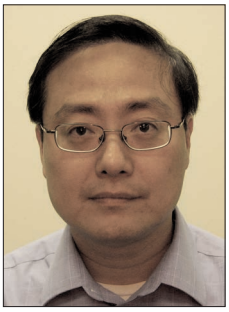
AUTOMOTIVE NETWORKING AND APPLICATIONS



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In this 14th issue of the Automotive Networking and Applications Series, we are pleased to present three articles that address

- Release 1 of the cooperative intelligent transport systems (C-ITS) standards in Europe
- The implementation of a virtual traffic lights application with only partial market penetration
- The usage of multihop wireless communications for intra-car sensor networking

By timely information exchanges among vehicles, and between vehicles and roadway infrastructure, vehicles can transform from autonomous systems into cooperative systems, thereby enabling applications such as active road safety and traffic efficiency. Cooperative intelligent transport systems (C-ITS) standards are crucial to achieve interoperability among communications equipment made by different manufacturers for vehicles and roadway infrastructure. Release 1 of the C-ITS standards was completed in early 2014, and it covers base standards for ITS-G5 radio (also named wireless access in vehicular environment, or WAVE, in the United States), ad hoc networking and transport with GeoNetworking and Basic Transport Protocol (BTP), the facilities layer such as messaging protocols CAM and DENM, security, privacy and requirements for applications, among others. The first article, "Cooperative Intelligent Transport Systems Standards in Europe" by A. Festag, provides a comprehensive overview of release 1 of the C-ITS standards in Europe. The article first gives a brief overview of the C-ITS core standards set and compares it with the U.S. dedicated short-range communications (DSRC) standards in IEEE 1609 and SAE J2735. The author then provides more detailed overviews of the Release 1 C-ITS standards covering the access layer, the networking and transport layers, the facilities layer, and applications, security, and management in the subsequent sections of the article. The article concludes with a brief outlook on the expected C-ITS corridor pilots in Europe starting in 2015, as well as future standardization directions.

Virtual traffic lights (VTL) technology has recently been proposed as a new traffic management solution, where vehicles equipped with both the DSRC and VTL technologies will self-organize to dynamically elect a leader that serves as a virtual traffic light to decide the right of way at a given street intersection, thereby replacing the physical traffic lights. However, how to roll out the VTL technology without assuming 100 percent market penetration has been a main challenge. The second article, "Implementing Virtual Traffic Lights with Partial Penetration: A Road Map" by O. Tanguz *et al.*, shows that 100 percent market penetration is not necessary for deploying VTL technology. The authors first present a new method and system for the coexistence of VTL with the current infrastructure-based traffic lights system, starting with very small penetration ratios of VTL-equipped vehicles (i.e., vehicles with both DSRC and VTL technologies). The article then discusses simulation results to illustrate how the proposed game-theoretic VTL deployment methodology may work in various cases. The authors conclude with an extensive discussion on open challenges that need to be resolved in order to bring the VTL application into the marketplace.

Vehicles incorporate an increasing number of sensors to feed crucial situation data to electronic control units, whereas typically the sensors and control units are connected through physical wires, which increase the weight, maintenance, and cost of vehicles. The third article, "Intra-Car Multihop Wireless Sensor Networking: A Case Study" by M. Hashemi *et al.*, investigates the use of multihop wireless communication to support intra-car sensor networking and demonstrates the potential for significant reliability and energy consumption improvements over existing single-hop (star topology) approaches. The article first gives an overview of the existing intra-car wireless sensor network (WSN) studies and outlines a multihop intra-car WSN approach using the Collection Tree Protocol. The authors then show, via extensive test results of two in-car networks (a suspension network and an engine network) under static and dynamic vehicular conditions, that the multihop WSN approach can achieve higher packet deliv-

ery rates across all sensor nodes as well as lower radio energy consumption than that of the star- topology (single-hop) approaches.

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BIOGRAPHIES

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TIMO KOSCH works as a team manager for BMW Group Research and Technology, where he is responsible for projects on distributed information systems, including such topics as cooperative systems for active safety and automotive IT security. He has been active in a number of national and international research programs, and serves as Coordinator for the European project COMeSafety, co-financed by the European Commission. He is also currently heading the system development for a large German Car2X field test. For more than three years, until recently, he chaired the working group Architecture and was a member of the Technical Committee of the Car-to-Car Communication Consortium. He studied computer science and economics at Darmstadt University of Technology and the University of British Columbia in Vancouver with scholarships from the German National Merit Foundation and the German Academic Exchange Service. He received his Ph.D. from the computer science faculty of the Munich University of Technology.

TADAO SAITO [LF] received a Ph. D degree in electronics from the University of Tokyo in 1968. Since then he has been a lecturer, an associate professor, and a professor at the University of Tokyo, where he is now a professor emeritus. Since April 2001 he is chief scientist and CTO of Toyota InfoTechnology Center, where he studies future ubiquitous information services around automobiles. He has worked in a variety of subjects related to digital communication and computer networks. His research includes a variety of communication networks and their social applications such as ITS. Included in his past study, in the 1970s he was a member of the design group of the Tokyo Metropolitan Area Traffic Signal Control System designed to control 7000 intersections under the Tokyo Police Authority. Now he is Chairman of the Ubiquitous Networking Forum of Japan working on a future vision of the information society. He is also Chairman of the Next Generation IP Network Promotion Forum of Japan. He wrote two books on electronic circuitry, four books on computers, and two books on digital communication and multimedia. From 1998 to 2002 he was chairman of the Telecommunication Business Committee of the Telecommunication Council of the Japanese government and contributed to regulatory policy of telecommunication business for broadband network deployment in Japan. He is also the Japanese representative to the International Federation of Information Processing General Assembly and Technical Committee 6 (Communication System). He is an honorary member and Fellow of IEICE of Japan.