

Date of current version September 14, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3019908

## EDITORIAL

# IEEE ACCESS SPECIAL SECTION EDITORIAL: COLLABORATION FOR INTERNET OF THINGS

The network of objects/things embedded with electronics, software, sensors, and network connectivity, Internet of Things (IoT), creates many exciting applications (e.g., smart grids, smart homes, and smart cities) by enabling objects/things to collect and exchange data so that they can be sensed and controlled. To fulfill IoT, one essential step is to connect various objects/things (e.g., mobile phones, cars, and buildings) so that they can “talk” to each other (i.e., collect and exchange data). However, substantial case studies show that simply connecting them without further collaboration among the objects/things when “talking” to each other leads to unnecessary energy consumption, uncertain security, unstable performance, etc., for IoT. Therefore, collaboration for IoT is very important. Specifically, there are a lot of critical issues to consider in terms of how to achieve robust collaboration among the objects/things for IoT. For instance, how to conduct collaboration among the objects/things so that more energy-efficient communication can be achieved for IoT? How to conduct collaboration among the objects/things so that computing with higher performance can be achieved for IoT? How to improve the security of IoT with collaboration among the objects/things? How to enhance the Quality of Service of IoT with collaboration among the objects/things? How to minimize the overhead costs when objects/things are collaborating in IoT?

This Special Section solicited articles with novel contributions that addressed such issues regarding collaboration for IoT. Emerging technologies (e.g., fog computing, cognitive computing, software-defined networks, deep learning) for collaboration for IoT were particularly welcome. This Special Section demonstrated great enthusiasm in the scientific community and received around 200 submissions. After a rigorous peer-review process, the following articles were accepted for inclusion in this Special Section.

In the article “An unequal clustering algorithm concerned with time-delay for Internet of Things,” by Feng *et al.*, the authors propose an improved K-means algorithm to cluster the network and use the weighted evaluation function to optimize the cluster structure. The data fusion mechanism was used to improve the energy utilization rate of cluster heads. A delay-optimized data fusion tree construction-based algorithm is proposed, which can effectively reduce the energy consumption of the network, and the constructing data fusion tree decreases the transmission delay caused by the data fusion process.

In the article “Security control redundancy allocation technology and security keys based on Internet of Things,” by Yang *et al.*, a high-order voting algorithm for object-networked control and a new security key predistribution scheme based on the elliptic curve are proposed. The simulation results show that the proposed scheme has good network connectivity and defense.

In the article “The satellite downlink replanning problem: A BP neural network and hybrid algorithm approach for IoT Internet connection,” by Song *et al.*, the authors propose an appropriate combination approach that is based on an improved genetic algorithm for a satellite downlink replanning problem, which can quickly complete the replanning of the downlink task sequence. A series of experiments is used to prove the validity, and the proposed algorithm performs better than other scheduling algorithms.

In the article “On minimizing sensing time via data sharing in collaborative Internet of Things,” by Wu *et al.*, the authors investigate a data-sharing problem to minimize the sensing time to collaborate Internet of Things and develop algorithms with performance guarantees in offline and online scenarios. The proposed algorithms are validated to be efficient in reducing the overhead of sensing.

In the article “An approach to resource and QoS-aware services optimal composition in the big service and Internet of Things,” by Min *et al.*, the authors first define the service features in various service domains, and a resource checking operator based on the analysis of the mutual relationships between services and resources is presented. The experimental results show that the proposed method is feasible and effective.

In the article “Application of Internet of Things technology and convolutional neural network model in bridge crack detection,” by Zhang *et al.*, a digital and intelligent detection method was studied to improve the efficiency of bridge safety diagnosis and reduce the risk factor. Bridge safety inspections are moving toward automation and intelligence.

In the article “Improving both quantity and quality: Incentive mechanism for social mobile crowdsensing architecture,” by Xu *et al.*, the authors provide a comprehensive solution to improve the quantity and quality of users simultaneously through social mobile crowdsensing architecture. The proposed mechanisms show prominent advantages in total unit quality cost and running time.

In the article “Application of multi-sensor image fusion of Internet of Things in image processing,” by Li *et al.*, the authors propose a novel layer of IoT (IFIOT) approach to fuse multispectral and panchromatic images. The IFIOT strategy is focused on superpixel technique and adaptive gain, which has been performed on multispectral data as the preferred application.

In the article “Consistent data collection and assortment in the progression of continuous objects in IoT,” by Rahman *et al.*, the authors propose consistent data collection and assortment in the progression of continuous objects in IoT to tackle congestion and throughput maximization problems, by taking the link capacity diversity, congested boundary node selection, and node remaining power into consideration. The results have been evaluated with promising results against equivalent schemes in terms of data loss, high-priority data packet delivery, end-to-end delay, hop-by-delay, and percentage of successfully received packets.

In the article “Secrecy performance analysis for fixed-gain energy harvesting in an Internet of Things With untrusted relays,” by Vo *et al.*, the authors propose optimal energy-harvesting time and optimal target secrecy rate algorithms for both schemes to improve secrecy performance of the considered system. The numerical results indicate that the secrecy performance analyses in terms of the secrecy outage probability for both best-sensor-best-untrusted-relay and random-sensor-random-untrusted-relay improved as the number of sensor nodes and untrusted relays increased.

In the article “Rapid and efficient bug assignment using ELM for IoT software,” by Yin *et al.*, the authors propose a software defect triage framework based on extreme learning machine (ELM). Through experiments, they conclude that the effects of the classification and the time consumption of the defect triage classifier based on ELM are much better than those of classifiers based on other algorithms.

In the article “Application of time-difference-of-arrival localization method in impulse system radar and the prospect of application of impulse system radar in the Internet of Things,” by Dang *et al.*, the authors propose a “point source approximation” analytical model, which considers an elementary antenna as the radiation point source and can reflect the radiation characteristics of specific elementary antennas. Experimental test results show that the presented method enables fairly accurate localization of targets.

In the article “Under the IoT platform a novel algorithm for minimization of current pulsation in PFC circuit,” by Zhang *et al.*, the authors propose an improved one-cycle hysteresis controlling circuit to address the problem of large pulsation in the switching current of the traditional one-cycle hysteretic control PFC circuit.

In the article “A novel anti-collision algorithm in RFID for Internet of Things,” by Zhi *et al.*, the authors propose an RFID anticollision algorithm based on tag grouping, which has effectively solved the issue of tag grouping and unique tag number allocation in the group by using the fuzzy c mean value cluster method. The experimental results indicate

clearly that algorithm performance in this article is superior to the traditional anticollision algorithm.

In the article “Separation of vehicle detection area using Fourier descriptor under Internet of Things monitoring,” by Fan *et al.*, the authors propose a new separation method of the vehicle detection area to improve the detection accuracy of vehicles from camera images. This method makes it possible to separate the area that the existing method cannot separate and has obtained a high accuracy of separation in the experimental data of Internet of Things monitoring.

In the article “Kernel estimation of Volterra using an adaptive artificial bee colony optimization and its application to speech signal multi-step prediction,” by Zhang *et al.*, the authors propose a novel adaptive Gbest-guide artificial bee colony algorithm based on the onlooker stage search equation in order to solve parameter selection problems when applying recursive least square, least mean square, or normalized LMS algorithms to estimate kernels of the second-order Volterra filter.

In the article “Secure roadside unit hotspot against eavesdropping based traffic analysis in edge computing based Internet of Vehicles,” by Huang *et al.*, the authors present a RSU hotspot attack in which a global adversary eavesdrops on wireless communications and records network traffic to monitor, locate, and attack a target roadside unit with heavy traffic. Extensive simulations show that the scheme with the Stackelberg game approach is effective and efficient to secure Edge computing-based Internet of Vehicles against RSU hotspot attacks.

In the article “Hybrid network coding scheme in cognitive radio networks with multiple secondary users,” by Mei *et al.*, the authors investigate the network coding scheme in cognitive radio networks and propose a hybrid network coding scheme to improve the utilization efficiency of idle spectrum. The simulation results show that the proposed scheme can achieve better performance in terms of both delay and throughput compared to the existing mechanisms.

In the article “Base station sleeping strategy for on-grid energy saving in cellular networks with hybrid energy supplies in IoT environment,” by Wang *et al.*, the authors propose a base station sleeping algorithm based on coalitional games to efficiently reduce on-grid energy consumption and maximize on-grid energy saving. Simulation results demonstrate that the proposed algorithm performs excellently in improving solar energy utilization and reducing on-grid energy consumption of the hybrid energy-powered cellular network.

In the article “An energy efficient and QoS aware routing algorithm based on data classification for industrial wireless sensor networks,” by Zhang *et al.*, the authors propose a link reliability estimation method and energy-efficient and QoS aware (EEQA) routing algorithm and provide timeliness parameters to measure the performance of the QoS routing algorithm. The simulation result shows that the EEQA routing algorithm is more efficient and effective.

In the article “Collaborative geolocation based on imprecise initial coordinates for Internet of Things,” by Xu *et al.*,

the authors propose a generally effective approach, degrading the sensitivity of nonlinear optimization algorithms on initial value accuracy, which can be applied for collaborative localization in areas with poor or no GNSS signal coverage. The results show that the sensitivity of algorithms on initial value accuracy is reduced efficiently, and accurate location estimation can be obtained even with random values as initial coordinates.

In the article “A delay-constrained network coding algorithm based on power control in wireless networks,” by Wang *et al.*, the authors study the problem of delay-constrained encoding by applying transmission power control in wireless networks, which includes an analysis of the probability of increasing any transmission power level without extra energy consumption in the power optimal algorithm.

In the article “Novel time series modeling methods for gyro random noise used in Internet of Things,” by Huang *et al.*, the authors propose a novel autoregressive modeling method for fiber optic gyro random noise requiring mass data due to the slow convergence speed of parameter estimation. The proposed method can work with smaller sample sizes due to its rapid parameter estimation convergence speed.

In the article “A green self-adaptive approach for online map matching,” by An *et al.*, the authors propose an adaptive online map-matching algorithm to improve the performances of the following methods: i) the probabilistic method integrating the geometric information and topological information is developed to improve the accuracy; ii) the adaptive sampling frequency method is proposed to reduce the energy consumption; and iii) the adaptive sliding window method is presented to reduce the output delay.

In the article “Time-sensitive and Sybil-proof incentive mechanisms for mobile crowdsensing via social network,” by Jiang *et al.*, the authors propose a novel mobile crowdsensing system to increase potential participants by diffusing sensing tasks in the social network. They present two system models, the multi-bid model and the single-bid model for the novel MCS system, and formulize the Sybil attack models for each model.

In the article “An approach to IoT service optimal composition for mass customization on cloud manufacturing,” by Li *et al.*, the authors propose an empirical knowledge-oriented genetic algorithm (EK-GA) for large-scale IoT service composition. By exploiting EK of IoT services for IoT-enabled service optimal composition problems, this work makes novel contributions for mass customization on cloud manufacturing and enriches the practice of EK-oriented intelligence optimization.

In the article “Active defense technology of power monitoring system with adaptive features,” by Liu *et al.*, the authors introduce the current security situation of power monitoring and control systems. They also introduce the key technologies of ontology security and active protection of power monitoring and control systems based on the TMAC model, including forced immunity and self-learning access

control technology, and automatic escalation of security policy and global situational awareness.

In the article “Research on depth estimation method of light field imaging based on big data in Internet of Things from camera array,” by Wu *et al.*, the author analyzes the disparity clues and focus clues contained in the multi-view data set and the light field refocusing image set of the camera array, respectively. The weighted linear fusion method based on the image gradient is used to fuse the two calculation results, which improves the accuracy and robustness of depth estimation. The results of depth estimation experiments on different sets of scenes show that compared with the method based on a single depth cue, the method proposed in this article shows higher accuracy in depth calculation in discontinuous areas of scene depth and similar texture areas.

In the article “Application of the improved chaotic self-adapting monkey algorithm into radar systems of Internet of Things,” by Cui *et al.*, a mathematical model of radar deployment is established based on the volume of airspace coverage. The results show that the improved chaotic self-adapting monkey algorithm can effectively solve the problem of radar deployment and provide technical support for the site selection of new observation and communication posts, deployment of maneuverable radar stations, and track planning of fleets.

In the article “The truthful evolution and incentive for large-scale mobile crowd sensing networks,” by Wang *et al.*, the authors propose a reputation updating mechanism (RUMG) based on evolution trends. In order to protect workers’ spatio-temporal privacy information effectively, a spatio-temporal privacy-preserving mechanism based on  $k$ -anonymity (LKAC) is proposed. The effectiveness of the proposed RUMG and LKAC is verified through comparison experiments.

In the article “Service optimization of Internet of Manufacturing Things based on mixed information axioms,” by Dong *et al.*, the authors propose a quality of service optimization method based on mixed information axioms to solve the optimization problem of manufacturing service in the Internet of Manufacturing Things environment. The mixed uncertainty model is expounded with random variables to express the range of system and with fuzzy variables to describe the design range.

In the article “Composition-driven IoT service provisioning in distributed edges,” by Deng *et al.*, the authors propose an optimized service cache policy by taking advantage of the composability of services to improve the performance of service provision systems. The result shows that the proposed approach can improve the average response time of these IoT services.

In the article “Artificial intelligence for cloud-assisted smart factory,” by Wan *et al.*, the authors propose a vertically integrated four-tier cloud-assisted smart factory architecture, with the aim to emphasize the role and potential of cloud computing and AI in improving the smart factories’ performances.

In the article “MCTS: Multi-channel transmission simultaneously using non-feedback fountain code,” by Liu *et al.*, the authors propose a method of multi-channel transmission simultaneously (MCTS) using no-feedback fountain code to reduce the transmission delay of data dissemination. This method technically avoids the delay from channel contention. Compared with the flooding method, the delay of the MCTS sending data from the sink node to all ZigBee nodes is decreased by one-fourth.

In the article “On using sampling Bloom filter for unknown tag identification in large-scale RFID systems,” by Chen *et al.*, the authors propose a basic efficient unknown tag identification protocol based on sampling Bloom filter called UTI-SBF, which consists of known tag deactivation phase and unknown tag identification phase. Then, they proposed an enhanced protocol called EUTI-SBF to improve the time efficiency.

In the article “Minimum Bayes-risk phrase table pruning for pivot-based machine translation in Internet of Things,” by Zhu *et al.*, the authors present a minimum Bayes-risk phrase table pruning method for pivot-based statistical machine translation. Experimental results on Europarl data show that the proposed method can both reduce the scalar of the phrase table and improve the performance of the translation.

In the article “Mining effective patterns of Chinese medicinal formulae using top-K weighted association rules for the Internet of Medical Things,” by Zhu, *et al.*, the authors present PWFPP, which is an efficient methodology for extracting the top-K weighted frequent patterns for Internet of Medical Things. PWFPP guarantees efficient mining performance by estimating the minimum weighted support threshold value. The rankings of the patterns mined from the prescriptions displayed a good rise in clinical efficacy.

In the article “Data offloading techniques through vehicular ad hoc networks: A survey,” by Zhou *et al.*, the authors survey the recent advances in data offloading techniques through vehicular *ad hoc* networks for satisfying users’ various mobile Internet service requests for data exchange anytime and anywhere, even in their moving vehicles.

In the article “Collaborative fusion for distributed target classification using evidence theory in IoT environment,” by Zhang *et al.*, the authors study the distributed target classification problem in IoT applications and propose an effective data fusion method on the basis of internal and relative reliability evaluation. Experimental results show that the fusion method can significantly enhance the classification accuracy of multi-pattern recognition.

In the article “Nonlinear vibration and control of underwater supercavitating vehicles,” by Xiong *et al.*, the authors propose a fin deflection control method based on the four-dimensional dynamic model of a supercavitating vehicle and the classical cavitator control to the supercavitating vehicle model. The research results have theoretical guidance and engineering significance for the stability control of supercavitating vehicles.

In the article “Investigation on tree molecular genome of *Arabidopsis thaliana* for Internet of Things,” by Mu *et al.*, the authors mainly discuss the establishment process of the tree molecular gene system platform under the background of the Internet of Things. They also study the molecular genome of *Arabidopsis*, combining the characteristics of the tree itself, and using the diversity of the frequency of different bases in the gene fragment to cluster the tree molecular genome, which is a molecular biology research and provides an important way of thinking.

In the article “Rapid reconstruction of a three-dimensional mesh model based on oblique images in the Internet of Things,” by Ma *et al.*, the authors propose a new method for quickly and efficiently constructing a high-quality manifold mesh model. The experimental results prove that the proposed method greatly improves the mesh reconstruction, effectively reflects the model details, and possesses a strong anti-noise ability. Also, it has good robustness and is particularly suitable for the 3-D reconstruction of large scenes and complex surfaces.

In the article “An effective framework for driver fatigue recognition based on intelligent facial expressions analysis,” by Khan *et al.*, the authors propose an efficient algorithm which is not only capable of working with multi-scale images but also can overcome the mentioned obstacles. The empirical results suggest that the proposed framework not only effectively utilizes the multi-scale images but also outperforms other similar techniques in terms of classification accuracy rate.

In the article “Strategy optimization of supply chain enterprises based on fuzzy decision-making model in Internet of Things,” by Yue *et al.*, the authors analyze the operation characteristics of supply chain enterprises under the Internet of Things. A fuzzy decision model is established to provide decision theory for the inventory nodes of supply chain enterprises, so as to optimize the resource allocation of the whole supply chain enterprise.

In the article “A density-based offloading strategy for IoT devices in edge computing systems,” by Zhang *et al.*, the authors study a computation offloading strategy based on the density of IoT devices. They evaluate that the proposed algorithm on network division can obtain smaller global cost and variance of latency.

In the article “Selecting key feature sequence of resource services in Industrial Internet of Things,” by Li *et al.*, an approach named Algorithms for Key Feature Sequence of IIoT Resource Service Chain (AKFSR-IIoT) is proposed to identify the KFSs from an RSC and then obtain the key resource service chains for improving the efficiency of IIoT resource service selection. As the trend of business processes constantly changes with markets and competition, the KFSs may not be static. Therefore, AKFSR-IIoT is a more practical approach to address change.

In the article “Smart logistics path for cyber-physical systems with Internet of Things,” by Zhang *et al.*, the author propose a path decision method based on intelligent algorithms.

Based on the CPS logistics path decision model, the Internet of Things technology and cloud platform data storage technology are introduced into the interconnection design and data processing of the equipment layer. The application effects of the ant colony algorithm, simulated annealing algorithm, and genetic algorithm in logistics path optimization are analyzed in detail.

In the article “MIHBS: A mobile interface of high bandwidth for wireless sensor networks,” by Sun *et al.*, the authors propose an enhanced Lempel–Ziv–Welch coding scheme called LZW-Huffmam, which is introduced to help transmit data faster. Furthermore, they apply it in a self-designed mobile extension, mobile interface of high bandwidth for sensor network, which is a universal interface that can transfer data to and from sensors using standard headset ports of high bandwidth.

In the article “Automatic non-taxonomic relation extraction from big data in smart city,” by Qiu *et al.*, the authors present a multi-phase correlation search framework to automatically extract non-taxonomic relations from domain documents toward big data in smart cities. Different kinds of semantic information are used to improve the performance of the system. Extensive experiments demonstrate the efficiency of the proposed framework.

In the article “Discovering urban traffic congestion propagation patterns with taxi trajectory data,” by Chen *et al.*, the authors attempt to model the congestion propagation phenomenon with a space-temporal congestion subgraph (STCS). They detected each segment regardless of whether it was congested during consecutive time intervals and built the connection of two segments in terms of their spatio-temporal properties. The experiment shows that the frequent congestion subgraph can reveal an urban congestion propagation pattern.

In the article “Fuzzy TOPSIS approaches for assessing the intelligence level of IoT-based tourist attractions,” by Guo *et al.*, the authors propose a framework of IoT-based intelligent tourist attractions and recognize specific intelligent functions brought by IoT techniques to tourist attractions. An application study shows the effectiveness and advantage of the proposed approaches in comparison with the classical technique for order preference by similarity with an ideal solution.

In the article “A security design for the detecting of buffer overflow attacks in IoT device,” by Xu *et al.*, the authors present an architectural-enhanced security hardware design to detect buffer overflow attacks. One part of the design is instruction monitoring and verification used to trace the execution behavior of programs. Another is a secure tag validation used to monitor the attributes of every memory segment. The experimental analysis shows that the proposed techniques can detect a wide range of buffer overflow attacks, and it takes low-performance penalties and minimal overheads.

In the article “Mobile sink-based path optimization strategy in wireless sensor networks using artificial bee colony

algorithm,” by Lu *et al.*, the authors propose a mobile sink-based path optimization strategy in wireless sensor networks using an artificial bee colony algorithm to obtain the optimal trajectory design of the mobile sink so as to improve the ability of data gathering. The simulation results show that the proposed algorithm is better than the traditional methods in the aspects of energy efficiency and the real-time performance of data collection.

In the article “Traffic shaped network coding aware routing for wireless sensor networks,” by Shao *et al.*, the authors present a universal network coding condition to solve the false decoding problem. A traffic shaping mechanism is proposed to shape the traffic of different flows to create more coding actions when coding opportunities exist. Extensive simulation results demonstrate that their approach increases the number of coding opportunities and the proportion of coded packets, improves network throughput, and extends the network lifetime of wireless sensor networks.

In the article “Analysis and identification of power blackout-sensitive users by using big data in the energy system,” by Shuai *et al.*, the authors take over 0.1 billion data, collected by various smart devices of the Internet of Things in the power system of China to analyze the consumption characteristics of power users. Then, a decision tree algorithm is proposed to capture the characteristics of electricity consumers and to recognize the crowd who is power blackout sensitive.

In the article “Topology-aware resource allocation for IoT services in clouds,” by Li *et al.*, the authors investigate the VM placement problem for balanced network utilization by avoiding network congestion. They conducted extensive simulations, and the simulation results show that the proposed algorithms have shown significant performance improvement in reducing network occupation and IoT service delay compared to the best-fit strategy and divide-and-conquer strategy.

In the article “Multi modal aptitude detection system for smart office,” by Tehseen *et al.*, the authors propose a novel “multi-modal aptitude detection system,” which helps in analyzing the working aptitude of employees in order to help them in providing a more conducive and healthy working environment. The proposed system helps in learning and identifying job preferences of employees based on their working aptitude.

In the article “An efficient parallel mining algorithm representative pattern set of large-scale itemsets in IoT,” by Zhang *et al.*, the authors present an online representative pattern-set parallel-mining algorithm which uses horizontal segmentation to process the database and then applies the online mining algorithm to mine locally represented pattern sets on each small database.

In the article “Self-organizing approximation command filtered backstepping control for higher order SISO systems in Internet of Things,” by He *et al.*, the authors propose a method including command filtered backstepping and online self-organizing approximation. The command filtered backstepping is to overcome the

analytic solution to virtual control command in ordinary backstepping control.

In the article “Dynamic gesture recognition in the Internet of Things,” by Li *et al.*, the authors analyze Kinect-based gesture recognition in detail and propose a dynamic gesture recognition method based on HMM and D-S evidence theory. Combinatorial logic is judged, dynamic gesture recognition is carried out, and a better recognition effect is obtained, which lays a good foundation for human–computer interaction under the IoTs technology.

In the article “EEG processing in Internet of Medical Things using non-harmonic analysis: Application and evolution for SSVEP responses,” by Jia *et al.*, the authors utilize nonharmonic analysis (NHA), which does not depend on the length of the analysis window, to analyze the continuous changes in and determine the classification accuracy of SSVEPs. Findings indicate that NHA resulted in exponential improvements in time–frequency resolution when compared with the STFT analysis.

In the article “Revenue model of supply chain by Internet of Things technology,” by Cai *et al.*, the authors establish a revenue model of the two-stage multi-product supply chain and make a quantitative analysis of the impact of the Internet of Things technology on multi-product supply chain revenue. They introduced an Imperialist Competitive Algorithm into the multi-product supply chain optimization field and improved the algorithm to further accelerate the convergence speed of the algorithm.

In the article “Collaboration of smart IoT devices exemplified with smart cupboards,” by García-Magariño *et al.*, the authors propose a collaboration mechanism for IoT devices based on multi-agent systems with mobile agents and illustrate the current approach with smart cupboards for potentially tracking memory losses. The user study revealed that users found working products of this approach usable, easy-to-learn, and useful, and they agreed that the current approach could provide a high quality of experience not only in the specific case of service-centric IoT devices for tracking memory losses but also in other domains.

In the article “WSN-based measurement of ion-current density under high-voltage direct current transmission lines,” by Cui *et al.*, the authors develop a WSN-based ion-current density measurement system. Wilson plate sensors were designed according to the IEEE standard and the software platform was implemented to establish communication. The measurement system was calibrated and successfully tested at the national high-voltage test base. The results show that the measurement system possesses the merits of good accuracy, simple structure, convenient operation, high stability, and reliability.

In the article “Impact of node deployment and routing for protection of critical infrastructures,” by Subhan *et al.*, the authors investigate the problem of sensor node placement and clustering in LWSNs and analyzed their performance. They also investigated the performance of linear sequential, linear parallel, and grid node deployment

schemes. The simulation results clearly show that the grid triangular node placement had better performance than the linear sequential and linear parallel schemes due to the multiple paths for data transmission.

In the article “Mining collaboration patterns between APIs for mashup creation in Web of Thing,” by Tang *et al.*, the authors propose an approach to mining collaboration patterns between APIs to aid mashup creation for the Web of Things. The goal of the approach is to disclose what kinds of Web APIs are frequently combined together in mashup creation and what kinds of API combinations are popular.

In the article “EdgeCare: Leveraging edge computing for collaborative data management in mobile healthcare systems,” by Li *et al.*, the authors leverage edge computing to present a secure and efficient system, called EdgeCare, for mobile healthcare systems. Thus, decentralized and collaborative data management is achieved. Numerical results with security analysis are provided to demonstrate that EdgeCare has significant advantages in security protection for healthcare data and supports efficient data trading.

In the article “TAW: Cost-effective threshold authentication with weights for Internet of Things,” by Ning *et al.*, the authors design a communication key distribution scheme for sensing networks based on a symmetric operator and propose a threshold authentication scheme based on weights, in which the higher weight represents the more important role in authentication.

In the article “Integrating artificial bee colony algorithm and BP neural network for software aging prediction in IoT environment,” by Liu *et al.*, the authors propose a novel software aging prediction method using the artificial bee colony algorithm to optimize the BP neural network model for achieving better software aging prediction accuracy. The experiment results show that the proposed method fits the prediction trend of software aging more accurately than the traditional BP neural network, and the proposed method also has faster convergence speed and more stable prediction results.

In the article “The Internet of Things enabled shop floor scheduling and process control method based on Petri nets,” by Wu *et al.*, the authors propose a schedule timed transition Petri net to represent operation sequencing information. On the basis of the mapping mechanism between the Petri net model and the XML, manufacturing resources become autonomous and interactive distributed intelligent manufacturing resources. The experimental results confirm that the proposed method is effective for scheduling and process control of the IoT-enabled shop floor.

In the article “Modeling IoT equipment with graph neural networks,” by Zhang *et al.*, the authors propose a graph neural network-based modeling approach for IoT equipment (GNNM-IoT), which considers both temporal and inner logic relations of data, in which vertices denote sensor data and edges denote relationships between vertices. They have evaluated the GNNM-IoT using air-conditioner data from a world-leading IoT company, which demonstrates that it is effective and outperforms ARIMA and LSTM methods.

In the article “Exploiting opportunistic coding in throwbox-based multicast in vehicular delay tolerant networks,” by Liu *et al.*, the authors introduce data coding into throwbox-based system architecture and propose the optimal coding option scheme under the constraints of memory space to provide efficient solutions for vehicular delay tolerant networks. The extensive trace-driven simulation demonstrates that the proposed method produces shorter delay and higher success rates in comparison with two baseline routing algorithms in VDTNs.

In the article “Cooperative transmission with priority and fairness in edge computing systems,” by Yin *et al.*, the authors propose a collaborative transmission optimization mechanism, CTOM, which takes into account various factors in selecting the relay node for IoT devices with poor channel quality and determining the priority of data flow to ensure fairness among all devices. The simulation results demonstrate the superiority of the proposed mechanism over baselines in improving transmission success ratio, network throughput, delay, and energy consumption.

In the article “Content recommendation algorithm for intelligent navigator in fog computing based IoT environment,” by Lin *et al.*, the authors propose a weighted interest user model based on association rules. The model uses the association rule to mine the users’ interest label to calculate its weight value and uses the scoring matrix to accurately calculate the users’ nearest-neighbor set.

In the article “A hybrid genetic algorithm on routing and scheduling for vehicle-assisted multi-drone parcel delivery,” by Peng *et al.*, the authors propose a novel hybrid genetic algorithm, which supports the cooperation of a ground vehicle and multiple UAVs for efficient parcel delivery. The performance evaluation results show that the proposed algorithm has significant efficiency over existing algorithms.

In the article “Resource-efficiently survivable IoT services provisioning via virtual network embedding in fiber-wireless access network,” by Liu *et al.*, the authors propose a connection availability model as an indicator of the network survivability and the IoT service robustness. The optimization problem of resource allocation is formulated in the integer linear programming model that is solved for the optimal solution in a small-scale network.

In the article “Modeling and application of the underground emergency hedging system based on Internet of Things technology,” by Wang *et al.*, a novel algorithm for underground geomagnetic GRPM positioning and a mathematical model of the underground emergency hedging path are proposed according to the concepts of spatial data mining and the intelligent mine, which verify the validity of the model in intelligent decision-making in the simulation test. The simulation results show that the algorithm and the model provided an effective idea for positioning and hedging in an

underground emergency, and help improve the intelligent analysis of the data in the mine Internet of Things.

In conclusion, we would like to thank all the authors who submitted their research articles to our Special Section. We highly appreciate the contributions of the reviewers for their constructive comments and suggestions. We also would like to acknowledge the guidance from the Editor-in-Chief and staff members.

**CHUNSHENG ZHU**, *Guest Editor*  
The University of British Columbia  
Vancouver, BC V6T 1Z4, Canada

**VINCENZO PIURI**, *Guest Editor*  
Università degli Studi di Milano  
20122 Milan, Italy

**JOEL J. P. C. RODRIGUES**, *Guest Editor*  
Federal University of Piauá  
Teresina 64000-040, Brazil  
Instituto de Telecomunicações  
3030-290 Coimbra, Portugal

**HUANSHENG NING**, *Guest Editor*  
University of Science and Technology Beijing  
Beijing 100083, China

**HUAN ZHOU**, *Guest Editor*  
China Three Gorges University  
Yichang 443002, China

**ZHANGBING ZHOU**, *Guest Editor*  
China University of Geosciences  
Beijing 100083, China



**CHUNSHENG ZHU** (Member, IEEE) is currently a Postdoctoral Research Fellow with The University of British Columbia, Canada. He has authored more than 100 publications published by refereed international journals (e.g., the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, the IEEE TRANSACTIONS ON COMPUTERS, the IEEE TRANSACTIONS ON INFORMATION FORENSICS AND SECURITY, the IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, the IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTING, the IEEE TRANSACTIONS ON CLOUD COMPUTING, *ACM Transactions on Embedded Computing Systems*, and *ACM Transactions on Cyber-Physical Systems*), magazines (e.g., *IEEE Communications Magazine*, *IEEE Wireless Communications*, and *IEEE Network*), and conferences (e.g., IEEE INFOCOM, IEEE IECON, IEEE SECON, IEEE DCROSS, IEEE ICC, and IEEE GLOBECOM). His research interests mainly include the Internet of Things, wireless sensor networks, cloud computing, big data, social networks, and security.



**VINCENZO PIURI** (Fellow, IEEE) received the Ph.D. degree in computer engineering from the Politecnico di Milano, Italy, in 1989. He has served as an Associate Professor with the Politecnico di Milano and as a Visiting Professor with The University of Texas at Austin, Austin, TX, USA, and George Mason University, Fairfax, VA, USA. He has been serving as a Full Professor of computer engineering with the Università degli Studi di Milano, Italy, since 2000. He is currently an Honorary Professor with Obuda University, Hungary, the Guangdong University of Petrochemical Technology, China, Northeastern University, China, the Muroran Institute of Technology, Japan, and the Amity University, India. His main research interests are artificial intelligence, computational intelligence, intelligent systems, machine learning, pattern analysis and recognition, signal and image processing, biometrics, intelligent measurement systems, industrial applications, digital processing architectures, fault tolerance, dependability, and cloud computing infrastructures. Original results have been published in more than 400 articles in international journals, proceedings of international conferences, books, and book chapters.

He is a Distinguished Scientist of ACM and a Senior Member of INNS. He received the IEEE Instrumentation and Measurement Society Technical Award in 2002. He has served as the IEEE Vice President for Technical Activities in 2015, the IEEE Director, the President of the IEEE Computational Intelligence Society, the Vice President for Education of the IEEE Biometrics Council, the Vice President for Publications of the IEEE Instrumentation and Measurement Society and the IEEE Systems Council, and the Vice President for Membership of the IEEE Computational Intelligence Society. He has been the President of the IEEE Systems Council since 2010. He was the Editor-in-Chief of the IEEE SYSTEMS JOURNAL from 2013 to 2019. He was an Associate Editor of the IEEE TRANSACTIONS ON COMPUTERS, the IEEE TRANSACTIONS ON NEURAL NETWORKS, the IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, and IEEE ACCESS. He is also an Associate Editor of the IEEE TRANSACTIONS ON CLOUD COMPUTING.



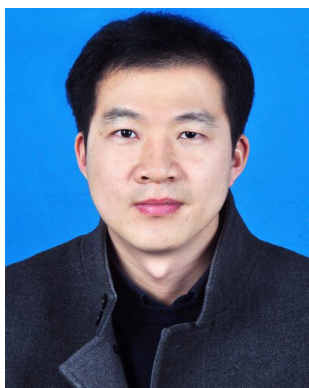
**JOEL J. P. C. RODRIGUES** (Fellow, IEEE) was the Director of Conference Development—IEEE ComSoc Board of Governors from 2018 to 2019, the Technical Activities Committee Chair of the IEEE ComSoc Latin America Region Board from 2018 to 2019, a Past-Chair of the IEEE ComSoc Technical Committee on eHealth, a Past-Chair of the IEEE ComSoc Technical Committee on Communications Software, a Steering Committee Member of the IEEE Life Sciences Technical Community, and Publications Co-Chair from 2014 to 2017. He is currently a Professor with the Federal University of Piau, Brazil, a Senior Researcher with the Instituto de Telecomunicações, Portugal, and a Collaborator of the Post-Graduation Program on Teleinformatics Engineering with the Federal University of Ceará (UFC), Brazil. He has been a Member Representative of the IEEE Communications Society on the IEEE Biometrics Council since 2011, the President of the Scientific Council with ParkUrbis–Covilhã Science and Technology Park since 2015, and the Leader of the Next-Generation Networks and Applications (NetGNA) Research Group (CNPq), and has been an IEEE Distinguished Lecturer

since 2018. He has authored or coauthored more than 850 articles in refereed international journals and conferences, three books, holds two patents, and one ITU-T Recommendation. He is a member of the Internet Society and Senior Member of ACM. He had been awarded several Outstanding Leadership and Outstanding Service awards by the IEEE Communications Society, and several best paper awards. He is the Editor-in-Chief of the *International Journal on E-Health and Medical Communications* and an Editorial Board Member of several highly-reputed journals. He has been the General Chair and the TPC Chair of many international conferences, including the IEEE ICC, the IEEE GLOBECOM, the IEEE HEALTHCOM, and the IEEE LatinCom.





**HUANSHENG NING** 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 and the Vice Dean of the School of Computer and Communication Engineering, University of Science and Technology Beijing, China. He is also the Founder of the Cyberspace and Cybermatics International Science and Technology Cooperation Base. His current research focuses on the Internet of Things and general cyberspace.



**HUAN ZHOU** received the Ph.D. degree from the Department of Control Science and Engineering, Zhejiang University. He was a Visiting Scholar with Temple University from November 2012 to May 2013, and a CSC-supported Postdoctoral Fellow with the University of British Columbia from November 2016 to November 2017. He is currently a Full Professor with the College of Computer and Information Technology, China Three Gorges University. He has published more than 50 research papers in some international journals and conferences, including the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS (JSAC), the IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS (TPDS), and the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY (TVT). His research interests include mobile social networks, VANETs, opportunistic mobile networks, and mobile data offloading. He received the Best Paper Award from I-SPAN 2014 and I-SPAN 2018. He was a Lead Guest Editor of *Pervasive and Mobile Computing*, the Special Session Chair of the Third International Conference on Internet of Vehicles (IOV 2016), and a TPC Member of the IEEE WCSP'13'14, the CCNC'14'15,

the ICNC'14'15, the ANT'15'16, the IEEE GLOBECOM'17'18, and the ICC'18'19. He is also serving as an Associate Editor for IEEE ACCESS and the *EURASIP Journal on Wireless Communications and Networking*.



**ZHANGBING ZHOU** received the B.S. degree from the China University of Geosciences, Wuhan, in 1995, the master's degree from the Institute of Automation, Chinese Academy of Sciences, in 2000, and the Ph.D. degree from the National University of Ireland, Galway, Ireland, in 2010. He is currently a Full Professor with the China University of Geosciences, Beijing, China, and an Adjunct Professor with TELECOM SudParis, Evry, France. He has published more than 150 research papers in some international journals and conferences, including the IEEE TRANSACTIONS ON SERVICES COMPUTING (TSC), the IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS(TII), and the IEEE TRANSACTIONS ON MOBILE COMPUTING (TMC). His research interests include services computing, business process management, and the Internet of Things. He is an Editor of IEEE ACCESS and the *Journal of Network and Computer Applications*, and serves as a Chair for more than 20 international conferences.

...