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Improved RFID Anti-collision Protocol for EPCglobal Class-1 Generation-2

Mohammed Baqer M. Kamel
Computer Science Department, Faculty of Education for Girls, University of Kufa, Iraq

Abstract

One of the important feature in the RFID technology is its functionality without needs to line of sight which makes it more feasible than other similar technologies. The problem occurs when more than one tag reply to the reader at the same time and collide together. To resolve the mentioned issue an anti-collision algorithm has to be used. The anti-collision algorithms are mostly efficient if the number of tags are small and has not been designed for large number of tags. In some applications that the number of tags may be hundreds of tags the existing mechanism may reduce the performance of the system due to delayed algorithms. In this paper an improved anti-collision protocol has been proposed. A modified two-parameter step size method for Q algorithm is also used to increase the efficiency of reading. The step sizes are adjusted depending on collisions in previous round. The number of slots in each round is also adjusted to prevent collisions in next rounds. The performance of proposed protocol has been evaluated using RFID module that implements EPCglobal C1G2 and designed especially for IoT environment and find the proposed protocol effective.

Keywords: *RFID, Anti-collision, EPCglobal, Q algorithm, DFSA*

1. Introduction

Radio Frequency Identifier (RFID) [19] with distinguished features comparing to similar technologies like its functionality without requiring to Line-of-Sight have widely used in numerous fields [13]. RFID is one of the main technologies that uses along with IoT [23] in various purposes [22] such as tracking, monitoring and identification [20]. The systems that designed using other technologies [12] could be replaced by RFID as an alternative technology to give better performance [2]. RFID system consists of two parts: readers and tags. Reader which has high computation capability is used to broadcast a signal to all near tags and read the incoming replies. The tag which is usually placed on the object communicates with reader to perform the required function. RFID tag has two main categories: active and passive [9]. The active tag provides with internal power to start communicating with near readers and tags. The passive tag has no internal power and receives the communication power from the transmitted RF waves of reader. The passive RFID technology is mostly used for identification of mobile objects.

When more than one RFID tag response to a reader simultaneously, a collision may occur. Therefore, an anti-collision protocol has to be used in order to prevent the collisions. RFID anti-collision protocols can be classified into deterministic and probabilistic methods [17]. In deterministic protocols that are mostly tree based protocols, each tag is identified by a unique identification number in a tree manner until identification of all collided tags. The probabilistic protocols are mostly based on Additive Link On-line HAwaii (ALOHA) and the tags are respond in randomly generated time to reduce the probability of collision.

EPCglobal Class-1 Generation-2 [8] is a UHF based RFID standard that uses Electronic Product Code (EPC) developed by EPCglobal organization. This standard uses passive tags in which the reader always starts the session and operates on 860 to 960 MHz [9]. To prevent the collisions in multiple tags, Q algorithm [5] and Dynamic frame slotted ALOHA [16] (DFSA) are used by this protocol. DFSA uses dynamic frame length depending on occurrence of collisions in previous cycle and considered to be higher performance that similar anti-collision algorithm [6]. This paper proposes a protocol using adaptive two-parameter step size along with a tag estimation method to solve the problem of collide passive tags in UHF RFID based on EPCglobal C1G2. It is designed and tested on IoT scenarios.

The rest of this paper is organized as follows. In section 2 types of collisions are explained. In section 3, a literature review of related works is discussed. Section 4 shows the proposed protocol to mitigate the collisions. In section 5 the test and analysis based on proposed protocol are discussed. Finally, in section 6 a number of conclusions are mentioned.

2. RFID Collisions

There are three main types of collision [1]: reader-to-tag, reader-to-reader and tag-to-tag collisions. The first type of collisions as shown in figure 1 occurs when a tag located in transmission range of two or more readers. In this case the tag communicates with more than one reader while each one of the communicating readers will suppose that it is the only reader communicating with the tag.

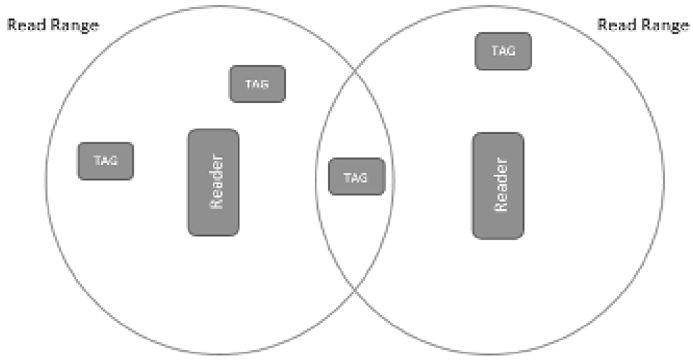

Figure 1. Reader to Tag Interference

The second type of collisions as shown in figure 2 occurs when two or more readers in the same range transmit a signal that interfere with each other and result in affecting the normal operation of other readers.

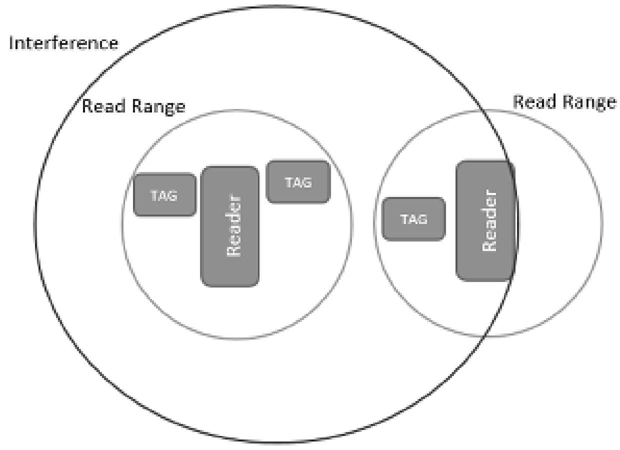

Figure 2. Reader to Reader Interference

The third type of collisions occurs when multiple tags try to communicate with the reader at the same time. Figure 3 shows the tag to tag collisions. This paper proposes an anti-collision protocol to solve this type of collisions.

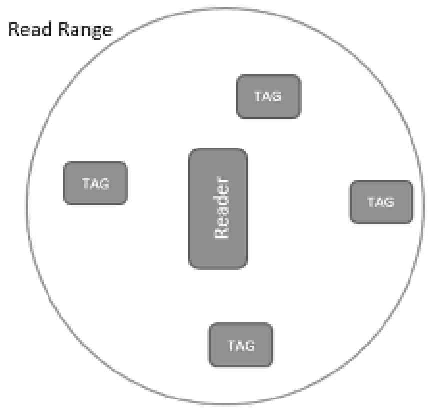

Figure 3. Tag to Tag Interference

In normal operation of tag identification, a tag sends an identification request to reader. The reader will identify the tag using various methods. When multiple tags try to identify themselves simultaneously, their transmitted signals may collide. Therefore, there has to be a coordination between tags and reader in order to prevents the possible collide connections.

3. Literature Review

There are number of anti-collision protocols which propose methods that try to reduce the possible collisions.

Cha and et al [3] proposed two dynamic frame slotted ALOHA based algorithms using Tag Estimation Method (TEM) which allocate dynamic size for frame in each round depending on estimating number of tags in each round. Band and et al [1] proposes QT reservation, BT anti-collision and enhance the speed of identification by using combination of these two methods. Jia and et al [11] proposed a protocol called collision tree protocol (CT), that finds the collision tree in communication between reader and tags and uses the collided bit to split the collided tags into groups.

Chen and Kao [4] proposed a novel Q algorithm by modifying step size value and splitting it into two parameters. Su and Wen [18] proposed a capture aware anti-collision algorithm that using probabilistic method to estimates the ideal frame length. Fu and et al [10] proposed a method called 4QTAP to avoid random responding and estimate time slot of responding of tags to the reader. Their method is based on 4-ary QT and ALOHA that uses both metrics of QT and slotted ALOHA.

Because of limited computation power of tags, anti-collision protocols have to result in minimal delay and power consumption and operates efficiently. They also have to be developed with ability to work in huge environment such as IoT scenarios. The proposed algorithm has been designed to meet the criteria of working in huge environments and evaluated using RFID module which is designed especially for IoT environment.

4. Proposed Anti-Collision Protocol

Due to low computation power of RFID tags and lack of internal power and ability to start the communication with neighbor objects, the applied anti-collision protocol has to be modified the basic method on the reader and keep the tags mechanism unchanged.

The reader issues a *Query* command in order to start a new round to identify tags. If no tag response in a slot, the reader resends *Query* command to start a new round or *QueryRep* to repeat the slot. The *Query* command will detect the tags that response in current round. Each *Query* has a Q parameter in which the participant tags will select a random number in range 0 to 2^Q-1 that determine their waiting period. The Q parameter in each round is computed by rounding Q_{fp} (Q floating point) value. The proposed system uses the modified technique of adjusting Q value method in [4] and [14]. The Q_{fp} adjustment will follow equation 1:

$$Q'_{fp} = \begin{cases} Q_{fp} - C_2 & ,no\ reply \\ Q_{fp} + C_1 & ,multiple\ reply \\ Q_{fp} & ,single\ reply \end{cases} \quad (1)$$

In which C_1 and C_2 are the step sizes. Since the decrement of Q_{fp} has to be less than the increment of Q_{fp} [4] and the typical value of C is 0.1<C<0.5 [21], the value for C_1 and C_2 will be $0.1<C_1<C_2<0.5$. figure 4 shows the adjusting of Q value parameter.

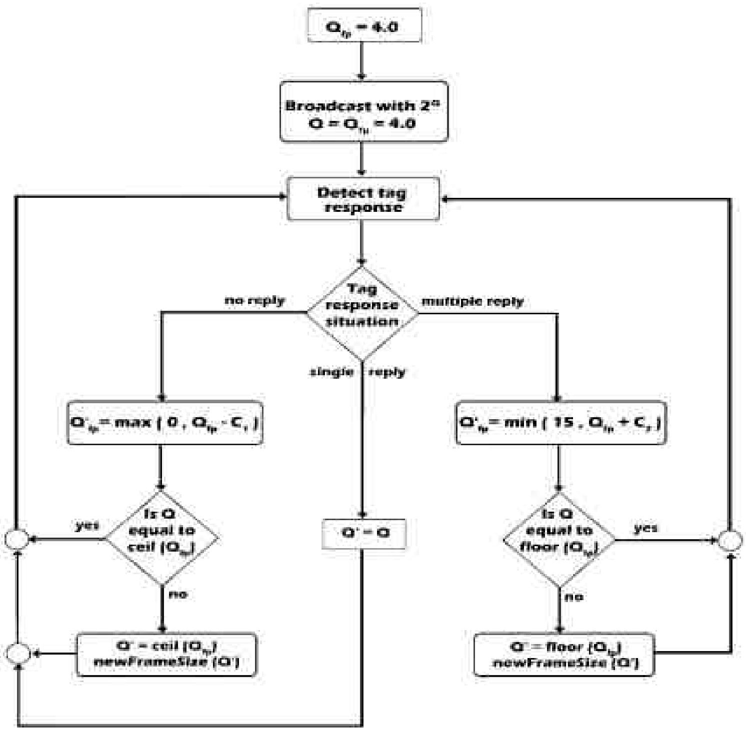

Figure 4. Adjustment of Q Parameter

After *Query* and generating the RN16 on tag side, if only one reply has been received by reader, it will acknowledge the same RN16 to the specific tag. The acknowledged tag will return back its protocol control, EPC and CRC-16 (which guarantee error-free delivery of transmitted data) [7] to the reader. The reader issues a *QueryRep* to move to the next slot.

There are two cases in which the Q parameter has to be adjusted. In case of no reply and multiple reply. If no reply received or if collision happened, the reader has to find the new value of Q using equation 1. After computing the new Q parameter, the reader informs the tags using *QueryAdj* about new Q parameter. The proposed protocol finds the ideal number of slots [3] by computing the probability of r tags out of available n tags can transmit their IDs in L slots per round is as in equation 2:

$$P(r) = \binom{n}{r}\left(\frac{1}{L}\right)^{r}\left(1-\frac{1}{L}\right)^{n-r} \quad (2)$$

Based on probability of collisions, the collision ratio (C_R) which is the ratio of number of collided slots to the total number of slots L in a frame can be calculated using equation 3:

$$C_R = 1-\left(1-\frac{1}{L}\right)^{n}\left(1+\frac{n}{L-1}\right) \quad (3)$$

Depending on collision ratio and number of slots in previous frame the number of tags (n) will be computed. The slots in next round can be adjusted to be same as number of tags to prevent the possible collisions. The second method of estimating number of tags is by multiplying number of collided slots in previous round by 2.39 [16] which results in finding the estimated number of tags.

5. Performance Analysis of Proposed Protocol

A comparison of proposed anti-collision protocol and standard RFID anti-collision protocol has been performed. The performance of proposed protocol has been evaluated using RFID module [15] that implements EPCglobal C1G2 and designed especially for IoT environment. Table 1 shows the used parameters in the simulation.

Table 1. Simulation Parameters

Parameters	Value
Simulator	NS (ver. 2.35) / RFID module
Simulation time	120 s
Simulation area	30m x 30m
Number of tags	50 to 700
Number of readers	1
Initial positions	15m X 15m
Movement	20m x 20m
Speed of objects	0 – 1.0 mps

The protocol throughput and delayed slots as a result of collisions have been used to evaluate the performance of proposed protocol. The proposed protocol increases the success tag identification and decrease number of collisions comparing to standard EPCglobal C1G2 [8]. The throughput of the proposed system has been computed as a percentage of successful identification slots to the total used slots and has been found that the number of successful slots higher than EPCglobal C1G2 between 5% and 18% in all performed tests in which the numbers of tags varies from 50 to 700. Figure 5 shows the throughput of proposed protocol comparing to the EPCglobal C1G1.

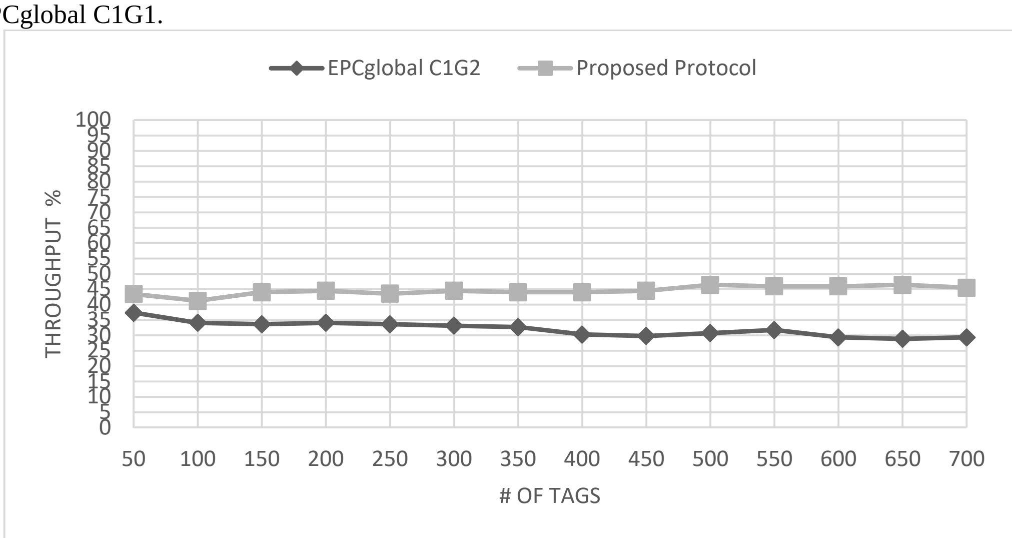

Figure 5. Throughput of Proposed Protocol

The delayed slots have been compared as shown in figure 6. The analysis of different cases (50 to 700 tags) show that there are 24% to 32% less delayed slots in proposed protocol.

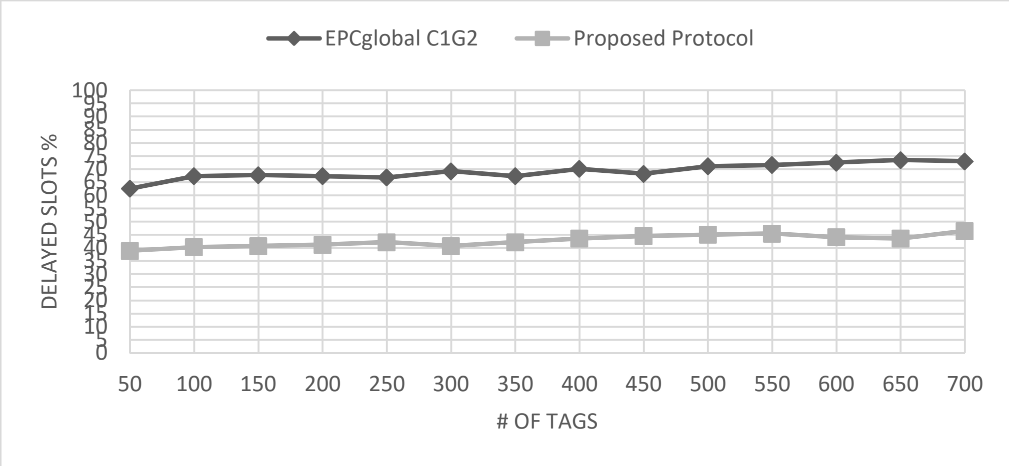

Figure 6. Delayed Slots of Proposed Protocol

6. Conclusions

In this paper an anti-collision protocol has been proposed. The proposed protocol improves the efficiency of basic EPCglobal C1G2 by using an improved method to update Q parameter using two step size instead of one which leads to compute an accurate Q value. The number of tags are also estimated in order to adjust the appropriate slot size which leads to decreasing in number of delayed slots and avoids decreasing in system efficiency that causes by collisions. The performance of proposed protocol has been evaluated using RFID module designed especially for IoT environment and find the proposed protocol effective in terms of increasing the throughput and decreasing the delayed slots.

References

[1] Bang, O., Choi, J., Lee, D., and Lee, H., (2009), “Efficient Novel Anti-collision Protocols for Passive RFID Tags”, Auto-ID Labs White Paper.

[2] Catarinucci, L., De Donno, D., Mainetti, L., Palano, L., Patrono, L., Stefanizzi, M.L. and Tarricone, L., (2014), “Integration of UHF RFID and WSN technologies in healthcare systems”, In RFID Technology and Applications Conference (RFID-TA), 2014 IEEE, pp. 289-294.

[3] Cha, J.R. and Kim, J.H., (2005), “Novel anti-collision algorithms for fast object identification in RFID system”, In Parallel and Distributed Systems, 2005. Proceedings. IEEE 11th International Conference on, vol. 2, pp. 63-67.

[4] Chen W. and Kao W., (2011), "A Novel Q-algorithm for EPCglobal Class-1Generation-2 Anti-collision Protocol", World Academy of Science, Engineering, and Technology, vol. 5, no. 6, pp. 774-777.

[5] Chen, Y. and Zhang, F.H., (2010), “Study on anti-collision Q algorithm for UHF RFID”, In IEEE Communications and Mobile Computing (CMC), 2010 International Conference on, vol. 3, pp. 168-170.

[6] Cheng, T., and Jin, L., (2007), "Analysis and Simulation of RFID Anti-collision Algorithms", In IEEE Advanced Communication Technology, The 9th International Conference on, vol. 1, pp. 697-701.

[7] Duc, D.N., Park, J., Lee, H. and Kim, K., (2006), “Enhancing security of EPCglobal Gen-2 RFID tag against traceability and cloning”, In SCIS 2006. Institute of Electronics, Information and Communication Engineers, pp. 97-102.

[8] EPCglobal, (2008), “EPC radio-frequency identity protocols class-1 generation-2 UHF RFID protocol for communications at 860 MHz-960 MHz”, version 1.2.0.

[9] Finkenzeller, K., (2003), “RFID Handbook: Radio-Frequency Identification Fundamentals and Applications, Second Edition,” Wiley & Sons Ltd.

[10] Fu, Z., Deng, F. and Wu, X., (2016), “Design of a Quaternary Query Tree ALOHA Protocol Based on Optimal Tag Estimation Method”, Information, vol. 8, no. 1, p.5.

[11] Jia, X.L., Feng, Q.Y., and Ma, C.Z., (2010), “An efficient anti-collision protocol for RFID tag identification”, IEEE Communications Letters, vol.14, no.11, pp.1014-1016.

[12] Kamel, M. B. M. and George, L. E., (2013), “Remote Patient Tracking and Monitoring System”, International Journal of Computer Science and Mobile Computing, vol.2, no.12, pp.88-94.

[13] Miodrag, B., Simplot-Ryl, D., and Stojmenovic, I., (2010), “RFID systems: research trends and challenges”, John Wiley & Sons.

[14] Moshref, M., (2017), "Improved Anti-Collision Algorithm for Tag Identification in Future Internet of Things", I. J. Computer Network and Information Security, vol. 3, pp.11-20.
[15] Mota, R.P.B. and Batista, D.M., (2013), "An ns-2 module for simulating passive rfid systems", In High Performance Computing and Communications & 2013 IEEE International Conference on Embedded and Ubiquitous Computing (HPCC_EUC), 2013 IEEE 10th International Conference on, pp. 2263-2270.
[16] Schoute, F. C., (1983), "Dynamic Frame Length ALOHA", IEEE Transactions on Communications, vol. 31, pp. 565-568.
[17] Shih, D., Sun, P., Yen, D., and Huang, S., (2006), "Short Survey: Taxonomy and Survey of RFID Anti-collision Protocols", Computer Communications, vol. 29, Issue. 11, pp. 2150-2166.
[18] Su, J. and Wen, G.J., (2012), "A capture-aware anti-collision algorithm for iso 18000-6c rfid protocol", In IEEE Wavelet Active Media Technology and Information Processing (ICWAMTIP), 2012 International Conference on, pp. 291-294.
[19] Weinstein, R., (2005), "RFID: A Technical Overview and Its Application to The Enterprise," IEEE IT Professional, vol. 7, Issue. 3, pp. 27-33, 2005.
[20] Welbourne, E., Battle, L., Cole, G., Gould, K., Rector, K., Raymer, S., Balazinska, M., and Borriello, G., (2009), "Building the Internet of Things Using RFID: The RFID Ecosystem Experience," IEEE Internet Computing, vol. 13, no. 3, pp. 48-55.
[21] Wu, H., Zeng, Y., Feng, J. and Gu, Y., (2013), "Binary tree slotted ALOHA for passive RFID tag anticollision", IEEE Transactions on Parallel and Distributed Systems, vol. 24, issue. 1, pp.19-31.
[22] Jia, X., Feng, Q., Fan, T., and Lei, Q., (2012), "RFID Technology and Its Applications in Internet of Things (IoT)", In IEEE Consumer Electronics, Communications and Networks (CECNet), 2012 2nd International Conference on, pp. 1282-1285.
[23] Zanella, A., Bui, N., Castellani, A., Vangelista, L., and Zorzi, M., (2014), "Internet of Things for Smart Cities", IEEE Internet of Things Journal, vol. 1, no. 1, pp. 22-32.

Mohammed Baqer M. Kamel received the M.Sc. degree from University of Baghdad / Iraq. He also received IT Administration from Technische Universität of Berlin / Germany. He was the top student of the department of computer science, at the college of science during the Master degree at University of Baghdad. He also was the top IT Administrator of the IT administration special course at the ZiiK center in Faculty of electrical engineering and computer science at TU Berlin. He also received B.Sc. in computer science holding top student of the university in University of Al-Qadisiya.
Mr. Kamel achieved the Iraqi minister of higher education and deputy of prime minister awards for holding the highest GPA in undergraduate program. His Interested Research Fields are: AdHoc Networks, Protocol Optimization, Mobile Computing, Network security, E-Health systems and GPS applications.