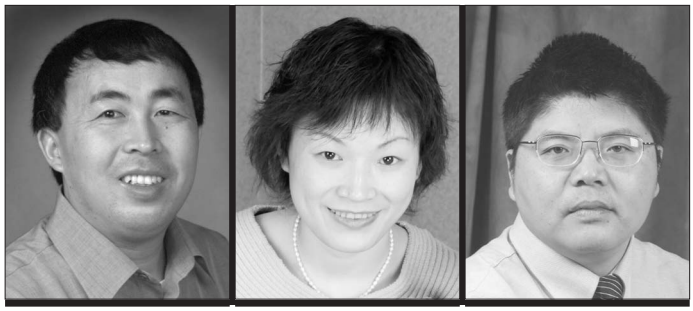
WIRELESS SENSOR NETWORKING



XUEMIN SHEN QIAN ZHANG ROBERT CAIMING QIU

Recent advances in digital electronics, embedded systems, and wireless communications have motivated significant research in wireless sensor networks (WSNs) from both academia and industry. The unique characteristics of WSNs, such as dense node deployment, unstable sensor nodes, frequent topology change, and severe power, computation, and memory constraints, result in a wide variety of new challenging problems. These include prolonging node/network lifetime, security and surveillance, efficient medium access control (MAC) protocols subject to power constraints, effective environmental monitoring and control, target detection and tracking, scalability and adaptability, and so on. This special issue consists of 10 articles addressing recent cutting edge research directions and state-of-the-art technologies in WSNs. The special issue is timely and valuable for future analysis, implementation, and experiments.

The first two articles study the localization and fault management issues in WSNs. In the first article, "Localization Systems for Wireless Sensor Networks," Azzedine Boukerche *et al.* study the localization problem in WSNs. They propose to divide the localization systems into three components: distance/angle estimation, position computation, and localization algorithm; each component can be analyzed and studied separately. In the second article, "Fault Management in Wireless Sensor Networks," Mengjie Yu, Mokhtar Hala, and Madjid Merabti survey the existing fault management approaches for WSNs to maintain a high quality of service in potentially harsh environments. These approaches are classified into three categories according to various phases: fault detection, diagnosis, and recovery. Fault management challenges for future sensor applications and self-managed WSNs are discussed as well.

The next two articles investigate the design and implementation issues in WSNs. In "Applications and Design Issues of Mobile Agents in Wireless Sensor Networks," Min Chen, Sergio Gonzalez, and Victor C. M. Leung survey the potential applications of mobile agents in WSNs and discuss the key design issues. They propose to decompose the agent design functionally into four components (i.e., architecture, itinerary planning, middleware system design, and agent cooperation) to facilitate the creation of an efficient component-based mobile agent system for a wide range of applications. In the fourth article, "Spectral Characterization of Wireless Networks," Pedro C. Pinto and Moe Z. Win propose the concept of spectral outage probability (SOP), a new characterization of the aggregate radio frequency emission generated by communicating nodes in a wireless network. The applications of SOP — the establishment of spectral regulations and the design of covert military networks — are presented as well. The proposed framework captures all the essential physical parameters that affect the aggregate network emission, and is simple enough to provide insights for design and deployment of WSNs.

Wireless multimedia sensor networks are gaining increasing popularity due to numerous potential applications such as voice/video surveillance, and environmental and habitat monitoring. In "Wireless Multimedia Sensor Networks: A Survey," Ian F. Akyildiz, Tommaso Melodia, and Kaushik R. Chowdury discuss the state of the art and major research challenges in architectures, algorithms, and protocols for wireless multimedia sensor networks. Existing approaches and open issues at the physical, link, network, transport, and application layers of the communication stack are investigated as well. In the sixth article, "QoS Provisioning in Wireless Video Sensor Networks: A Dynamic Power Management Framework," Afshin Fallahi and Ekram Hossain propose a dynamic power management framework based on a Markov decision process formulation. By jointly considering the video traffic arrival process in the sensor node, the sleep and wakeup processes in the camera and wireless transceiver electronics, the queue status, and the wireless channel conditions, the proposed scheme is capable of increasing the lifetime of wireless video sensor nodes while satisfying the QoS requirement.

Radio frequency identification (RFID) shows great potential for integration in WSNs to enable a range of

applications that can exponentially increase visibility and monitoring. The next two articles study the coexistence of WSNs and RFID systems. In "SARIF: A Novel Framework for Integrating Wireless Sensor and RFID Networks," Jaekyu Cho *et al.* propose a sensor and RFID integration framework (SARIF) for environment-sensitive object tracking and management based on the identified key requirements. As a middleware that operates on top of RFID networks and WSNs, SARIF allows flexible design of diverse applications and efficient management of network resources. In the eighth article, "Decentralized Enterprise Systems: A Multi-Platform Wireless Sensor Networks Approach," Mihai Marin-Perianu *et al.* address the integration of ubiquitous technologies into a decentralized enterprise environment. A three-layer service-oriented architecture is presented to accommodate different sensor platforms and exposes their functionality in a uniform way to business applications. Practical tests and application trials are conducted to confirm the feasibility of the proposed approach.

The last two articles present some projects and case studies of WSNs. In "ZigBee-Based Intra-Car Wireless Sensor Networks: A Case Study," Hsin-Mu Tsai *et al.* report the results of a ZigBee-based case study of intra-car WSNs conducted at General Motors and Carnegie Mellon University. They use Zigbee sensor nodes to perform packet transmission experiments in a car environment. The conducted experiments and measured results suggest that ZigBee might be a plausible and promising wireless technology for implementing an intra-car wireless sensor network; but some practical problems such as engine noise, interference, and location of sensors could have an adverse effect on the packet error rate and network goodput. Further research is needed to address MAC design and security concerns in such a network. In "China's National Research Project on Wireless Sensor Networks," Lionel M. Ni, Yunhao Liu, and Yanmin Zhu discuss an innovative project on networked sensor systems, which is supported by the prestigious National 973 program of China. The project adopts an application-driven methodology and aims to address the real-world critical problems facing China's society.

In closing, the guest editors would like to acknowledge the contribution of many experts who participated in the review process, and provided helpful suggestions to the authors on improving the content and presentation of the articles. The advice and support of the Editor-in-Chief, Dr. Abbas Jamalipour, are greatly appreciated.

BIOGRAPHIES

XUEMIN SHEN [M'97, SM'02] (xshen@bbcr.uwaterloo.ca) received a B.Sc.(1982) degree from Dalian Maritime University, China, and M.Sc. (1987) and Ph.D. (1990) degrees from Rutgers University, New Jersey, all in electrical engineering. He is a professor and university research chair, and associate chair for Graduate Studies, Department of Electrical and Computer Engineering, University of Waterloo, Canada. His research focuses on mobility and resource management in interconnected wireless/wired networks, UWB wireless communications systems, wireless security, and ad hoc and sensor networks. He is a co-author 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 Technical Program Committee Chair for IEEE GLOBECOM '07, General Co-Chair for Chinacom '07 and QShine '06, and Founding Chair of the IEEE Communications Society Technical Committee on P2P Communications and Networking. He also serves as a Founding Area Editor for *IEEE Transactions on Wireless Communications*; Editor-in-Chief of *Peer-to-Peer Networking and Application*; and Associate Editor for *IEEE Transactions on Vehicular Technology*, *KICS/IEEE Journal of Communications and Networks*, *Computer Networks*, *ACM/Wireless Networks*, and *Wireless Communications and Mobile Computing* (Wiley). He has also served as Guest Editor for *IEEE JSAC*, *IEEE Wireless Communications*, and *IEEE Communications Magazine*. He received the Excellent Graduate Supervision Award in 2006 and the Outstanding Performance Award in 2004 from the University of Waterloo, the Premier's Research Excellence Award (PREA) 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 of Ontario, Canada.

QIAN ZHANG [M'00, SM'04] (qianzh@cse.ust.hk) received B.S., M.S., and Ph.D. degrees from Wuhan University, China, in 1994, 1996, and 1999, respectively, all in computer science. She joined Hong Kong University of Science and Technology in September 2005 as an associate professor. Before that, she was in Microsoft Research, Asia, Beijing, China, from July 1999, where she was the research manager of the Wireless and Networking Group. She has published more than 150 refereed papers in international leading journals and key conferences. She is the inventor of about 30 pending patents. Her current research interests are in the areas of wireless communications, IP networking, multimedia, P2P overlay, and wireless security. She also participated many activities in the IETF Robust Header Compression WG group for TCP/IP header compression. She is an Associate Editor for *IEEE Transactions on Wireless Communications*, *IEEE Transactions on Vehicular Technologies*, *IEEE Transactions on Multimedia*, *Computer Networks* (Elsevier), and *Computer Communications* (Elsevier). She has also served as Guest Editor for special issues in *IEEE JSAC*, *IEEE Wireless Communications*, *IEEE Communications Magazine*, ACM/Springer *MONET*, and *Computer Networks*. She is vice-chair of the Multimedia Communication Technical Committee of the IEEE Communications Society. She has received the *MIT Technology Review* TR 100 world's top young innovator award in 2004. She also received the Best Asia Pacific Young Researcher Award elected by IEEE Communication Society in 2004. She received the Best Paper Award in MMTC of IEEE Communication Society and Best Paper Award for QShine 2006. She received the Oversea Young Investigator Award from the National Natural Science Foundation of China in 2006.

ROBERT CAIMING QIU [S'93, M'96, SM'01] (RQiu@tntech.edu)received a Ph.D. degree in electrical engineering from Polytechnic University, Brooklyn, New York. He is currently an associate professor in the Department of Electrical and Computer Engineering, Center for Manufacturing Research, Tennessee Technological University (TTU), Cookeville. His current interest is in wireless communication and networking systems, in particular ultrawideband. He was founder-CEO and president of Wiscom Technologies, Inc., manufacturing and marketing WCDMA chipsets. Wiscom was sold to Intel in 2003. Prior to Wiscom, he worked for GTE Labs, Inc. (now Verizon), Waltham, Massachusetts, and Bell Labs, Lucent, Whippany, New Jersey. He has worked in wireless communications, radio propagation, digital signal processing, EM scattering, composite absorbing materials, RF microelectronics, UWB, underwater acoustics, and fiber optics. He holds over 10 U.S. patents pending in WCDMA, and has authored over 40 technical papers and four book chapters. He has contributed to 3GPP and IEEE standards bodies, and delivered invited seminars to institutions including Princeton University and the U.S. Army Research Laboratory. He received the Kinslow Research Award from TTU. He serves as Associate Editor for *IEEE Transactions on Vehicular Technology*, *International Journal of Sensor Networks* (Interscience), and *Wireless Communication and Mobile Computing* (Wiley). He is a Guest Book Editor for *Ultra-Wideband Wireless Communications* (Wiley, 2005), and three special issues on UWB, including *IEEE JSAC* and *IEEE Transactions on Vehicular Technology*. He serves as a member of the Technical Program Committee for GLOBECOM, WCNC, and MILCOM. In addition, he served on the advisory board of the New Jersey Center for Wireless Telecommunications.