Vehicular Networking

Matthew N. O. Sadiku[1], Uwakwe C. Chukwu[2], Abayomi Ajayi-Majebi[3], Sarhan M. Musa[1]

[1]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[2]Department of Engineering Technology, South Carolina State University, Orangeburg, SC, USA
[3]Department of Manufacturing Engineering, Central State University, Wilberforce, OH, USA

ABSTRACT

Today, a growing number of vehicles are equipped with communication devices to facilitate vehicle-to-vehicle and vehicle-to-infrastructure communication and increase the safety of passengers. A new type of network called Vehicular Network (VANET) provides us with the infrastructure for developing new systems to enhance drivers' and passengers' safety and comfort. Vehicular networks are special types of mobile ad hoc networks that are used to help drivers access necessary information. This paper provides an introduction to vehicular networks.

KEYWORDS: *vehicular networking, VANET, MANET*

How to cite this paper: Matthew N. O. Sadiku | Uwakwe C. Chukwu | Abayomi Ajayi-Majebi | Sarhan M. Musa "Vehicular Networking" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-6, October 2021, pp.720-724, URL: www.ijtsrd.com/papers/ijtsrd46451.pdf

IJTSRD46451

INTRODUCTION

Next to home and office, vehicles are the third place where citizens spend more time daily. Today, vehicles communicate wirelessly with each other and with pedestrians in their immediate vicinity. In vehicular environment, the use of wireless technology is taking place at rapid pace. Various wireless communication technologies have been applied in vehicular systems in the form of safety and entertainment applications. Some are of the opinion that integrating these technologies with vehicle will revolutionize the way we travel.

The vehicular system, also known as Vehicular ad-hoc network (VANET), is regarded by as one of the most valuable means to improve road safety and transport efficiency. VANET is a mobile wireless technology which allows exchanging real time data between vehicles and providing different services to the users. It may be regarded as a subclass of mobile ad hoc networks (MANETs) where it is developed by moving vehicles. It consists of moving or stationary vehicles connected by a wireless network. It is a key component of the intelligent transportation systems (ITS) framework. A typical VANET is shown in Figure 1 [1].

VANET provides two types of communication: Vehicle to vehicle communication (V2V) and Vehicle to Infrastructure communication (V2I). Vehicle-to-vehicle (V2V) communications allow vehicles in close proximity to communicate and cooperate each other. The Institute of Electrical and Electronics Engineers (IEEE) 802.11p [2] is the standard that supports Intelligent Transportation Systems (ITS) applications in Vehicular Ad hoc Networks (VANETs). IEEE 802.11p is the first standard specifically designed for on-the-road communications. In VANETs, there are On Board Units (OBUs) which are situated in the vehicles and Road Side Units (RSUs) which are placed along the road for communication purposes. The high deployment costs of a ubiquitous 802.11p roadside infrastructure implies that only a few road side units (RSUs) will be installed to offer wireless connectivity to vehicles.

This chapter provides an introduction to the long-term evolution-vehicle (LTE-V) vehicular networks. It addresses he future trends of this technology, its benefits, and challenges to overcome.

LTE IN A NUTSHELL

LTE stands for Long Term Evolution and is a registered trademark owned by the European Telecommunications Standards Institute (ETSI) for the wireless data communications technology. It was first proposed by NTT DoCoMo of Japan in 2004.

LTE is often referred to as the next generation network beyond 3G. LTE is also known as LTE Super 3G and LTE Super 4G. LTE is a standard for wireless broadband communication for mobile devices and data terminals. The standard was developed by the 3rd Generation Partnership Project (3GPP) and finalized in December 2008. In May 2007, the LTE/SAE Trial Initiative (LSTI) alliance was formed as a global collaboration between vendors and operators with the goal of ensuring global introduction of the standard. The LTE standard covers a range of many different bands and different LTE bands are used in different countries. This consequently means that only multi-band phones are able to use LTE in all countries where it is supported. phones from one country may not work in other countries and users will need a multi-band capable phone for roaming internationally.

LTE connectivity can be provided through user devices such as the smartphones. It ensures subscribers fast and smooth access to the mobile internet. In 5G, LTE networks aim to provide high speed Internet of 300Mbps at a vehicle speed of up to 350 km/h [3].

An upgrade of LTE is LTE Advanced (or LTE-A), which was standardized in March 2011 [2]. 3GPP is working on evolving LTE-A to accommodate the requirements of machine-type communications.

LTE FOR VEHICULAR NETWORKING

Vehicular network is one of the key technologies in intelligent transportation system (ITS).

ITS integrates advanced communications technologies into vehicles and transportation infrastructure. It is a system that applies ICT to road transportation including infrastructure, vehicles and users. It is an indispensable component of the notion of a smart city transforming cities into digital societies. A typical intelligent transportation system is shown in Figure 2 [4].

Vehicular network is meant to provide wireless connectivity among vehicles, road sides' drivers, passengers, and pedestrians. There are three major applications of vehicular networks: road safety, traffic efficiency, and infotainment. In a vehicular network, there have many modes of communication including vehicle to vehicle (V2V), vehicle to pedestrian (V2P), and vehicle to infrastructure (V2I) communications, and vehicle-to-everything (V2X) communication. As shown in Figure 3, V2X communications will enable the exchange of information between vehicles (V2V) and between vehicles and other nodes (infrastructure and pedestrians) [5]. To implement V2X and V2I, two different approaches are been investigated: the use of a new technology standard, 802.11p and the use of an already established technology LTE.

IEEE802.11p technology has establishment Dedicated Short Range Communications (DSRC) technical standard. IEEE 802.11p has been selected as the technology for V2X communications in some nations such as the United States and in European nations [6].

Connected vehicles require highly reliable and low-latent V2X communications.

Although IEEE 802.11p is regarded as the de facto standard for on-the-road communications, stakeholders have recently started to consider the use of LTE as a potential access technology to support communications in vehicular environments.

IEEE 802.11p showed obvious drawbacks such as low reliability, hidden node problem, unbounded delay, and intermittent V2I connectivity.

The LTE network consists of four major nodes [7,8]: MME, SGW and PGW, HSS.

- MME (Mobility Management Entity) is responsible for LTE access control, mobility management, security control and session control. MME is the heart of the LTE network since it takes care of all the control procedures of the network operations that include signaling, routing information, hand off management, signal security, roaming, etc.
- SGW (Serving Gateway) is responsible for the transport, forwarding and routing of LTE user data.
- It also performs replication of the user traffic in case of lawful interception.
- PGW (Packet Data Network Gateway) manages the connection of mobile terminal and external packet data network. It allocates IP address for terminal and is responsible for the egress route of user service data. It also takes care policy enforcement, user by user packet filtering, charging support, lawful interception and packet screening.

- HSS (Home Subscriber Server) manages user subscription and authentication information. It also handles mobility management, call and session establishment support, user authentication and access authorization.

Figure 4 shows how an oil enterprise uses LTE network for video monitoring [8].

Applications of vehicular networks are divided into 2 categories: safety services and non-safety related services. Safety applications are tied to the main purpose of vehicles; moving from a point to another. They convey safety critical information based on sensor data from other vehicles or RSUs. Non-safety applications include entertainment and online connectivity [9].

The emerging technologies such Internet of things, wireless sensor networks, cloud computing, fog computing, and software-defined networking (SDN) have completely revolutionized the wireless networking industry. Today, each connected vehicle is equipped with an average of 100 sensors.

Software-defined networking (SDN) is a new computer networking architecture that uses standardized application programming interface. SDN addresses the failure of the traditional networks to support the dynamic, scalable computing and storage needs of today's applications. SDN achieves this by separating or decoupling network control from data forwarding, and the network intelligence is forwarded to a centralized SDN controller SDN has been deployed for wired networks [10]. Recently, there has been an increasing interest towards deploying SDN for both the wireless and ad hoc networks. There is an interest to design SDN-based vehicular networks that would enable secure and high bandwidth communication services as well as provide low latency for the safety-critical applications. SDN decouples the data plane and the control plane.

A recent development in LTE is an integration of SDN to enhance the network QoS and meet the requirements of various multimedia applications for vehicular users. The LTE network resembles the SDN environment, as the MME node performs all the control functions of LTE network operations.

BENEFITS AND CHALLENGES

LTE provides high data rate and low latency to mobile users. Like other cellular systems, LTE can benefit from a large coverage area, high penetration rate, and high-speed terminal support. LTE well fits the high-bandwidth demands and QoS-sensitive constraints while increasing channel utilization. Its simplified architecture allows it to provide a round trip time lower than 10 ms, and transfer latency in the radio access up to 100 ms. This is beneficial for delay-sensitive vehicular applications. Compared to 802.11p, LTE has higher penetration rate [3].

LTE faces several challenges before it can be massively exploited in vehicular environments. The major challenge comes from the centralized nature of LTE architecture that requires passing through infrastructure nodes in the core network.

Security is one of the major concerns in a vehicular networking environment. Safety in VANETs is another critical concern because it affects the life of people. A thorough understanding of the performance of LTE for the wide set of relevant applications is still required [3]. LTE is fairly expensive compared to Wi-Fi. Other challenges include [11]: (1) How to provide efficient V2V communications, (2) how to avoid system overload due to the heavy traffic, (3) how to offer better support for vehicular applications in high mobility environment, (4) how to simplify the equipment,

CONCLUSION

Vehicular networking or communications is a branch in the field of computer networks and telecommunication engineering. The vehicular network is the basic infrastructure and plays a critical role in future ITS. ??? Link

LTE represents the new generation of mobile radio networks defined by the 3rd Generation Partnership Project (3GPP). It plays a major role in vehicular ad hoc networks since it provides the necessary quality of service and mobility support for drivers. It is a standard for high-speed wireless communication for mobile phones and data terminals.

As LTE network technology is maturing day after day, LTE network is becoming more and more popular worldwide. More information about LTE vehicular networking can be found in [12-14].

REFERENCES

[1] H. Fatemidokht and M. K. Rafsanjani, "F-Ant: an effective routing protocol for ant colony optimization based on fuzzy logic in vehicular ad hoc networks," *Natural Computing Applications*, vol. 29, 2018, pp. 1127–1137.

[2] LTE (telecommunication), *Wikipedia*, the free encyclopedia, https://en.wikipedia.org/wiki/LTE_(telecommunication)

[3] G. Araniti et al., "LTE for vehicular networking: A survey," *IEEE Communications Magazine,* vol. 51, no. 5, May 2013, pp. 148-157.

[4] "Intelligent transportation systems, traffic light control,"https://www.cxr.com/en/applications/intelligent-transportation-systems-traffic-light-control-16.html

[5] H. Seo et al., "LTE evolution for vehicle-to-everything services," *IEEE Communications Magazine*, June 2016, pp. 22-28.

[6] H. G. V. de Andrade, C. C. L. L. Ferreira, A. G. S. Filho, "Latency analysis in real LTE networks for vehicular applications," *Brazilian Symposium on Computing Systems Engineering*, 2016, pp. 156-161.

[7] P. Rengaraju and C. H. Lung, "Network architecture and QoS study on software defined LTE vehicular ad hoc networks," *Proceedings of International Conference on Communication and Electronics Systems,* October 2016.

[8] "ZXUN iEPC, the best vhoice for building private LTE network," http://www.zte-deutschland.de/pub/en/solutions/core_network/mobile_broadband_pcn_evolution/201209/t20120911_343055.html

[9] M. Pourkiani1, S. Jabbehdari2, and A. Khademzadeh, "Vehicular Networks: A Survey on Architecture, Communication Technologies and Applications," *Journal of Advances in Computer Engineering and Technology,* vol. 2, no. 3, 2016, pp. 43-53.

[10] M. N. O. Sadiku, M. Tembely, and S.M. Musa, "Software-defined networking concepts," *Journal of Scientific and Engineering Research,* vol. 3, no. 5, 2016, pp. 92-94.

[11] S. Chen et al., "LTE-V: A TD-LTE-based V2X solution for future vehicular network," *IEEE Internet of* Things Journal, vol. 3, no. 6, December 2016, pp. 997-1005.

[12] C. Sommer and F. Dressler, *Vehicular Networking.* Cambridge, UK: Cambridge University Press, 2015.

[13] M. Emmelmann, B. Bochow, and C. Kellum, *Vehicular Networking Automotive Applications and Beyond.* John Wiley & Sons, 2010.

[14] H. Hartenstein and K. Laberteaux (eds.), *VANET: Vehicular Applications and Inter-Networking Technologies*. John Wiley & Sons, 2010.

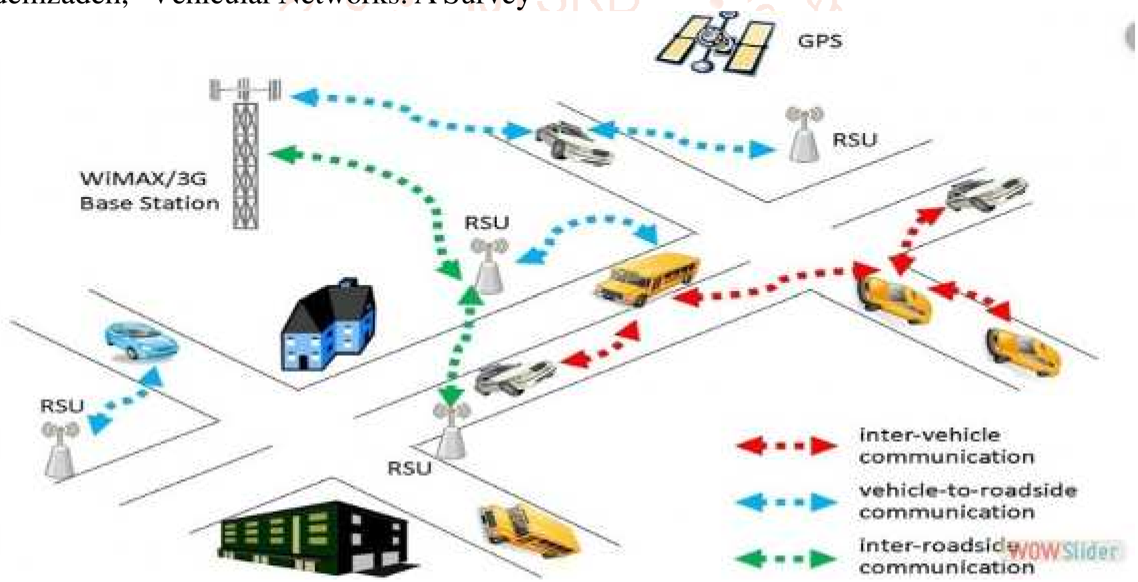

Figure 1 A typical vehicular ad hoc network (VANET) [1].

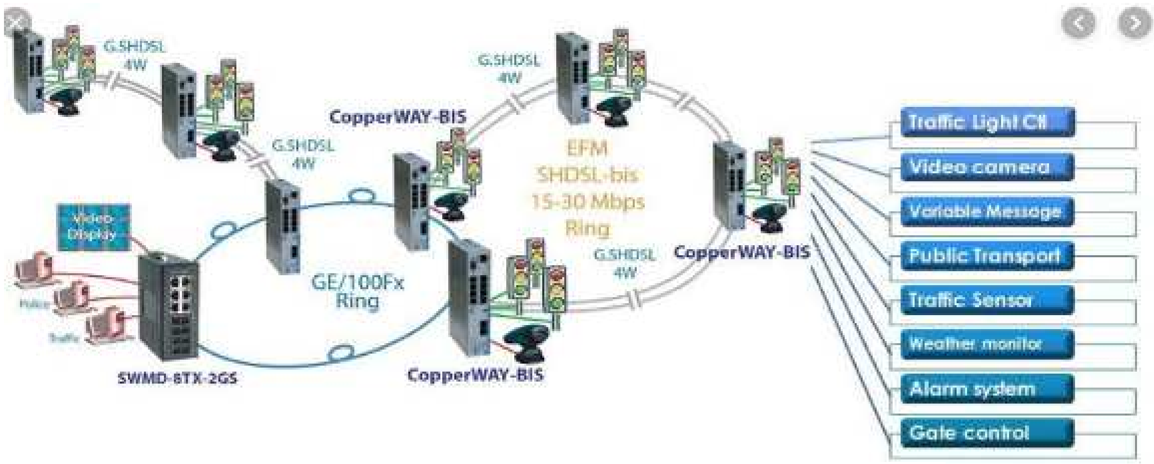

Figure 2 Typical intelligent transportation system [4].

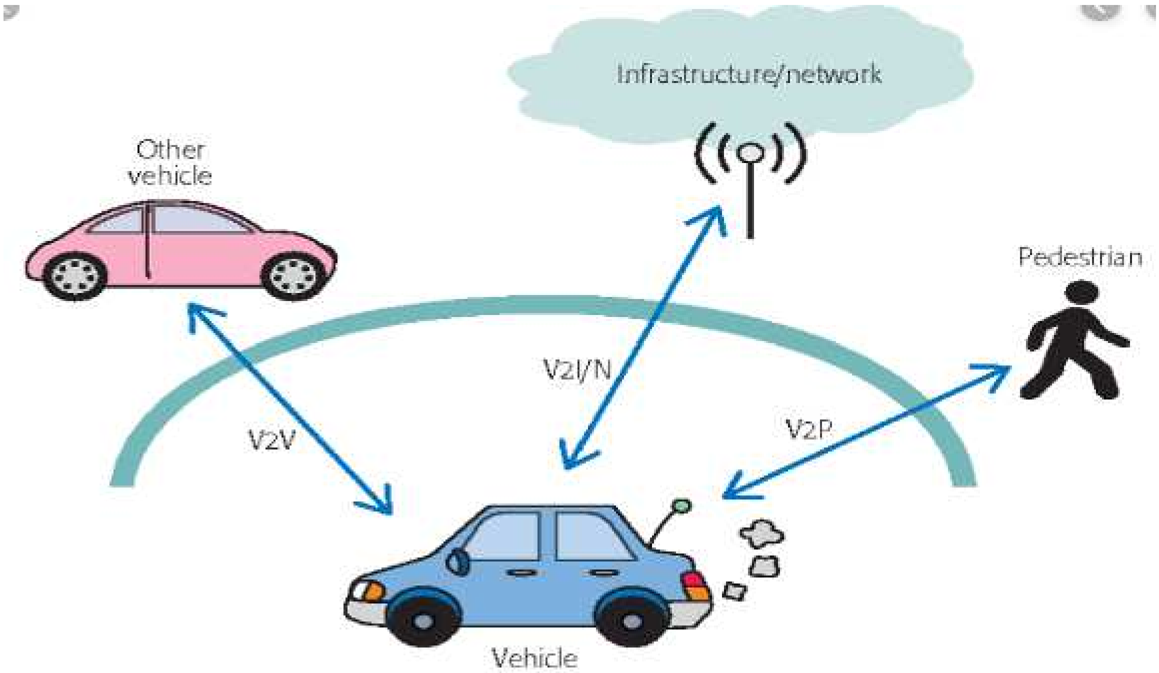

Figure 3 Typical vehicle-to-everything (V2X) communication [5].

Figure 4 An LTE network for video monitoring [8].