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Editorial

Special Issue Editorial "Deep Learning Technologies for Mobile Networks: A Themed Issue in Honor of Prof. Han-Chieh Chao"

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Han-Chieh Chao received his MS and PhD degrees in Electrical Engineering from Purdue University, West Lafayette, Indiana, in 1989 and 1993, respectively. He is currently a professor at the Department of Electrical Engineering, National Dong Hwa University, where he also serves as president. Additionally, he works with the Department of Computer Science and Information Engineering, National Ilan University, Taiwan. He was the Director of the Computer Center for Ministry of Education Taiwan from September 2008 to July 2010. His research interests include IPv6, cross-layer design, cloud computing, the Internet of Things (IoT), and 5G mobile networks. He has authored or co-authored four books and has published about 400 refereed professional research papers. He has supervised more than 150 MSEE thesis students and 11 PhD students. Prof. Chao was ranked among the Top 10 Computer Scientists in Taiwan in 2020 by Guide2Research. Prof. Chao was ranked among the Top 5 Authors in Taiwan in the field of Computer Networks and Communications, Information Systems, Computer Science Applications, and Hardware and Architecture by Scopus SciVal. Due to Prof. Chao's contribution to suburban ICT education, he was awarded the US President's Lifetime Achievement Award and the International Albert Schweitzer Foundation Human Contribution Award in 2016.

Prof. Chao has undertaken a pioneering role in the development and promotion of practical solutions for NGN. His research accomplishments are fundamental, innovative, and insightful, which are recognized by both academia and industry. The OSI-layered protocol works well in wired networks, but the traditional layered network design cannot meet the needs of users in terms of performance and efficiency for NGN. Prof. Chao proposed a "Cross-Layer Design" for 3G and 4G, which abandons the restriction imposed by the layered architecture on direct communication between adjacent layers; his design can transmit or share information between different protocol layers according to system requirements, thus reducing the complexity of network planning and enhancing the flexibility of networks. This technology has also become one of the major development technologies of 5G. In this regard, he proposed novel CLD frameworks (including the integration of SDN, SDR, and STIN) and conducted systematic studies to comprehensively evaluate system performance regarding delay, traffic load, cost, and quality of service (QoS). These studies transcend wireless access, networking, transport, and application layers, and clearly show that the proposed framework can effectively increase system capability, affordability, and sustainability.

Prof. Chao first proposed and established a novel network framework based on the cross-layer design technology for the Taiwan Academic Network (TANet). He cooperated with Cisco Taiwan to build the first commercial-grade 5G evolved packet core (EPC) testbed in Taiwan's academia. This project, along with his research results, strengthened the cooperation between Taiwan's leading telecommunication companies, FET (FarEasTone) and Ericsson, to further develop 5G testing on campus and set up a 5G lab in Taiwan to

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accelerate industrial and social transformation in the age of NGN and IoT. FET starts to offer 5G services on its LTE technology in 2018, two years ahead of commercial operations. In addition, the proposed STIN vision is included in the conclusion of the 3GPP standard TR 38.811, as one of the working items of R16.

It is with these achievements in mind that we honor Prof. Chao on this occasion for his immense contributions in the areas of cross-layer design, cloud computing, IoT, and mobile networks. His excellent research results are an inspiration to all. Hence, in this Special Issue of *Symmetry*, we invited original research investigating 5G/B5G/6G, deep learning, mobile networks, cross-layer design, wireless sensor networks, cloud computing, edge computing, Internet of Things, software-defined networks, or network security and privacy, which are relevant to Prof. Chao's research fields. After a rigorous peer-review process, we choose six high-quality research studies to be published in this Special Issue:

1. A Survey on Resource Management for Cloud Native Mobile Computing: Opportunities and Challenges (belong to the domains of mobile networks and cloud computing).
2. A Genetic Algorithm for the Wait-able Time-Varying Multi-Depot Green Vehicle Routing Problem (belong to the domains of deep learning and Internet of Things).
3. A Secure Interoperability Management Scheme for Cross-Blockchain Transactions (belong to the domain of network security and privacy).
4. Research and Application of Improved Clustering Algorithm in Retail Customer Classification (belong to the domain of deep learning).
5. Genetic Algorithms with Variant Particle Swarm Optimization Based Mutation for Generic Controller Placement in Software-Defined Networks (belong to the domains of deep learning and software-defined networks).
6. Applying Federated Learning in Software-Defined Networks: A Survey (belong to the domains of deep learning and software-defined networks).

First, in the paper "A Survey on Resource Management for Cloud Native Mobile Computing: Opportunities and Challenges" [1], Huang et al. investigated issues related to cloud native mobile computing, focusing on resource management issues of network slicing and containerization. The authors first reviewed the latest developments in cloud native technology, combined with mobile communication resource allocation, in which it is divided into four categories, i.e., virtualized network functions, network slicing, containers and resource management with software. The comparison and analyses of existing literatures are presented in terms of core techniques, underlying design concepts, strengths and weaknesses. The authors claimed that cloud native still has several significant challenges to overcome. First of all, as cloud native provides flexibility and scalability for deployment, the overall management and control will be more complicated than traditional cloud. In the view of microservice, it will be deleted or added over time, seriously affecting system performance and enhancing difficulty in detecting faults. Secondly, since using VMs (virtual machines) may have high energy consumption and waste computing resources due to running the same operations by various guest operating systems, the container technique will be a good solution to solve the energy consumption and computing resource-wasting problem. Thirdly, the software implementation of low-density parity-check (LDPC) decoding in the 5G physical layer is challenging due to its iterative and complex processing. Therefore, it may need to consume very high power to achieve the expected performance of 5G mobile networks. Second, in the paper "A Genetic Algorithm for the Wait-able Time-Varying Multi-Depot Green Vehicle Routing Problem" [2], Chen et al. introduced a mixed-integer programming model to try to minimize all costs incurred in the entire transportation process, considering the impact of time-varying speed, loading, and waiting time on costs. Considering the issue that time is directional, the multi-depot problems investigated in this study are modeled based on asymmetry, making the problem solving more complex. The proposed model adopts a genetic algorithm with simulated annealing to solve the optimal waiting time and path planning problem. In addition, the mutation operator is replaced in the outer layer by a neighbor search approach using a solution acceptance mechanism similar to simulated annealing to avoid a local optimum solution.

This study extends the path distribution problem (vehicle-routing problem) and provides an alternative approach for solving time-varying networks.

Third, considering that the widespread adoption of blockchain applications lack proper mechanisms of mutual consensus and management for across blockchains, it raises cross-blockchain consensus issue, which refers to one blockchain network reaching a consensus with another blockchain network to provide the ability to interact and share data. In the paper "A Secure Interoperability Management Scheme for Cross-Blockchain Transactions" [3], Yeh et al. presented a robust management scheme with symmetric cross-blockchain communication and certificateless signature primitives, in which two heterogeneous blockchains are linked by a relay chain to simultaneously deliver cross-blockchain transaction security, achieve compatibility among various blockchains, and ensure the consistency of data exchanged. To evaluate the practicability and security of the proposed scheme, the authors delivered an evaluation and security analysis and then demonstrated that their proposed scheme can be implemented on a common blockchain platform, i.e., Ethereum, with an acceptable computation cost. Fourth, in the paper "Research and Application of Improved Clustering Algorithm in Retail Customer Classification" [4], Fang and Liu aimed to improve and use the clustering algorithm for customer segmentation, which is an essential element in an enterprise's utilization of customer relationship management. First, the authors built a customer value system through analytic hierarchy process in which customer value can be quantified and divided into different classifications using clustering technology. In addition, an evaluating system for customer value is introduced, which is in line with the development of the enterprise, using the method of data mining based on the practical situation of the enterprise and through a series of practical evaluating indexes for customer value evaluation. The proposed system can be used to quantify customer value and segment customers, as well as to build a decision-supporting system for customer value management.

Fifth, in the paper "Genetic Algorithms with Variant Particle Swarm Optimization Based Mutation for Generic Controller Placement in Software-Defined Networks" [5], Liao et al. investigated a so-called generic controller placement problem considering the organization and placement of controllers, as well as the switch attachment, to optimize the delay between controllers and switches, the delay among controllers, and the load imbalance among controllers. To solve this problem without losing generality, the authors accordingly proposed a multi-objective genetic algorithm (MOGA) with a mutation based on a variant of the particle swarm optimization (PSO) technique. The proposed PSO technique chooses a global best position for a particle according to a pre-computed global best position set to lead the mutation of the particle. It successfully handles multiple conflicting objectives, fits the scenario of mutation, and can be applied in many other variants of MOGAs. Finally, evaluations over 12 real Internet service provider networks were conducted to show the effectiveness of the proposed MOGA in reducing convergence time and improving the diversity and accuracy of the Pareto frontiers. Sixth, in the paper "Applying Federated Learning in Software-Defined Networks: A Survey" [6], Ma et al. aimed to provide a comprehensive survey on related mechanisms and solutions that enable FL (federated learning) in SDNs (software-defined networks). The authors highlighted three major challenges consisting of an incentive mechanism, privacy and security, and model aggregation, which affect the quality and quantity of participants, the security and privacy in model transferring, and the performance of the global model, respectively. The state of the art in mechanisms and solutions that can be applied to address such challenges in the current literature are categorized based on the challenges they face, followed by suggestions for future research directions.

The Guest Editors, including Kuo-Hui Yeh, Chien-Ming Chen, and Wei-Che Chien, anticipate that this Special Issue will benefit the scientific community and contribute to existing knowledge base and would like to thank the authors for their contributions. In addition, we highly appreciate the contributions of the reviewers for their constructive

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