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Automotive Networking Series*

## TOPICS IN AUTOMOTIVE NETWORKING



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Recently there have been significant efforts to integrate communications and computing technologies into vehicular and transportation systems. The goal of these efforts is to improve preventive driving safety, reduce traffic congestion, and enable a plethora of new applications such as vehicle diagnostics, mobile commerce, and entertainment, all supported by the vehicle-to-vehicle and vehicle-to-infrastructure communication capabilities. Significant industrial and governmental efforts are underway to accelerate the introduction of vehicle-to-vehicle/vehicle-to-infrastructure networking functions in vehicles and highway infrastructure, including, for example, EU C2C-CC, EU COMeSafety, COOPERS, CVIS, and Safespot projects; US VII, US CAMP/VSC-2; Japan AHS/Smartway and ASV, ISO/CALM, IEEE WAVE, and ETSI TC ITS, among others.

Many research challenges, however, need to be addressed in order for vehicular communications to be widely deployed. The combination of diverging requirements of emerging applications and unique characteristics of the roadway environments leads to many interesting research areas. These requirements pose new challenges in the design of vehicular communication systems to achieve high reliability and low communications latency in mobile roadway environments. The mobility of vehicles can result in rapid network topology changes and node density fluctuations as well as constantly changing environmental conditions. This could overwhelm the limited bandwidth of radio links if the communication protocols are not well designed. Vehicular applications require efficient use of broadcast, multicast, and unicast in a heterogeneous network consisting of moving vehicles and stationary roadside units. Such features require radio technologies that are tailored to communications in roadways, medium access control (MAC) and network protocols that are scalable in performance and adaptive to environment changes to support vehicular application needs. Achieving security for applications and networking, and maintaining driver privacy in vehicular communications are also crucial challenges.

*IEEE Communications Magazine* is starting a new series on automotive networking this year, to be published in May and November. After the announcement of the new

series, we received a large number of article submissions. Most of them are still under review. In this issue of the Automotive Networking Series, we are pleased to present the first two articles addressing important topics related to the crucial physical layer: V2V channel modeling and characteristics of V2V channels at 5.9 GHz on scaled 802.11a waveforms. Physical layer channel modeling is crucial to the design and evaluation of vehicular communication systems. While the study of wireless channels has a long history, V2V channels pose new challenges given that both the sending and receiving vehicles can move at high speeds in roadway environments, and the antennas are mounted at low vehicle heights. V2V channels often have greater dynamic ranges than many conventional channels and experience severe fading. Thus, new V2V channel models as well as their effects on vehicular communications should be established and have received much research attention recently. These two articles provide a good sample of the state of the art in one of the many important research challenges in vehicular communications being addressed.

The first article, “Channel Modeling for Vehicle-to-Vehicle Communications” by D. Matolak, discusses key statistical channel parameters in V2V channel models, and briefly surveys existing analytical and experimental V2V channel results. The article reports the recent results by the author’s team on the measurement and channel modeling in the 5 GHz band in urban, small city, and highway environments; and shows the effects of V2V channel models on two transmission schemes (orthogonal frequency-division multiple access, OFDMA, and direct sequence spread spectrum) to demonstrate the need for high-fidelity channel models for V2V communications systems.

The second article, “A Measurement Study of Time-Scaled 802.11a Waveforms over the Mobile-to-Mobile Vehicular Channel at 5.9 GHz” by L. Cheng *et al.*, gives a brief overview of the DSRC standards and key channel parameters for the 802.11a family of OFDM waveforms, studies the characteristics of the mobile V2V channel on scaled versions of the current IEEE 802.11a standard, and evaluates how readily they can be applied to vehicular networks. The authors consider various roadway environments (highway, suburban, rural) and measurements in the 5.9

GHz DSRC band, and highlight necessary design trade-offs for best performance in the roadway environments.

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LUCA DELGROSSI is manager of the Vehicle-Centric Communications Group at Mercedes-Benz Research & Development North America Inc., Palo Alto, California. He started as a researcher at the International Computer Science Institute (ICSI) of the University of California at Berkeley and received his Ph.D. in computer science from the Technical University of Berlin, Germany. He served for many years as professor and associate director of the Centre for Research on the Applications of Telematics to Organizations and Society (CRATOS) of the Catholic University at Milan, Italy, where he helped create and manage the Masters in Network Economy (MiNE) program. In the area of vehicle safety communications, he coordinated the Dedicated Short

Range Communications (DSRC) Radio and On-Board Equipment work orders to produce the DSRC specifications and build the first prototype DSRC equipment as part of the Vehicle Infrastructure Integration (VII) initiative of the U.S. Department of Transportation. The Mercedes-Benz team in Palo Alto is a recognized leader in the research and development of vehicle-to-infrastructure as well as vehicle-to-vehicle communications safety systems.

TIMO KOSCH works as a team manager for BMW Group Research and Technology where he is responsible for projects on Car2X, 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. For more than three years, until recently, he chaired the Architecture working group 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 200 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.