sustainability

MDPI

Editorial

Advanced IT-Based Future Sustainable Computing (2017–2018)

Jong Hyuk Park

Department of Computer Science and Engineering, Seoul National University of Science and Technology (SeoulTech), Seoul 01811, Korea; jhpark1@seoultech.ac.kr; Tel.: +82-2-970-6702

Received: 29 March 2019; Accepted: 30 March 2019; Published: 15 April 2019

Abstract: Future Sustainability Computing (FSC) is an emerging concept that holds various types of paradigms, rules, procedures, and policies to support breadth and length of the deployment of Information Technology (IT) for abundant life. However, advanced IT-based FCS is facing several sustainability problems in different information processing and computing environments. Solutions to these problems can call upon various computational and algorithmic frameworks that employ optimization, integration, generation, and utilization technique within cloud, mobile, and cluster computing, such as meta-heuristics, decision support systems, prediction and control, dynamical systems, machine learning, and so on. Therefore, this special issue deals with various software and hardware design, novel architectures and frameworks, specific mathematical models, and efficient modeling-simulation for advance IT-based FCS. We accepted eighteen articles in the six different IT dimensions: machine learning, blockchain, optimized resource provision, communication network, IT governance, and information security. All accepted articles contribute to the applications and research in the FCS, such as software and information processing, cloud storage organization, smart devices, efficient algorithmic information processing and distribution.

Keywords: machine learning; blockchain; future sustainable computing; information security; communication network; IT governance

Nowadays, sustainable computing is a rapidly increasing and the research field is spreading into different interdisciplinary areas of computer and information technology as well as other core engineering disciplines [1]. Future sustainable computing (FSC) includes various kinds of policies, procedures, tasks, programming, and paradigms to execute the breadth and length of information technologies utilization in eco-rich life [2]. The problems of sustainability must be addressed in a variety of information processing and computing technologies and environments [3]. The solutions for sustainability problems, information collection, generation, aggregation, utilization, integration, and processing, can involve a variety of computational and algorithmic methodologies and frameworks within cloud, fog, edge, mobile, and cluster computing, such as security and privacy mechanisms, meta-heuristics and decision support systems, prediction and control, dynamical systems, machine learning, decentralization using blockchain, optimization, and so on [4–6]. The goal of advanced information technology (IT) based future sustainable computing (FSC) is to elaborate the myriad of research findings related to various kinds of paradigms, procedures, frameworks of different IT areas, such as machine learning, blockchain, optimized resource provision, a communication network for FSC [7,8]. The research findings provide a spectrum of related research issues such as applications of IT that can have ecological and societal impacts. We face a range of sustainability problems, such as economic, environmental, and societal (human resource) in a variety of computing environments [9,10].

However, how to optimize the FSC is a question now. Optimization can be accomplished by advancement in IT in terms of the mathematical interpretation and computer application [11,12].

The adoption of advanced IT in FSC can optimize it, but the challenge is to deal with software/hardware technologies, especially for architectures and frameworks. The three broad areas of scalability, security, and availability are crucial to focus on [13].

This Special Issue "Advanced IT-Based Future Sustainable Computing" covers innovative applications and research of advanced IT within the scopes related to FSC, such as the Internet of Things (IoT), supply chain management, efficient algorithmic information distribution/processing, new communication environment for data transfer, hardware and software information processing, optimization in cloud computing, smart devices. Furthermore, it deals with software/hardware paradigms, specific mathematical interpretations, novel frameworks and architectures, designs of theories for the FSC, efficient modeling-simulation. During our working period, we received many submissions, which had significant contributions for the main topics of interest of our special issue. However, only 18 high-quality papers were accepted after three-rounds of strict and rigorous review. In particular, these accepted papers mainly focused on various perspectives: sustainable decision-making, supply chain management, transparency and privacy for a sustainable donation environment, sustainable context-awareness, software security, environmental sustainability in IT governance, smart home security, computational theories, and technologies.

As the advancement in IT can provide optimization in FSC, in this special issue, 'Advanced IT-Based Future Sustainable Computing', eighteen articles were accepted (Contribution 1–Contribution 18). All accepted articles deliver recent development in future sustainable computing based on the six different IT dimensions: machine learning, blockchain, optimized resource provision, communication network, IT governance, and information security. In the machine learning dimension, Yunsick Sung, Yong Jin, Jeonghoon Kwak, Sang-Geol Lee, and Kyungeun Cho proposed a machine learning based approach to crop the input images for providing autonomous end-to-end control in self-driving cars. The proposed approach relied on a convolutional neural network to extract road parts from the input images and identify the significant parts for end-to-end control. The authors employed a sustainable computing environment called Open Racing Car Simulator (TORCS) to demonstrate the effectiveness of the proposed method for a self-driving car. The experimental results showed the performance improvement in the accumulated difference by 0.839% and 0.850% (Contribution 1). Yunsik Son, Junho Jeong, and YangSun Lee introduced an adaptive offloading scheme using a hybrid deep neural network that supports context management and estimation of Central Processing Unit usage for low-performance IoT devices. The proposed scheme extracts context information that is significant for job execution in the IoT-Cloud converged virtual machine system. The experimental evaluation showed a hybrid deep neural network is effective for adaptive offloading of the server load. It also estimates the optimal time for offloading and reduces network communication overheads for low-computing-powered IoT devices (Contribution 2). Hong-Jun Jang, Byoungwook Kim, Jongwan Kim, and Soon-Young Jung proposed an effective grid-based k-prototypes algorithm (GK-prototypes) that supports sustainable decision-making using clustering spatial objects. The proposed algorithm dropped down the unnecessary distance calculation by considering both minimum and maximum distance between clusters. It also employed a spatial dependence that enhanced the clustering performance over the skewed categorical data. The experimental results demonstrated that the proposed algorithm was outperformed over the existing k-prototypes algorithm (Contribution 3).

In the following paper of this special issue, two articles were accepted in the blockchain dimension, Minjae Yoo and Yoojae Won introduced a blockchain based price tracing system that provides the transparency of product price and additional information in supply chain management (SCM). The proposed system supports business organizations to improve transparency in the SCM and tracks their trades. It provides a more effective way to recognize potential consumer trends than existing electronic records. The blockchain-based data management in the proposed system prevents companies against data forgery and Distributed Denial-of-Service attacks. The overall analysis of the proposed scheme demonstrates that it outperformed over the conventional schemes for price tracing

(Contribution 4). Jaekyu Lee, Aria Seo, Yeichang Kim, and Junho Jeong studied the issue of transparency in donation systems and discussed the privacy problems for donors and recipients. Based on the study, they developed a one-off address system using blockchain technology to protect the privacy of donors and recipients in a donation system. The blockchain supports the protection of sensitive information and tracking the donation from a specific person to a specific recipient. The proposed system delivers the privacy aware and a sustainable donation environment. The comparison of the proposed system with existing centralized donation systems demonstrates that the proposed system outperformed in terms of security assurance, privacy protection, system transparency, system management type, and system management technology (Contribution 5).

In order to optimize resource provisions, Saurabh Singh, Pradip Sharma, Seo Moon, and Jong Hyuk Park addressed the challenge of harvesting energy generated from cloud data centers and proposed an effective solution to mitigate this challenge. They introduced a green cloud infrastructure to deliver the security and efficiency in a cloud computing environment. To provide green cloud computing, the infrastructure utilized a pyroelectric material to produce an electric current from heat at the data center and a genetic algorithm to allocate virtual machines properly. Moreover, a multivariate correlation analysis (MCA) correlation analysis was used in the proposed infrastructure to deliver detection of denial of service (DoS) attacks in the data center. The authors experimentally evaluated the proposed infrastructure and demonstrated its effectivities in terms of security and energy efficiency (Contribution 6). To address the challenge of low power sensing in mobile devices, Dusan Baek, Jae-Hyeon Park, Byungjeong Lee, and Jung-Won Lee proposed an exclusive context resolver (ExCore) system. The ExCore accumulates the exclusive contexts by employing unnecessary sensing operation search rules and provides a sustainable context-awareness in exclusive contexts. The proposed system was experimentally evaluated using middleware and mobile applications with low-power sensing operations. The experimental results showed a significant improvement of 12%–62% in power efficiency. The middleware developers and application developers can use the ExCore system to deliver a sustainable context-aware service in exclusive contexts (Contribution 7). Wenquan Jin and Dohyeun Kim proposed a consistent registration and discovery approach to manage the data from devices and web service providers in the IoT network. The proposed approach employed an embedded resource directory server to support a consistent registration service for publishing information from web service providers and IoT devices. Furthermore, a unified profile format was deployed to describe the information of registered devices and discover the registered web services in IoT network. With the help of the proposed approach, the client can discover the registered device information and access the resources of devices (Contribution 8). Jun-Ho Huh discussed the issue of the cost for networking equipment that satisfies consumer demands in the telecommunication services. They studied the significance of network function virtualization (NFV) to reduce the cost in the network server operation. NFV supports the equipment virtualization to operate on an x86-based compatible server rather than operate on the network equipment hardware. Based on the study, the authors introduced an effective scheme using NFV technology to reduce the cost of operation of the network server. The simulation results demonstrated a 24% reduction in the cost as compared to conventional network equipment (Contribution 9). Byoungwook Kim and Min Choi discussed the problem of performance degradation of feal-time operating systems (RTOS) in the embedded systems. To address this problem, they performed a performance comparison between individual execution of the RTOS and concurrent execution of more than one OSs (RTOS + Linux). The RTOS performance is measured on the NVidia Jetson TK-1 embedded board supporting virtualization technology and the performance of the more than one OSs (RTOS + Linux) is measured simultaneously on top of a hypervisor. The authors implemented the RTOS onto two real-world embedded boards (Contribution 10).

In the communication network dimension, Soohyun Cho introduced a mechanism to handle multiple users and multiple access points placed in each area of CSMA/CA-based wireless networks. The proposed scheme relied on homogeneous Poisson point processes (PPPs) to model and analyse the

signal outage probabilities of users in the case of different modulation and coding schemes (MCSs) and different numbers of access points. The authors also addressed the APs using different transmit powers and introduced heterogeneous CSMA/CA-based wireless networks. The outages of the proposed scheme were evaluated and compared with the signal-to-interference-plus-noise ratio (SINR) outage rates of users in both heterogeneous and homogeneous Institute of Electrical and Electronics Engineers 802.11a wireless networks using extensive event-driven simulations. The simulation results showed that the effectiveness of the proposed scheme on CSMA/CA-based wireless networks (Contribution 11). Dongkyun Kim, Yong-Hwan Kim, Ki-Hyun Kim, and Joon-Min Gil addressed the requirement of the advanced network infrastructure for distributed cloud computing in order to support high-performance data transfer, virtualization, network automation, and secured access of end-to-end resources across regional boundaries. To fulfil this requirement, they designed the integration of distributed cloud resources for on-demand and dynamic virtual networking on software-defined wide area network. The designated scheme was evaluated in order to demonstrate the effectiveness of advanced network infrastructure. The evaluation of the results showed the minimization of the virtual network convergence time in two types of network models, one is Mininet-based networks, and another is an operating openflow-oriented SD-WAN network (Contribution 12). Byoungwook Kim and Kwang-il Hwang studied the various LPWAN technologies, long-range wide-area network (LoRaWAN, or LoRa) and proposed downlink function from the network server to the end devices for increasing the energy efficiency of the network. The authors proved the applicability of the proposed scheme for the various communication models such as geocasting and groupcasting by combining with the data-centric models. The experimental evaluation of the proposed scheme showed that it increases the energy efficiency of the LoRa and reduces network traffic compared to LoRa (Contribution 13).

In the information security dimension, Seung-Hyun Kim, Daeseon Choi, Soo-Hyung Kim, Sangrae Cho, and Kyung-Soo Lim introduced the Fast IDentity Online (FIDO) authenticator to support regular authentication by employing user context. The FIDO authenticator satisfies the level of authentication demanded by the service provider by employing user biometrics, state of the mobile devices, and user context. It regularly provides an authentication service to the user and decreases the burden of the user's explicit authentication. It was also capable of responding to sensitive attacks such as session hijacking and theft of the authentication method. The proposed authenticator has experimentally evaluated a practical android environment by employing 22 participants over 42 days of activity. The experimental results showed that explicit authentication requests were reduced (Contribution 14). Jeesoo Jurn, Taeeun Kim, and Hwankuk Kim discussed common vulnerability enumeration (CVE) for software security as the number of vulnerabilities is increasing day by day and the recent response techniques have relied on manual analysis, leading to a slow response time. To support a fast response to the vulnerabilities, the authors proposed various automated vulnerability detection and remediation schemes that detect and patch vulnerabilities automatically. The proposed schemes rely on the binary complexity analysis to mitigate zero-day attacks. With the use of a Procedure Linkage Table and a Global Offset table modification, the authors also introduced an automatic patch generation technique to account for zero-day vulnerabilities (Contribution 15).

In the IT governance dimension, Wilmer Rivas-Asanza, Jennifer Celleri-Pacheco, Javier Andrade-Garda, Rafael García-Vázquez, Virginia Mato-Abad, Santiago Rodríguez-Yáñez, and Sonia Suárez-Garaboa studied information technologies governance (IT governance or ITG) and environmental sustainability (ES) that support an organization to solve intrinsically common issues such as resource management, mechanisms for performance improvement, generation of value, strategic alignment, and resource management. Based on the study, the authors introduced a fusion of both ITG and ES to determine how ES issues can be examined using current ITG models. They recognized 27 activities and 103 sub-activities of ES in the domain (ISO14001, GRI G4, EMAS, SGE21 and ISO26000). The conclusion of the study described Control Objectives for Information and Related Technologies 5 is the most sustainable ITG scheme to incorporate more ES issues (Contribution 16). J. David Patón-Romero, Maria Teresa Baldassarre, Mario Piattini, and Ignacio García Rodríguez

de Guzmán studied green information technology (IT) in the field of IT governance and proposed a "Governance and Management framework for Green IT". The framework establishes the necessary characteristics for performing the management and governance in organizations to support audits in IT governance. The strategy to design the framework relied on COBIT 5, a control and audit framework in the area of IT governance. The validation results of the framework demonstrated its effectiveness and usefulness in the field of green IT (Contribution 17). Namsu Hong, Mansik Kim, Moon-Seog Jun, and Jungho Kang addressed the various security threats in the smart home, such as the deployment of vulnerable OAuth and the vulnerability of sessions/cookies. The authors proposed a user authentication scheme by employing international mobile equipment identity (IMEI) and the JSON Web Token (JWT) to identify an unauthorized smart home device in the smart home. The results of the study demonstrated that the use of IMEI and JWT technology can provide an effective authentication of a smart home device (Contribution 18). The applications of IT in the area sustainable computing have become a major focus in recent years. Various IT fields such as machine learning, blockchain, optimized resource provision, and communication networks are increasing their presence to provide sustainable computing [13]. The advance in FSC has ecological and societal impacts. Hence, this editorial for the Special Issue, Advanced IT-Based Future Sustainable Computing, elaborates on the myriad of research findings related to various kind of paradigms, procedures, frameworks, architectures of different IT areas to optimize sustainable computing that provide significant contributions in recent research.

List of Contributions:

1. Sung, Y.; Jin, Y.; Kwak, J.; Lee, S.G.; Cho, K. Advanced Camera Image Cropping Approach for CNN-Based End-to-End Controls on Sustainable Computing. *Sustainability* **2018**, *10*, 816.
2. Son, Y.; Jeong, J.; Lee, Y. An Adaptive Offloading Method for an IoT-Cloud Converged Virtual Machine System Using a Hybrid Deep Neural Network. *Sustainability* **2018**, *10*, 3955.
3. Jang, H.J.; Kim, B.; Kim, J.; Jung, S.Y. An Efficient Grid-Based K-Prototypes Algorithm for Sustainable Decision-Making on Spatial Objects. *Sustainability* **2018**, *10*, 2614.
4. Yoo, M.; Won, Y. A Study on the Transparent Price Tracing System in Supply Chain Management Based on Blockchain. *Sustainability* **2018**, *10*, 4037.
5. Lee, J.; Seo, A.; Kim, Y.; Jeong, J. Blockchain-Based One-Off Address System to Guarantee Transparency and Privacy for a Sustainable Donation Environment. *Sustainability* **2018**, *10*, 4422.
6. Singh, S.; Sharma, P.K.; Moon, S.Y.; Park, J.H. EH-GC: An Efficient and Secure Architecture of Energy Harvesting Green Cloud Infrastructure. *Sustainability* **2017**, *9*,673.
7. Baek, D.; Lee, J.W. Exclusive Contexts Resolver: A Low-Power Sensing Management System for Sustainable Context-Awareness in Exclusive Contexts. *Sustainability* **2017**, *9*, 647.
8. Jin, W.; Kim, D. Consistent Registration and Discovery Scheme for Devices and Web Service Providers Based on RAML Using Embedded RD in OCF IoT Network. *Sustainability* **2018**, *10*, 4706.
9. Huh, J.H. Server Operation and Virtualization to Save Energy and Cost in Future Sustainable Computing. *Sustainability* **2018**, *10*, 1919.
10. Kim, B.; Choi, M. Design and Analysis of Multiple OS Implementation on a Single ARM-Based Embedded Platform. *Sustainability* **2017**, *9*, 684.
11. Cho, S. Signal Outages of CSMA/CA-Based Wireless Networks with Different AP Densities. *Sustainability* **2018**, *10*, 1483.
12. Kim, D.; Kim, Y.H.; Kim, K.H.; Gil, J.M. Cloud-Centric and Logically Isolated Virtual Network Environment Based on Software-Defined Wide Area Network. *Sustainability* **2017**, *9*, 2382.
13. Kim, B.; Hwang, K.I. Cooperative downlink listening for low-power long-range wide-area network. *Sustainability* **2017**, *9*, 627.
14. Kim, S.H.; Choi, D.; Kim, S.H.; Cho, S.; Lim, K.S. Context-Aware Multimodal FIDO Authenticator for Sustainable IT Services. *Sustainability* **2018**, *10*, 1656.

15. Jurn, J.; Kim, T.; Kim, H. An Automated Vulnerability Detection and Remediation Method for Software Security. *Sustainability* **2018**, *10*, 1652.
16. Rivas-Asanza, W.; Celleri-Pacheco, J.; Andrade-Garda, J.; García-Vázquez, R.; Mato-Abad, V.; Rodríguez-Yáñez, S.; Suárez-Garaboa, S. Environmental Sustainability in Information Technologies Governance. *Sustainability* **2018**, *10*, 4792.
17. Patón-Romero, J.D.; Baldassarre, M.T.; Piattini, M.; García Rodríguez de Guzmán, I. A Governance and Management Framework for Green IT. *Sustainability* **2017**, *9*, 1761.
18. Hong, N.; Kim, M.; Jun, M.S.; Kang, J. A Study on a JWT-Based User Authentication and API Assessment Scheme Using IMEI in a Smart Home Environment. *Sustainability* **2017**, *9*, 1099.

Funding: This study was supported by the Advanced Research Project funded by the SeoulTech (Seoul National University of Science and Technology).

Conflicts of Interest: The author declares no conflict of interest.

References

1. Mocigemba, D. Sustainable computing. In *Poiesis & Praxis*; Springer: Berlin/Heidelberg, Germany, 2006; Volume 4, pp. 163–184.
2. Gil, S.S.; Buyya, R. A taxonomy and future directions for sustainable cloud computing. *ACM Comput. Surv.* **2018**, *51*, 104. [CrossRef]
3. Buyya, R.; Gil, S.S. Sustainable cloud computing: Foundations and future directions. *arXiv*, 2018; arXiv:1805.01765.
4. Puthal, D.; Obaidat, M.S.; Nanda, P.; Prasad, M.; Mohanty, S.P.; Zomaya, A.Y. Secure and sustainable load balancing of edge data centers in fog computing. *IEEE Commun. Mag.* **2018**, *56*, 60–65. [CrossRef]
5. Rahman, M.A.; Hossain, M.S.; Hassanain, E.; Muhammad, G. Semantic multimedia fog computing and IoT environment: Sustainability perspective. *IEEE Commun. Mag.* **2018**, *56*, 80–87. [CrossRef]
6. Kumar, N.; Rodrigues, J.J.; Guizani, M.; Choo, K.K.R.; Lu, R.; Verikoukis, C.; Zhong, Z. Achieving Energy Efficiency and Sustainability in Edge/Fog Deployment. *IEEE Commun. Mag.* **2018**, *56*, 20–21. [CrossRef]
7. Li, W.; Yang, T.; Delicato, F.C.; Pires, P.F.; Tari, Z.; Khan, S.U.; Zomaya, A.Y. On enabling sustainable edge computing with renewable energy resources. *IEEE Commun. Mag.* **2018**, *56*, 94–101. [CrossRef]
8. Choi, M. Leadership of information security manager on the effectiveness of information systems security for secure sustainable computing. *Sustainability* **2016**, *8*, 638. [CrossRef]
9. Lee, J.; Seo, A.; Kim, Y.; Jeong, J. Blockchain-Based One-Off Address System to Guarantee Transparency and Privacy for a Sustainable Donation Environment. *Sustainability* **2018**, *10*, 4422. [CrossRef]
10. Kim, T.W.; Park, S.Y.; Yeo, J.M. A Study on Business-Based Screen Design Techniques for Designing Efficient Applications. *J. Inf. Process. Syst.* **2018**, *14*, 1420–1430.
11. Song, W.; Zou, S.; Tian, Y.; Fong, S.; Cho, K. Classifying 3D objects in LiDAR point clouds with a back-propagation neural network. *Hum. Cent. Comput. Inf. Sci.* **2018**, *8*, 29. [CrossRef]
12. Hilty, L.M.; Aebischer, B. ICT for sustainability: An emerging research field. *ICT Innov. Sustain.* **2014**, *310*, 3–36.
13. Liu, S.; Meng, X.; Tam, C. Building information modeling based building design optimization for sustainability. *Energy Build.* **2015**, *105*, 139–153. [CrossRef]