2021 IEEE International Conference on Web Services (ICWS 2021)

Virtual Conference 5 – 11 September 2021



IEEE Catalog Number: CFP21CWS-POD **ISBN:**

978-1-6654-1682-5

Copyright © 2021 by the Institute of Electrical and Electronics Engineers, Inc. All Rights Reserved

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

*** This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.

IEEE Catalog Number:	CFP21CWS-POD
ISBN (Print-On-Demand):	978-1-6654-1682-5
ISBN (Online):	978-1-6654-1681-8

Additional Copies of This Publication Are Available From:

Curran Associates, Inc 57 Morehouse Lane Red Hook, NY 12571 USA Phone: (845) 758-0400 Fax: (845) 758-2633 E-mail: curran@proceedings.com Web: www.proceedings.com



2021 IEEE International Conference on Web Services (ICWS) ICWS 2021

Table of Contents

Message from the Steering Committee Chair	xviii
Message from Congress General Chairs	xix
Message from the ICWS 2021 Chairs	xx
Organizing Committee	xxi
Program Committee	xxiii
Reviewers	xxvii
Message from the ISASSE Symposium Chairs	xxxii
Message from the QSAS Symposium Chairs	xxxiii
In Memoriam: Professor Mikio Aoyama	xxxiv

ICWS Papers

Invited Paper I

Hybrid Quantum Applications Need Two Orchestrations in Superposition: A Software Architecture Perspective Benjamin Weder (University of Stuttgart, Germany), Johanna Barzen (University of Stuttgart, Germany), Frank Leymann (University of Stuttgart, Germany), and Michael Zimmermann (University of Stuttgart, Germany)
Services for Zero Trust Architectures — A Research Roadmap
 SLO Script: A Novel Language for Implementing Complex Cloud-Native Elasticity-Driven SLOs 21 Thomas Pusztai (Distributed Systems Group, TU Wien, Austria), Andrea Morichetta (Distributed Systems Group, TU Wien, Austria), Victor Casamayor Pujol (Distributed Systems Group, TU Wien, Austria), Schahram Dustdar (Distributed Systems Group, TU Wien, Austria), Schahram Dustdar (Distributed Systems Group, TU Wien, Austria), Stefan Nastic (Reinvent Labs GmbH, Austria), Xiaoning Ding (Futurewei Technologies, Inc., USA), Deepak Vij (Futurewei Technologies, Inc., USA), and Ying Xiong (Futurewei Technologies, Inc., USA)

Invited Paper II

A Uniform Quantum Computing Model Based on Virtual Quantum Processors Georg Gesek (QMware AG, Switherland)	32
Crowd-Powered Hybrid Classification Services:Calibration is all you Need Burcu Sayin (University of Trento, Italy), Evgeny Krivosheev (University of Trento, Italy), Jorge Ramirez (University of Trento, Italy), Fabio Casati (University of Trento, Italy), Ekaterina Taran (Tomsk Polytechnic University, Russia), Verinika Malanina (Tomsk Polytechnic University, Russia), and Jie Yang (TU Delft, Netherland)	12
Deserv: Decentralized Serverless Computing Samuel H. Christie V (Lancaster University, UK), Amit K. Chopra (Lancaster University, UK), and Munindar P. Singh (North Carolina State University, USA)	51

Services Composition I

R-CASS: Using Algorithm Selection for Self-Adaptive Service Oriented Systems	51
Towards an Adaptive Curation Services Composition Based on Machine Learning	'3
Firas Zouari (University Jean Moulin Lyon 3, France), Chirine	
Ghedira-Guegan (University Jean Moulin Lyon 3, France), Nadia Kabachi	
(University Claude-Bernard Lyon 1, France), and Khouloud Boukadi	
(University of Sfax, Tunisia)	

Services Discovery, Selection and Recommendation I

TWLR: A Novel Truth Inference Approach Based on Worker Representations for Crowdsourcing in the Low Redundancy Situation	79
 SRaSLR: A Novel Social Relation Aware Service Label Recommendation Model Yeqi Zhu (Harbin Institute of Technology, China), Mingyi Liu (Harbin Institute of Technology, China), Zhiying Tu (Harbin Institute of Technology (Weihai)), Tonghua Su (Harbin Institute of Technology, China), and Zhongjie Wang (Harbin Institute of Technology, China) 	87
 ServeNet-LT: A Normalized Multi-head Deep Neural Network for Long-Tailed Web Services Classification	.97

Services Discovery, Selection and Recommendation II

Intention-Oriented Hierarchical Bundle Recommendation with Preference Transfer Meng Tan (Soochow University, China), Wei Chen (Soochow University, China), Weiqing Wang (Monash University, Australia), An Liu (Soochow University, China), and Lei Zhao (Soochow University, China)	107
Sequence and Distance Aware Transformer for Recommendation Systems Runqiang Zang (Renmin University of China, China), Meiyun Zuo (Renmin University of China, China), Jilei Zhou (Renmin University of China, China), Yining Xue (Renmin University of China, China), and Keman Huang (Renmin University of China, China)	117
 Time-Aware User Modeling with Check-in Time Prediction for Next POI Recommendation	125

Services Discovery, Selection and Recommendation III

 WSGCN4SLP: Weighted Signed Graph Convolutional Network for Service Link Prediction	135
 MatTrip: Multi-Functional Attention-Based Neural Network for Semantic Travel Route Recommendation	45
To Wait or To Buy: A Recommendation Service for Airline Ticket Purchase Timing	155

Services Discovery, Selection and Recommendation IV

WorP: A Novel Worker Performance Prediction Model for General Tasks on Crowdsourcing Platforms	161
Qianli Xing (Macquarie University, Australia), Weiliang Zhao (Macquarie University, Australia), Jian Yang (Macquarie University, Australia, Dong Hua University, China), Jia Wu (Macquarie University, Australia), and Qi Wang (Macquarie University, Australia)	
Relational Graph Neural Network with Neighbor Interactions for Bundle Recommendation Service	167
Xin Wang (Wuhan University, China), Xiao Liu (Deakin University, Australia), Jin Liu (Wuhan University, China), and Hao Wu (Yunnan University, China)	

Alleviating the Matthew Effect in O2O Service Matching Process 1	173
Yuying Yang (Tianjin University, China), Xiao Xue (Tianjin University,	
China), Fozhi Hou (Tianjin University, China), Shizhan Chen (Tianjin	
University, China), Zhiyong Feng (Tianjin University, China), and	
Lejun Zhang (Yangzhou University, China)	

Services Discovery, Selection and Recommendation V

Heterogeneous Graph Attention Network-Enhanced Web Service Classification	179
Mi Peng (Hunan University of Science and Technology, China), Buqing	
Mi Peng (Hunan University of Science and Technology, China), Buqing Cao (Hunan University of Science and Technology, China), Junjie Chen	
(Hunan University of Science and Technology, China), Guosheng Kang	
(Hunan University of Science and Technology, China), Jianxun Liu	
(Hunan University of Science and Technology, China), and Yiping Wen	
(Hunan University of Science and Technology, China)	
Transfer Learning for Web Services Classification	185
Yilong Yang (Beihang University, China), Zhaotian Li (Beihang	
University, China), Jing Zhang (Beihang University, China), and Yang	
Chen (Beihang University, China)	
Proactive Composition of Mobile IoT Energy Services	192
Abdallah Lakhdari (The University of Sydney, Australia) and Athman	
Bouguettaya (The University of Sydney, Australia)	
Douguettuyu (The University of Syuney, Australia)	

Service Applications beyond the Web I

NETR-Tree: An Efficient Framework for Social-Based Time-Aware Spatial Keyword Query 198 Xiuqi Huang (Shanghai Jiao Tong University, China), Yuanning Gao (Shanghai Jiao Tong University, China), Xiaofeng Gao (Shanghai Jiao Tong University, China), and Guihai Chen (Shanghai Jiao Tong University, China)
CUBIST: High-Quality 360-Degree Video Streaming Services via Tile-Based Edge Caching and
FoV-Adaptive Prefetching
Dongbiao He (Tsinghua University, China, Sangfor Inc, China), Jinlei
Jiang (Tsinghua University, China, Research Institute of Tsinghua
University in Shenzhen, China), Teng Ma (Tsinghua University, China,
Alibaba Inc., China), Guangwen Yang (Tsinghua University, China),
Cedric Westphal (Futurewei Technologies, Inc., USA), JJ
Garcia-Luna-Aceves (University of California, Santa Cruz, USA), and
Shu-Tao Xia (Tsinghua University, China)
Energy-Effective IoT Services in Balanced Edge-Cloud Collaboration Systems
Zhengzhe Xiang (Zhejiang University City College, China), Shuiguang
Deng (Zhejiang University, China), Yuhang Zheng (Zhejiang University,
China), Dongjing Wang (Hangzhou Dianzi University, China), Javid
Tehari (Karlstad University, Sweden), and Zengwei Zheng (Zhejiang
University City College, China)

Service Applications beyond the Web II

Provider-Centric Allocation of Drone Swarm Services Balsam Alkouz (The University of Sydney, Australia) and Athman Bouguettaya (The University of Sydney, Australia)	230
SiaSL: A Siamese Neural Network for Service Level Prediction Chenyu Hou (Zhejiang University of Technology, China) and Bin Cao (Zhejiang University of Technology, China)	240
An API Learning Service for Inexperienced Developers Based on API Knowledge Graph Hang Yin (Peking University, China), Yuanhao Zheng (Peking University, China), Yanchun Sun (Peking University, China), and Gang Huang (Peking University, China)	251

Service Applications beyond the Web III

CONFECT: Computation Offloading for Tasks with Hard / Soft Deadlines in Edge Computing 262 Xin He (Nanjing University, China), Jiaqi Zheng (Nanjing University, China), Qiang He (Swinburne University of Technology, Australia), Haipeng Dai (Nanjing University, China), Bowen Liu (Nanjing University, China), Wanchun Dou (Nanjing University, China), and Guihai Chen (Nanjing University, China)
 Optimal User Migration upon Server Failures in Edge Computing Environment
Lightweight and Context-Aware Modeling of Microservice-Based Internet of Things

Service Applications beyond the Web IV

Service Applications beyond the Web V

QoE-Aware Data Caching Optimization with Budget in Edge Computing Ying Liu (Northeastern University, China), Yuzheng Han (Northeastern University, China), Ao Zhang (Northeastern University, China), Xiaoyu Xia (Deakin University, Australia), Feifei Chen (Deakin University, Australia), Mingwei Zhang (Northeastern University, China), and Qiang He (Swinburne University of Technology, Australia)	324
DGPF:A Dialogue Goal Planning Framework for Cognitive Service Conversational Bot Bolin Zhang (Harbin Institute of Technology, China), Zhiying Tu (Harbin Institute of Technology, China), Yangqin Jiang (Harbin Institute of Technology, China), Shufan He (Harbin Institute of Technology, China), Guoqing Chao (Harbin Institute of Technology, China), Dianhui Chu (Harbin Institute of Technology, China), and Xiaofei Xu (Harbin Institute of Technology, China)	335
Game Theory-Based Task Offloading and Resource Allocation for Vehicular Networks in Edge-Cloud Computing Qinting Jiang (Nanjing University of Information Science and Technology, China), Xiaolong Xu (Nanjing University of Information Science and Technology, China; Soochow University, China), Qiang He (Swinburne University of Technology, Australia), Xuyun Zhang (Macquarie University, Australia), Fei Dai (Southwest Forestry University, China), Lianyong Qi (Qufu Normal University, China), and Wanchun Dou (Nanjing University, China)	341

Semantic Services I

 Dealing with Label Uncertainty in Web Service Anti-Patterns Detection using a Possibilistic Evolutionary Approach	47
Combining Label-Wise Attention and Adversarial Training for Tag Prediction of Web Services35 Qunbo Wang (Beihang University, China), Wenjun Wu (Beihang University, China), Yongchi Zhao (Beihang University, China), Yuzhang Zhuang (Beihang University, China), and Yanni Wang (Capital University of Physical Education And Sports, China)	58
A Generic Method to Rapidly Release Internet Services on Commercial Platforms	54

China), and Hongyue Wu (Tianjin University, China)

Services Composition II

ervice Composition Considering QoS Fluctuations and Anchoring Cost	70
TL-Based Dynamic IoT Service Composition	31
Deng Zhao (China University of Geosciences (Beijing), China),	
Zhangbing Zhou (China University of Geosciences (Beijing), TELECOM	
SudParis, France), Xiao Xue (Tianjin University, China), Zhuofeng Zhao	
(Beijing Key Laboratory on Integration and Analysis of Large-scale	
Stream Data, China), Walid Gaaloul (TELECOM SudParis, France), and	
Wenbo Zhang (Chinese Academy of Sciences, China)	
ata & Computation-Intensive Service Re-Scheduling In Edge Networks	39

Services Composition III

Service Recommendation for Composition Creation Based on Collaborative Attention Convolutional Network Ruyu Yan (Tsinghua University, USA), Yushun Fan (Tsinghua University,	397
USA), Jia Zhang (Southern Methodist University, USA), Junqi Zhang (Tsinghua University, USA), and Haozhe Lin (Tsinghua University, USA)	
Alliance-Aware Service Composition with Efficient Matching Search	406
Yanmei Zhang (Central University of Finance and Economics, China),	
Chong Zhu (Central University of Finance and Economics, China), Xiaoyi	
Tang (Central University of Finance and Economics, China), Hengyue Jia	
(Central University of Finance and Economics, China), and Xiuli Wang	
(Central University of Finance and Economics, China)	
COPA: A Combined Autoscaling Method for Kubernetes	416
Zhijun Ding (Tongji University, China) and Qichen Huang (Tongji	
University, China)	

Services QoS Management I

An Efficient Algorithm for Service Function Chains Reconfiguration in Mobile Edge Cloud	
Networks	. 426
Biyi Li (Beijing University of Posts and Telecommunications, China),	
Bo Cheng (Beijing University of Posts and Telecommunications, China),	
and Junliang Chen (Beijing University of Posts and Telecommunications,	
China)	

Sieve: Attention-Based Sampling of End-to-End Trace Data in Distributed Microservice	
Systems	436
Zicheng Huang (SUN YAT-SEN University, China), Pengfei Chen (SUN	
YAT-SEN University, China), Guangba Yu (SUN YAT-SEN University,	
China), Hongyang Chen (SUN YAT-SEN University, China), and Zibin Zheng	
(SUN YAT-SEN University, China)	
User Allocation in Mobile Edge Computing: A Deep Reinforcement Learning Approach	447
Arani Bhattacharya (IIIT-Delhi, India), Subrat Prasad Panda (Indian	
Statistical Institute, India), and Ansuman Banerjee (Indian	
Statistical Institute, India)	

Services QoS Management II

LETO: An Efficient Load Balanced Strategy for Task Offloading in IoT-Fog Systems Chittaranjan Swain (National Institute of Technology, India), Manmath Narayan Sahoo (National Institute of Technology, India), and Anurag Satpathy (National Institute of Technology, India)	459
QoA4ML – A Framework for Supporting Contracts in Machine Learning Services Hong-Linh Truong (Aalto University, Finland) and Tri-Minh Nguyen (Aalto University, Finland)	465
QoS-Based Trust Evaluation for Data Services as a Black Box Senda Romdhani (Univ. of Lyon, CNRS, Univ. of Lyon 3, France), Genoveva Vargas-Solar (CNRS, LIRIS, France), Nadia Bennani (Univ. of Lyon, CNRS, INSA-Lyon, LIRIS, France), and Chirine Ghedira-Guegan (Univ. of Lyon, CNRS, iaelyon - Univ. of Lyon 3, LIRIS, France)	476

Services Security, Privacy and Trust I

An Assurance-Based Risk Management Framework for Distributed Systems Marco Anisetti (Università degli Studi di Milano, Italy), Claudio Agostino Ardagna (Università degli Studi di Milano, Italy), Nicola Bena (Università degli Studi di Milano, Italy), and Andrea Foppiani (Technology Governance Risk and Control, Cargill Inc., Italy)	482
PRADA-TF: Privacy-Diversity-Aware Online Team Formation Yash Mahajan (Virginia Tech) and Jin-Hee Cho (Virginia Tech, USA)	493
An Edge Based Federated Learning Framework for Person Re-Identification in UAV Delivery Service	500
Chong Zhang (Deakin University, Australia), Xiao Liu (Deakin	
University, Australia), Jia Xu (Anhui University, China), Tianxiang	
Chen (Anhui University, China), Gang Li (Deakin University,	
Australia), Frank Jiang (Deakin University, Australia), and Xuejun Li	
(Anhui University, China)	

Semantic Services II

Multiple Features Driven Author Name Disambiguation Qian Zhou (Soochow University, China), Wei Chen (Soochow University, China), Weiqing Wang (Monash University, Australia), Jiajie Xu (Soochow University, China), and Lei Zhao (Soochow University, China)	506
Incremental Update of Knowledge Graph Embedding by Rotating on Hyperplane Yuyang Wei (Soochow University, China), Wei Chen (Soochow University, China), Zhixu Li (Soochow University, China), and Lei Zhao (Soochow University, China)	516
Efficient Grammatical Error Correction with Hierarchical Error Detections and Correction Fayu Pan (Zhejiang University of Technology, China) and Bin Cao (Zhejiang University of Technology, China)	525

Services QoS Management III

A Holistic Auto-Scaling Algorithm for Multi-service Applications Based on Balanced Queuing Network Jingwan Tong (Sun Yat-sen University, Guangzhou, China), Mingchang Wei (Sun Yat-sen University, Guangzhou, China), Maolin Pan (Sun Yat-sen University, Guangzhou, China), and Yang Yu (Sun Yat-sen University, Guangzhou, China)	531
Online Cost-Effective Edge Service Renting for Content Providers in Cloud and Edge	
Environments	. 541
Zizhe Jin (Shandong University, China), Li Pan (Shandong University, China), and Shijun Liu (Shandong University, China)	
QoS Prediction for Web Services via Combining Multi-Component Graph Convolutional	
Collaborative Filtering and Deep Factorization Machine	. 551
Linghang Ding (Hunan University of Science and Technology, China),	
Guosheng Kang (Hunan University of Science and Technology, China),	
Jianxun Liu (Hunan University of Science and Technology, China), Yong	
Xiao (Hunan University of Science and Technology, China), and Buqing	
Cao (Hunan University of Science and Technology, China)	

Services QoS Management IV

Instance-Frequency-Weighted Regularized, Nonnegative and Adaptive Latent Factorization of	
	560
Hao Wu (University of Chinese Academy of Sciences, China) and Xin Luo	
(University of Chinese Academy of Sciences, China)	
Microservice Pre-Deployment Based on Mobility Prediction and Service Composition in Edge	569
Jiale Deng (Wuhan University, China), Bing Li (Wuhan University,	
China), Jian Wang (Wuhan University, China), and Yuqi Zhao (Wuhan	
University, China)	

GoDeep: Intelligent IoV Service Deployment and Execution with Privacy Preservation in	
Cloud-Edge Computing	579
Wentao Liu (Nanjing University of Information Science and Technology,	
China), Xiaolong Xu (Nanjing University of Information Science and	
Technology, Soochow University, China), Lianyong Qi (Qufu Normal	
University, China), Xuyun Zhang (Macquarie University, Australia), and	
Wanchun Dou (Nanjing University, China)	

Services Security, Privacy and Trust II

Incentive-Driven Edge Cooperation for Service Provision	588
MemTrust: Find Deep Trust in Your Mind	598
Yanwei Xu (Tianjin University, China), Zhiyong Feng (Tianjin	
University, China), Xiao Xue (Tianjin University, China), Shizhan Chen	
(Tianjin University, China), Hongyue Wu (Tianjin University, China),	
Xian Zhou (Tianjin University, China), Meng Xing (Tianjin University,	
China), and Hongqi Chen (Tianjin University, China)	
Blockchain-Based Trust Information Storage in Crowdsourced IoT Services	608
Mohammed Bahutair (University of Sydney, Australia) and Athman	
Bouguettaya (University of Sydney, Australia)	

Services Security, Privacy and Trust III

NPS-AntiClone: Identity Cloning Detection Based on Non-Privacy-Sensitive User Profile Data618 Ahmed Alharbi (RMIT University, Australia), Hai Dong (RMIT University, Australia), Xun Yi (RMIT University, Australia), and Prabath Abeysekara (RMIT University, Australia)
Trust Management for Reliable Cross-Platform Cooperation Based on Blockchain
 A Certificateless Searchable Public Key Encryption Scheme for Multiple Receivers

Work-In-Progress

A Visualization Interface for Exploring Similar Brands on a Fashion E-Commerce Platform Natsuki Hashimoto (Doshisha University), Marie Katsurai (Doshisha University), and Ryosuke Goto (ZOZO Technologies, Inc.)	642
Automatic Control Network Anomaly Detection Based on Behavior Understanding Jianhui Luo (Fudan University)	. 645
Video Quality and Popularity-Aware Video Caching in Content Delivery Networks Yijun Sun (Beijing Institute of Technology), Zehua Guo (Beijing Institute of Technology), Songshi Dou (Beijing Institute of Technology), and Yuanqing Xia (Beijing Institute of Technology)	. 648

Service Applications beyond the Web VI

A Privacy-Aware Stackelberg Game Approach for Joint Pricing, Investment, Computation Offloading and Resource Allocation in MEC-Enabled Smart Cities Hualong Huang (Huaqiao University, China), Kai Peng (Huaqiao University, China), and Peichen Liu (Huaqiao University, China)	651
Mining Temporal Dependency Among Proactive Data Services and Its Delivery to System-Level Anomaly Prediction <i>Chen Liu (North China University of Technology, China) and Xiaoqi Li</i> <i>(North China University of Technology, China)</i>	657
Adaptive Priority-Based Conflict Resolution of IoT Services Dipankar Chaki (University of Sydney, Australia) and Athman Bouguettaya (University of Sydney, Australia)	663

Service Applications beyond the Web VII

A Holistic Service Provision Strategy for Drone-as-a-Service in MEC-Based UAV Delivery Liju Chu (Anhui University, China), Xuejun Li (Anhui University, China), Jia Xu (Anhui University, China), Azadeh Ghari Neiat (Deakin University, Australia), and Xiao Liu (Deakin University, Australia)	669
Robust Composition of Drone Delivery Services Under Uncertainty Babar Shahzaad (The University of Sydney, Australia), Athman Bouguettaya (The University of Sydney, Australia), and Sajib Mistry (Curtin University, Australia)	675
 Web Page Information Extraction Service Based on Graph Convolutional Neural Network and Multimodal Data Fusion Mingzhu Zhang (North China University of Technology, China), Zhongguo Yang (North China University of Technology, China), Sikandar Ali (China University of Petroleum-Beijing, China), and Weilong Ding (North China University of Technology, China) 	681

Special Track: QSaS

Quantum Token for Network Authentication	688
Huimin Chen (Central University of Finance and Economics, China),	
Hengyue Jia (Central University of Finance and Economics, China), Xia Wu (Central University of Finance and Economics, China), Xiuli Wang	
Wu (Central University of Finance and Economics, China), Xiuli Wang	
(Central University of Finance and Economics, China), and Maoning Wang	
(Central University of Finance and Economics, China)	
Best-Approximation Error for Parametric Quantum Circuits	693
Lena Funcke (Perimeter Institute for Theoretical Physics, Canada),	
Tobias Hartung (University of Bath, United Kingdom), Karl Jansen (NIC,	
DESY Zeuthen, Germany), Stefan Kühn (Computation-Based Science and	
Technology Research Center, The Cyprus Institute, Cyprus), Manuel	
Schneider (NIC, DESY Zeuthen, Germany), and Paolo Stornati (NIC, DESY	
Zeuthen, Germany)	

ISASSE Symposium Papers

ISASSE White Paper

Software Services Engineeri	ing Manifesto – A Cross-Cutting Declaration	
	University), Paolo Ceravolo (University of	
	BM T.J. Watson Research Center), Sumi Helal	
	i Jin (Peking University), Xuanzhe Liu	
(Peking University), and H	Jua Ming (Oakland Univesity)	

ISASSE Invited Talks

Edge Intelligence	. 710
Edge Intelligence	
Service Defined Software in E-SBOT	.711
Xiaofei Xu (Harbin Institute of Technology, China)	

ICWS Special Track on SSE

Special Track: Software Service Engineering (I)

Attaining Meta-Self-Awareness Through Assessment of Quality-of-Knowledge	712
Abdessalam Elhabbash (Lancaster University, United Kingdom), Rami	
Bahsoon (University of Birmingham, United Kingdom), Peter Tino	
(University of Birmingham, United Kingdom), Peter R. Lewis (Ontario	
Tech University, Canada), and Yehia Elkhatib (University of Glasgow,	
United Kingdom)	
MinerRepu: A Reputation Model for Miners in Blockchain Networks	724
Akram Alofi (University of Birmingham, United Kingdom), Rami Bahsoon	
(University of Birmingham, United Kingdom), and Robert Hendley	
(University of Birmingham, United Kingdom)	

Efficient Penetration of API Sequences to Test Stateful RESTful Services	734
Koji Yamamoto (Fujitsu Research, Fujitsu Ltd., Japan)	

Special Track: Software Service Engineering (II)

A Measurement Study on Serverless Workflow Services Jinfeng Wen (Peking University, China) and Yi Liu (Peking University, China)	741
An Empirical Study on Underlying Correlations between Runtime Performance Deficiencies and "Bad Smells" of Microservice Systems Lei Liu (Harbin Institute of Technology, China), Zhiying Tu (Harbin Institute of Technology, China), Xiang He (Harbin Institute of Technology, China), Xiaofei Xu (Harbin Institute of Technology, China), and Zhongjie Wang (Harbin Institute of Technology, China)	751
Monolith to Microservice Candidates using Business Functionality Inference Shivali Agarwal (IBM Research), Raunak Sinha (IBM Research), Giriprasad Sridhara (IBM Research), Pratap Das (Chennai Mathematical Institute), Utkarsh Desai (IBM Research), Srikanth Tamilselvam (IBM Research), Amith Singhee (IBM Research), and Hiroaki Nakamuro (IBM Research)	758

Author Index	55
--------------	----