

WIRELESS SENSOR NETWORKS



PAUL HAVINGA

JENNIFER C. HOU

FENG ZHAO

This issue of *IEEE Wireless Communications* is devoted to wireless sensor networks: theory and systems. Driven by the development in micro-electromechanical system (MEMS) microsensors, wireless networking, and embedded processing, ad hoc networks of sensors are becoming increasingly available for commercial and military applications such as environmental monitoring (e.g., traffic, habitat, security), industrial sensing and diagnostics (e.g., factory, appliances), monitoring critical infrastructures (e.g., power grids, water distribution, waste disposal), and collecting data for battlefield awareness.

The area of wireless sensor networks actually opens up new research venues, which include sensor tasking and control, tracking and localization, sensor data fusion, distributed databases, communication protocols and theory that addresses monitoring coverage, network connectivity, critical power, network lifetime and capacity, as well as system/software architecture and design methodologies. Moreover, all these issues have to consider many cross-cutting requirements such as efficiency/cost trade-off, robustness, self-organization, fault tolerance, timeliness, scalability, and network longevity. As numerous research advances have been made in the aforementioned subareas, we feel it is both timely and necessary to have a special issue in wireless sensor networks. The objective of this special issue is thus to present the latest research results and bring their enormous scope even closer to the wireless communications community.

This special issue is composed of nine articles that emphasize different aspects of wireless sensor networks. A few articles are tutorial in nature, two address theoretical aspects and/or explore the design space, one exploits an important theoretical result to facilitate protocol design, whereas the remaining articles are focused on specific applications of wireless sensor networks. There are three tutorial papers: Al-Karaki and Kamal present a comprehensive taxonomy of the various routing techniques in wireless sensor networks. Stojmenovic surveys specifically geographic routing — a lightweight routing protocol that does not require

each node to maintain a routing table — and its enhanced version that provides guaranteed delivery. A third tutorial article, authored by Shi and Perrig, discusses security from a networking perspective, and introduces mechanisms to achieve secure communications under various threat and trust models.

Sagduyu and Ephremides take an information theoretic approach and outline a throughput- and energy-efficient medium access control (MAC) algorithm that supports multihop communications for wireless sensor networks. Römer and Matern explore the design space and consider various design dimensions (e.g., cost, resources, energy, heterogeneity, and network topology and lifetime) and their impact on the performance of WSNs. Liu *et al.* apply an important computational geometry property, geometric duality, to form collaborative groups for sensor selection and non-local phenomena tracking.

This special issue also includes three interesting articles that deal with system implementations, experiments, and experiences in application domains. Elson *et al.* present a Linux-based software framework that facilitates development by improving system visibility and integrating simulation with real wireless communication and sensors situated in the environment. Van Hoesel *et al.* document an ongoing European research project, EYES, and describe how cross-layer design helps optimize the performance of wireless sensor networks. A third article authored by Zhang *et al.* documents Palo Alto Research Center's efforts in developing a system for tracking mobile robots and mapping an unstructured environment in an indoor setting.

We believe the interested reader will enjoy these articles and appreciate their contribution and quality the same way the guest editors did. In closing, we would like to thank the authors for their high-quality contributions to this special issue as well as to all authors who submitted their papers for consideration (which makes the selection process a very difficult task). We are indebted to our referees for their invaluable comments and criticism that greatly improved

the quality of the articles. Our special thanks go to the Editor-in-Chief, Dr. Michele Zorzi, for his involvement, continuing guidance, and encouragement without which this special issue would not be a reality.

BIOGRAPHIES

PAUL HAVINGA (p.j.m.havinga@utwente.nl) received his Ph.D. in mobile multi-media systems in 2000, and was awarded with the DOW Dissertation Energy Award for this work. Currently, he is within the Department of Computer Science of the University of Twente. His research interests are in the area of energy-efficient architectures and protocols, sensor networks, wireless communication, ubiquitous computing, personal communication systems, and (reconfigurable) hardware architectures. Currently, he is project leader of the Dutch project Smart Surroundings, on ambient intelligence, the Dutch project Featherlight on distributed operating system software, the European project EYES on energy efficient sensor networks, and the nationally funded project CONSENSUS on collaborative sensor networks. Besides these projects, he is also involved in several other projects, with a strong focus on sensor networks.

JENNIFER C. HOU [SM] (jhou@cs.uiuc.edu) received her Ph.D. degree in electrical engineering and computer science from the University of Michigan, Ann Arbor in 1993. Prior to joining the University of Illinois at Urbana Champaign (where she is currently an associate professor), she was with the University of Wisconsin — Madison (1993–1996) and Ohio State University (1996–2001). She has been on the TPC of several major networking, real-time, and distributed systems conferences, and served as a Technical Program Co-chair for 1st International Wireless Internet Conference in

2005, ACM 3rd Symposium on Information Processing in Sensor Networks in 2004, and IEEE Real-Time Technology and Application Symposium in 2000. She is currently on the editorial boards of *IEEE Transactions on Wireless Communications*, *IEEE Transactions on Parallel and Distributed Systems*, *IEEE Wireless Communications*, *ACM/Kluwer Wireless Networks*, *Kluwer Computer Networks*, and *ACM Transactions on Sensor Networks*. She has published over 120 papers and book chapters in archived journals and peer-reviewed conferences, and worked on a public domain network simulation and emulation package, J-Sim. The latest release is J-Sim Version 1.3, made in February 2004. Her research areas are in network modeling and simulation, network measurement and diagnostics, and both the theoretical and protocol design aspects of wireless sensor networks. She was a recipient of the Lumley Research Award in 2001 and an NSF CAREER award in 1996. She is a member of ACM.

MANI SRIVASTAVA also contributed to this issue as a Guest Editor. Biographical information and a photograph were not available at press time.

FENG ZHAO (zhao@microsoft.com) is a senior researcher at Microsoft, where he manages the Networked Embedded Computing Group. He received his Ph.D. in electrical engineering and computer science from MIT, and has taught at Stanford University and Ohio State University. He was a principal scientist at Xerox PARC and directed PARC's sensor network research effort. He serves as the founding Editor-In-Chief of *ACM Transactions on Sensor Networks*, and has authored or co-authored more than 100 technical papers and books, including a recent book on wireless sensor networks published by Morgan Kaufmann. He has received a number of awards including NSF and ONR Young Investigator Awards and a Sloan Research Fellowship, and his work has been featured in news media such as *BBC World News*, *BusinessWeek*, and *Technology Review*.