Improved Tag Identification Method for reducing the Process Time of Tag Recognition

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Abstract

In recent years, radio frequency identification(RFID) technology has moved from obscurity into mainstream applications that speed up in identifying objects(e.g. manufactured goods, healthcare services, etc.) which affect our daily lives. However, there are several issues arises such as RFID tag collision problem which occurs due to the usage characteristics of radio frequency communication. Therefore, to answer these issues, we proposed the tag identification method which uses a multi-reader to minimize tag collision and to reduce the tag recognition time. The proposed method analyze the tag recognition time by applying the adaptive group separation(AGS) algorithm. Based on our experimental results, the proposed method shows the improvement rate of over 40% increased on processing time.

Keywords : *RFID, Tag Identification, Anti-collision, Multi-reader*

1. Introduction

Recently, RFID system has increased in use for the identification of objects, taking the place of a bar code system [1]. RFID system features non-contact recognition of objects and has merits of identifying multiple objects at the same time; in particular, a tag contains its original ID for individual recognition, which enables the establishment of an efficient recognition system of objects. On the other hand, an RFID system proceeds with a way in which when a reader sends query to a tag through a broadcasting system, the tag responds to the query of the reader, which is likely to cause tag collision when multiple tags send information at the same time. To solve this problem, various anti-collision methods [2, 3, 4] were researches, but it has difficulty applying them to a passive tag-based system due to complicated process procedures.

Therefore, this study suggests an effective and efficient method in reducing the time for tag recognition process by minimizing tag collision through multi-reader application.

In this study we will illustrate and discussed the following. Chapter 2 investigates the existing anti-collision methods, and Chapter 3 suggests an efficient tag authentication method based on a multi-reader method. In Chapter 4, the result of performance evaluation of the suggested method, and finally Chapter 4 produces conclusion, and suggests further study plans.

2. Related Work

This chapter examines the AGS algorithm which was recommended to improve an existing tree-based, anti-collision algorithm and an existing multi-reader-applied method to improve tag recognition rate.

2.1. AGS Algorithm

The AGS algorithm is a method[5] by which an appropriate prefix size is determined by the number of tags; and tag groups becomes subdivided; so the number of tag calling signals decreases.

For instance, if six tag IDs are arranged in the order of '00010', '00101', '01001', '10110', '11010' and '11001', the execution process is shown as on Figure 1. After determining a prefix size, a reader subdivides tag groups, calls each group and inspects tags. If collision occurs, it adds '0' and '1' to the highest bit that was faced with collision, so as to produce a new query, and calls a tag again.

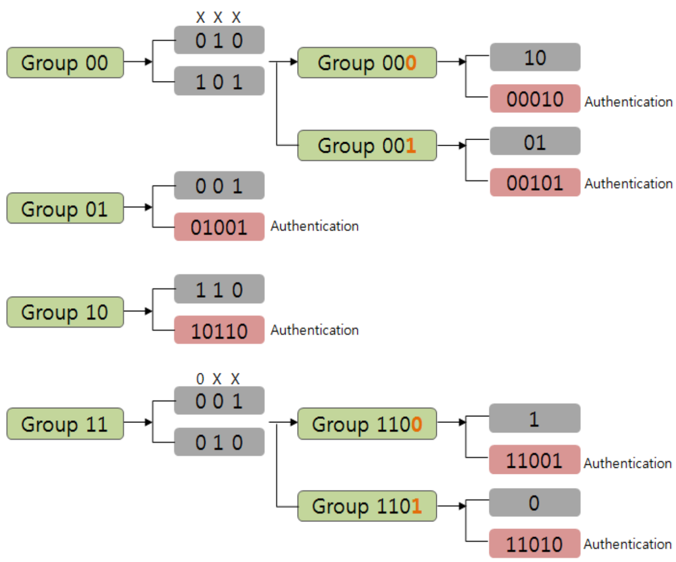

Figure 1. Execution Process of AGS Algorithm

If N numbers of tags are used in this AGS algorithm, the formula in order to obtain R (N) which is an average repeat count for searching tags is shown as on the formula (1).

$$R(N) = \frac{\log_2 N}{\log_2 N + 1} \times 2N \qquad \textbf{(1)}$$

2.2. Tag Recognition Method via Reader Cooperation

A tag recognition method via reader cooperation is a two reader-supported way in which, when multiple tags pass through readers, the first reader records tag information, and the second reader takes the information over and recognizes the rest tags [6].

This process is made in the form of configuring trees; Figure 2 shows the tree configuration.

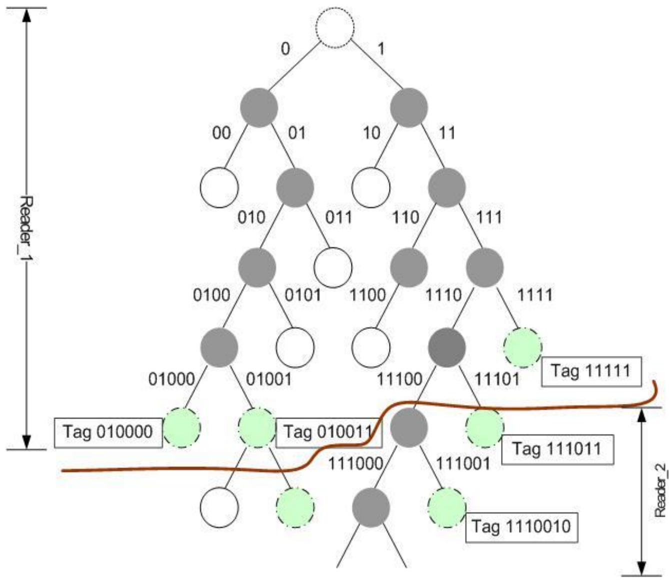

Figure 2. Tag Recognition Method via Reader Cooperation

3. Proposed System

In this chapter, we will illustrate and discuss the system configuration of multi-reader environment for the purpose of improving the process time of tag recognition of the RFID system.

The suggested method is that each reader is devised to read only a designated tag when readers identify objects in the RFID system, which enables preventing the collision of each tag signal, and thus reducing the process time of tag authentication.

3.1. Tag Recognition Process by using Single Reader

The configuration method of RFID systems which are currently being used is a way through which several tags are identified at the same time by one reader. When a tag signal is detected by a reader within its recognition range, the reader sends a query to the tag and receives an ID from each tag.

This process causes collision between tags which choose the same channel, consequently leading to decrease in tag recognition rate. In the result, the recognition speed of all systems becomes lower.

3.2. Tag Recognition Process by using Multi-reader

This paper suggests a tag recognition method which uses multiple readers so as to solve a problem of tag collision occurring in a single reader configuration method. The tag recognition process of the suggested system is shown on Figure 3.

Each reader in the multi-reader configuration system that is suggested by this study contains tag IDs previously before recognizing them. Therefore, the reader sends a query to a tag within its recognition range, and when a responding tag appears, the reader stops corresponding to tags which are not in its tag list.

Through this identification process, tag collision was minimized, and the process time for tag recognition becomes shorter.

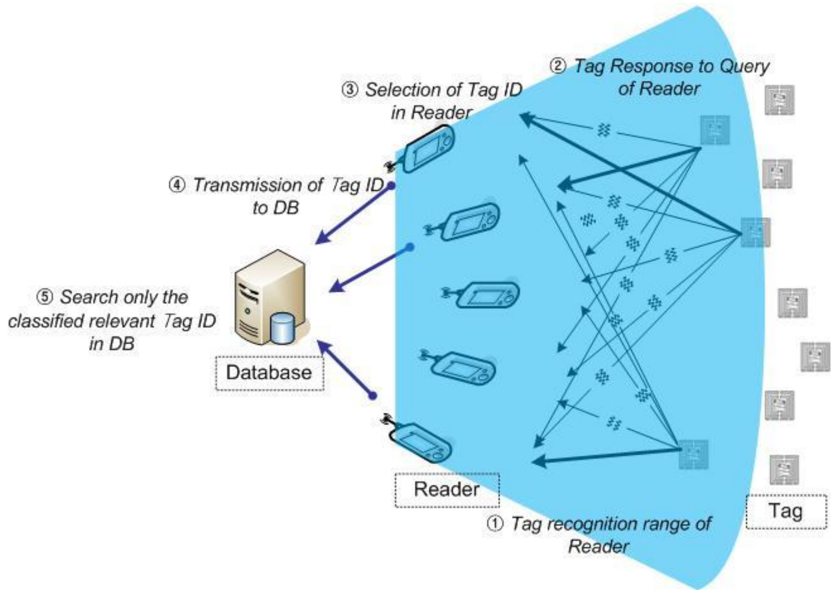

Figure 3. Tag Recognition Process by using Multi-reader

3.3. Tag Authentication Process of the Suggested System

Terms and notation which are used to express the process procedure in the whole authentication process of the suggested system are defined on the following Table 1.

Table 1. Definitions of Terms

Terms	Definitions
h( )	Hash Function
⊕	XOR(exclusive or)
ID	Tag ID
R_r	Random number produced by a reader
R_d	Random number produced by a Database
ǁ	Concatenation
CP_1	H(ID ǁ random number)
IB	Identification bits of Tag ID

Figure 4 shows the tag authentication process by using multiple readers which was suggested by this study. First, a reader produces random number Rr, and sends Rr and query to a tag.

Second, the tag concatenates Rr and its ID, and sends CP1 which is a value of hash function process to the reader. In addition, IB which needs for identifying tag IDs that are identified by each reader and CP2 which is a value of XOR process as well as CP1.

Third, the reader checks if IB which were transmitted from the tag is the IB that are supposed to be recognized by the reader, and if the IB information is in its list, it proceeds with the next process, but if not in the list, it stops corresponding to the tag. A reader which confirmed identifying the tag ID that was expected to be identified by it produces the value of CP1', and sends it to the database.

Fourth, the database which received the value from the reader verifies the validity of the tag information as the reader did in the third process, and sends its random number, Rd, and D which is the result value of CP1" to the reader.

Last, the reader sends the value to the tag and the tag which received the data from the reader finishes the authentication process by verifying the matching value of CP1.

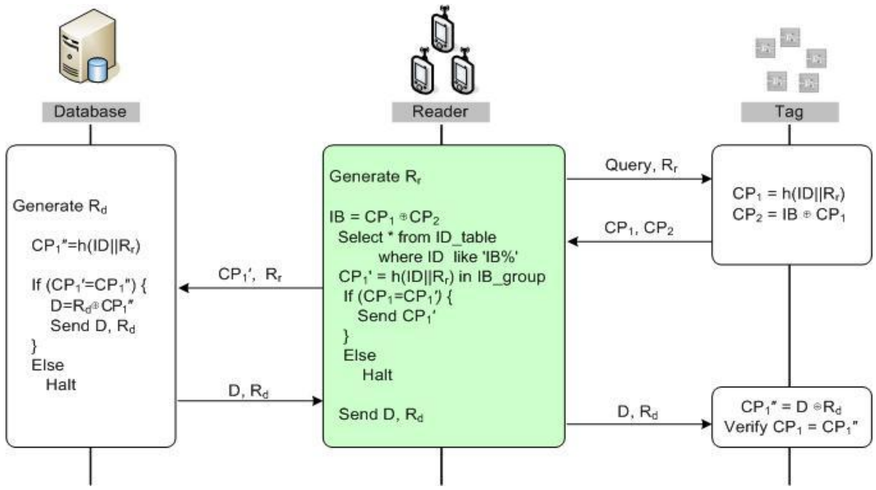

Figure 4. Authentication Process of Proposed Method

4. Performance Evaluation

In this chapter, we compare and analyze the whole time of authentication process between the tag recognition method in a single reader configuration and the suggested tag recognition method based on the multi-reader system with aim to analyze the performance of the suggested system.

It is provided that the frequency band of the suggested RFID system is standardized at 900 MHz, and that there is no collision between readers. Moreover, each reader is applied with AGS algorithm to minimize tag collision, and time for tag recognition process is calculated.

The parameters for analyzing performances of the suggested system are shown on Table 2. Tsum which is the process time of all systems consists of the sum of process time of each section, Trt_sum+ Trd_sum +Tdb_sum.

Table 2. System Parameter

Symbol	Explanation
N_r	Number of Reader (1~5ea)
N_t	Number of Tag (100~2,000ea)
T_{rt}	Communication Time between Reader-Tag (7ms)
T_{rd}	Communication Time between Reader-Database (3ms)
T_{db}	Execution Processing Time in Database (24ms)
T_{IB}	IB Searching Time (2ms)
T_{sum}	Total time for Tag Authentication

The suggested system reflected the number of tag collisions by applying the AGS algorithm in order to recognize all tags.

First, the formula to calculate Trt_sum, the total time between the reader and the tag which reflects the number of tag collisions is shown as (2).

$$T_{rt\_sum} = \left\{ \left(\frac{\log_2(N_t / N_r)}{(\log_2(N_t / N_r)) + 1} \times 2\left(\frac{N_t}{N_r}\right) \right) T_{rt} \right\} \quad \textbf{(2)}$$

Second, the formula to produce Trd_sum, the total time between the reader and the database which includes IB searching time is displayed by (3).

$$T_{rd\_sum} = \{(N_t)(T_{rd}) + (T_{IB})\} \quad \textbf{(3)}$$

Third, the formula to calculate Tdb_sum, the process time in the database is shown by (4).

$$T_{db\_sum} = (N_t)(T_{db}) \quad \textbf{(4)}$$

With regards to performance analysis, the number of tags of 100~2000 and readers of 1~5 were combined and experimented in order to get Tsum, sum of formulas (2), (3) and (4). But as for single-reader configuration, IB searching time, TIB is exceptionally calculated.

In the result of experiments, when the number of readers increased to 2 as shown by Table 3 and Figure 5, the improvement rate of process time increased to over 40%, but in case of over 3 readers, no significant difference was found in the improvement rate of process time. This result suggests that the use of 2 readers can produce the best efficiency in the system that is applied with the AGS algorithm.

Table 3. Total Authentication Time According to the Increase of Tag Numbers

Reader Number / Tag Number	1	2	3	4	5
100	5500.0	3891.3	3870.9	3853.9	3838.9
500	27500.0	19721.3	19666.8	19623.2	19586.2
1,000	55000.0	39597.2	39509.6	39440.5	39382.4
1,500	82500.0	59511.6	59394.8	59303.2	59226.5
2,000	110000.0	79448.6	79304.7	79192.4	79098.6

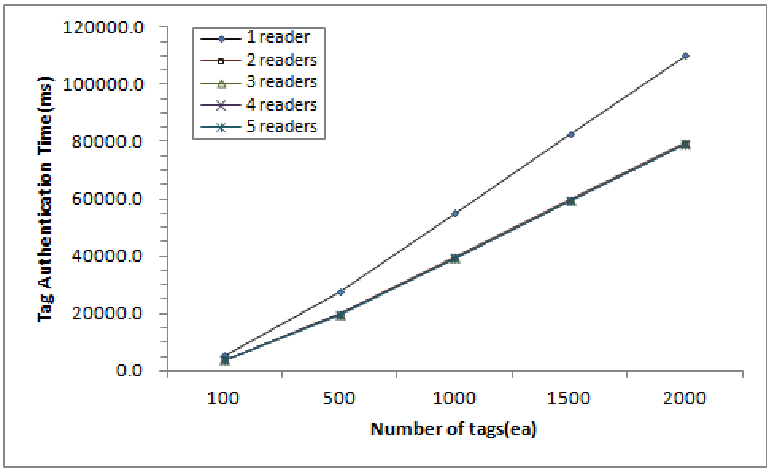

Figure 5. Tag Recognition Process by using Multi-reader

As shown on Figure 6, the result of analysis on the difference of process time between a single reader and 2 readers which are optimal reader numbers that were induced from the experiment above shows that as the number of tags increases, the fall of process time becomes significant. Therefore, the tag recognition method based on multiple readers which is suggested in this study can effectively be used in the fields of logistics and distribution that need to identify multiple tags at the same time.

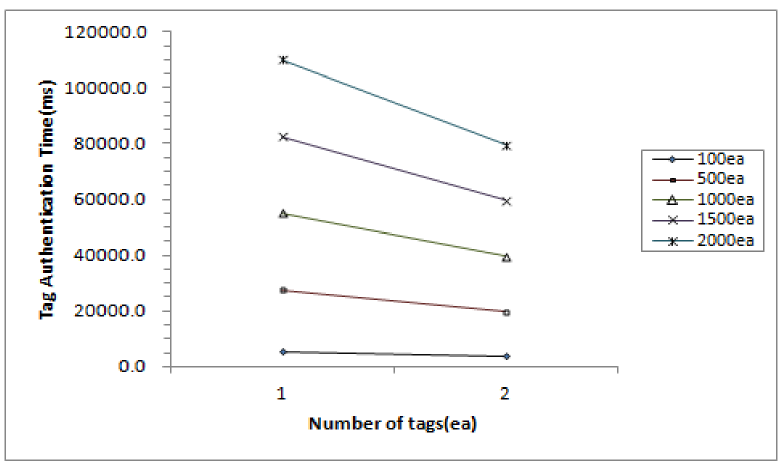

Figure 6. Comparison of Tag Authentication Time between a Single Reader and Multi-reader

5. Conclusion

This study explored an RFID system which has increasingly been used as an identification system of an object in recent times, and suggested a tag authentication method using multiple readers in order to utilize an efficient RFID system.

The tag recognition system to the present recognized tags by using one reader, which caused increase in tag collision rate and the whole time for tag recognition.

Therefore, to overcome these obstacles, this study minimized tag collision by applying the multi-reader configuration method, and thus reducing the whole time for tag recognition. In the result of performance analysis, the multi-reader configuration system improved to over 40% in process time compared to a single reader configuration system.

Further study needs to compare and investigate the system performance by applying a variety of anti-collision tag systems, consequently establishing an optimal RFID system.

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