Advances in Orchestrating Sustainable Smart Cities (Part 2)

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RAPID urbanization is a global megatrend with 66 percent of the world's population expected to live in urban areas by 2050. The staggering exponential increase in urbanization is leading to more people migrating to major cities in the search of better opportunities and quality of life. Cities need to increase the efficiency in which they operate and use their resources sustainability in order to meet the demands imposed by rapid urbanisation. The challenge is to continue providing basic resources such as sufficient fresh water; cleaner energy; transportation alternatives to commute efficiently from one place to another; adaption to changing climatic conditions; safety and security; while also ensuring economical, social, and environment sustainability.

Advances in disruptive digital technologies ranging from cyber-physical systems, Big Data analytics, clouds, edges, internet of things, etc., is widely accepted as the backbone for addressing these growing problems by impacting all city services and making cities smart. Smart cities [1] are envisioned as a wide-scale concord of internet of things [2] with sensors monitoring cyber and physical indicators; actuators that allow dynamic adaption to the changing complex urban environment; and cloud and edge computing offerings affordable easy to tap computing resources. Recently, we are witnessing an increased investment towards the development and deployment of intelligent and sustainable environments. In order to develop sustainable smart city solutions, smart cities must have an open, flexible, and secure platform on which to consolidate siloes and services. Such advances opens new opportunities for improving the efficiency of services offered by smart cities while simultaneously exposing novel vulnerabilities. For example, environments that are embedded with millions and billions of dedicated things (such as sensors) and communication capabilities provide real-time access to fine-grained consumer data while exposing new privacy and security risks. Furthermore, as connected things grow, we will witness a significant increase in data that will require novel data processing pipelines, architectures, methods, and techniques. These challenges represent a huge opportunity for a paradigm shift that will require the need for data processing, analysis, and security close to the connected "things" i.e., towards the edge of the network in-order to support the growing smart city ecosystem. This paradigm shift will lead to an explosive growth of independently owned and operated things and services including gateways, repeaters, smart infrastructure, and systems.

Such a paradigm needs to be architected in a way that is easy to operate and dramatically simplifies the management of service offerings through scalable orchestration and proper automation. It must allow management, integration, and deployment of different tenants (such as services and things independently owned) within the smart city ecosystem in a uniform way. It should also have a suitable policy framework, letting specific stakeholders access to data produced by other tenants, and analyze and extract values from the data. In order to address these challenges, this special issue asked for high quality original research papers (including smart city experience papers) that made significant contributions to the state-of-the-art in "method and techniques to build sustainable smart city solutions" research area. The call for papers received a number of submissions. After a two-phase peer review process, we accepted four high-quality papers related to the aforementioned areas of interest which will appear in this issue. Part 1 which was published in the October-December 2017 included the remaining five papers.

PART 2: JANUARY-FEBRUARY 2018

The first paper titled "Optimizing M2M Communications and Quality of Services in the IoT for Sustainable Smart Cities" by Jun Huang, Cong-Cong Xing, Sung Shin, Fen Hou, and Ching-Hsien Hsu addresses challenges that smart city solutions and application will face with increase amounts of machine-to-machine (M2M) communication primarily fueled by an increased deployment of Internet of Things and other smart infrastructure. They propose an admission control scheme that differentiates all M2M requests into delay-sensitive and delay-tolerant first, and then aggregates all delay-tolerant requests by routing them into one low-priority queue, aiming to reduce the number of requests from various devices to the access point in the IoT for smart cities. They demonstrate the effectiveness and correctness of the proposed scheme via network calculus, numerical experiments and OMNeT++ simulations.

The second paper titled "Energy Theft Detection in Multi-Tenant Data Centers with Digital Protective Relay Deployment" by Yuchen Zhou, Yang Liu, and Shiyan Hu focuses on energy theft cyberattacks in multi-tenant data centers that host smart city solutions and services. Energy theft cyber attack can be achieved through attacking a smart

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meter in the data center by malicious tenants to reduce monetary cost of the electricity consumption by undercounting the energy usage. To this end, the authors propose an anomaly rate range based dynamic programming algorithm for inserting Digital Protective Relays (DPR) into the data center while minimizing the deployment cost. DPR is a microprocessor based device for fault detection and event logging in the power system. The proposed algorithm optimizes the DPR deployment through exploring an innovative aggregated anomaly rate range which accounts for the long term effect of energy theft. Simulation-based evaluations show the proposed algorithm inserts 18:9 percent less DPRs into the data centre and requires 14:7 percent less tenants to be checked compared with a natural heuristic baseline algorithm.

The third titled "ElCity: An Elastic Multilevel Energy Saving Model for Smart Cities" by Gustavo Rostirolla, Rodrigo da Rosa Righi, Jorge Luis Victória Barbosa, and Cristiano André da Costa proposes ElCity, a model that combines citizens and city devices data to enable an elastic multilevel management of energy consumption for a particular city. As design decision, this management must occur automatically without affecting the quality of already offered services. The main contribution of the ElCity model concerns the exploration of the cloud elasticity concept in multiple target levels (smartphones from citizens, city devices involved in the public lighting and data center nodes), turning on or off the resources on each level in accordance with their demands. In this way, this paper presents the ElCity architecture, detailing its modules distributed along the three data sources, in addition to an experiment that uses city devices and citizens data from Rome to explore energy saving. The results are promising, with an Energy Monitor module that allows the estimation of the energy consumption of elastic applications based on CPU and memory traces with an average and median precision of 97.15 and 97.72 percent. Moreover, they proposed a reduction of more than 90 percent in the energy spent in public lighting in the city of Rome which was obtained thanks to an analysis of geolocation data from their citizens.

The fourth paper titled "Efficient Identity-Based Encryption Scheme with Equality Test for Smart City" by Wu et al. proposes an efficient Identity-based encryption with equality test (IBEET) scheme with bilinear pairing, which reduces the need for time-consuming HashToPoint function and each trapdoor can only be used to perform the equality test on a particular keyword. They then prove the security of their scheme for one-way chosen-ciphertext security against a chosen identity (OW-ID-CCA) attack in the random oracle model. The performance evaluation of the proposed scheme demonstrates that in comparison to the scheme of Ma (2016), our scheme achieves a reduction of 36.7 and 39.24 percent in computation costs during the encryption phase and test phase, respectively.

Overall, these special issues (Part 1 and Part 2) compile an excellent list of papers which make ground-breaking contributions to the design and development of techniques that will empower future smart cities. We hope that both scientific and academic communities will benefit from these special issues.

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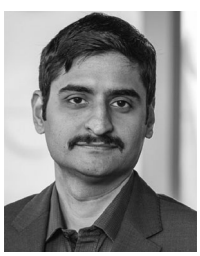
Guest Editors

References

[1] M. Vögler, J. M. Schleicher, C. Inzinger, S. Dustdar, and R. Ranjan, "Migrating smart city applications to the cloud," *IEEE Cloud Comput.*, vol. 3, no. 2, pp. 72–79, Mar./Apr. 2016. doi: 10.1109/MCC.2016.44.

[2] L. Wang and R. Ranjan, "Processing distributed internet of things data in clouds," *IEEE Cloud Computing*, vol. 2, no. 1, pp. 76–80, Jan./Feb. 2015. doi: 10.1109/MCC.2015.14.

Rajiv Ranjan is a reader (associate professor) in computing science with Newcastle. He is a chair (visiting) professor with the Chinese University of Geosciences, Wuhan, and the inventor of CloudSim, the world's most adopted and cited (2150+ Google citations since 2011) Cloud and Big Data application simulation and benchmarking toolkit. He was awarded the 2016 IEEE TCSC Award for Excellence in Scalable Computing (Middle Career Researcher), and has secured £5M+ in funding. For more than 10 years, he has conducted seminal research around the development of generic resource management models and methods for efficient scheduling and resource allocation for all types of parallel and distributed computing systems such as cloud computing, big data analytics, and Internet of Things (IoT). He has established an outstanding understanding of the fundamentals of computer science, which has enabled him to easily apply his research for the benefit of the society. For example, he has easily extended his research to develop novel IoT applications (e.g., smart buildings, urban hazard management) for supporting and fostering sustainable cities and societies. He has served on the technical program committess of 50+ international IEEE/ACM/EAI workshops and conferences. He has a proven record of international leading research reflected by 200+ scientific publications (full publication list available at: https://rajivranjan.net) that include 131 journal articles, 51 conference papers, 12 book chapters, and 11 edited research books. His research has been highly cited internationally (Google Scholar h-index 41, 9300+ citations; Scopus h-index 22, 4300+ citations, Thomson Reuters h-index 20, 2300+ citations). His papers have appeared in highly selective (as per Australian Ranking:- core.edu.au) journals and conferences including, the *ACM Computing Surveys* (ERA A*), the *IEEE Transactions on Parallel and Distributed Systems* (ERA A*), the *IEEE Transactions on Computers* (ERA A*), WWW (CORE A*), PVLDB (CORE A*), JCCS (ERA A*), FGCS (ERA A), SPE (ERA A), and ACM TECS (ERA A). He serves on editorial boards of the *IEEE Transaction on Cloud Computing*, the *IEEE Transactions on Computers* (2015-2017), the *IEEE Cloud Computing*, the *IEEE IT Professional*, and *Springer Computing*.



Prem Prakash Jayaraman is currently a research fellow with the Swinburne University of Technology, Melbourne. His research areas of interest include Internet of Things, cloud computing, mobile computing, sensor network middleware, and semantic internet of things. He has authored/co-authored more than 50 research papers in international Journals and conferences such as the *IEEE Transactions on Cloud Computing*, the *IEEE Selected Areas in Communication*, the *Journal of Computational Science*, the *IEEE Transactions on Emerging Topics in Computing*, *Future Generation Computing Systems*, *Springer Computing*, the *ACM Ubiquity Magazine*, and the *IEEE Magazine*. He is one of the key contributors of the Open Source Internet of Things project OpenIoT that has won the prestigious Black Duck Rookie of the Year Award in 2013. He has been the recipient of several awards including hackathon challenges at the 4th International Conference on IoT (2014) at the MIT Media Lab, Cambridge, MA and IoT Week 2014 in London and the best paper award at HICSS 2016/2017 and IEA/AIE-2010. Previously, he was a postdoctoral research fellow at CSIRO Digital Productivity Flagship, Australia, from 2012 to 2015.

Massimo Villari is an associate professor in computer engineering with the University of Messina (Italy). He is actively working as an IT security and distributed systems analyst in cloud computing, virtualization, and storage. For the EU Projects "RESERVOIR" he leaded the IT security activities of the whole project. For the EU Project "VISION-CLOUD," he covered the role of architectural designer for UniME. He is currently Scientific ICT Responsible in the EU Project frontierCities, the accelerator of FIWARE on Smart Cities – Smart Mobility. He is strongly involved in EU Future Internet initiatives, specifically cloud computing and security in distributed Systems. He is co-author of more of 130 scientific publications and patents in cloud computing (cloud federation), distributed systems, wireless network, network security, cloud security, and cloud and IoTs. He was general chair of ESOCC 2015 and IEEE-ISCC 2016. Since 2011, he has been a fellow of IARIA, recognized as a Cloud Computing Expert, and is also involved in the activities of the FIArch, the EU Working Group on Future Internet Architecture. In 2014, he was recognized by an independent assessment (the *IEEE Transactions on Cloud Computing*, vol. 2, no. 3, Jul-Sep. 2014) as one of the World-Wide active scientific researchers, top 27 classification, in the cloud computing area. He is general chair of EAI-CN4IoT. He is editor In chief of *EAI Endorsed Transactions on Smart Cities*. Currently, he is Scientific Responsible for UniME-IRCCSME Cloud initiative in eHealth.

Dimitrios Georgakopoulos joined the Swinburne University of Technology in July 2016 to start a new Key Laboratory on IoT. Before that, he served as a research director (2008-2014) at CSIRO's ICT Centre and the executive director of the Information Engineering Laboratory, which was the largest computer science research program in CSIRO and Australia. Prior to joining CSIRO, he held research and management positions in several industrial laboratories in the USA, including Telcordia Technologies (where he helped found two of Telcordia's Research Centers in Austin, Texas, and Poznan, Poland); Microelectronics and Computer Corporation (MCC) in Austin, Texas; GTE (currently Verizon) Laboratories in Boston, Massachusetts; and Bell Communications Research (Bellcore) in Piscataway, New Jersey. He was also a full professor at RMIT University (2014-2016), and is currently an adjunct professor with the Australian National University and a CSIRO adjunct fellow. He has authored/co-authored more than 160 journal and conference publications in computer science, which include three seminal papers in the areas of service computing, workflow management, and context management for the Internet of Things (IoT). According to Google Scholar, he has more than 11,000 lifetime citations. He has served as the general or program chair of more than 20 major international conferences as well as many other smaller conferences or workshops. He has received two outstanding paper awards from the IEEE Computer Society (CS), as well as several IEEE CS service awards. He was the recipient of GTE's (Verizon's) Excellence Award. He has attracted significant external research funding (AU$35M+) from various industry and government research funding agencies, ranging from DARPA and ARDA in the USA, to the Framework Program in the EU, to the Department of Human Services in Australia.