An Anti-collision Algorithms for Optimum Throughput in Passive RFID Identification System

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***Abstract*: This paper proposes an ALOHA based Dynamic Framed Slotted ALOHA algorithms using analytical procedure to estimate the number of tags within the radio range of the reader, and Time Division Multiple access (TDFSA) to dynamically allocate number of slots per frame through which the tags send their response to the reader. The common algorithms used for anti-collision algorithm in RFID system is the Framed slotted aloha, however most of the previous algorithm suffer from optimum object identification especially when the number of tags progressively increase. It is therefore the aim of this paper to propose an algorithm that can adaptively estimate the communication channel size with variation in the number of tags. The performance of the proposed TDFSA (Time Division Framed Slotted ALOHA) is compared to DFSA (Dynamic Framed Slotted ALOHA) using simulation. Simulation results show that the proposed algorithm though increases latency compared to DFSA by 3% outperforms the DFSA in throughput by 29% especially n scenario where many tags are involved.**

***Keywords*: tags, ALOHA, control packet collision, intelligent agents, data warehouse, reader**

I. INTRODUCTION

Modern information systems are used by organizations to acquire, interpret, retain, and distribute information [1]. The cost-performance capabilities of organizations in performing this tasks has been steadily improved through technological innovations in information technology (IT). The use of intelligent agents and knowledge management systems enable managers to interpret data and information from various sources in order to create useful managerial knowledge [2], [3]. The availability of vast data warehouses has been made possible through technical improvements in storage media, similarly the increasing processing power of the microcontroller enables managers to mine their data for useful information about their operations, existing customers and potential markets. The current breakthrough in real-time decision making has been made possible through advances in technology based real-time information gathering and decision support systems. This has ultimately led to organizations in refining their operational performance.

In recent times the use of RFID (Radio Frequency Identification) has replaced the use of bar codes for use in the distribution industry, supply chain and banking sector, this technology is generally referred to as IoT (Internet of Things). This is due to the fact that it doesn't require the use of line of sight. However the reliable identification of multiple objects has been a challenging proposition especially when information from such objects need to be aggregated and sent to a processing centre. A RFID system consists of a reader and the tag, messages are broadcast by the reader in RFID system to the tags. When the tags receive these messages, they respond with an acknowledgement to the reader. If the reader receives acknowledgement from only one tag, it means only one response is received and there is no problem. However if more than one tag response is received, their responses will collide on the RF communication channel, and thus cannot be received by the reader. This results in the collision of responses, a situation referred to as ”Tag-collision”. There are two types of RFID technology (i) passive RFID in which the tag has no power source, but derives its power from the reader and (ii) the active RFID in which the tag has a battery power source and therefore has a wider coverage area. The major limitation in the RFID technology [4-7] is when more than one tag from a plethora of objects respond to the reader, their responses can collide on the RF communication channel, and thus cannot be received by the reader. This is referred to as the "tag-collision".

One of the basic requirements of a good RFID system is the ability to identify multiple tags simultaneously thereby avoiding this collision by using anti-collision algorithm [1],[2],[3],[4]. The limitation of the Anti-collision algorithm using ALOHA-based method described in [5] was that it did not consider the mute state in which tags do not respond to next reader's request temporarily. Similarly the Dynamic Slot Allocation (DSA) algorithm introduced in [6], did not give detailed procedure on how to dynamically allocate the frame size. This results in limitation in the application of these two methods in RFID system. This paper presents an improvement on the ALOHA-based anti-collision algorithms. We propose a modification to the Dynamic Framed Slotted ALOHA algorithms (DFSA) used by researchers in [10] using Time Division Multiple Access Frame Slot Allocation (TDFSA) and Tag Estimation Method (TEM). Comparisons will be made between the DFSA and the TDFSA using MATLAB simulation. The rest of the paper is organized as follows; the second section discusses related works on RFID protocol, section three describes the common anti-collision algorithms for RFID system, section four describes the protocol used in this paper, section five gives results of simulation experiments and analysis thereof while section six concludes the paper.

II. RELATED WORKS

A good number of researchers have been addressing the problem of tag collision in RFID systems. While some methods seem to increase data transmission speed through extending the frequency bandwidth so as to increase tag identification efficiency thereby minimizing tag collisions. The frequency bandwidth is always limited hence the result will not always be satisfactory. The techniques most widely used in the industry is the framed slotted ALOHA algorithm and binary search algorithm. Due to the simplicity of implementation of the framed slotted ALOHA algorithm, it has a wider use than the binary search algorithm which uses the binary tree data structure [7], [8], [9]. It is also advantageous to the binary search algorithm due to the latency involved in detecting all objects within the radio range of the reader. The latency in the binary search algorithm causes security issues in the algorithm.

For example, Type A of ISO/JEC 18000-6 and 13.56 MHz ISM ban EPC Class 1 use the Framed Slotted ALOHA algorithm and Type B of ISO/JEC 18000-6 and 900 MHz EPC Class 0 use the binary search algorithm. As most RFID systems use passive tags, frame sizes are limited in the framed slotted ALOHA algorithm [12], [13], [14], 15] due to the smaller coverage area of the tag. In the slotted ALOHA algorithm, a slot number in a frame is randomly selected by a tag. The tag then responds to the reader using the slot number it selected. The probability of collision in this method is low when the number of tags is small, and ultimately the time needed to identify the all tags is relatively short. However as the number of tags increases, the probability of tag collision becomes higher and the time used to identify the tags increases rapidly.

Su- Ryun et al. [8] proposed an enhanced dynamic framed slotted ALOHA algorithm for RFID tag identification. Their algorithm results in a slot efficiency of more than 85% for about 1000 tags with frame size up to 256 slots. Huang [8] formulated a mathematical model for anti-collision in RFID system and came to the conclusion that the method presented in [11] was a special case of his model in [8]. In [12] the researchers first extended the results obtained [8] in order to derive a model involving a very large number of passive tags in an identification RFID system, with the aim of dynamically maintaining maximum efficiency in the whole identification process. The researchers in [10] proposed two ALOHA-based Dynamic Framed Slotted ALOHA algorithms (DFSA) using Tag Estimation Method (TEM) to estimate the number of tags in the coverage area of the reader, and Dynamic Slot Allocation (DSA) to allocate the frame size dynamically according to the number of tags. The shortcoming in the protocol is the increase in the number of collisions especially when the number of tags is greater than the estimated value.

In this paper, comparison is made between the performance of the proposed TDFSA with the conventional Framed Slotted ALOHA algorithm (FSA) and DFSA algorithm using simulation. In this paper we digress from this probabilistic approach to define an algorithm for anti-collision in RFID system using Time Division Multiple Access. It is argued here that this method will proffer an improvement over the probabilistic approach and thereby results in low latency and higher throughput in object identification. The analyses in [13] will also be discussed with a view to highlighting the problems and making corrections. Simulation results show that even though the TDFSA protocol lead to an increase in latency as compared to the DFSA, its throughput as measured with the collision frequency more than make up for this deficiency.

III. CATEGORIES OF ANTI-COLLISION ALGORITHMS

The first generation of Anti-collision algorithms for RFID systems was encouraged by the exploitation of the range of unlicensed UHF frequencies. This was implemented through the use of unlicensed industrial, scientific, and medical (ISM) bands. Among the companies that proffered these algorithms are EPCglobal, an organization that recognized the potential of RFID early. The International Standards Organization (ISO) originated the other standards as part of the ISO 18000 family, this comprises of 6 groups of documents dedicated to UHF operation. A comparison of the major attributes of the significant UHF standards is shown in table 1. The EPCglobal proposed the bit-based Binary Tree algorithm (deterministic) and ALOHA-based algorithm (probabilistic) for anti-collision algorithms. They also proposed the

Table 1 First-generation UHF standards for RFID tag

Standards	Anti-Collision Algorithm	Tag Read Speed	Throughput
EPCglobal CLASS 0 (UHF)	Bit-Based Binary tree (Deterministic)	Avg : 200 tags/s Max : 800 tags/s	Avg : 60% Max : 80%
EPCglobal CLASS 1 (UHF)	Binary tree (Bin Slot) (Probabilistic)	Not specified	
ISO 18000-6 TYPE – A (UHF)	Dynamic Framed ALOHA (Probabilistic)	Avg : 100 tags/s	Avg 72%
ISO 18000-6 TYPE – B (UHF)	Binary tree (Probabilistic)	Avg : 100 tags/s	Avg 84%

Table 2 TAG identification

TAG SERIAL	TAG ID
TAG 1	0010
TAG 2	0101
TAG 3	1100
TAG 4	1101

READER	1^{ST} REQ	Slot 1	Slot 2	Slot 3	Slot 4	2^{nd} REQ
STATE	0010	0010	IDLE	COLL	1101	
TAG 1 (0010)		0010				
TAG 2 (0101)				0101		0101
TAG 3 (1100)				1100		1100
TAG 4 (1101)					1101	

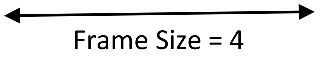

Figure 1 The FSA Procedure

Adaptive protocol which is similar to the ALOHA-based algorithm proposed by EPCglobal, and binary tree search algorithm [6]. One of the first implementation of the anti-collision algorithm was the Frame Slotted ALOHA (FSA) which is ideal for the optimization of low throughput RFID system where low latency of tags is not an issue.

The operation of the FSA is based on collision arbitration sequence which performs a census of the tags present in the reader field and then receive information on tag ID. The operation of the collision arbitration sequence is as follows; (i) allocation of tag transmission into frames and slots, with a given number of slots per frame. The tag can respond to the control packet from the reader using any of the slots for a round of communication between the tag and reader. (ii) A slot duration is defined such that it is long enough for the reader to receive a tag response. The actual duration of a slot is determined by the reader. (iii)The reader first sends its request to the tags and waits for a certain amount of time for their answers. A collision occurs when multiple tags use the same slot resulting in data loss. The procedure of FSA is shown in Fig. 1 and an illustration of how the transmission of four tags can be identified is shown in table 2. In the FSA algorithm the reader sends REQ control packet (Request command sent by the reader) to the tags. The tags respond by randomly selecting a slot, the frame size which is defined as the number of slots in a round is determined by the reader[5], [7], [8], [9].

As can be seen in Fig. 1, TAG 1, TAG 2, TAG 3, and selected Slot 1, Slot 3, Slot 3, and Slot 4 respectively. There are no tags assigned to Slot 2 hence it is idle, Slot 1 and Slot 4 has only one tag assigned to the channel i.e. TAG 1 and TAG 4 respectively, therefore both channels will accomplish successful transmission. However there will be collision in Slot 3 where two tags TAG 2 and TAG 3 forwarded their response. This will then require a retransmission in next reader's request (2nd REQ).

IV. DFSA ALGORITHMS AND PERFORMANCE ANALYSIS

The shortcoming of the FSA algorithm is that when the number of tags is much higher than the number of slots available, the delay in the identification of a set of tags increases substantially. On the other hand, wasted slots occur when the number of tags is lower than the number of slots leading to inefficient channel utilization. Therefore, there is the need to appropriately vary the frame size according to the number of tags. This led to the design of the Dynamic Slot Allocation (DSA). DSA is introduced in [4],[7], however the researchers did not give a detailed description on how to dynamically allocate the frame size. This is because they (researchers in [4], [7]) did not consider the mute state, which is the state in which tags don't temporarily respond to the reader's next request [4.]. In this paper, two DFSA algorithms will be proposed using a combination of TDMA and CDMA. The proposed algorithms estimate the number of tags using TEM I and TEM II as defined in DFSA I and DFSA II respectively.

4.1 Time Division Multiple Access Frame Slot Allocation (TDFSA)

This section proposes two methods to obtain the optimal frame size. For any given number of tags. In the first instance, the delay (D) which is defined as the time taken by the tags to transfer their ID successfully is as shown in equation 1.

D = number of retransmission × frame size (1)

It should be realized here that since the value of the frame size is only known after a round, therefore in order to calculate the delay (D), the number of retransmission needs to be determined. The probability (p) that only one tag transmits over particular slot in a frame is 1/T. (where T is the number of slots per frame). Then the probability for a successful transmission of a tag ID along any given slot is given by equation 2

$$P_{CORR} = \frac{1}{T} \text{ X } \left(1 - \frac{1}{T}\right)^{n-1} \qquad (2)$$

Similarly, the probability that there is successful transmission of only one tag ID in a frame slot (U) is given by equation 3

$$P_{CORR}(U) = \frac{1}{T} \text{ X } \left(1 - \frac{1}{T}\right)^{n-1} \text{ X } U = \left(1 - \frac{1}{T}\right)^{n-1} \qquad (3)$$

If $P_{CORR}(U)$ is the probability that one tag successfully transmits its ID in uth frame. Then $P_{CORR}(k)$ is given by equation 4

$$P_{CORR}(U) = P_{CORR}(U)\ \left(1 - P_{CORR}(T)\right)^{U-1} \qquad (4)$$

The average number of retransmission for one tag using the mean of geometric distribution, is given by equation 5.

$$E[\ X = u] = \sum_{u=1}^{\infty} uP_{CORR}(u) = \frac{1}{(1-\frac{1}{T})^{n-1}} \qquad (5)$$

Therefore, D can be computed from equations 1 and 5 to get the expression in equation 6

$$D = \frac{T}{(\ 1-\frac{1}{T}\ )^{n-1}} \qquad (6)$$

We now move to derive an expression for the optimal frame size (Loptimal). In order to calculate L when D is minimum, equation 6 will be differentiated to obtain the expression in equation 7.

$$\frac{d}{dn}\ D = \frac{d}{dn}\frac{L}{(\ 1-\frac{1}{T}\ )^{\ n-1}} \ = \ 0 \qquad (7)$$

$L_{optimal}$ can be computed from equation 7 to get the solution given in equation 8

$$L_{optimal} = n. \qquad (8)$$

The second method which will be used to compute the optimal frame size is by using the throughput of the system. The probability that there is no successful transmission of a tag ID in a slot is as shown in equation 9.

$$P_{free} = (\ 1 - p\ )^{n} \qquad (9)$$

where n is the number of rounds required to scan all objects within the coverage area of the reader. The probability that at least one tag has a successful transmission of its tag ID is given by equation 10.

$$P_{\mathbf{CORR}} = np(1 - p)^{n-1}. \qquad (10)$$

Therefore, the probability of a collision in a given slot is given by equation 11.

$$Pjam = 1 - Pfree - P_{CORR} \qquad (11)$$

Throughput M can now be defined by equation 12.

$$M = \frac{P_{CORR}}{P_{CORR}\ + P_{jam}\ + P_{free}} \ = np\ (1 - p\ )^{n-1} \qquad (12)$$

The throughput is maximum when

$$\frac{dM}{dp} = n(\ 1 - p\ )^{\ n-1} \ - n(n - 1\ )p\ (\ 1 - p\ )^{\ n-2} = 0 \qquad (13)$$

Solving equation 13 yields the solution given by equation 14

$$P = \frac{1}{n} \qquad (14)$$

From this solution, the optimal frame size ($L_{optimal}$) can be computed from equation 14 using the expression that the probability (p) that a tag transmit its response successfully along a particular slot in a frame be given by 1/L.

$$L_{optimal} = n. \qquad (15)$$

As can be seen from both equations (8) and (15) It can be found that the optimal frame size is the same either using the delay or the throughput of the system.

The next stage in the design is allocation of time for the successful transmission of a tag. This is given by equation 16

$$S = (\text{number of retransmission} \times \text{frame size}) / T\ . \qquad (16)$$

Substituting this in equation 1, gives D / T, hence each tag will be allocated time S = D/T in a round robin manner in order to send its response to the reader over successive slots (channels) in the frame. The idea here is that instead of the tags randomly transmitting their response over the slots, each identified tag will be assigned unique codes which will be transmitted over the different slots within the allocated time. This will automatically eradicate the possibility of multiple tags using a single slot or idle slots occurring within the frames.

From equation 14, it can be seen that the maximum throughput of the transmission is dependent on the probability of success and the number of round required to scan through all the objects (tags) in the coverage radius of the reader. From equation 14, it can be seen that the higher the number of tags, the lower the maximum throughput attainable. This is the contribution of the technique is substantial increase in throughput as validated through the simulations in section 5. The increase in throughput is due to reduction in collision of tags and the absence of idle slots. The next subheading describes the tag estimation method. This will help to determine the number of tags from which codes will be automatically assigned.

4.2. Tag Estimation Method

This section describes the procedure for estimating the number of tags in the coverage radius of a reader. The description proceeds as follows: Assume that the number of slots in a frame is given by T and the number of tags is d, probability that among the d tags, only c tags transfer their ID in a slot is given by equation 1

$$P\ (\ X = c\ ) = \binom{d}{d}\left(\frac{1}{T}\right)^{c}\ (\ 1 - \frac{1}{T})^{d-c} \qquad (17)$$

From the dynamic frame size allocation in [9]. The number of tags r in a particular slot is referred to as the occupancy number of the slot. Therefore the expected value of the number of slots having r as its occupancy number is as shown in equation 18

$$E\ (\ X = c\ ) = T\ \binom{d}{c}\left(\frac{1}{T}\right)^{c}\ (\ 1 - \frac{1}{T})^{d-c} \qquad (18)$$

In order to estimate the number n of tags in the coverage area of a reader, the collision ratio (Cratio) is defined as the ratio of the number of the slots with collision to the frame size, is as shown in equation 19

$$C_{ratio} = 1 - (\ 1 - \frac{1}{T})^{d}\ (\ 1 + \frac{d}{T-1}\ ) \qquad (19)$$

The frame size and the collision ratio is known after a round. Based on this information, the number of tags can be estimated. The simulation results based on this analytical mode in comparison to the TDFSA algorithm I shown in the next section.

4. 3 Transmission protocol in TDFSA

In order to transmit the response from the tags on the slots within the frame the following steps are taken:

i. The number of tags in the coverage radius of the reader is determined using equation 18

ii. A time slice of T = D/L is assigned to each tag in around robin manner in order to send its response on the slots.

iii. The estimated number of tags is equated to the number of slots per frame

iv. Each tag is assigned a code (Code Division Multiple Access) in other to transmit with a unique code on the channel

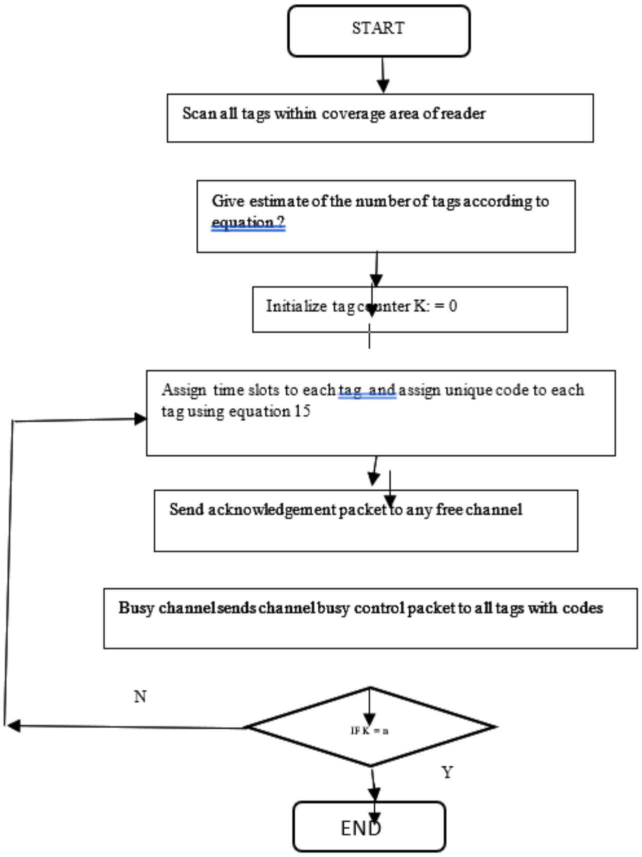

Figure 2 Flowchart for TDFSA4.

A tag will send its response only on a free channel. This is achieved by a busy channel sending a channel busy control packet to tags yet to respond to the reader's message broadcast.

v. Transmission of response from the tags is in synchronous fashion so that there will be no time differentials in sending data from the different tags. The flowchart for the TDFSA protocol is shown in figure 2.

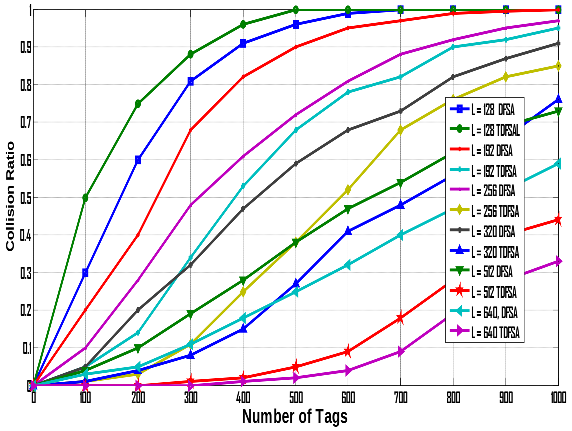

Figure 3 Ratio of Number of tags to Collision

V. SIMULATION RESULTS

The following section shows the results from simulation. The simulation was done in MATLAB 2017. Fig. 3 shows the comparison of the ratio of the number of tags to collision in DFSA and the TDFSA proffered in this paper. If nest is the estimate of the number of the tags (n) as given by equation 19. As can be seen from figure 3, if the frame size is 320 and the collision ratio is 0.46323 as measured by the reader, then the number of estimated tags nest1 is 400. This is based on the estimation from equation 19, The collision rate increases with increase in the number of tags, however, the TDFSA protocol designed in the paper reduced collision

the rate by 28% compared to DFSA algorithm. This is due to the unique code used in the identification of tags wherein each tags is scanned in a round robin manner before sending their response to the reader. Secondly the channel busy control packet sent by the occupied slots to all tags prevents tags from sending response on an already busy slot. From figure 3,it can be seen that when the range of the tags was within 0 – 300, and the frame size was 128 (SLOT 128), FSA algorithm shows good performance. However as the number of tag exceeds 300, the time required for tag identification increases in direct proportion for the time of SLOT 128. This increase gets more pronounced as the number of tags increases.

Therefore, if FSA algorithm is used for the purpose of resolving anti-collision problem in RFID system when the number of tags is known in advance, the performance of the FSA algorithm may become unstable as the number of tags increases. However, the pro- posed TDFSA combines both dynamic slot allocation with Time Division Multiple access to give high throughput in tag identification for a wide range of tag number.

The collision in TDFSA can only be as a result of unacknowledged response control packet from the tags and jitters in delay between tags and the reader.

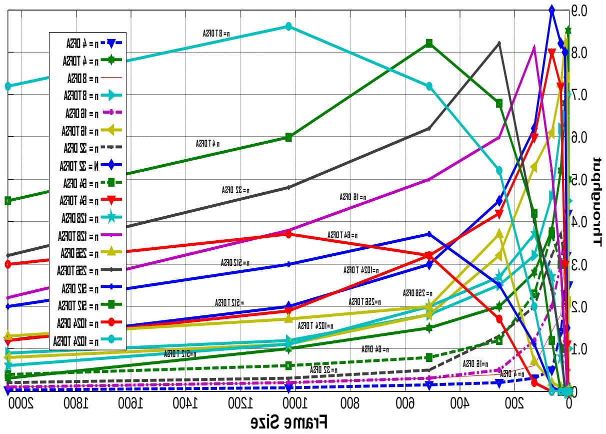

Figure 4 Throughput vs frame size

The comparison of throughput is shown in figure 4 between the DFSA and TDFSA algorithm for different number of slots per frame. On the average. The TDFSA outperforms the DFSA algorithm by 28%. This is due to the unique code employed in the TDFSA algorithm where each tag sends their response in

round robin manner, together with the control packet sent by all busy channels to te tags thereby preventing tags from sending response on an already occupied channel. From figure 4,it can be seen of the system is shown in figure 2 for the different frame size. From Fig. 2, the optimal frame size can be computed by equating the frame size with the estimated number of tags.

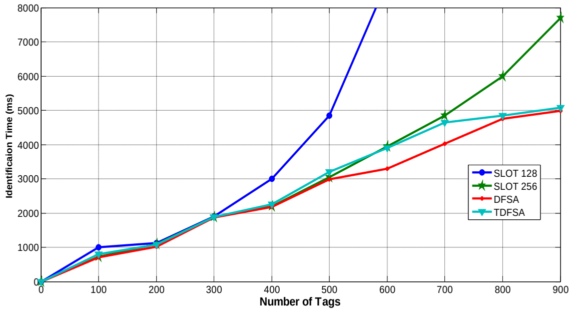

Figure 5. Time required for tag identification to the number of tags

Fig. 5 shows the results obtained from the time required in identifying tag for different number of tags. From the figure, SLOT 128 and SLOT 256 shows the mean conventional FSA algorithms using the fixed frame size with 128 slots and 256 slots respectively. DFSA represents the results obtained from the model proffered by researchers in [10] using TEM and DSA, while TDFSA represent the results from the protocol used in this paper.

The results obtained from the FSA (SLOT 128 and SLOT 256) was based on simulation experiments when the number of tags which were fixed to 128 and 256respectively. It can be seen from figure 5 that the performance of FSA algorithm varies according to the number of tags. The identification time foe the SLOT 128 algorithm is very high when the number of tags exceed 600, and hence wasn't captured in the graph. In general the TDFSA has a longer identification time when compared to the DFSA algorithm. This is due to the overhead involved in each occupied channel sending channel busy control packet to all tags within the reader's coverage radius. Secondly the tags must scan only free channels before sending its response, causing an increase in identification time due to selective channel search. The DFSA outperforms the TDFSA algorithm by 7%. However the comparative increase in throughput from figure 4 for the TDFSA far outweigh this slight limitation in latency in tag identification.

VI. CONCLUSION

A dynamic frame slotted ALOHA protocol is designed using Time Division Multiple Access. The strength of the algorithm is in substantial increase in throughput by reducing collision rate especially when many tags are within the coverage area of a reader. The performance measure used in determining optimal frame size was delay and throughput. The number of slots was estimated using the analytical procedure explained earlier and the tags were made to send their response in a round robin manner to the frame slots. Also the busy slots send busy control packet to the remaining tags in order to prevent collision. The performance of the proposed TDFSA was compared to that of FSA and DFSA algorithms using MATLAB simulation. The proposed TDFSA algorithms show better performance in reducing the collision rate, thereby increasing the throughput compared to the DFSA protocol by 26% and the FSA algorithm by 46% irrespective of the number of tags. Though the overhead in the TDFSA protocol caused an increase in latency compared to the DFSA protocol by 3% the gain in throughput far outweighs this shortcoming. The TDFSA protocol is therefore recommended in RFID system where the necessity of simultaneously identifying many tags is crucial for many applications. It will also contribute in improve the performance of RFID system due to its ability to reduce collision.

REFERENCES

[1] Huber G. P., (2014) "Organizational Learning: Contributing Processes and the Literatures," Orgizational . Sci., vol. 2, no. 1 pp 88-115.

[2] Standford, V. (2018) "Pervasive Computing Goes the Last Hundred Feet with RFID Systems," IEEE Pervasive. Computing. .

[3] Angeles R. (2019) "RFID Technologies: Supply-Chain Applications and Implementation Issues," Information. System. Management Jornal Vol 2 No 1 pp 51-65..

[4] Thompson C. A. (2018) "Radio Frequency Tags for Identifying Legitimate Drug Products Discussed by Tech Industry, Amer. J. Health System. Pharmaceutical journal . Vol 61, No 2 pp 1430-1431.

[5] Yang G. and Jarvenpaa S. I. (2019), "Trust and Radio Frequency Identification (RFID) Adoption within an Alliance," In Sprague R. (Ed.), Proc 38th Hawaii Intl. Conference System. Science Journal ., Big Island, pp 855-864, IEEE Comp. Soc. Press. Los. Alamitos, CA, USA.

[6] Singer P (2018). "A new Approach to Low Cost RFID Tags," Semiconductor Intl.. www.reed.electronlics.com/semiconldu.ctor/article/CA499653?-Dubd.ate=2

[7] Clemons E. K. and Wang Y. ((2015), "Special Issue: Tchnology Strategy for Electronic Marketplaces," Mgmt. Info. Sys. vol 17, no.2, pp.5 - 12.

[8] Xu Huang,"(2019) "An Improved ALOHA Algorithm for RFID Tag Identification," in the Proceeding of the KES 2019, the 17th International Conference on Knowledge Based & Intelligent Information & Engineering Systems, Bournemouth, UK, Vol 3 pp 9-11.

[9] Su-Ryun Lee, Sung-Don Joo, and Chae-Woo Lee, (2018) "An Enhanced Dynamic Framed Slotted ALOHA Algorithm for RFID Tag Identification," The Proceeding of the 8th Annual International Conference on Mobile and Ubiquitous Systems.

[10] Jae R. C and Jae H. K (2019) Novel Anti-collision Algorithms for Fast Object Identification in RFID System in Proceeding of the 18th International Conference on Parallel and Distributed Systems.

[11] Rom R. and Sidi M., (2006) "Multiple Access Protocols/Performance and Analysis." Springer-Verlag, pp 47-77, .

[12] Vogt H. (2015).~ Efficient Object Identification with Passive RFID Tags'in Journal of Artificial intelligence Vol 4 pp.98-113.

[13] Wieselthier J. E. , A. Ephermides A. and L. A. Michels L. A. ,(2002) "An exact Analysis and Performance Evaluation of Framed ALOHA with Capture," IEEE Tans. on Communications. Vol 37 No (2), pp l25-137.

[14] Vogt. H. ,(2017) "Multiple Object Identification with Passive RFID Tags," IEEE International Conference on Systems, Man and Cybernetics.

[15] Sarma S., Waldrop J., and Engels D. (2017), "Colour wave : An Anti- collision Algorithm for the Reader Collision Problem," IEEE International Conference on Communications, ICC '03, vol. 2, pp. 1206-1210.