Alam, M.; Rayes, A.; He, X.; Atiquzzaman, M.; Lloret, J.; Tsang, KF. (2018). Special issue on dependable wireless vehicular communications for intelligent transportation systems. IEEE Transactions on Intelligent Transportation Systems. 19(3):949-952. https://doi.org/10.1109/TITS.2018.2808778

# Introduction to the Special Issue on Dependable Wireless Vehicular Communications for Intelligent Transportation Systems (ITS)

Over the past couple of decades, transportation systems have begun to receive widespread attention from the scientific community and emerged toward Intelligent Transportation Systems (ITS). Effective vehicular connectivity techniques can significantly enhance efficiency of travel, reduce traffic incidents and improve safety, and alleviate the impact of congestion; devising the ITS experience. Furthermore, during the past decades, the volume and density of vehicles increased significantly, especially the road traffic; this lead to a dramatic increase in the number of accidents and congestion, with negative impacts on the economy, environment, and quality of people's lives. In particular, according to the World Health Organization (WHO), road traffic injuries are estimated to be the leading cause of death for young people aged 15-29 and the ninth cause of death worldwide in 2015. The enabling communication technologies are intended to realize the frameworks that will spur an array of applications and use cases in the domain of road safety, traffic efficiency, and driver's assistance. Although these applications will allow the dissemination and gathering of useful information among vehicles and between transportation infrastructure and vehicles in pursuance of assisting drivers to travel safely and comfortably, much effort is required to implement these practices for the success of these applications.

Traffic safety applications such as hazard location warnings and collision warnings etc. rely heavily on the timely delivery of safety-critical real-time data. Most of these applications demand a strictly bounded timing response and are highly dependent on the performance of the underlying wireless vehicular communication technology. In most cases, these systems are required to have dependable timeliness requirements since data communication must be conducted within predefined temporal bounds along with fulfilling other requirements such as reliability, security etc. This is mainly because the unfulfillment of these requirements may compromise the expected behaviour of the system and cause economic losses or endanger human lives. In addition, the broadcast nature of wireless communications in an open environment makes it more vulnerable to unwanted external entities compared to the wired communications. Therefore, the consideration of the real-time aspects in the implementation of ITS services offers great potential to improve the level of safety, efficiency, and comfort on our roads. In addition, European ITS considered the deterministic medium access methods as one of the criteria for the evaluation of possible ITS communication technologies.

In addition to the fact that applications for traffic safety rely heavily on the support of wireless vehicular communications, the existing standards such as IEEE 802.11p do not provide deterministic real-time support and the other enabling technologies such as LTE-V from 3GPP and traffic sensors are either in their definition staged or not fully deployed and tested for dependable real-time communication. Therefore, the purpose of this special issue is to attract and publish high-quality research, expecting both from academic and industrial stakeholders, and serves as an outlet for disseminating innovative solutions toward meeting the expectation of ITS and mainly real-time dependable communication.

A total of 11 papers were submitted and only 5 papers of high quality were accepted. The details of these accepted papers are as follows.

The first accepted paper is "Dependable content distribution in D2D-based cooperative vehicular networks: A big data-integrated coalition game approach" by Z. Zhou *et al.* The paper presents dependable content distribution sharing in device-to-device (D2D) vehicular networks. The paper discuses that dependable vehicular connectivity has become essential to realize future ITS. Therefore, in this paper, the authors have investigated how to achieve dependable content distribution in D2D-based cooperative vehicular networks by combining big data-based vehicle trajectory prediction with coalition formation game-based resource allocation. The vehicle trajectory is predicted based on a global positioning system and geographic information system data, which is critical for finding reliable and long-lasting vehicle connections. Then, the determination of content distribution groups with different lifetimes is formulated as a coalition formation game. They have modeled the utility function based on the minimization of average network delay, which is transferable to the individual payoff of each coalition member according to its contribution. The merge and split process is implemented iteratively based on preference relations, and the final partition is proved to converge to a Nash-stable equilibrium. The proposed algorithm has been evaluated based on real-world maps and realistic vehicular traffic. Numerical results demonstrate that the proposed algorithm can achieve superior performance in terms of average network delay and content distribution efficiency compared to other heuristic schemes.

The second accepted paper is by Joao Almeida *et al.*, titled "A medium guardian for enhanced dependability in

safety-critical wireless systems". The paper discusses the safety-critical requirements of dependable wireless vehicular communications and presents a test bed-based experimental work. The authors presented that, to achieve the dependability goals, novel solutions will need to be introduced both at the communications devices and at the network protocols. Fault tolerance mechanisms are good candidates to attain such dependability attributes. In this paper, a medium guardian concept is proposed to guarantee fail-silent behaviour, both in time and value domains, for the nodes of a wireless network. After a generic description of the wireless medium guardian concept, its application to the case of ETSI ITS-G5-based vehicular communications is demonstrated. In this way, the design and practical implementation of a medium guardian for real-time vehicular communications is reported, together with the experimental evaluation of this first prototype. The obtained results demonstrate the low latency of the fault detection mechanism and the effectiveness of the guardian in preventing error propagation to other nodes of the network.

The third paper is by Syed Shah, titled "Shapely value perspective on adapting transmit power for periodic vehicular communications". The paper discusses the transmit power control for the for vehicular ad hoc networks. The authors have presented an approach that seeks to address wireless channel congestion by adapting transmission power based on the principles of cooperative game theory. The power control method uses a Shapely value system model to determine vehicles' marginal contributions to generate fair levels of transmitting power by which each vehicle is required to reduce its transmit power to reduce congestion. The simulation results demonstrate the utility of the proposed approach in order to determine a fair power decrease for an effective congestion control.

The fourth accepted paper is titled "Improving bivious relay selection in vehicular delay tolerant networks" by Syed Hassan Ahmed *et al.* The authors have proposed an adaptive multiple-relay selection scheme for vehicular DTNs that ensures a more reliable data retrieval to the vehicle(s). For relay vehicles selection, the protocol ranks one-hop neighbors by considering the multiple criteria such as limited caching time, communication time, relevant speed, and the distance between the target vehicle and its neighbors. The proposed scheme is simulated and the results demonstrate its performance in comparison to the other existing schemes.

The last accepted paper is a survey titled "Cooperative vehicular networking: A survey" by Ejaz Ahmed *et al.* The paper presents a comprehensive survey of recent advances in cooperative vehicular networking. The authors have covered important aspects of cooperative vehicular networking research, including Physical (PHY), Medium Access Control (MAC), and routing protocols, as well as link scheduling and security. The have classified these research efforts in a taxonomy of cooperative vehicular networks. A set of key requirements for realizing the vision of cooperative vehicular networks is then identified and discussed. Open research challenges in enabling cooperative vehicular networking are also presented.


MUHAMMAD ALAM, *Guest Editor*
Instituto de Telecomunicações
Campus Universitário de Santiago
3810-193 Aveiro, Portugal
e-mail: alam@av.it.pt

AMMAR RAYES, *Guest Editor*
School of Engineering
San José State University
San Jose, CA 95192 USA
e-mail: ammar.rayes@sjsu.edu

XIANGJIAN HE, *Guest Editor*
University of Technology Sydney
Ultimo, NSW 2007, Australia
e-mail: xiangjian.he@uts.edu.au

MOHAMMED ATIQUZZAMAN, *Guest Editor*
School of Computer Science
University of Oklahoma
Norman, OK 73019 USA
e-mail: atiq@ou.edu

JAIME LLORET, *Guest Editor*
University of Valencia
46010 València, Spain
e-mail: jlloret@dcom.upv.es

KIM FUNG TSANG, *Guest Editor*
City University of Hong Kong
Hong Kong
e-mail: ee330015@cityu.edu.hk


**Muhammad Alam** (M'14–SM'17) received the Ph.D. degree in computer science with a specialization in cooperative design strategies for green mobile networks from the University of Aveiro, Portugal, in 2014. In 2009, he joined the Instituto de Telecomunicaçõ̃es, Aveiro, Portugal, as a Researcher. He has participated in several European Union FP7 projects, such as Hurricane, C2POWER, ICSI, PEACE, and Portuguese government funded projects such SmartVision. He is currently a Senior Researcher with the Instituto de Telecomunicaçõ̃es and participating in European Union and Portuguese government funded projects. His research interests include intelligent transportation systems, IoT, real-time wireless communication, 5G, vehicular networks, context-aware systems, and radio resource management in next generation wireless networks. He has authored several journal and conference publications as well as book chapters. He is also a TPC Member and Reviewer for a number of reputed conferences, journals, and magazines. He is an IEEE IES Member. He served as a General Co-Chair of the Future 5V conference and also served as a Session Chairs for a number of reputed conferences, such as IEEE IECON 2016, IEEE WFCS 2016, and IEEE ITSC 2015. He is the Editor of *Intelligent Transportation Systems, Dependable Vehicular Communications for Improved Road Safety*. He also provided his services as a Guest Editor to several journals.

**Ammar Rayes** received the B.S. and M.S. degrees in electrical engineering from the University of Illinois at Urbana–Champaign, IL, USA, and the Ph.D. degree in electrical engineering from Washington University in St. Louis, St. Louis, MO, USA. He is currently a Distinguished Engineer (Technology Director) at Cisco Systems with a focus on the Technology Strategy for Cisco Services. Previously at Cisco, he led solution teams focusing on mobile wireless, network management NMS/OSS, and metro Ethernet. Prior to joining Cisco, he was the Director of Traffic Engineering at Bellcore (formally Bell Labs). He has authored three books and over 100 publications in refereed journals and conferences on advances in software and networking related technologies and holds over 25 patents. His current research includes IoT, advanced analytics, machine learning, and data security. He received the Outstanding Graduate Student Award in Telecommunications from Washington University in St. Louis. He is the Founding President of the International Society of Service Innovation Professionals, an Adjunct Professor at San José State University, USA, the Editor-in-Chief of *Advances of Internet of Things*, and an Editorial Board Member of the European Alliance for Innovation–Industrial Networks and Intelligent Systems. At Cisco, he is the Founding Chair of Cisco Services Research and the Cisco Services Patent Council. He received the Cisco Chairman's Choice Award for IoT Excellent Innovation and Execution. He has served as an Associate Editor of *ACM Transactions on Internet Technology*, *Wireless Communications*, and *Mobile Computing*, a Guest Editor of multiple journals and several *IEEE Communication Magazine* issues, co-chaired the Frontiers in Service Conference, and appeared as a keynote speaker at multiple IEEE and industry conferences.

**Xiangjian He** (SM'06) is a Professor of computer science at the School of Computing and Communications, University of Technology Sydney (UTS), Sydney, Australia. He is also the Director of Computer Vision and Pattern Recognition Laboratory with the Global Big Data Technologies Centre, and the Director of the UTS-NPU International Joint Laboratory on Digital Media and Intelligent Networks at the UTS. He has received many research grants, including four national research grants awarded by the Australian Research Council. He has been awarded Internationally Registered Technology Specialist by the International Technology Institute. He has been carrying out research mainly in the areas of image processing, network security, pattern recognition, computer vision, and machine learning in the previous years. He is a leading researcher for image processing based on hexagonal structure. He held various chair roles in many international conferences, such as ACM MM, MMM, IEEE TrustCom, IEEE CIT, IEEE AVSS, IEEE TrustCom, IEEE ICPR, and IEEE ICARCV. He has been a supervisor of post-doctoral research fellows and Ph.D. students. Since 1985, he has been an Academic, a Visiting Professor, an Adjunct Professor, a Post-Doctoral Researcher, or a Senior Researcher at various universities/institutions, including Xiamen University, China, Shanghai Jiaotong University, China, University of New England, Australia, University of Georgia, Athens, GA, USA, Electronic and Telecommunication Research Institute of Korea, University of Aizu, Japan, Hongkong Polytechnic University, and Macau University.

**Mohammed Atiquzzaman** received the M.S. and Ph.D. degrees in electrical engineering and electronics from the University of Manchester, U.K., in 1984 and 1987, respectively. He currently holds the Edith J. Kinney Gaylord Presidential Professorship with the School of Computer Science, University of Oklahoma, USA. His research has been funded by the National Science Foundation, National Aeronautics and Space Administration, U.S. Air Force, Cisco, and Honeywell. He co-authored *Performance of TCP/IP Over ATM Networks* and has authored over 270 refereed publications. His current research interests are in areas of transport protocols, wireless and mobile networks, ad hoc networks, satellite networks, power-aware networking, and optical communications. He Co-Chaired the IEEE High Performance Switching and Routing Symposium (2003, 2011), IEEE GLOBECOM and ICC (2014, 2012, 2010, 2009, 2007, and 2006), IEEE VTC (2013), and SPIE Quality of Service Over Next Generation Data Networks conferences (2001, 2002, and 2003). He was the Panels Co-Chair of INFOCOM'05, and has been on the program committee of many conferences, such as INFOCOM, GLOBECOM, ICCCN, ICCIT, Local Computer Networks, and serves on the review panels at the National Science Foundation. He is the current Chair of the IEEE Communication Society Technical Committee on Communications Switching and Routing. He received the IEEE Communication Society's Fred W. Ellersick Prize and the NASA Group Achievement Award for outstanding work to further NASA Glenn Research Center's efforts in the area of the Advanced Communications/Air Traffic Management's Fiber Optic Signal Distribution for Aeronautical Communications project. He is the Editor-in-Chief of *Journal of Networks and Computer Applications*, the founding Editor-in-Chief of *Vehicular Communications*, and serves/served on the editorial boards of many journals, including *IEEE Communications Magazine*, *Real Time Imaging Journal*, *International Journal of Communication Networks and Distributed Systems*, *Journal of Sensor Networks*, and *International Journal of Communication Systems*.

**Jaime Lloret** (SM'10) received the M.Sc. degree in physics in 1997, the M.Sc. degree in electronic engineering in 2003, and the Ph.D. degree (Dr. Ing.) in telecommunication engineering in 2006. He is a Cisco Certified Network Professional Instructor. He was a Network Designer and Administrator in several enterprises. He is currently an Associate Professor with the Polytechnic University of Valencia, Spain. He has authored 22 book chapters and has over 360 research papers published in national and international conferences and international journals (over 140 with ISI Thomson JCR). He is an IARIA fellow. He is the Chair of the Integrated Management Coastal Research Institute and the Head of the Active and Collaborative Techniques and Use of Technologic Resources in the Education Innovation Group. He is also the Director of the University Diploma Redes y Comunicaciones de Ordenadores and of the University Master Digital Post Production. He was the Internet Technical Committee Chair (IEEE Communications Society and Internet Society) from 2013 to 2015. He has been involved in over 320 program committees of international conferences, and over 130 organizations and steering committees. He leads many national and international projects. He is currently the Chair of the Working Group of the Standard IEEE 1907.1. He has been the General Chair (or Co-Chair) of 38 international workshops and conferences (the Chairman of SENSORCOMM 2007, UBICOMM 2008, ICNS 2009, ICWMC 2010, eKNOW 2012, SERVICE COMPUTATION 2013, COGNITIVE 2013, ADAPTIVE 2013, 12th AICT 2016, 11th ICIMP 2016, 3rd GREENETS 2016, 13th IWCMC 2017, and 10th WMNC 2017, the Co-Chairman of ICAS 2009, INTERNET 2010, MARSS 2011, IEEE MASS 2011, SCPA 2011, ICDS 2012, 2nd IEEE SCPA 2012, GreeNets 2012, 3rd IEEE SCPA 2013, SSPA 2013, AdHocNow 2014, MARSS 2014, SSPA 2014, IEEE CCAN 2015, 4th IEEE SCPA 2015, IEEE SCAN 2015, ICACCI 2015, SDRANCAN 2015, FMEC 2016, 2nd FMEC 2017, 5th SCPA 2017, and JITEL 2017, and the Local Chair of MIC-WCMC 2013 and IEEE Sensors 2014). He is the Editor-in-Chief of *Ad Hoc and Sensor Wireless Networks* (with ISI Thomson Impact Factor), the international journal *Networks Protocols and Algorithms*, and *International Journal of Multimedia Communications*, and IARIA Journals Board Chair (eight journals). He has been a Co-Editor of 40 conference proceedings and a Guest Editor of several international books and journals. He has been an Associate Editor of 46 international journals (16 of them with ISI Thomson Impact Factor).

**Kim Fung Tsang** (M'95–SM'14) received the Ph.D. degree in microwave/millimeter wave engineering from Cardiff University of Wales, Cardiff, U.K., in 1995. He is currently an Associate Professor with the Department of Electronic Engineering, City University of Hong Kong. He has close ties with industry, where he is currently involved actively in IoT applications, including energy management system for utilities, metering infrastructure, security, and office/home automation. He has published about 200 technical papers. He is a fellow of The Hong Kong Institution of Engineers. He was the ZigBee Chair of the IEEE Consumer Electronics Society from 2014 to 2015, the Chairman of the Internet of Things Special Users Group Hong Kong, Internet of Things Committee, Smart City Consortium, and the Technical Committee Wireless and Cloud Architecture For Industrial Applications of the Industrial Electronics Society. He is currently an Associate Editor and a Guest Editor of IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, an Associate Editor of *IEEE Industrial Electronics Magazine*, and an Editor of the Korean Society for Internet Information *Transactions on Internet and Information Systems*.