

WIRELESS TECHNOLOGIES FOR E-HEALTHCARE



XUEMIN SHEN

NEI KATO

XIAODONG LIN

E-healthcare systems, developed over heterogeneous networks including wireless body sensor networks (WBSN) and wireless personal area networks (WPANs), are emerging as a promising approach to providing higher-quality medical services and more efficient medical responses and treatments to patients. In such an e-healthcare system, the body sensors in/on/around patients gather all critical health information and report it to remote healthcare service providers immediately for monitoring patients' real-time conditions and long-term trends. However, this newly emerging form of communication poses new challenges to traditional wireless networks and has promoted a promising research area in recent years. The challenging issues related to wireless technologies in e-healthcare systems are:

- The design of WBSN architecture
- Integration of various medical data types and heterogeneous wireless networks
- Secure and efficient transmission of sensitive medical information through wireless networks
- Patients' privacy preservation for sensitive medical information

This special issue consists of eight papers addressing the wireless technologies for e-healthcare systems from different aspects such as different types of medical resources, quality of service, secure and efficient transmission, as well as patient privacy.

In the first article, "Resource-Aware Secure ECG Healthcare Monitoring through Body Sensor Networks," Wang et al. develop a cross-layer framework of body sensor networks (BSNs) to support efficient biomedical data monitoring and secure data transmission based on unequal resource allocation. In particular, a wearable electrocardiogram (ECG) device consisting of small low-powered healthnode sensors are implemented to demonstrate that their approach is efficient and practical.

Electromagnetic interference and different priorities of e-health applications make the design of wireless networks challenging. In the second article, "A Cognitive Radio System for E-Health Applications in a Hospital Environment," Phunchongharn et al. propose a cognitive radio system in a hospital environment to resist harmful interference. An EMI-aware handshaking protocol is proposed for channel access by two different types of applications with different priorities.

The collaboration of heterogeneous networks in e-healthcare systems is critical. In the third article, "Wireless Telemedicine Services over Integrated IEEE 802.11/WLAN and IEEE 802.16/WiMAX Networks," Zhang, Ansari, and Tsunoda

investigate the application of integrated IEEE 802.16/WiMAX and IEEE 802.11/WLAN broadband wireless access technologies and make a comparison between them. Potential challenges and open research issues including QoS support, radio resource management, scheduling and connection admission control schemes, handover, and mobility management are discussed.

Radio frequency identification (RFID) is an important wireless technology for e-healthcare. In the fourth article, "A 2G-RFID-Based E-Healthcare System," Chen et al. address the passive features in the existing RFID systems, called first-generation RFID systems (1G-RFID-Sys), and indicate the difficulties of their adaptation to application-specified requirements. They propose second-generation RFID systems (2G-RFID-Sys), in which encoded rules are dynamically stored in the RFID tags. A novel e-healthcare management system based on 2G-RFID-Sys is demonstrated with improved system scalability, information availability, automated monitoring, and processing of sensitive information.

Remote human motion tracking and gait analysis are helpful for fast medical prognosis and diagnosis. In the fifth article, "Remote Markerless Real-Time Human Gait Monitoring for E-Healthcare Based on Content-Aware Wireless Multimedia Communications," Luo et al. propose an e-healthcare system based on video content analysis and quality-driven content-aware wireless streaming for remote human gait tracking. The extracted human motion region is coded, transmitted, and protected in video encoding with higher priority through wireless communications. The experimental results suggest that the proposed scheme offers great convenience and cost effectiveness for fast prognosis and diagnosis of pathological locomotion bio-rhythm over resource-constrained wireless networks.

The last three articles focus on the security and privacy issues in e-healthcare systems. In the sixth article, "Data Security and Privacy in Wireless Body Area Networks," Li, Lou, and Ren analyze the state-of-the-art solutions for two key research problems in e-healthcare systems: secure dependable distributed data storage and fine-grained data access control. Several existing techniques are discussed and compared, including a redundant residue number system for distributed data storage, and attribute-based encryption for fine-grained access control.

In the seventh article, "Monitoring Patients via a Secure and Mobile Healthcare System," Ren, Pazzi, and Boukerche indicate that providing round-the-clock healthcare services to those patients who require it via wearable wireless medical devices is

a critical problem, and present several techniques that can be applied to securely and efficiently monitor patients. The confidentiality of patients' information, secure transmission in m-healthcare and body sensor networks, and patient privacy are considered with a discussion of current techniques. The eighth article, "Privacy and Emergency Response in E-Healthcare Leveraging Wireless Body Sensor Networks," by Sun, Zhu, and Fang, introduces a specific requirement for an e-healthcare system: efficient and effective response to medical emergencies. One proposed solution achieves the conflicting goals of unlinkability and emergency responses by restricting the emergency medical technicians' access to only necessary data.

In closing, we would like to thank all the authors who submitted their research work to this special issue. We would also like to acknowledge the contribution of many experts in the field who have participated in the review process, and provided helpful suggestions to the authors on improving the content and presentation of the articles. We would also like to extend our sincere thanks to Dr. A. Jamalipour, the former Editor-in-Chief, and Dr. Y. Fang, Editor-in-Chief of IEEE Wireless Communications, for their support and help in bringing forward this special issue. We hope you enjoy the articles in this collection.

BIOGRAPHIES

XUEMIN (SHERMAN) SHEN [F] (xshen@bbr.uwaterloo.ca) received a B.Sc. (1982) degree from Dalian Maritime University, China, and M.Sc. (1987) and Ph.D. degrees (1990) from Rutgers University, New Jersey, all in electrical engineering. He is a University Research Chair Professor, 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 networks, wireless network security, wireless body area networks, and vehicular ad hoc and sensor networks. He is a co-author of three books, and has published more than 400 papers and book chapters on wireless communications and networks, control, and filtering. He served as Tutorial Chair for IEEE ICC '08, 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 for *Peer-to-Peer Networking and Application*; Associate Editor for *IEEE Transactions on Vehicular Technology*; *KICS/IEEE Journal of Communications and Networks*, *Computer Networks*; and *ACM Wireless Networks*; *Wireless Communications and Mobile Computing* (Wiley), among others. He has also served as Guest Editor for *IEEE JSAC*, *IEEE Wireless Communications*, *IEEE Communications Magazine*, and *ACM Mobile Networks and Applications*. He received the Excellent Graduate Supervision Award in 2006, and the Outstanding Performance Award in 2004 and 2008 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 and 2007 from the Faculty of Engineering, University of Waterloo. He is a registered Professional Engineer of Ontario, Canada.

NEI KATO [SM] (kato@it.ecei.tohoku.ac.jp) received his M.S. and Ph.D. Degrees in information engineering from Tohoku University, Japan, in 1988 and 1991, respectively. He joined Computer Center of Tohoku University at 1991, and has been a full professor at the Graduate School of Information Sciences since 2003. He has been engaged in research on computer networking,

wireless mobile communications, image processing and neural networks. He has published more than 180 papers in journals and peer-reviewed conference proceedings. He currently serves as Vice Chair of Technical Committee of Satellite Communications, IEICE, a technical editor of IEEE Wireless Communications (2006~). He served as a symposium co-chair for GLOBECOM'07, ICC'10, ChinaCom'09, and WCNC2010 TPC Vice Chair (Network Track). His awards include Minoru Ishida Foundation Research Encouragement Prize (2003), Distinguished Contributions to Satellite Communications Award from the IEEE Communications Society, Satellite and Space Communications Technical Committee (2005), the FUNAI information Science Award (2007), the TELCOM System Technology Award from Foundation for Electrical Communications Diffusion (2008), and the IEICE Network System Research Award (2009). Besides his academic activities, he also serves on the expert committee of Telecommunications Council, Telecommunications Business Dispute Settlement Commission Special Commissioner, Ministry of Internal Affairs and Communications, Japan, and as the chairperson of ITU-R SG4, Japan. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).

XIAODONG LIN (xdlin@bbr.uwaterloo.ca) received a Ph.D. degree in information engineering from Beijing University of Posts and Telecommunications, China, in 1998 and a Ph.D. degree (with Outstanding Achievement in Graduate Studies Award) in electrical and computer engineering from the University of Waterloo in 2008. He is currently an assistant professor of information security with the Faculty of Business and Information Technology, University of Ontario Institute of Technology, Oshawa, Canada. His research interests include wireless network security, applied cryptography, computer forensics, software security, and wireless networking and mobile computing. He was the recipient of a Natural Sciences and Engineering Research Council of Canada (NSERC) Canada Graduate Scholarship (CGS) Doctoral and the Best Paper Awards of the IEEE International Conference on Computer Communications and Networks (ICCCN 2009) and IEEE ICC '07 Computer and Communications Security Symposium.

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