■ 624

Towards Improving Road Safety Using Advanced Vehicular Networks

Wajeb Gharibi*[1], Nasrullah Armi[2]
[1,2]College of Computer Science & Information Systems, Jazan University, Jazan, Kingdom of Saudi Arabia
[2]Indonesian Institute of Sciences, Bandung, Indonesia
*Corresponding author, e-mail gharibi@jazanu.edu.sa

Abstract

Vehicular Ad-hoc Networks (VANETs) are advanced network technologies applied to improve safety on roads and to offer suitable solutions for Intelligent Transportation Systems (ITS). The goal of VANETs is to assistdrivers and to act as a smart co-pilot that can alret about accidents and help avoiding them while prodivding high-end infotainment systems for both the driver and passengers. Consequently, VANETs can save millions of lives around the world, especially in Saudi Arabia, which has a very high rate of road accidents annualy. In this paper, we introduce and discuss VANETs, related routing protocols, challenging problems, and the existing solutions. This work is a part of a bigger project that aims to enhance VANETs technologies and to updapteITS to significantly promote road safety in general and Saudi Arabia's roads in particular.

Keywords: Road safety; Vehicular ad-hoc networks (VANETs), Intelligent Transportation Systems (ITS), Routing Protocol

1. Introduction

Wireless networks has been playing critical roles in many vital sciences and applications. A vehicular Ad-hoc Network (VANET) is considered one of the most important wireless and sensing technologies due to its role in improving road safety and reducing the huge number of road accidents. Recently, car manufacturers started providing vehicles with wireless equipment that allow vehicles to communicate with each other, to communicate with road-side units, and to interact with sensors that observe the environmental aspects, such as traffic status, weather, and road conditions as shown in Figure 1. In addition, VANET is the leading technology in enhancing road safety and providing infotainment systems as well [1-6].
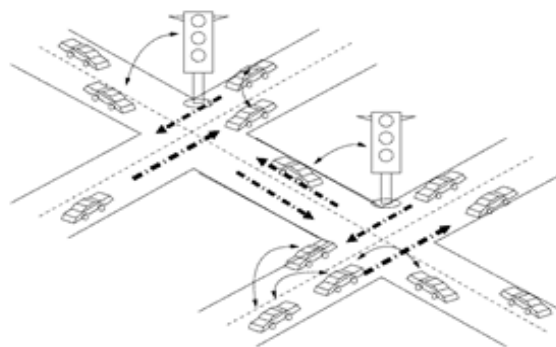

Figure 1. Overview of VANET communication units

Recent research efforts have placed a strong emphasis on designing novel VANET architectures and implementations. The first generation VANET is considered as a variant of a

Mobile Ad-hoc NETwork (MANETs) in which vehicles are mainly allowed to create a self-organized network with the aim of supporting safety applications that can prevent collisions and save many lives. In fact, wireless sensors have proved its efficiency in improving road safety. Sensors, such as speed sensors, wheel-speed sensors, torque sensors, movement sensors, etc. can detect the vehicle's movement and its direction. When these sensors are connected to other vehicle's sensors, such a network can alert drivers about speeding and approaching vehicles and consequentally help preventing accidents such as rear-end collisions. Figure 2 illustrates some of the existing sensors in new cars.
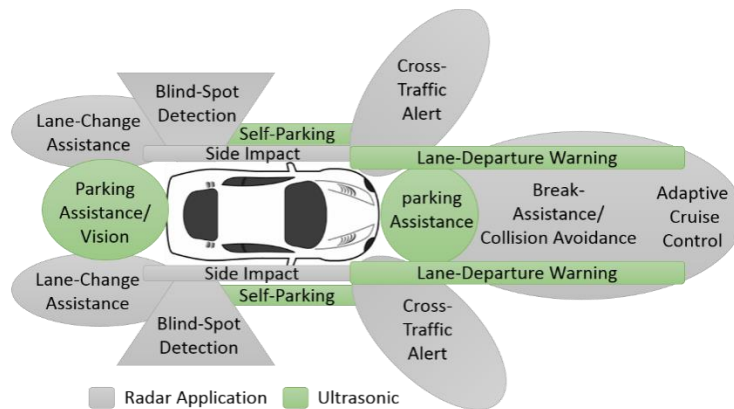

Figure 2. On-board vehicle sensors with their functions

In Table 1 we present the differences between the standards 802.11a (IEEE, 1999) and 802.11p (IEEE.2010) that have been used in VANETS, in which data is collected by a vehicle and sent to other nearby vehicle and/or to road-side units using the available on vehicle short-range radio.

Table 1. Differences between the 802.11a and 802.11p Standards

Parameter	802.11a	802.11p
Data Rate (Mbps)	6, 9,12, 18, 24, 36, 48, 54	3, 4.5, 6, 9, 12, 18, 24, 27
Communication Radius (m)	35-120	100-400
Frequency (GHs)	5	5.9
Bandwidth (MHz)	20	10

As seen from the Table.1 that the main differences between 802.11a and 802.11p is that the latter is proposed to use 10 MHz frequency bandwidth (half bandwidth of 802.11a) in order to make thesignal more robust against fading and increase the tolerance of multipath propagation effects of signals in a vehicular environment.

2. Methodology

We investigated the routing protocols and multichannel communications in VANETs and introduced the the traffic prediction mechanism that helps classifying different applications. Protocols and cross-layer designs are the cornerstone for handling efficient group communications in wireless and ad-hoc networks, in which unpredictable variables such as node mobility and node densitycan greatly affect the network performance. Most existing studies consider the cross layer within limited applications and only in stable traffic. In addition, it is worth stating here that the optimal interactions between the physical, MAC, and routing layers have not been fully exploited yet in IEEE 802.11p.

Indeed, by exploiting the interactions between various layers of the network stack, the cross-layer design can play a critical key role in overcoming current communication limitations.

Our proposed paper builds on the obtained previous results [7-8] and addresses some of the most challenging open problems in the field.

3. Results and Discussion

The instability of VANET introducednew challengesthat need to be addressed, in particular the data dissemination problems in VANETS, including:

a. Vehicle Localization Position: determining the exact position of a vehicleis a critical issue in VANET that has limitations, which need to be addressed. Generally, geographical positioning system (GPS) is the most common technology used for providing accurate position, tracing, and monitoring. However, GPS signals might be lost or distributed when hitting geomagnetic storms, high buildings, and urban areas. One of the novel solutions suggests using a group of sensors that can locate the exact position of a vehicle [9]. Other techniques that focused on addressing the positioning problem are presented in [7-8,10-12]. While several solutions exist, there is still a need for an optimal solution that can sucessfully solve this issue.

b. Ubiquity in data disseminating in VANETS is an important desirable attribution. It can cover awide range of areas that cannot be covered with regular cellular phone networksin distant place due to their high cost, especially in the developed third world countries. In this case, VANET that relies on vehicle-to-vehicle communication (V2V) and/or vehicle-to-road side unit communication (V2R) is more reliable, especially that these networks donot need cellular networks to transmit data.Instead VANETs use short-range radio technologies. Itis even cheaper to trasmit data using VANTEs. In addition, VANETS scalability is higher than cellular networks that require more cellular towers to cover distant areas. VANETS can extend to any area that vehicles drive to. For example, cellular smart phones carried in vehicles can use GSM to send and receive small control packet, while using WiFi connection to upload large files or to communicate with other vehicles in real-time. A basic comparision between traditional cellular networks and VANETS is presented In Table 2. More detailed explainational chronological research, including research design, research procedures, in the form of algorithmsand pseudocode, data acquisition, and test cases are presented in [1] and [10].

Table 2. Comparison between Cellular Networks and VANETS

Traditional Cellular Networks	VANETS
High Cost	Low Cost
Need more Hardware installations; cables, towers, etc.	High Scalability
Rich Privacy and Security	Poor Privacy and Security

Having surveyed, in-depth, the state-of-the-art of VANETs, we came to the conclusion that QoS aware group on communications, such as multicast and broadcast in VANETs, is still in its infancy and is an active research area due to several reasons. Moreover, many interesting challenges have revealed related to GPS, data dissemination, security, and authentication issues. To address these issues, we suggest the following:

a. Free GPS specialization for vehicle localization should be built using a group of sensors for real-time prediction of location with error correction-based cellular networks or nearby available WiFi access points.

b. For data dissemination on time without problems, a Diverse Routing is suggested [9].

c. For security, an advanced protocol should be developed and it will be our future work.

d. Data Disseminating Protocol will help delivering packets to available nodes in timely manner without delay. The proposed DR protocol [10] aims to limit the delay transmission, but it does not discuss the QoS of the transmission and how reliable is the transmission.

e. Figure 3 summarizes VANET's protocols, which are classified into two groups depending on their position and route update method [10].
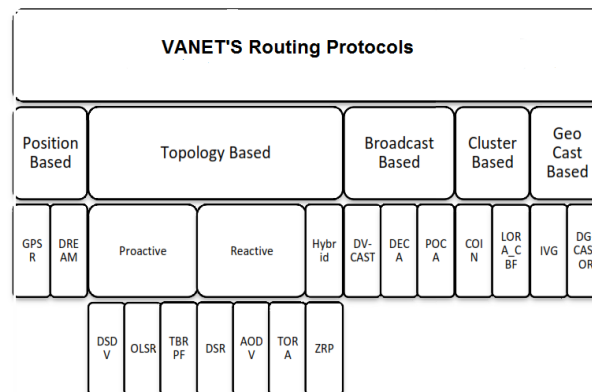
Figure 3. VANET's routing protocols

In fact, VANET's protocols are clearly proposed in [10] with their Pros and Cons in details. In Table 3, we present a comparison of protocols using the criteria: forwarding methods, recovery strategy, realistic traffic flow, and examples.

Table 3. Comparison between Cellular Networks and VANETS

Protocol Based (Examples)	Forwarding Method	Recovery Strategy	Realistic Traffic Flow
Position (GPSR, RDEAM)	Heuristic method	Carry & Forwarding	Yes
Broadcast (DV-CAST, DECA, POCA)	Wireless multihop	Carry & Forwarding	No
Geo Cast (IVG, DG-CASTOR)	Wireless multihop	Flooding	Yes
Cluster (COIN, LORA_CBF)	Wireless multihop	Carry & Forwarding	No
Topology Proactive/ Reactive (DSDV, OLSR, TBRPF/DSR, OADV, TORA)	Wireless multihop	Carry & Forwarding/ Multihop	Yes

4. Conclusion

There is no doubt that VANET is the future technology that will reduce the number of traffic accidents and save millions of peoples' lives worldwide. In our paper, we discussed the current challenges of VANET, its development process, and its most widely used protocols. We also presented the differences between the standards 802.11a and 802.11p that have been used in VANETS.

Moreover, we suggested some solutions that could overcome the current challenges. Nevertheless, VANET is a relatively new technology that is still facing many challenging issues, which need to be addressed.

Acknowledgement

References

[1] Fujimoto N, Moriya M, Ishizuka A, Goto M. Intra-and InterVehicle Communication Network Using Low-Cost POF Links. *IEICE TRANSACTIONS on Information and Systems.* 2002; E85-D (11): 1839-1850.

[2] Deling Huang, Yusong Yan. A Contention-Based Routing Protocol for VANET. *TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*. 2016; 14(1): 319-325.

[3] Doan Perdana, Rendy Munadi, Robbi C. Manurung. Performance Evaluation of Gauss-Markov Mobility Model in Hybrid LTE-VANET Networks.*TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*. 2017; 15(2): 606-621.

[4] Kashif Naseer Qureshi, Abdul Hanan Abdullah, Raja Waseem Anwar. Wireless Sensor Based Hybrid Architecture for Vehicular Ad hoc Networks. *TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*. 2015; 12(4): 942-949.

[5] AF Morabito, AR Laganà, G Sorbello, T Isernia. Mask-constrained power synthesis of maximally sparse linear arrays through a compressive-sensing-driven strategy. *Journal of Electromagnetic Waves and Applications.* 2015; 29(10): 1384-1396.

[6] AF Morabito, AR Lagana, T Isernia. Isophoric array antennas with a low number of control points: a size tapered solution. *Electromagnetics Research Letters.* 2013; 36: 121-131.

[7] V Hahanov, A Zhalilo, W Gharibi, E Litvinova. *Cloud-driven traffic control: Formal modeling and technical realization.* Proc. of 4th Mediterranean Conference on Embedded Computing (MECO). Budva. 2015: 21-24.

[8] Y Al-Dubai, MB Khalaf, W Gharibi, J Ouenniche. *A New Adaptive Probabilistic Broadcast Protocol for Vehicular Networks.* Proc. of IEEE 81st Vehicular Technology Conference (VTC Spring). Glasgow. 2015: 1-5.

[9] Tong Zhou. Data Collection, Dissemination, and Security in Vehicular Ad Hoc Network. Dissertation. Graduate School of Duke University. 2015.

[10] Surmukh Singh, Sunil Agrawal. *VANET Routing Protocols: Issues and Challenges.* Proceedings of 2014 RAECS UIET. Panjab University Chandigarh, India. 2014: 1-5

[11] Korichi, A Lakas, M El Amine Fekair. *An efficient QoS-compliant routing scheme for VANET.* In Proc. of 5th International Conference on Electronic Devices, Systems and Applications (ICEDSA). UAE. 2016: 1-4.

[12] Vishal Kumar, Shailendra Mishra, Narottam Chand. Applications of VANETs: Present & Future. *Journal of Computer Science and Communications*. 2013; 5(1B): 12-15.