Improvement of Collision-Arbitration for the ISO 18000-6 Type C RFID system

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ABSTRACT

In RFID systems, a number of tags simultaneously respond to a reader's request signal, which may cause tag collision in the reader. This collision makes the reader difficult to identify tags. To solve this problem, the ISO 18000-6 Type C protocol adopts a slotted ALOHA-based anti-collision method with a Q parameter and a weighting factor C. Although the anti-collision performance varies with Q and C parameters, any selection rules have not existed. To approach the optimal performance based on appropriately selected Q and C values, we present a selection method of effective Q and C values. Simulation results show that the anti-collision method using Q and C values selected by the proposed method improves the number of identified tags at the same interval by 18.5 % with the unknown number of tags and by 37 % with the known number of tags, compared with the anti-collision method with the parameters given in an example in the protocol.

Keywords: RFID, 18000-6 type C, collision arbitration, anti-collision

1. INTRODUCTION

Radio frequency identification (RFID) systems have become very popular as an automatic identification procedure due to their advantages, such as the data density, robustness, security, and reading speed. An RFID system is made up of two components: the reader and the tag [1]. The reader is a device for reading object's information from the tag attached to the object through wireless communications.

The rule of communications between the reader and the tag is defined by air interface protocols. There are three types of air interface protocols in 900 MHz RFID systems: ISO 18000-6 Type A, B, and C [2], [3]. For the last several years, Type B had dominated in 900 MHz RFID systems but Type C is now rapidly replacing Type B. However, there are some problems to be solved for the practical in use of Type C. Especially, tag collision, which occurs due to the simultaneous responses of tags for the reader's request, is a very troublesome problem to make one hesitate to introduce RFID systems in commercial applications. To solve this problem, most of RFID standard protocols include their own specific anti-collision methods.

Type A and C protocols adopt a slotted ALOHA-based anti-collision method and Type B protocol adopts a binary tree algorithm-based anti-collision method [4]. Although the anti-collision method of Type A and C is based on the same slotted ALOHA protocol, there is one difference between them. The anti-collision method of Type A has to continue each identification round once the number of slots is determined, whereas that of Type C may continue or terminate the identification round depending on the change of the floored value of Q. The value of Q is dependant upon its initial value and a weighting factor C. Unfortunately, there is not an explicit way to determine the value of C and the initial value of Q. Hence, it is important to find the optimal values of the above parameters to reduce the performance degradation caused by improper selection.

In order to remove the ambiguity of the selection of parameters and improve the anti-collision performance, we propose a selection method of an appropriate value of Q based on the estimated number of tags without C.

The rest of this paper is organized as follows. Section 2 describes the conventional anti-collision method in the ISO 18000-6 type C. Section 3 describes our proposed parameter selection method and the estimation algorithm for the number of tags. In section 4, we show the performance of the proposed anti-collision method with the estimation algorithm through simulation results. Finally in section 5, we conclude the paper.

2. ANTI-COLLISION METHOD IN ISO 18000-6 TYPE C

An anti-collision method of the ISO 18000-6 Type C employs the Q-algorithm, which is based on the slotted ALOHA protocol [3]. Using a Q-parameter, we determine the number of slots in one identification round. Since the number of slots is directly related to the time of identifying all tags, the performance of the anti-collision method in the ISO 18000-6 Type C system highly depends on the Q parameter. It is therefore important to select an appropriate Q parameter for given number of tags.

Figure 1 shows how the ISO 18000-6 Type C selects a Q value. The Q parameter is divided into integer value Q which is used for determining the number of slots and

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This work was supported by the Regional Research Centers Program (Research Center for Logistics Information Technology), granted by the Korean Ministry of Education & Human Resources Development.

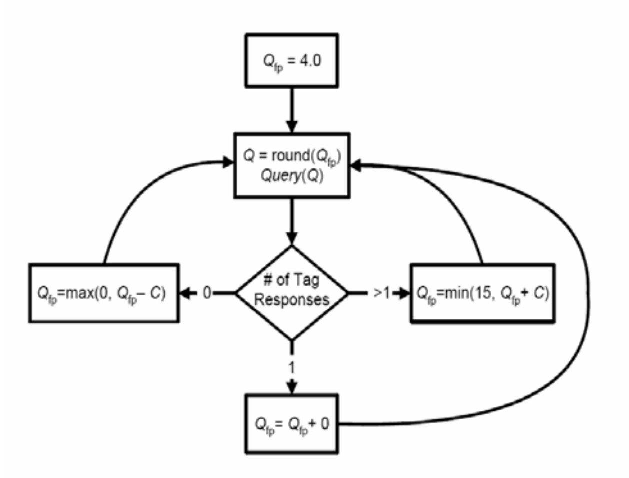

Fig.1: *An example of a Q-selection algorithm.*

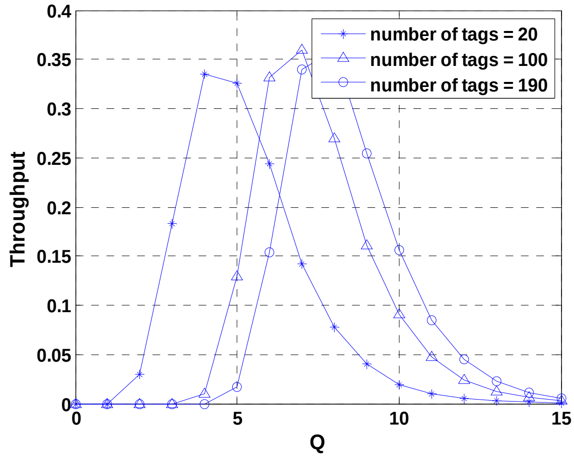

Fig.2: *Throughput curves for three cases of number of tags.*

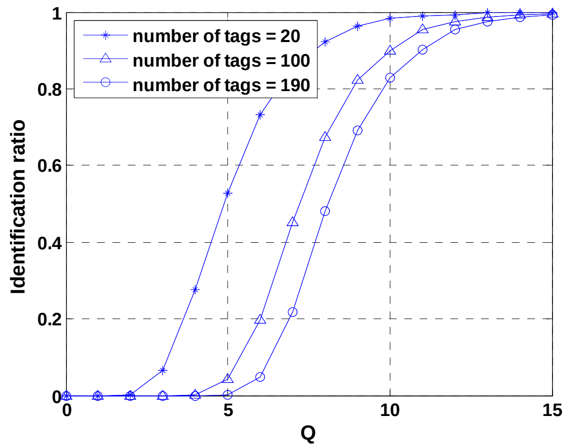

Fig.3: *Identification rate for three cases of number of tags.*

for floating point calculation. To initiate a new identification round, the reader sets Q_{fp} =4.0 and also sets that Q is a rounded value of Q_{fp} then sends Query command with the Q value. Tags randomly select one of 2^Q slots. There can be three outcomes. First, there is only one tag response in the slot. In this case, the reader keeps the present Q value. Second, there is no tag response in the slot. It means that the slot is empty then the reader subtracts weighting factor C (typically 0.1<C<0.5, we choose C as 0.33 [5]) from Q_{fp}. Lastly, There is two or more tags' responses in the same slot, which means that collision occurs in the slot. In this case the reader adds the Q_{fp} value to the weighting factor C.

During one identification round, Q_{fp} is changed by subtractions and summations and the reader checks a rounded value of Q_{fp} and Q. As soon as the reader recognizes the change of Q value, it stops the present identification round and sends QueryAdjust command with a new Q value. Then the tags select one of 2^{Qnew} slots and a new identification round is started.

Although an initial Q value and a weighting factor C which are decisive parameter for change of Q, they are not precisely specified for the optimal operation. The selection of inappropriate initial Q and C may cause the performance degradation. To avoid such an improper operation and improve the anti-collision performance, we propose a novel anti-collision method using only Q value regardless of C value.

3. PROPOSED ANTI-COLLISION METHOD

We assume that the number of tags to be identified is known. The slotted ALOHA has an explicit Q_{sa} value which maximizes the throughput to the number of tags. Figure 2 shows the example of the slotted ALOHA throughput curves for the number of tags, such as 20, 100 and 190.

The Q_{sa} value, which maximizes the slotted ALOHA protocol's efficiency, is valid under the condition that all slots in the identification round have the same slot length [1]. In Type C, however, the collision slot length is much longer than the empty slot length. This yields that the collision slot requires longer identification time than the empty slot does. In spite of the fact that the Q_{sa}, is the best choice in the slotted ALOHA, we select slightly a large Q_{op} to reduce the collision slots instead of Q_{sa}. Although the selected large Q_{op} also increases the number of empty slots, the increased identification time by the increased empty slots is shorter than the reduced identification time by the decreased collision slots.

To find an appropriate value of Q_{op}, we define the identification ratio (the number of identified tags in one identification round / the total number of tags to be identified). Figure 3 shows the example of the slotted identification ratio curves for the number of tags, such as 20, 100 and 190. High identification ratio means that not only the total number of slots (most of them are empty slots) in one identification round is large but also the number of the collision slots is small. Through extensive simulation results, we found that the optimal value Q_{op} for anti-collision is the maximum Q value yielding the identification ratio of below 0.55 in figure 3.

In general, since we cannot know the number of tags, the proposed anti-collision method may not be applied to

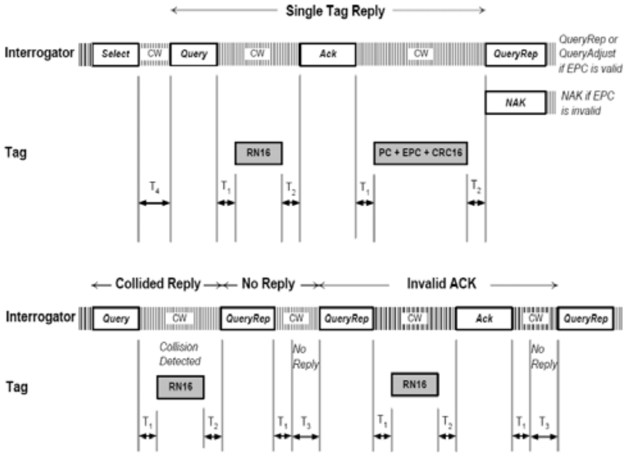

Fig.4: *Link timing.*

Table 1: *Link timing parameters*

Parameter	Minimum	Typical	Maximum
T_1	MAX(RTcal, 10 T_{pri}) × (1-FT)-2 μs	MAX (RTcal, 10 T_{pri})	MAX(RTcal, 10 T_{pri}) × (1+FT)+ 2 μs
T_2	3.0 T_{pri}		20.0 T_{pri}
T_3	0.0 T_{pri}		
T_4	2.0 RTcal		

real field. To solve this problem, we need to estimate the number of tags. It can be done simply but efficiently by using the slotted ALOHA throughput curves shown in figure 2. Through the first identification round, we can get a throughput value at a specific Q (denoted as Q_s). It is compared with all throughput values corresponding to Q_s in the throughput curves of all possible tag numbers between 1 and 1,000. Then there exists a curve which matches the best. Finally, we can obtain the estimated number of tags from the matched curve. For example, we assume that there are only three throughput curves, such as 20, 100, 190 tags and we have a value of 0.1 at Q_s = 10 after the first identification round. At Q_s =10, the best matched curve to the value of 0.1 is the one with 100 tags. Therefore we estimate that the number of tags is 100.

4. SIMULATION RESULTS

4.1 Simulation Environment

The frequency hopping spread spectrum is not considered. In reader to tag transmitting (R->T), 1 T_{ari} (Reference time interval for a data-0 in reader-to-tag signalling) is 12.5 μs and 1 bit is assumed to be 1.5 T_{ari}. In tag to reader transmitting (T->R), LF (Link Frequency) is 160kHz and 1 T_{pri} (Link pulse-repetition interval) is 6.25 μs. After Ack - command, Tag transmits PC (16 bits), EPC (96

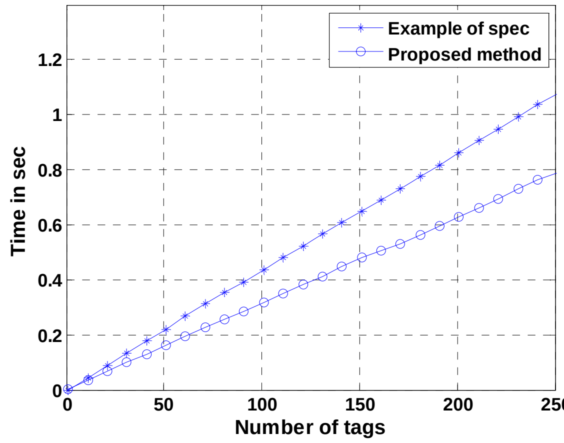

Fig.5: *Comparison of the proposed method and the conventional method.*

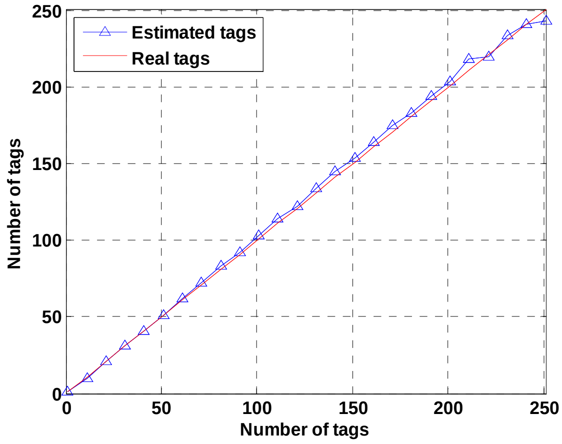

Fig.6: *Estimation of the number of tags*

bits) and CRC-16 (16 bits). Link timing is denoted in figure 4 and link timing parameter is denoted in table 1 [3].

4.2 Performance of the proposed method with known number of tags

Figure 5 shows the total identification time of the proposed anti-collision method compared with an example of the anti-collision method given in the ISO 18000-6 type C [5]. We achieve about 37% improvement in terms of the number of identified tags during the same interval.

4.3 The Accuracy of the Estimation algorithm

The estimation the result performed at Q_{sp} =9 is shown in figure 6. When the number of tags is small, the proposed method estimates the number of tags precisely. However, as the number of tags increases, the difference between the estimated number and the correct number of tags appears. However the effect to the anti-collision performance by the error is negligible.

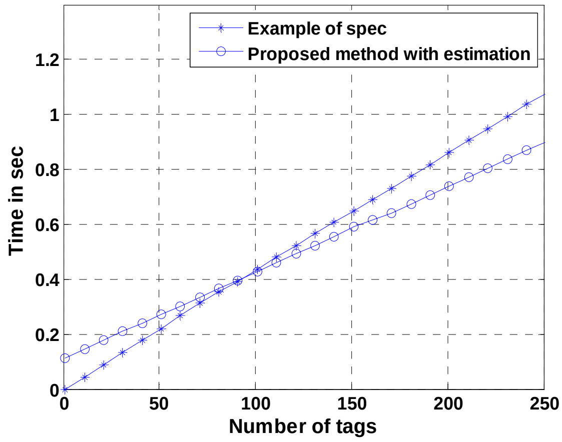

Fig.7: *Comparison of the proposed method with estimated tag numbers and the conventional method.*

4.4 Performance of the proposed method with the estimated number of tags

The identification time of the proposed method with the estimated number of tags is shown in figure 7. Because of the estimation time, it takes longer time to identify the same number of tags below one hundred tags. Over one hundred tags, however, it is powerfully compensated. We achieve about 18.5 % improvement the anti-collision performance in terms of the number of identified tags during the same interval.

5. CONCLUSION

We achieved about 37 % improvement in terms of the number of identified tags during the same interval with our proposed anti-collision method in the case of known number of tags. To cope with practical situations of unknown number of tags, we propose an estimation algorithm of the number of tags. With the estimated number of tags, the performance improvement is about 18.5 %.

Despite of the significance of the anti-collision method in the ISO 18000-6 Type C, there have been few researches on the improvement of anti-collision performance. It is expected that the proposed method will trigger researches on anti-collision methods in the ISO 18000-6 type C.

6. REFERENCES

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