15. Ilmenauer TK-Manager Workshop
Technische Universität Ilmenau, 17. Mai 2019
DOI: 10.22032/dbt.38489
URN: urn:nbn:de:gbv:ilm1-2019200270

Vehicle-to-Everything Communication for Safety of Vulnerable Road Users

by Parag Sewalkar

Parag Sewalkar is currently pursuing his PhD at Technical University of Ilmenau. His dissertation topic focuses on network congestion control and Quality of Service (QoS) mechanisms in Vehicle-to-Pedestrian networks. During his PhD, he also worked with Fraunhofer ESK, Munich on ezCar2X framework to implement European Cooperative Intelligent Transportation Systems (C-ITS) standards. He is involved in various workshops held by DG MOVE and European Telecommunication Standards Institute (ETSI) for ITS developments across Europe. He holds a master's degree in Computer Engineering from Syracuse University, New York, USA and bachelor's degree in Computer Engineering from University of Pune, India. His primary research interests are in vehicle-to-vehicle, vehicle-to-pedestrian communication, and Intelligent Transportation Systems.

DOI: 10.22032/dbt.38498

Motivation

Motorized Two Wheelers (MTW), cyclists, and pedestrians are called as Vulnerable Road Users (VRUs). Various safety features, such as, camera, RADAR, have been added to vehicles in order to detect and prevent crashes with VRUs. However, these safety features are limited by their Line of Sight (LOS) requirements. Vehicle-to-Everything (V2X) communication technology has been proposed to complement these technologies by overcoming their LOS limitation and enhance the safety features further. V2X system enables vehicle-to-vehicle (V2V), vehicle-to-VRU (V2P), and Vehicle-to-Infrastructure (V2I) communication. It requires that vehicles and VRUs periodically broadcast safety messages containing their speed and location. Pedestrians are the largest group of VRUs, especially in the urban areas. Due to their large number, pedestrian-generated messages can quickly congest the network. This also affects the reliable delivery of crucial messages e.g. between vehicle and pedestrian that are on the verge of collision. Hence, a mechanism that I) controls the network congestion, and II) guarantees the delivery of crucial messages in presence of large number of pedestrians is required. This work addresses these needs by designing a context-sensitive mechanism that uses pedestrians' context information for optimization of exchange of V2P messages.

State of the Art

V2X Technologies

Cooperative ITS (C-ITS) and Dedicated Short Range Communication (DSRC) technologies have been proposed for V2X communication in Europe and USA respectively. These technologies operate in 5.850 – 5.925 GHz spectrum and are based on IEEE 802.11p for PHY and Medium Access Control (MAC) layer. This spectrum is further divided into 10 MHz channels. These channels can be used by vehicles for exchange of safety-critical messages as well as messages with non-critical information. Safety-critical messages are exchanged over a dedicated channel that takes higher priority over the channels exchanging non-critical information. Figure 1. shows the channel allocation for DSRC technology in USA.

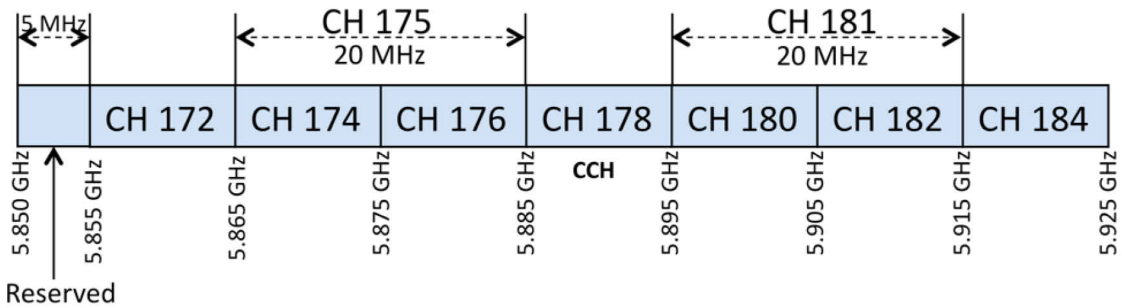

Figure 1. Channel allocation in DSRC

V2P Efforts

Multiple efforts have been undertaken to study and implement proof-of-concept V2P safety systems (Anaya, Merdrignac, Shagdar, Nashashibi, & Naranjo, 2014) (Wu, et al., 2014). These proofof- concept efforts prove that it is possible to establish V2P communication and also to warn drivers and pedestrians of eminent collision. Both the efforts use smartphones as pedestrian devices in order to establish communication. (Sewalkar & Seitz, 2019) propose a framework for a VRU safety system design based on various aspects such as type of VRU, mode of communication, etc. They also perform a case study of various VRU crash scenarios and different roles of VRU devices. While designing an effective V2P system, it is necessary to consider the performance of V2P communication as well as its effect on V2V communication. Efforts by (Sewalkar, Krug, & Seitz, 2017) show that if large number of pedestrians are present then it severely affects the performance of network as well as reliability of crucial communication.

Approach

Methods

Our approach aims to control network congestion and improve QoS of crucial communication with following two methods:

1. Reduce number of pedestrian-generated safety messages: This is achieved by making transmission of pedestrians' safety messages context-sensitive. Pedestrians' smartphones can be used to determine the context of pedestrians, such as, location, speed, which can then be used to optimize the transmission of safety messages.

2. Variable periodicity and priority of safety messages for crucial communication: Once it is determined that higher level of QoS is required for crucial communication, periodicity and priority of safety messages may be varied to achieve desired QoS.

Validation

OMNeT++, Veins, and SUMO provide capabilities to simulate V2X communication in a realistic scenario. We plan to use this framework in order to implement our solution. Various real-life scenarios will be simulated that would contain varying densities of vehicles, and pedestrians. Figure2. shows an example of real-life intersection scenario.

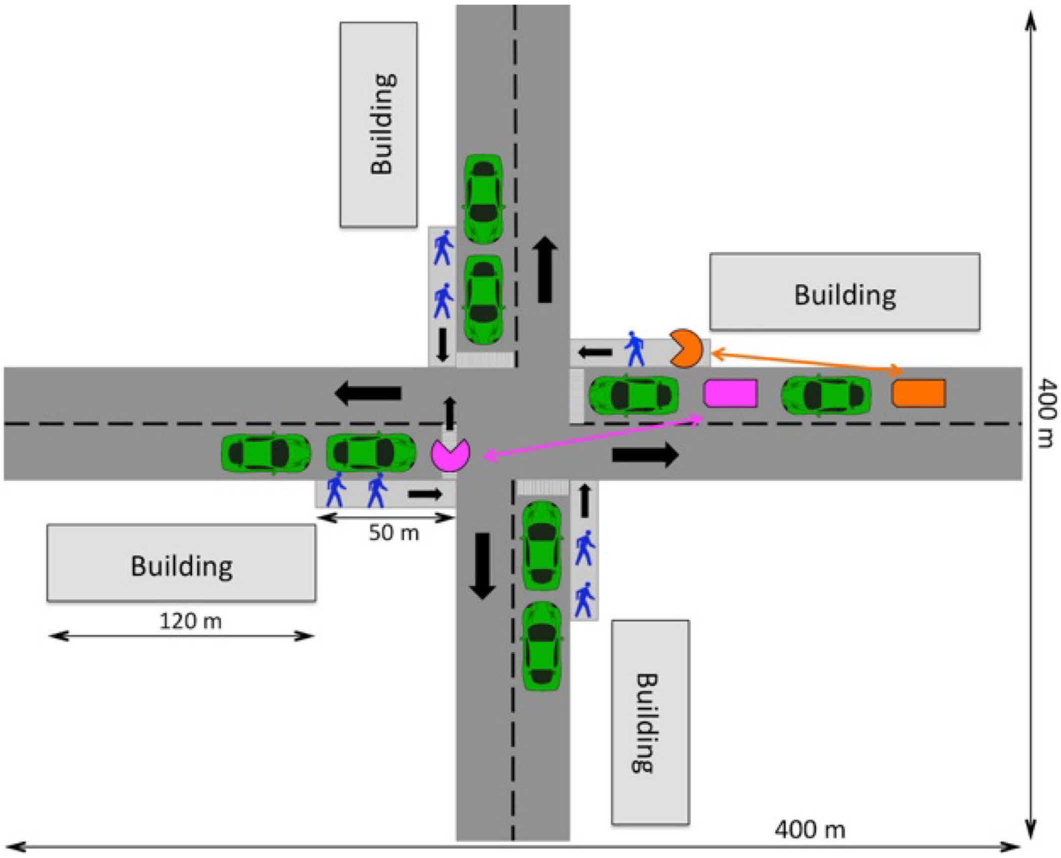

Figure 2. Real-life intersection Scenario (Sewalkar,Krug, & Seitz, 2017)

These scenarios then shall be used to validate our methods. We plan to measure the effect of pedestrians' safety messages on channel availability for vehicles (Channel Busy Percentage) and crucial beacon delivery ratio for a vehiclepedestrian pair that is on the verge of collision.

Conclusion

V2X technology can overcome the limitations of existing safety system in the vehicles to prevent crashes involving the VRUs. However, V2P communication has various challenges, such as, the target VRU group, network congestion, QoS requirements for crucial communication. VRU characteristics may be used to design an efficient V2P system that leverages the VRU context, minimizes the network congestion, and supports reliabile crucial communication.

References

[1] Wu, X.; Miucic, R.; Yang, S.; Al-Stouhi, S.; Misener, J.; Bai, S.; Chan, W. Cars Talk to Phones: A DSRC Based Vehicle-Pedestrian Safety System. In Proceedings of the 80th Vehicular Technology Conference (VTC Fall), Vancouver, BC, Canada, 14–17 September 2014.

[2] Anaya, J.J.; Merdrignac, P.; Shagdar, O.; Nashashibi, F.; Naranjo, J.E. Vehicle to Pedestrian Communications for Protection of Vulnerable Road Users. In Proceedings of the Intelligent Vehicles Symposium (IV), Dearborn, MI, USA, 8–11 June 2014.

[3] Sewalkar, P.; Krug, S.; Seitz, J. Towards 802.11p-based Vehicle-to-Pedestrian Communication for Crash Prevention Systems. 9th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), Munich, Germany, November 2017.

[4] Sewalkar, P.; Seitz, J. Vehicle-to-Pedestrian Communication for Vulnerable Road Users: Survey, Design Considerations, and Challenges. Sensors 2019, 19, 358.