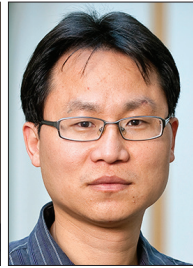# Drones in the Era of V2X Communications

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The new paradigm of vehicle-to-everything (v2X) communications consolidates all vehicular networking models into the 3D domain for exchanging information between the vehicle and its surroundings. Besides other ground objects and vehicles, the conventional models consider the surroundings to be infrastructure consisting of WiFi and cellular networks. However, the unmanned aerial vehicles (UAVs), widely known as drones, offer air-mounted transceivers for location monitoring and communications relay. This drone-to-everything (D2X) complements all other types of ground V2X including vehicle-to-infrastructure (V2I), vehicle-to-network (V2N), vehicle-to-vehicle (V2V), vehicle-to-device (V2D), vehicle-to-grid (V2G), vehicle-to-pedestrian (V2P), and so on. Up to this point, the radio interfacing for all those technologies can be facilitated through minor changes in coverage zones, spectrum allocations, and mobility management. However, the operations management of such complicated distributed system requires adopting other supplementary modern technologies that can successfully integrate all different vehicle networking components. For instance, the ultra-reliable low-latency communication (URLLC) of the fifth-generation core network (5GC) is the type of service-based architecture (SBA) that supports vehicular networking within 5G. URLLC requires efficient automation of virtual resources to bring this type of core network to associated mobile edge computing (MEC). Moreover, the data transactions from various systems need to be maintained locally within each 3D V2X domain initiating new opportunities for employing blockchains and big data. Considering both sliced infrastructure and data categorization, artificial intelligence (AI) becomes the only efficient entity that can administrate and provision such a complicated system. To make such systems integration successful, there are still requirements to develop supporting protocols, codecs, over-the-top (OTT) connectivity agents, and so on. Therefore, there are many research challenges that need to be addressed by the community of vehicular technology as well as products to be developed by the cellular and automotive industries.

The engineering cycle includes theory and analysis, definition of use cases, product engineering, field trials, product delivery, and continuous refinement. However, the cloud dependency and virtualized applications that use open source codes raise many questions about the overall life cycle management of wireless networks, particularly vehicular networking. From the above, we understand the enabling technologies for both system and software layers, but we have no evaluation of a complete network that comprises all those components in an end-to-end model. Therefore, it is necessary to develop V2X trials that verify the complacency of various technologies to 5G key performance indicators (KPIs) as well as maintain safety on both ground roads and air corridors.

This issue has three articles. The first article, "Intelligent Link Adaptation in 802.11 Vehicular Networks: Challenges and Solutions" by Wenchao Xu, Haibo Zhou, Huaqing Wu, Feng Lyu, Nan Cheng, and Xuemin (Sherman) Shen, studies the Internet of Vehicles (IoVs) considering V2X usage and communications. The authors investigate the supporting radio interface by developing data-driven learning bed link adaptation (LA) for 802.11. The article also includes a data-driven model to capture the channel variance in order to improve the drive-thru Internet throughput. The authors support their proposals with interesting results that may contribute to standards evolution.

The second article, "Integrating Fog Computing with VANETs: A Consumer Perspective" by Hasan Ali Khattak, Saif Ul Islam, Ikram Ud Din, and Mohsen Guizani, studies vehicular ad hoc network (VANET) applications and their intensive communication and computation requirements. The authors propose to use fog computing for more agile migration of computational resources toward the edge of the network to meet the VANET, increasing processing and storage requirements. This proposal for vehicular fog extends the fog computing paradigm to vehicular networking domains supporting more intelligent provision of resources, improved response time, and lower latency. The article provides details about the testbed developed for proposal assessment with relevant results.

The last article, by Gábor Fodor, Hieu Do, Shehzad Ali Ashraf, Ricardo Blasco, Wanlu Sun Marco Belleschi, and Liang Hu, is "Vehicle-to-Everything (V2X) Services by LTE Release-15 Systems". The authors provide an interesting tutorial on the new V2X features enabled by Rel-15 Long Term Evolution (LTE) systems. The article focuses on carrier aggregation, higher order modulation, low latency support, and new resource management solutions. The authors provide analysis to compare the technology evolution performance between Rel-14 and Rel-15 as well as explain the trends for 3GPP V2X technology in the upcoming releases.

Biographies

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