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Improved Dynamic Frame Size with Grouping Slotted Aloha (IDFSG)

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Abstract: Radio Frequency Identification (RFID) system is an emerging technology in field of automatic identification and object tracking. It's a wireless communication between sender tag and receiver via radio frequency. One of the challenges it faces is tag collision at reader. It's an important factor that determines the performance of RFID system. Different approaches and algorithms have been developed to reduce collision and to efficiently read the RFID tags. The basic concept is the best utilization of time slots between reader and tag during data transmission. DFSG [17] algorithm improves EDFSA [19] by implementing dynamic group sizing technique. However it is dependent upon initial frame-length. The proposed algorithm removes initial frame-length dependency. The proposed algorithm is compared with previous techniques. Identification time, iteration taken to read group and system efficiency comparison is included in this research work. The proposed algorithm shows improved results for Identification time, iteration taken to read group and system efficiency is much closer to possible ideal values.
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Introduction:

RFID system is a result of an effort to have a low cost radio frequency system to communicate between two or more equipment. It consists of Reader (which send query) and a Tag (Accept the query and reply with its ID. In response of the reader broadcast query message all tags within range tries to reply and some replies arrive at the reader at same time resulting a misconception at reader end i.e collision. Aloha protocol [15] (better known as pure Aloha) was the first successful algorithm to cater this problem. However pure Aloha had very less successful transmission rate of 18.4%.

Slotted Aloha [16,21] was improved version of Pure Aloha. A communicator can send only at the timeslot beginning and not during the transmission of data. Slotted Aloha was further enhanced by N. Abramson [21] deciding frame size dynamically on the bases of tag estimation. This greatly improved Aloha and become bases of other anti-collision algorithms such as, An Enhanced Dynamic Framed Slotted ALOHA Algorithm (EDFSA) by S. Lee et al [19], Dynamic Grouping Frame-slotted Aloha (DGFS) by Mian Hammad Nazir at al [9] and Dynamic Frame Sizing with Grouping Slotted Aloha (DFSG) by Sobia Arshad et al [14].It was quite noticeable fact in RFID system that higher the numbers of tags available within the reader range greater the number of collision exists. The main requirement of any anti collision algorithm is to efficiently read all the tags in minimum possible time.

In following chapters we discuss frame-length and time slot concept. We will see previous anti-collision techniques and compare our scheme with them.

Material and Methods

RFID anti-collision algorithms can be categorized into two groups: Tree-based and Aloha based algorithms. A tree-based algorithm organizes tags identities in a binary search tree. Tree-based algorithms are considered accurate and have low computational cost but they are limited to few applications because of identification delay. Tree-based algorithms are examined by Hush et al [1] and by Myung et al [5]. Aloha based algorithms are less accurate and have low performance however they are more attractive because of less identification delay. EPC class 1 Generation 2 protocol is based upon Dynamic Frame Size Slotted Aloha. It restricts the frame-length to 2^k {where k =0 - 15}[4] where frame-length is time slices to read a tag and each time slice is known as slot . The identification delay increases and the throughput suffer badly when the number of available tags is much larger than the number of available slots in frame or *vice versa*. Commercial readers can be categorized as fixed frame-length non-customizable, fixed frame-length user-customizable and, variable frame-length readers [13]. Fixed frame-length readers have fixed frame size so same number of slots are available in each identification cycle [9]. Those readers which can change (increase or decrease) number of slots per frame without human interaction is known as variable frame-length readers [9]. In readers with fixed frame-length, non-customizable [6-8, 10, 11] frame length is pre-set by manufacturer. In Readers with fixed frame-length, user-customizable [12][11,13] frame length value {k= 0 -15} can be manually set by user . In most of the variable frame-length readers users can configure frame-length only for the first time [12][11,13]. Frame Slotted Aloha, Binary Frame size Aloha, Dynamic Frame size Aloha[15,16], Enhanced Dynamic Framed Slotted ALOHA [19], Dynamic Grouping Frame-Slotted Aloha[9] and Dynamic Frame Sizing with Grouping Slotted Aloha[14] are some of the examples.

2.1 DFSA and EPCGLOBAL CLASS-1 GEN-2 STANDARD

EPC Global Gen 2 or Class 1 Generation 2 defines the physical and logical requirements of RFID systems [18]. It operates between 860MHz ~ 960 MHz frequency. RFID systems comprised of electronic chips known as tags and reader. EPCglobal provides standards for RFID. It is mainly based on DFSA[17]. The EPCglobal Gen2 defines protocol to interaction between reader and tag using three procedures [17] as shown in figure 1.

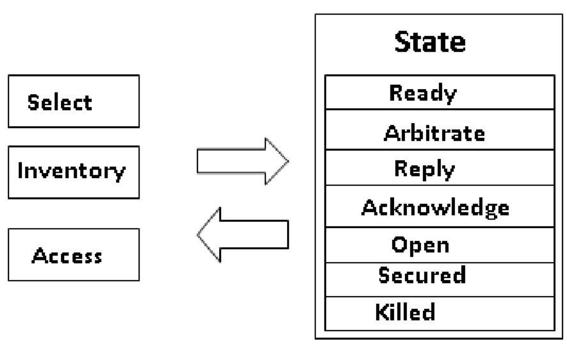

Figure 1: Read Procedure between RFID Reader and Tag [17]

During Select procedure reader selects the frame length for inventory. The frame has number of slots. The frame-length is defined by DFSA algorithm and its value is between k=0 -15. During Inventory process reader identifies all the tags available in his range by sending a query command. All the available tags will reply with their own 16 bit random number. During access procedure reader will read tags and for remaining tags reader will start again from Select procedure. The complete inventory procedure is shown in figure (2).

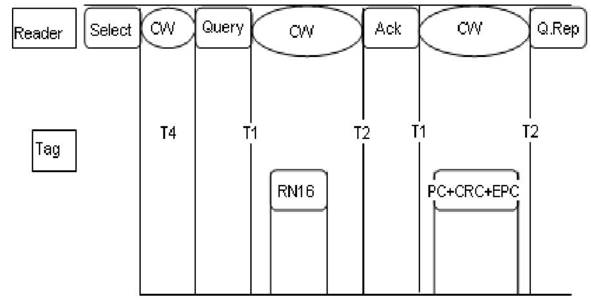

Figure 2: Generation 2 for Single tag reading

2.2 Mathematical analysis of DFSA

The maximum throughput of DFSA algorithm is approximately 37%. If t is the total number of tags available in reader's range and S is total number of slots available in frame-length then the maximum efficiency (E_{max}) can be defined using following equation [14].

$$E_{max} = \begin{cases} 1 & , t = 1 \\ (1 - 1/S)^{S-1} & , t > 1 \end{cases} \quad (1)$$

Table 1. Maximum RFID Efficiency using DFSA

t	1	2	4	8
E_{max}	1	0.5	0.42	0.393
t	16	32	64	128
E_{max}	0.38	0.374	0.371	0.369
t	256	512	1024	2048
E_{max}	0.368	0.368	0.368	0.371

Table1 shows the efficiency DFSA for different frame-lengths using equation (1).

2.3 Improvement of DFSA in DFSG

Dynamic frame sizing with grouping Slotted Aloha [14] (DFGS) adjusts frame-length dynamically along with tag grouping. DFGS shows efficiency around 0.368. DFGS is a grouping technique, we examine group tagging technique in next section.

2.4 Group tagging technique with variable frame sizing

Frame-length is limited to maximum size of 2^{15}. When reading very large or infinite number of tags, tag grouping is necessary because of the limitation of frame-length. Static and dynamic grouping are two main methods of tag grouping. Division of large number of tags into equal number of groups is known as Static grouping [19]. Enhanced Dynamic Frame Slotted Aloha (EDFSA) [19] is an example of Static grouping. The number of groups is determined by dividing total number of unread tags by maximum frame-length. EDFSA performance depends upon the initial frame-length selected since it does not adjust frame-length and frame size determines the number of groups. In dynamic grouping frame-length is variable and tags read in particular frame are categorized as one group. Select and Inventory steps shown in figure (1) are repeated for the remaining tags [20].

3. Result and Discussion

3.1 DFSG algorithm and its limitation

DFSG improved DFSA performance by dividing tags into groups but with limitations. The number of iteration DFSG takes to read a group depends upon initial frame size. While the frame-length is adjusted before tag reading, it gets reset to initial frame-length after every group reading which may or may not be the best choice for next group. Frame-length cannot be reduced than the initial frame size during group reading.

3.2 Proposed algorithm

We proposed an algorithm which is independent of initial frame size. The pseudo code is shown in figure (3).

```
N= number_of_Tags
Total_slots = 0 , Frame_size=0 ,
Tag_succ =0
While N > 256
Frame size = 2 ^ ceil (log2(N));
Tag_succ = ceil (N * (1 – 1/N)^(N-1)) ;
N=N – Tag_succ ;
Total_slots= Total_slots+ Frame_size
```

Figure 3: Pseudo code for proposed Algorithm

For the number of Tags less than 256 we use same scheme as of DFSG i.e. frame length is selected from following table.

Table 2. Frame size selection for Tags <256

n	Q	Frame-length
2-5	2	4
6-11	3	8
12-22	4	16
23-44	5	32
45-88	6	64
89-176	7	128
177-255	8	256

3.3 Identification time

Identification time is associated with number of iterations and total slots taken to read all tags. Comparison of proposed scheme with DFSG and BFSA is shown in following graphs.

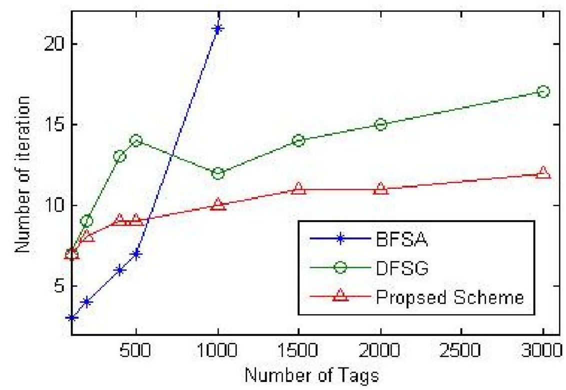

Figure 4: Comparison of BFSA, DFSG and Proposed Scheme with respect to Number of iteration

Figure 4 shows that proposed algorithm takes less number of iterations for reading tags as compared to both BFSA and DFSG. When tags are less than 256 number of iteration are same for both DFSG and proposed scheme but for larger number of tags proposed scheme take less number of iteration.

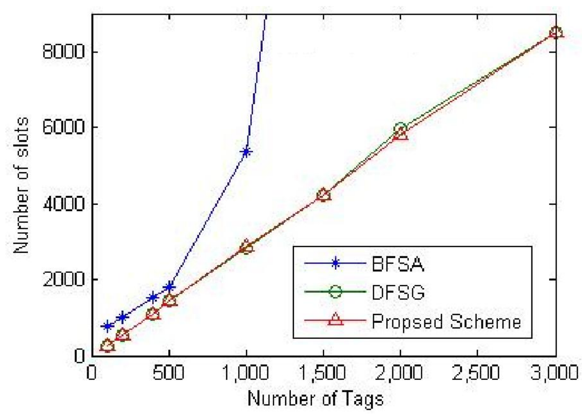

Figure 5: Number of slot comparison of BFSA, DFSG and Proposed Scheme

Figure 5 shows that proposed scheme takes less number of total slots than BFSA. We observe that number of slots for both proposed scheme and DFSG are very close. Proposed scheme take slightly less number of slots than DFSG.

3.3 Iteration and Efficiency of Proposed Scheme

From the above proposed scheme we found that it uses less number of iteration to read all the tags. The system efficiency is given by following equation.

$$\text{System Efficiency} = \frac{\text{No.of Successful Slots}}{\text{Total No.of Slots}} \quad (2)$$

Comparison of iteration and efficiency between BFSA, DFSG and proposed scheme is shown in Table 3. which shows that results obtained from proposed scheme are better than previous techniques.

Table 3. Comparison of BFSA, DFSG and Proposed Scheme

Tags	BFSA with 256 Frame-length		DFSG with 256 Frame-length		Proposed Scheme	
	Iteration	Efficiency	Iteration	Efficiency	Iteration	Efficiency
100	3	0.130	7	0.384	7	0.384
200	4	0.195	9	0.369	9	0.369
400	6	0.260	13	0.361	9	0.361
500	7	0.279	14	0.342	9	0.348
1000	21	0.186	12	0.354	10	0.346
1500	77	0.076	14	0.355	11	0.354
2000	313	0.024	15	0.335	11	0.345
3000	1313	0.008	17	0.352	12	0.353

5. Conclusion

DFSG[14] is based upon EDFSA[19] and it improves system efficiency to a great deal as compared to BFSA and EDFSA. Improved Dynamic Frame size with tag grouping algorithm that we have just presented above further extends the performance of DFSG by reducing the number of iteration. Also it removes the dependency of algorithm on initial frame-length. The comparison of iteration, system efficiency and identification time between BFSA, DFSG and proposed algorithm is shown in above figure (4), figure (5) and table (3). Result obtained for proposed algorithm is much closed to possible optimal values.

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