IEEE Transactions on Sustainable Computing: Guest Editorial on Special Issue on Sustainable Cyber-Physical Systems

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THE research on cyber-physical systems (CPSs) addresses the close interactions between the cyber computational components and the physical components spanning from mechanical components, energy systems, human activities, to surrounding environment. CPS is expected to play a major role in the development of next-generation smart energy systems and data centers. Innovative computational methodologies such as green and energy efficient cyber-physical system design have become critical to enable the sustainable development of such systems. These technologies can be used to tackle various sustainability challenges, such as the reduction of energy induced from the large scale data center computing infrastructures, the improvement of computational efficiency in smart energy systems and connected vehicle systems, and the exploration of the renewable energy resources to mitigate classical energy usages.

This special issue of the *IEEE Transactions on Sustainable Computing* presents the state-of-the-art research results on the topic of sustainable computing for CPS. It serves as a stimulus to promote highly interdisciplinary research and development in sustainable CPS. This special issue received a significant number of submissions while only a small portion of them were selected for publication. These papers showcase how interesting sustainability techniques have been leveraged to optimize different metrics in CPS, such as timing, efficiency, schedulability, power, reliability, and security, etc. Some details of them are elaborated as follows.

The paper entitled "Resource Management in Sustainable Cyber-Physical Systems Using Heterogeneous Cloud Computing" by Keke Gai, Meikang Qiu, Hui Zhao, and Xiaotong Sun discusses the issue of bottlenecks of the web server capacities during task assignments in the resource management in the context of heterogeneous cloud computing, from a cyber-physical systems point of view. Combining CPS with heterogeneous cloud computing is an alternative approach to improve the sustainability of the system. This paper proposes the Smart Cloud-based Optimizing Workload (SCOW) Model that uses predictive cloud capacities to assign tasks to heterogeneous clouds. To reach the optimized objective, new algorithms are proposed to support the SCOW model, which include the Workload Resource Minimization Algorithm, Smart Task Assignment Algorithm, and Task Mapping Algorithm.

The paper "Consideration of Cyber-Physical Interdependencies in Reliability Modeling of Smart Grids" by Koosha Marashi, Sahra Sedigh Sarvestani, and Ali R. Hurson addresses one of the most important issues in the design of reliable smart grid. In such CPSs, reliability of power distribution and transmission is one of the key requirements to achieve sustainability. The paper first presents an analytical reliability model that captures cyber-physical interdependencies and impairments from both physical and cyber components, which can be instantiated with failure data from field use or simulation. Dependencies in the smart grid are also categorized and quantified in order to analyze the impact on reliability of introducing additional interdependencies.

The paper entitled "Sustainability-Oriented Evaluation and Optimization for MPSoC Task Allocation and Scheduling under Thermal and Energy Variations" by Mingsong Chen, Xinqian Zhang, Haifeng Gu, Tongquan Wei, and Qi Zhu targets at optimizing performance yield under the process variation. To achieve this, two interesting methods are developed, including a statistical model checking technique and a supervised-learning based optimization method. The first method can automatically transform the mapped TAS into NPTA models. Since evaluating all the solutions by model checker is time consuming, the second method uses BPNN to largely speed up the evaluation process by extracting the features from TAS solutions.

The paper "A Cyber-Physical Systems Approach for Implementing the Receding Horizon Optimal Power Flow in Smart Grids" by Alessio Maffei, Seshadhri Srinivasan, Daniela Meola, Giovanni Palmieri, Luigi Iannelli, Øystein Hov Holhjem, Giancarlo Marafioti, Geir Mathisen, and Luigi Glielmo proposes an interesting receding horizon control based optimal power flow technique, which is embedded with the forecast information to predict renewable generation and demand. It also develops new data models to exchange information among different applications.

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The paper entitled "Enabling Sustainable Cyber Physical Security Systems through Neuromorphic Computing" by Jialing Li, Lingjia Liu, Chenyuan Zhao, Kian Hamedani, Rachad Atat, and Yang Yi develops a novel neuromorphic computing architecture with the signal preprocessing by analog spike trains, and applies it to anomaly detection in CPS. The comprehensive design including all the modules that are needed for the architecture of delayed feedback reservoir computing systems is provided in the paper. According to the results for the temporal encoder, the proposed neuron circuit consumes much less energy than the state-of-the-art works, and the delayed feedback reservoir designs exhibits the superior capability to process spikes.

The paper entitled "A Joint Optimization Scheme for Artificial Noise and Transmit Filter for Half and Full Duplex Wireless Cyber Physical Systems" tackles one of the most important problems of physical layer security in CPS. It proposes a joint optimization scheme for artificial noise signal and transmit filter to preserve secrecy of communication in the presence of an eavesdropper without sacrificing the required quality of service. The derivation for both half and full duplex communication is clearly presented and the effect of channel estimation and self-interference is considered. The paper also presents interesting insights regarding advantage of FD communication for preserving secrecy over HD communication, and the effect of various transmit/receive filters.

The CPS community has started to embrace the emerging research opportunities from the sustainability perspective. In addition to the problems considered in the above selected papers, there are many other interesting and challenging CPS aspects, such as synthesis, verification, and analytics, which need sustainability techniques. It is our vision that leveraging advanced sustainability techniques for tackling various emerging CPS design challenges will become a major research field in the future.

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Guest Editors

Shiyan Hu (SM'10) received the PhD degree in computer engineering from Texas A&M University, in 2008. He is an associate professor with Michigan Tech., and he was a visiting professor with IBM Research (Austin) in 2010, and a visiting associate professor with Stanford University from 2015 to 2016. His research interests include cyber-physical systems (CPS), CPS security, data analytics, and computer-aided design of VLSI circuits, where he has published more than 100 refereed papers. He is an ACM distinguished speaker, an IEEE Systems Council distinguished lecturer, an IEEE Computer Society distinguished visitor, an invited participant for the US National Academy of Engineering Frontiers of Engineering Symposium, a recipient of the US National Science Foundation (NSF) CAREER Award, a recipient of the ACM SIGDA Richard Newton DAC Scholarship (as the faculty advisor), and a recipient of the JSPS Faculty Invitation Fellowship. He is the chair of the IEEE Technical Committee on Cyber-Physical Systems. He is the editor-in-chief of the *IET Cyber-Physical Systems: Theory & Applications*. He serves as an associate editor for the *IEEE Transactions on Computer-Aided Design*, the *IEEE Transactions on Industrial Informatics*, and the *IEEE Transactions on Circuits and Systems*. He is also a guest editor for eight IEEE and ACM journals such as the *Proceedings of the IEEE* and the *IEEE Transactions on Computers*. He has held chair positions for numerous IEEE/ACM conferences. He is a fellow of IET and senior member of the IEEE.

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