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Research Article

The Analysis and Research of the Hybir Redundancy Elimination Algorithm (HRRE) Based on RFID Middleware Reader

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Abstract: LEO (Layered Elimination Optimization) algorithm and RRE (Redundant Reader Elimination) algorithm are widely used because of their needless of complicated operations and efficient redundant elimination ability. This study puts forward an improved hybrid redundant elimination algorithm HRRE. By introducing the candidate holder, the maximize redundant-readers and the minimize work readers are guaranteed. At the same time the use of label information in the RFID middleware to identify the reader redundant state reduces the performance effect of the system effectively which is caused by write operation. The power consumption of the system caused by the reader write information to label is also reduced at the same time. The simulation results show that the improved hybrid redundancy elimination algorithm has a good solving effect.

Keywords: LEO algorithm, middleware, RFID, redundant-reader, RRE algorithm

INTRODUCTION

Radio Frequency Identifier (RFID) system is a kind of automatic identification system (Finkenzeller, 2001). RFID technology has many advantages when it is compared with other automatic identification technology. Such as rapid scanning, labels volume miniaturization and diversification, the strong anti-pollution and endurance abilities, the repeated use of the tags, the big capactiy of data memory, the penetrability, no barrier reading ability and strong security. With the development of the electronic industry, RFID technology has been widely used in the entrance guard management, transportation, medical application, animal control, security applications, anti-counterfeiting application, supply chain management, positioning navigation and other fields. It is regarded as one of the core technology to realize Internet of Things (Conti, 2006).

Along with the RFID technology matures increasingly, it is believed that hundreds of millions of RFID readers and tags will be deployed. Because of the limitation of the distance of the individual reader's reading and writing, if you want to deploy RFID readers to a specific system and make the whole system labels covered, you may need hundreds of thousands of a reader. The readers will form a dense deployment RFID system. So the redundancy problem of reader is one of the key problems which influence the performance of RFID system.

Redundancy reader refers to a reader which covers a group of RFID tags in the RFID system. All labels which are covered by the reader recognition range are also covered by other readers. When the reader is closed, it does not affect the system to read other tags. Bogdanar Carbunar (Bogdan and Murali, 2009) put forward the redundant reader problems at first. The elimination of the redundancy reader problem was attributed to seeking the best solution of the problem. And it is a NP problem. In order to solve the problem, Bogdan Carbunar adopted redundancy Reader Elimination algorithm RRE (Redundant- Reader Elimination). Hsu and Chen (2008) put forward LEO algorithm to solve some problems which caused the RRE algorithm losing efficacy due to system topology. But LEO algorithm depends on the reader's recognition sequence. The reliability of the algorithm is poor. The hybrid algorithm of LEO algorithm and RRE algorithm was proposed by Hsu on the basis of LEO algorithm. Although the hybrid algorithm integrated the advantages of the two algorithms and to a certain extent, the redundant elimination ability of the system was improved. It still demanded readers write information in tags which increased the system power consumption.

THE BASIC REDUNDANCY ALGORITHMS

The analysis of RRE algorithm: The thought of RRE algorithm is finding out a minimum set of work reader that can cover all labels in a set of given labels and

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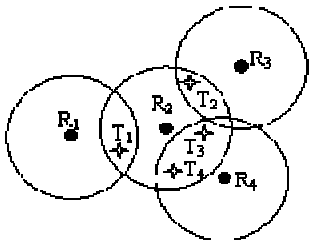

Fig. 1: The topology of system network

Table 1: The case analysis of RRE algorithm of Fig. 1

	T_1	T_2	T_3	T_4
R_1	1, R_1			
R_2	4, R_2	4, R_2	4, R_2	4, R_2
R_3		1, R_3		
R_4			2, R_4	2, R_4
Lock	4, R_2	4, R_2	4, R_2	4, R_2
Redundant-reader	R_1 , R_3, R_4			

Table 2: The case analysis of RRE algorithm of Fig. 2

	T_1	T_2
R_1	2, R_1	2, R_1
R_2	2, R_2	2, R_2
Lock	2, R_1	2, R_2
Redundant-reader	Ø	

readers which cover these labels. In other word, the thought is finding out the biggest number of readers which can be closed at the same time.

As it shown in Fig. 1, the diagram star represents label and round is on behalf of the reader's radio-frequency range. Label T_1 is both in the radio-frequency region of R_1 and R_2. Label T_2 is both in individual of the population, such as the disturbance, the radio-frequency region of R_2 and R_3. T_3 and T_4 are in the radio-frequency region of R_2 and R_4.If R_1, R_3 and R_4 closed don't affect the system, R_1, R_3 and R_4 are redundancy-readers. Make R_2 closed and make R_1, R_3 and R_4 read the information of the labels, so R_2 is the redundancy-reader. But in RRE algorithm, the weight of R_2 is 4. The weight of R_1, R_3 and R_4 are R_3 and R_4 are the redundancy-readers. R_2 is the working reader. But for chart 2, the weight of R_1 is 2 and the weight of R_2 is 2 too. Due to the reader and tag one-on-one write information work characteristics, R_1 may recognize T_2 and R_2 may recognize T_1.Vice versa. At this time the number of redundant reader can not determine. This kind of reader and tag one-on-one write nature of information at the same time may result in redundancy reader leaked. The analysis of RRE algorithm is shown in Table 1 and 2.

The analysis of LEO algorithm: RFID readers are general only through reading and writing tag information to realize information exchange (Yang and Chen, 2009; Yu *et al*., 2008; Hung *et al*., 2010; Ifran and Yagoub, 2010). Reducing the set size of overlap area of the tag can reduce the probability of conflict when readers reading and writing labels. RRE algorithm depends on the number of working label that readers cover in the RFID system to discriminated

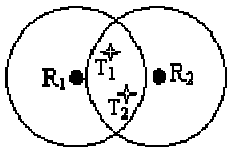

Fig. 2: The topology of system network

Table 3: The case analysis of RRE algorithm of Fig. 1

	T_1	T_2	T_3	T_4
R_1	R_1			
R_2				
R_3		R_3		
R_4			R_4	R_4
Lock	R_1	R_3	R_4	R_4
Redundant-reader	R_2			

Table 4: The case analysis of RRE algorithm of Fig. 2

	T_1	T_2
R_1	R_1	R_1
R_2		
Lock	R_1	R_1
Redundant-reader	R_2	

redundancy reader. When more than one reader appears cross reader conflict and the numbers of labels which readers cover are same, this algorithm may appear leakage to the redundancy-reader. Hsu put forward the LEO algorithm. Although this algorithm improved the shortcomings of the RRE algorithm to a certain degree, as a result of LEO algorithm identifying labels depent on the recognition sequence of readers. So this may appear the case that the redundancy- reader can't be identified. The analysis of LEO algorithm is shown in Table 3 and 4 .The graphics of the system reference Fig. 1 and 2.

From Table 3 for LEO algorithm can't get the largest number of work readers and the minimum number of redundant -readers for Fig. 1. So the phenomenon of miscarriage of justice of readers is appeared. In Fig. 2 LEO algorithm can get redundancy reader. From the case analysis results of Fig. 1 and 2 that are analysed by LEO algorithm can be concluded that the reliability of LEO algorithm is poor.

THE HYBRID REDUNDANCY HRRE ALGORITHM

The requirements of HRRE algorithm for the system:

- The radio frequency range of readers can cover all tags.
- The number of labels and readers in RFID system are unlimited. And the RFID system topology model is unrestricted.
- RFID middleware has the ability of accepting and storaging the information that readers send to labels.

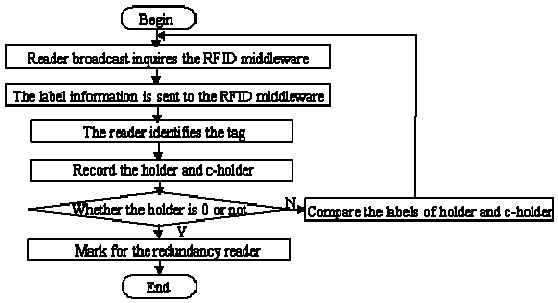

Fig. 3: The HRRE algorithm flow chart

The description of HRRE algorithm: Jiang (2011) put forward the idea of increasing candidate holder considering the shortage of LEO algorithm and RRE algorithm. And the reader the holder of which was zero was attached to the highest priority, in order to achieve the largest number of redundant readers and the minimum number of work readers. This study presents the HRRE algorithm based on the idea which was put forward by Lv and Yu (2012). The idea was using RFID middleware storage tag information to discriminate redundancy readers.

Variable definitions. The label number of RFID system is n. The number of reader is r.

Concept descriptions:

Definition 1: In the RFID system, the readers send the label number which the reader covers to the RFID middleware. The reader that the maximum corresponding is the holder.

Definition 2: In the RFID system, when the reader send the label number that the reader covers to the RFID middleware, the reader which the second maximum value corresponding is the candidate holder.

HRRE algorithm procedures are shown. The chart is as shown in Fig. 3.

Step 1: The reader sends the inquiring packert to the RFID middleware. The reader counts the tag number inside RFID middleware. If there is no label information recorde in the RFID middleware, the reader will be marked as the redundant-Reader r that sends information to the RFID middleware

Step 2: The reader sends the tag number in radio frequency range to the RFID middleware. The RFID middleware only stores the reader (holder) which covers the largest tag number and its number, the second biggest reader (c-holder) and its number.

Step 3: The reader inquires the RFID middleware. The reader in queries the c-holder in the RFID middleware and compares the same number of labels in the holder and c-holder. The smaller the same number of labels, the smaller probability the holder is flagged as redundant-reader.

Step 4: Repeat Step 1-3. And close redundancy reader until all tags are marked.

Table 5: The case analysis of RRE algorithm of Fig. 4

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
R_1	2, R_1							
R_2	4, R_2	4, R_2	4, R_2	4, R_3				
R_3			4, R_3	4, R_3	4, R_3	4, R_3		
R_4					4, R_4	4, R_4	4, R_4	4, R_4
R_5							2, R_5	2, R_5
Lock	4, R_1	4, R_2	4, R_2	4, R_2	4, R_4	4, R_4	4, R_4	4, R_4
Redundant-reader	R_1	R_3	R_5					

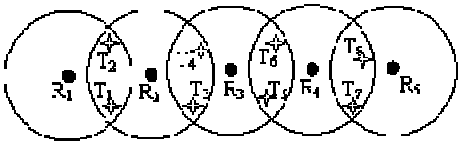

Fig. 4: The topology of system network

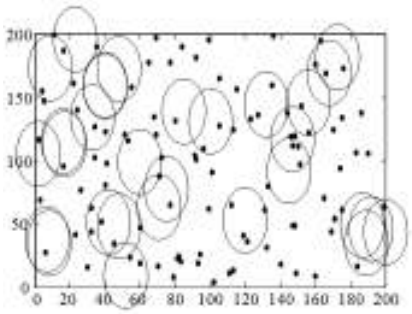

Fig. 5: The local network topology of the RFID syestem

The case analysis of HRRE algorithm: Table 5 is the analysis sheet that the HRRE algorithm analyses to Fig. 4. From Fig. 4, the label number of R_2, R_3 and R_4 are 4. Using basic RRE algorithm can't identify redundant-reader, but HRRE algorithm using the information of holder and c-holder in RFID middleware. Through comparing the same number of labels, T_3 and T_4 reponse reader R_2 and T_2 and T_6 response R_4.So the work readers are R_2 and R_4.The redundant-readers are R_1, R_3 and R_5.

THE SIMULATIONS OF HRRE ALGORITHM

The configuration of experimental environment: This experiment uses 2000 labels which are randomly distributed in the randomly generated RFID system. The radio-frequency region of readers are set in [30100] UD. The experimental environment is Matlab 7.0. The settings of experimental parameters reference (Lv and Yu, 2012). The local network topology of the randomly generatded RFID network system is shown in Fig. 5.

The red points represent labels. The purple circle represents readers. The radius represents radio-

Table 6: The coverage reader to label

Classifications of algorithm/MRA		30	40	50	60	70	80	90	100
Read rate	RRE	73.55	92.15	98.10	99.35	99.55	99.90	99.95	100
	LEO+RRE	73.57	92.08	98.37	99.31	99.70	99.89	99.95	100
	HRRE	76.55	92.55	98.40	99.35	99.60	99.90	99.95	100
Write rate	RRE	48.00	70.65	84.75	93.80	96.65	97.90	98.85	99.10
	LEO+RRE	48.12	70.59	85.07	93.96	97.09	98.13	99.05	99.46
	HRRE	48.80	71.30	85.89	94.32	98.00	98.41	99.38	99.65

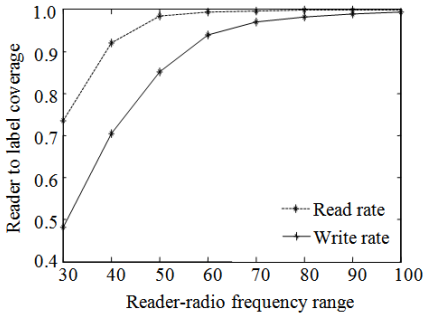

Fig.6: The reader to label coverage in RRE algorithm (2000 labels)

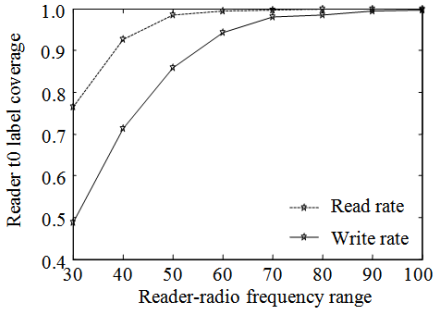

Fig.7: The reader to label coverage in LEO and RRE algorithm (2000 labels)

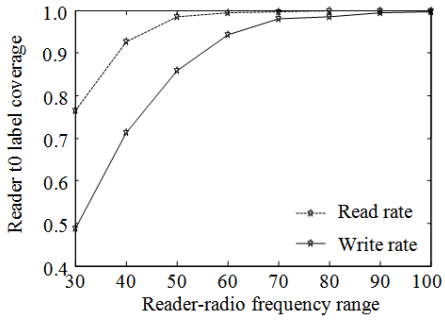

Fig. 8: The reader to label coverage in HRRE algorithm (2000 labels)

frequency region of readers' .The reader number is 500.The label number is several. The read and write distance ratio of reader to label references (Lv and Yu, 2012).

The contrast and analysis: In order to validate the efficiency of the method, this study selects the coverage

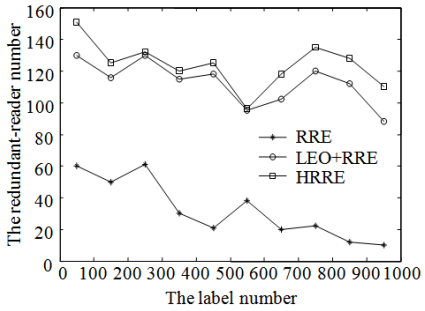

Fig. 9: The contrast of performance of redundant elimination algorithms

reader to label to contrast with basic RRE algorithm and LEO+RRE algorithm. The contrast test results are shown in Table 6.

When the number of reader is fewer, the label information cannot be written. So in the study the reader number is at least 30. Because of the poor reliability of RRE algorithm and LEO+RRE algorithm, each set of data is simulated 100 times and takes average in this study.

From Table 6, it is known that the coverage reader to label of HRRE algorithm is bigger than that of RRE algorithm and LEO+RRE algorithm. In the possible situation that the reader to label read and write distance is unequal, HRRE algorithm does not affect the coverage of the system. But in this case the reader to label coverage of RRE algorithm and LEO+RRE algorithm appears different degree of decline. The probability of miscarriage of justice redundant-readers is bigger. The performance of the system is poor.

Figure 6 to 9 are the changes that reader to label coverage with the reader's radio frequency range. The performance of RRE algorithm is the worst.The reader to label coverage rate of HRRE algorithm is large. Because HRRE algorithm does not need write information to label, the requirements of computation and storage of data reduced and the performance of the system improved effectively.

CONCLUSION

This study puts forward a hybrid redundancy elimination algorithm-HRRE algorithm. This study analyses the shortage of RRE algorithm and LEO algorithm and combines with the efficient redundancy elimination ability and low complexity operations of LEO and RRE algorithm. In view of the shortages the

candidate holder is introduced to realize the optimization of redundant reader so as to achieve redundant-reader maximization and work reader minimized. In order to further improve the performance of the system, the operation that readers write information to labels is improved of RRE algorithm and LEO algorithm. By using RFID middleware to store and transfer information the system power consumption is reduced. And the simulation results verifies that the rationality and validity of this algorithm. HRRE algorithm restrains the system label information effectively and improves the performance of the system.

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