GEORGE BROWN PRESS
JOURNALS, BOOKS & PROCEEDINGS

Journal of Computer, Signal, and System Research

Review

From Large Language Models to Innovative Applications of Blockchain AI in Web3

Hongjun Wu [1,*]

[1] Department of AI/ML, Bullpen Labs, Inc., New York, 10044, USA
* Correspondence: Hongjun Wu, Department of AI/ML, Bullpen Labs, Inc., New York, 10044, USA

Abstract: With the gradual development of Web3 technology, the deep integration of artificial intelligence and blockchain AI provides new solutions for achieving decentralized intelligent applications. This article summarizes the key technical support elements in the Web3 environment and proposes innovative solutions for training data authentication, computing hosting, parameter control, and other issues between big language models and blockchain AI. These solutions include online deployment of lightweight models, token-based data ownership reward mechanisms, and AI decentralized management DAOs. These can serve as useful guidance for building a secure, transparent, and efficient Web3 intelligent ecosystem.

Keywords: big language model; blockchain AI; Web3; data ownership confirmation; decentralized governance

Received: 15 April 2025
Revised: 22 April 2025
Accepted: 13 May 2025
Published: 22 May 2025

1. Introduction

Web3 is the main form of the future network, based on the attributes of decentralization, user centeredness, and value connectivity, gradually redrawing the pattern of the digital world. With their powerful cognitive abilities and creativity, big language models have become the main driving force for implementing intelligent services. By deploying smart contracts and decentralized ledgers on blockchain technology, information security and transparency can be achieved. However, there are still issues such as data ownership, limited computing power, and governance deficiencies in the integration of large-scale models and blockchain AI with Web3, which require in-depth analysis and proposed strategies to address.

2. Technical Support Elements in the Web3 Ecosystem

Web3 is the future of Internet development. It is characterized by decentralized governance, autonomy, and efficient transmission value. To achieve these features, multiple underlying technologies need to be deeply integrated and work together. In terms of structure, the construction of the Web3 system requires a combination of important components such as distributed accounting methods, smart contracts, decentralized identity authentication (DID), consistency algorithms, and cross chain communication protocols to ensure the reliable transmission of trusted information, resources, and actions in an untrusted environment [1].

The foundation of Web3 is blockchain technology, which enables an immutable and transparent ledger structure for data. A typical blockchain ledger can be formalized using the following mathematical model: let the blockchain ledger be an ordered sequence of blocks $\{B_1, B_2, B_3, \dots, B_n\}$, where each block B_i contains its block header H_i and block body T_i, and the block header stores the hash value $h(B_{i-1})$ of the previous block. This structure satisfies:

$$H_i = \{MerkleRoot(T_i), h(B_{i-1}), Timestamp, Nonce\} \quad (1)$$

The chain hash connection method can increase the cost of tampering with data, thereby maintaining data immutability in a trustless environment. Smart contract technology provides the Web3 ecosystem with automation and self-execution features, enabling point-to-point interaction and business rule constraints through programming logic on the chain. If Contract Function $f(x)$ maps Input x to Output y, the core execution model of a smart contract can be described as a state machine transition:

$$S_{i+1} = f(S_i, T_i) \tag{2}$$

Among them, S_i represents the global state after the i-th transaction, and T_i is the operation instruction input by the user. The status is executed synchronously across all nodes in the network, ensuring the certainty and transparency of contract operation. In addition, Web3's Identity Authentication System (DID) gives users autonomy over their data and identity verification, avoiding the problems of traditional centralized platforms monopolizing data and abusing it [2]. On the DID architecture of cryptography, the elliptic curve digital signature algorithm (ECDSA) is used. The user's private key k_{priv} generates the corresponding public key k_{pub} , and the identity credential ID is bound to the user's control through the signature function $Sign$. Through the public key verification mechanism, any node can confirm the authenticity of its identity without relying on a central authority:

$$Signature = Sign_{k_{priv}}(ID) \tag{3}$$

The consensus mechanism, as the core of Web3 network operation, ensures that multiple nodes reach consensus on the ledger status in a trustless environment. Taking proof of stake as an example, the accounting weight w_i of node n_i is determined by the number of pledged tokens s_i, and the overall block probability p_i satisfies:

$$P_i = \frac{s_i}{\sum_{j=1}^{N} s_j} \tag{4}$$

The role of this economic incentive mechanism is not only to save energy and reduce consumption, but also to improve the safety and scalability of the system.

3. From Big Language Models to the Challenges Faced by Blockchain AI in Web3

3.1. Training Data Certification Gap

Although the construction of the big language models requires a large number of diversified data sources, the property right control of data in the existing Internet 3D world is not clear enough. Although the current blockchain system has been relatively mature in the confirmation of transaction rights, it has not yet formed a control method for unordered data materials, and the ownership, licensing and income distribution of training materials such as text and pictures need to be further improved. According to the survey, more than 80% of the verifiable data in mainstream blockchains such as Ethereum and Polygon is structured data, while less than 15% of unstructured data can be verified [3]. Moreover, due to the high operational difficulty and high gas consumption issues faced by smart contracts in the process of verifying a large amount of data rights, the data yield is relatively low, indirectly affecting the compliance and completeness of information resources available to the big language model (Table 1).

Table 1. Statistics of Data Rights Confirmation Status on Blockchain Platforms.

Blockchain platform	Total amount of confirmed ownership data (10,000 pieces)	Proportion of structured data ownership confirmation	Proportion of ownership confirmation for unstructured data	Average Gas Cost for Smart Contract Execution (Gwei)
Ethereum	350	83%	12%	21,000
Polygon	280	85%	10%	9000
Solana	160	80%	15%	5000

As shown in the table, the current mainstream blockchain platforms have a low proportion of unstructured data in the consensus data composition structure, and the high cost of using smart contracts has dampened the motivation for authorized data usage, making it difficult for big language models to obtain and train datasets on Web3.

3.2. Insufficient Computing Power Capacity of Blockchain

To achieve a perfect combination of blockchain and artificial intelligence, sufficient computing power is needed to support it. However, in the current public network environment, the phenomenon of uneven distribution of computing power and uneven performance between nodes is more prominent, which is more evident when conducting large-scale model inference or training. According to statistics, the current number of transactions per second (TPS) on the Ethereum mainnet can only reach 15-30, which still cannot meet the real-time inference needs of AI. In addition, in the current device configuration of blockchain nodes, only about 10% use high computing power devices such as GPUs or TPUs, and the vast majority are built on CPUs, which cannot meet the computing needs of large models [4]. What's even more terrifying is that Ethereum, which adopts PoW consensus, consumes over 105 TWh of electricity annually, far violating the environmental spirit of advocating AI green and low-carbon development (Table 2).

Table 2. Comparison of Main Public Chain Computing Power and AI Computing Carrying Capacity.

Blockchain platform	Average TPS (pen/second)	Proportion of GPU/TPU nodes	Annual energy consumption (TWh)	AI Large Model Reasoning Support
Ethereum	25	8%	105	low
Solana	3000	12%	3.8	centre
BNB Chain	55	6%	2.2	low
Dedicated AI chains (such as Bittensor)	1200	65%	4.5	tall

Data shows that traditional public chain platforms have shortcomings in TPS, GPU/TPU node deployment, and energy consumption, and cannot achieve the high efficiency and low energy consumption required for AI model inference and training. The only option is an AI friendly professional chain.

3.3. Lack of Decentralized Management of Model Parameters

Most of the existing major language model parameter management relies on centralized cloud service platforms, and the technology for decentralized storage and collaborative updates of parameters on Web3 is not yet mature enough. According to the survey, over 90% of mainstream language models are hosted on centralized servers such as AWS or Google Cloud, while solutions for storing on chain model parameters account for less than one tenth of them. At the same time, due to the lack of effective parameter synchronization techniques, there may be parameter asynchrony among various nodes, which can affect the performance and security of the entire model [5]. Although blockchain AI communities such as Bittensor and Gensyn have attempted distributed learning, the total amount and maturity are still insufficient (Table 3).

Table 3. Current Status of Parameter Management in Mainstream Large Language Models.

Model platform	Deployment Environment	Centralized management ratio	Decentralized hosting ratio	Perfection of parameter synchronization mechanism
OpenAI (GPT)	Azure Cloud	100%	0%	low
Anthropic (Claude)	AWS Cloud	100%	0%	low
Bittensor	Build a self built distributed network	20%	80%	centre

Gensyn	Decentralized training chain	15%	85%	centre

From the table, it can be seen that the current management process of large language model parameters is still too centralized, and a complete on chain centralized hosting and synchronization process has not been implemented, which affects the traceability of model governance and the decentralization of Web3.

4. Innovative Application Path of Blockchain AI for Web3

4.1. On Chain Deployment Scheme for Lightweight Large Language Models

In order to execute on chain deployment within the large language model, we require technological means to modify the model architecture and computation process to ensure its normal execution in a decentralized blockchain environment. Firstly, emphasis is placed on simplifying the model structure, using model pruning techniques to find and remove redundant parameters and non-primary nodes within the network, reducing the model size and computational load without significantly affecting the basic functionality of the model. Through knowledge distillation techniques, a large amount of language comprehension ability in the "teacher model" can be imparted to the low parameter quantity of the "student model" to achieve a balance of model lightweighting and ensure model accuracy.

We will change the model parameters from high-precision floating-point numbers to 8-bit or smaller bit representations to reduce storage requirements and improve computation speed. This method can save a lot of storage space and make it easier for each node on the chain to bear its load. In addition, given the distributed nature of blockchain systems, we divide the model into multiple parts based on functional modules or hierarchical structures, and assign them to different nodes for execution. Utilizing cross chain communication protocols to achieve inference collaboration and sharing, ensuring the overall inference results of the model.

During execution, we utilized smart contracts to implement model application and inference steps, and managed model versions on the chain. Through this method, we can automate the inspection of model parameters and inference steps to prevent malicious tampering, ensuring that all modification steps of the model are open and controllable. For the upgrade and management of the model, we will introduce a token-based reward participation system to guide community members in deciding the direction of model improvement in the Web3 environment, better reflecting the decentralized approach in the Web3 environment. This deployment plan reduces the technical threshold for on chain operations of a class of large language models, realizes decentralized execution trust of AI intelligent services, endows Web3 applications with powerful, diverse, and secure artificial intelligence understanding and communication capabilities, and promotes the deep integration and innovative development of blockchain and artificial intelligence.

4.2. Token-Based on Chain Data Authentication and Incentive Mechanism

The use of Token technology to confirm ownership of data and provide corresponding incentives is mainly divided into three stages: confirmation of ownership, evaluation of contribution, and use of Token incentives. The data uploaded by the user will be generated into a data NFT, which will record its owner, public key address, upload timestamp, and data hash on the chain. Ensure that the ownership of data on the blockchain is transparent and tamper proof to avoid situations where data ownership is unclear and stolen. The entire property rights confirmation process does not rely on any centralized platform to participate, but is automatically executed by smart contracts to reduce trust costs.

After the confirmation of ownership is completed, the system will use a contribution evaluation algorithm embedded in the smart contract to conduct real-time quantitative evaluation of the value generated by each data in the training of the artificial intelligence model and the final model application. The contribution evaluation will comprehensively consider the degree of improvement in the accuracy of the artificial intelligence model prediction, the frequency of use, and the community's rating and voting of the data based on each data, and establish a fair and objective scoring system. At the same time, a tracking and feedback system will be established for the referencing behavior of data stored in the blockchain and the changes in model training results, in order to prevent all fraudulent activities or pollution sources from damaging the entire ecological environment.

In the profit-sharing stage, according to the grading of data contribution, network tokens are released on time as rewards based on pre-set smart contracts, and contributors are rewarded in a non-intrusive, immediate, and fair manner. In addition, in order to further improve the utilization of data, we have pre-set a two-layer profit distribution mechanism: once the data is referenced, processed, or rewritten again, the original data provider can still receive a portion of the network token revenue, thus forming a goal driven circular loop based on continuous value flow. In summary, this mechanism enables data ownership, reasonable valuation, and automatic settlement of contribution values on the chain, while also safeguarding the interests of data contributors and promoting the continuous influx of high-quality data, providing a solid data foundation for the development of blockchain artificial intelligence on Web3.

4.3. Decentralized AI Governance DAO Model

In order to successfully implement AI governance in the Web3 world, we should address the drawbacks brought by centralized platforms in a decentralized, autonomous, and open manner. Therefore, we need a decentralized AI governance DAO based on smart contracts, which relies on token staking driven proposals and voting systems to achieve self-governance throughout the lifecycle of AI governance. Firstly, build a basic protocol provided by developers or communities, which includes operational regulations, standards for proposal suggestions, voting requirements, and incentive measures during the processing of AI models. Secondly, users have the right to choose proposals and votes by using staking governance tokens as chips, which to some extent ensures fairness for everyone. When a new model change or parameter change requirement is proposed, the person holding the token can raise this opinion and publish it for everyone to see and vote on. The system uses anti witch attack rules to prevent individual actions from causing harm to the system. After the vote is passed, the governance contract will automatically trigger the required actions, such as model upgrades or parameter changes, without the need for centralized personnel to intervene. Those who make positive contributions to governance will receive token rewards, while those who engage in malicious behavior will have their pledged tokens confiscated. In addition, the governance architecture also includes an arbitration system and a performance monitoring system. In the event of AI model errors or governance deadlocks, these arbitration nodes or predictors can maintain good governance through their behavior.

The overall governance process covers a closed loop of proposal, voting, execution, incentives, and arbitration, ensuring that AI governance is open, transparent, and decentralized. The specific process is shown in Figure 1:

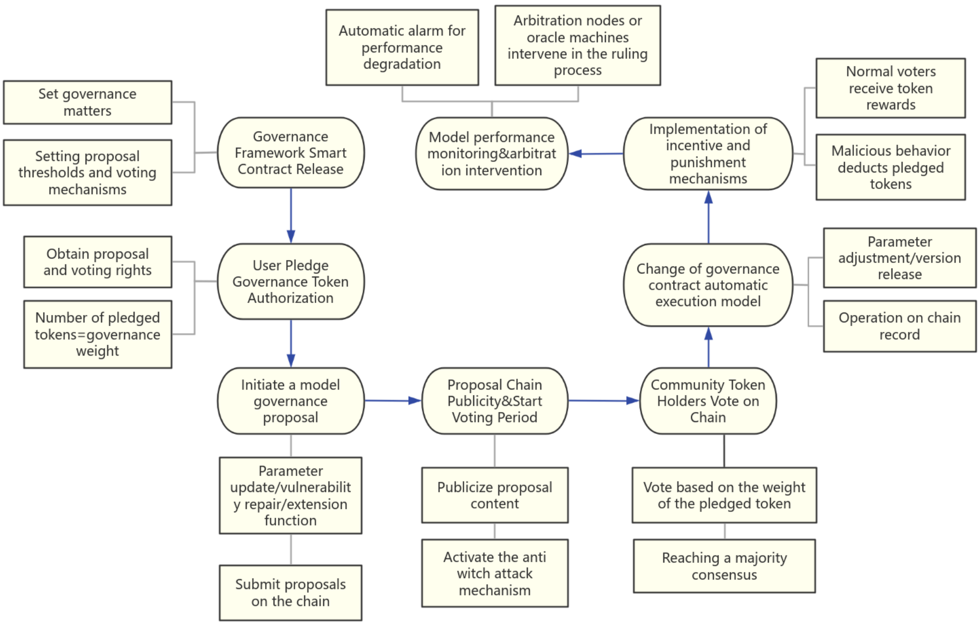

Figure 1. Flow Chart of Decentralized AI Governance DAO Model.

By utilizing this approach, AI not only achieves adaptive self-learning capabilities, but also ensures real-time and publicly manageable means throughout the entire process through blockchain technology, in order to prevent excessive concentration of power and resist external intervention, ensuring the fairness and credibility of AI model operation. Fully in line with the principles of decentralization, open-source sharing, and user autonomy advocated by Web3, it helps to achieve trust collaboration and widespread application of AI technology in Web3.

5. Conclusion

In the context of the integration of big language models and blockchain, the development trend of Web3 has led to a change in the decentralized intelligent ecosystem. In addition to enhancing the self-regulatory and transparent features of AI systems, it also provides more intelligent capabilities for centralized applications. However, there are also many difficulties in practice, such as identity recognition of data providers during model training, sharing and allocation of computing power, and lifecycle management. In order to address these difficulties, a novel solution has recently been attempted: by optimizing the design of lightweight large language models and combining them with on chain deployment, the models can perform operations based on limited blockchain resources; By adopting a Token reward mechanism to identify the rights and interests of data providers, the recognition and traceability of data contributions have been achieved; Using DAO to introduce a community governance model to ensure fairness and transparency in the process of model training, installation, and upgrade. Combining the various technical methods mentioned above with organizational structure is not only a transformation of the centralization problem of existing AI systems, but also provides solid and intelligent foundational support for decentralized applications in the context of Web3, with enormous potential and practicality.

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