

# Guest Editorial

## Special Section on Vehicular Communication Networks

**T**RAFFIC congestion, delays, and accidents in transportation systems have caused significant loss of life, wasted energy, and loss of productivity. To improve the safety, security, and efficiency of transportation systems and to enable new mobile services and applications for the traveling public, intelligent transportation systems (ITS) have been developed, which apply rapidly emerging information technologies in vehicles and transportation infrastructures. The development of inter-/intravehicle and infrastructure-to-vehicle mobile, mesh, and *ad hoc* networks is one of the most challenging and critical issues for the ITS industry and is of considerable interest to the communication and networking research community. This special section consists of 18 papers, selected from 78 submissions, that represent the state of the art in this fast-moving research area. The objectives of this section are to facilitate the deployment of vehicular communication networks and to promote further research and activities that enable new transportation products and services, such as advanced traffic management, vehicle control, safety control, networking and information services on the road, etc.

Wireless intervehicular communication is expected to enable a broad range of information applications in the future. Safety applications, including incident detection, are the top priority. In the first paper, "Efficient Coordination and Transmission of Data for Cooperative Vehicular Safety Applications," Robinson, Caveney, Caminiti, Baliga, Laberteaux, and Kumar present a Message Dispatcher architecture for efficiently communicating vehicle data among neighboring vehicles. This paper provides important insights for wireless-channel-usage optimization and describes an experimental deployment in several vehicles at the Toyota Technical Center, Ann Arbor, MI. In the second paper, "Extending Driver's Horizon Through Comprehensive Incident Detection in Vehicular Networks," a comprehensive and efficient incident-detection approach is proposed by Chatzigiannakis, Grammatikou, and Papavassiliou. The approach provides an effective way to process and organize information taken at different times from different locations and to integrate it into a consistent model. In the third paper, "Data Pouring and Buffering on the Road: A New Data Dissemination Paradigm for Vehicular *Ad Hoc* Networks," Zhao, Zhang, and Cao propose a data pouring and buffering paradigm to address the data-dissemination problem in vehicle *ad hoc* networks (VANETs), considering the unique characteristics of VANETs.

In high-mobility, high-density, random-topology vehicular networks, sharing limited wireless resources and reliably communicating between vehicles are very challenging. In the fourth paper, "Reliable Neighborcast," Maxemchuk and Tientrakool introduce a new communication paradigm—reliable neighborcast—and present a reliable-neighborcast protocol that operates as an overlay on existing reliable broadcast protocols. In the fifth paper, "Distributed Mobility Transparent Broadcasting in Vehicle to Vehicle Networks," Yang, Ye, and Sikdar propose a broadcast protocol to achieve efficient broadcasting in vehicle-to-vehicle networks. In the sixth paper, "A Distributed MAC Scheme for Emergency Message Dissemination in Vehicular *Ad Hoc* Networks," the objective is to ensure that emergency messages in VANETs can be disseminated in a timely manner; Peng and Cheng present a fully distributed medium-access-control (MAC) scheme, based on a pulse-control mechanism, which realizes strict packet-level priority scheduling for emergency packets.

In addition to safety, VANETs will support a wide range of multimedia (e.g., video/audio) and data (e.g., e-maps, road/vehicle-traffic/weather information) applications. In the seventh paper, "Clustering-Based Multi-Channel MAC Protocols for QoS-Provisionings Over Vehicular *Ad Hoc* Networks," Su and Zhang propose a cluster-based multichannel communication scheme. The communication scheme integrates clustering with contention-free and contention-based MAC protocols. An analytical model is developed to determine the delay for safety messages transmitted by cluster-head vehicles and the MAC parameters that result in acceptable delays.

Directional antennas reduce radio interference and improve channel utilization; however, they constrain the MAC-protocol design because of deafness and other problems. To address this issue, in the eighth paper, "LMA: Location and Mobility Aware Medium Access Control Protocols for Vehicular *Ad Hoc* Networks Using Directional Antennas," Feng develops a location- and mobility-aware MAC protocol for vehicle networks deploying directional antennas.

Scalable and reliable routing is a critical issue for multihop, mobile, and highly dynamic VANET. In the ninth paper, "A Stable Routing Protocol to Support ITS Services in VANET Networks," Taleb, Sakhaee, Jamalipour, Hashimoto, Kato, and Nemoto propose a routing protocol that groups vehicles according to their velocity vectors, which decreases the rate at which links between vehicles change. In the tenth paper, "Conditional Transmissions: A Communication Strategy for Highly Dynamic Vehicular *Ad Hoc* Networks," Ducourthial, Khaled, and Shawky propose a novel approach for routing in

highly dynamic networks, relying on condition-based communication. Instead of using addresses or positions, a message is sent with some conditions used for retransmission or reception. Simulations and experiments on a road show the effectiveness of the solution. In the 11th paper, "A Multihop Peer Communication Protocol with Fairness Guarantee for IEEE 802.16 Based Vehicular Networks," Yang, Ou, Chen, and He propose a multihop communication protocol for relaying and peer collaboration when vehicles can reach IEEE 802.16 base stations.

The following five papers consider localization, mobility management, and network-topology control. In the 12th paper, "Vehicular Node Localization Using Received Signal Strength Indicator," Parker and Valaee present a cooperative vehicle-position-estimation algorithm, which achieves higher accuracy and greater reliability than GPS-based positioning solutions, by using intervehicle distance measurements taken by a ranging technique. In the 13th paper, "Performance Evaluation of SUVnet with Real-Time Traffic Data," Huang, Luo, Li, Li, Li, Shu, and Wu construct a mobility model using the GPS data from more than 4000 taxis collected in Shanghai, China. Based on this model, the network topology, connectivity, and performance are studied. In the 14th paper, "Optimized FMIPv6 Using IEEE802.21 MIH Services in Vehicular Networks," Mussabbir, Yao, Niu, and Fu propose a cross-layer mechanism to make intelligent handover decisions and to optimize handover procedures in vehicular networks. In the 15th paper, "Design and Implementation of a SIP-Based Mobile and Vehicular Wireless Network with Push Mechanism," to maintain Internet connectivity anytime and anywhere, Tseng, Chen, and Cheng propose a SIP-based mobile-network gateway, which is equipped with both internal and external wireless interfaces. In the 16th paper, "The Optimal Placement of Gateways in Vehicular Networks," Li, Huang, and Fang propose 1-D and 2-D placements of gateways that minimize the average number of hops from access points to gateways so that the communication delay is decreased.

In addition to intervehicle communications, intravehicle communication networks are also an important component of future ITS systems. In the 17th paper, "Systematic Message Schedule Construction for Time-Triggered CAN," Schmidt and Schmidt propose a framework to construct message schedules in time-triggered controller area networks, considering several performance metrics, such as bandwidth utilization and jitter, and taking hardware constraints into account.

Future proliferation of ITS will also depend on its ability to enforce security measures. In the last paper, "GSIS: A Secure and Privacy Preserving Protocol for Vehicular Communications," Lin, Sun, Ho, and Shen identify some of the unique design requirements in the aspects of security and privacy preservation for VANETs and propose a novel secure and privacy-preserving protocol based on group signatures and identity-based signature techniques. Extensive simulations are conducted to verify the effectiveness of the proposed protocol under various road-system scenarios.

In closing, the guest editors would like to acknowledge the contributions of the many experts who submitted their work, participated in the review process, and provided constructive and helpful comments to the authors to improve the technical content and presentation quality of the papers. They would also like to extend their sincere thanks to Dr. T. Wong, the former Editor-in-Chief, and Dr. W. Zhuang, the Editor-in-Chief of the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, for their support and help in bringing this special section to press. We hope you will enjoy the papers in this collection.

XUEMIN SHEN, *Guest Editor*

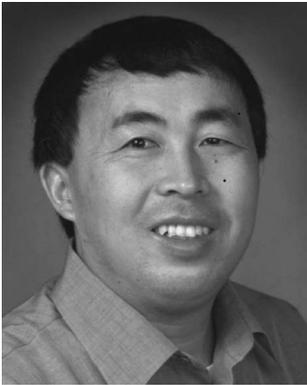
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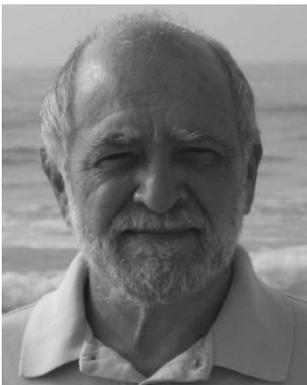


**Xuemin (Sherman) Shen** (M'97–SM'02) received the B.Sc. degree in electrical engineering from Dalian Maritime University, Dalian, China, in 1982 and the M.Sc. and Ph.D. degrees in electrical engineering from Rutgers University, Camden, NJ, in 1987 and 1990, respectively.

He is a Professor, a University Research Chair, and an Associate Chair of Graduate Studies, Department of Electrical and Computer Engineering, University of Waterloo, Waterloo, ON, Canada. His research focuses on mobility and resource management in interconnected wireless/wired networks, ultrawideband wireless-communication systems, wireless security, and *ad hoc* and sensor networks. He is a coauthor of three books and has published more than 300 papers and book chapters in wireless communications and networks, control, and filtering.

Dr. Shen serves as the Technical Program Committee Chair for IEEE Globecom'07, the General Cochair for Chinacom'07 and QShine'06, and the Founding Chair for the IEEE Communications Society Technical Committee on P2P Communications and Networking. He also serves as the Founding Area Editor for the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS;

the Editor-in-Chief for *Peer-to-Peer Networking and Application*; Associate Editor for the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, the *KICS/IEEE Journal of Communications and Networks*, *Computer Networks*, *ACM/Wireless Networks*, *Wireless Communications and Mobile Computing (Wiley)*, etc. He has also served as the Guest Editor for the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, *IEEE Wireless Communications*, and *IEEE Communications Magazine*. He received the Best Paper Award from IEEE ICC 2007 and IEEE CCNC 2006, the Outstanding Performance Award in 2004 and the Excellent Graduate Supervision Award in 2006 from the University of Waterloo, the Premier's Research Excellence Award in 2003 from the Province of Ontario, Canada, and the Distinguished Performance Award in 2002 from the Faculty of Engineering, University of Waterloo. He is a Registered Professional Engineer in the province of Ontario.

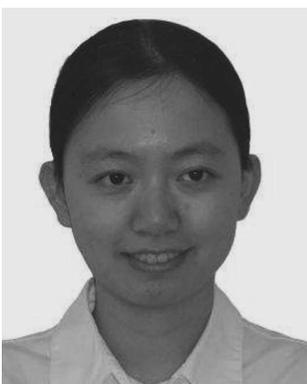


**Nicholas F. Maxemchuk** (M'72–SM'85–F'89) received the B.S.E.E. degree from the City College of New York and the M.S.E.E. and Ph.D. degrees from the University of Pennsylvania, Philadelphia.

For the past six years, he has been a Professor with the Electrical Engineering Department, Columbia University, New York. Before he joined Columbia University, he spent 25 years with Bell Laboratories and AT&T Laboratories, Middletown, NJ, as a member of the technical staff, as a Department Head, and as a Technical Leader. Moreover, before he joined Bell Laboratories, he spent eight years at the RCA David Sarnoff Research Center, Princeton, NJ, as a member of the technical staff.

Dr. Maxemchuk has been the Editor-in-Chief for the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, an Editor for the IEEE TRANSACTIONS ON COMMUNICATIONS and the *Journal of the Association for Computing Machinery*, and was on the founding committee of the IEEE/ACM TRANSACTIONS ON NETWORKING, where he served on their steering committee for

11 years. In 2006, he received the Koji Kobayashi Award for his work in computer communications. He also received the IEEE's Leonard G. Abraham Prize Paper Award in 1985 and 1987 (for his papers on data and voice on CATV networks and the Manhattan Street networks) and the William R. Bennett Prize Paper Award in 1997 (for his paper on an anonymous credit card).



**Lin Cai** (S'00–M'06) received the M.A.Sc. and Ph.D. degrees (with an Outstanding Achievement in Graduate Studies Award) in electrical and computer engineering from the University of Waterloo, Waterloo, ON, Canada, in 2002 and 2005, respectively.

Since July 2005, she has been an Assistant Professor with the Department of Electrical and Computer Engineering, University of Victoria, Victoria, BC, Canada. Her research interests span several areas in wireless communications and networking, with a focus on network protocol and architecture design supporting emerging multimedia traffic over wireless, mobile, *ad hoc*, and sensor networks. She serves as an Associate Editor for the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY (since 2007), the *EURASIP Journal on Wireless Communications and Networking* (from 2006 to the present), and the *International Journal of Sensor Networks* (from 2006 to the present).