

# **2022 IEEE International Conference on Web Services (ICWS 2022)**

**Barcelona, Spain  
11 – 15 July 2022**



**IEEE Catalog Number: CFP22CWS-POD  
ISBN: 978-1-6654-8144-1**

**Copyright © 2022 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:	CFP22CWS-POD
ISBN (Print-On-Demand):	978-1-6654-8144-1
ISBN (Online):	978-1-6654-8143-4

**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](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

# 2022 IEEE International Conference on Web Services (ICWS) **ICWS 2022**

## Table of Contents

Message from the Steering Committee Chair .....	xiv
Message from the Steering Committee Chair-Elect .....	xv
Message from the Congress General Chair .....	xvi
Message from the Program Chairs-in-Chief .....	xvii
Message from the General Co-Chair .....	xviii
Message from the TCSVC Chair .....	xix
Message from the ICWS Chairs .....	xx
Organizing Committee .....	xxi
Reviewers .....	xxiv
Keynote: Unleashing the Potential of IoT - Michael Sheng .....	xxvii
Symposium on Services For Machine Learning .....	xxviii
Panel: Bias in ML - From Bias in ML Service to Bias in ML-Powered Processes .....	xxix

## The International Conference on Web Services

### Services And Data/Big Data I (CWS 1)

A DevSecOps-Based Assurance Process for Big Data Analytics .....	1
<i>Marco Anisetti (Università degli Studi di Milano, Italy), Nicola Bena (Università degli Studi di Milano, Italy), Filippo Berto (Università degli Studi di Milano, Italy), and Gwanggil Jeon (Incheon National University, Korea)</i>	
Multi-Agent Multi-Armed Bandit Learning for Content Caching in Edge Networks .....	11
<i>Lina Su (Wuhan University, China), Ruiting Zhou (Wuhan University, China; School of Cyber Science and Engineering, Wuhan University, China), Ne Wang (Wuhan University, China), Junmei Chen (Wuhan University, China), and Zongpeng Li (3Insititue for Network Sciences and Cyberspace, Tsinghua University, China)</i>	

### Services Discovery, Selection And Recommendation I (CWS 2)

Spatio-Temporal Mogrifier LSTM and Attention Network for Next POI Recommendation .....	17
<i>Yihao Zhang (Chongqing University of Technology, China), Pengxiang Lan (Chongqing University of Technology, China), Yuhao Wang (Chongqing University of Technology, China), and Haoran Xiang (Chongqing University of Technology, China)</i>	

Integrating the Pre-Trained Item Representations with Reformed Self-Attention Network for Sequential Recommendation .....	27
<i>Guanzhong Liang (Chongqing University, China), Jie Liao (Chongqing University, China), Wei Zhou (Chongqing University, China), and Junhao Wen (Chongqing University, China)</i>	

Call Limit-Based Composite Service Selection .....	37
<i>Karim Benouaret (Université Claude Bernard Lyon 1, France), Juba Agoun (Université Claude Bernard Lyon 1, France), Idir Benouaret (Université Grenoble Alpes, France), and François Charoy (Université de Lorraine, France)</i>	

## Service-Oriented Technology Trends (CWS 3)

Joint Service Placement and Computation Scheduling in Edge Clouds .....	47
<i>Ran Bi (Dalian University of Technology), Ting Peng (Dalian University of Technology), Jiankang Ren (Dalian University of Technology), Xiaolin Fang (Southeast University), and Guozhen Tan (Dalian University of Technology)</i>	

Low Latency Deployment of Service-Based Data-Intensive Applications in Cloud-Edge Environment .....	57
<i>Jingtian Jia (Donghua University, China) and Pengwei Wang (Donghua University, China)</i>	

A Mobility-Aware and Fault-Tolerant Service Offloading Method in Mobile Edge Computing .....	67
<i>Tingyan Long (Chongqing University, China), Yong Ma (Jiangxi Normal University, China), Yunni Xia (Chongqing University, China), Xuan Xiao (Chongqing Normal University, China), Qinglan Peng (Chongqing University, China), and Jiale Zhao (Chongqing University, China)</i>	

## Services Applications (CWS 4)

CLOSED: A Cloud-Edge Dynamic Collaborative Strategy for Complex Event Detection .....	73
<i>Jian Cao (Shanghai Jiaotong University, China), He Huang (Shanghai Jiaotong University, China), and Shiyong Qian (Shanghai Jiaotong University, China)</i>	

Databox-Based Delivery Service via Blockchain .....	79
<i>Minfeng Qi (Swinburne University of Technology, Australia), Zhiyu Xu (Swinburne University of Technology, Australia), Ziyuan Wang (Swinburne University of Technology, Australia), Shiping Chen (CSIRO Data61, Australia), and Yang Xiang (Swinburne University of Technology, Australia)</i>	

Handling Memory Pointers in Communication Between Microservices .....	85
<i>Vini Kanvar (IBM Research, India), Srikanth Tamilselvam (IBM Research, India), and Raghavan Komondoor (Indian Institute of Science, India)</i>	

## Extended Session On Service Architecture (CWS 5)

Quality of Experience Optimization in IoT Energy Services .....	91
<i>Amani Abusafia (The University of Sydney, Australia), Athman Bouguettaya (The University of Sydney, Australia), and Abdallah Lakhdari (The University of Sydney, Australia)</i>	
IoS-OSA: Open System Architecture for Internet of Services .....	97
<i>Xiaofei Xu (Harbin Institute of Technology, China), Xiao Wang (Harbin Institute of Technology, China), Hanchuan Xu (Harbin Institute of Technology, China), Guiling Wang (North China University of Technology, China), Zhiying Tu (Harbin Institute of Technology, China), Shuangxi Huang (Tsinghua University, China), and Zhongjie Wang (Harbin Institute of Technology, China)</i>	
Service-Oriented Architecture for Drone-Based Multi-Package Delivery .....	103
<i>Babar Shahzaad (The University of Sydney, Australia) and Athman Bouguettaya (The University of Sydney, Australia)</i>	

## Services QoS Management (CWS 6)

TS-InvarNet: Anomaly Detection and Localization Based on Tempo-Spatial KPI Invariants in Distributed Services .....	109
<i>Zijun Hu (SUN YAT-SEN University, China), Pengfei Chen (SUN YAT-SEN University, China), Guangba Yu (SUN YAT-SEN University, China), Zilong He (SUN YAT-SEN University, China), and Xiaoyun Li (SUN YAT-SEN University, China)</i>	
Service Caching for Meteorological Emergency Decision-Making in Cloud-Edge Computing .....	120
<i>Hanzhi Yan (Nanjing University of Information Science and Technology, China), Xiaolong Xu (Nanjing University of Information Science and Technology, China; Soochow University, China), Fei Dai (Southwest Forestry University, China), Lianyong Qi (Qufu Normal University, China), Xu Yun Zhang (Macquarie University, Australia), and Wanchun Dou (Nanjing University, China)</i>	
HRA: An Intelligent Holistic Resource Autoscaling Framework for Multi-Service Applications.....	129
<i>Chunyang Meng (Sun Yat-sen University, China), Jingwan Tong (Sun Yat-sen University, China), Maolin Pan (Sun Yat-Sen University, China), and Yang Yu (Sun Yat-Sen University, China)</i>	

## Service Applications Beyond The Web I (CWS 7)

History-Assisted Online User Allocation in Mobile Edge Computing .....	140
<i>Xin He (Nanjing University of Posts and Telecommunications, China), Jiaqi Zheng (Nanjing University, China), Haipeng Dai (Nanjing University, China), Bowen Liu (Nanjing University, China), Wanchun Dou (Nanjing University, China), Guihai Chen (Nanjing University, China), and Fu Xiao (Nanjing University of Posts and Telecommunications, China)</i>	

Context-Aware IoT Service Recommendation: A Deep Collaborative Filtering-Based Approach .....	150
<i>Zhen Wang (University of Science and Technology Beijing, China), Chang-ai Sun (University of Science and Technology Beijing, China), and Marco Aiello (University of Stuttgart, Germany)</i>	
LightPro: Lightweight Probabilistic Workload Prediction Framework for Database-as-a-Service .....	160
<i>Xiuqi Huang (Shanghai Jiao Tong University, China), Shiyi Cao (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)</i>	

## Services Discovery, Selection & Recommendation II (CWS 8)

srVPA: A Multi-Domain Conversational Service Recommendation Approach .....	170
<i>Min Liu (Harbin Institute of Technology, China), Demin Yu (Harbin Institute of Technology, China), Zhiying Tu (Harbin Institute of Technology, China), and Zhongjie Wang (Harbin Institute of Technology, China)</i>	
A Knowledge Graph Based Approach for Apps Permission Recommendation .....	176
<i>Huwei Zhang (Tianjin University, China), Zhiyong Feng (Tianjin University, China), Jianmao Xiao (Jiangxi Normal University, China), Zhixiong Ye (Tianjin University, China), Guodong Fan (Tianjin University, China), Shizhan Chen (Tianjin University, China), and Xiao Xue (Tianjin University, China)</i>	
Capturing Users' Fresh Interests via Evolving Session-Based Social Recommendation .....	182
<i>Hongqi Chen (Tianjin University, China), Zhiyong Feng (Tianjin University, China), Shizhan Chen (Tianjin University, China), Xiao Xue (Tianjin University, China), Hongyue Wu (Tianjin University, China), Yingchao Sun (Tianjin University, China), Yanwei Xu (Tianjin University, China), and Gaoyong Han (Tianjin University, China)</i>	

## Services And Data Big Data II (CWS 9)

CEDS:Center-Edge Collaborative Data Service for Mobile IoT Data Management .....	188
<i>Ziang Huang (Shanghai Jiao Tong University, China), Haopeng Chen (Shanghai Jiao Tong University, China), Lin Gui (Shanghai Jiao Tong University, China), Jiansi Wang (Shanghai Jiao Tong University, China), and Zhengtong Zhang (Shanghai Jiao Tong University, China)</i>	
Phoebe: QoS-Aware Distributed Stream Processing Through Anticipating Dynamic Workloads ....	198
<i>Morgan K. Geldenhuys (Technische Universität Berlin, Germany), Dominik Scheinert (Technische Universität Berlin, Germany), Odej Kao (Technische Universität Berlin, Germany), and Lauritz Thamsen (University of Glasgow, United Kingdom)</i>	
Utility-Aware Semantics for Alternative Service Expressions in Federated SPARQL Queries .....	208
<i>Lars Heling (Karlsruhe Institute of Technology, Germany) and Maribel Acosta (Ruhr University Bochum, Germany)</i>	

## Services Security, Privacy & Trust (CWS 10)

Privacy Leakage Vulnerability Detection for Privacy-Preserving Computation Services .....	219
<i>Su Zhang (Peking University, China) and Ying Zhang (Peking University, China)</i>	
RuleCache: Accelerating Web Application Firewalls by On-Line Learning Traffic Patterns .....	229
<i>Xiaoyi Chen (Peking University, China), Qingni Shen (Peking University, China), Peng Cheng (Microsoft Research, China), Yongqiang Xiong (Microsoft Research, China), and Zhonghai Wu (Peking University, China)</i>	
Dependable Workflow Scheduling for Microservice QoS Based on Deep Q-Network .....	240
<i>Xiaoming Yu (Beihang University, China), Wenjun Wu (Beihang University, China), and Yangzhou Wang (Beihang University, China)</i>	

## Service Oriented Software Engineering (CWS 11)

MisuseHint: A Service for API Misuse Detection Based on Building Knowledge Graph from Documentation and Codebase .....	246
<i>Qingmi Liang (Central South University, China), Zhirui Kuai (Central South University, China), Yangqi Zhang (Central South University, China), Zhiyang Zhang (Central South University, China), Li Kuang (Central South University, China), and Lingyan Zhang (Central South University, China)</i>	
ASTL: Accumulative Signal Temporal Logic for IoT Service Monitoring .....	256
<i>Deng Zhao (China University of Geosciences (Beijing), China), Zhangbing Zhou (China University of Geosciences (Beijing), China; TELECOM SudParis, France), Zhipeng Cai (Georgia State University, USA), Teng Long (China University of Geosciences (Beijing), China), Sami Yangui (University of Toulouse, France), and Xiao Xue (Tianjin University, China)</i>	
An Integrated Framework for Fault Resolution in Business Processes .....	266
<i>Muhammad Adeel Zahid (Lahore University of Management Sciences, Pakistan), Ahmed Akhtar (Lahore University of Management Sciences, Pakistan), Basit Shafiq (Lahore University of Management Sciences, Pakistan), Shafay Shamail (Lahore University of Management Sciences, Pakistan), Ayesha Afzal (Air University, Pakistan), and Jaideep Vaidya (Rutgers University, USA)</i>	

## Semantic & Services Composition (CWS 12)

Game Theory Based D2D Collaborative Offloading for Workflow Applications in Mobile Edge Computing .....	276
<i>Cheng Qian (South China Normal University, China; Key Lab on Cloud Security and Assessment technology of Guangzhou, China), Gansen Zhao (South China Normal University, China; Key Lab on Cloud Security and Assessment technology of Guangzhou, China), and Haoyu Luo (South China Agricultural University, China)</i>	

WoR Ontology: Modeling Resources in Web Connected Environments .....	286
<i>Lara Kallab (Open Group, France), Richard Chbeir (Univ Pau &amp; Pays Adour, France), Sana Sellami (Aix Marseille Univ, Université de Toulon, France), and Omar Boucelma (Aix Marseille Univ, Université de Toulon, France)</i>	
Online Learning Using Incomplete Execution Data for Self-Adaptive Service-Oriented Systems.....	296
<i>Niranjana Deshpande (Rochester Institute of Technology, USA), Naveen Sharma (Rochester Institute of Technology, USA), Qi Yu (Rochester Institute of Technology, USA), and Daniel E. Krutz (Rochester Institute of Technology, USA)</i>	

## Extended Session On Service Systems (CWS 13)

Density-Based Pruning of Drone Swarm Services .....	302
<i>Balsam Alkouz (The University of Sydney, Australia), Athman Bouguettaya (The University of Sydney, Australia), and Abdallah Lakhdari (The University of Sydney, Australia)</i>	
A Deep Learning Based Personalized QoE/QoS Correlation Model for Composite Services .....	312
<i>Min Li (Harbin Institute of Technology, China), Hanchuan Xu (Harbin Institute of Technology, China), Zhiying Tu (Harbin Institute of Technology, China), Tonghua Su (Harbin Institute of Technology, China), Xiaofei Xu (Harbin Institute of Technology, China), and Zhongjie Wang (Harbin Institute of Technology, China)</i>	
A Privacy-Preserving Oriented Service Recommendation Approach Based on Personal Data Cloud and Federated Learning .....	322
<i>Haochen Yuan (Faculty of Computing, Harbin Institute of Technology, China), Chao Ma (Harbin University of Science and Technology, China), Zhenxiang Zhao (Faculty of Computing, Harbin Institute of Technology, China), Xiaofei Xu (Faculty of Computing, Harbin Institute of Technology, China), and Zhongjie Wang (Faculty of Computing, Harbin Institute of Technology, China)</i>	

## Service Applications Beyond The Web II (CWS 14)

Evidential Temporal-Aware Graph-Based Social Event Detection via Dempster-Shafer Theory .....	331
<i>Jiaqian Ren (Institute of Information Engineering, Chinese Academy of Sciences, China; University of Chinese Academy of Sciences, China), Lei Jiang (Institute of Information Engineering, Chinese Academy of Sciences, China), Hao Peng (Beihang University, China), Zhiwei Liu (Salesforce, USA), Jia Wu (University of Macquarie, Australia), and Philip S. Yu (University of Illinois Chicago, USA)</i>	
A Declarative Approach to Topology-Aware Serverless Function-Execution Scheduling .....	337
<i>Giuseppe De Palma (Università di Bologna, Italy), Saverio Giallorenzo (Univ. di Bologna, Italy and INRIA, France), Jacopo Mauro (University of Southern Denmark, Denmark), Matteo Trentin (Università di Bologna, Italy), and Gianluigi Zavattaro (Università di Bologna, Italy and INRIA, France)</i>	



Improving Business Process Resilience to Long-Tailed Business Events via Low-Code .....	343
<i>Jingwei Zhu (Fudan University, Shanghai Institute of Intelligent Electronics &amp; Systems, China), Jun Peng (Fudan University, Shanghai Institute of Intelligent Electronics &amp; Systems, China), Liang Zhang (Fudan University, Shanghai Institute of Intelligent Electronics &amp; Systems, China), and Hong-Linh Truong (Aalto University, Finland)</i>	

## Services QoS Management II (CWS 15)

Online Pricing-Based Content Cache Trading for Multi-Provider Vehicular Networks .....	349
<i>Haowei Chen (Zhejiang University, China), Shuiguang Deng (Zhejiang University, China), Hongze Zhu (Zhejiang University, China), and Cheng Zhang (Zhejiang University, China)</i>	
Is it fair? Resource Allocation for Differentiated Services on Demands .....	355
<i>Ran Zhang (Shandong University, China), Ning Liu (Shandong University, China), Lei Liu (Shandong University, China), Wei Zhang (East China Normal University), Haitao Yuan (Beijing University of Posts and Telecommunications, China), Mianxiong Dong (Muroran Institute of Technology, Japan), and Lizhen Cui (Shandong University, China)</i>	
Interval-Valued Skyline Web Service Selection on Incomplete QoS .....	361
<i>Yanjun Shu (Harbin Institute of Technology, China), Jianhang Zhang (Harbin Institute of Technology, China), Decheng Zuo (Harbin Institute of Technology, China), and Quan Z. Sheng (Macquarie University, Australia)</i>	
BIECS: A Blockchain-Based Intelligent Edge Cooperation System for Latency-Sensitive Services .....	367
<i>Xin Du (Fudan University, China; Engineering Research Center of Cyber Security Auditing and Monitoring, China), Xuzhao Chen (Fudan University, China; Engineering Research Center of Cyber Security Auditing and Monitoring, China), Zhihui Lu (Fudan University, China; Shanghai Blockchain Engineering Research Center, China), Qiang Duan (Pennsylvania State University, United States), Yujie Wang (Fudan University, China; Engineering Research Center of Cyber Security Auditing and Monitoring, China), and Jie Wu (Fudan University, China; Peng Cheng Laboratory, China)</i>	

## Service Oriented Software Engineering II (CWS 16)

Deep Attentive Anomaly Detection for Microservice Systems with Multimodal Time-Series Data...	373
<i>Yufu Chen (1Key Laboratory of Dependable Service Computing in Cyber Physical Society, Chongqing University, China; Chongqing University, China), Meng Yan (1Key Laboratory of Dependable Service Computing in Cyber Physical Society, Chongqing University, China; Chongqing University, China), Dan Yang (Chongqing University, China), Xiaohong Zhang (1Key Laboratory of Dependable Service Computing in Cyber Physical Society, Chongqing University, China; Chongqing University, China), and Ziliang Wang (1Key Laboratory of Dependable Service Computing in Cyber Physical Society, Chongqing University, China; Chongqing University, China)</i>	

Cost-Aware Multidimensional Auto-Scaling of Service- and Cloud-Based Dynamic Routing to Prevent System Overload .....	379
<i>Amirali Amiri (University of Vienna, Austria), Uwe Zdun (University of Vienna, Austria), André van Hoorn (University of Hamburg, Germany), and Schahram Dustdar (Technical University of Vienna, Austria)</i>	
An Intelligent Data-Centric Web Crawler Service for API Corpus Construction at Scale .....	385
<i>Mehdi Assefi (University of Georgia), Mehdi Bahrami (Fujitsu Research of America, Inc.), Sarthak Arora (University of Southern California), Thiab R. Taha (University of Georgia), Hamid R. Arabnia (University of Georgia), Khaled M. Rasheed (University of Georgia), and Wei-Peng Chen (Fujitsu Research of America, Inc.)</i>	
Log2MS: a Framework for Automated Refactoring Monolith into Microservices Using Execution Logs .....	391
<i>Bo Liu (Southwest University, China), Jingliu Xiong (Southwest University, China), Qiurong Ren (Southwest University, China), Shmuel Tyszberowicz (Afeka Academic College of Engineering, Israel; Southwest University, China), and Zheng Yang (Southwest University, China)</i>	

## ICWS Symposium on Services for Machine Learning

### Session 1 (CWS-SYM1)

Temporal Match Analysis and Recommending Substitutions in Live Soccer Games .....	397
<i>Yuval Berman (University of Western Australia), Sajib Mistry (Curtin University), Joby Mathew (Curtin University), and Aneesh Krishna (Curtin University)</i>	
Enabling Multi-Provider Cloud Network Service Bundling .....	405
<i>Imen Jerbi (SAMOVAR, Telecom SudParis, Institut Polytechnique de Paris, France; OASIS, National Engineering School of Tunis, University of Tunis El Manar, Tunisia; ISITCom Hammam Sousse, University of Sousse, Tunisia), Nour Assy (SAMOVAR, Telecom SudParis, Institut Polytechnique de Paris, France), Mohamed Sellami (SAMOVAR, Telecom SudParis, Institut Polytechnique de Paris, France), Hayet Brabra (SAMOVAR, Telecom SudParis, Institut Polytechnique de Paris, France), Walid Gaaloul (SAMOVAR, Telecom SudParis, Institut Polytechnique de Paris, France), Sami Bhiri (University of Monastir, Tunisia; OASIS, National Engineering School of Tunis, University of Tunis El Manar, Tunisia), Olivier Tirat (BYO NETWORKS, France), and Djamel Zeghlache (SAMOVAR, Telecom SudParis, Institut Polytechnique de Paris, France)</i>	
How Composable is the Web? An Empirical Study on OpenAPI Data Model Compatibility .....	415
<i>Souhaila Serbout (Software Institute ( USI ), Switzerland), Cesare Pautasso (Software Institute ( USI ), Switzerland), and Uwe Zdun (University of Vienna, Austria)</i>	
Knowledge Base 4.0: Using Crowdsourcing Services for Mimicking the Knowledge of Domain Experts .....	425
<i>Amin Beheshti (Macquarie University, Australia)</i>	

## Session 2 (CWS-SYM2)

A Blockchain-Based Framework in Support of Privacy Preferences Enforcement for Scientific Workflows .....	428
<i>Federico Daidone (University of Insubria, Italy), Barbara Carminati (University of Insubria, Italy), and Elena Ferrari (University of Insubria, Italy)</i>	
<b>Author Index</b> .....	<b>439</b>