Emergent Information Diffusion in RFID Systems on Roads

Tao Jing*, Xing Wei*, Wei Cheng†, Mingyang Guan*, Yan Huo*
*School of Electronics and Information Engineering, Beijing Jiaotong University, China
†Department of Computer Science, Virginia Commonwealth University, USA
Email:wcheng3@vcu.edu†, { tjing, 12120152, 12120073, yhou }@bjtu.edu.cn*

***Abstract*—The framework of RFID systems on Roads (RSR) was recently proposed to improve the driving safety and the drivers' comfortability. In RSR, RFID readers are installed on vehicles, and passive RFID tags are deployed on each lane. The tags store the lane level road information, which will be provided to the vehicles when they are passing by the tags. As the RFID tags are passive and have to be programmed/updated by vehicles, a native challenge in RSR is how to quickly update the information stored in all the tags when emergent events occur. In this digest paper, we design a multi-tag information diffusion algorithm, which can fast and accurately update all the tags' information. Simulations demonstrate that the proposed algorithm is effective in all the testing environments.**

***Index Terms*—RFID Systems on Roads; tag information update; VANETs.**

I. Introduction

RFID technology has recently been applied to vehicular network applications. In addition to the ETC liked applications, [1]–[3] proposed a new application model, where passive RFID tags are deployed on the road side/surface to provide road information to the vehicles, which are equipped with RFID readers. The literatures demonstrate that there is no tag reading collision problem in RSR and that the tag access time is sufficient for transmitting data from a RFID tag to a RFID reader when the vehicle's speed is up to $160km/h$. In [2], RFID tags are deployed on traffic signs to help vehicles to identify the traffic signals. [3] proposed to deployed RFID tags on road sides to provide lane level localization. In [1], the framework of RFID Systems on Roads (RSR) was proposed to support a series of vehicular network applications, which are designed for improving driving safety or drivers' comfortability through utilizing the information stored in the RFID tags deployed on road surface.

Considering the fact that the safety related vehicular network applications in RSR require the tags to provide near real-time information, and that the content of a tag can only be updated by the vehicle, who passes by the tag, a native challenge for supporting these applications is how to update the tag information as quick as possible, so that the number of vehicles that misses the emergent road information can be minimized. In this digest paper, we, therefore, propose a multi-tag information diffusion algorithm to fast and accurately update the tag information in RSR. To the best of our knowledge, this research is the first work that targets on addressing the challenge of tag information update in RSR. In brief, the main contributions of this work include: (i) We propose a multi-tag information diffusion algorithm for RSR. (ii) Simulation results justify the effectiveness of our work.

II. System Model

The architecture of RSR is illustrated in Fig. 1, where the stars represent the RFID tags, the triangles in front of the vehicles are the reading zones of RFID readers. The red star (tag) has an emergent information, which should be diffused over all the stars. In RSR, each vehicle has been equipped with RFID readers and DSRC for the communication between the vehicle and the RFID tags and the communication among vehicles, respectively.

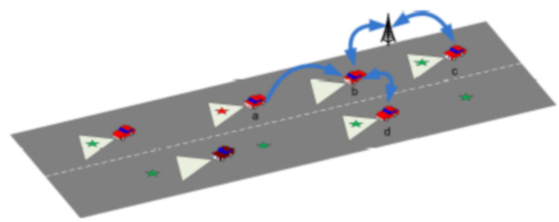

Fig. 1. RSR architecture

After reading the emergent information from the red tag, the vehicle a will share the information with its neighbors via broadcasting, so that its neighbors can update the information into the tags that they will pass by in the future. Generally, this broadcasting based update process facing the challenges such as (i) a tag may be updated multiple times; (ii) heavy collisions may occur during the broadcasting. We, therefore, design an algorithm in the following section to address these challenges.

III. Algorithm Design

In our algorithm, each vehicle maintains a Tag Information Form (TIF), which records the update progress of the tags in a cluster as shown in Fig. 2, where the cluster consists of the tags in the same colored circle. Note that, TIF is stored in RFID tags and updated by vehicles, and that each tag have its own TIF centered by itself. A vehicle will update the tag and broadcasts the updated TIF if not all the tags in the TIF have been successfully updated. When a vehicle receives TIFs from its neighbors, it will match and update the information in its own TIF, and write the updated TIF back to the tag. Algorithm 1 depicts our proposed tag information update method.

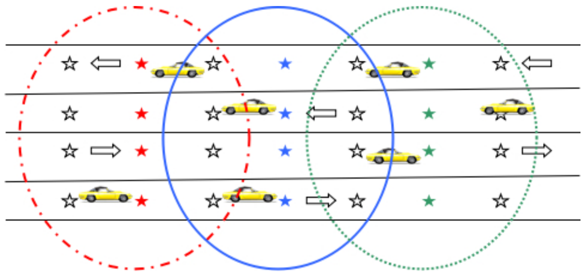

Fig. 2. Clustering

Algorithm 1 Multi-tag information diffusion algorithm

When a vehicle received a TIF from its neighbors
if The vehicle and its neighbor are in the different direct **then**
  Transpose the received TIF;
end if
if the coverage of the received TIF overlaps its own TIF **then**
  Compare the information in the overlapping part;
  Update the information accordingly and write the updated TIF to the tag;
end if
if There are tags that still have not been updated in its own TIF **then**
  Broadcast the TIF;
end if

IV. Simulations

In this section, we use the RSR simulation tool, which is developed by us based on OMNeT++4.1 network simulator, to evaluate the performance of our proposed algorithm. The environment settings in the simulations are summarized in the following Table. Note that the vehicle speed is determined by the traffic density in our simulations.

TABLE I
Simulation environment setting

Test road	$600m$
Road width	$20m$
Lanes	4
Traffic density	$1, 3, 5, 8, 10, 25, 50, 100veh/km$
Communication distance	$50, 100, 200, 300m$
Maximum speed	$120km/h$
Tags interval	$10m$
MAC protocol	802.11
Packet loss probability	15%
Simulation times	100

We examine the performance of our algorithm in terms of *Diffusion Time*, which represents the time when all the tags in the test road have been updated, and the *number of missing vehicles*, which records how many vehicles have leaven the test road without the updated information by the diffusion time. Note that each reported result below is the average of 100 instances. Fig. 3 presents the diffusion time of our proposed algorithm under several environment settings.

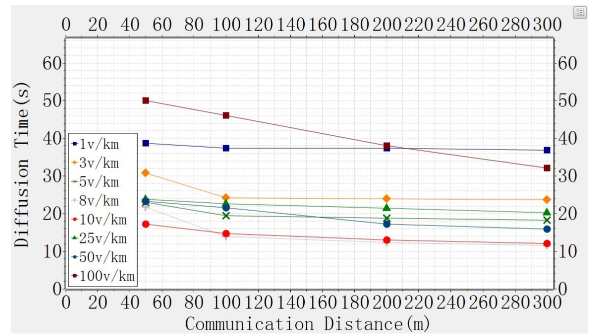

Fig. 3. Diffusion time

We can see from Fig. 3 that all the tags can be successfully updated within 50 seconds under all the environment settings. At the beginning, with the increase of traffic density, the diffusion time is generally decreasing. However, if the traffic density continues to increase after passing the turn point ($10veh/km$), the diffusion time increases because the vehicles are generally slow under high traffic densities. The increase of communication range always has a positive impact on the diffusion time as a vehicle will find more neighbors to help to diffuse the information. The number of missing vehicles is reported in Table.II.

TABLE II
The number of missing vehicles

communication(m) / traffic density(veh/km)	50	100	200	300
1	0	0	0	0
3	0	0	0	0
5	4	2	0	0
8	4	2	0	0
10	6	2	0	0
25	7	2	0	0
50	8	2	0	0
100	16	10	6	2

V. Conclusion

This digest paper briefly presents our proposed algorithm for emergent information diffusion in RSR. In the future, we will conduct more experiments to evaluate its performance and improve the design to further reduce the diffusion time.

References

[1] W. Cheng, X. Cheng, and a. W. W. Z. Min Song, and Biao Chen, "On the design and deployment of rfid assisted navigation systems for vanets," in *Parallel and Distributed Systems, IEEE Transactions on*, july 2012, pp. 1267–1274.

[2] J. Prez, F. Seco, V. Milans, A. Jimnez, J. C. Dłaz, and T. de Pedro, "An rfid-based intelligent vehicle speed controller using active traffic signals," *Sensors*, january 2010.

[3] H. D. Chon, S. Jun, H. Jung, and S. W. An, "Using rfid for accurate positioning," *Journal of Global Positioning Systems*, 2004.