ISSN: 1999-1630

SEU Journal of Science and Engineering, Vol. 12, No. 2, December 2018

A Reliable Highway Based Inter-Vehicle Communication Scheme using Wireless Sensor Network and RF Technology Simultaneously

Sadia Sharmin[1*] and Kawser Been Amir[2]

[1]*Department of Electrical and Electronic Engineering, Southeast University, Dhaka, Bangladesh*
[2]*Technology for Development, Technology Division, BRAC, Dhaka, Bangladesh*.

Abstract
In the recent years, the quick development of the wireless communication and the information technologies have increased research interests of inter-vehicle communication in the area of Intelligent Transportation System (ITS) as well as attracted the intense attention of the researchers too. A good number of researches have already been done to enhance the safety, to ensure an accurate automatic control and comfortable surroundings for the drivers to drive. These researches are based on the exchanging of information among the vehicles. Inter-vehicle communication is one of these techniques which are responsible to ensure the communication among the vehicles. In this paper, we have proposed a new scheme for highway based inter-vehicle communication combining wireless sensor network and radio frequencies. Simulation result demonstrates that the proposed scheme shrinks the traffic volume in the system and additional discussion proves that the proposed scheme is more reliable at the same time.

Keywords: Inter-Vehicle Communication, Wireless Sensor Network, Intelligent Transport System, Radio Frequencies

I. Introduction

These last years, the rapid development of wireless communication and information technologies enable the development of vehicular communication systems, especially the inter-vehicle communication systems, which can improve the comfort, safety and operational efficiency of transportation systems (M. Sichitiu *et al.*, 2008, Y. Toor *et al.*, 2008). Moreover, automated vehicles are an important constituent of future Intelligent Transportation Systems. Vehicle-to-vehicle communication will certainly be indispensable to maintain safe and efficient automated driving. Currently, major research thrusts on automated highway systems and automated driving include the PATH program in California (P. Varaiya *et al*., 1991); the DARPA-supported Unmanned Ground Vehicle (UGV) project in Carnegie Mellon University (D. Bradley *et al*., 2004); the Prometheus program in Europe (*Automatic Vehicle Guidance, 1999*) and Super Smart Vehicle System (SSVS) project in Japan (S. Tsugawa *et al*., 2000) etc.

Mostly, there are two ways of vehicle communication in the highway transportation system, which are classified as Vehicle-Infrastructure-vehicle communication (V2I) and vehicle to vehicle communication (V2V) as shown in Figure 1. The first approach (V2I) is based on the installations of the communicating infrastructures near to the roads via which the vehicles communicate with each other. This approach ensures the competence and the consistency of the communication management but is not cost efficient as the implementation of V2I requires a large number of expensive infrastructures which also does not allow fast adaptation to a new situation. That is why, researchers are keeping eye on the vehicle to vehicle communication (V2V) which is known as Inter- Vehicle Communication (IVC).

In Inter-vehicle communication (IVC), a vehicle can communicate to its neighboring vehicles even in the absence of a central Base Station. In this paper, the authors have presented a much reliable highway based method for inter-

* **Corresponding Author:** Sadia Sharmin, Lecturer, Department of Electrical and Electronic Engineering, Southeast University, 251/A & 252, Tejgaon I/A, Dhaka, Bangladesh; Email: *ssharmin@seu.edu.bd*

vehicle communication using wireless sensor network and RF which guarantees the reduction of traffic volume and ensures more reliability in the network.

II. Inter-Vehicle Communications (IVC) and Previous Works

When the communication happens between vehicles, it is called inter-vehicle communication (IVC). In this communication process the vehicles communicate without the use of beforehand deployed infrastructures. The main goal of IVC is to upgrade on-board devices like GPS, Sensors etc and to extend the horizon of the drivers. Moreover, an IVC network quickly adapts to several situations. That is why; this paper is focused on upgrading IVC network to ensure an automatic control, secured and comfortable environment for the drivers by reducing the traffic volume of the total system.

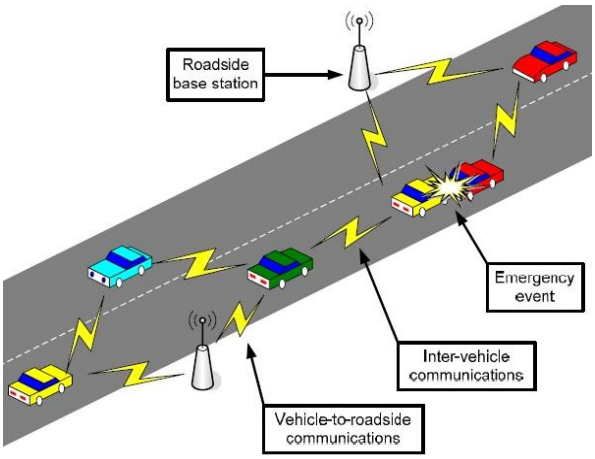

Figure 1: Management of Vehicle to Roadside (V2I) and Iner-vehicle communication system

Initial studies on IVC were started by JSK (Association of Electronic Technology for Automobile Traffic and Driving) of Japan in the early 1980s. Later, well known research results on platooning1 have been demonstrated by California PATH (J.K. Hedrick *et al.*, 1994) and Chauffeur of EU (O. Gehring *et al*., 1997). The cooperative driving systems of Japan in the late 1990s and 2000 exhibit another set of important applications of IVC. A related topic is adaptive cruise control (ACC). Traditional solutions to this issue involve mainly automatic control systems for individual vehicles (A. Vahidi *et al*., 2003), but IVC can help to make the coordination more efficient. In recent times, the transmission of information regarding incidents, emergencies, or congestion from the preceding vehicle(s) to vehicles following behind turned into a significant application of IVC. The newly initiated European Project CarTALK 2000 (D. Reichardt *et al.*, 2002) tries to cover problems related to safe and comfortable driving based on IVC. It focuses on the design, test and evaluation of co-operative driver assistance systems by assessing both IVC and road-to-vehicle communication (RVC), where RVC is used to give vehicles access to fixed networks (J. Ott *et al*., 2004). CarTALK 2000 also co-operates with other projects like German FleetNet (W. Franz *et al*., 2001) for the development of IVC.

In parallel with the academic efforts, industry has also contributed to the definition and fulfillment of security needs in vehicular communications. The most important work is carried out by the industrial consortium that launched DSRC in the context of the IEEE P1556 Working Group (Security and Privacy of Vehicle and Roadside Communications including Smart Card Communications). Yet the results of this working group are not publicly available.

III. Proposed System Model

For the case of inter-vehicle communication, vehicles communicate directly with the neighboring vehicles without the use of beforehand-deployed infrastructures and without the interference of the central administration. In this paper, a new scheme combining wireless sensors and radio frequencies has been proposed.

In the IVC network, previous researches are based on the communication among the vehicles through radio channels. But the topology of this network changes frequently and the bandwidth is also limited. So, the topology of the network can give bottleneck which can create a catastrophic situation. However, it is necessary to reduce the use of traffic volume by decreasing the transmission of useless signals or by replacing the total system with a new scheme. That is why, the objective of this paper is to decrease the use of traffic volume in the network and to make the whole system more reliable and secure.

To exchange vehicular information, existing IVC systems generally use a proactive approach (K. Y. Menouar et al., 2004), in a sense that vehicular information is sent consciously to inform near vehicles about the current state of the vehicles which is bandwidth consuming. Further work on IVC deals with Reactive and Adaptive Protocol (K. Y. Menouar et al., 2004) which is also not reliable.

In the paper, the total communication process can be segmented in two sections:

A. Use of Wireless Sensor Networks:

According to this new scheme each vehicle passing through the highway will be having its personal wireless sensor network in the vehicle. The network will have a covering area which will be like an oval shape as shown in Figure 3**.** If any vehicle gets into any particular vehicle's covering region then both of the vehicles will get a notification through their wireless sensor network. So, extra use of traffic is reduced in this system as the vehicles are communicating only with their own wireless equipments. Moreover, because of using Oval shaped network coverage, sensor of a particular vehicle will cover more area of its front and back side without covering more at the sideways. So, this system is more secure and reliable rather than using circularly covering wireless sensor network in the system.

B. Use of Radio Frequencies (RF):

The proposed protocol can also sense the speed of the vehicles and also the significance of the encountered danger. If any accident occurs by any particular vehicle then to avoid cascaded accidents and letting the other vehicles know about the incident- an informing message will be delivered at least 1km behind it in order to avoid pile-up. This message will also give the other vehicles an option to choose the other road. This notifying messaging will be delivered through radio frequencies.

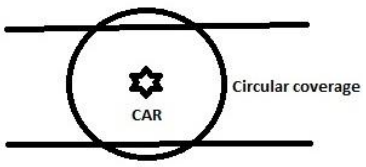

Figure 2: A car with circular coverage region

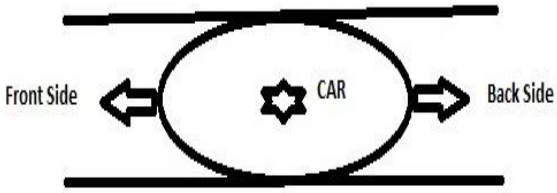

Figure 3: A Car with oval shaped coverage region

IV. Significance of Using Oval Shaped Covering Region

If any particular vehicle has a wireless sensor network of circular coverage region then it covers information of its circular area. But there is some wastage of covering area at the road sideways. If we increase the covering range, the wastage will be higher. Therefore, in this paper, an oval shaped covering area has been considered to reduce the wastage at the road sideways as shown in Figure 3**.** Moreover, it will cover more area at the front and back sides of a vehicle. If more area could be covered, drivers would get a notification about the existence of any vehicle much before. It would be really very helpful for the drivers and would significantly reduce the possibility of casualties as well. So, proposed oval shaped covering region of wireless sensor network of any particular vehicle is a much reliable scheme.

V. Simulation Results

In order to evaluate the performance of the proposed scheme we carry out the simulation. Simulation parameters are listed below at the Table 1.

Table 1: Simulation Parameters

Parameters	Value taken
Simulation Time	120 sec
Road structure	Highway, One way road, Two Lanes
Length of the Road	5 km
Radius of WSNs	200 m
Covering Shape	Oval
Number of Vehicles	100
Average accidents/Month	2
Size of transmitted message during accidents	75 byte
Transmitting Radius	1000 m

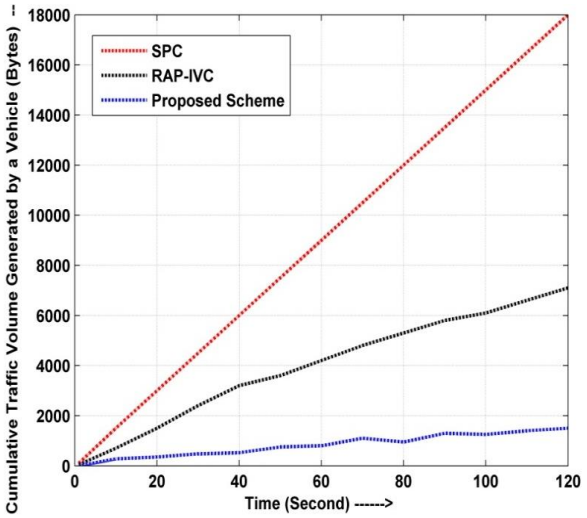

Figure 4: Cumulative traffic volume in the network

In the simulation, we compare our scheme with a Simple Proactive Communication (SPC) protocol where vehicles broadcast their information periodically. So, this protocol needs the highest traffic volume in the network which is clearly seen in Figure 4. We also compare our scheme with Reactive and Adaptive Protocol (RAP-IVC) (K. Y. Menouar *et al.*, 2004) where this protocol sends only *HELLO* message periodically and sends the messages of information only when any vehicle changes its state. So, the communication traffic volume is much less than the SPC protocol. However, our proposed protocol uses the radio frequencies to send the message only when any accident occurs and other acknowledging process is done by wireless sensor of that particular vehicle. So, the proposed scheme uses the least amount of traffic volume in the network as shown in Figure 4. This implies that the proposed new protocol shrinks the traffic volume in the network.

VI. Conclusion

In this paper, a highway based inter-vehicle communication scheme has been presented jointly using oval shaped wireless sensor network for a particular vehicle and radio frequencies in case of any occurrence of accident. This scheme ensures high security because of the implementation of individual wireless sensor network. Moreover, it significantly saves the bandwidth of the total system which is proved by the simulation result.

References

A. Vahidi and A. Eskandarian, “Research advances in intelligent collision avoidance and adaptive cruise control”, IEEE Trans. on Intelligent Transportation Systems, 4(3), 2003.

Automatic Vehicle Guidance: the experience of the ARGO Autonomous Vehicle. World Scientific Co. Publisher, Singapore, 1999.

D. Bradley, S. Thayer, A. Stentz, and P. Rander, “Vegetation detection for mobile robot navigation”, Technical report, Robotics Institute, Carnegie Mellon University, CMU-RI-TR-04-12, Pittsburgh, PA, 2004.

D. Reichardt, M. Miglietta, L. Moretti, P. Morsink, and W. Schulz “CarTALK 2000 -safe and comfortable driving based upon inter-vehicle-communication”, In Proc. of the IEEE Intelligent Vehicle Symposium (IV’02), 2002.

J. K. Hedrick, M. Tomizuka, and P. Varaiya, “Control issues in automated highway systems” IEEE Control Systems Magazine, 14(6):21–32, 1994.

J. Ott and D. Kutscher, “Drive-thru Internet: IEEE 802.11 for Automobile users”, In Proc. of the 23rd IEEE INFOCOM, 2004.

K B Amir, I. J. Tani, S Sarwar, K.M.A. Salam and H. A. Rahman, “A scheduling method for multiple target coverage to prolong lifetime of wireless sensor networks”, 2nd International Conference on Advances in Electrical Engineering (ICAEE 2013),2013

K. Y. Menouar, H. Challal, Y., “Reactive and adaptive protocol for inter-vehicle communications (RAP-IVC)”, Information and Communication Technologies: From Theory to Applications, 2004. Proceedings. 2004 International Conference on, vol., no., pp.63,64, 19-23 April 2004

M. Sichitiu and M. Kihl, “Inter-vehicle communication systems: a survey”, IEEE Communications Surveys and Tutorials, 10(2):88–105, 2008

O. Gehring and H. Fritz, “Practical results of a longitudinal control concept for truck platooning with vehicle to vehicle communication”, In Proc. of the 1st IEEE Conference on Intelligent Transportation System (ITSC’97), pages 117–122, 1997.

P. Varaiya, “Smart cars on smart roads: Problems of control”, Technical report, University of California, Berkeley, TECH MEMO-91-05, Berkeley, CA, 1991.

S. Tsugawa, "An introduction to demo 2000: The cooperative driving scenario", IEEE Intelligent Transportation Systems, July/Aug, 4:78–79, 2000.

W. Franz, R. Eberhardt, and T. Luckenbach, "Fleetnet – internet the road". In Proc. of the 8th World Congress on Intelligent Transportation Systems (ITS'01), 2001.

Y. Toor, P. Muhlethaler, and A. Laouiti, "Vehicle adhoc networks: applications and related technical issues", Communications Surveys and Tutorials, IEEE, 10(3):74–88, 2008.