

2024 IEEE 25th International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM 2024)

**Perth, Australia
4 – 7 June 2024**



**IEEE Catalog Number: CFP24WOW-POD
ISBN: 979-8-3503-9467-2**

**Copyright © 2024 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:	CFP24WOW-POD
ISBN (Print-On-Demand):	979-8-3503-9467-2
ISBN (Online):	979-8-3503-9466-5
ISSN:	2770-0526

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

2024 IEEE 25th International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM) **WoWMoM 2024**

Table of Contents

Message from the General Chairs	xiv
Message from the Technical Program Committee	xvi
Message from the Workshop Committee	xviii
Organizing Committee	xx
Technical Program Committee	xxii
Reviewers	xxiv
Keynotes	xxviii

WoWMoM 2024 Workshops

Cybersecurity of Critical National Infrastructures - CCNI 2024

CCNI Session 1

WIP: Performance Metrics of PUF-Based Authentication Protocols for Smart Grid: A Review	1
<i>Taylah Griffiths (Edith Cowan University, Australia), Mohiuddin Ahmed (Edith Cowan University, Australia), and Shihao Yan (Edith Cowan University, Australia)</i>	

CCNI Session 2

An Enhanced Threat Intelligence Driven Hybrid Model for Information Security Risk Management	5
<i>Habib El Amin (Faculty of Engineering, CRSI, Lebanese University, Lebanon), Abed Ellatif Samhat (Faculty of Engineering, CRSI, Lebanese University, Lebanon), Maroun Chamoun (Ecole Supérieure d'Ingénieurs de Beyrouth, Saint Joseph University of Lebanon), Lina Oueidat (Faculty of Engineering, CRSI, Lebanese University, Lebanon), and Antoine Feghali (P.O.TECH Labs)</i>	
Survey and Experimentation to Compare IoT Device Model Identification Methods	13
<i>Norihiro Okui (KDDI Research, Inc., Japan), Masataka Nakahara (KDDI Research, Inc. Japan), and Ayumu Kubota (KDDI Research, Inc., Japan)</i>	

Preserving Data Integrity and Detecting Toxic Recordings in Machine Learning Using Blockchain	18
<i>Bechir Alaya (IRESCoMath - Gabes University, Tunisia), Tarek Moulahi (IRESCoMath - Gabes University, Tunisia), Salim El Khediri (IRESCoMath - Gabes University, Tunisia), and Suliman Aladhadh (Qassim University, Saudi Arabia)</i>	
Enhancing Cybersecurity Training Efficacy: A Comprehensive Analysis of Gamified Learning, Behavioral Strategies and Digital Twins	24
<i>Yagmur Yigit (Edinburgh Napier University, UK), Kitty Kioskli (trustilio B.V., Netherlands), Laura Bishop (Airbus Limited, UK), Nestoras Chouliaras (University of West Attica, Greece), Leandros Maglaras (Edinburgh Napier University, UK), and Helge Janicke (Edith Cowan University, Australia)</i>	

Smart Computing for Smart Cities - SC2 2024

Session 1: SC2 Session 1

Efficient Binary Task Offloading Optimization in Large-Scale IoT Networks via UAV-Enhanced Mobile Edge Computing	33
<i>Xiangdong Yang (University of Electronic Science and Technology of China, China), Huaiwen He (University of Electronic Science and Technology of China, Zhongshan Institute, China), Hong Shen (Central Queensland University, Australia), Aiguo Chen (University of Electronic Science and Technology of China, China), and Hui Tian (Griffith University, Australia)</i>	
Unveiling Behavioral Transparency of Protocols Communicated by IoT Networked Assets	39
<i>Savindu Wannigama (University of Peradeniya, Sri Lanka), Arunan Sivathanan (UNSW Sydney, Australia), Ayyoob Hamza (UNSW Sydney, Australia), and Hassan Habibi Gharakheili (UNSW Sydney, Australia)</i>	
Is Edge Computing Always Suitable for Image Analysis? An Experimental Analysis	45
<i>Francesca Righetti (University of Pisa, Italy), Carlo Vallati (University of Pisa, Italy), Nirmalya Roy (University of Maryland Baltimore County, USA), and Giuseppe Anastasi (University of Pisa, Italy)</i>	

Session 2: NTN 6G Session and SC2 Session 2

Performance Analysis of a Cognitive Radio Assisted Cooperative NOMA UAV System	51
<i>Thi My Chinh Chu (Blekinge Institute of Technology, Sweden) and Hans-Jürgen Zepernick (Blekinge Institute of Technology, Sweden)</i>	
Minimizing Age of Information: Adaptive Spectrum Sharing in Ultra-Reliable and Low-Latency eVTOL Communications	57
<i>Ishan Aryendu (Stevens Institute of Technology), Sudhanshu Arya (Vellore Institute of Technology), and Ying Wang (Stevens Institute of Technology)</i>	

Advancing Federated Learning: Optimizing Model Accuracy through Privacy-Conscious Data Sharing	64
<i>Rihab Saidi (University of Gabes, Tunisia), Tarek Moulahi (Qassim University, Saudi Arabia), Suliman Aladhadh (Qassim University, Saudi Arabia), and Salah Zidi (University of Gabes, Tunisia)</i>	

Security and Privacy of AR, VR, and XR: Challenges and Opportunities - SEPAR 2024

Session 1: Privacy Challenges in Extended Realities

Effect of Duration and Delay on the Identifiability of VR Motion	70
<i>Mark Roman Miller (Illinois Institute of Technology, USA), Vivek Nair (UC Berkeley, USA), Eugy Han (Stanford University, USA), Cyan DeVeaux (Stanford University, USA), Christian Rack (University of Würzburg, Germany), Rui Wang (Carnegie Mellon University, USA), Brandon Huang (UC Berkeley, USA), Marc Erich Latoschik (University of Würzburg, Germany), James F. O'Brien (UC Berkeley, USA), and Jeremy N. Bailenson (Stanford University, USA)</i>	
Threats of Extended Reality (XR) Applications to Teaching and Learning: Instructors' Perspectives	76
<i>Aidrina Sofiadin (International Islamic University Malaysia, Malaysia)</i>	

Session 2: Opportunities for Privacy in XR

Protecting Privacy: A Gateway to Freedom of Opinion and Expression in Virtual Reality	79
<i>Hinako Sugiyama (International Justice Clinic at the University of California, United States), Curtis Ferrarini (International Justice Clinic at the University of California, United States), and Eric Lau (International Justice Clinic at the University of California, United States)</i>	
Effect of Data Degradation on Motion Re-Identification	85
<i>Vivek Nair (UC Berkeley, USA), Mark Roman Miller (Illinois Institute of Technology, USA), Rui Wang (Carnegie Mellon University, USA), Brandon Huang (UC Berkeley, USA), Christian Rack (University of Würzburg, Germany), Marc Erich Latoschik (University of Würzburg, Germany), and James F. O'Brien (UC Berkeley, USA)</i>	
Towards Privacy-Preserving Mixed Reality: Legal and Technical Implications	91
<i>Juliane Mendelsohn (Technische Universität Ilmenau, Germany), Stephan Werner (Technische Universität Ilmenau, Germany), Philipp Richter (Max Planck Institute Collective Goods, Germany), Thomas Köllmer (Fraunhofer IDMT, Germany), Tobias Schwandt (Technische Universität Ilmenau, Germany), and Wolfgang Broll (Technische Universität Ilmenau, Germany)</i>	
Multiclass AUC for Comparison of Identification Effectiveness Across Classification Set Sizes	97
<i>Mark Roman Miller (Illinois Institute of Technology, USA)</i>	

Metaverse-6G Convergence: Enabling Future Networking - M6CEN 2024

A Hybrid NFV/In-Network Computing MANO Architecture for Provisioning Holographic Applications in the Metaverse	99
<i>Farzaneh Ghasemi Javid (Concordia University, Canada), Mouhamad Dieye (Université du Québec À Montréal, Canada), Felipe Estrada-Solano (Concordia University, Canada), Roch H. Glitho (Concordia University, Canada), Halima Elbiaze (Université du Québec À Montréal, Canada), and Wessam Ajib (Université du Québec À Montréal, Canada)</i>	
First Steps Towards Game and Activity Inference on Encrypted VR Datastreams	105
<i>Yushan Yang (Haptic Communication Systems, TU Dresden, Germany), Simon Hanisch (KASTEL Security Research Labs, Karlsruhe Institute of Technology, Germany; Centre for Tactile Internet with Human-in-the-Loop (CeTI)), Mingyu Ma (Haptic Communication Systems, TU Dresden, Germany; Centre for Tactile Internet with Human-in-the-Loop (CeTI)), Stefanie Roos (University of Kaiserslautern-Landau, Germany), Thorsten Strufe (KASTEL Security Research Labs, Karlsruhe Institute of Technology, Germany; Centre for Tactile Internet with Human-in-the-Loop (CeTI)), and Giang Nguyen (Haptic Communication Systems, TU Dresden, Germany; Centre for Tactile Internet with Human-in-the-Loop (CeTI))</i>	
Securing the Metaverse: Traffic Application Classification and Anomaly Detection	111
<i>Vishal Murgai (F5 Networks), Venkata Rama Raju Lolabhattu (F5 Networks), Roxy Stimpson (F5 Networks), Eishita Tripathi (F5 Networks), and Shiva Chickala (F5 Networks)</i>	
LSTM-GRU Based Efficient Intrusion Detection in 6G-Enabled Metaverse Environments	118
<i>Brij B. Gupta (Asia University, Taiwan), Akshat Gaurav (Ronin Institute, USA), Varsha Arya (Asia University, Taiwan), and Kwok Tai Chui (Hong Kong Metropolitan University (HKMU), Hong Kong)</i>	
Enhanced Virtual Try-On in the Metaverse Leveraging Unet Model for Improved Cloth Detection	124
<i>Akshat Gaurav (Ronin Institute, USA), Varsha Arya (Asia University, Taiwan), Kwok Tai Chui (Hong Kong Metropolitan University (HKMU), Hong Kong), and Brij B. Gupta (Asia University, Taiwan)</i>	

WoWMoM 2024 Technical Sessions

Technical Session 1: Machine Learning

Signal as Point: Deep Learning Signal Detector on Time Domain	130
<i>Chengzhi Ji (Institute of Software Chinese Academy of Sciences, China; University of the Chinese Academy of Sciences, China) and Xin Xhou (Institute of Software Chinese Academy of Sciences, China; University of the Chinese Academy of Sciences, China)</i>	
A Graph Neural Network Power Allocation Algorithm Based on Fully Unrolled WMMSE	138
<i>ChunWei Miao (Central South University, China), Jian Zhang (Central South University, China), JiaQi Huang (Central South University, China), and JinHong Yang (Central South University, China)</i>	

Dependable Distributed Training of Compressed Machine Learning Models	147
<i>Francesco Malandrino (CNR-IEIIT, Italy; CNIT, Italy), Giuseppe Di Giacomo (Politecnico di Torino, Italy), Marco Levorato (UC Irvine, USA), and Carla Fabiana Chiasserini (Politecnico di Torino, Italy; CNR-IEIIT, Italy; CNIT, Italy; Chalmers University of Technology, Sweden)</i>	

Technical Session 2: Cellular Networks

ADDeR: Service-Specific Adaptive Data-Driven Radio Resource Control for Cellular-IoT	157
<i>Yingjing Wu (University of Utah, Salt Lake City, Utah), Ahmed Elmokashfi (Simula Metropolitan CDE, Oslo, Norway), Foivos Michelinakis (Simula Metropolitan CDE, Oslo, Norway), Jacobus Van der Merwe (University of Utah, Salt Lake City, Utah), and Shandian Zhe (University of Utah, Salt Lake City, Utah)</i>	
Cluster-Then-Match: Efficient Management of Human-Centric, Cell-Less 6G Networks	167
<i>E. Chiaramello (CNR-IEIIT, Italy; CNIT, Italy), C. F. Chiasserini (Politecnico di Torino, Italy; CNIT, Italy), F. Malandrino (CNR-IEIIT, Italy; CNIT, Italy), A. Nordio (CNR-IEIIT, Italy; CNIT, Italy), M. Parazzini (CNR-IEIIT, Italy; CNIT, Italy), and A. Valcarce (Nokia Bell Labs, France)</i>	
On the Impact of 5G User Equipments on Latency Across Chipset Generations	177
<i>Mauri Seidel (Dresden University of Technology, Germany), Andreas Ingo Grohmann (Dresden University of Technology, Germany), Christopher Lehmann (Dresden University of Technology, Germany), Justus Rischke (Dresden University of Technology, Germany), and Frank H.P. Fitzek (Dresden University of Technology, Germany; Centre for Tactile Internet with Human-in-the-Loop (CeTI))</i>	

Technical Session 3: Wireless Networks 1

DC-PPO for Joint User Association and Power Allocation in Dynamic Indoor Hybrid VLC/RF Networks	186
<i>Peijun Hou (Saint Louis University, USA) and Nan Cen (Saint Louis University, USA)</i>	
NaviSplit: Dynamic Multi-Branch Split DNNs for Efficient Distributed Autonomous Navigation... ..	196
<i>Timothy K Johnsen (University of California Irvine, USA), Ian Harshbarger (University of California Irvine, USA), Zixia Xia (University of California Irvine, USA), and Marco Levorato (University of California Irvine, USA)</i>	
RiSi: Spectro-Temporal RAN-Agnostic Modulation Identification for OFDMA Signals	202
<i>Daulet Kurmantayev (Tele2 Kazakhstan, Kazakhstan), Dohyun Kwun (Ulsan National Institute of Science and Technology (UNIST), Republic of Korea), Hyoil Kim (Ulsan National Institute of Science and Technology (UNIST), Republic of Korea), and Sung Whan Yoon (Ulsan National Institute of Science and Technology (UNIST), Republic of Korea)</i>	

Landmark-Based Localization using Stereo Vision and Deep Learning in GPS-Denied Battlefield Environment	209
<i>Ganesh Sapkota (Missouri University of Science and Technology, USA) and Sanjay Madria (Missouri University of Science and Technology, USA)</i>	
Effects of Lossy Compression on the Value of Information in a Low Powered Network	216
<i>Frederick M. Chache (The Pennsylvania State University, University Park, USA; Arcfield, USA), Caden Pici (U.S. Naval Research Laboratory, USA), and Ramesh Bharadwaj (U.S. Naval Research Laboratory, USA)</i>	
Evaluation and Optimization of Positional Accuracy for Maritime Positioning Systems	222
<i>Atilla Alpay Nalcaci (Technical University of Munich, Germany), Fidan Mehmeti (Technical University of Munich, Germany), Wolfgang Kellerer (Technical University of Munich, Germany), and Florian Schiegg (Covadonga GmbH, Germany)</i>	

Technical Session 4: Physical Layer

Spectrum Painting for On-Device Signal Classification	229
<i>Bingyang Li (Institute of Information Engineering, Chinese Academy of Sciences, China; University of Chinese Academy of Sciences, China), Weiqing Huang (Institute of Information Engineering, Chinese Academy of Sciences, China), Wen Wang (Institute of Information Engineering, Chinese Academy of Sciences, China), and Qing Wang (Delft University of Technology, The Netherlands)</i>	
Optimizing Ray Tracing Techniques for Generating Large-Scale 3D Radio Frequency Maps	239
<i>Bernard Tamba Sandouno (Inria, Université Côte d'Azur, France; ZoneADSL & FIBRE, France), Chadi Barakat (Inria, Université Côte d'Azur, France), Thierry Turetletti (Inria, Université Côte d'Azur, France), and Walid Dabbous (Inria, Université Côte d'Azur, France)</i>	
Predictability of LoRaWAN Link Quality Based on Weather Data: Insights from a Long-Term Study	249
<i>Daniel Szafranski (Clausthal University of Technology, Germany)</i>	

Technical Session 5: Transport and Routing

EABC: Energy-Aware Centrality-Based Caching for Named Data Networking in the IoT	259
<i>Xingyun He (Inner Mongolia University, China), Hu Liu (Inner Mongolia University, China), Wuyungerile Li (Inner Mongolia University, China), Alvin Valera (Victoria University of Wellington, New Zealand), and Winston K.G. Seah (Victoria University of Wellington, New Zealand)</i>	
DCP: A TCP-Inspired Method for Online Domain Adaptation Under Dynamic Data Drift	269
<i>Alessandro Buratto (University of Padova, Italy), Marco Levorato (Donald Bren School of Information and Computer Science, California), and Leonardo Badia (University of Padova, Italy)</i>	
Improving TCP Slow Start Performance in Wireless Networks with SEARCH	279
<i>Maryam Ataei Kachooei (Worcester Polytechnic Institute, USA), Jae Chung (Viasat, USA), Feng Li (Viasat, USA), Benjamin Peters (Viasat, USA), Joshua Chung (Lexington Christian Academy, USA), and Mark Claypool (Worcester Polytechnic Institute, USA)</i>	

Deep Reinforcement Learning Based Resource Allocation Method in Future Wireless Networks with Blockchain Assisted MEC Network	289
<i>Prakhar Consul (Bennett University, India), Ishan Budhiraja (Bennett University, India), Deepak Garg (SR University, India), Sachin Sharma (State Bank of India, India), and Ammar Muthanna (Friendship University of Russia (RUDN University), Russia)</i>	

Posters/Demos/Graduate Forum

Poster: Unified Fog Node Utilization for Multiple Content Providers through Cluster-Based Cooperative Caching	295
<i>Ferdous Sharifi (Macquarie University, Australia; Sharif University of Technology, Iran), Young Choon Lee (Macquarie University, Australia), and Shaahin Hessabi (Sharif University of Technology, Iran)</i>	
Poster: Cloud Computing with AI-Empowered Trends in Software-Defined Radios: Challenges and Opportunities	298
<i>Ekta Sharma (University of Southern Queensland, Australia), Ravinesh C. Deo (University of Southern Queensland, Australia), Christopher P. Davey (University of Southern Queensland, Australia), Brad D. Carter (University of Southern Queensland, Australia), and Sancho Salcedo-Sanz (Universidad de Alcalá, Spain)</i>	
Poster: Integration of Wearable and Affective Computing via Abstraction and Decision Fusion Architecture	301
<i>Mohammadreza Najafi (Chosun University, South Korea), Mohammad K Fallah (Chosun University, South Korea), Saeid Gorgin (Chosun University, South Korea), Ghassem Jaberipur (Chosun University, South Korea), and Jeong-A Lee (Chosun University, South Korea)</i>	
Demo: P4 Based In-Network ML with Federated Learning to Secure and Slice IoT Networks	304
<i>Chamara Madarasingha (University of New South Wales, Australia), Thilini Dahanayaka (The University of Sydney, Australia), Kanchana Thilakarathna (The University of Sydney, Australia), Suranga Seneviratne (The University of Sydney, Australia), Young Choon Lee (University of Macquarie, Australia), Salil S Kanhere (University of New South Wales, Australia), Albert Y. Zomaya (The University of Sydney, Australia), Aruna Seneviratne (University of New South Wales, Australia), and Phil Ridley (IoT Factory, Australia)</i>	
Optimizing Ray Tracing Techniques for Generating Large-Scale 3D Radio Frequency Maps	307
<i>Bernard Tamba Sandouno (Inria, Université Côte d'Azur, France; ZoneADSL & FIBRE, France), Chadi Barakat (Inria, Université Côte d'Azur, France), Thierry Turletti (Inria, Université Côte d'Azur, France), and Walid Dabbous (Inria, Université Côte d'Azur, France)</i>	
Ph.D. Forum: Multi-Agent Reinforcement Learning in Wireless Network Communication	317
<i>Sabrina Pochaba (Salzburg Research Forschungsgesellschaft mbH, Austria; University of Salzburg, Austria), Peter Dorfinger (Salzburg Research Forschungsgesellschaft mbH, Austria), Matthias Herlich (Salzburg Research Forschungsgesellschaft mbH, Austria), Roland Kwitt (University of Salzburg, Austria), and Simon Hirlaender (University of Salzburg, Austria)</i>	

Technical Session 6: Localisation, Tracking, and Navigation

Leveraging the Movements of Occupants to Generate Indoor Maps Using RF Signals	319
<i>Usman Mahmood Khan (North Carolina State University, USA) and Muhammad Shahzad (North Carolina State University, USA)</i>	
Informative and Communication-Efficient Multi-Agent Path Planning for Pollution Plume Monitoring	329
<i>Mohamed Sami Assenine (INSA Lyon, Inria, France), Walid Bechkit (INSA Lyon, Inria, France), and Hervé Rivano (INSA Lyon, Inria, France)</i>	
Noisy Labels Make Sense: Data-Driven Smartphone Inertial Tracking without Tedious Annotations	339
<i>Yuefan Tong (Tianjin University, China), Jiankun Wang (Tianjin University, China), Zenghua Zhao (Tianjin University, China), Jiayang Cui (Tianjin University, China), and Bin Wu (Tianjin University, China)</i>	

Technical Session 7: Wireless Networks 2

ALI-DPFL: Differentially Private Federated Learning with Adaptive Local Iterations	349
<i>Xinpeng Ling (East China Normal University, China), Jie Fu (East China Normal University, China), Kuncan Wang (East China Normal University, China), Haitao Liu (East China Normal University, China), and Zhili Chen (East China Normal University, China)</i>	
WIP: An Open Data Set about Multi-Provider Redundancy in Cellular Networks	359
<i>Sabrina Pochaba (Salzburg Research Forschungsgesellschaft mbH, Austria), Christian Maier (Salzburg Research Forschungsgesellschaft mbH, Austria), Matthias Herlich (Salzburg Research Forschungsgesellschaft mbH, Austria), and Peter Dorfinger (Salzburg Research Forschungsgesellschaft mbH, Austria)</i>	
Queueing Theoretical Performance Assessment of Mobile Virtual Reality Video Streaming	363
<i>Thi My Chinh Chu (Blekinge Institute of Technology, Sweden) and Hans-Jürgen Zepernick (Blekinge Institute of Technology, Sweden)</i>	
PROMPT: Prediction of Channel Metrics for Proactive Optimization in Cellular Networks	370
<i>Subhramoy Mohanti (InterDigital Communications, Inc., USA), Akshay Malhotra (InterDigital Communications, Inc., USA), Muhammad Umar Bin Farooq (University of Oklahoma, USA), and Jaideep Chandrashekar (InterDigital Communications, Inc., USA)</i>	
TuplePick: A High Stability Packet Classification Based on Neural Network	377
<i>Zhuo Li (Tianjin University, China), Tongtong Wang (Tianjin University, China), Jindian Liu (Tianjin University, China), Yu Zhang (Harbin Institute of Technology, China), Tianxiang Ma (State Grid Hebei Electric Power Research Institute, China), and Kaihua Liu (Tianjin Ren'ai College, China)</i>	
On the k-Weak Coverage of Random Mobile Sensors	383
<i>Sajal K. Das (Missouri University of Science and Technology, USA) and Rafał Kapelko (Wrocław University of Science and Technology, Poland)</i>	

Author Index 391