Future connected vehicles: Communications demands, privacy and cyber-security

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1. Introduction

With the advance of data collection, data processing, telecommunication and vehicular technologies, connected vehicles (CVs) have been emerging as a crucial branch of smart mobility (Olia et al., 2015; Li et al., 2021). Its basic idea is to realize real-time exchanges and processing of essential information, such as positions and destinations, among surrounding vehicles and infrastructures. With connected vehicles, we can expect a paradigm shift of traffic management from the traditional reactive approach to the more efficient proactive approach. Specifically, the merits and implications of CVs can be found in bringing new solutions to the most challenging and vital transportation problems, and from group-based management to more individualized management, including but not limited to congestion mitigation, energy minimization, and traffic safety improvement.

At the macroscopic level, CVs will be able to receive real-time route choice guidelines to avoid bottlenecks (Wang et al., 2021). Although there are already similar services such as Google Maps, the information only indicates aggregated traffic states. With information from CVs, the accuracy and usability of traffic state estimation will be considerably improved, which is pivotal for congestion mitigation. At the tactical level, taking signalized intersection control as an example, CVs could feed their positions and destinations to the traffic controller and receive driving guidelines from the controller to enhance the centralized control. At the microscopic level, vehicle-to-vehicle (V2V) communication techniques could preliminarily realize cooperative driving. Although the cooperation cannot be as advanced as that in autonomous driving cases, the benefits are still significant. Existing studies have demonstrated that, through basic communication, CVs could reduce travel time up to 50% at work zone areas and drive more safely in critical scenarios (Cao et al., 2021), as illustrated in Fig. 1.

Another immediate implication is to reinforce emergency vehicle (EV) preemptions (Wu et al., 2020). Emergency vehicles are critical in saving lives and avoiding property loss and thus have been the focus in post-accident management. In the current practice, emergency vehicles, i.e., fire trucks and ambulances, largely rely on the horns and obligations of surrounding vehicles, which are not only highly unreliable for EVs but also disruptive for normal traffic. It is commonly seen that an EV is blocked in the middle of a less-congested road only because surrounding vehicles are not able to clear one lane on such short notice of the horn.

With V2V techniques, the communication between EVs and normal vehicles can be substantially extended and enable a more gradual and reliable clearance of the lane.

2. Communication demands

To realize the above possibilities, reliability, low latency, and secure connectivity will be a key enabler. The 5th generation of mobile communications (5G) technologies and beyond will enable road users and vehicles to be connected to the networks as well as to communicate directly with each other (Fallgren, 2020; Fallgren et al., 2018). With 5G and its evolutions, users will expect the connected society to be available with no limitations, and users will make use of bandwidth-demanding services like augmented reality and virtual office applications, also when on the move. The modern vehicle itself is also emerging as a heavy consumer and producer of information that constantly collects and receives information that could be highly valuable to support smart city, such as sensing air quality, monitoring noise levels, route guidance, etc.

In this context, future transportation system may also play an important role in wireless networks and thus become an integrated part of the communications infrastructure, thus forming integrated moving networks to improve capacity and coverage of the mobile networks. In return, vehicles would benefit from the additional capacity and reliability of the mobile network service for their own connectivity and sensing needs. Such steps are currently being taken within ongoing research towards the 6th generation of mobile communications (6G), in the area of joint communications and sensing (radar) and mapping (De Lima et al., 2021), as well as on the evolution of mobile edge computing towards a distributed platform hosting artificial intelligence based learning and inference services. There are also untapped possibilities to explore various kinds of situational awareness information to improve communications, like road infrastructure information, driving route information, positioning, and social networks.

3. Cyber-security and privacy

Key challenges when implementing all these new services are how to guarantee privacy, security and implement authentication and owner protection of the information sources. Safety work for vehicles has in the past focused on hardware and software failures but with the increased...
Finally, we also have to consider component to trace back the sources of all messages preceding an event. In addition, to ease forensics investigations, send a particular type of message, verification to arrive (Rosenstatter et al., 2020). Therefore, they must be designed to be resilient and able to immediately recon the backbones paving the road towards this future. Without sufficient high bandwidth and low delays. It is so far not obvious where these solutions to the same problem. This will possibly result in different outcomes since we cannot guarantee that they will receive the same information due to message loss, corruption, or limited bandwidth. If computations instead are conducted by roadside servers or in the cloud, computations can be more efficient, and it is possible to make optimal decisions albeit being more dependent on good network coverage with high bandwidth and low delays. It is so far not obvious where these computations should be done and it may vary depending on the type and quality of service needed and on communication quality. In this regard, communication and computation are to some extent twisted, and the current solutions are far from satisfactory. In summary, more research is warranted before highly functional and safe connected vehicles can be eventually realized.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References


Tomas Olovsson is an Associate Professor at the Department of Computer Science and Engineering at Chalmers University of Technology, Gothenburg, Sweden. He has been working actively with computer security for more than 25 years, both in the industry and in the academia. His research interests are communications and security and he is currently focusing on security and privacy for Internet-connected vehicles. This work includes secure internal network architectures and secure V2X communications.

Tommy Svensson is Full Professor in Communication Systems at Chalmers University of Technology in Gothenburg, Sweden, where he is leading the Wireless Systems research on air interface and wireless backhaul networking technologies for future wireless systems. He received a Ph.D. degree in Information theory from Chalmers in 2003, and he has worked at Ericsson AB with core networks, radio access networks, and microwave transmission products. He is heavily involved in European top research projects towards next generation mobile communications systems, from 4G, 5G to currently 6G. He has co-authored 5 books, and 230 journal/conference papers. He has been editor/organizer of several top IEEE journals, conferences and workshops, and chair of the awards winning IEEE Sweden joint Vehicular Technology/ Communications/ Information Theory Societies chapter.

Jiaming Wu is a researcher in the Department of Architecture and Civil Engineering. His research interests include cooperative control of connected and automated vehicles and emerging Mobility-as-a-Service systems. He is now leading and involved with several research projects regarding public transit systems, connected and automated vehicle control, and modular autonomous buses. He has published several research articles in top-tier journals such as TR-Part A, TR-Part B, TR-Part C, and CACAIE.

Tomas Olovsson
Department of Computer Science and Engineering, Chalmers University of Technology, Gothenburg, SE, 41296, Sweden
E-mail address: tomas.olovsson@chalmers.se.

Tommy Svensson
Department of Electrical Engineering, Chalmers University of Technology, Gothenburg, SE, 41296, Sweden
E-mail address: tommy.svensson@chalmers.se.

Jiaming Wu*
Department of Architecture and Civil Engineering, Chalmers University of Technology, Gothenburg, SE, 41296, Sweden
* Corresponding author.
E-mail address: jiaming.wu@chalmers.se (J. Wu).