

Guest Editorial

Special Issue on Theories and Applications of NB-IoT

RECENTLY, demands for low-power wide-area (LPWA) machine-type communications have increased dramatically. It is expected that LPWA connections will reach 2 billion in 2020, exceeding the number of traditional cellular users. Narrowband Internet of Things (NB-IoT), a new radio access technology, has been released by the Third Generation Partnership Project for such demands. NB-IoT supports super coverage extension, massive number of connections and long user lifetime with low power cost and low device complexity. With such prominent features, NB-IoT has become one of the dominating technologies in LPWA networks, applicable to a large range of IoT application scenarios such as smart meter, smart parking, smart home, smart tracking, e-health, etc. However, NB-IoT is still in its infancy, needing deep theoretical investigation of modeling and optimizing system performance. Also, emerging applications that can be enabled by NB-IoT and implementation challenges therein need further exploration.

The objective of this special issue is to bring recent progress in theories and applications of NB-IoT that may help put together a clear picture for this new area. To this end, we selected 12 papers, which can be divided into four categories. Papers in the first category focus on media access control protocols design and its performance evaluation. The paper “Throughput Modeling and Analysis of Random Access in Narrowband Internet of Things” by Sun *et al.* attempts to systematically analyze the performance of random access in NB-IoT. The paper “Network Throughput Optimization for Random Access Narrowband Cognitive Radio Internet of Things (NB-CR-IoT)” by Li *et al.* derive a unique set of optimal sensing parameters which achieve the maximum throughput of a narrowband cognitive radio IoT (NB-CR-IoT) network.

Papers in the second category attempt to introduce the concept of “group” into NB-IoT to improve the communication efficiency for meeting the requirements of different IoT applications. The paper “Group Communications in Narrowband-IoT: Architecture, Procedures, and Evaluation” by Tsoukaneri *et al.* focuses on group communications (i.e., multicast) in NB-IoT to efficiently support the transmission of firmware, software, task updates, or commands toward a large set of devices. The paper “Grouping-Based Discontinuous Reception for Massive Narrowband Internet of Things Systems” by Xu *et al.* proposes a grouping based energy efficient DRX strategy. The studies by Ning *et al.* and Li *et al.* try to solve the problems in NB-IoT systems when D2D communications are incorporated.

The third category is concerned with the applications of NB-IoT. The work “Smart Choice for the Smart Grid: Narrowband Internet of Things (NB-IoT)” introduces NB-IoT to the smart grid and compares it with the existing

representative communication technologies in the context of smart grid communications in terms of data rate, latency, and range, etc. The paper by Zhang proposes an architecture to connect intelligent things in smart hospitals based on NB-IoT, and introduces edge computing to deal with the requirement of latency in medical process. In addition, Guo *et al.* propose a CSI amplitude fingerprinting based localization algorithm in NB-IoT system, where the centroid algorithm based on CSI propagation model is optimized.

The fourth category is about the review of NB-IoT and its related technical topics. Xu *et al.* survey the NB-IoT’s evolutions, technologies and issues, spanning from performance analysis, design optimization, combination with other leading technologies, to implementations and applications. Yang *et al.* investigate the small-cell assisted traffic offloading for NB-IoT systems. Deng *et al.* provide an in-depth study on how to energy-efficiently heal the multi-modal confident information coverage holes in an NB-IoT-enabled hybrid IoT deployed for radiological pollution monitoring.

These selected papers showcase the recent advances in NB-IoT, covering a broad spectrum ranging from theoretical contributions to system-oriented contributions.

We would like to thank many people who contributed to the success of this special issue. In particular, we thank the numerous reviewers for their valuable feedback to the authors. We would also like to thank the Editor-in-Chief, Prof. S. Shen, and Ms. N. Cicero for their support in the review and publication process.

JIMING CHEN, *Guest Editor*
College of Control Science and Engineering
Zhejiang University
Hangzhou 310027, China

KAORU OTA, *Guest Editor*
Department of Information and Electronic Engineering
Muroran Institute of Technology
Muroran 050-8585, Japan

LU WANG, *Guest Editor*
College of Computer Science and Software Engineering
Shenzhen University
Shenzhen 518060, China

PREETHA THULASIRAMAN, *Guest Editor*
Department of Electrical and Computer Engineering
Naval Postgraduate School
Monterey, CA 93943 USA

ZHIGUO SHI, *Guest Editor*
College of Information Science and Electronic Engineering
Zhejiang University
Hangzhou 310027, China