An Efficient Anti-Collision Protocol for Tag Identification in RFID Systems with Capture Effect

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Abstract— **RFID tag identification is one of challenging issues since the simultaneous transmissions in the shared wireless medium cause collisions between the replies. Many anti-collision protocols have been proposed to resolve this problem by detecting the collisions so that the tags are identified. However, the capture effect inhibits the collision detection, since the reader regards the collision as a successful transmission instead. In the paper, we show that Collision Tree (CT) protocol suffers from the capture effect. We then propose a Multi-Round Collision Tree (MRCT) protocol which successfully identifies all the tags within the reader's coverage.**

***Keywords*— anti-collision algorithm, capture effect, collision tree, RFID.**

I. INTRODUCTION

RADIO Frequency Identification (RFID) is a technology which uses radio waves to identify tagged objects. An RFID system consists of a reader and multiple tags. The reader broadcasts query messages and identifies the tags based on the reply messages from the tags. Since the tags typically reply over the shared wireless medium, however, simultaneous transmissions of the replies can collide and thus be dropped at the reader.

To resolve this collision problem and to successfully identify all the tags in RFID systems, many tag anti-collision protocols have been proposed. Generally, the anti-collision protocols are categorized into two classes: *aloha-based* and *tree-based* protocols. In aloha-based protocols such as Dynamic framed-slotted ALOHA (DFSA) [1] and Enhanced DFSA (EDFSA) [2], each tag randomly selects a time slot for reply to avoid collision. Tree-based protocols continuously split the set of tags into two subsets each time a collision occurs. For the splitting, the binary tree (BT) protocol [3] uses a random number and the query tree (QT) protocol [4] uses tag IDs. Collision tree (CT) protocol [5] enhances QT by using the Manchester code.

Unfortunately, these solutions may not work properly in real wireless communication environments since they do not consider the *capture effect*. Recent measurement studies [6][7] in RFID systems have shown that the collided frames are not necessarily corrupted and can be decoded successfully at the reader if the signal to interference and noise ratio (SINR) is sufficiently high enough. Under this capture effect, the reader would capture a single tag ID in the midst of a collision and would leave all the other tags in that collision unidentified [8].

In this letter, we propose an efficient tag anti-collision protocol, Multi-Round Collision Tree (MRCT) protocol which works efficiently even under the influence of capture effect. MRCT enhances the Collision tree (CT) protocol [5] in which the Manchester code is used to detect the collided bit [1] but the capture effect has not been considered. We show that the CT protocol suffers from the capture effect, i.e., the CT protocol does not identify many tags when the capture effect occurs, while the proposed MRCT protocol effectively copes with the problem.

II. EFFECT OF CAPTURE ON COLLISION TREE PROTOCOL

We show that the Collision Tree (CT) protocol [5] suffers from the capture effect, i.e., the CT protocol does not identify many tags when the capture effect occurs. Fig. 1 shows the flow diagram of CT protocol. Suppose there are n tags to be identified. At first, reader will broadcast a query message with NULL prefix and then all n tags will reply. If the capture effect occurs at these replies, reader misunderstands that only one tag responded to the query. If the strongest tag is identified with the first NULL prefix query message, then no prefix remains in the stack and the identification process ends. Consequently, reader does not know there remain (n-1) unidentified tags and will finish tag identification process.

Fig. 2 shows that the number of unidentified tags by reader depending on the capture probability, α when CT protocol is employed via computer simulation. Although the capture probability varies depending on many factors such as the number of nodes, node placement, and radio propagation model, we assume that the probability is fixed to α for simplicity.

When the capture effect never occurs (α=0), all tags are successfully identified by CT. Note, however, that some tags are not identified when the capture effect occurs (α>0). When the capture effect always occurs (α=1), only one tag is successfully identified, but (n-1) tags are not.

III. MULTI-ROUND COLLISION TREE PROTOCOL

We propose Multi-Round CT (MRCT) protocol which is based on CT protocol. MRCT protocol separates the

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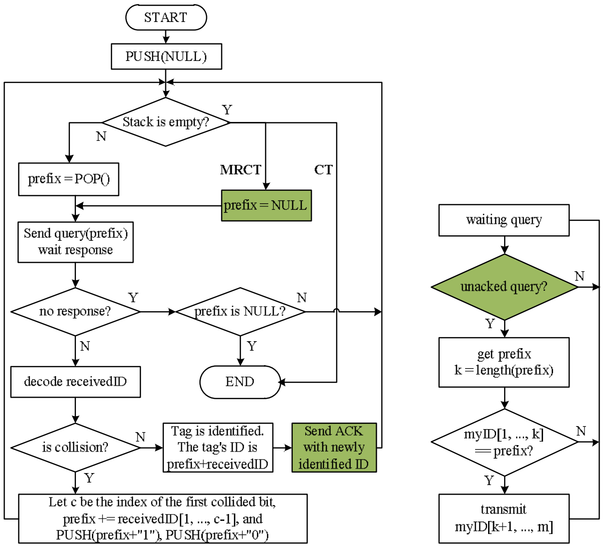

(a) Reader (b) Tag

Fig. 1. Flow diagram of CT and MRCT.

identification process into multiple rounds. The reason why we repeat identification round is to check whether there are unidentified tags due to the capture effect. Each round employs CT protocol and tries to identify tags which are not recognized until the previous round. Fig. 1 shows the flow diagram of MRCT protocol. While CT protocol finishes its identification process when the prefix stack becomes empty, MRCT protocol starts a new round with a NULL prefix.

In addition, multi-round identification makes the protocol robust to the channel errors. When the wireless channel is imperfect, the responds from the tags may fail to reach the reader. For the tree-based protocol, when this occurs, the failed tag may not have the chance to respond again. MRCT provides those tags additional chances to respond.

Fig. 3 shows an example of the identifying process using MRCT to identify five tags, which have 0001, 0010, 0011, 1110, 1111 as tag IDs. We assume that the two tags, 0010 and 1111, are located close to the reader. Therefore, they are likely to be decoded even when collision occurs because of the capture effect at the reader. In this scenario, it takes 3 rounds with 9 queries to identify all 5 tags. In the first round, 3 tags are identified with 5 queries. Two tags 0011 and 1110 are not identified due to collisions, but those tags are identified in the second round with 3 queries. In the third round, one query is used to ascertain that there are no unidentified tags and finally to terminate the identification. On the other hand, CT finishes tag identification after the first round and thus 2 tags (0011 and 1110) are left unidentified which are hidden by the capture effect.

IV. Conclusion

In this letter, we show that the CT may miss some tags in identification process when capture effect occurs, and then propose the MRCT protocol to cope with the problem.

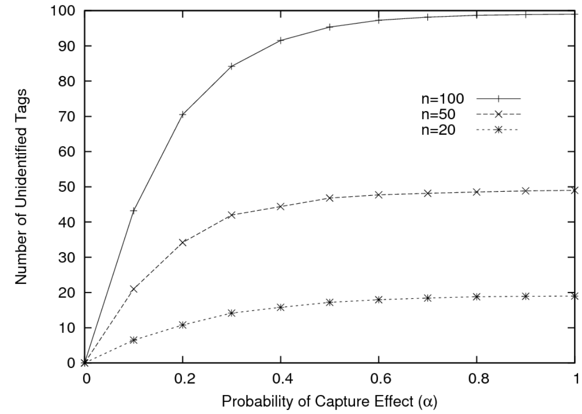

Fig. 3. Number of unidentified tags by CT under the capture effect.

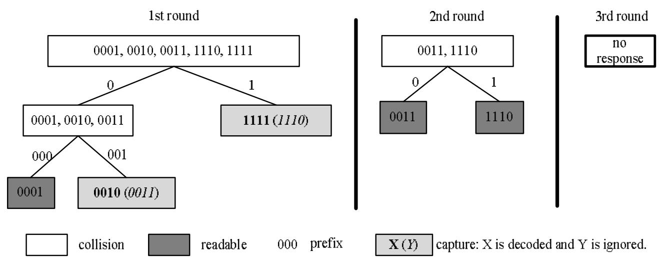

Fig. 2. Identifying process example for MRCT.

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