Date of publication December 1, 2023.

TRUE Autonomous Organizations and Operations for Web3

JUANJUAN LI[1], XIAOLONG LIANG[2], RUI QIN[1], AND FEI-YUE WANG[12]
[1]The State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing 100190, China
[2]The Macao Institute of Systems Engineering, Macau University of Science and Technology, Macao 999078, China

Corresponding author: Fei-Yue Wang (e-mail: feiyue.wang@ia.ac.cn).

"This work was partially supported by 0093/2023/RIA2 the Science and Technology Development Fund, Macau SAR under Grant 0050/2020/A1."

ABSTRACT As the key component of the emerging Web3, Decentralized Autonomous Organizations and Operations (DAOs) enables decentralized decision-making and governance mainly driven by blockchain and smart contracts. This paper first provides a comprehensive examination of DAOs' evolution, tracing their historical development and the progression of their definitions and underlying concepts. Then, it presents their classical governance models founded on token economics and analyzes typical practical cases, subsequently identifying the current dilemmas faced by DAO governance. To address these dilemmas, TRUE Autonomous Organizations and Operations (TAOs) are proposed, which underscores the trustable, reliable, usable, efficient and effective essence of decentralization. Besides, the distinctions between TAOs and DAOs are discussed from perspective of the value systems, governance structures, incentive allocation, decision-making model. Furthermore, it highlights the research issues that need to be addressed to realize the full potential of TAOs.

INDEX TERMS Decentralized Autonomous Organizations and Operations (DAOs), Governance Models, Token Economy, TRUE Autonomous Organizations and Operations (TAOs), Value Systems

I. INTRODUCTION

DECENTRALIZED Autonomous Organizations (DAOs) are a novel organizational structure powered by blockchain and smart contracts [1]-[4], allowing members to make collective decisions through a consensus mechanism, thereby breaking free from traditional centralized power structures. The core philosophy of DAOs is to ensure the decentralization of power, preventing it from being concentrated only by a few members [5][6][7]. They place a strong emphasis on community autonomy, enabling every member to participate in the decision-making process, thereby enhancing the democracy and justice. Besides, DAOs achieve a transparent and reliable governance structure by relying on blockchain to ensuring that information is open and transparent to all members. This decentralized approach to governance not only reduces manipulation and unfair practices but also strengthens the cohesion and common purpose within the community. With the development of blockchain technology and the growing recognition of decentralized values, DAOs have found increasingly widespread applications in fields such as finance, investment, art, media, etc., and also become an indispensable part of Web3 (or Web 3.0).

However, the development of DAOs still faces multi-faceted challenges. First, as a new organizational form, DAOs lack a clear governance structure and principles [8][9] to deal with various issues, such as the efficient design of governance models, the proper allocation of decision-making power, and the balance of different members' interests. This can lead to organizational inefficiencies and frequent internal conflicts, severely limiting the large-scale applications of DAOs. Second, DAOs primarily rely on internal tokens as a medium for incentive mechanisms and value exchanges [10]. However, the economic models and value systems of these tokens often lack transparency and stability, making the operational principles of DAOs' economic systems unclear. Third, although the core purpose of DAOs is to achieve democratic decision-making, decision-making power in practice may become overly concentrated in a few members holding large amounts of tokens.

In view of this, this paper primarily analyzes the development histories and evolution of DAOs, along with their governance models, common governance mechanisms, and token economic models. The challenges and risks faced by DAOs are also discussed by analyzing some typical DAO

governance cases. Building on this, the paper proposes TRUE Autonomous Organizations and Operations (TAOs) and analyzes their main objectives and key features. Furthermore, TAOs are compared with DAOs across multiple dimensions to highlight their advantages. Additionally, a preliminary exploration of the key research issues of TAOs are conducted.

TAOs propose a more in-depth and equitable method of distributing power and equity, integrating artificial intelligence (AI) technologies to address issues of governance and decision-making efficiency. TAOs also employ a multi-dimensional value system that recognizes various forms of contributions to reduce over-reliance on token and promote long-term development. Additionally, TAOs are designed as a flexible structure that adapts to various legal environments, reducing potential legal risks. Contributions of this paper are summarized as follows:

1) We propose TAOs as the improved organizational structure and technical architecture for DAOs, aimed at solving issues faced by DAOs in practice.
2) We provide a thorough review of the development path of DAOs to indicate the necessity of technological and methodological evolution from DAOs to TAOs.
3) We discuss the core differences between DAOs and TAOs, and explore the key research issues concerning TAOs. The structure of this paper is arranged as follows: Section II introduces the histories of DAOs, Section III discusses decentralized governance of DAOs and its essence. Section IV proposes TAOs and conducts a comparative analysis with DAOs. Section V discusses key research issues of TAOs. Section VI concludes this paper.

II. THE HISTORY OF DAOS

The concept of DAOs originated from the Bitcoin network proposed by Satoshi Nakamoto in 2008. Bitcoin Network is generally considered the most successful application of DAOs, even though the term "DAOs" had not yet evolved to its current connotation during the inception of Bitcoin. The Bitcoin network embodied almost all the characteristics of a DAO, including algorithmic management of machines with human supervision, automated task assignment, and reward distribution, but fails to meet the burgeoning demand for algorithmic governance, due to the functional limitations of its scripting capabilities.

In 2013, Ethereum was proposed, which pioneered the implementation of smart contracts, thus paving the way for a general DAO. In 2014, Vitalik Buterin, co-founder of Ethereum, gave the formal definition of DAOs and made a detailed comparison of them to Decentralized Autonomous Corporations (DACs), Decentralized Organizations (DOs), and Decentralized Applications (DAs), defining a DAO as an organization that has internal capital and is characterized by "automation at the center, humans at the edges". Under this definition, "The DAO" brought the long-desired decentralized organization model into reality for the first time in 2016, aiming to utilize blockchain to create a novel business model where anyone with a project could present their ideas and possibly get secure funding from it. Unfortunately, "The DAO" revealed a critical vulnerability of DAOs, that is, their openness, transparency, and anonymity making them particularly susceptible to hacker attacks. In June 2016, a hacker exploited a loophole to drain funds from "The DAO" [11]. Ethereum ultimately remedied the situation via a hard fork to return stolen funds to their original owners, signaling the failure of "The DAO".

The failure of "The DAO" dealt a severe blow to DAO practitioners and provoked a reevaluation of DAOs. By 2018, with the maturation of DAO infrastructure such as Aragon, Colony, and DAOhaus, DAOs began to make a comeback [12]. Particularly, the rise of Decentralized Finance (DeFi) in 2020 drew increasing attention to DAOs [13]. By the end of 2022, the total market capitalization of DAOs was approximately $8.8 billion, with an impressive count of 10,752[1], reflecting their significance and influence in Web3.

III. THE DECENTRALIZED GOVERNANCE OF DAOS AND ITS ESSENCE

This section will discuss the decentralized governance models of DAOs, revealing how they operate effectively without reliance on centralized authority. It also explores the essence and challenges of DAO governance by case studies.

A. GOVERNANCE MODELS

In general, decisions within DAOs are determined by the consensus of members, governed by rules encoding in smart contracts. Each member gains their rights by holding the governance tokens, which not only represent their ownership share and also serve as an incentive to guide the operation of governance models. The typical governance process of DAOs can be generally summarized into five stages: proposal, evaluation, voting, execution, dispute and arbitration [14], as shown in Fig. 1.

Proposal: It serves as a mechanism for consultation, supervision, conflict resolution, and governance stabilization. The existing proposal mechanism primarily includes two stages: pre-proposals and proposals. Pre-proposals are initial ideas and suggestions usually shared in a forum for feedback and further discussion; and proposals are these refined suggestions that are subjected to a vote by DAO members.

Evaluation: Its primary purpose is to deter malicious activities and prevent proposals that violate community norms from being approved. This is typically achieved through the role of evaluators, who scrutinize proposals to ensure their viability, relevance, and value to the community. Depending on the voting mechanism of DAOs, the evaluators can be fully decentralized or relatively centralized.

Voting: It is the core of democratic governance and currently there are multiple voting mechanisms, including direct voting, representative voting, conviction voting, quadratic

[1]Data Source: CryptoDose.net

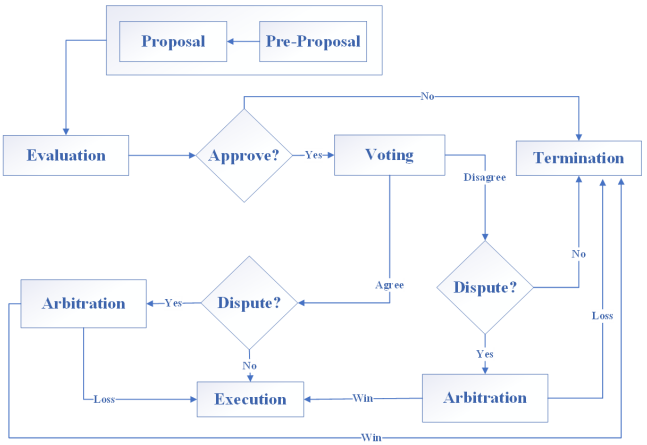

FIGURE 1. The typical governance process of DAOs.

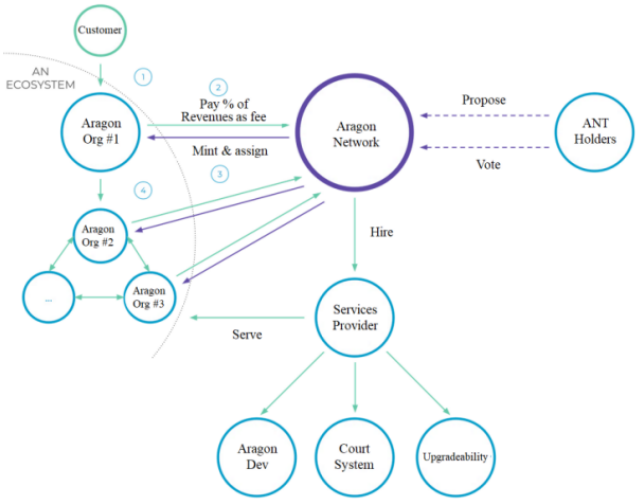

FIGURE 2. Aragon Network.

voting, Futarchy voting and so on. Each voting mechanism has its own suitable contexts and inherent issues.

Execution: According to the consensus reached by voting, execution can be divided into on-chain execution and off-chain execution. On-chain execution is often related to code, protocol, rules, etc. Off-chain execution indicates that the consensus results currently cannot be well defined or regularized, and the off-chain execution method continues to be improved until rules that can be encoded are formed. It should be noted that even the consensus that cannot currently be executed on-chain still adopts various decentralized storage methods or vouchers to ensure the transparency and traceability of the consensus.

Dispute and Arbitration: They usually occur when community members have doubts about the relevant results or when disputes arise. At this time, community members can choose to appeal through a decentralized court to resolve the dispute. Decentralized courts are a form of "digital court" supported by blockchain technology, aimed at resolving disputes by crowdsourcing jurors under economic incentives to provide fair judgments. Another way is to exercise the power of an anger exit, which involves community members withdrawing their support or participation from the DAO as a form of protest or disagreement with the decisions made.

B. CASE STUDIES

This section analyzes governance models of three exemplary DAOs, including Aragon, Colony, and PandaDAO.

1) Aragon

Aragon[2] stands as a representative DAO due to its innovative platform that simplifies the creation and management of decentralized organizations, offering a unique blend of customizable governance structures and open-source development. Aragon was initially managed by a non-profit foundation in Switzerland, was designed to navigate legal risks with its founders holding key roles. In 2022, the community initiated a transition towards a more decentralized model by establishing the Aragon DAO, although the Aragon association retained control over substantial assets, leading to internal discontent and calls for transparency.

As shown in Fig. 2, the governance of Aragon is a balanced mix of decentralization and stakeholder protection, structured into three main elements: rules, guidelines, and practices. Rules set by on-chain deployment and legal frameworks, provide a secure baseline for the organization. Guidelines shaped by voting among token holders and delegates, offer flexible operational standards for organizational effectiveness. Practices encourage innovation within guilds, allowing them to experiment and potentially shape future guidelines.

The governance of Aragon is expected to evolve, enforcing stakeholders' rights and responsibilities with appropriate mechanisms. However, the model has faced challenges due to its initially ambiguous equity definitions and the significant powers held by founding members, which have led to unclear governance structures and potential for centrifugal forces threatening community cohesion. The high barriers to participation, the inherent anonymity and censorship resistance aggravate this challenge, complicating Aragon's efforts towards effective and transparent governance.

2) Colny

Colony[3] was originally conceived in 2014 with the objective of creating a platform for decentralized organizations. The project was officially unveiled in 2016, with development progressing on an open-source basis. Facing challenges with high gas fees on the Ethereum network, Colony initiated a transition in 2021 towards Colony v2. This evolution involved migrating from the Ethereum to the xDAI network, which is known for its lower fees and faster transaction times.

The Colony architecture is shown in Fig. 3. The Colony Network is structured into four functional layers and four log-

[2]https://aragon.network

[3]https://colony.io

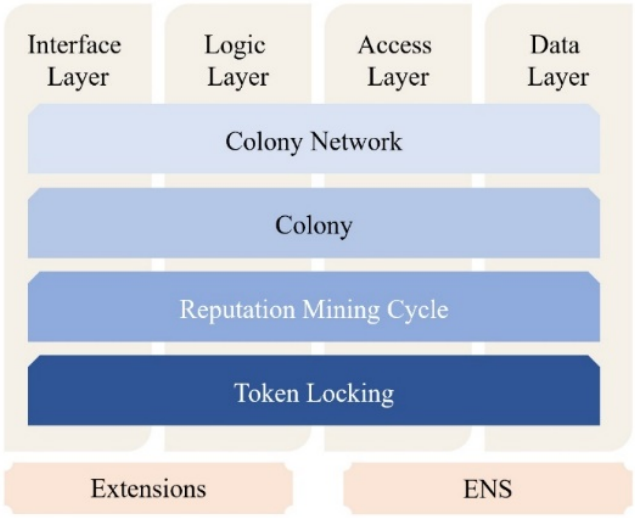

FIGURE 3. Colony Architecture.

ical entities. Essentially, it is a complex smart contract system based on the Ethereum blockchain, designed to manage and operate "Colony" and features a unique reputation mining cycle that aggregates members' contributions to compute their reputations. Colony is recognized as a representative DAO for its advanced system that enables users to create and manage organizations with a focus on reputation-based incentives, task management, and budget allocation. Its governance model emphasizes decentralized decision-making, facilitated by reputation-weighted voting.

Colony's main challenges include its intricate smart contract architecture and high gas fees on public blockchains, hindering routine governance. Migration to more cost-efficient blockchains like xDAI eases, but doesn't fully resolve, these issues due to Colony's reliance on public blockchains. Additionally, the platform's algorithmic complexity raises barriers to entry, requiring technical savvy for effective participation and potentially limiting its user base. These challenges are common in many DAOs, where the technical nature of blockchain and smart contracts can deter wider user engagement. Addressing these concerns necessitates simplifying user interfaces, enhancing educational resources, and reducing participation barriers to make DAOs more accessible and user-friendly.

3) Panda DAO

PandaDAO[4] stands out as a representative DAO for its innovative approach to decentralizing information and human resources management. It focuses on transferring control of personal data to individuals and developing tools that enable more people to engage full-time in this new organizational form, going beyond just being a decentralized media entity. PandaDAO's governance model is centered around community-driven decision-making and decentralization, especially in managing its treasury. Key elements include community management with token holders owning treasury assets, operational rules led by community-elected leaders, a voting system that balances stakeholder influence and prevents dominance by large investors, and a proposal process that promotes inclusivity and consensus. This model ensures active community involvement in key decisions, fostering transparency and accountability within it.

Governance challenges for PandaDAO revolve around ensuring broad-based participation and understanding amidst the technical complexities. The requirement for technical knowledge and active engagement in the proposal and voting process could limit accessibility for a wider user base. Besides, the community's excessive pursuit of profits and token values led to poor decision-making.

C. THE DILEMMAS OF DAO GOVERNANCE

As indicated in above analysis, DAOs are met with unprecedented challenges in governance. As follows, we will discuss the core dilemmas of DAO governance, identifying the gap between the ideals of decentralized and autonomous governance and the realities of their practice [15] and also uncovering the key factors that contribute to it.

1) The allocation of governance power and rights within DAOs via token holdings is designed to foster engagement and democratize decision-making by incentivizing token retention and active participation. Nonetheless, the token issuance, distribution, and circulation mechanisms often precipitate an aggregation of governance power among a limited cohort of token holders. This concentration contravenes the foundational democratic governance principles and the decentralization ethos that DAOs aspire to uphold. Besides, members within DAOs can also obfuscate their centralized influence through creating multiple on-chain identities [16], which further exacerbates this concentration.
2) The disproportionate emphasis on token-centric economy and incentives within DAOs can eclipse the imperative progress in their technological and operational realms. A myopic focus on the valorization of native tokens frequently characterizes many DAOs, inadvertently steering the organization's trajectory toward serving token holders' interests rather than the collective goals and enduring stability of DAOs [17]. Short-term decisions aimed at inflating token value can misalign with DAOs' overarching mission and vision, potentially diverting from its foundational objectives.
3) The inefficiencies of DAO governance can manifest in the decision-making processes, where the consensus necessary for action is hindered by the very democratic structures [18]. The extensive deliberations required to reach a majority consensus can result in operational sluggishness, delaying critical actions and responses to market dynamics. This inefficiency is further compounded by the potential for low engagement from their members thus low voter turnout, which challenges

[4]https://www.pandadao.info

the legitimacy of decisions and can lead to nominally democratic governance be ineffectual. Therefore, the democratic ethos that underpins DAOs is not fully actualized, undermining the legitimacy and efficiency of DAOs' collective decision-making.

4) The governance costs of DAOs are notably high, attributed in part to the gas fees incurred for operations conducted on public blockchains. Each transaction, including voting and implementation of decisions, requires gas fees that fluctuate and may become prohibitively expensive during network congestion [19]. Besides, the technical threshold for participation is significant, because understanding the intricacies of smart contracts and the underlying blockchain technology presents a barrier to entry, which can elevate the costs of members to participate in DAO governance.

The future of DAOs may manifest in various forms as technologies advance and governance models evolve, but their success will depend on how these issues can be addressed.

IV. TRUE AUTONOMOUS ORGANIZATIONS AND OPERATIONS

Despite the recognition of centralization within many DAOs, the discourse has largely lacked robust remedial frameworks. In response, the concept of TRUE Autonomous Organizations and Operations (TAOs) is proposed, advocating for a paradigm that highlights the essence of decentralization instead of itself. This will make TAOs trustable, reliable, usable, efficient and effective [20]. Decentralization fundamentally embodies the dispersion of power, authority, and decision-making from a centralized entity to a distributed network [1]. This paradigm shift redistributes control across a wider base, mitigating the risks of a single point of failure and fostering a more democratic and equitable system. In a decentralized framework, each node or member operates autonomously yet interdependently, contributing to the resilience and robustness of the entire system. Decentralization challenges traditional hierarchies, promoting transparency, inclusivity, and collective governance. Based on this consideration, TAOs emphasize the attainment of justice in the distribution of decision-making power. They seek to ensure that governance is not the preserve of a privileged few but instead a right equitably shared among all contributors, reflecting a commitment to fairness within the community. This distributive democracy in decision-making underpins the integrity and legitimacy of decentralized systems, fostering a more balanced organizational structure. As shown in Table 1, TAOs differ from DAOs across multiple dimensions, including value systems, governance structures, incentive allocations, and decision-making models.

TAOs represent a paradigm shift away from token-centric valuation, embracing a more diversified value system to circumvent the excessive focus on token prices and the resulting speculative behaviors. By broadening the scope of value systems via including data, knowledge, reputation, etc., TAOs aim to dilute the emphasis on token accumulation as the primary measure of worth. This approach mitigates the risks associated with price volatility and speculation, fostering a healthier ecosystem where the collective interests align with sustainable growth and innovation of TAOs, rather than short-term financial gains. Additionally, such a value system should not be confined solely to the blockchain network but ought to interface with the centralized societal value systems. This interconnectivity ensures that the diverse forms of value recognized by TAOs are also acknowledged and integrated within the broader economic and social frameworks, allowing for a seamless exchange of value and ideas between decentralized and traditional structures. By establishing these linkages, TAOs can facilitate a reciprocal flow of resources and values that generated within them. TAOs use the contribution-based and on-demand incentive allocation mechanisms that underpin equitable resource allocation reflective of individual member inputs and necessities. This approach aims to transcend the traditional, token-centric models by recognizing and rewarding the diverse forms of value members bring to the organization, including but not limited to, intellectual contributions, active participation, and task execution. By aligning rewards with contributions, TAOs cultivate an ecosystem that incentivizes meaningful participation and fosters a collaborative environment where every member has a stake in the community's success. Furthermore, taking into account the developmental stage and resource restriction of TAOs, the contribution-based distribution is combined with on-demand allocation to fully express collective fairness across various dimensions. This approach balances the recognition of individual efforts with the broader communal requirements, ensuring that the allocation of rewards and responsibilities is not solely meritocratic but also considerate of the changing needs within the TAO community. This dual-faceted distribution mechanism is designed to support both the growth of the community and the well-being of its members, fostering a sustainable and equitable ecosystem. The decision-making efficiency and cost within DAOs constrain their democratic nature and the effectiveness of collective choices. TAOs seek to alleviate these issues by restructuring the power dynamics, refining the methods of decision-making, and incorporating AI technology to assist in governance. TAOs employ a dynamic equity distribution structure that adapts to the evolving engagement and contributions of its members. This fluid architecture allows for the reallocation of decision-making power in alignment with the current and active inputs of participants, rather than static token holdings. By integrating mechanisms that assess and respond to the varying degrees of involvement and value brought by each member, TAOs promote a more responsive and equitable governance model. Such a structure not only incentivizes ongoing contribution but also ensures that the governance reflects the present composition and dynamics of the community, fostering a system that is adaptive to its members' changing roles and contributions. Moreover, the costs associated with decision-making can be mitigated by

TABLE 1. The Comparison of DAOs and TAOs

Features	DAOs	TAOs
Value Systems	Token-centric	Multi-dimensional
Governance Structures	The token-centric structure can drive power concentration	The dynamic and equitable distribution of power can reduce the risk of centralization
Incentive Allocations	Fixed token rewards may not reflect the dynamic evaluations of contributions	Dynamic mechanisms can balance contributions and demands
Decision-Making Models	The voting-based decision models may result in high decision-making costs and low efficiency	The enhancement of blockchain infrastructures and the incorporation of AI can diminish decision barriers and costs

altering the blockchain architecture and its fee ecosystem, as well as by introducing decision support systems powered by AI. For example, utilizing agentAI-based predictable DAO governance technology to present the possible outcomes of critical decisions before they are officially madegenerated and executed, guiding will guide members to vote more scientifically and rationally. Adjustments to the blockchain can involve optimizing transaction efficiency or adopting more cost-effective consensus protocols to lower the transaction fees that often hinder participation. Moreover, AI can play a supportive role in reducing the cognitive requirement on TAO members by processing complex data, providing predictive analytics, and offering actionable insights, which streamline the decision-making process. This integration of technological advancements is aimed at reducing governance barriers, thereby enhancing the efficiency and effectiveness of TAO governance.

V. KEY RESEARCH ISSUES OF TAOS

As the definition and key attributes of TAOs are discussed, it is imperative to identify and address the following research issues that shape their future and enable their applications.

A. FAIR POWER AND RIGHTS DISTRIBUTION

The primary research issue for TAOs involves devising equitable methods for distributing ownership, decision-making powers, yield-sharing rights and resources among members. This ensures all members enjoy fair access to propose, vote and get benefits, irrespective of token possession. Factors such as contribution levels, time investment, skills, knowledge, reputation and so on must be taken into consideration. The challenge lies in creating dynamic, adaptive decision-making models and establishing fair criteria for power, rights and benefits allocation. The aim is to mitigate the risk of decision-making domination by a few members, thereby enhancing the overall fairness and justice in the governance and distribution processes within TAOs.

B. NON-TOKEN-CENTRIC VALUE SYSTEMS

Constructing a value system not centered on tokens or crypto-currency is the second research issue facing by TAOs. In TAOs, value is no longer defined solely by digital currency or tokens, but is based on a broader and more diversified set of values. This requires the establishment of a new system for value assessment, which can accurately, comprehensively, and fairly evaluate and quantifies the various contributions of members. These contributions include community constructions, creative inputs, professional skills, time investments, social influences, volunteer services, and so on. The system should determine members' influences, reputations, and decision-making weights in TAOs based on their contributions, and also weigh it with members' demands to make final allocation, thereby enhancing the scientific validity and effectiveness of TAOs' value systems.

C. DEMOCRATIC DECISION-MAKING METHODS

The proper decision-making methods that can ensure the transparency and democracy of the decision process, outcomes and execution is very crucial to TAOs. This requires the design of new decision-making mechanisms, the establishment of voting weight measurement methods that comprehensively reflect the key indicators such as members' contributions and professional knowledge, along with open and transparent decision-making processes. Additionally, it is necessary to establish effective conflict resolution mechanisms to address divergences and disputes that may arise during the decision-making processes, thereby reducing the time to reach consensus and enhancing the efficiency and democratic nature of TAOs' decision-making.

D. GOVERNANCE MECHANISM DESIGN AND EVALUATION

Due to the complex governance environments and structures faced by TAOs, how to enhance members' participations in the governance processes and reduce governance risks, thereby improving the efficiency of TAO governance, has become a key research issue faced by TAOs. This requires the establishment of an efficient governance structure and a dynamic, flexible governance mechanism tailored to the characteristics and needs of TAOs. In the distribution of power and responsibilities, it is essential to comprehensively consider members' contributions from multiple dimensions, balancing the interests of different stakeholders to prevent manipulation and unfair practices as well as motivating more members to actively and honestly participate in TAO governance. Moreover, developing an effective mechanism for evaluating and optimizing the proposed governance and incentive mechanisms is necessary, which can greatly enhance the stabilities and efficiencies of TAOs.

E. THE LEGAL RECOGNITION AND RISKS

TAOs raise intricate questions regarding their recognition and treatment under existing legal frameworks. TAOs not only challenge traditional notions of corporate personhood, liability, and jurisdiction but also necessitate a reconceptualization of regulatory approaches to accommodate the unique attributes of decentralized decision-making. As such, it is critical to study how to integrate them with the local legal frameworks, ensuring its transactions and decisions are recognized and legally protected within the existing legal structures.

F. EFFICIENT AND EFFECTIVE APPLICATIONS

In terms of applications, a significant research area for TAOs centers on integrating technologies like blockchain, smart contracts, and AI to boost their applicability. This involves an in-depth analysis of TAOs' primary application fields and scenarios, identifying current challenges and issues in deployment. A critical part of this research is to explore how these advanced technologies can address existing problems and which bridge protocols should be designed, thereby improving TAOs' performance, application scope, and scalability.

VI. CONCLUSION

DAOs support the transformative ethos of Web3 by embodying decentralized governance and autonomous collaboration that aligns with the open and interoperable nature of the next-generation internet. They offer a foundational structure for community-led initiatives, fostering a new paradigm of collective ownership and decision-making in the digital realm. However, DAOs' practices have not fully lived up to their visions, grappling with various governance issues that challenge their decentralization essence, democratic ideals as well as organization and operation efficacy. By examining the evolution of DAOs and the governance dilemmas they face, this paper proposes TAOs to offer a promising avenue for addressing the current limitations of DAOs by focusing on the trustable, reliable, usable, efficient and effective essence of decentralization. On this basis, the distinctions between TAOs and DAOs are elucidated from the perspective of the value systems, governance structures, incentive allocation, decision-making model. Furthermore, the future research issues of TAOs are emphasized to harness their transformative power in creating more equitable and sustainable Web3.

REFERENCES

[1] S. Wang, W. Ding, J. Li, et al., "Decentralized Autonomous Organizations: Concept, Model, and Applications," IEEE Trans. Comput. Soc. Syst., vol. 6, no. 5, pp. 870–878, Oct. 2019.

[2] R. Qin, W. Ding, J. Li, S. Guan, G. Wang, Y. Ren, and Z. Qu, "Web3-Based Decentralized Autonomous Organizations and Operations: Architectures, Models and Mechanisms," IEEE Trans. Syst., Man, Cybern.: Syst., 2022, doi: 10.1109/TSMC.2022.3228530.

[3] R. Qin, Y. Yuan, and F.-Y. Wang, "A Novel Hybrid Share Reporting Strategy for Blockchain Miners in PPLNS Pools," Decision Support Syst., vol. 118, pp. 91–101, 2019.

[4] R. Qin, Y. Yuan, and F.-Y. Wang, "Optimal block withholding strategies for Blockchain mining pools," IEEE Trans. Comput. Soc. Syst., vol. 7, no. 3, pp. 709–717, 2020.

[5] F.-Y. Wang, W. Ding, R. Qin, and B. Hu, "Parallel philosophy for MetaOrganizations with MetaOperations: From Leibniz's Monad to HanoiDAO," IEEE Trans. Comput. Soc. Syst., vol. 9, no. 3, pp. 658–666, 2022.

[6] J. Li, R. Qin, and F.-Y. Wang, "The future of management: dao to smart organizations and intelligent operations," IEEE Trans. Syst., Man, Cybern.: Syst., 2022, doi: 10.1109/TSMC.2022.3226748.

[7] F.-Y. Wang, R. Qin, X. Wang, and B. Hu, "MetaSocieties in metaverse: MetaEconomics and MetaManagement for MetaEnterprises and MetaCities," IEEE Trans. Comput. Soc. Syst., vol. 9, no. 1, pp. 2–7, 2022.

[8] M. Rikken, M. Janssen, and Z. Kwee, "Governance challenges of blockchain and decentralized autonomous organizations," Information Polity, vol. 24, no. 4, pp. 397–417, 2019.

[9] W. Ding, X. Liang, J. Hou, J. Li, Y. Rouabah, Y. Yuan, and F.-Y. Wang, "A Novel Approach for Predictable Governance of Decentralized Autonomous Organizations Based on Parallel Intelligence," IEEE Trans. Syst., Man, Cybern.: Syst., 2022.

[10] A. Braun, N. Häusle, and S. Karpischek, "Incentivization in Decentralized Autonomous Organizations," [Online]. Available: http://dx.doi.org/10.2139/ssrn.3760531, Apr. 22, 2022.

[11] M. I. Mehar, C. L. Shier, A. Giambattista, et al., "Understanding a revolutionary and flawed grand experiment in blockchain: the DAO attack," J. Cases Inf. Technol., vol. 21, no. 1, pp. 19–32, 2019.

[12] X. Liang, W. Ding, J. Hou, et al., "A comprehensive survey of decentralized autonomous organizations enabled by blockchain and smart contracts," Int. J. Informatics Comput. Sci., vol. 2, no. 1, pp. 35–48, 2021.

[13] C. R. Harvey, A. Ramachandran, and J. Santoro, DeFi and the Future of Finance. John Wiley & Sons, 2021.

[14] W. Ding, X. Liang, J. Hou, et al., "A Novel Approach for Predictable Governance of Decentralized Autonomous Organizations Based on Parallel Intelligence," IEEE Trans. Syst., Man, Cybern.: Syst., 2022, doi: 10.1109/TSMC.2022.3224250.

[15] S. A. Wright, "Measuring DAO Autonomy: Lessons From Other Autonomous Systems," IEEE Trans. Technol. Soc., vol. 2, no. 1, pp. 43–53, Mar. 2021.

[16] M. Nadler and F. Schär, "Decentralized Finance, Centralized Ownership? An Iterative Mapping Process to Measure Protocol Token Distribution," [Online]. Available: https://arxiv.org/abs/2012.09306, 2020.

[17] C. Gao and A. Leung, "True or False Prosperity? The Effect of Token Incentives in Decentralized Autonomous Organizations," in ICIS 2022, [Online]. Available: https://aisel.aisnet.org/icis2022/blockchain/blockchain/11.

[18] P. Garimidi, S. Kominers, and T. Roughgarden, "DAO Governance Attacks, and How to Avoid Them," [Online]. Available: https://a16zcrypto.com/posts/article/dao-governance-attacks-and-how-to-avoid-them/, Jul. 28, 2022.

[19] Y. Faqir-Rhazoui, M. Ariza-Garzón, J. Arroyo, and S. Hassan, "Effect of the gas price surges on user activity in the DAOs of the Ethereum blockchain," in Extended Abstracts of the 2021 CHI Conf. Hum. Factors Comput. Syst., May 8, pp. 1–7, 2021.

[20] F.-Y. Wang, "The Generalized Godel Theorem and Blockchain Intelligence: In Math We Can't Trust," in The Conf. Blockchain and Mathematics, Dec. 17, 2018.

JUANJUAN LI received her M.S. degree in economics from Renmin University of China and Ph.D. degree in control science and engineering from Beijing Institute of Technology, Beijing, China. Currently she is an associate professor with The State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing, China. Her research interests include blockchain, DAO and parallel management.

XIAOLONG LIANG received the B.S. and M.S. degrees in computer science and technology from Shandong University, Jinan, Shandong, China, in 2011 and 2016, respectively. He is currently pursuing the Ph.D. degree with the Faculty of Innovation Engineering, Macau University of Science and Technology, Macau, China. His main interests include parallel intelligence, parallel governance, blockchain, knowledge graph, and DAO.

RUI QIN received the Ph.D. degree in computer application technology from University of Chinese Academy of Sciences, Beijing, China, in 2016. She is currently an associate professor with The State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing, China. Her research interests include blockchain, DAO and parallel management.

FEI-YUE WANG received the Ph.D. degree in computer and systems engineering from the Rensselaer Polytechnic Institute, Troy, NY, USA, in 1990. He joined The University of Arizona, Tucson, AZ, USA, in 1990, where he became a Professor and the Director of the Robotics and Automation Laboratory and the Program in Advanced Research for Complex Systems. In 1999, he founded the Intelligent Control and Systems Engineering Center, Institute of Automation, Chinese Academy of Sciences (CAS), Beijing, China, under the support of the Outstanding Chinese Talents Program from the State Planning Council, and in 2002, he was appointed the Director of the Key Laboratory of Complex Systems and Intelligence Science, CAS, and the Vice President of the Institute of Automation, CAS, in 2006. He found CAS Center for Social Computing and Parallel Management in 2008, and became the State Specially Appointed Expert and the Founding Director of the State Key Laboratory for Management and Control of Complex Systems in 2011. He is a Distinguished Professor at the Macau University of Science and Technology, Macao, China. His current research focuses on methods and applications for parallel intelligence, social computing, and knowledge automation. Dr. Wang is a fellow of the International Council on Systems Engineering (INCOSE), the International Federation of Automatic Control (IFAC), the American Society of Mechanical Engineers (ASME), and the American Association for the Advancement of Science (AAAS). In 2007, he received the National Prize in Natural Sciences of China, numerous best papers awards from the IEEE TRANSACTIONS, and became an Outstanding Scientist of the Association for Computing Machinery (ACM) for his work in intelligent control and social computing. He received the IEEE Intelligent Transportation Systems (ITS) Outstanding Application and Research Awards in 2009, 2011, and 2015, respectively, the IEEE Systems, Man, and Cybernetics Society (SMC) Norbert Wiener Award in 2014, and became the IFAC Pavel J. Nowacki Distinguished Lecturer in 2021. Since 1997, he has been serving as the General or Program Chair of over 30 IEEE, Institute for Operations Research and the Management Sciences (INFORMS), IFAC, ACM, and ASME conferences. He was the President of the IEEE ITS Society from 2005 to 2007, the IEEE Council of Radio Frequency Identification (RFID) from 2019 to 2021, the Chinese Association for Science and Technology, USA, in 2005, the American Zhu Kezhen Education Foundation from 2007 to 2008, the Vice President of the ACM China Council from 2010 to 2011, the Vice President and the Secretary General of the Chinese Association of Automation (CAA) from 2008 to 2018, and the Vice President of the IEEE SMC from 2019 to 2021. He was the Founding Editor-in-Chief (EiC) of the International Journal of Intelligent Control and Systems from 1995 to 2000, IEEE ITS Magazine from 2006 to 2007, IEEE/CAA JOURNAL OF AUTOMATICA SINICA from 2014 to 2017, China's Journal of Command and Control from 2015 to 2021, and China's Journal of Intelligent Science and Technology from 2019 to 2021. He was the EiC of IEEE INTELLIGENT SYSTEMS from 2009 to 2012, IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS from 2009 to 2016, and IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS from 2017 to 2020. He is currently the President of the CAA's Supervision Council and the EiC of the IEEE TRANSACTIONS ON INTELLIGENT VEHICLES.