RECENT PROGRESS IN MACHINE-TO-MACHINE COMMUNICATIONS

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In the past few years, the cost of access to public wireless data networks has been dropping while the capabilities of these networks continue to increase. Machine-to-machine (M2M) communications is a new technology that leverages these networks to bring smart services to a much wider audience. Different from the traditional human to human (H2H) communications for which the current wireless networks are designed and optimized, M2M communications is seen as a form of data communications between entities that do not necessarily need any form of human intervention. It is different from current communication models in the sense that it involves new or different market scenarios, low cost and low effort, a potentially very large number of communicating terminals, and small and infrequent traffic transmission per terminal. The industry has already been working on providing M2M communications and smart services offerings across a wide variety of market segments, including healthcare, manufacturing, utilities, distribution, and consumer products. Smart services are the new services and business models enabled by M2M capabilities. For example, smart grid technology enables utility providers to wirelessly connect to their grid assets, such as circuit breakers, transformers, and other substation equipment. This wireless monitoring capability allows them to develop interactive utility networks that are more intelligent, resilient, reliable, and self-balancing. M2M communications, or machine-type communications (MTC) as sometimes referred by the Third Generation Partnership Project (3GPP), is enabling a ubiquitous computing environment toward the pervasive Internet.

The current wireless networks are mainly designed for H2H communication mode, which means there are high requirements for mobility and human interactive experience such as call setup delay and quality of service (QoS). Since M2M communication brings very different requirements and the number of M2M communication devices may increase quickly, the wireless access network is proposed to be enhanced for M2M communications by the industry. The topic of M2M communications has gained much momentum in the industry and research community recently. It has attracted the attention of standardization bodies such as 3GPP Long Term Evolution (LTE), whose objectives are looking into potential requirements to facilitate improvements in M2M communications, and more efficient use of radio and network resources.

There is an urgent need in both industry and the research community to better understand the technical details and recent progress of M2M communications. We planned this feature topic to help address that need, and wanted to focus on recent advances as well as survey articles on M2M communications.

The response to our Call for Papers on this feature topic was overwhelming, with a large number of articles submitted from around the globe. During the review process, each paper was assigned to and reviewed by at least three experts in the relevant area, with a rigorous two-round review process. Due to the lack of space, we can only accommodate six excellent articles covering various aspects of M2M communications involving network architecture and standards, wireless access network enhancements, security, and smart and green services.

The first article, "GRS: The Green, Reliability, and Security of Emerging Machine to Machine Communications," by Lu *et al.*, explores the emerging M2M communications in terms of the potential green, reliability, and security issues, and aims to promote an energy-efficient, reliable and secure M2M communication environment.

In the second article, "M2M: From Mobile to Embedded Internet," Wu *et al.* highlight the key M2M application requirements and major technology gaps, and analyze the future directions of air interface technology improvements and network architecture evolution to enable the mass deployment of M2M services, toward embedded Internet and the Internet of Things.

The third article, "Home M2M Networks: Architectures, Standards, and QoS Improvements" by Zhang *et al.*, identifies the fundamental challenges in home M2M networks, and presents an architecture of home M2M networks that is decomposed into three subareas depending on the radio service ranges and potential applications.

Niyato *et al.* in the fourth article, "Machine-to-Machine Communications for Home Energy Management System in Smart Grid," present an investigation of the applications of M2M communications in smart grid. They address the network design issues of M2M communications for a home energy management system in the smart grid.

In the fifth article, "Toward Intelligent Machine to Machine Communications in Smart Grid," Fadlullah *et al.* survey a number of existing communication technologies that can be adopted for M2M communications in the smart grid. They also present a possible solution to improve the scalability of smart grid communications.

Finally, Lien, Chen, and Lin present the sixth and last article, "Toward Ubiquitous Massive Accesses in 3GPP Machine to Machine Communications." In this article, the authors provide an overview of the network architecture and features of M2M communications in 3GPP, and identify potential issues with the air interface, including physical layer transmissions, the random access procedure, and the radio resource allocations supporting the most critical QoS provisioning. They further propose a solution to provide QoS guarantees to facilitate M2M applications with hard timing constraints.

In closing, we would like to thank all the authors for their excellent contributions. We also thank the reviewers for their

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dedication in reviewing the papers, and providing valuable comments and suggestions for refining the quality of the articles. We appreciate the advice and support from Dr. Steve Gorshe, Editor-in-Chief of *IEEE Communications Magazine*, and Joseph Milizzo, Devika Mittra, Jennifer Porcello, and Cathy Kemelmacher for their help in the publication process. Finally, we hope that the readership will find this feature topic interesting and stay tuned for new developments in this research area.

BIOGRAPHIES

ROSE QINGYANG HU [S'95, M'98, SM'06] (rosehu@ieee.org) received her B.S. degree from the University of Science and Technology of China, her M.S. degree from Polytechnic Institute of New York University, and her Ph.D. degree from the University of Kansas. During 1998–2000 she worked for Nortel Networks, where she led Nortel broadband multimedia satellite performance evaluation and 1xRTT CDMA Wireless Priority Service system design and evaluation. During 2000–2001 she worked for Yotta Networks as a senior systems engineer, leading the system design and performance evaluation for optical switch scheduling, reliability, and QoS. From January 2002 to June 2004 she was with the Department of Electrical and Computer Engineering at Mississippi State University as an assistant professor, where she advised graduate students on their research and taught advanced level courses on wireless networks and performance analysis. From 2006 to 2009 she was a manager with Nortel's wireless standards and architecture team, leading Nortel 4G wireless technology performance evaluation and standards development. Between April 2009 and December 2010 she was a senior researcher with RIM and a senior wireless platform architect with Intel. Currently she is an associate professor in the Department of Electrical and Computer Engineering at Utah State University. She is a member of the Phi Kappa Phi and Epsilon Pi Epsilon Honor Societies.

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