aloha, doesn't have required effectiveness, and in those environments which have numerous tags many collisions would be created. Thus, other protocols have created based on Aloha based protocol which increased its effectiveness by applying changes like changing frame size and etc. in one hand, this effectiveness enhancement would have some disadvantages. For example, some techniques needed to know number of available tags in range, which caused increase in system computational load, and when number of tags was large, computations were so time-consuming.

1.2. Non-deterministic method

Non-deterministic methods are based on tree algorithms, and as tag identification would be finished in limited time, they called deterministic. As ID of each tag is included a code bite of zero and one, in this method reader send a request for tags, such that this request makes that certain number of tags answer to this request. For example, "01" request specifics that those tags request, which their ID's start with "01". One of big disadvantage of this technique is that in environments with numerous tags would have low effectiveness, because in in upper level of tree, many collision would be have better performance for less severalty of tags.

As seen in Figure.2, trend of identifying 3 tags is performed in 7 time intervals. Tree-based methods have more extent, so that in addition to two children trees, there are 4 children trees, such that each trees have 4 children and requests are added in twos bites.

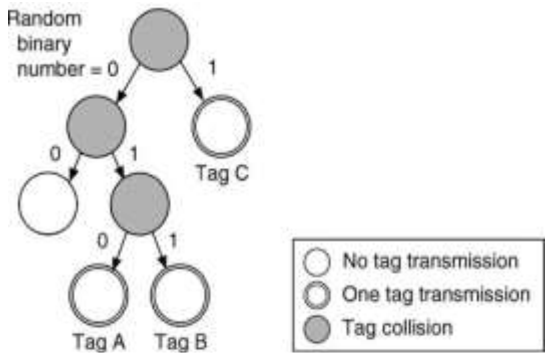

Fig.2. *Trend of identifying in tree-based methods*

Next steps of this paper are organized as follows: In section 2, some of protocols are offered and performed works would be evaluated. Then in section 3, combined method would be proposed, and in next section, results would be discussed and finally we conclude paper.

2. Related Works

One of basic derivatives of Aloha protocol is basic framed slotted Aloha method. This method is like slotted Aloha [3] which is shown in Figure.3. Its maximum efficacy is 36.8%. Dynamic framed slotted Alohas method was improved BFSA method, somehow, so that in DFSA method size of frame was variable in regard to number of available tags in range, and as the more size of frame be larger than number of tags, more collisions would be exist, thus efficacy would be improved somehow [3]. After that, EDFSA[1] method is proposed. Its difference with former method was that calculate number of unread tags by counting number of collisions and dividing it to size of frames, and then categorize tags in groups that each group send its information through a frequency channel.

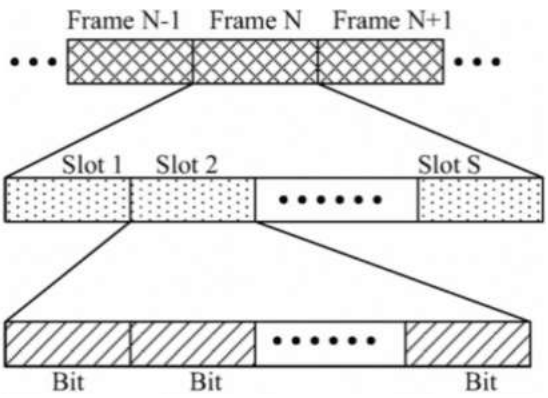

Fig.3. *Sending information in Aloha protocol*

But tree-based methods act based on request sending and are categorized into two main groups of Query tree and binary tree, which former method acts based on interrogator, request that mentioned in above and latter method acts based on choosing zero and one bits by tags. Of course, both methods are among basic methods [3, 4]. Figure.3 shows Binary tree method and Figure.4 shows Query method. In addition to above mentioned methods, there one some combined methods which are combination of tree-based and Aloha-based protocols.

		Interrogator						
		t1	t2	t3	t4	t5	t6	t7
		Broad cast	0	00	000	001	01	1
Tag1	0000							
Tag2	0010							
Tag3	0101							
Tag4	1100							
Iterrogator	receive	xxxx	0xxx	00xx	0000	0010	0101	1100

Fig.4. *Query Tree Method*

[1] - Enhanced Dynamic Framed Slotted Aloha

2.1. *Optimized DFSA*

This method optimized DFSA method by applying some changes on it. The trend is as follows: Size of frame is determined in nth step based on what happened in (n-1) th step, and the formula is:

$$N_{i+1} = \begin{cases} \frac{N_i}{2}, & P_c < 15\% \\ N_i, 15\% < P_c < 40\% \\ 2N_i, P_c > 40\% \end{cases} \qquad (1)$$

According to above formula, if the size of frame might is half, when the probability of collision is less than 15%. If this probability becomes more than 40%, then the size of the frame would be becomes double, so the results of this optimization are shown in Figure.5 [5]:

Diagram of Figure.5 shows that by increase in number of tags probability of collision is increased too, but with using relation 1, probability of collision never enters to darker part.

2.2. *Improved ADFSA*

This method is an adaptive one, which decreased collision and time of identifying tags using some calculations, but due to much calculation, increases calculational load of system. Furthermore, by storing information of tags from last cycles, sometimes withdraws identifying some tags. This model would have high efficacy due to storing information of last phases in systems such as production cycle of continuous object (in arrival and departure, doing different tasks …) and identifying their information which are recorded in different phases [6-7].

2.3. *ABS*[1]

This method is based on tree identifying and like former method acts based on receiving feedback of identifying last phase. This method has high calculational lead, too, but rather than BT and QT methods is almost more optimized [8-9].

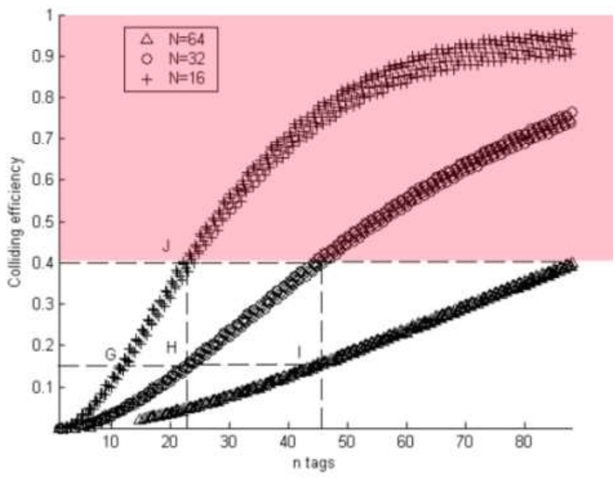

Fig.5. *optimizing reduction in collision possibility*

[1] - Adaptive Binary Splitting

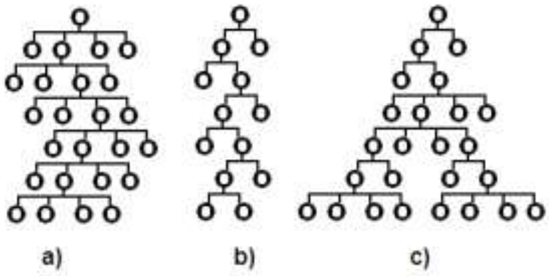

Fig.6. *a: 4-ary tree, b: 2-ary tree, c: Joined Q-ary tree*

Figure.6 shows the example of Naive 2-ary, naive 4-ary, and Joined Q-ary Tree. Joined Q-ary Tree has bonded both the 2-ary and 4-ary trees together and applied them to specific bits of the EPC depending on how Identical or Unique they are.

2.4. *Q-ary- Based Methods*

Q-ary based methods are those methods which could have Q children in each identification node of trees.

In addition, there is another model called Joined-Q-Tree which is formed in result of joying two Q-ary trees [10].

Q-ary tree methods usually decrease amount of collision and time of identification for Q>2, but due to increase in number of houses in each level of tree, demands high load of calculation. Moreover, though tags code bit have large diversity, but in much of them, in nodes of above tree there would be no identification neither collision in lower level of tree. Thus, Joined Q-ary model is proposed, which is used for declining number of idle houses in nodes of Q-ary tree, disadvantages of this method are huge calculations and complicated data structure [11].

3. PROPOSED MODEL

Before discussing proposed method, we offer some explains for this method.

1- This method is based on Joined q-ary tree method, in which each node of tree could have 2 or 4 children

2- Like EDFSA method, tags could be divided into groups based on their numbers.

3- Each group of tags includes a Joined q-ary tree.

4- In this phase, we would have two scenarios:

a. If system has different frequency channel, each group or each tree would send information in it's correspond frequency channel.
b. B. If system has one frequency channel for sending information, information of each tree would be sent frame-by-frame, and so trees send their information sequentially.

Thus, we could claim that by increase in number of tags in one system, complexity of produced tree would be distributed on several trees and when no tag send information, number of collisions and even number of time intervals would be very less, and in this way calculational node of system would be increased.

But if we act based on scenario 4-Q, complexity of system would be decreased, too, because even those tag which distributed on trees virtually, could sent information through their own channel.

As seen in Figure.7, instead of distributing n tag into on tree and forming a tree with log(n)+1 depth, which is unreachable, we would have n/m trees with less depth, which eventually it decrease complexity and calculations.

As seen in Figure.8, each level of trees sends its data (tag id) in each loop.

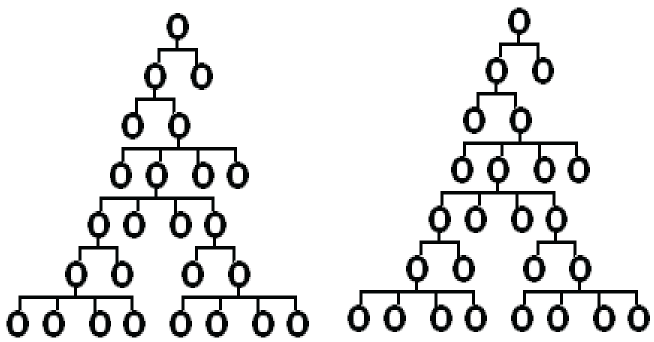

Fig.7. *Proposed model*

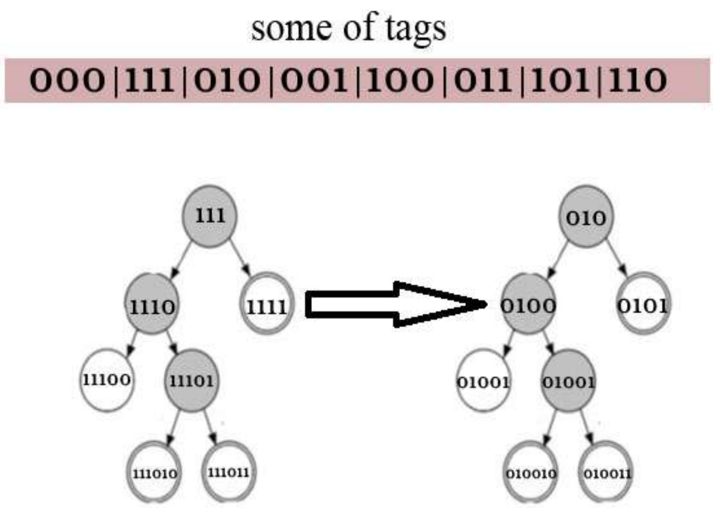

Fig.8. *Parallel Tag Identification*

4. Simulation Results

Our proposed model is implemented using MATLAB and the number of tags and size of groups are varied. In simulation of proposed model, we have some of parameters that are base of comparison that shown in Table.1.

TABLE I. PARAMETERS

Number of tags	***10,20,50,100,200***
Number of reader	***1***
EPC length	***17***
EPC	***Randomly selected***
Number of groups	2^n

In multi-access protocols, the main condition for performance evaluation consists of throughput, packet delay, and stability. However, in RFID arbitration, the total time consumed to identify all tags successfully, is more important [12]. To evaluate the performance, total time slots taken to identify the tags and number of collisions are calculated, and the results are compared with Binary Search Tree, QT protocols and Adaptive Binary Splitting.

Figure.9 shows multi query tree method performance which by increasing the number of tags is better than other methods because we break a large binary tree into the several smaller trees and reduce the number of time slots.

Figure.10 shows the number of collision when number of tags is varied. In our proposed model, number of collision is greater than other methods when number of tags is less than 50 but in other cases our proposed model has better result because we diffuse a large binary tree into the several smaller trees, so reduce time slots and collisions.

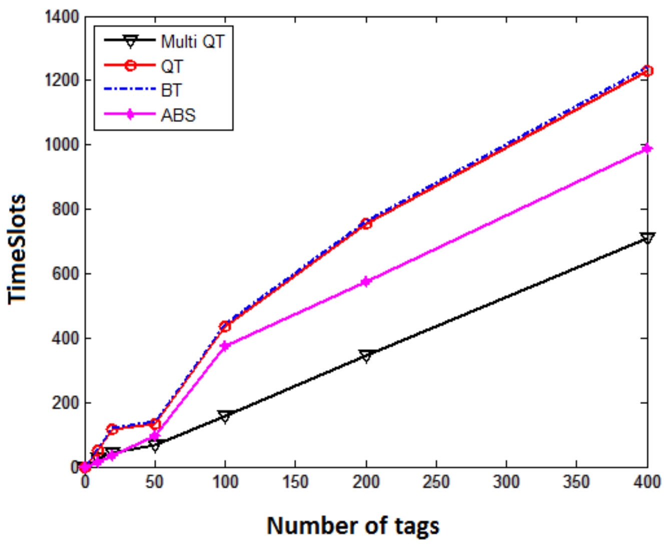

Fig.9. *Performance comparison with varying the number of tags*

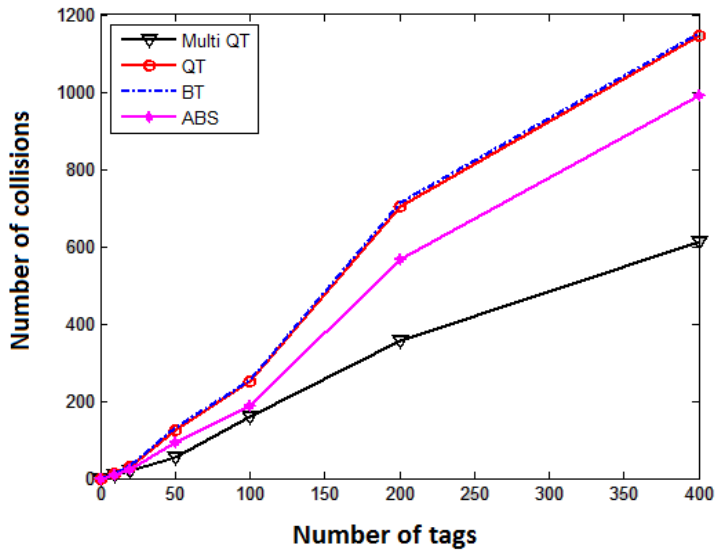

Fig.10. *Collision comparison with varying the number of tags*

5. CONCLUSION AND FUTURE WORKS

In this paper we have discussed main protocols of confronting collisions in RFID systems, and then we evaluated some of related methods and specified that some of them have some problems such as increased calculational load or complexity in data structure, and so we optimized former methods. In this paper, we provided a new technique based on virtual distribution of tags on different covered trees which leads to decrease in complexity of produced tree after simulation.

One of the disadvantages of the proposed model is more computational load and also complexity of the data structure. In the next step, our aim is to reduce computational load and minimize the complexity of the data structure. In addition, we can receive feedback from tags and reduce the number of collisions too.

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