

INTER-CAR COMMUNICATION IMPLEMENTATION AND ADVANCEMENT

Thomas Macklin, Kailey Stettler, Aidan Wright,
Aanuoluwapo C Oshakuade Engineering students,
Sophie Liu, Ph.D. professor
Engineering School, Oral Roberts University
Email: sliu@oru.edu

Inter-vehicle communication has emerged as a promising technology in the modern car market, with the potential to enhance traffic coordination and reduce car accidents. When employed on a large scale, vehicles can receive real-time notifications about potential hazards or obstructions on the road, regardless of their proximity to the obstacle. As a result, the frequency of accidents and casualties can be significantly reduced. This technology relies on inter-vehicle communications networks known as VANETs, which have raised concerns regarding network security. Nevertheless, ongoing research is being conducted to fortify these networks against road hijacking and other forms of exploitation. When successfully implemented, the VANET network operates as a domino effect-like relay system, which could greatly improve the efficiency of vehicular travel on the road.

Automotive vehicles are among the emerging technologies that are relevant to the inter-vehicle communication discussion. The potential benefits of this technology are numerous, with improved road safety being one of the primary ones. However, for this technology to become a reality, communication between vehicles is necessary. Fortunately, this is already in development. According to the U.S. Department of Transportation, "connected vehicle (CV) technologies are equipment, applications, or systems that use V2X communications to address safety, system efficiency, or mobility on our roadways."

One aspect of V2X technology is vehicle-to-vehicle communication (V2V), where two vehicles communicate with each other. This technology, which offers 360-degree coverage, also includes vehicle-to-infrastructure (V2I) communication. It has the potential to save lives and a significant amount of money. According to NHTSA,

615,000 motor vehicle crashes could have been prevented had this technology been widely available. Through V2X technology, omnidirectional messages can be broadcast from one vehicle to another up to 10 times per second. The communication range of V2X is over 300 meters, which, combined with its ability to detect potential dangers blocked by weather, traffic, or terrain, makes it a useful communication tool for drivers.

In addition, the amount of use of this technology can be adjusted based on population and density. For example, it will be used more often in very populated, dense urban areas. However, in rural areas that are less dense, the technology will instead single in on specific wrecks. In addition, the V2X technology inside a car has the ability to “determine the other vehicle’s heading, speed, movement-related information, or operational status” (U.S.). This is far more advanced than line-of-sight sensors that are more commonly found in vehicles, as they can have a hard time even detecting the presence of another vehicle.

The United States of America, and the world in general, is diverse when it comes to the land itself: the terrain, population, height of manmade structures, and especially weather. Because of this, V2X technology has systems in place for potential situations that could occur unexpectedly. Power levels and data rates can be adjusted to message vehicles more often that could potentially get in a crash. The algorithms of this technology can be adjusted based on the type of vehicle, with it featuring many different message sizes. Because of this, V2X technology being widely available for cars across the country has the potential to save countless lives, as someone knowing to expect a stoppage, such as a wreck, up ahead is more likely to drive more cautiously, so as to not accidentally run into said stoppage himself.

In the United States, there are approximately 5,250,837 traffic accidents, with 35,760 being fatalities as of 2020. The average driver has a reaction time of 0.75 seconds to 1.5 seconds. This means that at a speed of 31.29 meters/second (70 mph), the driver will travel between 22.86 meters (75 ft) and 45.72 meters (150 ft) before any reaction occurs. Studies have shown that with at least 0.5 seconds of warning, nearly 60% of roadway collisions could be avoided.

Cooperative Collision Avoidance (CCA) is a system that allows vehicles to communicate with one another by sending wireless collision warning messages (W-CWM) when a collision is detected in car A, allowing the other vehicles near the accident to avoid it. With the CCA, a W-CWM is immediately sent with vehicle-to-vehicle communication (V2V), potentially enabling the reaction times of the following drivers to decrease and avoiding chain collisions. Some of the drawbacks of V2V are the potential of unreliability caused by channel fading, packet collisions, and communication obstacles that can prevent W-CWM from being delivered in time.

VANETs are wireless networks that are designed for vehicles, using the same principles as mobile ad hoc networks (MANETs). They were initially introduced in 2001 as "car-to-car ad-hoc mobile communication and networking," allowing cars to form networks and relay information to one another. The primary goal of VANETs is to provide road safety, navigation, and other services to motorists. These networks are an integral part of the Intelligent Transportation Systems (ITS) framework and are sometimes referred to as Intelligent Transportation Networks. They have evolved over

time into a broader "Internet of vehicles," and many experts predict that they will eventually become part of an "Internet of autonomous vehicles."

Despite initially being considered as an extension of MANET principles, VANETs have evolved to become a major research area in their own right. As of 2015, the term VANET is now largely used interchangeably with inter-vehicle communication (IVC), emphasizing the importance of vehicles being able to network with one another spontaneously, without the need for infrastructure such as road side units (RSUs) or cellular networks. Nevertheless, VANETs remain distinct in their capacity to facilitate direct communication between vehicles, thereby creating a reliable and robust network that has the potential to enhance both road safety and efficiency.

Several research efforts have been undertaken in recent years by researchers at Oral Roberts University to improve reliability and latency of VANET systems. One such paper discusses the performance of IEEE 802.11 bd wireless communication systems in Vehicular Ad Hoc Networks (VANETs). While previous systems had reliability issues, the newer IEEE 802.11 bd system offers improvements in the physical layer. The performance gains and packet loss rates of the system are evaluated further, as well as its ability to meet Quality of Service (QoS) requirements for safety applications in VANETs. Based on their analysis, the paper presents conclusions on the suitability of IEEE 802.11 bd for critical safety services in VANETs and suggests areas for future development.

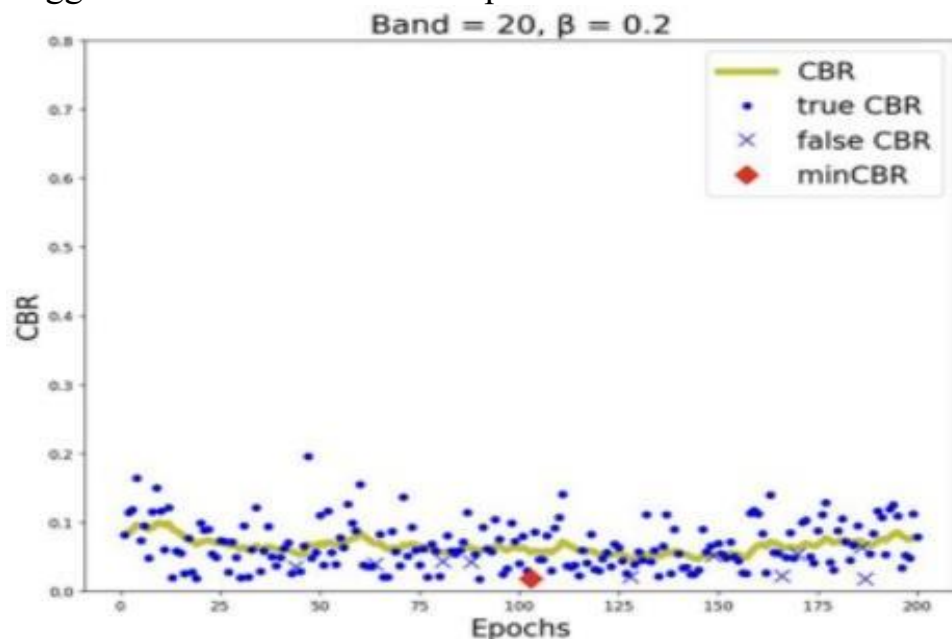


Figure 1. Optimization and convergence curve. Bandwidth = 20MHz, $\beta = 0.2$ nodes/m

Another paper discusses a real-time optimization scheme for Vehicular Ad Hoc Networks (VANETs) to improve balance between Quality of Service (QoS) and channel spectrum efficiency. The scheme uses a deep learning neural network (DLNN) working with a stochastic model, which predicts the QoS of VANET given a set of communication parameters. The DLNN and stochastic model complement each other to find an optimal solution of the parameters that maximizes channel efficiency while meeting QoS requirements. Inter-vehicle communication is a wonderful technology that has the potential to revolutionize everyday road experience for

drivers. Many automotive companies are looking to begin implementation of this technology on a large scale. However, for this to happen, considerable amounts of research and targeted planning must be done in order to eliminate risks and ensure a stable and secure network that properly services its users.

One area that needs significant work is in the security protocols and resources of the network. If left without improvement, these networks could likely become subject to exploitation, leading to actions that could result in data theft and even death. What was presented over these few pages has just been a small taste of the various studies and research that has been pumped into this technology. It is important to be aware of the fact that proper implementation of this technology can drastically lower accidents and damage to private property. As time advances, more insight will be made into this realm of tech that can greatly improve the state of travel on the roads.

References

1. C. Bieber. "Car Accident Statistics for 2023." Edited by Adam Ramirez, Forbes Advisor, Forbes Media LLC, 14 Mar. 2023, <https://www.forbes.com/advisor/legal/car-accident-statistics/>.
2. J. Zhao, Y. Wang, H. Lu, Z. Li and X. Ma, "Interference-Based QoS and Capacity Analysis of VANETs for Safety Applications," in IEEE Transactions on Vehicular Technology, vol. 70, no. 3, pp. 2448-2464, March 2021, doi: 10.1109/TVT.2021.3059740.
3. S. Biswas, R. Tatchikou and F. Dion, "Vehicle-to-vehicle wireless communication protocols for enhancing highway traffic safety," in IEEE Communications Magazine, vol. 44, no. 1, pp. 74-82, Jan. 2006, doi: 10.1109/MCOM.2006.1580935.
4. S. Ding and X. Ma, "Model-based Deep Learning Optimization of IEEE 802.11 VANETs for Safety Applications," 2022 International Wireless Communications and Mobile Computing (IWCMC), Dubrovnik, Croatia, 2022, pp. 835-840, doi: 10.1109/IWCMC55113.2022.9824558.
5. X. Yang, L. Liu, N. H. Vaidya and F. Zhao, "A vehicle-to-vehicle communication protocol for cooperative collision warning," The First Annual International Conference on Mobile and Ubiquitous Systems: Networking and Services, 2004. MOBIQUITOUS 2004., Boston, MA, USA, 2004, pp. 114-123, doi: 10.1109/MOBIQ.2004.1331717.
6. Zhanguzhinova, Symbat et al. "Communication between Autonomous Vehicles and Pedestrians: An Experimental Study Using Virtual Reality." Sensors (Basel, Switzerland) vol. 23,3 1049. 17 Jan.2023, doi:10.3390/s23031049.
7. "How Connected Vehicles Work." U.S. Department of Transportation, USA.gov, 27 Feb. 2020, <https://www.transportation.gov/research-and-technology/how-connected-vehicles-work>.
8. "Vehicle-to-Vehicle Communication." National Highway Traffic Safety Administration, U.S. Department of Transportation, <https://www.nhtsa.gov/technology-innovation/vehicle-vehicle-communication>.

Міністерство
освіти і науки
України



Міністерство освіти і науки України

Національний університет біоресурсів і
природокористування України

Механіко-технологічний факультет

Кафедра транспортних технологій та засобів у АПК

Академія прикладних наук Університету
управління та адміністрування в Ополі

Академія інженерних наук України
Українська асоціація аграрних інженерів



**ЗБІРНИК ТЕЗ
доповідей
VI Міжнародної
науково-практичної конференції
«Автомобільний транспорт та інфраструктура»**



AutoTransport and Infrastructure

19-21 квітня 2023 року
м. Київ

ББК 40.7
УДК 631.17+62-52-631.3

Рекомендовано до друку рішенням наукової ради механіко-технологічного факультету Національного університету біоресурсів і природокористування України від 18 квітня 2023 р., протокол № 8 .

Збірник тез доповідей VI Міжнародної науково-практичної конференції «Автомобільний транспорт та інфраструктура» (19–21 квітня 2023 року). Національний університет біоресурсів і природокористування України. Київ. 2023. 250 с.

ISBN 978-617-8102-96-8

В збірнику представлені тези доповідей науково-педагогічних працівників, наукових співробітників, аспірантів і докторантів, студентів, фахівців транспортної галузі, учасників VI Міжнародної науково-практичної конференції «Автомобільний транспорт та інфраструктура», в яких розглядаються нинішній стан та шляхи розвитку автотранспортної галузі.

ISBN 978-617-8102-96-8

© НУБіП України, 2023.

ОРГАНІЗАЦІЙНИЙ КОМІТЕТ:

Отченашко В. В., начальник науково-дослідної частини – голова організаційного комітету;

Братішко В. В., декан механіко-технологічного факультету – заступник голови організаційного комітету;

Тадеуш Покуса, проректор Академії прикладних наук Університету управління та адміністрування в Ополь, Польща – заступник голови організаційного комітету;

Киричок П.О., президент Академії інженерних наук України – заступник голови організаційного комітету;

Загурський О.М., професор кафедри транспортних технологій та засобів у АПК – секретар організаційного комітету.

Войтюк В. Д., професор кафедри технічного сервісу та інженерного менеджменту імені М. П. Момотенка;

Дьомін О.А., доцент кафедри транспортних технологій та засобів у АПК;

Калінін Є. І., завідувач кафедри тракторів, автомобілів та біоенергоресурсів;

Новицький А. В., завідувач кафедри надійності техніки;

Мацюк В. І., заступник декана з наукової роботи механіко-технологічного факультету, професор кафедри транспортних технологій та засобів у АПК;

Михайлович Я. М., професор кафедри технічного сервісу та інженерного менеджменту імені М. П. Момотенка;

Роговський І. Л., завідувач кафедри технічного сервісу та інженерного менеджменту імені М. П. Момотенка.

Савченко Л.А., завідувачка кафедри транспортних технологій та засобів у АПК.