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Editorial

Scalable platforms and advanced algorithms for IoT and cyber-enabled applications

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ABSTRACT

In recent years, with the development of highly distributed cyber–physical systems across physical, social, and mental spaces, researchers have been increasingly interested in developing a variety of cyber-enabled applications. More and more people are engaged into this vortex of cyber technology revolutions, due to the rapid growth of a series of emerging technologies and computing paradigms, such as IoT technology and smart computing. Computational models and advanced algorithms are designed and developed to provide the cyber-related smart services in the integrated cyberspace. This special issue aims at promoting the design of practical algorithm and scalable platform in terms of high performance computing and parallelism across cyber–physical–social–mental systems. A summary of the selected papers is addressed to introduce the current solutions and achievements with respect of cyber technologies. Specifically, topics among the selected papers include heterogeneous data processing and management for IoT and cyber-enabled applications, smart energy system development, algorithms and applications based on sensor networks, cyber-related trust model and verification mechanism, and security and safety issues, which may provide a vision of the provision of cyber-enabled applications in the future.

1. Introduction

With the help of emerging technologies and computing paradigms, such as mobile computing, social computing, and internet of things, cyber–physical systems have continuously permeated into all walks of our life at the personal, urban, and global scale, which is involving more and more people into an integration of physical, social, and mental space, called cyberspace. The process of producing numerous cyber things and developing cybermatic applications is progressively accelerating requirements of cyber-infrastructure support, promising technology innovation, and smart platform development. Practical algorithms and mechanisms regarding to high performance computing and parallelism should be explored to deal with the new phenomena, behaviors, and practices in highly distributed cyber–physical systems across the cyber–physical–social–mental conjugation. A number of challenge issues include: How to develop the foundational architecture and platform to support the efficient and scalable processing of hybrid dataset? How to figure out parallel optimization methods for the distributed control and real-time interaction issues? How to handle the security and privacy, scalability and reliability, efficiency and energy issues in cyber-enabled applications, etc.

Therefore, this special issue on Scalable Platforms and Advanced Algorithms for IoT and Cyber-Enabled Applications, aims to review and address the current practical strategies and solutions to deal with the computational intelligence algorithm development and emerging computing platform design across cyber–physical–social–mental systems, not only to investigate the advanced technology which can provide the foundational parallel optimization, HPC hardware design, and adaptive mechanism in cyber–physical–social systems, but also to attract all cyber-related researchers, engineers, and interested pioneers from both academia and industry together to explore the future direction, and promote the better provision of cyber-enabled applications.

2. Distinctive elements and contributions

Currently, cyber-enabled applications have attracted more and more research attentions, ranging from algorithm design to system development. Research efforts have been paid to deal with new challenges in cyber–physical systems, cyber–social networks, and

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IoT environments, etc., which results in lots of research papers and technical reports presented in representative journals and conferences.

This special issue tries to promote promising and significant research works in terms of the development of cyber-enabled applications, in order to exchange novel ideas and thoughts across interdisciplinary research fields. In particular, a variety of key topics are engaged into this special issue to attract new ideas and approaches in both research and application aspects, including: Hybrid Platform and Middleware Design for Cyber-Enabled Applications; Parallel and Distributed Models for Cyber–Physical Systems; Parallel Optimization Algorithm for Cyber-Enabled Applications; Cloud-based Parallel and Distributed Algorithms for Wearable Computing; High Performance Evaluation Metrics of Distributed Cyber–Physical Systems; Real-Time Behavior Analysis and Interaction Measure in Cyberspace; Data Transfer Scheduling and Resource Management for Cyber-Enabled Applications; Framework and Implementation for Smart Energy Systems in Cyberspace; Advanced PDC for Heterogeneous Data Storage and Management; Distributed Computing and Algorithm in Sensor Networks; Parallel and Distributed Mechanism for Intelligent Transportation Systems; Parallel and Distributed Computing for Cyber-Enabled Healthcare; Security, Privacy and Safety in Cyber-Enabled Applications; Scalable Platform of High Reliability, etc.

Eventually, the call for this special issue has received 38 submissions. After a two-phase review process based on an international editorial committee, during which each submission needs to be reviewed by at least three referees, a total of 12 papers, presenting the majority of topics mentioned above, have been accepted for publication in this issue. An acceptance rate of 31% has resulted from this selection. Accepted papers covered a wide range of topics in the domain of IoT and cyber-enabled applications, including foundational architectures and methods for hybrid data processing, routing protocols and verification mechanisms for real-time interaction, advanced models and algorithms for security and privacy, scalability and reliability, efficiency and energy issues.

3. Content of this issue

Specifically, papers accepted for this special issue addressed five major aspects relevant to the scalable platforms and advanced algorithms for IoT and cyber-enabled applications, including algorithms development for real-time routing problems, scalable processing of heterogeneous data, parallel and distributed models for IoT systems, and so on. The detail contribution of each paper can be summarized as follows.

3.1. Heterogeneous data processing and management for IoT and cyber-enabled applications

Along with the rapid development of IoT technology in a variety of cyber applications and services, several emerging computing paradigms, such as transparent computing, has attracted more and more attentions. The paper presented by Hui Guo, Ju Ren, Deyu Zhang, Yaoxue Zhang, and Junying Hua, entitled "A Scalable and Manageable IoT Architecture based on Transparent Computing" [4], proposes a transparent computing based IoT architecture to build scalable and manageable IoT applications. The significance of this architecture comes from the fact that it can provide centralized management of various resources like operating systems, services and data for IoT applications, and enable on-demand services to be executed on heterogeneous IoT devices. The authors build a prototype system to evaluate the performance of the proposed architecture in terms of the delay and energy consumption in remote service updating. Experiment results demonstrate its effectiveness and superiority, and the authors discuss that the performance highly depends on network conditions.

The paper addressed by Binbin Yong, Zijian Xu, Xin Wang, Libin Cheng, Xue Li, Xiang Wu, and Qingguo Zhou, entitled "IoT-Based Intelligent Fitness System" [11], focuses on the health-related application using IoT and AI technologies. The authors design an IoT based fitness system to monitor the health statuses of exercisers. In particular, this system provides more scientific and practical guidance for exercisers with the help of artificial intelligence technology. Details including implementation technologies of the proposed system are presented. In addition, it argues the significance to focus on the combination of health and artificial intelligence, and the design of this system points out a trend for the development of future fitness application.

Semantic information modeling is another hotly discussed topic. The paper addressed by Shengli Song, Yishuai Lin, Bin Guo, Qiang Di, and Rong Lv, entitled "Scalable Distributed Semantic Network for Knowledge Management in Cyber Physical System" [6], designs a new scalable model named distributed semantic network (DSN) for heterogeneous data representation. It can extract more semantic information from different data sources. The authors use the prior knowledge of WordNet and Wikipedia to scale out the DSN horizontally and vertically. They propose a MapReduce based framework to effectively construct the knowledge base in parallel and distributed computing. Experiments indicate that the DSN can better model the textual information and extract the semantic information with a higher precision.

In addition, researchers are increasingly paying more efforts on communications in 5G network environments. The paper addressed by Sadia Din, Awais Ahmad, Anand Paul, and Seungmin Rho, entitled "MGR: Multi-parameter Green Reliable Communication for Internet of Things in 5G Network" [2], presents a scheme for green IoT in 5G network achieved by grouping mobile nodes in a cluster. A mobility management model is designed for triggering efficient handover and selecting optimal networks based on the multi-criteria decision modeling. A network architecture is then designed and integrated in green IoT with 5G network, which maps internet protocol, medium access protocol, and location identifiers. The proposed scheme is implemented using C programming language, and extensive mathematical and statistical analysis is carried out in terms of cost, energy, and quality of service.

3.2. Smart energy system development

The energy-saving issue is always an attractive topic, especially in mobile computing environments. Although using the cloud computing technology can mitigate energy costs, simply offloading the workloads to the remote side cannot efficiently reduce energy consumptions in some situations. The paper presented by Keke Gai, Meikang Qiu, and Hui Zhao, entitled "Energy-Aware Task Assignment for Mobile Cyber-Enabled Applications in Heterogeneous Cloud Computing" [3], aims to reduce the total energy cost of mobile heterogeneous embedded systems by a novel task assignment to heterogeneous cores and mobile clouds. Considering energy wastes when tasks are assigned to remote cloud servers or heterogeneous core processors, the model, called energy-aware heterogeneous cloud management (EA-HCM), and the heterogeneous task assignment algorithm (HTA2), are proposed and developed. Experiment evaluations verify the effectiveness of the proposed method in saving energy within heterogeneous embedded systems from mobile cloud environments.

The paper addressed by Shaojie Wen, Chuanhe Huang, Xi Chen, Jianhua Ma, Naixue Xiong, and Zongpeng Li, entitled "Energy-efficient and Delay-aware Distributed Routing with Cooperative Transmission for Internet of Things" [9], presents an adaptive and distributed routing method with the cooperative transmission.

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This method effectively solves the routing problem, especially for real-time routing, considering the delay constraint for FANETs. The authors use the local information to select relay and cooperative nodes and transmit the packets with the help from their cooperative nodes. A corresponding mathematical optimization problem is formulated and solved, in order to maximize the network utility, and keep end-to-end delay below a prescribed threshold. Simulation results demonstrate the efficiency of the proposed routing method, which can improve network performance in terms of energy efficiency, throughput and end-to-end delay.

3.3. Algorithms and applications based on sensor networks

Wireless sensor networks (WSNs) have a wide range of applications in IoT environments. Following a confident information coverage (CIC) model, the paper addressed by Lingzhi Yi, Xianjun Deng, Zenghui Zou, Dexin Ding, and Laurence T. Yang, entitled "Confident Information Coverage Hole Detection in Sensor Networks for Uranium Tailing Monitoring" [10], discusses the confident information coverage hole detection problem (CICHD), in order to diminish negative effects of coverage holes. Two effective heuristic CIC hole detection algorithms are designed and developed, in which the root mean square error (RMSE) is utilized as the evaluation indicator. Simulations in two hole detection schemes demonstrate the proposed method can efficiently detect the emerged coverage holes, and the CHDRE algorithm, which takes the nodes' residual energy into account, results in more practical performance than the CHD algorithm without considering the nodes' residual energy.

Human activity recognition is another significant issue in smart IoT development. The paper presented by Liang Cao, Yufeng Wang, Bo Zhang, Qun Jin, and Athanasios V. Vasilakos, entitled "GCHAR: An Efficient Group-Based Context–Aware Human Activity Recognition on Smartphone" [1], proposes an efficient group-based context-aware classification method, named as group-based context-aware human activity recognition (GCHAR), for human activity recognition on smartphones. The authors design a hierarchical group-based scheme to improve the efficiency of classification, and reduce the classification error through the context awareness rather than the intensive computation. Experiments demonstrate that the GCHAR can achieve the better classification accuracy among those popular classifiers such as RandomTree, Bagging, J48, BayesNet, KNN and Decision Table.

3.4. Cyber-related trust model and verification mechanism

The trust modeling is playing an important role in cyber-enabled social recommendation services. The paper presented by Weimin Li, Jun Mo, Minjun Xin, and Qun Jin, entitled "An Optimized Trust Model Integrated with Linear Features for Cyber-enabled Recommendation Services" [5], constructs a trust recommendation model, in which the credible rating neighborhood relation is built based on the latent factor model. Recommendation algorithms improved from traditional neighborhood algorithms are then developed, to deal with the failure problem of latent factor model in cold-start cases. The feature similarity based filling method and feature regression based filling method are proposed to optimize the integrated model. Experiments using the real world data demonstrate the high recommendation accuracy compared with the traditional collaborative recommendation, especially when facing the cold-start problem.

On the other hand, the paper addressed by Bin Yu, Zhenhua Duan, Cong Tian, and Nan Zhang, entitled "Verifying Temporal Properties of Programs: A Parallel Approach" [12], develops a parallel runtime verification mechanism to verify full regular temporal properties of programs in multi-core systems. The proposed mechanism overcomes the problem that the overhead for analyzing the desired temporal properties usually degrades performance greatly. With the program divided into several segments, the verification process with nondeterministic choices in the relative automaton of a temporal property is handled in a parallel way. The execution and verification of programs are carried out at the same time. The implementation with evaluation results demonstrate the practicability of the proposed method in the real world, comparing with three other related tools.

3.5. Security and safety issues

To deal with the cross-site scripting (XSS) attack in web applications across cyberspace, the paper presented by Ran Wang, Guangquan Xu, Xianjiao Zeng, Xiaohong Li, and Zhiyong Feng, entitled "TT-XSS: a Novel Taint Tracking Based Dynamic Detection Framework for DOM Cross-Site Scripting" [8], proposes a dynamic detection framework (TT-XSS) for DOM-XSS by means of taint tracking at client side. This framework effectively solves the problem that the dynamic detection is complex and expensive. In addition, the authors rewrite all the JavaScript features and DOM APIs to taint the rendering process of browsers. They also present new data types and methods to extend the semantic description ability of the original data structure. Attack vectors are then derived to verify vulnerabilities automatically. Experiments show that the TT-XSS can detect more DOM-XSS vulnerabilities and generate the corresponding attack vectors to verify vulnerabilities.

As for other security and privacy issues in IoT environments, the paper addressed by Ming Tao, Kaoru Ota, Mianxiong Dong, and Zhuzhong Qian, entitled "AccessAuth: Capacity-aware Security Access Authentication in Federated-IoT-enabled V2G Networks" [7], introduces the AccessAuth, a lightweight protocol of capacity-based security access authentication, to deal with the security and privacy issues in Vehicle-to-Grid (V2G) networks. A high-level authentication model with specific authentication procedures is then constructed, to provide the mutual authentication and maintain the data privacy. Evaluation results demonstrate the effective performance of the proposed method that it can be practical in enhancing the strict access authentication for V2G services.

4. Conclusions

The accepted papers, attracting researchers from six different countries, including Canada, Japan, China, the US, Korea, and Sweden, have demonstrated the smart platform design, advanced algorithm, and practical application through the development of highly distributed cyber–physical–social systems.

The rapid development of cyber technologies have brought a wide range of cyber-enabled applications across the integrated cyber–physical–social–mental space. Emerging computing paradigms have continuously changed the way we work, live, think and learn. Internet of Things is playing an important role to seamlessly interconnect the heterogeneous cyber entities with various cybermatic functions across the hyper worlds. Therefore, this special issue across transdisciplinary research fields will significantly promote the establishment of systematic knowledge and development of innovative practice in the smart IoT environment.

Acknowledgments

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