ANTI-COLLISION ASPECT OF RFID TAGS AND READERS

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ABSTRACT

The problems occur in data transferring between readers and tags in a Radio Frequency Identification (RFID) system are collision problems. The main focus of this paper is to survey, classify and compare a series of anti-collision protocols for RFID arbitration.

INTRODUCTION

RFID systems are composed of three main components, as shown in Figure 1 [1]. The operation of RFID systems often involves a situation in which numerous tags are present in the interrogation zone of a single reader at the same time. The tags can collide and cancel each other out, leading to retransmission of tag IDs that results in wastage of bandwidth and an increase in the total delay. Besides, readers physically located near one another may interfere with one another's operation. Such reader collision must be minimized to ensure the current operation of the RFID system. In this paper, we surveyed some novel collision resolution protocols.

COLLISION PROBLEM TAXONOMY

The RFID collision problems could be classified it into **tag collision** and **reader collision** as follow in Figure 2. In Figure 2(a) explains the problem in transmission of data from many individual tags to the reader. When a reader attempts to obtain the unique ID number of each tag, messages from the tags can collision and cancel each other out. The reader collision is subdivided into frequency interference or tag interference [7]. Frequency interference, namely **Reader interference**, in Figure 2(b), explains the problem when two readers with overlapping interrogation zones communicate using the same frequency at the same time, each may difficulty in communication with tags due to interfering signals transmitted by the other reader. **Tag interference**, in Figure 2(c), explains the problem when one tag is simultaneously located in the interrogation zones of two or more readers and more than one reader attempts to communicate with that tag at the same time.

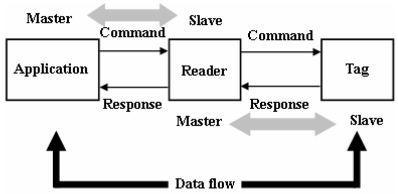

Figure 1 RFID systems.

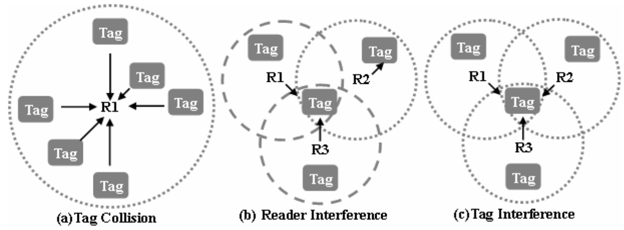

Figure 2 Collision problems taxonomy.

COUNTERMEASURES OF COLLISION PROBLEM

In literatures [1-6], they discussed the tag collision problem and resolutions. It can be defined as to identify multiple objects reliably without significant delay, utilizing minimal transmission power and computation. Basically, there are four different procedures [1]: SDMA, FDMA, TDMA and CDMA. In RFID systems, TDMA procedures are the largest group of anti-collision procedures. Tag-driven and reader-driven procedures has been differentiated and shown in Figure 3. Tag-driven procedures function asynchronously, since the reader does not control the data transfer. For example, the SuperTags approach [2], which operates on the Aloha anti-collision principle, tags continuously retransmit their identifier at random intervals until the reader acknowledges their transmission. Tag-driven procedures are very slow and inflexible. Most applications therefore use reader-driven procedures, which can be considered as synchronous, since all tags are controlled and checked by the reader simultaneously. Reader-driven procedures could be subdivided into polling [1], splitting method-Tree Algorithm [3], QT Protocol [4], Variations of QT protocol [4], I-code protocol [5] and contact-less protocol [6]. Table 1 shows a contrast with most multiple access collision-resolution methods surveyed in this paper. In deterministic anti-collision algorithms, polling, tree algorithm and QT protocol have the same time complexity and read accuracy rate for $n_1=n_2$. If there is a cost consideration, polling protocol is the choice. If we emphasize on cost and time both, QT protocol will be better. In probabilistic anti-collision algorithms, tag-driven procedures are slower and more inflexible than reader-driven procedures. Therefore, if it is time concern, I-Code protocol is a better choice.

While in other literatures [8-12], they discussed another collision problem about reader and resolution, which is how to structure an optimal assignment of frequencies over time globally minimizes a cost function and/or the time for all readers to communication given a fixed frequency allotment. The classification and solution of reader collision problems- Color-wave [8], HiQ algorithm [9], neural networks [10], Simulated annealing [11], Genetic algorithms [12], was shown in Figure 4. Table 2 shows a contrast with five algorithms for resolving the reader collision problem. The algorithms vary greatly and have many fundamental differences. Many rely on centralized control for channel assignment, while others boast distributed control where individual readers are responsible for communication.

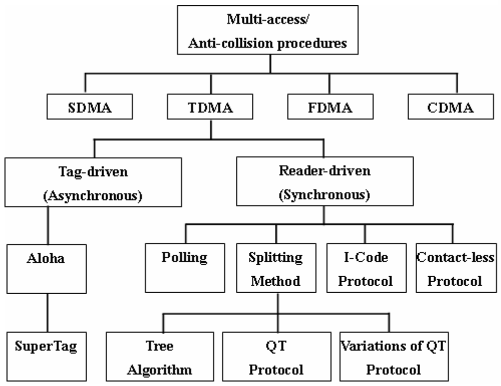

Figure 3 Countermeasures of tags collision

Criteria \ Protocols	Tag-driven	Reader-driven				
			Splitting Methods			
	SuperTag	Polling	Tree Algorithm	QT Protocol	I-Code	Contact-less
Deterministic		✓	✓	✓		✓
Probabilistic	✓				✓	
TTF/RTF	TTF	RTF	RTF	RTF	RTF	RTF
Aloha	✓					
Slotted-Aloha			✓	✓		
Framed-slotted Aloha					✓	
Switch-off	✓	✓	✓	✓		✓
Slow-down	✓					✓
Terminating/Muting					✓	
Reader "Carrier Sense"	✓					✓
Accuracy level	Close to 100%	100%	100%	100%	Close to 100%	100%
Time Complexity	-	$O(n_1)$	$O(n_2)$	$O(n_1)$	$t_0 * s + T_N$	$O(2^N)$
Message Complexity	-	$O(m(N+1))$	$mlong_2^n$	$2.21klong_2^n + 4.19k$	$N(m*p) + N(m*s)$	$O(m(N+1))$

n_1 : is the total number of unique tags possible with a possible with a tag id of length k.
n_2 : is the number of tags that need to be identified.
T_N : Time required to estimate N
N : is the length of the tag identification number.
m : stands for the number of tags that needs to be identified.
$(m*p)$: Number of read cycles required to estimate N.
$(m*s)$: Number of read cycle performed with fixed N.

Table 1 Comparison of tag collision-resolution

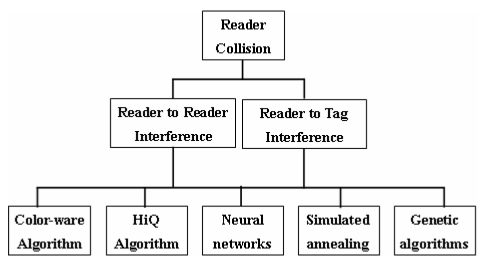

Figure 4 Countermeasures of readers collision

Method \ Criteria	Optimize function	Centralized control	Distributed control	Fixed Channel Assignment (FCA)	Dynamic Channel Assignment (DCA)
Colorwave Algorithm	Smallest possible color number		✓	✓	✓
HiQ Algorithm	Cost function	✓	✓		✓
Neural network	Energy function		✓	✓	
Simulated annealing	Reward value	✓		✓	
Genetic algorithm	Performance value	✓		✓	

Table 2 Comparison of reader collision-resolution

CONCLUSIONS AND FUTURE WORK

We have surveyed a series of anti-collision protocols for RFID arbitration in this paper. Comparative views of surveyed protocol are provided for other researchers to resolve. In further research, it remains challenging to find a procedure that would take environmental effects into account. We hope this paper will help implementing pervasive computing environments that employ RFID systems.

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(Other references are upon request)

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