

Editorial **Embedded IoT Systems: Network, Platform, and Software**

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Received 19 April 2017; Accepted 19 April 2017; Published 24 May 2017

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With the rapid development of connected embedded devices being placed everywhere in our everyday life, the vision of the Internet of Things (IoT) is coming close to reality where billions of physical world devices have a digital presence on the Internet. However, despite the importance of IoT, there are still several technical challenges remaining before the next Internet revolution. This special issue has focused on technical challenges that can enable IoT. We call for manuscripts presenting and discussing the most recent advances in embedded systems for IoT. Until the deadline of the special issue, 17 manuscripts have been received worldwide. After the review process, 7 manuscripts have been accepted by this special issue. The accepted research manuscripts have focused on the energy efficiency and power transfer for IoT devices, device-to-device communication, multithreading for multicore IoT platforms, and topology construction and scalability of IoT networks. Accepted manuscripts present the important research findings and these advances will contribute to the development of IoT.

Evaluation of power efficiency is important for low power wireless personal area network (LoWPAN) devices and applications in IoT. Conventional methods to evaluate the power efficiency of LoWPAN devices rely deeply on the accuracy of the testing equipment, which trades off high cost with limited accuracy. To tackle this challenge, a low cost, real-time power measurement platform called PTone is proposed, which can be used to detect the real-time power usage of LoWPAN devices and be able to determine the state of each module of device under test. Based on PTone, an abnormal status diagnosis mechanism is developed which can not only judge abnormal status, but also classify the abnormal status and locate the abnormality causing module accurately.

Power transfer wirelessly is another promising technology that can enable a massive number of wireless devices in IoT. For this purpose, destination-aided simultaneous wireless information and power transfer (SWIPT) is proposed for a decode-and-forward relay network, in which massive multiple-input multiple-output (MIMO) antennas are deployed at relay to assist communications among multiple source-destination pairs. During relaying, energy signals are emitted from multiple destinations when multiple sources are sending their information signals to relay. Analysis reveals that asymptotic harvested energy is independent of the fast fading effect of wireless channels; meanwhile, transmission powers of each source and destination can be scaled down inversely proportional to the number of relay antennas. To reduce energy leakage interference and multipair interference, zero-forcing processing and maximum ratio transmission are employed at relays. Fundamental trade-off between harvested energy and achievable sum rate is quantified, and it is shown that asymptotic sum rate is neither convex nor concave with respect to power splitting and destination transmission power. Thus, a one-dimensional embedded bisection algorithm can be used to jointly determine the optimal power splitting and destination transmission power, which shows that destination-aided SWIPT are beneficial for harvesting energy and increasing the sum rate.

For the past decade, wireless sensor networks have focused primarily on data collection. As a result, the network topology for these systems was usually heavily centralized. However, for these networks to form a full IoT system, the introduction of proper actuation units and decision-making intelligence is inevitable. To that end, a new distributed wireless sensor and actuator network (DWSAN) system has been proposed. The DWSAN system architecture effectively combines both sensor and actuation hardware devices to a single network and manages this network so that the actuation decisions are made in a distributed manner and the topology of the network maintains a multitier architecture. Intensive sets of evaluations reveal that, compared to the centralized approaches that have been used in most wireless sensor network systems until now, when actuation units are introduced to the system, the DWSAN architecture reduces the transmission load of the network and the actuation decision-making latency by close to twofold and threefold, respectively. Furthermore, this benefit naturally leads to better scalability of the system, making it suitable for various sensing applications in different environments.

Device heterogeneity and device-to-device (D2D) communication are another important enabler for the Internet of Things. For the D2D communication, transmit and receive beamforming with the channel state information for virtual MIMO enabled by D2D receive cooperation can be used. Analysis on the sum rate achieved by a device pair has been made, and a distributed algorithm for device pairing to maximize the throughput of the multidevice network has been developed in this special issue. Furthermore, for heterogeneous multicore IoT systems, efficient thread mapping and scheduling mechanism primed for heterogeneously configured multicore systems had been proposed which considers CPU utilization for mapping running threads with the appropriate core that can potentially deliver the actual needed capacity.

Finally, topology management for IoT has been studied analytically. For successful realization of IoT, challenges such as heterogeneous connectivity, ubiquitous coverage, reduced network and device complexity, enhanced power saving, and enhanced resource management have to be solved, and all these challenges are heavily impacted by the IoT network topology consisting of a massive number of connected devices. Small-world networks and scale-free networks are important complex network models with a massive number of nodes and have been actively used to study the network topology of brain networks, social networks, and wireless networks. These models, also, have been applied to IoT networks to enhance synchronization, error tolerance, and more. However, due to the interdisciplinary nature of the network science, with heavy emphasis on graph theory, it is not easy to study the various tools provided by complex network models. Therefore, the concept of basic graph theory has to be used, including small-world networks and scalefree networks, to provide system models that can be easily implemented to be used as a powerful tool in solving various research problems related to IoT.

Acknowledgments

We would like to thank all the reviewers that have contributed their time and insight to this special issue.

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