Guest Editorial >>>

Special Topic on Advancements in Web3 Infrastructure for the Metaverse

Guest Editors

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Web3, also known as Web 3.0, has recently been attracting increasing attention from industry and academia. Leveraging the potential of blockchain technologies, Web3 has emerged as a pivotal foundation in the realm of metaverse development, which is considered by many as the next-generation Internet. Specifically, Web3 technologies such as smart contracts and protocols like non-fungible tokens (NFTs) have supported the immersive and content-rich experience of current Web3 metaverse projects. In addition, the decentralized autonomous organization (DAO) based on Web3 technologies has built the prototype of the future virtual society. Besides, many advanced breakthroughs in Web3 infrastructure for the metaverse have become accessible to the general public. Despite its significance, Web3 encounters several technical challenges that require attention, such as enhancing network and communication capabilities, designing efficient consensus protocols, and addressing human-centric factors in system designs and evaluations. Moreover, as an infrastructure for the metaverse, there are many research topics that are imperative to be addressed. For example, the existing NFT standards cannot well satisfy the interoperability and scalability of digital assets in the Web3 metaverse; the tokenomics system in the Web3 metaverse needs better token liquidity and balancing; the virtual identity in the Web3 metaverse is facing challenges of privacy and security. Therefore, the current development of Web3 infrastructure for the metaverse is still in its early stage, and several research directions are waiting for further study. This special issue of *ZTE Communications* aims to explore the state-of-the-art development in Web3 infrastructure dedicated to empowering the metaverse.

In this editorial, we will navigate through the key themes and insights offered by the accepted papers, each contributing a unique perspective to the ongoing discourse surrounding Web3 infrastructure for the metaverse.

The first paper titled "Building a Stronger Foundation for Web3: Advantages of 5G Infrastructure" delves into the multifaceted advantages of integrating 5G into the fabric of Web3. By leveraging its advancements in network speed, edge computing, capacity, security, and power efficiency, the authors underscore how 5G offers a robust foundation for the decentralized future of the internet. Through a comprehensive technical review, they elucidate the symbiotic relationship between 5G infrastructure and the transformative potential of Web3 technologies, laying the groundwork for enhanced user experiences and seamless connectivity within the metaverse.

The second paper titled "MetaOracle: A High-Throughput Decentralized Oracle for Web3.0-Empowered Metaverse" presents a pioneering approach to addressing the challenges associated with decentralized oracles in the Web3 metaverse. This paper introduces MetaOracle, a novel architecture designed to provide high-throughput, reliable data for blockchain-based applications. By leveraging a multi-identifier network (MIN) framework, MetaOracle mitigates risks associated with data integrity, offering increased reliability and throughput crucial for the seamless operation of Web3 metaverse applications. Through experimental validation, the authors demonstrate the efficacy of their approach in enhancing the trustworthiness and efficiency of oracles, thereby catalyzing the development of robust decentralized ecosystems

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within the metaverse.

In the third paper titled "Optimization of High-Concurrency Conflict Issues in Execute-Order-Validate Blockchain," the authors delve into the scalability challenges inherent in blockchain architectures, particularly pertinent in the context of Web3 metaverse applications. Their paper proposes a novel approach based on MIN to address high-concurrency conflict issues in Execute-Order-Validate (EOV) blockchains. Through a meticulous analysis of consensus protocols and transaction processing mechanisms, the authors highlight the scalability and reliability benefits of their proposed architecture. Through empirical evaluation, they demonstrate significant enhancements in throughput and reliability, laying the groundwork for a more efficient and scalable Web3 infrastructure capable of supporting the diverse demands of the metaverse ecosystem.

The fourth paper titled "Utilizing Certificateless Cryptography for IoT Device Identity Authentication Protocols in Web3" proposes a decentralized authentication protocol tailored for IoT devices within the Web3 metaverse. This paper introduces a novel approach that integrates certificateless cryptography and physically unclonable functions to ensure robust security and privacy in the Internet of Things (IoT) networks. By leveraging blockchain technology, the proposed protocol distributes authentication services to edge authentication gateways and servers, mitigating risks associated with centralization and single points of failure. Through a comprehensive analysis of security threats and attack vectors, the authors demonstrate the effectiveness of their protocol in safeguarding the integrity and confidentiality of IoT device identities within the evolving landscape of the metaverse.

The fifth paper titled "Hierarchical Federated Learning Architectures for the Metaverse" explores the paradigm of Hierarchical Federated Learning (HFL) as a distributed machine learning approach ideally suited for the metaverse environment. This paper presents a comprehensive analysis of existing federated learning architectures and proposes a three-layer client-edge-cloud architecture tailored for the unique requirements of the metaverse. By leveraging hierarchical organization and edge computing capabilities, HFL offers scalability and privacy-preserving properties crucial for collaborative learning within decentralized environments. Through empirical evaluation and case studies, the authors highlight the potential of HFL to enable collaborative learning and knowledge sharing within the metaverse, paving the way for innovative applications and services.

Collectively, these contributions epitomize the interdisciplinary nature of Web3 infrastructure research, spanning advanced networking technologies, decentralized architectures, security mechanisms, and machine learning paradigms. As we delve deeper into the possibilities of the metaverse, it becomes evident that collaboration and innovation are paramount in realizing its full potential. Looking ahead, the journey towards a fully realized Web3 metaverse is fraught with challenges and opportunities alike. From enhancing network scalability to fostering inclusive and privacy-preserving ecosystems, the road ahead demands concerted efforts from researchers, developers, and industry stakeholders.

As guest editors, we extend our gratitude to the authors for their invaluable contributions and insights, as well as to the reviewers for their meticulous evaluations. We are also grateful for the conscientious and timely support of the staff of the ZTE Communications editorial office. We hope that this special issue serves as a catalyst for further exploration and collaboration in the dynamic landscape of Web3 infrastructure for the metaverse. Together, let us embark on this transformative journey towards a decentralized, interconnected, and immersive digital future.

Biographies

Victor C.M. LEUNG received the BASc (Hons.) and PhD degrees in electrical engineering from The University of British Columbia (UBC), Canada in 1977 and 1981, respectively. Dr. LEUNG is the Dean of the Artificial Intelligence Research Institute and a Professor of Engineering at Shenzhen MSU-BIT University, China, a Distinguished Professor of Computer Science and Software Engineering at Shenzhen University, China, and also an Emeritus Professor of Electrical and Computer Engineering and Director of the Wireless Networks and Mobile Systems (WiNMoS) Laboratory at UBC, Canada. His research is in the broad areas of wireless networks and mobile systems, and he has published widely in these areas. Dr. LEUNG is serving on the editorial boards of the *IEEE Transactions on Green Communications and Networking*, *IEEE Transactions on Computational Social Systems*, and several other journals. He received the 1977 APEBC Gold Medal, 1977-1981 NSERC Postgraduate Scholarships, IEEE Vancouver Section Centennial Award, 2011 UBC Killam Research Prize, 2017 Canadian Award for Telecommunications Research, 2018 IEEE TCGCC Distinguished Technical Achievement Recognition Award, and 2018 ACM MSWiM Reginald Fessenden Award. He co-authored papers that won the 2017 IEEE ComSoc Fred W. Ellersick Prize, 2017 IEEE Systems Journal Best Paper Award, 2018 IEEE CSIM Best Journal Paper Award, and 2019 IEEE TCGCC Best Journal Paper Award. He is a Life Fellow of IEEE, and a Fellow of the Royal Society of Canada (Academy of Science), Canadian Academy of Engineering, and Engineering Institute of Canada. He is named in the Clarivate Analytics lists of "Highly Cited Researchers" in the last four years.

CAI Wei received his PhD, MSc and BEng from The University of British Columbia (UBC), Canada, Seoul National University, Korea, and Xiamen University, China in 2016, 2011 and 2008, respectively. Dr. CAI is an Assistant Professor of Computer Engineering in the School of Science and Engineering at The Chinese University of Hong Kong, Shenzhen, China. He currently serves as the Director of the Human-Crypto Society Laboratory and the CUHK(SZ)-White Matrix Joint Metaverse Laboratory. Prior to joining CUHK-Shenzhen, he was a postdoctoral research fellow in the Wireless Networks and Mobile Systems (WiNMoS) Laboratory at UBC. He has also completed research visits at Academia Sinica (Taiwan), China, The Hong Kong Polytechnic University, China, and National Institute of Informatics, Japan. Dr. CAI has co-authored more than 100 journal/conference papers and received six best paper awards. His recent research interests focus on decentralized computing, including decentralized mechanisms, decentralized social computing, decentralized multimedia, and decentralized applications. He is an associate editor for *ACM Transactions on Multimedia Computing, Communications, and Applications* (TOMM), *IEEE Transactions on Computational Social Systems* (TCSS), and *IEEE Transactions on Cloud Computing* (TCC). He is a senior member of the IEEE and a member of the ACM.