A Computing Perspective on Smart City

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DEVELOPING smart city is the key to the next generation urbanization process for improving the efficiency, reliability, and security of a traditional city. The concept of smart city includes various aspects such as environmental sustainability, social sustainability, regional competitiveness, natural resources management, cybersecurity, and quality of life improvement. With the massive deployment of networked smart devices/sensors, an unprecedentedly large amount of sensory data can be collected and processed by advanced computing paradigms, which are the enabling techniques for smart city. For example, given historical environmental, population, and economic information, salient modeling and analytics are needed to simulate the impact of potential city planning strategies, which will be critical for intelligent decision-making. Analytics are also indispensable for discovering the underlying structure from retrieved data in order to design the optimal policies for real time automatic control in the cyberphysical smart city system. Furthermore, uncertainties and security concerns in the data collected from heterogeneous resources aggravate the problem, which makes smart city planning, operation, monitoring, and control highly challenging.

Green, sustainable, and secure computing in smart cities has recently become a very active area of research in academia and has attracted significant industry interest. Since the computing issues for smart cities are highly interdisciplinary and cover various topics, a special section of Smart City Computing in the *IEEE Transactions on Computers* becomes an ideal forum for presenting and discussing the latest research results. The goal of this special section is to present the outstanding research results dedicated to the topics of green, sustainable, and secure computing for smart cities. We have received 40 manuscript submissions in total and six papers have finally been accepted after several rounds of very constructive and deep reviews.

The smart city brings convenience to users through providing personalized yet efficient services. However, it also introduces privacy and security issues. Two different methods are used to counteract these issues. The active method is to prevent the overcollection of private data (Dai et al.), while the passive method is to make private data more secure via certain encryption algorithms (Zhang et al.). Dai et al. study the current state of data overcollection and look at some of the most frequent cases of overcollected data. They present a mobile cloud framework, which is an active approach to eradicate data overcollection. Through putting all users' data into a cloud, the security of the data can be greatly improved. Zhang et al. use the BGV encryption scheme to encrypt the private data and employ cloud servers to perform the high-order back-propagation algorithm on the encrypted data efficiently for deep computation model training. Furthermore, their proposed scheme approximates the sigmoid function as a polynomial function to support the secure computation of the activation function with the BGV encryption.

Data infrastructures play an important role in smart city computing. Two interesting topics are included in this special section, which are wireless sensor network for data collection (Santos et al.) and spatial-temporal database for data storage (Ding et al.), respectively. Santos et al. propose a decentralized algorithm for detecting damage in structures using a WSAN. As key characteristics, beyond presenting a fully decentralized (in-network) and collaborative approach for detecting damage in structures, the algorithm makes use of cooperative information fusion for calculating a damage coefficient, which represents frequency and amplitude shifts simultaneously. Ding et al. propose the Parallel-Distributed Network-constrained Moving Objects Database (PD-NMOD), a general framework that manages big trajectory data in a scalable manner. The PD-NMOD provides an infrastructure that is able to support a wide variety of smart transportation applications, thus benefiting the smart city vision as a whole.

Furthermore, two interesting applications are selected to instantiate the effect of smart city computing, which includes smart grid (Wei et al.) and smart railway transportation (Huang et al.). Concerning the application domain of the smart grid, Huang et al. propose a comprehensive framework to integrate the operations of smart buildings into the energy scheduling of bulk power systems through proactive building demand participation. This new scheme enables buildings to proactively express and communicate their energy consumption preferences to smart grid operators rather than passively receive and react to market signals and instructions such as time varying electricity prices. For smart railway transportation, Huang et al. propose an energy-efficient train control framework through integrating both offline and onboard optimization techniques. The offline processing builds a decision-tree based sketchy solution through a complete flow of sequence mining, optimization, and machine learning. The onboard system feeds the train parameters into the decision tree to derive an optimized control sequence.

For this special section of the *IEEE Transactions on Computers* we have selected the above very interesting papers to represent some important advances in smart city computing. As a conclusion, it should be noted that the research

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in smart city computing has been fast growing. Many new formulations spanning multiple disciplines are being formed. Thus, innovative interdisciplinary techniques, together with high performance computer algorithms, are highly desirable in studying smart city from a computing perspective.

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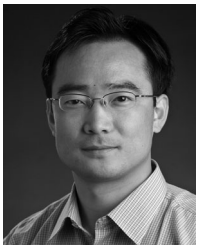
Guest Editors



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Shiyan Hu received the PhD degree in computer engineering from Texas A&M University in 2008. He is currently a visiting associate professor at Stanford University, an associate professor in the Department of Electrical and Computer Engineering at Michigan Tech., where he is the director of the Michigan Tech Cyber-Physical System Research Group, and the director of the Michigan Tech VLSI CAD Research Lab. He was a visiting professor at IBM Research (Austin) during Summer 2010. His research interests include cyber-physical systems, cybersecurity, computer-aided design of vlsi circuits, and embedded systems, where he has published about 100 refereed papers, including 20+ in IEEE transactions. He is a founding chair for IEEE Technical Committee on Cybernetics for Cyber-Physical Systems, an ACM distinguished speaker, an IEEE Computer Society distinguished visitor, a recipient of National Science Foundation (NSF) CAREER Award, a recipient of ACM SIGDA Richard Newton DAC Scholarship (as the faculty advisor), an invited participant for Frontiers of Engineering Symposium by US National Academy of Engineering, and a recipient of Faculty Invitation Fellowship from Japan Society for the Promotion of Science (JSPS). He is an associate editor/guest editor for seven IEEE/ACM transactions including the *IEEE Transactions on Computers*, *IEEE Transactions on CAD*, *IEEE Transactions on Circuits and Systems*, *IEEE Transactions on Industrial Informatics*, *IEEE Transactions on Multi-Scale Computing Systems*, *ACM Transactions on Cyber-Physical Systems*, and *ACM Transactions on Embedded Computing Systems*. He has served as a general chair, technical program committee (TPC) chair, TPC subcommittee chair, session chair, and TPC member for various conferences for more than 70 times. He is a senior member of the IEEE.

Gilles Betis is an engineer who graduated in 1987 from the Ecole Supérieure d'Electricité in France. He leads the Urban Life and Mobility action line of EIT ICT Labs (www.eitictlabs.eu). He is also a chair of the IEEE Smart Cities Initiative (smartcities.ieee.org). Since the end of the 1980s, he has been involved in Thales in the design of complex systems. He has extensive industrial experience in transportation systems IT, anytime in an international and multi-industrial environment. At the time when he joined EIT ICT Labs, he was a smart city and mobility solution leader in Thales Communication and Security. Holding positions of product line manager, marketing manager, and solution leader, he has been constantly involved with prospective, innovation, and product design matters. Through a holistic systemic approach, his goal was always to link up emerging behaviours and societal needs to innovative technological solutions, allowing a smooth adoption by final users.

Rajiv Ranjan received the PhD degree. He has been a reader (associate professor) of computing science at Newcastle University since September 1, 2015. He is an internationally renowned researcher in the areas of cloud computing, Internet of Things (IoT), and big data. By applying ground-breaking combination of well-founded formal models from four domains (Operations Research, Computational Statistics, Peer-to-Peer Networking, and Performance Engineering) of computer science, he has developed novel algorithmic techniques and distributed system architectures that facilitate service level agreement (SLA) driven autonomic provisioning of multimedia (e.g., content delivery networks), eScience (e.g., scientific workflows), and IoT big data applications (e.g., remote sensing, smart homes, smart cities, etc.) applications over multiple private and public cloud datacentres. He has authored approximately 150 scientific publications, including publications in the *IEEE Transactions on Parallel and Distributed Systems* (ERA A*), *IEEE Transactions on Computers* (ERA A*), *Journal of Computer and System Sciences* (ERA A*), and IEEE/ACM World Wide Web conference (CORE A+). He is widely recognised by his peers through citations (4,800+ Google Scholar citations—https://goo.gl/7FONZN and 730+ Web of Science citations—http://goo.gl/St567J).