

Studies in Systems, Decision and Control

Volume 164

Series Editor

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Habib M. Ammari
Editor

Mission-Oriented Sensor Networks and Systems: Art and Science

Volume 2: Advances

Editor

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*To Allah, the Most Beneficent, the Most
Merciful; and His Prophet, Mohamed, Peace
Be Upon Him*

*To my first teachers: My mother, Mbarka,
and my father, Mokhtar.*

*To my very best friends: My lovely wife
Fadhila, and beautiful children, Leena,
Muath, Mohamed-Eyed, Lama, and Maitham.*

*To my dearest brother, Lazhar, and sisters,
Naima, Saloua, Monia, Faouzia, Alia, and
Najeh.*

*To all my wonderful nieces, Rahma, Safa,
Marwa, Amani, Omayma, and Sabrine; and
my nephews, Mohamed, Bilel, Ahmed, and
Youssef.*

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Abdelkarim and Fatma, and my uncle,
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To the profound soul of my Professor, Dr. Hedi Ben Saad, Professor of Mathematics in the Department of Mathematics at the Faculty of Sciences of Tunis, Tunisia (May 25, 1950–June 30, 2016). He taught me mathematics in my second year of Physics and Chemistry major at the Faculty of Sciences of Tunis during the academic year 1987–1988. He was extremely knowledgeable in mathematics, very humble, and so kind. I have never seen anyone so far in his goodness, humility, and acute intelligence in mathematics.

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Foreword

It has been more than a decade and a half since the first set of research papers on wireless sensor networks came out in the early 2000s. Academic research through the 2000s and 2010s has addressed many problems in the area rather comprehensively—from communication and routing protocols to time synchronization and localization, many problems that once appeared wide open have a number of practical and efficient solutions that can be used by practitioners.

Another transformation that has occurred in this time is that researchers have figured out how to place the problems of sensor networks within the broader context of large-scale cyber-physical systems and the Internet of Things. And entirely new areas of research have started to emerge, such as wireless charging, robotic wireless sensor networks, vehicular networks, and drone swarms.

Mission-Oriented Sensor Networks and Systems: Art and Science is a first-rate two-volume book with a collection of chapters contributed by experts, which provide not only a broad overview of many of the mature topics in this field but also a thorough introduction to some of the newer areas of inquiry. It is truly an outstanding contribution to the literature that owes much to the diligent efforts of Professor Habib M. Ammari from Texas A&M University-Kingsville, who has single-handedly edited both volumes.

As indicated in its title, a running theme through the book is a consideration of mission-critical applications where the dependability and security issues of sensor networks must be given significant attention. After an introduction, the book begins with an exploration of these mission-critical issues, from communication and routing perspectives, in Part I (Chapters “[Autonomous Cooperative Routing for Mission-Critical Applications](#)”, and “[Using Models for Communication in Cyber-Physical Systems](#)”).

Part II of the book explores ideas at the transition to the Internet of Things, with Chapters “[Urban Microclimate Monitoring Using IoT-Based Architecture](#)”, “[Models for Plug-and-Play IoT Architectures](#)”, and “[Digital Forensics for IoT and WSNs](#)” addressing topics from microclimate monitoring to localization, while these topics have been at the heart of sensor networking research since the beginning.

The shift toward IoT has highlighted the design of more ambitious applications often spanning large areas and the use of wide-area networks.

Another aspect of interest in this domain has been the development of crowd-sensing applications in the context of smart cities, treated in Part III. Developing appropriate incentives for users contributing data remains an area with significant open questions.

Part IV looks at wearable computing, which has been a trend on the rise for IoT systems intended to be able to collect relevant meaningful information about and from individuals that is relevant for many applications, while Part V of the book looks at novel approaches to wireless charging and how they can be integrated with real applications. Part VI of the book turns to providing an overview of robotic wireless sensor networks, which bring to the fore new challenges and opportunities associated with the added dimension of (often, decentrally) controlled mobility. Finally, last but not the least, the seventh and final part focuses on reliability, security, and interference mitigation.

These chapters collectively point to some of the most cutting-edge topics in sensor networks today. I believe the prospect is bright for further enhancements and developments, particularly as IoT and dependable cyber-physical systems become an increasingly bigger part of smart city operation.

As one example of ongoing academic work relevant to sensor networks, at the University of Southern California, together with my students and collaborators, I have been exploring the design of IoT data marketplaces for smart cities. In such marketplaces, buyers and sellers of data from IoT devices can interact with each other systematically over an economic layer. We have also been exploring how blockchain technologies can provide an additional layer of trust, robustness, and ultimately decentralization, compared to traditional approaches. And finally, we have been exploring how distributed computing and networked robotics systems can be developed from the ground-up.

Something we are likely to see going ahead in this field is a greater focus on systems rather than just algorithmic components or building blocks, and as these systems develop and need to scale in a heterogeneous and distributed manner, there will be new challenges such as the problem of interoperability and others. These will provide opportunities for corresponding solution techniques to be developed by researchers. Sensor networking as a whole is going to remain a relevant subject for years to come. This book is making a valuable and timely contribution in helping researchers catch up quickly with the latest advances in various aspects of the field.

Los Angeles, USA
October 25, 2018

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About the Editor



Habib M. Ammari is an Associate Professor and the Founding Director of Wireless Sensor and Mobile Ad-hoc Network Applied Cryptography Engineering (WiSeMAN-ACE) Research Lab, in the Department of Electrical Engineering and Computer Science, Frank H. Dotterweich College of Engineering, at Texas A&M University-Kingsville (TAMUK) since August 2019. He received his tenure in May 2014 in the Department of Computer and Information Science, College of Engineering and Computer Science, at the University of Michigan-Dearborn, where he served on the Distinguished Research Award Committee in 2015. Also, he received tenure at the Higher School of Communications in Tunis, Tunisia (Sup'Com Tunis) in 1998. Recently, he received the 2018 Albert Nelson Marquis Lifetime Achievement Award. He was selected as instructor at Stanford University in the Stanford Summer College Academy 2016 program, where he taught “Discrete Mathematical Structures: Foundational Concepts in Computer Science, Engineering, and Mathematics”. He obtained his second Ph.D. degree in Computer Science and Engineering from the University of Texas at Arlington, in May 2008, and his first Ph.D. in Computer Science from the Faculty of Sciences of Tunis, in December 1996. His main research interests lay in the area of wireless sensor and mobile ad hoc networks, including connected k -coverage, geographic forwarding, physical and information security, applied cryptography, and computational geometry in wireless sensor networks. He has a strong publication record in top-quality journals, such as ACM TOSN, ACM TAAS,

IEEE TPDS, IEEE TC, Elsevier Ad Hoc Networks, Elsevier COMNET, Elsevier PMC, Elsevier JPDC, Elsevier COMCOM, and high-quality conferences, such as IEEE SECON, IEEE ICDCS, IEEE MASS, and EWSN. He published his first Springer book, “Challenges and Opportunities of Connected k -Covered Wireless Sensor Networks: From Sensor Deployment to Data Gathering” in August 2009. Also, he is the author and editor of two Springer books, “The Art of Wireless Sensor Networks: Fundamentals” and “The Art of Wireless Sensor Networks: Advanced Topics and Applications”, which have been published in January 2014. In addition, he published these two current Springer books, “Mission-oriented sensor networks and systems: Art and science—Foundations” and “Mission-oriented sensor networks and systems: Art and science—Advances” in January 2019. He is the recipient of the US National Science Foundation (NSF) CAREER Award in January 2011, a 3-year US NSF Research Grant Award in June 2009, the National Security Agency (NSA) Award in 2017, and the Faculty Research and Development Grant Award from Hofstra College of Liberal Arts and Sciences in May 2009. In March 2014, he was recognized with the Distinguished Research Award at the University of Michigan-Dearborn. Furthermore, in May 2010, he was recognized with the Lawrence A. Stessin Prize for Outstanding Scholarly Publication (*i.e.*, Distinguished Research Award) at Hofstra University. He is the recipient of the Nortel Outstanding CSE Doctoral Dissertation Award in February 2009, and the John Steven Schuchman Award for 2006–2007 Outstanding Research by a Ph. D. student in February 2008. He received the Best Paper Award at EWSN in 2008, and the Best Paper Award at the IEEE PerCom 2008 Google Ph.D. Forum. He received several other prestigious awards, including the Best Graduate Student Paper Award (Nokia Budding Wireless Innovators Awards First Prize) in May 2004, the Best Graduate Student Presentation Award (Ericsson Award First Prize) in February 2004, and Laureate in Physics and Chemistry for academic years 1987 and 1988. Also, he was selected as the ACM Student Research Competition Finalist at the ACM MobiCom in September 2005. Also, he was selected for inclusion in the Marquis Who’s Who in the World in 2019 and 2018,

AcademicKeys Who's Who in Sciences Higher Education in 2017, Who's Who in America in 2017, AcademicKeys Who's Who in Engineering Higher Education in 2012, the AcademicKeys Who's Who in Sciences Higher Education in 2011, Feature Alumnus in the University of Texas at Arlington CSE Department's Newsletter in Spring 2011, Who's Who in America in 2010, and the 2008-2009 Honors Edition of Madison Who's Who Among Executives and Professionals. He received several service awards, including the Certificate of Appreciation Award at MiSeNet 2014, the Certificate of Appreciation Award at ACM MiSeNet 2013, the Certificate of Appreciation Award at the IEEE DCSS 2013, the Certificate of Appreciation Award at the ACM MobiCom 2011, the Outstanding Leadership Award at the IEEE ICCCN 2011, and the Best Symposium Award at the IEEE IWCMC 2011. He serves as the Founding Coordinator of the CIS Distinguished Lecture Series, and as Coordinator of the CIS Faculty Research Talk Series since 2017. In addition, he was the Founding Coordinator of both the Distinguished Lecture Series and the Research Colloquium Series, in the College of Engineering and Computer Science at the University of Michigan-Dearborn from 2011 to 2015. He was successful to invite ACM Turing Award Winners to his distinguished lecture series, such as Dr. Manuel Blum from Carnegie Mellon University (CMU), and Dr. Shafi Goldwasser from MIT, who gave talks at the University of Michigan-Dearborn on January 25, 2013, and October 25, 2013, respectively, and Dr. Martin E. Hellman from Stanford University, who gave a talk at Fordham University on October 22, 2018. He was invited to give several invited talks at reputed universities. Indeed, he was invited to give a talk at the Third Arab-American Frontiers of Sensor Science Symposium, which was organized by the US National Academy of Sciences on December 5–7, 2015. Also, he served as external examiner of several Ph.D. Dissertations. He is the Founder of the Annual International Workshop on Mission-Oriented Wireless Sensor Networking (MiSeNet), which has been co-located with ACM MobiCom, IEEE INFOCOM, and IEEE MASS conferences since 2012. He served as Associate Editor of several prestigious journals, such as ACM TOSN, IEEE TC, IEEE Access, and Elsevier PMC. He serves

on the Steering Committee of MiSeNet, the Annual International Conference on Distributed Computing in Sensor Systems (DCOSS), and the International Workshop on Wireless Mesh and Ad-hoc Networking (WiMAN). Moreover, he served as General Chair, Program Chair, Track Chair, Session Chair, Publicity Chair, Web Chair, and Technical Program Committee member of numerous ACM and IEEE conferences, symposia, and workshops. He is an IEEE Senior Member.