IEEE Access
The journal for rapid open access publishing

Received October 10, 2015, accepted November 23, 2015, date of publication November 26, 2015, date of current version December 10, 2015.

Digital Object Identifier 10.1109/ACCESS.2015.2504123

Top Challenges for Smart Worlds: A Report on the Top10Cs Forum

JIANHUA MA[1], (Member, IEEE), YUMEI ZHENG[2], HUANSHENG NING[2], (Senior Member, IEEE), LAURENCE T. YANG[3,4], (Senior Member, IEEE), RUNHE HUANG[1], (Member, IEEE), HONG LIU[5], (Member, IEEE), QITAO MU[2], AND STEPHEN S. YAU[6], (Life Fellow, IEEE)

[1]Faculty of Computer and Information Sciences, Hosei University, Tokyo 184-8584, Japan
[2]School of Computer and Communication Engineering, University of Science and Technology Beijing, Beijing 100083, China
[3]School of Computer Science and Technology, Huazhong University of Science and Technology, Wuhan 430074, China
[4]Department of Computer Science, St. Francis Xavier University, Antigonish, NS B2G 2W5, Canada
[5]Research Institute, Run Technologies Company, Ltd., Beijing 100192, China
[6]School of Computing, Informatics, and Decision Systems Engineering, Arizona State University, Tempe, AZ 85281, USA

Corresponding author: H. Ning (ninghuansheng@ustb.edu.cn)

This work was supported in part by the Fundamental Research Funds for the Central Universities under Grant 06105031, in part by the Japan Society for the Promotion of Science through the Grants-in-Aid for Scientific Research under Grant 25330270 and Grant 26330350, in part by the National Natural Science Foundation of China under Grant 61471035, and in part by the Top10Cs Open Forum and 2015 Smart World Congress.

ABSTRACT Smart worlds begin with smart things, such as smart objects, smart cities, smart manufacturing, and smart systems, are overlaid with sensing and actuation, many embedded in things, and eventually encompass all aspects of the cyber, physical, social, and thinking hyperspace. In the future, human beings will live in a smart environment where both life and work are well addressed by technology, whereas humans will be responsible only for providing creativity. For this purpose, we have organized the first 2015 Smart World Congress, including five IEEE International Conferences. Specifically, a variety of challenges are presented in the field of smart world. Therefore, an open forum on the top ten challenges (Top10Cs) for smart worlds was held under the congress to identify the main challenges through collecting the intelligence existing particularly in crowd wisdom. Top10Cs and related works, as a crowdsourcing approach, discuss and analyze the top challenges for smart worlds based on the selective results of the crowd and experts via an online platform. Moreover, we summarize the experiences obtained in organizing the Top10Cs forum.

INDEX TERMS Smart worlds, top challenges, collective intelligence, crowdsourcing, crowd wisdom.

I. INTRODUCTION

With the rapid progress of information science and technology, novel disciplinary fields have emerged, such as the mobile Internet, Internet of Things (IoT), Cyber-Physical System (CPS), social computing, cloud computing, big data, brain informatics, and Internet of People (IoP). These research areas and applications have accelerated the formation of cyber space, which will further lead to revolutionary developments in information science, as well as human production and living.

The development of technologies contributes directly to a deep convergence between cyber space and traditional spaces, including physical, social and thinking spaces, toward a quaternionic hyperspace, called the Cyber-Physical-Social-Thinking hyperspace, on which basis smart worlds are being established [1]. Smart worlds are mainly characterized by ubiquitous intelligence and integrations in the Cyber-Physical-Social-Thinking hyperspace, covering smart things, including smart objects, smart environments, and smart systems, which are overlaid with sensing, actuating, and computing [2], [3].

The smart worlds are expected to be the next generation of a new era in human history, continuously introducing more significant changes. Due to the variety of challenges to be confronted in smart worlds, it becomes vitally necessary to identify technological trends and challenging issues.

Recently, the challenges for smart worlds have received much attention from various perspectives. Pahlavan presented several localization challenges for smart devices, RFID, transportation, health, and intelligence in the smart world [4]. Leung mentioned a profound challenge—a green Internet of things—for smart worlds to enable a greener society [4]. Previous studies noted that a series of challenges exist to propel the ubiquitous world with universal services of any means/place/time toward trustworthy services-oriented smart worlds [2]. Additionally, there are many studies on smart

cities, smart grids, smart homes, and smart wearable devices, which are important components of smart worlds [5]–[8].

Special attention should be paid to challenges in smart worlds associated with the combination of various technologies. However, it is arduous for either a single person or a small number of individual organizations to identify these top challenges in smart worlds. Crowdsourcing may be an applicable method for addressing this problem. Therefore, an online platform, the Top10Cs forum, is established as a crowdsourcing approach [9]. The Top10Cs forum involves three groups of people as follows: public crowds, technical committee members, and keynote speakers in the Smart World Summit [4].

In this work, Section II introduces crowdsourcing and the Top10Cs forum and describes the main process and design of this practice. Section III identifies the top challenges for smart worlds based on the results of crowdsourcing and presents increasing research directions and interests through comprehensive statistics and analysis. Meanwhile, the experiences obtained in organizing the Top10Cs forum are summarized in Section IV. Finally, Section V draws a conclusion.

II. Top10Cs - A PRACTICE OF CROWDSOURCING

A. CROWDSOURCING

In 2006, crowdsourcing was proposed by Howe and Robinson in Wired Magazine [10] and defined as an online, distributed problem-solving and collaborative model enabled by people-centric web technologies to solve individual, organizational, and societal problems for academic or commercial purposes using a dynamically formed crowd of people who respond to an open call for participation [11], [12].

Crowdsourcing seeks to collect the crowd wisdom from a large group of people while reducing the costs and time of addressing several fundamental challenges (e.g., how to combine pieces of contributions to solve a target problem [13]). Web technology has gone beyond a medium between messages and people and is suitable for integrating a wide area range of participants, enabling a high degree of automation and providing a large supply of communication tools to achieve user interactivity [11], [13].

Recent advances in web technology and associated fields have driven the emergence of various crowdsourcing platforms specialized for certain tasks with pressing demands. For instance, Threadless [14] is a web-based platform for T-shirt design and sale, which crowdsources the design process for the shirts through an ongoing online interaction. Anyone can visit the website and download the templates to submit a design. Then, the designs are voted on to determine the winning designers. In addition to the creative and design industry, crowdsourcing is functional in corporate research and development (R&D) for related problems. InnoCentive collects innovation solutions from the world's smartest people, who compete to provide ideas and solutions on important business, social, policy, scientific, and technical challenges [15]. Other approaches to solving corresponding problems have also experimented broadly with crowdsourced works. Chiu *et al.* [16] discussed the effects of crowdsourcing on decision support. Amrollahi *et al.* [17] introduced an in-progress case study of using the crowdsourcing model to implement an open strategy concept in an Australian university. In particular, an open forum [18], "Top 10 Questions in Intelligent Informatics/Computing" in the World Intelligence Congress [18], was established to identify the top questions in Intelligent Information/Computing, depending greatly on the participation of the crowd.

B. Top10Cs PLATFORM

Based on the crowdsourcing model, the online platform Top10Cs, an open forum on the top 10 challenges for smart worlds, is established to enable a large number of crowds to contribute regarding the main challenges in smart worlds.

1) Top10Cs ORGANIZATION

The organization of Top10Cs consists of committees, the keynote speakers in the Smart World Summit and crowds. The committees include an organizing committee and a technical committee (TC). The organizing committee coordinates the entire process, which involves multiple experts from different various institutions and countries. The technical committee, namely the organizing and technical program committee members of the 2015 Smart World Congress (UIC 2015, ATC 2015, ScalCom 2015, CBDCom 2015, and IoP 2015), are invited to participate in the Top10Cs forum. Crowds play a profound role as the subject of participation and can submit and select ideas using a valid email address.

2) Top10Cs ORGANIZING STAGES

Top10Cs aims to identify the top challenges for smart worlds via an online platform and define the research directions of increasing interest in this realm through discussion among experts. Thus, the Top10Cs forum is organized into a series of events divided into the following stages:

- Stage I: Challenge Collection. At this stage, the Top10Cs platform solicits challenges from crowds worldwide. Anyone may submit a viewpoint by filling out an online form, in which the title of the challenge and the name, email address and affiliation of proposer are required. To avoid malicious or mistaken submissions, the committee checks all submissions and excludes any that are not related to the topic.
- Stage II: Challenge Selection. A full list of the challenges submitted in stage I will be posted on the Top10Cs website for open selection. The selection will be performed by two groups of people, the TC and the crowd, and each person can select up to 10 challenges via the selection page.
- Stage III: Forum Panel. The Top10Cs open forum panel is held together with the Smart World Summit during the 2015 Smart World Congress. Two sets of selected top 10 challenges and detailed information on the selection will first be reported by the Top10Cs committee.

Then, the invited keynote speakers will offer their own comments or ideas on the top 10 challenges. Afterwards, the forum will have open discussions.

- Stage IV: Challenge Report. The Top10Cs committee produces a final Top10Cs summary report on the top 10 challenges, including the selected results, keynote statements, and other data, including a complete list of the challenges collected, their total selections, statistical data, and other information.

Stage I and Stage II refer to the process of collecting intelligence through crowdsourcing. To mobilize the energies of the participants, social networking services (SNS) such as Facebook, LinkedIn and Sina Weibo are influential and effective channels for publicity and are employed for collecting challenges, inviting selections, and publishing related issues.

3) Top10Cs ONLINE SYSTEM

To enlist a multitude of participants to submit and select challenges with great convenience, the Top10Cs system is designed with two main functions as follows: online submission and selection. The proposers first submit challenging issues, and a confirmation email will be sent to each proposer. The submitted and reviewed challenges will be listed on the webpage for the final selection. During the challenge selection, the effectiveness of public participation should be guaranteed, which has a direct relationship with the results. The crowds and TC members perform relatively independent operations for further analysis of the results. A verification code is adopted as a password to prevent malicious brush ticket behaviors.

Anyone who registers with a valid email address can participate in the selection. The crowd members receive an email containing a randomly assigned password, input the password and information, select the challenges and submit them during the online selection page. Participants who are Top10Cs TC members can skip the registration step and directly complete the process at the online selection page with the uniformly preset password in the invitation mail for the TC members. Meanwhile, the system checks the contents. For either a TC member or a crowd participant, if the email and password match up to the stored copy in the database and the contents conform to the standards, the selections are count as valid and kept in the system. Then, an acknowledgement email will be sent to the selector, which is also used to confirm that the submission is indeed from the email user. Otherwise, appropriate error(s) will be displayed on the page. For re-submission using the same email, the last selection is kept in the system.

III. Top10Cs RESULT STATISTICS AND ANALYSIS

The Top10Cs platform utilizes crowdsourcing to identify the top challenges in smart worlds, and 71 challenges and 327 selections (111 from the TC and 216 from the crowd) have been received. However, there are a handful of abnormal selections consisting of the same challenges. To guarantee the validity and justice of the results, only one effective selection is counted for identical selections. Based on the statistical results, the top 10 challenges for smart worlds are separately generated from both the TC and the crowd. Then, further analyses are performed to obtain more valuable results.

Top 10 challenges selected by the TC members:

- C1. Can machines and people think together?
- C60. Privacy protection in the Internet of Things.
- C5. Wearable device development and security challenges.
- C7. Bridging the gap between the world and its computer model.
- C27. How to process heterogeneous big data from smart things.
- C10. Ubiquitous computing and security.
- C17. Smart software infrastructure for smart worlds.
- C3. Can memory storage devices be embedded in the human brain?
- C36. Can machines have their own thoughts?
- C44. Brain-to-brain communication with human charging.

Top 10 challenges selected by the crowd:

- C3. Can memory storage devices be embedded in the human brain?
- C1. Can machines and people think together?
- C60. Privacy protection in the Internet of Things.
- C5. Wearable device development and security challenges.
- C10. Ubiquitous computing and security.
- C36. Can machines have their own thoughts?
- C7. Bridging the gap between the world and its computer model.
- C44. Brain-to-brain communication with human charging.
- C27. How to process heterogeneous big data from smart things.
- C16. How to evaluate the intelligence of the smart world.

The results of the technical committee and the crowd are relatively independent. Nine of the ten selection results overlap, and there are 11 challenges in total, as illustrated in Fig. 1.

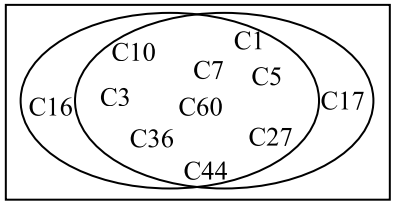


FIGURE 1. Intersection of the selection results. The characteristics within the left and right ellipses represent the top 10 challenges selected by the TC and crowd. The challenges enclosed in the rectangle represent the union.

Thus, 11/15 selection results and 14/20 selection results are in the intersection of the top 15 and 20 selections, respectively. These numbers directly show that the TC and crowd

selections converge well regarding the top challenges, clearly embodying the wisdom of the crowd.

To contribute to further analysis, we extract words of high frequency from the challenges, formally describing the importance of the words using a word cloud, as illustrated in Fig. 2.

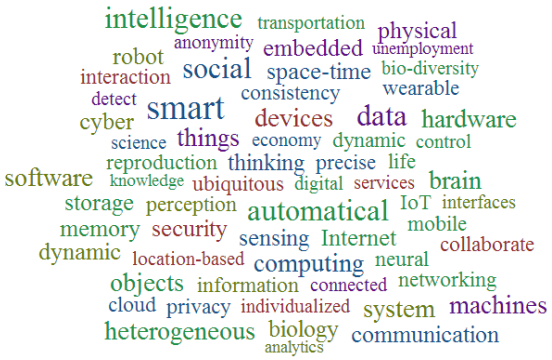


FIGURE 2. The word cloud of the high-frequency words among the challenges. The size of the word indirectly reflects its frequency; words with higher frequency are shown in a larger size.

The research directions of increasing interest are further analyzed with respect to the following main aspects:

- Privacy/Security and Things: C5, C10, C60,
- Brain/Human and Machines: C1, C3, C36, C44,
- Data/World and Computing: C7, C16, C17, C27.

The top 20 challenges are classified into seven supplemental categories.

- Brain Informatics
- Privacy and Security
- Human-Computer Interaction
- Smart Algorithms and Software
- Object and Thing Modeling
- Impact of Smart Worlds on Life
- New Opportunities in Smart Worlds

From the above statistics and analysis, the crucial research directions are emerging by many people working together. The word cloud fully reveals the key points of general interest among the challenges (e.g., data, brain, storage, intelligence, ubiquitous, sensing). Then, the categories of the top challenges further define these increasing interests and crucial research topics, which provide impetus for the development of smart worlds.

Smart worlds cover ubiquitous intelligence, which is closely related to Brain Informatics (BI) and Human-Computer Interaction (HCI). BI, an interdisciplinary research area that addresses brain sciences involving human thoughts and thinking, focuses on the functions of the human brain, referring to aspects such as attention, emotion, memory, reasoning, decision making, and problem solving, and aims to demonstrate systematic approaches to the Internet of thoughts and thinking, which appears to offer an attractive perspective in smart worlds. HCI focuses on the interaction relationship between users and various systems, which could provide supplement for BI technology. The perfect collaboration between BI and HCI technologies will promote the application of human intelligence. Security and Privacy, the safeguards of smart worlds, play an important role in preventing the malicious activities of u-things and guaranteeing a variety of applications with the properties of reliability, trust, and controllability, such as the smart city, smart grid, and smart healthcare, etc. To achieve the above goal, research on security and privacy focuses mainly on technical aspects, such as identity authentication, signature, access control, encryption, and privacy protection, etc. Meanwhile, considering the new challenges of integrating multidimensional spaces, the systematic and scientific study of security frameworks are worthwhile research directions. Object and Thing Modeling, the foundation of building smart worlds, has broad research spaces to solve these problems during the modeling process, such as the space-time consistency and space-time registration between physical objects and smart entities. The achievement of smart worlds is supported by Smart Algorithms and Software, and finely designed algorithms and software must innovate unceasingly to satisfy new demands. In addition to these research topics, people also care about the new opportunities and the impact on life associated with smart worlds. Eventually, smart worlds will result in qualitatively different lifestyles from today. It is time to for us to be ready for change.

IV. EXPERIENCES OF ORGANIZING Top10Cs

Several experiences of note were obtained while organizing the Top10Cs forum, involving the organizing process, online system design, and statistics and analysis approaches.

The main motivation is to identify the top challenges for smart worlds, but such identification is difficult for a single person or a handful of individual organizations. The Top10Cs adopt the crowdsourcing model as the organizational approach to collect crowd intelligence and achieve this goal, which can be seen as one general model for effective problem solving. It is necessary and vital to mobilize the mass of participants to ensure the rationality and reliability of the results. SNS can be utilized for this purpose. In the process, we enlist two independent groups—the TC members of Top10Cs and the crowd—to select the top challenges. The multiple independent results are helpful to us for the final analysis.

An excellent online system design could attract more participants and facilitate obtaining equitable results. In this design, we largely prevent malicious brush ticket behavior in the selection function by using an email verification code as the password for selectors. Many online selection processes have shown that it is almost impossible to completely eliminate malicious brush ticket behavior. Another point to be aware of is the challenge display order on the selection page. The challenges submitted were shown in the order of submission time on the system, which remained unaltered. To guarantee the validity and correctness of the results, the challenges should be presented to the selectors in a random, dynamically varied order.

The automatic and real-time statistics and display of the selections are significant for monitoring and preventing malicious behavior. Deep and comprehensive approaches to statistics and analysis greatly contribute to uncovering overall knowledge, such as the extraction of high-frequency words.

V. CONCLUSION

This work introduces the crowdsourcing service of collecting crowd wisdom on the top challenges for smart worlds and utilizes statistical methods to analyze the challenges and selections from the Top10Cs platform. The keywords with high frequency are extracted, and the relevant subjects and research areas are analyzed accordingly. We make the topics public to the crowd to solicit suggestions via the Top10Cs platform. To ensure more rational results, we enlist two independent groups—TC members and the crowd— to participate in the selection, and the statistical results converge well on the top challenges, embodying the wisdom of the crowd. This example has revealed that the crowdsourcing model is greatly helpful for solving problems using the collective wisdom and unleashing mass creativity. Finally, the experiences drawn from organizing the Top10Cs forum are discussed in terms of the organizing process, online system design, and statistical and analysis approaches, which may be a reference for similar events.

Smart worlds are expected to be the next important stage in human history, raising interest in the crucial challenges of building truly smart worlds. These increasing interests and crucial challenges are involved in multiple research fields, such as Brain Information, Privacy and Security, and more. It is hoped that as more attention is focused on these research fields, the related challenges will be overcome to build truly smart worlds that benefit humanity and simultaneously safeguard the natural environment for sustainable development and evolution.

ACKNOWLEDGMENT

The authors are grateful to all organizing committee members, technical committee members, keynote speakers and panelists of the Top10Cs Panel, particularly J. Bourgeois, S. Helal, C. K. Chang, M. Yousif, V. Piuri, T. Dohi, M. Pecht, Z. Zhou, F. Wang, J. Cao, K. Pahlavan, M. S. Obaidat, V. Leung, V. Piuri, and Y. Chen. Our special thanks also go to all proposers and selectors of challenges who have submitted challenges and participated in the online selection, particularly the proposers of top 10 challenges including F. Gorgonio (C1), Y. Song (C60), Q. Mu (C5), W. Zhang (C7), Y. Sheng (C27), W. Zhao (C17), X. Wang (C3), A. Mckeown (C10), Karven Ping (C36), N. Ullah (C44), and W. Zhan (C16). F. Gorgonio (C1) means the challenge numbered C1 was proposed by F. Gorgonio, and so on.

REFERENCES

[1] (2015). *Smart World Congress*. [Online]. Available: http://www.cybermatics.org

[2] J. Ma, L. T. Yang, B. O. Apduhan, R. Huang, L. Barolli, and M. Takizawa, "Towards a smart world and ubiquitous intelligence: A walkthrough from smart things to smart hyperspaces and UbicKids," *Int. J. Pervasive Comput. Commun.*, vol. 1, no. 1, pp. 53–68, Mar. 2005.

[3] J. A. Stankovic, "Research directions for the Internet of Things," *IEEE Internet Things J.*, vol. 1, no. 1, pp. 3–9, Feb. 2014.

[4] (2015). *Smart World Summit*. [Online]. Available: http://www.cybermatics.org/SWC2015/SWSummit/index.htm

[5] M. Brenna *et al.*, "Challenges in energy systems for the smart-cities of the future," in *Proc. IEEE Int. Energy Conf. Exhibit. (ENERGYCON)*, Sep. 2012, pp. 755–762.

[6] M. Batty *et al.*, "Smart cities of the future," *Eur. Phys. J. Special Topics*, vol. 214, no. 1, pp. 481–518, Nov. 2012.

[7] Y. Yan, Y. Qian, H. Sharif, and D. Tipper, "A survey on smart grid communication infrastructures: Motivations, requirements and challenges," *IEEE Commun. Surveys Tuts.*, vol. 15, no. 1, pp. 5–20, Feb. 2013.

[8] M. Chan, D. Estève, J.-Y. Fourniols, C. Escriba, and E. Campo, "Smart wearable systems: Current status and future challenges," *Artif. Intell. Med.*, vol. 56, no. 3, pp. 137–156, Nov. 2012.

[9] (2015). *The Open Forum on Top10Cs: Top 10 Challenges for Smart Worlds*. [Online]. Available: http://www.cybermatics.org/SWC2015/Top10Cs/index.php

[10] J. Howe, "The rise of crowdsourcing," *Wired Mag.*, vol. 14, no. 6, pp. 1–4, Jun. 2006.

[11] D. C. Brabham, "Crowdsourcing as a model for problem solving. An introduction and cases," *Converg., Int. J. Res. New Media Technol.*, vol. 14, no. 1, pp. 75–90, 2008.

[12] J. Pedersen *et al.*, "Conceptual foundations of crowdsourcing: A review of IS research," in *Proc. 46th Hawaii Int. Conf. Syst. Sci. (HICSS)*, Jan. 2013, pp. 579–588.

[13] A. Doan, R. Ramakrishnan, and A. Y. Halevy, "Crowdsourcing systems on the World-Wide Web," *Commun. ACM*, vol. 54, no. 4, pp. 86–96, Apr. 2011.

[14] *Threadless*. [Online]. Available: http://www.threadless.com/, accessed Sep. 2015.

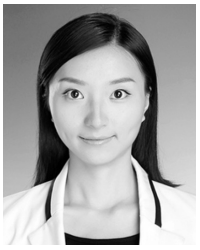
[15] *InnoCentive*. [Online]. Available: http://www.innocentive.com/about-innocentive, accessed Sep. 2015.

[16] C.-M. Chiu, T.-P. Liang, and E. Turban, "What can crowdsourcing do for decision support?" *Decision Support Syst.*, vol. 65, pp. 40–49, Sep. 2014.

[17] A. Amrollahi, A. H. Ghapanchi, and A. Talaei-Khoei, "Using crowdsourcing tools for implementing open strategy: A case study in education," in *Proc. 20th Amer. Conf. Inf. Syst.*, May 2014, pp. 1–7.

[18] (2012). *The Open Forum on Top 10 Questions in Intelligent Informatics/Computing*. [Online]. Available: http://wi-consortium.org/blog/top10qi/

JIANHUA MA is currently a Professor with the Department of Digital Media, Faculty of Computer and Information Sciences, Hosei University, Japan. He had 15 years of working experience with the National University of Defense Technology, Xidian University, and the University of Aizu, Japan. He has authored over 200 papers, and edited over 20 books/proceedings and over 20 journal special issues. His research interests include multimedia, networks, ubiquitous computing, social computing, and cyber intelligence. He is the Co-Founder of the IEEE International Conference on Ubiquitous Intelligence and Computing, the IEEE Conference on Cyber, Physical and Social Computing, and the IEEE Conference on Internet of Things.



YUMEI ZHENG received the B.E. degree from the University of Science and Technology Beijing, China, where she is currently pursuing the M.S. degree with the School of Computer and Communication Engineering. She focuses on spatio-temporal data model, location privacy issues, and Internet of Things. Her research interests include time-space registration, location privacy protection protocol design, and spatio-temporal data model design.

HUANSHENG NING (SM'13) received the B.S. degree from Anhui University, in 1996, and the Ph.D. degree from Beihang University, in 2001. He is currently a Professor with the School of Computer and Communication Engineering, University of Science and Technology Beijing, China. He has authored over 50 papers in journals and international conferences/workshops. His current research interests include Internet of Things, cybermatics, electromagnetic sensing, and computing.

LAURENCE T. YANG received the B.E. degree in computer science from Tsinghua University, China, and the Ph.D. degree in computer science from the University of Victoria, Canada. He is currently a Professor with the School of Computer Science and Technology, Huazhong University of Science and Technology, China, and the Department of Computer Science, St. Francis Xavier University, Canada. His research interests include parallel and distributed computing, and embedded and ubiquitous/pervasive computing.

RUNHE HUANG received the Ph.D. degree in computer science and mathematics from the University of the West of England, in 1993. She has been involved in computer science and engineering since 1982. She is currently a Professor with the Faculty of Computer and Information Sciences, Hosei University, Japan. Her research fields include artificial intelligence and its applications, distributed intelligence computing, big data mining and service computing, mobile computing, ubiquitous intelligence computing, cloud computing, and hyper world modeling.

HONG LIU received the Ph.D. degree from the School of Electronic and Information Engineering, Beihang University, China. She is currently a Research Fellow with the Research Institute, Run Technologies Company, Ltd., Beijing, China. She focuses on the security and privacy issues in wearable devices, vehicle-to-grid networks, cyber-physical-social system, and Internet of Things. She has authored over 20 papers in journals and international conferences. Her research interests include authentication protocol design, and security formal modeling and analysis.

QITAO MU received the B.E. degree from the University of Science and Technology Beijing, China, where she is currently pursuing the M.S. degree with the School of Computer and Communication Engineering. She focuses on the attribute-based access security and privacy protection of physical objects in wearable devices. Her research interests include access control protocol design, and anonymous privacy protection protocol design.

STEPHEN S. YAU (F'73) received the B.S. degree from National Taiwan University, and the M.S. and Ph.D. degrees from the University of Illinois at Urbana–Champaign, all in electrical engineering. He was with the University of Florida, Gainesville, and Northwestern University, Evanston, IL. He is currently a Professor of Computer Science and Engineering and the Director of the Information Assurance Center with Arizona State University, Tempe. His research interests include cyber trust, cloud computing, software engineering, service-based systems, and parallel and distributed computing systems. He was the President of the IEEE Computer Society and a member of the Board of Directors of the IEEE and the Computing Research Association, and is a fellow of the American Association for the Advancement of Science.