

Improvement of Anti-Collision Performance for the ISO 18000-6 Type B RFID System

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ABSTRACT

This paper proposes a novel method for the anti-collision of the ISO/IEC 18000-6 type B protocol which is one of the standard protocols of 900 MHz RFID systems. We improve the anti-collision performance by reducing the transmission number of commands and the length of bits required for multi-tag identification in the ISO/IEC 18000-6 type B protocol. Simulation results show that the proposed method improves the multi-tag identification time by 21.7 % over the conventional method, irrespective of the number of tags.

Keywords: RFID, anti-collision, collision resolution, tag identification, ISO 18000-6

1. INTRODUCTION

Radio frequency identification (RFID) systems have recently drawn much interest in automatic identification fields. An RFID system consists of a reading device called reader and a number of small devices known as tags. An RFID reader recognizes objects through wireless communications with tags attached to the objects [1]. Advantages of RFID systems, such as lone-range, non-line-of-sight and fast reading, are expected to accelerate the introduction of RFID systems in logistics replacing barcode systems but there still remains to be solved in practical use of RFID systems.

Two major issues are the multi-tag identification time and the successful read rate of tags under severe RF environments. Researches on the first have been extensively performed as anti-collision algorithms and those on the latter in the fields of antenna or RF designs. The purpose of this paper is to present an effective solution for the first issue of anti-collision algorithms for multi-tag identification

To identify tags, the reader sends queries to the tags requesting their identification (ID). If there are multiple tags within the range of the reader, then all tags send their ID to the reader at the same time in response to the reader's query command. The simultaneous responses of tags result in a collision at the reader. In this case, the reader can not obtain any useful information from the tag responses. Since the collision prevents the reader from identifying tags, it is needed to escape from the collision

situation by means of an anti-collision algorithm. Typical anti-collision method for generic multi-access communication systems can not be directly applied to the RFID system due to the constraints on the design of the tag such as the lack of battery, low memory, minimum computation power, etc. Especially, since low-cost passive tags can not figure out neighbouring tags or detect collisions, anti-collision protocols are indispensable for multi-tag identification [2].

The ISO 18000-6 protocols deals with parameters for air interface communications at 860 to 960 MHz. Air interface specifies the communication link between a reader and a tags including physical layer, collision arbitration algorithm, command and response structure, and data-coding methodology. The ISO 18000-6 air interface protocol has three different types of type A, type B and type C. This paper manages the type B protocol [3].

There are some related works for anti-collision algorithms of the type B protocol. The splitting or tree-search algorithms introduced by Capetanakis [4] is similar to the anti-collision algorithm of the type B protocol. Hush and Wood [5] show how the above splitting algorithm can be applied to RFID systems to uniquely identify the set of tags within the readable range and analyze the number of time slots needed to complete the arbitration process. However the above results do not consider the realistic operations of RFID systems. Hence, it is difficult to estimate the performance in real operations. To minimize the difference between the development of an algorithm and its real application, we evaluate the time for the tag identification by counting the number of the reader commands and tag responses at bit unit. With the realistic consideration of RFID operations we proposes a novel method to improve the anti-collision performance by reducing the transmission number of commands and the length of bits required for multi-tag identification.

The rest of this paper is organized as follows. Section 2 describes the anti-collision method of the ISO 18000-6 type B protocol. In Section 3, we describe a proposed method which is a modification to the type B protocols. Simulation results are shown in section 4 to verify the superior performance of the proposed method. Finally, the conclusions of the paper will be drawn in Section 5.

2. ANTI-COLLISION IN THE ISO 18000-6 TYPE B

The basic concept of anti-collision method in the type B protocol is to split the group of colliding tags into two

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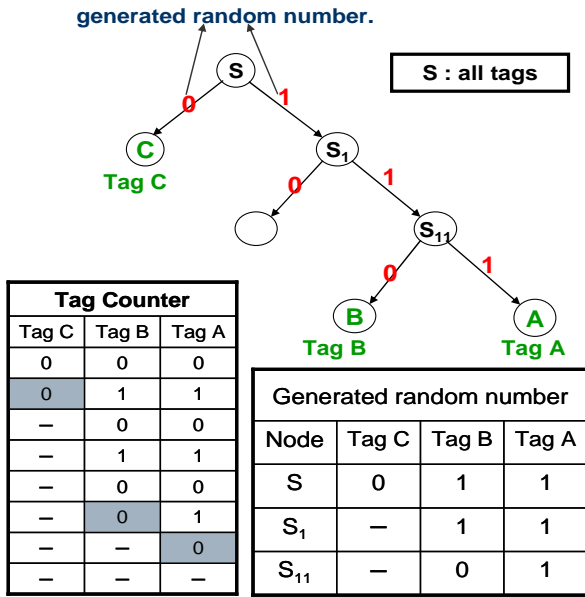


Fig.1: An example of identifying three tags.

subgroups using random numbers until the reader recognizes the IDs of tags without collisions. Figure 1 shows an example of identifying three tags.

In the type B protocol, each tag should generate random numbers for splitting and then remember the corresponding node for keeping track of its position in the tree. To achieve this, the tag shall support two pieces of hardware on the tag. One is an 8-bit counter named as COUNT and the other is a random generator with two possible values of '0' and '1'.

To know the exact collision arbitration procedure in the type B protocol, it is required to understand the communication mechanism between a reader and tags. We will see this mechanism through the tag state diagram shown in figure 2.

The reader may use the GROUP_SELECT commands to define a subset of tags participating in the collision arbitration. Selected tags are moved from the READY state to the ID state and shall set their internal counters to '0'. All tags in the ID state with the counter of COUNT at '0' shall transmit their ID. One of four possibilities now occurs.

(Case 1) If more than one tag replied, the reader receives an erroneous response. The FAIL command shall be sent by the reader. All tags receiving the FAIL command with a count of 0 (those that just transmitted) shall generate a random number '0' or '1'. Tags generating '1' shall increment COUNT and shall not transmit. Tags generating '0' shall keep COUNT at zero and shall send their IDs again. The other tags receiving the FAIL command with a count of none zero shall increment COUNT and shall not transmit.

(Case 2) If no tag reply, none transmits. The reader receives nothing. It sends the SUCCESS command. All the counters decrement, and the tags with a count of '0' transmit.

(Case 3) If only one tag transmits and the ID is received correctly, the reader shall send the

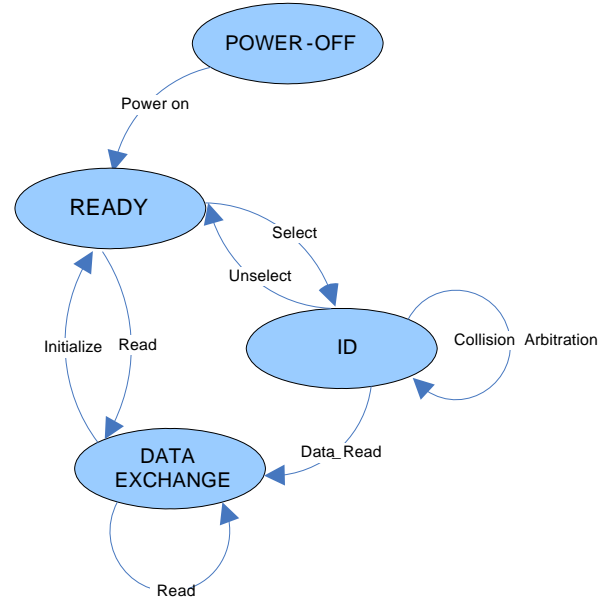


Fig.2: Tag state diagram.

DATA_READ command with the received ID. If the DATA_READ command is received correctly, that tag shall move to the DATA_EXCHANGE state and shall transmit its additional 64 bit data. Then the reader shall send the SUCCESS command. All tags in the ID state shall decrement COUNT.

(Case 4) If only one tag transmits the erroneous ID, the reader shall send the RESEND command. The tag receiving the RESEND command transmits the ID again. If the ID is received correctly by the reader, Case 3 repeats.

Case 4 is related with the data integrity, not the anti-collision algorithm for multi-tag identification. So, we do not consider the case any longer.

The anti-collision of the type B protocol can be performed through the above four cases according to the newly-generated random numbers and the stored COUNT values in the tags. The performance of an anti-collision algorithm depends on the number of commands and the length of bits required for multi-tag identification. In this respect, there may be a redundancy at Case 3 and a possible reduction in the transition between Case 1 and Case 2. We show the improvement of the anti-collision performance by reducing these redundancies

3. PROPOSED METHOD

3.1 Method 1 – Reducing transmission data

The first proposed method is to reduce transmission data at Case 3 in section 2. After the reader receives only one tag's ID, the reader transmits the DATA_READ command with the ID. At this time the reader already knows the tag's ID. The role of DATA_READ command is to move the state of the identified tag and to request some additional 64 bit data from the tag response. To pull out the identified tag in the collision arbitration, the reader transmits the DATA_READ command and moves the state of tag from the ID state to the DATA

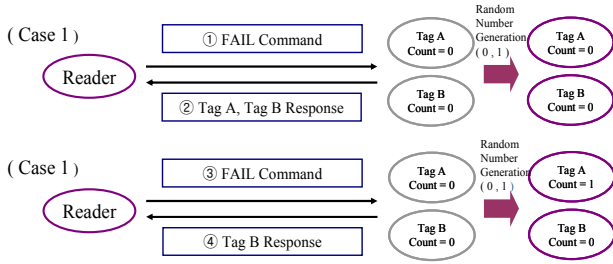


Fig.3: An example of all colliding tags generating a random number '0'.

EXCHANGE state. The additional 64 bit data is not necessary to identify tags because most readers need only tag ID. For that reason we use another short command like READ_FLAGS or make a new command to remove additional data transmission and to move tag's state. This is the first proposed method. If we need to read additional data, we might use READ command.

3.2 Method 2 – Reducing transmission command

In the type B protocol, the anti-collision algorithm is done by splitting the group of colliding tags into two subgroups with generated random number '0' or '1'. If all colliding tags generate the same number, they can not split the colliding tags and should regenerate a random number. It is a fundamental problem of the type B protocol.

However all colliding tags generating a random number '0' and all colliding tags generating a random number '1' are gone through different procedure. The reader transmits the FAIL command when all colliding tags generate '0' at Case 1 in section 2 and transmit their IDs. Then the tags received the FAIL command with the counter COUNT at '0' generate random number again. Figure 3 shows an example of this procedure with two tags. On the other side, the reader transmits the SUCCESS command when all colliding tags generate '1' at Case 1 in section 2 and none transmit. The SUCCESS command decrement the COUNT of all tag in the ID state. After transmitting SUCCESS command, the situation is the same as all colliding tags generating '0'. Thus all colliding tags generating '1' uses more reader command and tag response than all colliding tags generating '0'. Figure 4 shows an example of this procedure with two tags.

To reduce this redundancy procedure, we use the FAIL_RNG command which is proposed in this paper. The role of the FAIL_RNG command is to generate a random number of tags with the counter COUNT at '1'. If no tags reply after a collision was detected at the reader (Case 1 → Case 2), we should regard that all colliding tags generate '1'. At this time we use the FAIL_RNG command to generate a random number of tags with the counter COUNT at '1'. Using the FAIL_RNG command all colliding tags generating '1' uses the same number of reader commands and tag responses as all colliding tags generating '0'. Figure 5 shows the procedure with two tags. This is the second proposed method.

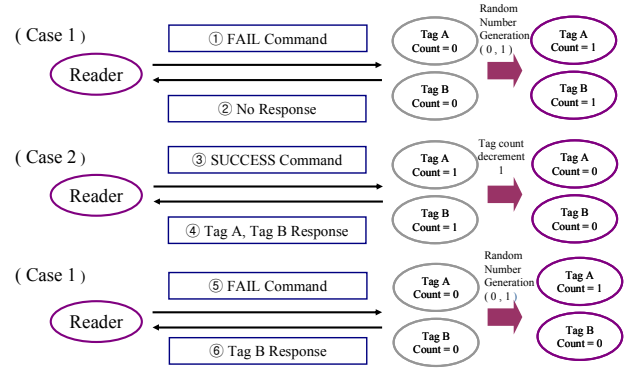


Fig.4: An example of all colliding tags generating a random number '1'.

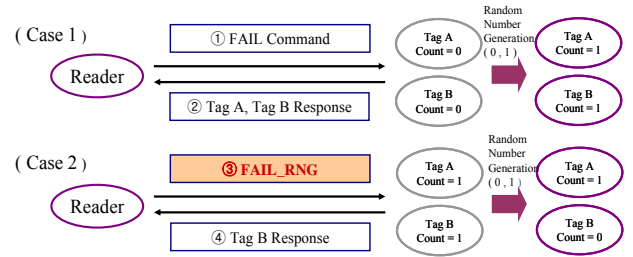


Fig.5: An example of all colliding tags generating a random number '1' with FAIL_RNG command.

For applying method 2 to the type B protocol, it is sufficient just adding additional command, FAIL_RNG command. This is easy way and should not change the hardware architecture of a tag or a reader.

4. SIMULATION RESULTS AND PERFORMANCE COMPARISON

In this section we evaluate the time required to identify tags compared the type B protocol with the proposed method. Ideal conditions have been assumed so that there is no near-far effect, or errors in the communication between a reader and tags. Data rate between reader and tag is 40 kbps. A reader waits the tag response during preamble detection time which is set 16 bit and a tag waits the reader response during the quiet time which is set 400 μ s. To evaluate the exact time for tag identification we count the number of the reader commands and tag responses at bit unit. The reader recognizes no response of tag at Case 2 in section 2 when the time is over the preamble detection time of the reader. Finally it is disregarded about time for uses FHSS (Frequency Hopping Spread Spectrum) because it does not effect the anti-collision performance.

We need to know when the reader identifies all the tags within the range of the reader. The type B protocol does not specify when the reader finishes the collision arbitration. So we put the instance as the end time of the tag identification when the number of the SUCCESS commands transmitted by a reader is more than that of the FAIL commands transmitted.

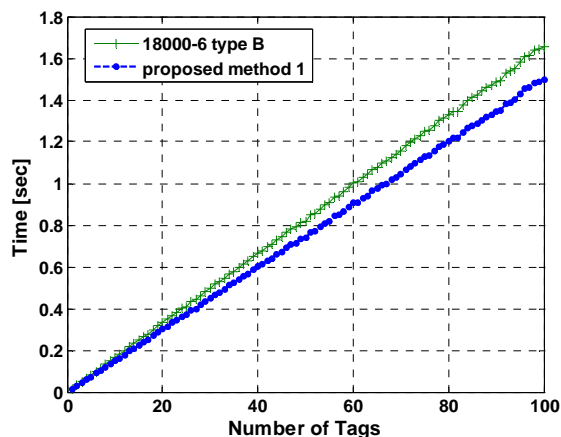


Fig.6: Performance of anti-collision between type B and applying proposed method 1.

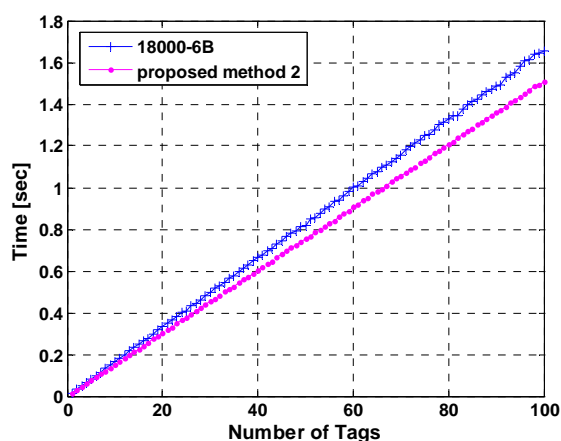


Fig.7: Performance of anti-collision between type B and applying proposed method 2.

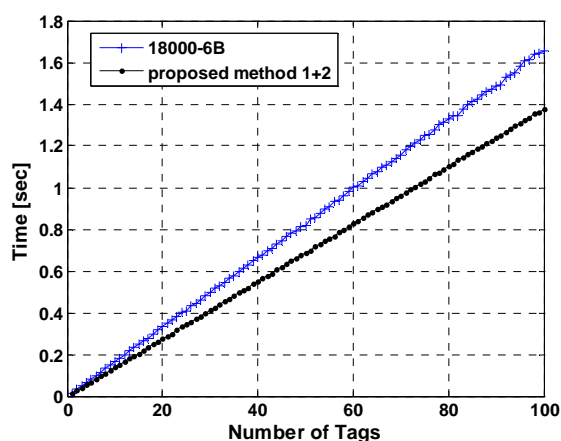


Fig.8: Performance of anti-collision between type B and applying proposed method 1 plus 2.

To compare the performance we focus on the number of identified tags in one second. Figure 6 shows the performance of anti-collision between the type B protocol and applying proposed method 1. The tag identification time of the type B protocol is 60 tags per second and the tag identification time of applying proposed method 1 is

66 tags per second. Figure 7 shows the performance of anti-collision between the type B protocol and applying proposed method 2. The tag identification time of the type B protocol is the same above and the tag identification time of applying proposed method 2 is 67 tags per second. Figure 8 shows the performance of anti-collision between the type B protocol and applying proposed method 1 plus 2 simultaneously. The tag identification time of applying proposed method 1 plus 2 is 73 tags per second. This is 21.7 % enhancement about the anti-collision performance of the conventional type B protocol, irrespective of the number of tag.

5. CONCLUSION

In this paper, we improved the anti-collision performance of the ISO 18000-6 type B protocol and evaluated anti-collision performances of the ISO 18000-6 type B protocol and the proposed method with the consideration of the realistic RFID operations. Simulation results show that the proposed method improves the tag identification time by 21.7 % over the conventional method, irrespective of the number of tag. To apply the proposed method, it is sufficient just adding additional command to the conventional RFID systems using the type B protocol. The proposed method does not need to change the hardware architecture of a tag or a reader and is therefore easy to be applied to currently used RFID systems based on the ISO 18000-6 type B protocol.

6. REFERENCES

- [1] Klaus Finkenzeller, *RFID Handbook*, John Wiley and Sons, Inc., New York, 1997.
- [2] T. Scharfeld, "An Analysis of the Fundamental Constraints on Low Cost Passive Radio-Frequency Identification System Design," Master's thesis, Dept. of Mechanical Eng., Mass. Inst. of Tech., Cambridge, Mass., 2001.
- [3] "Information technology automatic identification and data capture techniques - radio frequency identification for item management air interface - part 6: parameters for air interface communications at 860-960 MHz," *ISO/IEC FDIS 18000-6*, Nov. 2003
- [4] J. I. Capetanakis, "Tree algorithms for packet broadcast channels," *IEEE Trans. Inform. Theory*, vol. 25, pp. 505-515, Sept. 1979.
- [5] Hush, Don R. and Wood, Cliff, "Analysis of Tree Algorithms for RFID Arbitration," *In IEEE International Symposium on Information Theory*, pages 107-. IEEE, 1998