

2023 IEEE International Conference on Metaverse Computing, Networking and Applications (MetaCom 2023)

**Kyoto, Japan
26 – 28 June 2023**



**IEEE Catalog Number: CFP23DK5-POD
ISBN: 979-8-3503-3334-3**

**Copyright © 2023 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:	CFP23DK5-POD
ISBN (Print-On-Demand):	979-8-3503-3334-3
ISBN (Online):	979-8-3503-3333-6

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

CURRAN ASSOCIATES INC.
proceedings
.com

2023 IEEE International Conference on Metaverse Computing, Networking and Applications (MetaCom) **MetaCom 2023**

Table of Contents

Message from the General Chairs	xxiii
Message from the Technical Program Chairs	xxiv
Organizing Committee	xxvi
Technical Program Committee	xxviii
Keynotes	xxxiii
Panel	xxxvii
Tutorials	xlii
DORM Workshop	xlvi
DIM Workshop	xlvii
MANP Workshop	xlviii
Meta-XP Workshop	xlix
VSM Workshop	1

Part I: IEEE MetaCom 2023 Main Conference

MetaCom-V-1: Metaverse Applications, Blockchain, Security (I)

Digital Twin & Blockchain: Technology Enablers for Metaverse Computing	1
<i>Marco Picone (University of Modena and Reggio Emilia, Italy), Stefano Mariani (University of Modena and Reggio Emilia, Italy), Antonio Virdis (University of PisaItaly, Italy), and Paolo Castagnetti (University of Modena and Reggio Emilia, Italy)</i>	
Layerwise Interoperability in Metaverse: Key to Next-Generation Electronic Commerce	9
<i>Shakila Zaman (University of North Texas, USA), Ram Dantu (University of North Texas, USA), Syed Badruddoja (University of North Texas, USA), Sirisha Talapuru (University of North Texas, USA), and Kritagya Upadhyay (University of North Texas, USA)</i>	
Wi-Six: Precise Positioning in the Metaverse via Optimal Wi-Fi Router Deployment in 6G Networks	17
<i>Alireza Famili (Virginia Tech, USA), Tolga Atalay (Virginia Tech, USA), Angelos Stavrou (Virginia Tech, USA), and Haining Wang (Virginia Tech, USA)</i>	

Production Capacity Negotiation for Blockchain-Enabled Collaborative Manufacturing: A Stackelberg Game Approach	25
<i>Ying Chen (Zhejiang Normal University, P. R. China), Feilong Lin (Zhejiang Normal University, P. R. China), Riheng Jia (Zhejiang Normal University, P. R. China), Zhongyu Chen (Zhejiang Normal University, P. R. China), Changbing Tang (Zhejiang Normal University, P. R. China), and Minglu Li (Zhejiang Normal University, P. R. China)</i>	
Threat Model-Based Security Analysis and Mitigation Strategies for a Trustworthy Metaverse.....	33
<i>Md Ismail Hossain (University of Alabama at Birmingham) and Ragib Hasan (University of Alabama at Birmingham)</i>	
Feedback-Enhanced Data Broker Routing Protocol for Multi-Hop Blockchain Radio Access Network	41
<i>Qianqi Meng (Southeast University, China), Yixiao Cao (Southeast University, China), Xintong Ling (Southeast University; Purple Mountain Laboratories, China), Jiaheng Wang (Southeast University; Purple Mountain Laboratories, China), and Athanasios V. Vasilakos (Center for AI Research (CAIR), University of Agder(UiA), Norway)</i>	
Inferring Private Data from AI Models in Metaverse through Black-Box Model Inversion Attacks	49
<i>Zhiyi Tian (University of Technology Sydney, Australia), Chenhan Zhang (University of Technology Sydney, Australia), Keshav Sood (Deakin University, Australia), and Shui Yu (University of Technology Sydney, Australia)</i>	

MetaCom-V-2: Networking and Communications (I)

Multi-Features Fusion based Viewport Prediction with GNN for 360-Degree Video Streaming	57
<i>Xiang Xu (University of Science and Technology of China, China), Xiaobin Tan (University of Science and Technology of China; Institute of Artificial Intelligence of Hefei Comprehensive National Science Center, China), Shunyi Wang (University of Science and Technology of China, China), Zhuolin Liu (University of Science and Technology of China, China), and Quan Zheng (University of Science and Technology of China; Institute of Artificial Intelligence of Hefei Comprehensive National Science Center, China)</i>	
Self-Sustaining Multiple Access with Continual Deep Reinforcement Learning for Dynamic Metaverse Applications	65
<i>Hamidreza Mazandarani (n/a), Masoud Shokrnezhad (Oulu University, Finland), Tarik Taleb (Oulu University, Finland), and Richard Li (Futurewei Technologies, USA)</i>	
RSU-Assisted Proactive Perception and Edge Computing for Autonomous Driving	71
<i>Ke Shi (Anhui University of Technology, China), Wei Zhao (Anhui University of Technology, China), Cheng Wu (Anhui University of Technology, China), Runhu Zhong (Anhui University of Technology, China), Xuangou Wu (Anhui University of Technology, China), Yangzhao Yang (Academy of Cyber, China), and Xiao Zheng (Anhui University of Technology, China)</i>	

Instantaneous Account Settlement in Roll-Up based Layer-2 Blockchain Framework for Metaverse Applications	78
<i>Mohd Sameen Chishti (Galgotias University, India) and Amit Banerjee (South Asian University, India)</i>	
A Digital Healthcare Service Architecture for Seniors Safety Monitoring in Metaverse	86
<i>Qian Qu (Binghamton University, USA), Ronghua Xu (Binghamton University, USA), Han Sun (Binghamton University, USA), Yu Chen (Binghamton University, USA), Sumantra Sarkar (Binghamton University, USA), and Indrajit Ray (Colorado State University, USA)</i>	
Metaverse Cybersecurity Threats and Risks Analysis: The Case of Virtual Reality Towards Security Testing and Guidance Framework	94
<i>Omego Nnamonu (University of Salford, United Kingdom), Mohammad Hammoudeh (King Fahd University of Petroleum and Minerals Dhahran, Saudi Arabia), and Tooska Dargahi (Manchester Metropolitan University, United Kingdom)</i>	

MetaCom-V-3: [Short Paper] Metaverse Designs

How to Design for the Metaverse: A Strategic Design Perspective	99
<i>Martin Böckle (BCGX, United Kingdom), Flynn Booter-Stewart (BCGX, United Kingdom), and Kristi Woolsey (BCGX, USA)</i>	
Performance Analysis of Non-Ideal Wireless PBFT Networks with mmWave and Terahertz Signals.....	104
<i>Haoxiang Luo (University of Electronic Science and Technology of China, China), Xiangyue Yang (University of Electronic Science and Technology of China, China; University of Glasgow, UK), Hongfang Yu (University of Electronic Science and Technology of China, China; Peng Cheng Laboratory, China), Gang Sun (University of Electronic Science and Technology of China, China), Shizhong Xu (University of Electronic Science and Technology of China, China), and Long Luo (University of Electronic Science and Technology of China, China)</i>	
Exploring the Data of Blockchain-Based Metaverses	109
<i>S. Casale Brunet (École Polytechnique Fédérale de Lausanne; WhaleAnalytica.com, Switzerland), M. Mattavelli (École Polytechnique Fédérale de Lausanne, Switzerland), and L. Chiariglione (CEDEO SRL, Italy)</i>	
A Test-Driven Action Verification Method for Intrusion Response Systems	114
<i>Pushpinder Kaur Chouhan (British Telecommunications PLC, UK), Bronagh Quigley (Ulster University, UK), Alfie Beard (British Telecommunications PLC, UK), and Liming Chen (Ulster University, UK)</i>	
Security Risks, User Privacy Risks, and a Trust Framework for the Metaverse Space	119
<i>Prakash Laxman Kharvi (Marymount University, USA)</i>	
ScrapeIOC: Designing a Web-Scraping Tool for Malware Detection based on Indicators of Compromise	124
<i>Katherine Cardoso Petulante Fernandes (Technical University of Denmark, Denmark), Simon Lucas Jonker (Technical University of Denmark, Denmark), Weizhi Meng (Technical University of Denmark, Denmark), and Brooke Lampe (Technical University of Denmark, Denmark)</i>	

NPNNL: A Non-Interactive Privacy-Preserving Neural Network Learning Scheme	129
<i>Dian Lei (Beijing Institute of Technology, China), Chenfei Hu (Beijing Institute of Technology, China), and JinYang Dong (Chinese Academy of Military Science, China)</i>	
Privacy and Ethical Concerns of Brain-Computer Interfaces	134
<i>Catherine Yue (Cherry Creek High School, USA)</i>	
Exploring Domain Randomization's Effect on Synthetic Data for Activity Detection	139
<i>Megani Rajendran (NVIDIA AI Technology Center, Singapore), Chek Tien Tan (Singapore Institute of Technology, Singapore), Indriyati Atmosukarto (Singapore Institute of Technology, Singapore), Aik Beng Ng (NVIDIA AI Technology Center, Singapore), Andrew Grant (NVIDIA, Canada), Eric Cameracci (NVIDIA, Canada), and Simon See (NVIDIA AI Technology Center, Singapore)</i>	
VICTOR: Video Content-Aware Partially Reliable Transmission over Multipath QUIC	141
<i>Yahui Li (National University of Defense Technology, China), Biao Han (National University of Defense Technology, China), Xueqiang Han (National University of Defense Technology, China), Xiaolan Ji (National University of Defense Technology, China), Congxi Song (National University of Defense Technology, China), and Guo Chen (Hunan University, China)</i>	
Security, Privacy and Trust for the Metaverse of Things	146
<i>Shantanu Pal (Deakin University, Australia), Anusha Vangala (International Institute of Information Technology (IIIT), India), Zahra Jadidi (Griffith University, Australia), Zhe Hou (Griffith University, Australia), and Ashok Kumar Das (International Institute of Information Technology (IIIT), India)</i>	
Integrating Pupilometry and Self-Assessment for Holistic Evaluation of Metaverse Experiences	151
<i>Agasthya Gangavarapu (Safety4XR, USA)</i>	

MetaCom-1: Invited Paper (I)

Incentive Mechanism for Throughput Enhancement in Blockchain-Based Energy Trading System ..	153
<i>Yunshu Liu (The Chinese University of Hong Kong, China), Man Hon Cheung (City University of Hong Kong, China), and Jianwei Huang (The Chinese University of Hong Kong, China)</i>	
Challenges in Metaverse Research: An Internet of Things Perspective	161
<i>Tarek Abdelzaher (University of Illinois, USA), Matthew Caesar (University of Illinois, USA), Charith Mendis (University of Illinois, USA), Klara Nahrstedt (University of Illinois, USA), Mani Srivastava (University of California, USA), and Minlan Yu (Harvard University, USA)</i>	
Human-Centered Traffic Management Supporting Smart Cities and the Metaverse	171
<i>Dinesh Cyril Selvaraj (Politecnico di Torino, Italy; TU Berlin, Germany), Falko Dressler (TU Berlin, Germany), and Carla Fabiana Chiasserini (Politecnico di Torino, Italy)</i>	

Fast and Atomic Cross-Blockchain Asset Exchange for Metaverse Interoperability	177
<i>Shan Jiang (The Hong Kong Polytechnic University, China), Jiannong Cao (The Hong Kong Polytechnic University, China), and Hanqing Wu (The Hong Kong Polytechnic University, China)</i>	

MetaCom-2: Metaverse Architectures and Applications (I)

Parking Lots Management and Visualization in the Smart City - Digital Twin Context	185
<i>Chinmay Satish Shrivastav (University of Parma, Italy), Alessio Masola (University of Modena and Reggio Emilia, Italy), Nicola Capodiecì (University of Modena and Reggio Emilia, Italy), and Roberto Cavicchioli (University of Modena and Reggio Emilia, Italy)</i>	

An Interactive Platform for a High Performance Digital Twin of a Human Heart	193
<i>Yujie Gong (University of Macau, China), Fenfen Qi (University of Macau, China), Yingzhi Liu (University of Macau, China), Jing-Yuan Wang (University of Macau, China), Tianhao Ma (University of Macau, China), Zaiheng Cheng (University of Macau, China), Yi Jiang (Chinese Academy of Sciences, China), Rongliang Chen (Chinese Academy of Sciences, China), Xinhong Wang (Zhejiang University, China), Li Luo (University of Macau, China), and Xiao-Chuan Cai (University of Macau, China)</i>	

MetaLung: Towards a Secure Architecture for Lung Cancer Patient Care on the Metaverse	201
<i>Michele Zanitti (Aalborg University, Denmark), Mieszko Ferens (Aalborg University, Denmark), Alberto Ferrarin (MLcube s.r.l., Italy), Francesco Trovò (Politecnico di Milano, Italy), Vanja Miskovic (Politecnico di Milano, Italy), Arsela Prelaj (Istituto Nazionale dei Tumori, Italy; Politecnico di Milano, Italy), Ming Shen (Aalborg University, Denmark), and Sokol Kosta (Aalborg University, Denmark)</i>	

A Novel Metaverse-as-a-Service Architecture from an Operator View	209
<i>Vesal Ahsani (Sharif University of Technology, Iran), Ali Rahimi (Sharif University of Technology, Iran), Mehdi Letafati (Sharif University of Technology, Iran), and Babak Hossein Khalaj (Sharif University of Technology, Iran)</i>	

Semantic Digital Twin for Interoperability and Comprehensive Management of Data Assets	217
<i>Kazuma Inokuchi (University of Tokyo, Japan), Jin Nakazato (University of Tokyo, Japan), Manabu Tsukada (University of Tokyo, Japan), and Hiroshi Esaki (University of Tokyo, Japan)</i>	

MetaCom-3: Security, Privacy, and Trust (I)

Securing Distributed Computing in the Metaverse: A Balanced TGDH Encryption Scheme	226
<i>Anway Bose (Temple University, PA), John L Nori (Temple University, PA), and Li Bai (Temple University, PA)</i>	

Privacy of the Metaverse: Current Issues, AI Attacks, and Possible Solutions	234
<i>Chamara Sandeepa (University College Dublin, Ireland), Shen Wang (University College Dublin, Ireland), and Madhusanka Llyanage (University College Dublin, Ireland)</i>	

A Blockchain-Based Authentication Protocol for Metaverse Environments using a Zero Knowledge Proof	242
<i>Awaneesh Kumar Yadav (Indian Institute of Technology Roorkee, India), An Braeken (Vrije Universiteit Brussel, Belgium), Mika Ylianttila (University of Oulu, Finland), and Madhusanka Liyanage (University College Dublin, Ireland)</i>	

MetaCom-4: Blockchain and Web 3.0 (I)

Quantitative Analysis of Play-to-Earn Blockchain Games: A Case Study of Axie Infinity	250
<i>Yiming Lai (The Chinese University of Hong Kong, China), Sizheng Fan (The Chinese University of Hong Kong, China), and Wei Cai (The Chinese University of Hong Kong, China)</i>	
A Distributed Asset Trading Mechanism Based on Automated Negotiation	258
<i>Jiahao Zeng (Beijing University of Posts and Telecommunications, China), Xiuhuan Zang (State Grid Economic and Technological Research Institute Co., Ltd, China), Chang Liu (Beijing University of Posts and Telecommunications, China), Zhiyi Chen (State Grid Economic and Technological Research Institute Co., Ltd, China), Shaoyong Guo (Beijing University of Posts and Telecommunications, China), Feng Qi (Beijing University of Posts and Telecommunications, China), and Jianhong Pan (State Grid Jilin Electric Power Co., Ltd, China)</i>	
Integration of MPC into Besu through an Extended Private Transaction Model	266
<i>Daniel Morales (Universidad de Málaga, Spain), Isaac Agudo (Universidad de Málaga, Spain), and Javier Lopez (Universidad de Málaga, Spain)</i>	
Complex Network Analysis on Blockchain Payment Channel Networks for Metaverse	274
<i>Bicheng Liu (Hong Kong Baptist University, Hong Kong), Bishenghui Tao (Hong Kong Metropolitan University, Hong Kong), and Hong-Ning Dai (Hong Kong Baptist University, Hong Kong)</i>	

MetaCom-5: Theories, Experiments and Evaluations

Avatar Fusion Karaoke: Research and development on multi-user music play VR experience in the metaverse	281
<i>Alexandre Berthault (REALITY, Inc., Japan), Takuma Kato (REALITY, Inc., Japan), and Akihiko Shirai (REALITY, Inc., Japan)</i>	
Grid-Metaverse: The Path From Digital Twins and Prototype Tests on DC Microgrids	290
<i>Wenxuan Ma (Zhejiang University, China), Mengxiang Liu (Imperial College London, UK), Guangrun Hong (Zhejiang University, China), Shuo Yang (Zhejiang University, China), and Ruilong Deng (Zhejiang University, China)</i>	

Achieving Distributed and Privacy-Preserving Cross-Chain Transactions in Account-Model Blockchain Systems	297
<i>Chuan Zhang (Beijing Institute of Technology; Guangdong Provincial Key Laboratory of Novel Security Intelligence Technologies, China), Weijie Wang (Beijing Institute of Technology, China), Weiting Zhang (Beijing Jiaotong University, China), Jiangtian Nie (Nanyang Technological University, Singapore), Jinwen Liang (Hong Kong Polytechnic University, China), and Liehuang Zhu (Beijing Institute of Technology, China)</i>	
Ownership Tokenization and Incentive Design for Learning-Based User-Generated Content	306
<i>Qinman Zhang (Central University of Finance and Economics, China), Zehui Xiong (Singapore University of Technology and Design, Singapore), Jianming Zhu (Central University of Finance and Economics, China), Sheng Gao (Central University of Finance and Economics, China), Wanting Yang (Jilin University, China), and Dusit Niyato (Nanyang Technological University, Singapore)</i>	

MetaCom-6: Networking and Communications (II)

Enable Cross-Domain QoS for Internet-Scale Metaverse	314
<i>Haoyu Song (Futurewei Technologies, USA)</i>	
Multi-Server Stable Rendezvous for the Metaverse	322
<i>Ningxin Su (University of Toronto), Baochun Li (University of Toronto), and Bo Li (Hong Kong University of Science and Technology)</i>	
Using Stellar Consensus Protocol to Ensure the Security of Message Transmission in VANETs	330
<i>Hung-Chin Jang (National Chengchi University, Taiwan) and Che-Wei Chang (National Chengchi University, Taiwan)</i>	
Task Allocation Optimization Strategy in UAV-Enabled Mobile Edge Computing System	338
<i>Sanhuan Yang (Shanghai University, China), Zhou Su (Xi'an Jiaotong University, China), Qichao Xu (Shanghai University, China), Rui Xing (Xi'an Jiaotong University, China), and Dongfeng Fang (California Polytechnic State University San Luis Obispo, USA)</i>	

MetaCom-7: [Short Paper] Networking and Communications

Towards a Bandwidth Market for the Metaverse	345
<i>Wenjie Cao (National University of Singapore, Singapore), Felix Kottmann (Singapore-ETH Centre, Singapore), and Richard T. B. Ma (National University of Singapore, Singapore)</i>	
Fast Detection of Cyberattacks on the Metaverse through User-Plane Inference	350
<i>Beyza Bütün (IMDEA Networks Institute, Spain; Universidad Carlos III de Madrid, Spain), Aristide Tanyi-Jong Akem (IMDEA Networks Institute, Spain; Universidad Carlos III de Madrid, Spain), Michele Gucciardo (IMDEA Networks Institute, Spain), and Marco Fiore (IMDEA Networks Institute, Spain)</i>	
Identifying Traffic Prioritization on the Internet	355
<i>Vahab Pournaghshband (University of San Francisco, USA)</i>	

Visual Data Compression for Metaverse: Technology, Standard, and Challenges	360
<i>Peilin Chen (City University of Hong Kong, China), Bolin Chen (City University of Hong Kong, China), Meng Wang (City University of Hong Kong, China), Shiqi Wang (City University of Hong Kong, China), and Zhu Li (University of Missouri-KC, USA)</i>	
Imperfect Digital Twin Assisted Low Cost Reinforcement Training for Multi-UAV Networks	365
<i>Xiucheng Wang (Xidian University, China), Nan Cheng (Xidian University, China), Longfei Ma (Xidian University, China), Zhisheng Yin (Xidian University, China), Tom. Luan (Xi'an Jiaotong University, China), and Ning Lu (DQueen's University, Canada)</i>	
Task Offloading for Fog-Based Meta Networks: An Energy and Delay Aware Mechanism	370
<i>Chengcheng Lv (Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences; University of Chinese Academy of Sciences, China), Fei Shen (Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China), Feng Yan (National Mobile Communications Research Laboratory, Southeast University, China), Lili Cao (Shanghai Aerospace Electronic Technology Institute, China), Chao Wang (Shanghai Huace Navigation Technology Ltd, China), and Yueyue Zhang (Shanghai Aerospace Electronic Technology Institute, China)</i>	
Cache Replacement Based on Similarity in Mobile Crowd Photographing	378
<i>Qianyi Deng (Ritsumeikan University, Japan) and Noriaki Kamiyama (Ritsumeikan University, Japan)</i>	

MetaCom-8: [Short Paper] Blockchain and Web 3.0

Utilizing Latent Codes for Minting AI-Generated Digital Assets into NFTs	383
<i>Yifan Chen (Tongji University, China), Lei Li (Tongji University, China), Xinyu Hu (Tongji University, China), Jiahao Li (Tongji University, China), Junyuan Wang (Tongji University, China), and Fuqiang Liu (Tongji University, China)</i>	
Ethereum DeFi Apps in the Wild: Profiling and Implications	388
<i>Ziwei Wang (Southern University of Science and Technology, China), Haotian Lu (Southern University of Science and Technology, China), and Xuetao Wei (Southern University of Science and Technology, China)</i>	
Non Fungible Mutable Tokens: Dynamic Assets Traceability for the Metaverse	393
<i>Damiano Di Francesco Maesa (University of Pisa, Italy), Andrea Lisi (University of Pisa; Consiglio Nazionale delle Ricerche - IIT, Italy), Paolo Mori (Consiglio Nazionale delle Ricerche - IIT, Italy), Laura Ricci (University of Pisa, Italy), and Simone Schiavone (University of Pisa, Italy)</i>	
Inducing Trust in Blockchain-Enabled IoT Marketplaces Through Reputation and Dispute Resolution	398
<i>Panagiotis Michalopoulos (University of Toronto, Canada), Srisht Fateh Singh (University of Toronto, Canada), and Andreas Veneris (University of Toronto, Canada)</i>	

Community Detection Algorithm for Mitigating Eclipse Attacks on Blockchain-Enabled Metaverse	403
<i>Fatemeh Erfan (Polytechnique Montréal, Canada), Martine Bellaiche (Polytechnique Montréal, Canada), and Talal Halabi (Laval University, Canada)</i>	
ATOM : A Decentralized Task Offloading Framework for Mobile Edge Computing through Blockchain and Smart Contracts	408
<i>Roshan Singh (Indian Institute of Technology, India), Debanjan Roy Chowdhury (Indian Institute of Technology, India), Sukumar Nandi (Indian Institute of Technology, India), and Sunit Kumar Nandi (Indian Institute of Technology, India)</i>	

MetaCom-9: [Short Paper] Security, Privacy, and Trust

Blockchain Enabled Architecture for Secure Authentication in the Metaverse Environment: A Student Training Use Case	413
<i>Sonali Patwe (COEP Tech University, India) and Sunil Mane (COEP Tech University, India)</i>	
The Interplay Between Policy and Technology in Metaverses: Towards Seamless Avatar Interoperability Using Self-Sovereign Identity	418
<i>Romain Laborde (Université Paul Sabatier Toulouse III), Afonso Ferreira (CNRS, France), Cristian Lepore (Université Paul Sabatier Toulouse III), Mohamed-Ali Kandi (Université Paul Sabatier Toulouse III), Michelle Sibilla (Université Paul Sabatier Toulouse III), and Abdelmalek Benzekri (Université Paul Sabatier Toulouse III)</i>	
An Implementation and Analysis of Zero Knowledge Based E-Voting Solution With Proof of Vote on Public Ethereum Blockchain	423
<i>Roshan Singh (Indian Institute of Technology, Guwahati, India), Sukumar Nandi (Indian Institute of Technology, Guwahati, India), and Sunit Kumar Nandi (Indian Institute of Technology, Guwahati, India)</i>	
A Survey on the Security of the Metaverse	428
<i>Chi Zhang (University of Chinese Academy of Sciences, China), Xijuan Si (University of Chinese Academy of Sciences, China), Xiaoyan Zhu (Xidian University, China), and Yuqing Zhang (University of Chinese Academy of Sciences, China)</i>	

MetaCom-10: Blockchain and Web 3.0 (II)

Blockchain for Decentralized Know Your Customer (KYC) and Customer Due Diligence (CDD) Pipelines in the Metaverse	433
<i>Valerie Huiying Tan (Nanyang Technological University, Singapore), Wei Yang Bryan Lim (Nanyang Technological University, Singapore), Zehui Xiong (Singapore University of Technology and Design, Singapore), and Dusit Niyato (Nanyang Technological University, Singapore)</i>	

CD-PBFT: Incentive-Based Efficient Blockchain Consensus Mechanism for Web 3.0	441
<i>Zhipeng Gao (Beijing University of Posts and Telecommunications; State Key Laboratory of Networking and Switching Technology, China), Yifeng Wang (Beijing University of Posts and Telecommunications; State Key Laboratory of Networking and Switching Technology, China), Yijing Lin (Beijing University of Posts and Telecommunications; State Key Laboratory of Networking and Switching Technology, China), Lanlan Rui (Beijing University of Posts and Telecommunications; State Key Laboratory of Networking and Switching Technology, China), and Yang Yang (Beijing University of Posts and Telecommunications; State Key Laboratory of Networking and Switching Technology, China)</i>	
First-Price Sealed-Bid Auction for Ethereum Gas Auction Under Flashbots	449
<i>Congying Jin (Shenzhen University, China), Taotao Wang (Shenzhen University, China), Zhe Wang (Nanjing University of Science and Technology, China), Long Shi (Nanjing University of Science and Technology, China), and Shengli Zhang (Shenzhen University, China)</i>	

MetaCom-11: Networking and Communications (III)

A Game Theoretic Approach for Data Asset Protection in Metaverse	458
<i>Yaqi Yang (Xidian University, China), Jinkai Zheng (Xidian University, China), Guanjie Li (Xidian University, China), Tom H. Luan (Xidian University, China), Zhou Su (Xi'an Jiaotong University, China), and Mianxiong Dong (Muroran Institute of Technology, Japan)</i>	
Range and Velocity Estimation for RadCom-Meta Network: a Fully Connected Neural Network based Mechanism	466
<i>Xiaoming Xu (Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences; University of Chinese Academy of Sciences, China), Liang Tang (Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China), Fei Shen (Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China), Chao Wang (Shanghai Huace Navigation Technology Ltd, China), Yu Zhao (Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China), and Zhiyong Bu (Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China)</i>	
Optimizing IoT Networks Deployment Under Connectivity Constraint For Dynamic Digital Twin	474
<i>Chambon Aurélien (LIGM (UMR8049)), Sahli Abderrahim (COSYS/GRETTIA), Rachedi Abderrezak (LIGM (UMR8049)), and Merbaki Ahmed (Université Gustave Eiffel, France; Nanjing Tech University (China), China)</i>	
Task Freshness-Aware Incentive Mechanism for Vehicle Twin Migration in Vehicular Metaverses	481
<i>Jinbo Wen (Guangdong University of Technology, China), Jiawen Kang (Guangdong University of Technology, China), Zehui Xiong (Singapore University of Technology and Design, Singapore), Yang Zhang (Nanjing University of Aeronautics and Astronautics, China), Hongyang Du (Nanyang Technological University, Singapore), Yutao Jiao (Army Engineering University of PLA, China), and Dusit Niyato (Nanyang Technological University, Singapore)</i>	

A Lightweight and Secure Three-Factor Access Authentication Scheme in Metaverse	488
<i>Guanjie Li (Xidian University, China), Tom H. Luan (Xidian University, China), Zheng Li (Xidian University, China), Chengzhe Lai (Xi'an University of Posts and Telecommunications, China), Nan Cheng (Xidian University, China), and Lina Zhu (Xidian University, China)</i>	

MetaCom-12: Security, Privacy, and Trust (II)

Can We Revitalize Interventional Healthcare with AI-XR Surgical Metaverses?	496
<i>Adnan Qayyum (University of Glasgow, United Kingdom; Information Technology University, Pakistan), Muhammad Bilal (University of the West of England, England), Muhammad Hadi (Information Technology University, Pakistan), Paweł Capik (University of the West of England, England), Massimo Caputo (Bristol Heart Institute, University of Bristol, England), Hunaid Vohra (Bristol Heart Institute, University of Bristol, England), Ala Al-Fuqaha (Hamad Bin Khalifa University, Qatar), and Junaid Qadir (Qatar University, Qatar)</i>	
Joint Beamforming and Trajectory Optimization for UAV-Assisted Double IRS Secure Transmission System: A Deep Reinforcement Learning Approach	504
<i>Yihao Qi (Shanghai University, China), Zhou Su (Xi'an Jiaotong University, China), Qichao Xu (Shanghai University, China), and Dongfeng Fang (California Polytechnic State University, USA)</i>	
AFNT: A Secure Data Storage Scheme Based on IOTA Tangle for Wireless Sensor Networks	510
<i>Shiyun Wang (Dalhousie University, Canada), Qiang Ye (Dalhousie University, Canada), and Kai Liu (University of PEI, Canada)</i>	
XVRS: Extended Vulnerability Risk Scoring based on Threat Intelligence	516
<i>Ensar Seker (SOCRadars, USA) and Weizhi Meng (Technical University of Denmark, Denmark)</i>	
Detecting Smart Contract Project Anomalies in Metaverse	524
<i>Shen Su (Guangzhou University, China), Yuntian Tan (Guangzhou University, China), Yue Xue (Guangzhou University, China), Chao Wang (Guangzhou University, China), Hui Lu (Guangzhou University, China), Zhihong Tian (Guangzhou University, China), Chun Shan (Guangdong Polytechnic Normal University, China), and Xiaojiang Du (Stevens Institute of Technology, USA)</i>	

MetaCom-13: Invited Paper (II)

Cell-Free Massive MIMO Enabled URLLC Communication for the Green Metaverse	533
<i>Jiakang Zheng (Beijing Jiaotong University, China), Jiayi Zhang (Beijing Jiaotong University, China), Hongyang Du (Nanyang Technological University, Singapore), Dusit Niyato (Nanyang Technological University, Singapore), and Bo Ai (Beijing Jiaotong University, China)</i>	
A Survey on Metaverse: Applications, Crimes and Governance	541
<i>Kaixin Lin (Sun Yat-Sen University, China), Jiajing Wu (Sun Yat-sen University, China), Dan Lin (Sun Yat-Sen University, China), and Zibin Zheng (Sun Yat-Sen University, China)</i>	

Identification Codes for Increased Reliability in Digital Twin Applications over Noisy Channels	550
<i>Caspar von Lengerke (Technische Universität Dresden, Germany), Juan A. Cabrera (Technische Universität Dresden, Germany), and Frank H. P. Fitzek (Technische Universität Dresden, Germany; Centre for Tactile Internet with Human-in-the-Loop (CeTI))</i>	

Unlicensed Spectrum Assisted Connection in 5G-NR Enabled Metaverse	558
<i>Wenbin Rao (Zhejiang University of Technology, China), Jiantao Yuan (Hangzhou City College, China), Meng Zhou (Hangzhou City College, China), Celimuge Wu (University of Electro-Communications, Japan), Yusheng Ji (National Institute of Informatics, Japan), Weidang Lu (Zhejiang University of Technology, China), and Rui Yin (Hangzhou City College, China)</i>	

MetaCom-14: Metaverse Computing

Multiobjective Resource Allocation Strategy for Metaverse Resource Management	564
<i>Bin Cao (Hebei University of Technology, China), Yong Chen (Hebei University of Technology, China), Xin Liu (Hebei University of Technology, China), Hua He (Hebei University of Technology, China), Houbing Song (University of Maryland, USA), and Zhihan Lv (Uppsala University, Sweden)</i>	

Joining Edge-Enabled Metaverse Services with Network Externality: A Stackelberg Game Approach	571
<i>Yuna Jiang (Huazhong University of Science and Technology, China), Jiawen Kang (Guangdong University of Technology, China), Dusit Niyato (Nanyang Technological University, Singapore), Xiaohu Ge (Huazhong University of Science and Technology, China), Zehui Xiong (Singapore University of Technology and Design, Singapore), Minrui Xu (Nanyang Technological University, Singapore), and Ruilong Deng (Zhejiang University, China)</i>	

Metaverse Remote Rendering Testbed	578
<i>Louay Bassbouss (Fraunhofer FOKUS, Germany), Andy Neparidze (Fraunhofer FOKUS, Germany), Kolja Kieslich (Fraunhofer FOKUS, Germany), Stephan Steglich (Fraunhofer FOKUS, Germany), Stefan Arbanowski (Fraunhofer FOKUS, Germany), and Peter Pogrzeba (Deutsche Telekom AG, Germany)</i>	

A Layered Architecture Enabling Metaverse Applications in Smart Manufacturing Environments..	585
<i>Armir Bujari (University of Bologna, Italy), Alessandro Calvio (University of Bologna, Italy), Andrea Garbugli (University of Bologna, Italy), and Paolo Bellavista (University of Bologna, Italy)</i>	

Device to Device Caching Delivery Using Predicted Demand on Trajectory	593
<i>Makoto Tsunekiyo (Fukuoka University, Japan) and Noriaki Kamiyama (Ritsumeikan University, Japan)</i>	

MetaCom-15: [Short Paper] Metaverse Computing

Edge-Enabled Consumer Digital Twins in Industrial Metaverse	601
<i>Yue Han (Nanyang Technological University), Wei Yang Bryan Lim (Nanyang Technological University), Dusit Niyato (Nanyang Technological University), Cyril Leung (University of British Columbia), and Chunyan Miao (Nanyang Technological University)</i>	
Generative AI-Empowered Effective Physical-Virtual Synchronization in the Vehicular Metaverse	607
<i>Minrui Xu (Nanyang Technological University, Singapore), Dusit Niyato (Nanyang Technological University, Singapore), Hongliang Zhang (Peking University, China), Jiawen Kang (Guangdong University of Technology, China), Zehui Xiong (Singapore University of Technology and Design, Singapore), Shiwen Mao (Auburn University, USA), and Zhu Han (University of Houston, USA; Kyung Hee University, South Korea)</i>	
The Metaverse for Intelligent Healthcare using XAI, Blockchain, and Immersive Technology	612
<i>Md Ariful Islam Mozumder (Inje University, Republic of Korea), Tagne Poupi Theodore A. (Inje University, Republic of Korea), Sumon Rashedul Islam (Inje University, Republic of Korea), Imtiyaj Uddin Shah Muhammad (Inje University, Republic of Korea), Ali Athar (Inje University), and Kim Hee Cheol (Inje University, Republic of Korea)</i>	
Federated Dynamic Match-Making for Co-Opetition among Participants in Mobility-as-a-Service	617
<i>Yu-Wei Chang (National Taiwan University, Taiwan) and Tsung-Nan Lin (National Taiwan University, Taiwan)</i>	
Metaverse Key Technologies and Blockchains: Impacts & Considerations	622
<i>Mustaqeem Khan (Mohamed Bin Zayed University of Artificial Intelligence, UAE), Abdulmotaleb El Saddik (Mohamed Bin Zayed University of Artificial Intelligence, UAE; University of Ottawa, Canada), and Wail Gueaieb (Mohamed Bin Zayed University of Artificial Intelligence, UAE; University of Ottawa, Canada)</i>	
A Practical Guide to Autoscaling Solutions for Next Generation Internet Applications	627
<i>Nicolò Bartelucci (University of Bologna, Italy) and Paolo Bellavista (University of Bologna, Italy)</i>	
Trial of Risk Assessment for Business Application of Metaverse	632
<i>Toshiya Seyama (PwC Consulting LLC) and Ryoichi Sasaki (Tokyo Denki University)</i>	

MetaCom-16: [Short Paper] Theories, Experiments and Evaluations

Efficient Kernel Design of Support Vector Machine for IoT Networks	637
<i>Haesik Kim (VTT Technical Research Centre of Finland, Finland)</i>	
A Cloud-Edge-Terminal Collaborative System for Image-Based Crowd Counting	642
<i>Zijie Mo (Tongji University, China), Shuaifan Xia (Tongji University, China), Shuze Shen (Tongji University, China), Siyuan Du (Tongji University, China), and Qingwen Liu (Tongji University, China)</i>	

A Payment Channel Network Fee Allocation Strategy Integrating Auction Theory	648
<i>Jingjing Zhang (Guangdong University of Foreign Studies, China), Shanbin Xiao (Sun Yat-sen University, China), Weigang Wu (Sun Yat-sen University, China), and Jieying Zhou (Sun Yat-sen University, China)</i>	
Toward Blockchain-Based Fashion Wearables in the Metaverse: the Case of Decentraland	653
<i>Amaury Trujillo (IIT-CNR, Italy) and Clara Bacciu (IIT-CNR, Italy)</i>	

MetaCom-V-4: Ph.D. Student Forum

Revolutionizing Virtual Shopping Experiences: A Blockchain-Based Metaverse UAV Delivery Solution	658
<i>Chengzu Dong (Deakin Univeristy, Australia), Jingwen Zhou (Deakin Univeristy, Australia), Qi An (Deakin Univeristy, Australia), Frank Jiang (Deakin Univeristy, Australia), Shiping Chen (Deakin Univeristy, Australia), and Xiao Liu (Deakin Univeristy, Australia)</i>	
TOTPAAuth: A Time-Based One Time Password Authentication Proof-of-Concept against Metaverse User Identity Theft	662
<i>Pengyu Li (Deakin University, Australia), Lei Pan (Deakin University, Australia), Feifei Chen (Deakin University, Australia), Thuong Hoang (Deakin University, Australia), and Rui Wang (Data61, CSIRO, Australia)</i>	
Text-to-Metaverse: Towards a Digital Twin-Enabled Multimodal Conditional Generative Metaverse	666
<i>Ahmed Elhagry (MBZ University of Artificial Intelligence, UAE) and Abdulmotaleb El Saddik (MBZ University of Artificial Intelligence, UAE)</i>	
An Analysis of Zero-Knowledge Proof-Based Privacy-Preserving Techniques for Non-Fungible Tokens in the Metaverse	670
<i>Dorottya Zelenyanszki (Griffith University), Zhé Hóu (Griffith University), Kamanashis Biswas (Australian Catholic University), and Vallipuram Muthukkumarasamy (Griffith University)</i>	

Poster Session

Zero Trust Architecture of Token Network	674
<i>Po-Han Ho (National Taiwan University, Taiwan), Hong-Yen Chen (National Taiwan University, Taiwan), and Tsung-Nan Lin (National Taiwan University, Taiwan)</i>	
Edge-Based Joint User Association and Resource Allocation for Light Field Metaverse Systems	676
<i>Chenchen Wang (Beijing University of Posts and Telecommunications, P.R.C), Xinjue Hu (Wuhan University of Technology, P.R.C), and Lin Zhang (Beijing University of Posts and Telecommunications; Beijing Big Data Center, P.R.C)</i>	
Web3 Meets Behavioral Economics: An Example of Profitable Crypto Lottery Mechanism Design .	678
<i>Kentaroh Toyoda (Institute of High Performance Computing (IHPC), Agency for Science, Technology and Research (A*STAR), Republic of Singapore; Keio University, Japan)</i>	

Development of a Metaverse Platform for Tourism Promotion in Apulia	680
<i>Enrico Carmine Ciliberti (Polytechnic University of Milan, Italy), Marco Fiore (Polytechnic University of Bari, Italy), and Marina Mongiello (Polytechnic University of Bari, Italy)</i>	
AR Assembly Navigation with Local 5G to Improve Industrial Production Efficiency	682
<i>Nobuyuki Muranaka (Hitachi, Ltd., Japan), Masashi Kono (Hitachi, Ltd., Japan), and Daisuke Ito (Hitachi, Ltd., Japan)</i>	
Holographic Multi-Channel QR Code based Copyright Distribution Management System	684
<i>Soonhong Kwon (Sejong University, Republic of Korea), Wooyoung Son (Sejong University, Republic of Korea), and Jong-Hyouk Lee (Sejong University, Republic of Korea)</i>	
akaTick: Hybrid Mobile E-Ticketing System Based on Non-Fungible Tokens	686
<i>Hung Ming Sung (National Taiwan University, Taiwan), Timothy Chen (National Taiwan University, Taiwan), Hung-Chun Tseng (National Taiwan University, Taiwan), Beatrice Prayogo (National Taiwan University, Taiwan), Jin-Yao Lin (Tainan National University of Arts, Taiwan), and Yi-Ping Hung (National Taiwan University, Taiwan)</i>	
UCI and EICN Integrated Model for Copyright Distribution Management	688
<i>Soonhong Kwon (Sejong University, Republic of Korea), Wooyoung Son (Sejong University, Republic of Korea), and Jong-Hyouk Lee (Sejong University, Republic of Korea)</i>	
Copyright and License Agreement History Management Framework for Outsourced Software	690
<i>Taeyang Lee (Sejong University, Republic of Korea), Jinsue Lee (Sejong University, Republic of Korea), Seungchan Woo (Sejong University, Republic of Korea), and Jong-Hyouk Lee (Sejong University, Republic of Korea)</i>	
Decentralized Identifier System for Software Copyright Transfer and License Management	692
<i>Seungchan Woo (Sejong University, Republic of Korea), Taeyang Lee (Sejong University, Republic of Korea), and Jong-Hyouk Lee (Sejong University, Republic of Korea)</i>	

Part II: IEEE MetaCom 2023 Co-Located Workshops

The First Workshop on “Connecting Physical World to Metaverse using IoT and Digital Twin Platforms (Meta-XP)”

Crawling Method for Image-Based Space Matching in Digital Twin Smart Cities	694
<i>Hyeonji Kim (Sejong University, Republic of Korea), Soorim Yang (Sejong University, Republic of Korea), and Jaeho Kim (Sejong University, Republic of Korea)</i>	
A Metaverse Avatar Teleport System Using an AIoT Pose Estimation Device	698
<i>Jae-won Lee (Hanshin University, South Korea), Youngwoo Lee (Hanshin University, South Korea), Hyeon-beom Choi (Hanshin University, South Korea), Sang-woo Son (Hanshin University, South Korea), Eeksu Leem (Hanshin University, South Korea), and Jeongwook Seo (Hanshin University, South Korea)</i>	

A Metaverse Emotion Mapping System with an AIoT Facial Expression Recognition Device	704
<i>Hye-min Lee (Hanshin University, South Korea), Seung-mi Ham (Hanshin University, South Korea), Hansol Moon (Hanshin University, South Korea), Hye-min Kwon (Hanshin University, South Korea), Jae-hyun Rho (Hanshin University, South Korea), and Jeongwook Seo (Hanshin University, South Korea)</i>	
An Edge-Enabled IoT Framework for Metaverse in Smart City	708
<i>JiHo Lee (Sejong University, Republic of Korea), JiEun Lee (Sejong University, Republic of Korea), and JaeSeung Song (Sejong University, Republic of Korea)</i>	
Efficient Federated Digital Twin Synchronization in Edge-Cloud Collaborative System	714
<i>Ji-Wan Kim (Sejong University, Republic of Korea), Hong Je-Gal (Sejong University, Republic of Korea), and Hyun-Suk Lee (Sejong University, Republic of Korea)</i>	
Optimal Resource Allocation for 6G UAV-Enabled Mobile Edge Computing with Mission-Critical Applications	720
<i>Dang Van Huynh (Queen's University, UK), Yijiu Li (Queen's University, UK), Antonino Masaracchia (Queen's University, UK), Trang Hoang (Ho Chi Minh City University of Technology; Vietnam National University, Vietnam), and Trung Q. Duong (Queen's University, UK)</i>	
Design and Implementation of Intelligent Safety Services for Personal Mobility Devices	724
<i>Taein Yong ((Sejong univ.), Republic of Korea), Sohyun Lee ((Sejong univ.), Republic of Korea), Hyeonji Kim ((Sejong univ.), Republic of Korea), Pyeongjoo Kim ((Sejong univ.), Republic of Korea), and Jaeho Kim ((Sejong univ.), Republic of Korea)</i>	
Mesh Deformation Scheme for High Quality 3D Model Reconstruction	728
<i>Jung Suk Park (Seoul National University of Science and Technology, Korea), Bong-Seok Seo (Seoul National University of Science and Technology, Korea), and Dong Ho Kim (Seoul National University of Science and Technology, Korea)</i>	
Cell Partitioning Scheme for UAV Communications to Maximize Throughput	731
<i>Su Bin Hwang (Seoul National University of Science and Technology, Korea), Bong-Seok Seo (Seoul National University of Science and Technology, Korea), and Dong Ho Kim (Seoul National University of Science and Technology, Korea)</i>	
Metaverse: Design of the Car Price Prediction Model Through a Machine-Learning Approach	734
<i>Jiseok Yang (Kwangwoon University, Republic of Korea), Jinseok Kim (KAFLIX, Republic of Korea), Jiwoon Lee (Kwangwoon University, Republic of Korea), Hanwoong Ryu (Kwangwoon University, Republic of Korea), Dongwook Kwon (Kwangwoon University, Republic of Korea), Seonghyeok Yeo (KAFLIX, Republic of Korea), Panjung Kim (KAFLIX, Republic of Korea), Yoongi Kim (KAFLIX, Republic of Korea), Jiyeun Lim (KAFLIX, Republic of Korea), Hyungjoon Yoon (KAFLIX, Republic of Korea), and Cheolsoo Park (Kwangwoon University, Republic of Korea)</i>	
Meta-Human Synchronization Framework for Large-Scale Digital Twin	738
<i>Donghoon Lee (Sejong University, Republic of Korea), Joongho Cho (Sejong University, South Korea), and Jaeho Kim (Sejong University, South Korea)</i>	

RID: LiDAR Range Image Descriptor for Fast and Efficient Loop Closure Detection in Indistinguishable Environments	742
<i>Hyeong-Jun Joo ((Sejong univ.), Republic of Korea) and Jaeho Kim ((Sejong univ.), Republic of Korea)</i>	

Energy Trading Framework Based on IoT and Digital Twin for Nanogrid Environment	749
<i>Faiza Qayyum (Jeju National University, South Korea), Naeem Iqbal (Jeju National University, South Korea), Harun Jamil (Jeju National University, South Korea), Atif Rizwan (Jeju National University, South Korea), Anam Nawaz Khan (Jeju National University, South Korea), Rashid Ahmad (Jeju National University, South Korea), Salabat Khan (Jeju National University, South Korea), and Do-Hyeun Kim (Jeju National University, South Korea)</i>	

The First International Workshop on Visualization & Simulation in the Metaverse (VSM 2023)

DONNA: A Data Model for Enabling Extensible and Efficient Metaverse Applications	756
<i>Georgios Bouloukakis (Télécom SudParis, Institut Polytechnique de Paris, France) and Ajay Kattepur (Ericsson Research Artificial Intelligence, India)</i>	

IEEE MetaCom Workshop on Metaverse as a network problem: performance and enabling technologies (MANP) & Decentralized, Data-Oriented Networking for the Metaverse (DORM)

AQUA: Adding Bandwidth Allocation to QUIC for Metaverse Multi-Stream Applications	762
<i>Neta Rozen-Schiff (Huawei Research Center, Israel), Amit Navon (Huawei Research Center, Israel), Itzack Pechtalt (Huawei Research Center, Israel), Leon Bruckman (Huawei Research Center, Israel), and Yu Boyuan (Huawei Research Center, China)</i>	
BGP Blockchain for Metaverse - A Distributed Consensus System for BGP	769
<i>Mike McBride (Futurewei Technologies), Xinxin Fan (IoTeX), and David Guzman (Technical University of Munich, Germany)</i>	
Securing the Internet of Things Network using a Hierarchical Hyperledger Fabric Model	775
<i>Mohammed Ahmad Abuhaliqa (Qatar University, Qatar), Cagatay Catal (Qatar University, Qatar), and Qingzhi Liu (Wageningen University & Research, The Netherlands)</i>	
What Happens in the Avatar Stays in the Avatar	780
<i>Fernando Beltran (University of Auckland, New Zealand) and David White (University of Auckland, New Zealand)</i>	
Blockchain's Role in Metaverse Trust and Transactions	786
<i>R. Can Aygun (UCLA, USA), Turan Vural (UCLA, USA), and Lixia Zhang (UCLA, USA)</i>	

The First International Workshop on Distributed Intelligence for Metaverse (DIM)

Connectivity-Aware Redirected Walking in 5G mmWave Networks	793
<i>Ching-Chieh Huang (National Taiwan University, Taiwan), Yi-Zih Chen (National Taiwan University, Taiwan), and Wanjiun Liao (National Taiwan University, Taiwan)</i>	
Advanced Learning Schemes for Metaverse Applications in B5G/6G Networks	799
<i>Sherief Hashima (Computational Learning Theory Team, RIKEN-AIP, Japan; Egyptian Atomic Energy Authority, Egypt), Mostafa M. Fouda (Idaho State University, USA), Kohei Hatano (Computational Learning Theory Team, RIKEN-AIP, Japan; Kyushu University, Japan), and Eiji Takimoto (Kyushu University, Japan)</i>	
Holographic Remote Interactive Operating Technology for Controlling Networked Communication	805
<i>Tse Chuan Hsu (Soochow University, Taiwan) and Jia Yu Wang (Soochow University, Taiwan)</i>	
Author Index	811