An integrated platform for virtual ecosystems and wireless edge computing for Web 3.0

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Abstract : A core technology that enables Web 3.0 goals is blockchain, which offers security services by recording content decentralized and transparently. It is compatible with decentralized wireless edge computing designs. Analyzing the semantic information of contents that may accurately express the intended meanings without requiring a lot of resources is a promising paradigm. This study suggests a paradigm for unified blockchain-semantic ecosystems for Web 3.0 with wireless edge intelligence. We then present a semantic proof technique built on Oracle to enable Web 3.0's off-chain and on-chain interactions. In order to increase interaction efficiency and support Web 3.0, Oracle has developed an adaptable Deep Reinforcement Learning-based sharding technique. The next-generation Internet, known as Web 3.0, allows users to view, publish, and own content independently. The main driving forces behind it are blockchain, semantic communication, edge computing, and artificial intelligence because they can create value networks to implement participation economics based on participatory decision-making. By including blockchain, semantic extraction, and communication capabilities, it can precisely perform decentralized semantic sharing and information transfer. In this work, we propose a blockchain-based semantic exchange architecture to further achieve the advantages of semantic extraction and communication in Web 3.0. We initially attempt to tokenize semantic data into non-fungible tokens for semantic exchange in this system. (NFT). We employ Zero-Knowledge Proof to trade real semantic information without posting it first before accepting payment, in contrast to traditional NFT marketplaces. This makes it possible to trade in a fair and private manner.

Keywords: Blockchain, Web3.0, NFT, Edge computing, centralised server, Oracle

1 Literature Survey

This is described by Bella et al. [2] this paper aimed to formalize a semantic description of business transactions made possible by Ethereum blockchain smart contracts. Such a representation facilitates formal reasoning at a lower level as well as interlinking with other out-of-chain information in addition to being machine accessible. The automatic discovery of smart contracts, the connectivity of services operating on several blockchains (also known as cross-chain integration), and the integration of on-chain and off-chain services are all made possible by a semantic behavioristic perspective of blockchains. In this paper Lin et al. [8] , we've put out a comprehensive framework that links the blockchain and semantic ecologies for Web 3.0 services with wireless edge intelligence, preventing information overload for users. An Oracle-based proof-of-semantic technique is provided within the suggested framework to move on-chain computing to off-chain Oracle for ensuring service security. In addition, to increase interaction efficiency, we have created an adaptive DRL-based sharding technique on Oracle. Additionally, we've provided an example to demonstrate how the suggested framework works using simulation results. We have now covered the concerns that still need to be resolved as well as some potential remedies. Alkhateeb et al. [1] proposed that even while blockchain platforms that are excellent for security and transparency, not all the created data can be kept on them. To store the enormous amount of data that cannot be directly kept on the blockchain platform, it is typically necessary to employ a separate data warehouse. Recently, a lot of blockchain platforms and applications have been created leveraging the cloud as storage. Blockchain platforms are frequently accompanied by cloud data warehouses, which is referred to as hybrid blockchain platform because they cannot store all the created data. The use of both public and private blockchains in a single project offers another viewpoint for hybrid blockchain definitions. A hybrid blockchain can be entirely customized, where hybrid blockchain users can decide which transactions are made public or who can take part within the blockchain. According to the research report authored by Bhutta et al. [4], blockchain is a revolutionary technology that offers a foundation for the creation of distributed and secure applications for all fields outside of the financial markets. A few important application and development frameworks serve to illustrate the research advancements in consensus algorithms. A thorough discussion of open research opportunities is also conducted, which may serve to open the door for researchers to investigate the most difficult topics in the field of blockchain technology. In this paper, Lin et al. [9] discussed their knowledge of Web 3.0, Blockchain, and Semantic Communication as well as research gaps in these areas. In order to achieve this, we provide a fair and effective semantic trading framework for the participatory economy based on blockchain technology. In this concept, value networks are built by circulating semantic data in the blockchain via NFT. Then, using a Stackelberg game method, we evaluate the best pricing and buying tactics for counterparts transacting with semantic knowledge. We use the zero-knowledge proof and take into account fairness to enable genuine semantic sharing. A case study of urban planning is used to demonstrate the effectiveness of the suggested framework, and simulation results are used as well. Finally, the main issues, future research directions, and potential for blockchain and semantic communication in Web 3.0 are highlighted. In this paper, Chondrogiannis et al. [5] proposed a distributed application that enables users to negotiate with an HIO their health condition and compensation in the event of an injury. The distributed application is built on blockchain and semantic web technologies. On this basis, health contracts are signed and kept in the blockchain so that their terms cannot be altered. However, an external service (also known as Oracle) that may retrieve and evaluate the data associated with each individual performs the evaluation of contract terms based on the data gathered by the healthcare companies. The interesting technology of blockchain, according to Labazova et al. [7] study, promises to convert contracts, procedures, companies, and financial models into digital code that is recorded and shared in immutable, distributed ledgers and identified and verified by cryptographic signatures. The methodology takes into account the four areas of blockchain design, inter-organizational integration, blockchain applicability, and implementation environment while evaluating blockchain evaluation parameters. By highlighting their links and combining data on blockchain evaluation parameters, this study adds to the body of scientific knowledge. Farooq et al. [6] used a survey-based methodology in this research report to understand the most recent advancements in blockchain-acquainted SRE techniques. In two key areas, they have offered a thorough understanding of SRE methods related to blockchains. The first component includes SRE techniques used in blockchain engineering. While the idea of the SRE framework based on blockchain technology is encapsulated in the second element. The workflows that are shown illustrate the importance of using the model for SRE procedures. As discused by Ren et al. [10] ,the quantum blockchain and most Web 3.0 advancements have been covered in-depth in this article. They have mostly discussed the integration in terms of two aspects: optimizing internal technology and enhancing performance outside. Then, they discussed some potential Web 3.0 applications and tutorials for quantum blockchain technology. They have now covered a number of significant issues and future research directions for Web 3.0 development. In this research, Xu et al. [11] studied the quantum blockchain-driven Web 3.0 through the decentralization, scalability, and security benefits of quantum cryptography protocols in the blockchain. We have outlined the framework for a quantum blockchain-driven Web 3.0, which consists of supporting infrastructure, quantum cryptography protocols, and services based on quantum blockchains. Additionally, we have spoken about potential applications and difficulties with the suggested platform. Finally, a QDLA-based optimal auction has been suggested for enhancing fluidity in the NFT trading market based on the QNFT protocol based on QDPoS that has been explored as the use case. The effectiveness and efficiency of the suggested QDLA have been shown by the experimental findings. As studied by Bhattacharya et al. [3], the Metaverse is the medium for Web 3.0 users' future communication and engagement, and as such, it establishes the fundamental concepts around which the Future Internet will be based. High-tech businesses have recognized the Metaverse's promise and are taking proactive measures to make it a reality. Novel Metaverse-related techniques are being presented in various industrial applications in the research community because they improve the user experience in both the real and virtual worlds.

2 Problem Statement

There are numerous challenges in the development of a blockchain-semantic ecosystem. On the one hand, processing and exchanging substantial semantic information in the blockchain is challenging for wireless edge devices. Blockchain cannot actively invoke off-chain data to reach a consensus, which is the cause. Furthermore, semantic extraction techniques cannot be carried out by miners via smart contracts due to the limited availability and expensive nature of on-chain resources. On-chain and off-chain interactions are made insecure by these limitations. On the other hand, sending irrelevant data to consumers can use up fewer additional network resources thanks to a well-designed semantic verification system. The efficiency of distributed wireless edge computing systems is further hampered by the data exploration that is taking place in the Web 3.0 era. To take use of the many advantages of semantic communication, to keep services secure, and to boost interaction effectiveness. Therefore, before operating Web 3.0 services, it is required to audit the underlying codes of smart contracts and use federated learning or zero-knowledge proof to preserve security and privacy.

3 Introduction

The web has become an integral part of human life Worldwide since the unprecedented development of Wireless communication technologies from 4G, and 5G to 6G. There are three iterations of the web categorized Web 1.0, Web 2.0, and Web 3.0. Web 1.0 was created by Tim Berners-Lee [9] built his information network in 1989, Providing users with static resources for focused browsing architecture. The current web, or Web 2.0, is a coined term By Tim O'Reilly in 2007, available for users to read. Create dynamic content across distributed architectures and Form a social network. Recently, Web 3.0 has A promising concept as a next-generation information infrastructure based on the development of cutting-edge technology, e.g., Blockchain, semantic communications, and wireless edge computing. In Web 3.0, instead of implementing computation and data storage in centralized data centers, Distributed wireless edge computing architecture for offloading Compute and storage capacity to the wireless edge side user. More importantly, it can be read, written, and owned by the user. content. ,e.g., Decentralized text, images, and video wireless Edge Computing Architecture for Building Smarter and Smarter Networks A more socially and economically networked society. Secure data storage and efficient information interaction it has always been the focus of web research. To ensure the First Goal: Data Security, Blockchain-Based Web 3.0 Proposed by Ethereum co-founder Gavin Wood in 2014, extensive use of the blockchain ecosystem Enables user-generated content and user-selected permissions, especially in contrast to today's Web 2.0 content. Web 3.0 is controlled by tech giants without user involvement and permission, using blockchain to record its content on-chain decentralized, transparent, and easy to understand. In the meantime, Academia and industry agree that Web 3.0 should do this transparency, security, and efficiency. As a new generation of Internet applications Evolves, d.H. Metaverse, User Has Access to Her Web 3.0 Virtual avatar services provided by Metaverse. With the help of the integration of new technologies, web 3.0 can back up data information without user intervention from a third party. However, it comes at a high computational and memory cost Resources are consumed to record content information Web 3.0 Congestion Uses Massive Resources on WLANs It is an edge device and limits the number of devices covered in Web 3.0 network.

4 Preceding Methodological Framework

The authors of "A Blockchain smart contract based on the light-weighted quantum blind signature" [11] propose a smart contract-based architecture. Defend against quantum attacks on quantum networks based on quantum blind signatures. Theoretical analysis Based on the properties of the quantum signature scheme proposed in this article Quantum entanglement can be used for both single and multiple signatures, improving blockchain security Smart contracts against quantum attacks. First, the authors carefully analyze message processing and delivery of Quantum blind signature for this frame. Next, we describe the quantum blind signature lifecycle and signing rules for smart contracts. In addition, the authors describe the design and operation of the algorithm, We evaluate the security performance of algorithms and propose a quantum blind signature protocol for lightweight smart signature contracts. Finally, a more complex quantum blind signature algorithm based on the original single signature algorithm We analyzed the security performance of multiple signatures. In addition, Kai et al. [8] suggested a framework for multi-party transactions based on distributed quantum-blind multi-signatures. Within this framework, authors can initialize, sign, validate, and implement to provide a computationally efficient and scalable quantum blockchain solution. For blockchains that rely on smart contracts, the usefulness of smart contracts against quantum attacks can also be enhanced by post-quantum cryptography. Calvasi et al. [5] "Post-quantum end-to-end encryption with smart contract-based blockchains to combat man-in-the-middle and eavesdropping attacks" and eavesdropping attacks. In the recently proposed Logic Programming Using Post-Quantum Cryptographic Primitives for Smart Contracts in Quantum-Secure Blockchains for Using Logic-Based Smart Contract Programming Languages in Quantum-Secure Blockchain Frameworks, the authors write Smart contract design. The authors propose a logic-based smart contract programming language called Logicontract (LC). The language extends the logic used in LC with modern declarative logic programming techniques. The introduction of post-quantum signatures overcomes a particular limitation of LC that unconditionally secure signatures, despite their strength, offer only limited protection to users of the same node. The next step would be to consider using secure multi-party computing. Another goal is to extend the logic language with the original quantum language to create a programming language for quantum logic smart contracts. As an important application of cloud computing, Li and others consider the use of post-quantum blockchains for verifiable data ownership. To avoid single points of failure and partial trust caused by centralized external auditors. Grid-based, privacy-preserving, and auditable data ownership is enabled based on smart contracts. The analysis demonstrates the correctness, robustness, and performance of the proposed system through a series of interactive games.

5 Analytical Framework

To break the forenamed problems, we're the first to propose a unified blockchain- semantic ecosystems frame for wireless edge intelligence- enabled Web 3.0. The frame contains six crucial factors to consider the content semantics and exploit Oracle to integrate blockchain and off-chain semantic ecosystems. Our benefactions are epitomized as follows:

- To subsidize the great benefits of semantic communication, we propose a unified blockchain and semantic ecosystems frame for wireless edge intelligence enabled Web 3.0. To the best of our knowledge, this is the first work on wireless edge-intelligence-enabled Web 3.0. We believe that this is a timely study, as the blockchain and semantic ecosystems are extensively used in numerous scripts, like Metaverse.

- To maintain service security, we design an Oracle-grounded evidence of semantic medium to apply on-chain and off-chain relations and transfer on-chain semantic verification algorithms to out-chain Oracle for reaching an agreement on semantic information in approximately trusted surroundings.

- To ameliorate commerce effectiveness, we establish an adaptive DRL- grounded sharding medium for verifiers of Oracle to feed to varied semantic demands in dynamic Web 3.0 surroundings.

5.1 Oracle-based Proof of Semantic Mechanism

Since edge waiters are needed to render and de law semantic information in approximately trusted surroundings, blockchain is constructed among edge waiters(i.e., miners) for semantic information sharing. The semantic information has to be vindicated before being added to a blockchain due to the blockchain's scrap- in scrap- eschewal challenge. still, the semantic verification algorithm enforced in edge waiters will affect inconsistent results due to different background knowledge, which is delicate for miners to corroborate semantic information and reach an agreement. either, since blockchain requires all miners to repeat smart contracts to corroborate correctness, it's insolvable to execute complex on-chain semantic verification algorithms. also, semantic verification algorithms bear participated knowledge inout-chain storehouses to corroborate semantic information, while blockchain can not laboriously bring out-chain knowledge to do with the process. thus, we transfer on-chain semantic verification to out-chain Oracle to total and corroborate semantic information from different knowledge and report added up semantic information to the blockchain to reach an agreement. Oracle is also a decentralized network composed of edge waiters(verifiers). Oracle is needed to emplace smart contracts(Oracle Contract) in advance for verifiers to subscribe to semantic tasks. New content can be written into smart contracts(stoner Contract) and bring interfaces handed by Oracle Contract to do with semantic tasks. Verifiers hear to events touched off by Oracle Contract and execute semantic verification algorithms to corroborate semantic information. Since there are multiple verifiers with different background knowledge, it's hard for the verifiers to gain the same result about semantic verification. thus, there are out-chain and on-chain aggregation mechanisms to maintain the delicacy of semantic information.

6 Module Overview

- Introduction to Web 3.0: This topic provides an overview of Web 3.0, including its definition, characteristics, and potential impact on the future of the Internet. It may explore the evolution of the web from Web 1.0 (static web) to Web 2.0 (interactive web) and the emerging trends and technologies that are shaping Web 3.0.

- Virtual Ecosystems: This topic delves into the concept of virtual ecosystems, which involves the integration of virtual and physical environments to create immersive and interactive experiences. It may cover the key features of virtual ecosystems, such as virtual reality (VR), augmented reality (AR), and mixed reality (MR), and their applications in the context of Web 3.0. It may also explore the challenges and opportunities associated with building and managing virtual ecosystems.

- Wireless Edge Computing: This topic focuses on the concept of wireless edge computing, which refers to the computation and data processing that takes place at the edge of the network, closer to the end-users and devices. It may cover the advantages of edge computing, such as reduced latency, improved scalability, increased privacy and security, and its relevance in the context of Web 3.0. It may also discuss the challenges and limitations of wireless edge computing, such as resource constraints, network connectivity, and data management.

- Integration of Virtual Ecosystems and Wireless Edge Computing: This topic explores the benefits, challenges, and opportunities associated with integrating virtual ecosystems and wireless edge computing for Web 3.0. It may discuss how virtual ecosystems can leverage edge computing to enhance their performance, interactivity, and responsiveness. It may also address the challenges and considerations involved in integrating virtual ecosystems and edge computing, such as interoperability, data synchronization, and security.

- Existing Research and Platforms: This topic reviews relevant literature and existing platforms related to virtual ecosystems, wireless edge computing, and Web 3.0. It may cover state-of-the-art research, technologies, and frameworks in the field, as well as their strengths and limitations. It may also highlight real-world examples of applications or use cases that have leveraged integrated platforms for virtual ecosystems and wireless edge computing in the context of Web 3.0.

- Applications and Use Cases: This topic explores the potential applications and use cases of an integrated platform for virtual ecosystems and wireless edge computing for Web 3.0. It may cover various domains such as healthcare, gaming, education, entertainment, and smart cities, where the integration of virtual ecosystems and edge computing can enable new and innovative services. It may also discuss the benefits, challenges, and future prospects of these applications and use cases.

- Conclusion and Future Directions: This topic summarizes the key findings of the module, discusses the challenges and opportunities in the field of integrated platforms for virtual ecosystems and wireless edge computing for Web 3.0, and provides insights into future research directions and trends. It may encourage students or researchers to think critically and creatively about the potential of Web 3.0 and integrated platforms and to identify areas for further exploration and investigation.

7 Analyzing the Architecture for Wireless Edge Computing

The user layer, service layer, pragmatic layer, semantic layer, blockchain layer, and communication layer are among the six layers that make up the architecture of the integrated platform for virtual ecosystems and wireless edge computing for Web 3.0. Wireless edge devices that make up the user layer are resource-constrained and unable to do complicated semantic tasks. Users can immediately access Web 3.0 services without being aware of underlying technology thanks to the service layer, which offers users Web 3.0 services. The pragmatic layer organizes semantic ecosystem duties for Web 3.0, which enables a variety of semantic encoding and decoding demands. In order to efficiently compress and release semantic information, the term "semantic layer" refers to semantic ecosystems, which are made up of semantic transfer, semantic verification, semantic storage, and semantic communication. Decentralized ledgers, smart contracts, off-chain storage, and Oracle are used to construct the blockchain layer, which enables Web 3.0 services in a decentralized, safe, and transparent manner. Through the physical channel, the communication layer implements channel encoding and decoding to connect semantic information producers with consumers.

The workflow of the proposed design is explained in the following steps:

- Step 1: Propose new content. Through front-end interfaces of Web 3.0 services implemented on wireless edge devices, semantic information producers make new content available to consumers in the user layer. In Web 3.0, edge devices are low-cost IoT or wearables that have limited resources for transmitting and receiving semantic content.

- Step 2: Transmit new content. Through front-end interfaces, Web 3.0 services accept contents and send them to the pragmatic layer for semantic content encoding and decoding.

- Step 3: Process new content. Strong computational and storage capabilities are used by edge servers to encode and decode content in accordance with various semantic requirements and environmental knowledge from areas like image processing, computer vision, and natural language processing.

- Step 4: Circulate semantic ecosystems. Before identifying entity elements and logical relationships, each edge server that receives data initially looks for shared or local knowledge. They begin to train a new semantic model when the contents cannot be recognized by local or shared knowledge. Each edge server should be aware of communication-related surroundings before conducting semantic information encoding and decoding in order to increase the search speed of semantic knowledge. When interacting with the blockchain layer through the semantic channel, the encoded and decoded semantic contents can go forward with the semantic transfer, semantic verification, semantic storage, and semantic communication operations. Using digital asset management to manage content ownership is made available to users via semantic transfer. Users can use semantic verification to check whether semantic content accurately conveys the intended meanings. Users can shift computationally intensive semantic tasks to edge servers thanks to semantic storage. Users can exchange semantic content with common knowledge through semantic communication for more effective discussions.

- Step 5: Share semantic information. When semantic data is in off-chain storage provided by edge servers, it is actively recorded by blockchain through smart contracts installed by Oracle. An Oracle-based proof of semantic mechanism is necessary since blockchain cannot actively activate off-chain semantic information. Additionally, an adaptive DRL-based sharding strategy on Oracle is proposed to respond to the various semantic needs.

- Step 6: To communicate with semantic information producers and consumers, semantic information is delivered over physical means.

  The architecture below shows all the six steps which when integrated make a platform for virtual ecosystems and wireless edge computing.

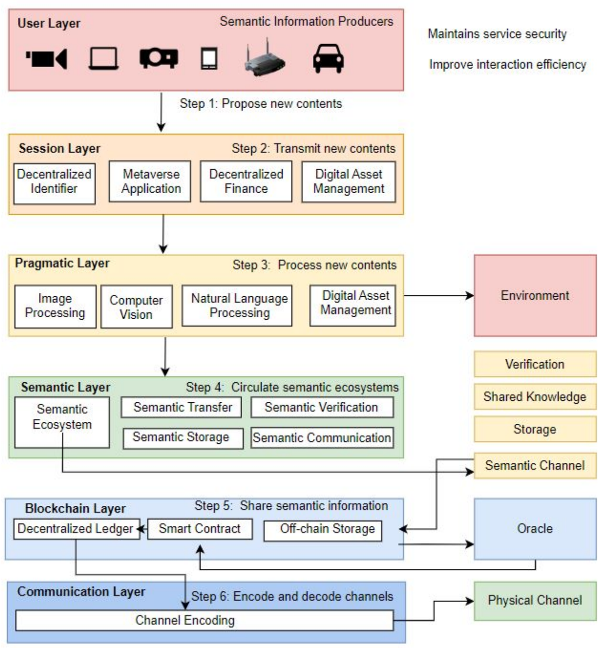

Figure 1: Architecture for Web 3.0's Wireless edge computing

8 Implementation Strategy

A key requirement for a semantic ecosystem is that all participants (including producers and consumers of semantic information) have the same or similar background knowledge, including semantic entity elements and logical relationships. In order to flexibly connect block-chains and semantic ecosystems, we need to solve the following challenges.

- How can blockchain layer Oracle verifiers be adapted to different semantic requirements?

- How can a static sharding strategy with defined fixed settings meet dynamic semantic requirements when creating multiple shards for Oracle verifiers?

Therefore, we propose a DRL-based sharding mechanism for creating or collapsing shards in various Web 3.0 settings where Oracle verifiers in the blockchain layer dynamically adapt to different types of semantic tasks, allowing validator transaction processing Speed can be improved with Oracle.

Since reviewers maintain a distributed deployment in Web 3.0, they cannot be scheduled using dynamic sharding strategies to reach consensus. Therefore, the choice of dynamic sharding strategy is realized by Oracle's leading verifier in the blockchain layer. If a leader implements the above process to get the best sharding settings, they can package the best settings into a message and send that message to other validators for consensus. Other validators check the message and extract the optimal settings to reach consensus on the sharding strategy.

Dynamic strategies related to various semantic requirements are used at the blockchain layer to improve the throughput (transaction processing speed) of validators from Oracle. Throughput is affected by message size propagated across the network, number of shards, average message size, and message processing time. Message processing time includes intrashard time, intershard time, and configuration time. Configuration time includes a sharding phase where the leader implements her DRL process to obtain optimal shard settings and reach consensus from other reviewers. Intra-shard time includes message propagation, validation delays, and maximum semantic processing time to complete semantic tasks. Inter-shard time is calculated using the ratio of message size and transfer rate when oracle verifiers send off-chain aggregated results to the blockchain for reward.

Considering the dynamic situation of Web 3.0, Oracle's Deep Q Learning Network (DQN) based verifier sharding mechanism is used to improve transaction speed. This action takes into account the number of nodes, message transfer rate and semantic processing time, and communication rounds to adapt to the dynamic Web 3.0 environment. The state takes into account the number of shards, the message size, the shard leader, and the consensus algorithm for responding to actions. Transaction speed is used as a reward for various states and actions.

DQN introduces Q-estimate and Q-target networks with the same structure. The reader interacts with her Web 3.0 environment to get state transitions (states, actions, rewards, next states) and stores them in the render buffer. If there are enough state transitions in the replay buffer, the leader randomly samples a mini-batch of transitions from the replay buffer to compute the Q-estimate and Q-target network rewards. Comparing reward differences updates the parameters of the Q-estimator network. After a few steps, the Q target network parameters are updated to get the optimal sharding settings.

To evaluate the performance of the proposed integration A Block chain Semantic Ecosystem Framework for the Wireless Edge Implement an intelligent Web 3.0 simulation A case based on the well-known Jim framework PyTorch showing rewards under different Web 3.0 conditions. In the simulation-built network, latency to configure shards, messages Validation delay, average message size, maximum Semantic processing time and minimum transfer rate 0.001 seconds, 0.1 seconds, 1 MB, 20 seconds and 10 Mbps respectively. We use PB-FT as an example to illustrate the message. run time = 2 *(number of nodes in shard) * (Number of nodes in shard 1) * message size / transfer rate. The leader's policy network employs a two-tier fully connected network. Network and ReLU activation functions. Its learning rate is discount rate, exploration rate, batch size, step intervals, training epochs are 0.002, 0.98, 0.1, 64, 10, or 1000. It also shows the performance of the proposed reward A framework for dynamic Web 3.0 configuration, including initial number of nodes [100,500,100] and maximum transfer rate [60,100,10]. The proposed frameworks are compared In the scheme currently in use, i.e. MaOEADRP with fixed shards (max number of shards) and message size (maximum message size). We can see it the proposed framework performs better than MaOEA-DRP In a different Web 3.0 setting. because it was suggested the framework can adaptive increase or decrease the count Shards and message sizes to accommodate different starting numbers Can increase the number of nodes and maximum transmission speed Rewards for the proposed framework.

9 Simulation Setup and Environment

This integrated platform's simulation environment is made up of a virtual ecosystem that replicates real-world situations. It consists of a wide variety of interconnected things, including users, devices, and apps. The virtual environment is created using various terrains, landscapes, and geographic features to mimic actual surroundings and give the simulations a genuine setting.

Users are simulated with different traits, behaviours, and preferences inside the virtual ecosystem. These users may represent a variety of people or entities, each having their own mobility habits, levels of activity, and preferences for using particular services or programs. The demand for edge computing resources is driven by user-generated traffic and interactions with the ecosystem.

Devices, which represent a variety of gadgets like smartphones, IoT gadgets, sensors, and edge computing nodes, are essential to the simulation. Realistic capabilities, communication protocols, and power limitations are present in these gadgets. Devices are connected wirelessly while taking into account signal quality, interference, and bandwidth restrictions. This makes it possible to assess how well the platform performs in a wireless communication setting.

A variety of Web 3.0 applications, such as augmented reality, machine learning, real-time data processing, and others are represented by the programmes operating on the devices. These programmes can dynamically transfer jobs to neighbouring edge computing nodes since they have varying resource requirements. Additionally modelled inside the environment are the deployment and operation of edge computing nodes.

Realistic edge computing scenarios are simulated by taking into account variables like resource availability, capacity, processor power, and task offloading choices. Simulated data and network traffic are produced within the ecosystem to mimic real-world events. Depending on the needs of the user and the application, the data's volume, kind, and attributes change. Additionally, the simulation contains dynamic components that affect how entities behave and the ecosystem as a whole, such as shifting network circumstances, shifting user needs, and environmental factors. Thus, the complexity and dynamics of a real-world Web 3.0 ecosystem are accurately reflected in the simulation.

Simulated data and network traffic are produced within the ecosystem to mimic real-world events. Depending on the needs of the user and the application, the data's volume, kind, and attributes change. Additionally, the simulation contains dynamic components that affect how entities behave and the ecosystem as a whole, such as shifting network circumstances, shifting user needs, and environmental factors. Thus, the complexity and dynamics of a real-world Web 3.0 ecosystem are accurately reflected in the simulation.

Performance indicators are established during the simulation in order to assess the integrated platform. Response time, latency, throughput, energy use, and resource utilisation are some of these indicators. To evaluate the platform's performance, pertinent data is gathered, including user behaviour, network statistics, application performance, and edge computing resource utilisation. The gathered data is then analysed to gain knowledge, spot bottlenecks, and assess how various factors affect the ecosystem. Techniques for visualisation may be used to effectively present the results.

A suitable simulation toolkit or framework, such ns-3, OMNeT++, or SimPy, can be used to make the simulation easier. These frameworks offer the architecture and resources required for creating and running the simulation. It can also be necessary to construct specialised simulation components, algorithms, and models to meet the needs of the integrated platform.

10 Comparative analysis of technical findings

Table 1: Comparative analysis of different Frameworks.

Author, year	Key Contributions	Architecture	User selected permission	Security Measures	Integration of additional ecosystem	Use of Blockchain
Bella et al.,2022 [2]	Formalise a semantic description of business transactions made possible by Ethereum blockchain smart contracts	No	No	High	No	Research
Lin et al., [8] 2023	An Oracle-based proof-of-semantic technique is provided within the suggested framework to move on-chain computing to off-chain Oracle for ensuring service security.	Yes	No	High	Yes	Production
Alkhateeb et al., [1] 2022	Hybrid blockchain customization, where hybrid blockchain users can decide which transactions are made public or who can take part within the blockchain	No	Yes	Low	No	Research

Bhutta et al., [4] 2021	A few important application and development frameworks serve to illustrate the research advancements in consensus algorithms.	Yes	No	Med	No	Research
Chondrogiannis et al., [5] 2022	Proposed a distributed application that enables users to negotiate with an HIO their health condition and compensation in the event of an injury.	Yes	No	Low	No	Production
Labazova et al., [7] 2019	Aims to convert contracts, procedures, companies, and financial models into digital code that is recorded and shared in immutable, distributed ledgers	Yes	Yes	High	Yes	Both
Farooq et al. [6] 2022	Used a survey-based methodology in this research report to understand the most recent advancements in blockchain-acquainted SRE techniques	No	No	Med	Yes	Research

11 Results

The proposed integrated platform for virtual ecosystems and wireless edge computing for Web 3.0 offers users digital asset management, semantic verification, semantic storage, and semantic communication in a decentralized, safe, and transparent manner. The platform enables edge servers to encode and decode semantic content in accordance with various semantic requirements and environmental knowledge, providing users with Web 3.0 services without being aware of the underlying technology. Further research can be done to evaluate the performance of the proposed platform in terms of efficiency, scalability, and security.

12 Conclusion

In conclusion, creating an integrated platform for wireless edge computing and virtual ecosystems is a big step towards making Web 3.0 a reality. This ground-breaking technology combines the capabilities of wireless edge computing with the strength of virtual ecosystems, where various digital entities connect and collaborate, to enable effective and decentralised data processing.

The platform promotes a dynamic and interconnected environment where people, programmes, and gadgets can easily interact by utilising virtual ecosystems. This promotes teamwork, creativity, and the sharing of ideas, which ultimately results in the development of new products and experiences.

By offering computational resources and data processing capabilities at the network edge, wireless edge computing plays a significant role in this integrated platform. Real-time analysis and decision-making are possible thanks to the reduction in latency that results from relocating computing capacity closer to the location where data is generated. The efficiency and scalability of programmes are improved by this distributed method, allowing them to manage massive volumes of data and provide quicker reaction times.

Numerous opportunities for Web 3.0 are made possible by the platform's integration of virtual ecosystems and wireless edge computing. It makes it possible to create programmes that are aware of their context and can instantly adjust to the needs and preferences of users. It makes it easier to create intelligent services that can look at and react to data streams coming from different sources, like IoT devices, sensors, and social media.

Additionally, by eliminating dependency on centralised servers and infrastructure, this integrated platform encourages the decentralisation and democratisation of the internet. Edge computing resources and dispersed networks are utilised to enable people and organisations to actively contribute to the development and evolution of the digital world.

An integrated platform for wireless edge computing and virtual ecosystems would be a big step towards the Web 3.0. It creates new opportunities for cooperation, creativity, and decentralised computing, ultimately changing how we interact with digital spaces and releasing the internet's full potential.

13 Future Scope

- Web 3.0 security and privacy

  As mentioned in above, the blockchain and semantic ecosystem play an important role in the proposed framework. Security and privacy issues with these components can have serious consequences. For example, DeFi lost at least 10 billion dollars to hacks and fraud in his 2021. Additionally, attackers can inject toxic knowledge into the semantic ecosystem to subvert the framework. Therefore, before running Web 3.0 services, the underlying code of smart contracts should be examined to protect security and privacy using federated learning or zero-knowledge evidence.

- Web 3.0 management and integration

  Because the semantic layer requires local and shared knowledge from edge servers to encode and decode semantic information, heterogeneous knowledge specifications for wireless edge intelligence-enabled Web 3.0 services must be managed. The proposed framework uses a dynamic sharding mechanism to categorize the same semantic requirements and solve the above problems. It also requires some mathematical model for semantic information to unify knowledge specifications. The proposed framework should also integrate new technologies such as 6G and quantum computing to significantly improve communication and computing capabilities.

- Web 3.0 Scalability and Interoperability

  Blockchain throughput is limited by consensus algorithms. Additionally, there are at least 1,000 blockchain networks with heterogeneous architectures. Therefore, the future Web 3.0 framework will maintain decentralization and integrate cross-chain technology into a unified blockchain semantic ecosystem framework to facilitate the circulation of Web 3.0 services across multiple blockchains, while maintaining network connectivity. Regardless of the amount, we need to build a more efficient consensus algorithm.

- Authentication and Governance for Web 3.0

  Web 3.0 allows users to read, write and own content. To share the value of data, it must be easy to exchange data. Therefore, we need to allow data governance in blockchain and semantic ecosystems. However, in Web 3.0, the decentralization of transaction partners makes it difficult to verify the authenticity of data. In addition, data can be easily copied in Web 3.0. Therefore, Web 3.0 requires secure multi-party computation to implement data governance in blockchain and semantic ecosystems.

The proposed integrated platform for virtual ecosystems and wireless edge computing for Web 3.0 offers users digital asset management, semantic verification, semantic storage, and semantic communication in a decentralized, safe, and transparent manner. The platform enables edge servers to encode and decode semantic content in accordance with various semantic requirements and environmental knowledge, providing users with Web 3.0 services without being aware of the underlying technology. Further research can be done to evaluate the performance of the proposed platform in terms of efficiency, scalability, and security.

References

[1] A. Alkhateeb, C. Catal, G. Kar, and A. Mishra. Hybrid blockchain platforms for the internet of things (iot): A systematic literature review. *Sensors*, 22(4):1304, 2022.

[2] G. Bella, D. Cantone, M. N. Asmundo, and D. F. Santamaria. A behaviouristic semantic approach to blockchain-based e-commerce, 2022.

[3] P. Bhattacharya, D. Saraswat, D. Savaliya, S. Sanghavi, A. Verma, V. Sakariya, S. Tanwar, R. Sharma, M. S. Raboaca, and D. L. Manea. Towards future internet: The metaverse perspective for diverse industrial applications. *Mathematics*, 11(4):941, 2023.

[4] M. N. M. Bhutta, A. A. Khwaja, A. Nadeem, H. F. Ahmad, M. K. Khan, M. A. Hanif, H. Song, M. Alshamari, and Y. Cao. A survey on blockchain technology: Evolution, architecture and security. *Ieee Access*, 9:61048–61073, 2021.

[5] E. Chondrogiannis, V. Andronikou, E. Karanastasis, A. Litke, and T. Varvarigou. Using blockchain and semantic web technologies for the implementation of smart contracts between individuals and health insurance organizations. *Blockchain: Research and Applications*, 3(2):100049, 2022.

[6] M. S. Farooq, M. Ahmed, and M. Emran. A survey on blockchain acquainted software requirements engineering: Model, opportunities, challenges, and future directions. *IEEE Access*, 10:48193–48228, 2022.

[7] O. Labazova. Towards a framework for evaluation of blockchain implementations. *Blockchain: Research and Applications*, 2019.

[8] Y. Lin, Z. Gao, H. Du, D. Niyato, J. Kang, R. Deng, and X. S. Shen. A unified blockchain-semantic framework for wireless edge intelligence enabled web 3.0. *IEEE Wireless Communications*, 2023.

[9] Y. Lin, Z. Gao, Y. Tu, H. Du, D. Niyato, J. Kang, and H. Yang. A blockchain-based semantic exchange framework for web 3.0 toward participatory economy. *arXiv preprint arXiv:2211.16662*, 2022.

[10] X. Ren, M. Xu, D. Niyato, J. Kang, Z. Xiong, C. Qiu, and X. Wang. Building resilient web 3.0 with quantum information technologies and blockchain: An ambilateral view. *arXiv preprint arXiv:2303.13050*, 2023.

[11] M. Xu, X. Ren, D. Niyato, J. Kang, C. Qiu, Z. Xiong, X. Wang, and V. Leung. When quantum information technologies meet blockchain in web 3.0. *arXiv preprint arXiv:2211.15941*, 2022.

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