An Estimation Scheme of the Number of RFID Tags Based on Probability for Anti-Collision Algorithm

Chen-Chung Liu
Department of Electronic Engineering
National Chin-Yi University of Technology
ccl@ncut.edu.tw

Yin-Tsung Chan
Department of Electronic Engineering
National Chin-Yi University of Technology
YinTsung.Chan@gmail.com

Abstract

Anti-Collision algorithm based on probability can be used to estimate the number of frame slots needed at the next query round in tag identification of RFID. Each tag is equipped with a random counter to save the number that is relevant to whether the tag responds the query of reader or not. For this type anti- collision algorithm, to estimate the number of tags is the most important task in the algorithm. The estimation is conducted to decide the number of frame slots suitably such that to reduce the number of collisions and to increase the tag identification speeds in RFID communication. In this paper, an algorithm for estimating the number of tags in the interrogation zone based on pigeonhole principle is presented. The presented algorithm assumes that if the number of collisions is not less than 50% of frame size in the presented query round, then the offered frame size in this query round is less than the number of tags needed to be identified, and the frame size has to be increased to reduce the number of collisions. If the frame size is unchanged and the real number of tags is increased, then the number of collisions will be increased and the number of idle will be decreased, and the speed of tag identification will be slowed down. The presented algorithm analyses the number of collisions, the number of idles, and the number of identification in the present query round to evaluate the optimal number of time slots for the next query round. The experiment results show that the presented algorithm is efficient for estimating the real number of tags.

Keywords: RFID, Anti-Collision, Estimation.

1. Introduction

Radio frequency identification (RFID) is a contact-less automatic technology that through wireless communication to identify objects with a unique electrical identity embedded in each one of them. RFID consists of readers, tags and back end processor as shown in **figure 1** **[1, 2]**. An object equipped with a RFID tag can be checked directly the object's content without breaking the package of the object. Each Tag has a unique identification code (ID) and RFID reader gets the information from tags by radio. The international standard suggests the size of ID is 96 bits **[2]**. In recent years, RFID has been widely used in supply chain management, tracking of objects, and supermarket checkout process **[3-5]**. If there are tags need to be identified, reader will broadcast a request message to tags in the interrogation zone for capturing the IDs. Then all the tags in the interrogation zone respond their ID at the same time. But, a problem happened, there are too many IDs flow into the reader at the same time, it will be collided and cause that the reader can't identifies any IDs **[6-9]**. Anti-collision algorithm resolves the collision problem. Anti-collision algorithms can be divided into two categories; the anti-collision algorithms based on tree structure and the anti-collision algorithms based on probability distribution. There three types of responses from tags are consisted of collision, idle and identification **[10-13]**.

Manchester code is a kind of binary phase-shift keying (BPSK). The code result is encoded using clock and data to be logic operations. There are two types of Manchester code. A type of Manchester code was released by G.E. Thomas in 1949. In this type of Manchester code, the logical '0' is expressed by a low-to-high transition, and the logical '1' is expressed by a high-to-low transition. The other type of Manchester code is IEEE 802.3. In IEEE 802.3 type, the logical '0' is expressed by a high-to-low transition and the logical '1' is expressed by a low-to-high transition, the two types of Manchester code are showed in figure 2. The Manchester code has an ability that it can automatically detect whether and where the responding signal of tags is collision. More than one tag responds at the same time may cause collisions. Let M(***d***) denotes the encoding result for Manchester code, ***d*** denotes encoded data and ***t*** denotes the clock. G.E. Thomas Manchester Code and IEEE 802.3 Manchester Code can be represented as the following equations:

$$M_{G.E.}(d) = d \oplus t \qquad \textbf{(1)}$$

$$M_{IEEE}(d) = \overline{d \oplus t} \qquad \textbf{(2)}$$

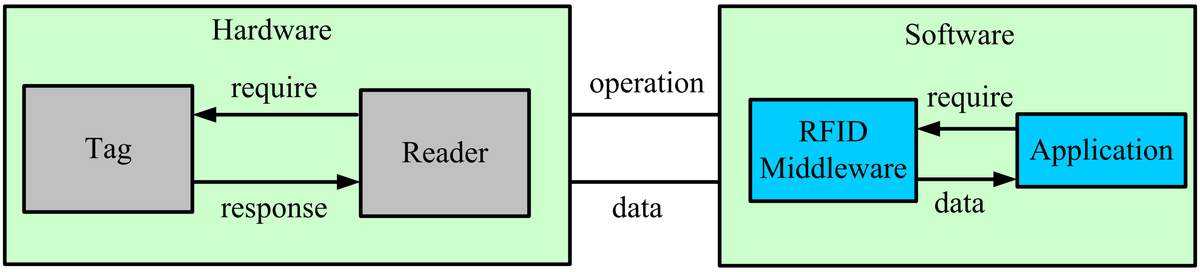


Figure 1. The communicate flow of RFID system construction.

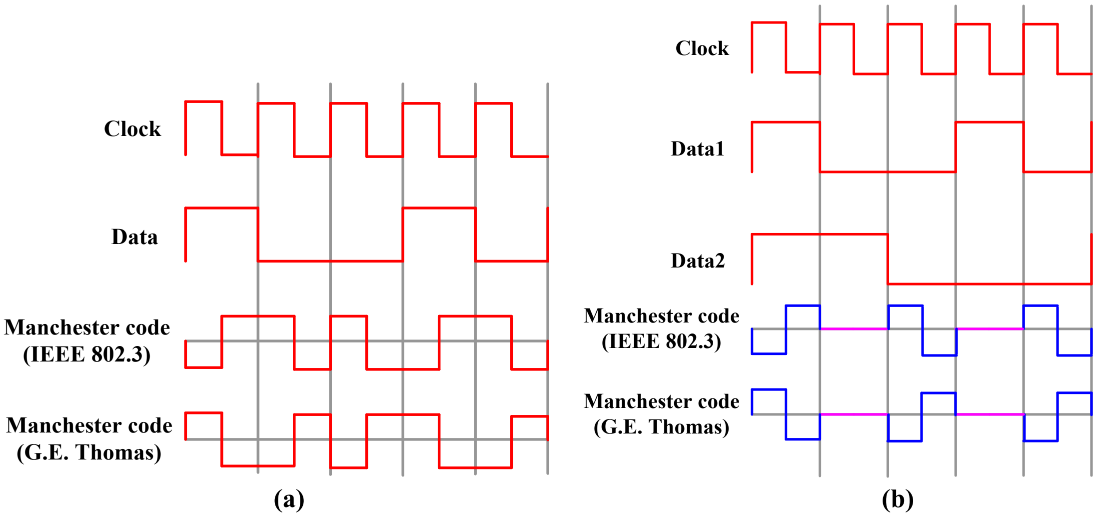


Figure 2. Manchester Code. (a) Two versions of Manchester Code. (b) The collisions made the signal unknowable.

IDs can be represented by a binary tree, it called ID-Tree as shown in figure 3, two most well-known algorithms are binary tree algorithm and query tree algorithm. In binary tree algorithm uses grouping strategy to identify tags. The reader always queries tags and waiting for the response from tags. A collision may occur in the interrogation zone and the collision tags are split into two sub trees, sub tree 0 and sub tree 1. Reader will selects one of sub trees to participate identification process at next time. Repeated the process, a tag will be identified and only one tag response this time. The identification process works until all tags in the interrogation zone are identified [14, 15]. In the algorithm, there are three events of collision, idle and identification. Collision happened if two tags response at the same time, idle happened if no response and identification happened if only one tag response. Figure 3 shows an example of the binary tree anti-collision and the corresponding inquire results are shown in table 1.

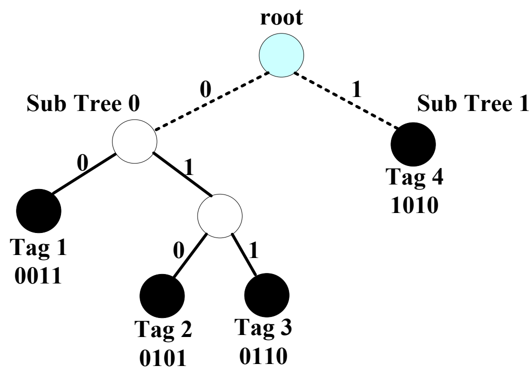


Figure 3. IDs can be represented a ID-Tree.

Table 1. Identification results of binary tree algorithm, ε denoted restart a next round.

ID={0011, 0101, 0110, 1010}		
Step	Select	Response
1	0	Collision
2	0	Collision
3	ε	0011
4	0	Collision
5	ε	0101
6	ε	0110
7	ε	1010

In query tree anti-collision algorithm, a query string is sent to tags, the size of query string is between 0 to 96 bits [16-19]. Tags respond if the query string corresponding their IDs. Figure 2 shows an example of the query tree anti-collision and the corresponding inquire results are shown in table 2.

Table 2. Identification results of query tree algorithm.

ID={0011, 0101, 0110, 1010}		
Step	Query	Response
1	ε	Collision
2	0	Collision
3	00	0011
4	000	Idle
5	01	Collision
6	010	0101
7	0100	Idle
8	011	0110
9	0111	Idle
10	1	1010

Anti-Collision algorithm based on probability can be used to estimate the number of frame slots needed at the next query round in tag identification of RFID. Each tag is equipped with a random counter to save the number that is relevant to whether the tag responds the query of reader or not. For this type anti- collision algorithm, to estimate the number of tags is the most important task in the algorithm. The estimation is conducted to decide the number of frame slots suitably such that to reduce the number of collisions and to increase the tag identification speed in RFID communication. Both the case that the number of offering frame slots is too larger than the number of frame slots really need, and the case that the number of offering frame slots is too less than the number of frame slots really requiring will slow down the identification speed. For speeding up the tag identification system, this paper proposed a algorithm to estimate the number of tags. However, the research in this field is very little now.

The remainder of this paper is organized as follows. Section 2 shows the algorithm and the corresponding experimental results. Section 3 is the conclusions of this research.

2. Method and Experimental Results

In this paper, a pigeonhole principle based algorithm for estimating the number of time slots needed for next tag identification round is presented, it is used to evaluate the number of tags in the interrogation zone. The presented algorithm assumes that if the number of collisions takes up 50% of the offered frame size, it means that the offered frame size is not enough, such that the presented algorithm increased the frame size to reduce the number of collisions. The flow chart of the algorithm is shown in figure 4. In figure 4, reader starts the query process with randomly selecting a frame size as the first estimation of the number of tags and then collects the information of tags' responses; they are the number of idles, the number of collisions and the number of identifications. If the number of collisions is larger than the half of the frame size, the frame size is then increased to be twice of the original frame size. The reader then broadcasts the new frame size to tags, and each of the original tags will reselect a random number. The reader queries tags slot by slot. When a slot is just occupied by a tag then the only one tag responds its ID to the reader (means it is identified). A collision occurs while a slot is selected by one more tags at the same time. And, an idle appears while a slot is not selected by any tag. The same query and response process repeats until the number of collisions (n_c) is less than half of the frame size (n_{fz}), and the presented algorithm output the final frame size as the estimation of the number of the real tags . In the simulations, the initial frame size is 16. The experimental results are represented in figure 5. In figure 5(a), a significant result shows that when the number of tags is increased higher and higher, the estimated number of total tags is not increased instantaneously to match the increasing of tags. There is always a flat interval between two adjacent critical points and the critical points usually appear around the place where the frame size is changed from n to $2*n$,where n is a positive integer.

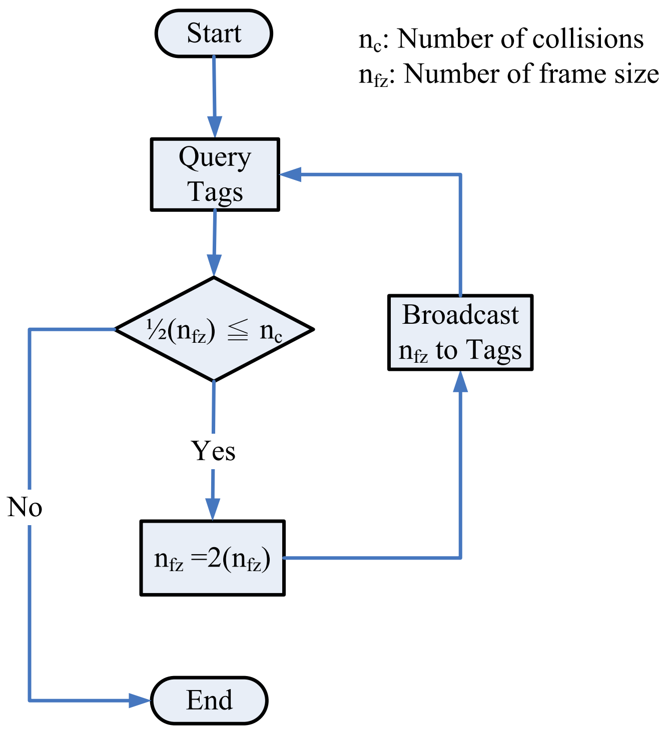
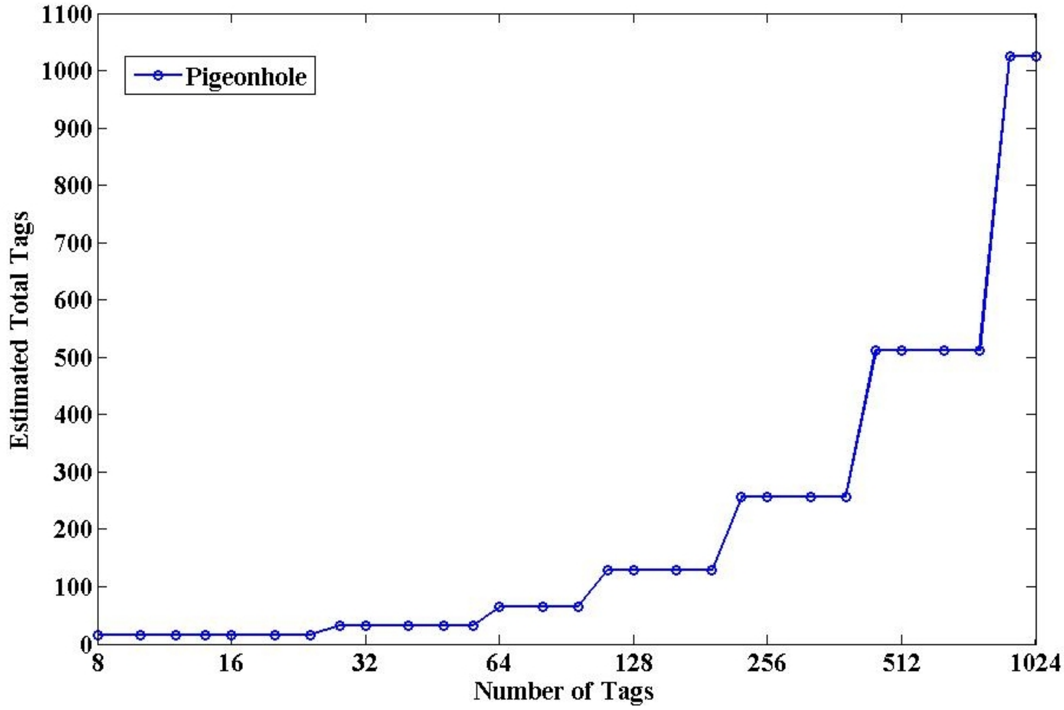


Figure 4. The flows char of the method of estimation.

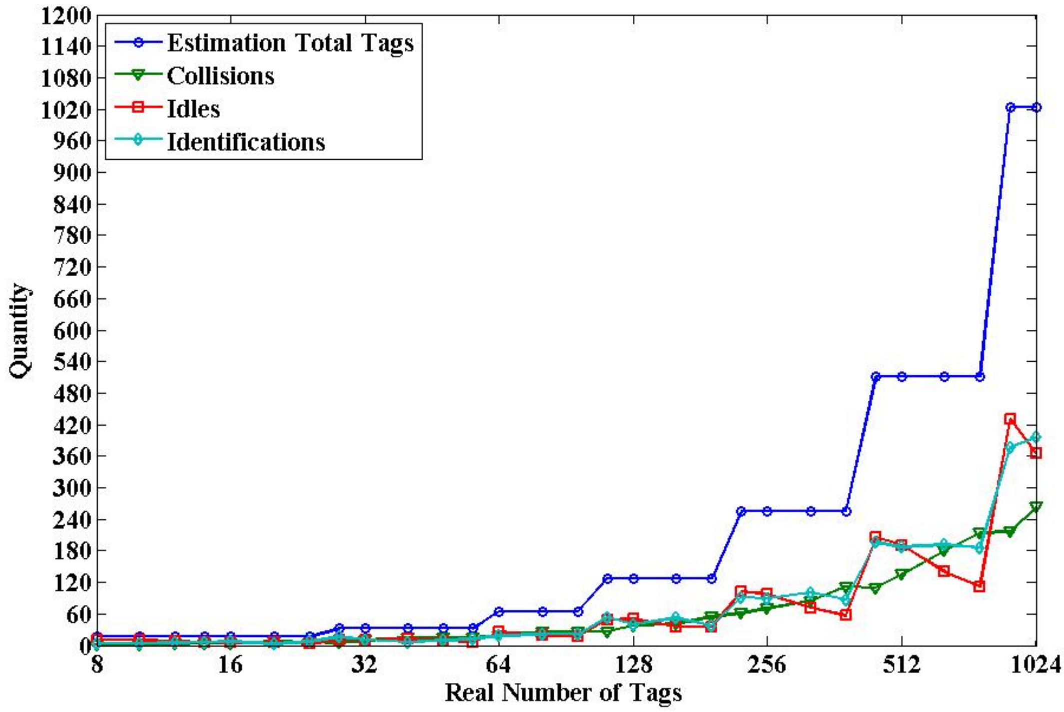
Table 3. The simulation results of estimations, collisions idle and identifications based on pigeonhole.

Tags Estimate based on Pigeonhole Principle

	Quantity			
No. of tags	Estimations	Collisions	Idle	Identifications
8	16	2	10	4
16	16	4	5	7
32	32	10	11	11
64	64	20	25	10
128	128	38	50	40
256	256	70	97	89
512	512	135	190	187
1024	1024	263	365	396



(a)



(b)

Figure 5. The experimental results of estimation based on pigeonhole principle. (a) The number of estimation tags via the number of real tags. (b) the number of collisions, the number of idles, and the number of identifications via real number of tags, respectively.

In each flat interval, figure 5(b) shows that the number of collisions is increasing while the number of real tags is increasing, the number of idles is decreasing while the number of real tags is increasing, and the number of identifications is almost unchanging while the number of real tags is increasing. In each case (different number of real tags), the IDs of real tags are generated by a pseudorandom number sequence generator with input a seed and the frame size. The same simulation is repeated 100 times with the same number of real tags and using different tag identification numbers (IDs), the mean of the same100 simulations is collected and listed in table 3. Due to the presented algorithm increases the current frame size with doubling the frame size of last iteration and the initial frame size is 16, so the estimation of real tags is $16*2^n$ where *n* is a positive integer. The presented algorithm can precisely estimate the number of real tags while the number of tags is n, where *n* is a positive integer. The presented algorithm can also be modified to precisely estimate the number of real tags that the number of real tags is anyone of the nature number, and to speed up the tag identification rate of a RFID system.

3. Conclusions

The presented algorithm analyzes the number of collision slots of each query round to increase the number of slots needed to estimate the number of real tags in the interrogation zone. The simulation results show that when the number of tags is increased higher and higher, the estimated number of total tags is not increased instantaneously to match the increasing of tags. On the other hand, the number of collisions is increasing while the number of real tags is increasing, the number of idles is decreasing while the number of real tags is increasing, and the number of identifications is almost unchanging while the number of real tags is increasing. The simulation results also show that the presented algorithm can precisely estimate the number of real tags in the interrogation zone although the presented algorithm is simple. The estimating speed is decided by the growth function and the input initial frame size. The length of the flat interval between two critical points can be adjusted by changing the growth function or changing the input initial frame size. The presented algorithm can also be modified to precisely estimate the number of real tags that the number of real tags is anyone of the nature number, and to speed up the tag identification rate of a RFID system.

References

[1] S. Sandoval-Reyes, J. L. Soberanes Perez, Mobil RFID Reader with Database Wireless Synchronization, 2nd International Conference on Electrical and Electronics Engineering (ICEEE) and XI Conference on Electrical Engineering (CIE 2005), Sep. 2005.

[2] EP GCBlobal Tag Data Standards Version 1.4, http://www.ep GCBlobalinc.org/standards/tds/tds_1_4-standard-20080611.pdf, Jun. 2008.

[3] Ramaswamy Chandramouli, Tim Grance, Rick Kuhn, Susan Landau, Security Standards for the RFID Market, IEEE COMPUTER SOCIETY, Nov. 2005.

[4] Tassos Dimitriou, A Secure and Efficient RFID Protocol that could make Big Brother (partially) Obsolete, Proceedings of the Fourth Annual IEEE International Conference on Pervasive Computing and Communications (PERCOM'06), 2006.

[5] FOTEL precision imaging, http://www.fotel.com/rfid-solutions/what-is-rfid/introduction, 2009.

[6] Jieun Yu, Wonjun Lee, GENTLE: Reducing Reader Collision in Mobile RFID Networks, The 4th International Conference on Mobile Ad-hoc and Sensor Networks, 2008.

[7] Yan Xin-qing, Yin Zhou-ping, and Xiong You-lun, A Comparative Study on the Performance of the RFID Tag Collision Resolution Protocols, 2008 Second International Conference on Future Generation Communication and Networking, 2008.

[8] Jihoon Myung, Wonjun Lee, Timothy K. Shih, An Adaptive Memoryless Protocol for RFID Tag Collision Arbitration, IEEE TRANSACTIONS ON MULTIMEDIA, VOL. 8, NO. 5, Oct. 2006.

[9] Yan Xin-qing, Yin Zhou-ping, Xiong You-lun, QTS ALOHA: A Hybrid Collision Resolution Protocol for Dense RFID Networks, IEEE International Conference on e-Business Engineering, 2008.

[10] Jongho Park, Min Young Chung, Tae-Jin Lee, Identification of RFID Tags in Framed-Slotted ALOHA with Robust Estimation and Binary Selection, IEEE COMMUNICATIONS LETTERS, VOL. 11, May. 2007.

[11] FENG Bo, LI Jin-Tao, GUO Jun-Bo, DING Zhen-Hua, ID-Binary Tree Stack Anticollision Algorithm for RFID, Proceedings of the 11th IEEE Symposium on Computers and Communications, 2006.

[12] C. Law, K. Lee, and K.-Y. Siu, "Efficient Memoryless Protocol for Tag Identification." in International Workshop on Discrete Algorithms and Methods for Mobile Computing and Communications, August 2000.

[13] Jung-Sik Cho, Jea-Dong Shin, Sung Kwon Kim, RFID Tag Anti-Collision Protocol: Query Tree with Reversed IDs, International Conference on Advanced Communication Technology 2008, Feb. 2008.

[14] SungSoo Kim, YongHwan Kim, SeongJoon Lee, KwangSeon Ahn, An Improved Anti Collision Algorithm using Parity Bit in RFID System, Seventh IEEE International Symposium on Network Computing and Applications, 2008.

[15] M Ayoub Khan, Manoj Sharma, Brahmanandha Prabhu R, FSM based Manchester Encoder for UHF RFID Tag Emulator, Proceedings of the 2008 International Conference on Computing, Communication and Networking (ICCCN 2008), 2008.

[16] T. S. Lee, H. M. H. Shalaby, H. Ghafouri-Shiraz, Estimation and cancellation of multi-user interference in synchronous fiber-optic PPM-CDMA system using Manchester coding, Optics & Laser Technology 33 (2001) 573–580

[17] Young Gil Kim, A. J. Han Vinck, A New Collision Arbitration Algorithm for FM0 Code in RFID Applications, 2007 International Conference on Multimedia and Ubiquitous Engineering(MUE'07), 2007.

[18] SungSoo Kim, YongHwan Kim, SeongJoon Lee, KwangSeon Ahn, An Improved Anti Collision Algorithm using Parity Bit in RFID System, Seventh IEEE International Symposium on Network Computing and Applications, 2008.

[19] Nak-Gwon Choi, Hyuek-Jae Lee, Sang-Hoon Lee, Seong-Jeen Kim, Design of a 13.56MHz RFID system, International conference on Advanced Computing Technology, 2006, Feb. 2006.