A Systematic Literature Review on Decentralized Governance Design

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Abstract. In a decentralized governed ecosystem, decisions are made through a collaborative and consensus building design mechanism. Such a governance process is multifaceted, complex, dynamic, and challenging. Appropriate design contributes to the success and sustainability of the ecosystems. This paper presents a systematic literature review (SLR) of decentralized governance design (DGD), by exploring concepts such as Decentralized Governance (DG), Decentralized Autonomous Organization (DAO) from a computer science perspective. We identify and assess the characteristics of DG and the drawbacks that exist in current DGD approaches. A novel approach on DGD has been recently introduced, coined as DECENT that utilizes a conceptual modeling approach to improve decentralized ecosystems modeling. Contribution of this SLR study are: (1) Present a concise overview of current approaches on DG (2) Discuss decentralized ecosystems that employ DG and identification of drawbacks (3) Motivate why conceptual modeling is a design requirement for DGD and discuss a DGD modeling method DECENT (5) Provide a clear direction to evolve the development of decentralized governance frameworks.

Keywords: Decentralized Governance Design · DAO · Conceptual Modeling· Digital Platform Governance· Systematic Literature Review.

1 Introduction

Decentralization has been a growing trend in recent years, with an increasing number of organizations and systems moving from centralized towards decentralized systems [5, 11, 37, 52]. Decentralization is a concept that emerged and widely used in the field of politics and economics. To some extent, decentralization has had a dramatic impact on various public sectors‘ competencies, such as levels of investment, public service delivery, education and health indicators, and macroeconomic stability [22]. As a result, decentralization is often seen as a means of promoting individual freedom, greater inclusiveness and a sustainable form of decision-making [37]. Decentralized governance as an emerging research topic offers potential solutions to many of the challenges faced by traditional forms of governance. For example, centralized governance eco-systems often end up with a monopoly on the markets in which they are located, which can easily

lead to economic unbalance in society. Decentralized governance is based on the idea that decision-making power should be allocated to multiple participants rather then concentrated in a central body. This approach has several potential benefits, such as increased transparency, better consistency with the interests of those being governed and reduced potential for corruption [17, 25]. Therefore, we can consider decentralization and the emergence of decentralized governance (DG) as a response to the limitations of centralization and the need for a more flexible and adaptable ecosystems.

One of the reasons driving the continued development of ideas such as decentralized governance is the rise of the internet and digital technologies, including the increasing presence of powerful computing technologies and companies. Blockchain technology can be seen as an important driver in the conceptualization and adaption in the field of decentralized governance [42, 51, 52]. Along with the development of blockchain technology, the idea of web 3.0 as a new iteration of the World Wide Web was proposed[1]. This public blockchain-based World Wide Web aims to build a more open, decentralized and user-centric Internet [15]. Decentralized governance, involves decision-making and resource allocation through a decentralized network of participants, this is a key feature of Web 3.0.

In decentralized governed ecosystems, decisions are usually made through a consensus-based process where stakeholders in the network agree on the best course of action after consultation. Kaya et al. define governance in an ecosystem as a set of rules that one system must follow, which are set by another system [35]. Although many blockchain-based DAOs and decentralized governance frameworks have emerged, very limited research has been done on the theoretical foundations and model validation of the decentralized ecosystem design [16]. Also, DAOs and DGD still face some problems in the actual implementation process [24, 58], which can be simply concluded to the following aspects: (1) difficulty in finding a balance between decentralization and decision-making efficiency, (2) the issue of scalability, (3) application scenarios and functions of DAO ecosystems is limited, and (4) the potential legal risk. The main research goal of this paper is to present a systematic literature review on decentralized governance design from a computer science perspective. The related concepts (DGs, DAOs and DGD) and existing DGD approaches will be detailed explained and evaluated for searching and exploring corresponding research gaps.

This paper is structured as follows. In Sec. 2, we explain our research approach. Sec. 3 presents the results of SLR, Sec. 4 we discuss and answer the research questions. Sec. 5 presents our conclusions, limitations, and suggestions for further research.

[1] https://www.wired.com/story/web3-gavin-wood-interview/

2 Research Approach

The research goal of this paper is to present a systematic literature review (SLR) on Decentralized Governance Design (DGD) from a computer science perspective. We do so by exploring the concepts and developments in the field of DGs, DAOs and DGDs. We selected the PRISMA [39] as our research approach presented in Fig. 1. We formulated two research questions:

RQ1: Evaluate existing methods for decentralized governance and what are the drawbacks of the existing methods?

RQ2: Why is a conceptual modeling relevant for decentralized governance design?

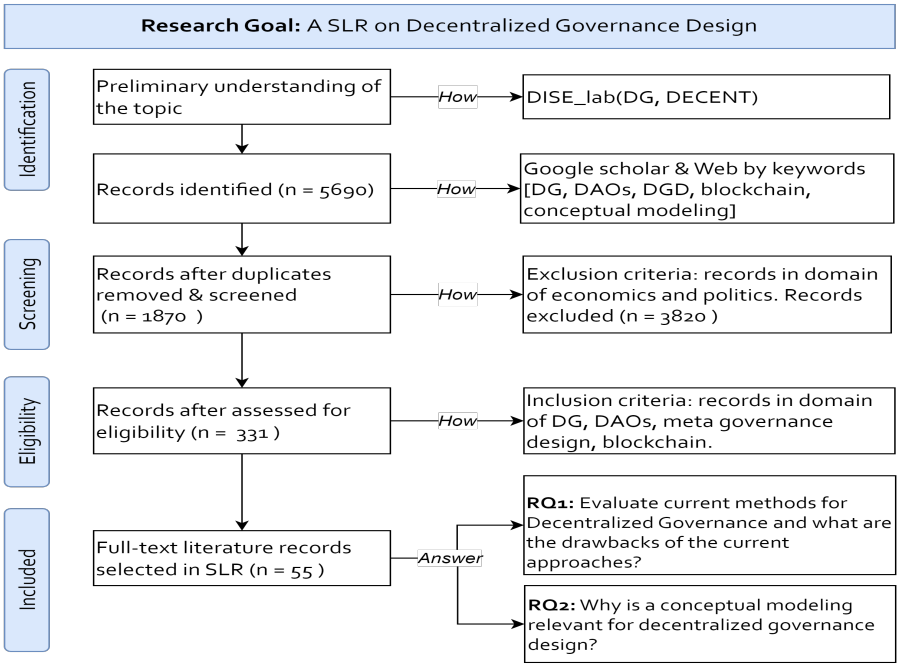

Fig. 1. PRISMA SLR Research Approach

An advantage of PRISMA is that every step of the SLR is reflected, delineated and conceptualized graphically. We also present a novel interpretation by extending the PRISMA method by connecting and presenting clearly the inclusion and exclusion criteria's, and how these are connected to our research questions. We discuss step by step our research process following the PRISMA method hereafter.

Identification. Having a preliminary understanding of DGD is necessary for the

SLR. DISE-Lab[2] lists numerous publications which provide a general answer to the question of why decentralized governance design is important and why it should be carried out. Some real-life case studies such as Decentralized Finance (DeFi)[3], contribute to the clarity of the purpose of the research. It can be found that a close relationship exists between DGD and blockchain, DAOs, and conceptual modeling. As this DGD is an emerging research domain we cannot only limit ourselves to google scholar, but also focus on some relevant organization websites, conference proceedings, white papers and reports. To distinguish these sources from an academic citation, we present them directly as a footnote. The total number of retrieved literature records is 5690. When manually reading and scanning the literature, the 'snowball' method [53] is applied.

Screening. Our research domain of this SLR is based on the Computer Science perspective. Records discussed from a economic, business or political perspective are excluded. We screen these literature records mainly by abstract and keywords. The number of records excluded in this part is 3820.

Eligibility. The number of remaining literature records after being assessed for eligibility is 331. We keep 55 records related to the area of DG, DAOs, meta governance design and blockchain.

Included. We read and analyzed 55 literature records in this SLR ultimately. After in-depth reading and critical understanding of the selected records, we can answer the 2 research questions through the SLR results.

We summarize and present the research selection in table 1.

Table 1. Research Selection

Period	Keyword Selection Criteria	Reference
2011-2015	DACs, DAOs, digital currency platform, blockchain, public service	[4, 9–11, 13, 14, 21, 22, 54]
2016-2018	Smart contract, DAOs, design principle, decentralized computing	[2, 3, 6, 28, 43] [18, 19, 36, 40, 43]
2019-2021	DeFi, regulation, model construction, DGD, DGD frameworks	[1, 7, 8, 26, 29, 45, 48, 51, 52, 59] [17, 23, 25, 27, 29, 33–35, 48, 56, 58]
2022-2023	Meta organization, challenge	[15, 16, 24, 31, 47, 57] [12, 38, 44, 46, 49, 50, 55]

[2] https://dise-lab.nl/

[3] https://ethereum.org/zh/defi/

3 Results of Systematic Literature Review

We present and discuss the results of our SLR in two subsections.
We focus on our first RQ1:
Evaluate existing methods for decentralized governance and what are the drawbacks of the existing methods?
-Explain Decentralized Governance characteristics.
-Present current approaches on decentralized governance.
-Synthesize existing decentralized ecosystems that follow DAO philosophy.
-Discuss drawbacks of current DGD methods and DAO philosophy.
Consequently we focus on our second RQ2:
Why is a conceptual modeling relevant for decentralized governance design?
-Discus the relevance of taking a conceptual modeling approach.
-Present DECENT which is a novel and innovative conceptual modeling approach that allows to design decentralized governance.

3.1 Summary of Decentralized Governance Characteristics

We identified and present the characteristics of decentralized governance.
Fairness. DG is usually based on a consensus-driven decision-making process [4], where governance takes into account the views of different participants before decisions are made and implemented. In other words, decisions are usually made based on the agreement of the majority of participants, rather than by a single centralized actor [25]. A solid, unbiased governance structure for the participants is therefore important to help ensure that decisions are made fairly and represent the views of the wider community.
Transparency. DG is often transparent. As decentralized systems are usually built on open and transparent platforms and require that stakeholders, as well as information related to the operation of the system, have certain access channels [29]. It is helpful for participants to promote trust and confidence in the decision-making process if it is easy to see how decisions are made.
Accountable. DG requires that participants are accountable. Responsibility means that decision-makers, whether internal or external, are accountable to themselves and to those affected by their actions or decisions [48]. These decision-makers are morally or legally obliged to clarify the ultimate action decisions taken by the decentralized governance community in which they are embedded and the impact they have [29], which makes stakeholders more cautious in the governance process.
Flexible. DG is often flexible and adaptable. Because it is not dependent on a single central authority, it can more easily adapt to changing circumstances and needs. This helps to ensure that decisions remain responsive and effective over time and as the environment in which they are made changes. The responsiveness of a responsive and equitable governance structure can motivate participants to engage in the governance process [29].
Effectiveness. DG can be perceived as an effective and efficient means of governance that requires a corresponding balance in the distribution of power in

the system through incentive or punishment mechanisms [33]. Meeting goals by making the best use of available resources can take more perspectives into account [29]. However, the effectiveness of these decentralized governance mechanisms is inherently limited because any implementation of governance relies on the basic framework provided by the community [2].

Resilience. DG is more resilient to failures or attacks because there is no central point of control, which means that the system can continue to operate even if some part of the system is compromised. Weaknesses in that part can be compensated for by the governance of other participants in the same category, or the current work can be renewed or continued at another governance center [1].

3.2 Synthesis DAO Philosphy

In 2013, Daniel Larimer first introduced the concept of 'DAC' (Decentralized Autonomous Corporation) as a potent metaphor for a decentralized system of providing useful goods and services to society[4]. In Larimer's terms, DAC can be thought of as a company that runs its business rules through its stakeholder computers and gives stakeholders ongoing rewards based on DAC's success. Subsequently, Vitalik Buterin proposed DAOs, arguing that DACs are just one of the subcategories of DAOs and are for-profit entities due to the concept of shares introduced by DACs, whereas Vitalik Buterin emphasized that a DAO should be a non-profit entity.

DAOs. Decentralized Autonomous Organization refers to an organizational form that completes decisions and automatically executes tasks in the form of decentralized autonomy under shared rules through codes and programs [8, 20, 45]. That is to say, some people gathered under a certain "big goal" make collective decisions on different "small goals", and let the actions corresponding to the decisions be automatically executed on the chain. In the blockchain perspective a DAO is implemented through tokens and smart contracts which is often used for project governance or resource allocation [4, 47]. We can therefore assume that DAOs are a starting point towards DG [27]. The concept of DAO contains two important features, autonomy and decentralization. Autonomy means the specific operational activities within the organization are generated by prewritten codes and the organization can govern itself [48, 51]. Decentralization means that there is no central node and hierarchical management structure in DAO [27]. Each organization node will cooperate effectively under the incentive mechanism of the certificate according to its own resource advantages and talents, thus generating a strong synergy effect [51]. Vitalik publishes 'DAOs, DACs, DAs, and More: An Incomplete Terminology Guide" in 2014, detailing the potential of this blockchain-based organizational governance [13]. This first DAO was based on Ethereum, a blockchain-based smart contract code system that was introduced in July 2015 using the Ethereum cryptocurrency [47]. The theoretical support for this groundbreaking technological experiment likely came from a white paper released in 2014 [14].

[4] https://letstalkbitcoin.com/dac-revisited

3.3 Decentralized Ecosystems that follow a DAO philosophy

Compound[5] is a decentralized financial (DeFi) platform that enables peer-to-peer operations in the form of an on-chain market, and one of its key features is that loan rates are automatically adjusted according to supply and demand. All decisions regarding the platform are made via smart contracts, and its token holders have governance rights [24].
Uniswap[6] is a decentralized exchange (DEX) platform, currently the largest decentralized financial project in terms of market capitalization and inventory, and one of its key features is that it allows users to trade cryptocurrency tokens without the need for intermediaries [24]. The feature of this project is transactions executed there using a mathematical formula that takes into account the price and reserves of the tokens traded [56]. However while the philosphy is market the decision making structure is still highly centralized [24].
Ethereum Name Service (ENS)[7] is a decentralized domain name service system running on the Ethereum blockchain. It allows users to register domain names and associate them with Ethernet addresses, making it easier for people to access decentralized applications [57]. From the data in the study by R. Fritsch et al. it can be found that about 60% of the voting power is in the hands of community representatives, while for Compound and Uniswap it is less than 10% [24]. Thus, to a certain extent, ENS can be considered more decentralized.
Aragon[8] is a DApp that facilitates the creation and management of DAOs. It is deployed on Ethernet and each DAO created exists on the basis of a series of smart contracts that define the composition of the organization's shareholders and their corresponding rights and obligations [51]. It provides a modular governance framework while this framework does not provide a governance coordination mechanism [23].
MakerDAO[9] is a DeFi project running on Ethereum that combines functions from voting to execution and issuing governance passes [12]. The governance framework features a collaborative off-chain portfolio, multiple on-chain voting models and secondary voting mechanisms. Accordingly, due to the off-chain coordination mechanism, it suffers from the inevitable drawbacks like progressive centralization of governance, increased governance costs and reduced governance initiative of participants[10].
Moloch DAO[11] is a governance framework emerged to crowdfund and allocate funds for Ethereum infrastructure projects. Moloch DAO V1 provides a relatively simple coordination mechanism, with governance accomplished through only 3 core rules. Moloch DAO V2 adds a multi-pass system and adds mecha-

[5] https://compound.finance/
[6] https://app.uniswap.org/
[7] https://ens.domains/
[8] https://aragon.org/
[9] https://makerdao.com/
[10] https://makerdao.com/zh-CN/whitepaper/
[11] https://dao.molochdao.com/

nisms such as open commits, Loot and guild kickouts[12]. To a certain extent, this has improved the degree of distribution and governance stability. However, it is still difficult to handle malicious proposal attacks and the governance decision cycle is long.

DAO stack[13] aims to solve the scalability problem that exists in governance and is therefore more focused on effective distributed decision-making. The core technology of this governance framework is the proposed Holographic Consensus (HC) decision system[14][15] which implemented through a two-channel system. In HC, proposals can pass not only by absolute majority vote, but also by relative majority by creating a prediction market as an intermediate layer with a set threshold [23]. However, the bettors who use their capital voting may choose proposals that seem hotter rather than more sensible owing to the incentive model of predictive betting, reducing voting quality[16].

3.4 Drawbacks of current DG approaches

This section summarizes the drawbacks of the current approaches on DG that follow a DAO philosophy.

Drawback 1. Difficulty in finding a balance between decentralization and decision-making efficiency. Decentralization is a key feature of DAOs, as it ensures that no individual or group can control the organization. However, decentralized decision-making can also lead to inefficiencies and slow down the decision-making process [7]. At the same time, there may be potentially competing points of interest for different stakeholders, which can lead to bottlenecks and inefficiencies in decision-making.

Drawback 2. The issue of scalability. The problem source is actually the limitations of the underlying blockchain technology on which the DAO is based [46]. Many of the blockchain platforms currently building DAOs (e.g. Ether) have scalability limitations. As the number of users and transactions grows, transactions on these networks can become slow and expensive [41]. This can make it difficult for DAO to gain mainstream adoption.

Drawback 3. Application scenarios and function of the DAO ecosystem are limited. There is a lack of exploration for some real-life scenarios that have dis-intermediation and distributed requirements, such as freelance platforms. For current mainstream DAOs, the overall governance efficiency and governance quality are limited by the problems of the existing framework itself, and the lack of new modules on the governance framework platform also means that DAOs cannot use new functions [50].

Drawback 4. Potential legal risks. Although some regions, such as Wyoming in the US, have passed bills to legislate for DAOs[17], it has not yet gained recognition in the subject legal sphere worldwide. There is still doubt as to whether

[12] https://github.com/MolochVentures/Whitepaper/blob/master/Whitepaper.pdf
[13] https://daostack.io/
[14] https://medium.com/daostack/holographic-consensus-part-1-116a73ba1e1c
[15] https://medium.com/daostack/holographic-consensus-part-2-4fd461e8dcde
[16] https://daostack.io/wp/DAOstack-White-Paper-en.pdf
[17] https://wyomingcompany.com/decentralized-autonomous-organizations-dao/

a DAO approach can act as an officially recognized legal method to represent governance decisions [55].

3.5 Conceptual Modeling to Design Decentralized Governance

Decentralized governance design is clearly an emerging research domain and it has been identified there is a need and requirement for a conceptual modeling method that allows to design decentralized governance [17, 49]. A conceptual modeling approach is a method used to design and represent complex systems in a simplified approach. In the context of DGD, conceptual modeling is useful as it can be used to design and represent complex, decentralized systems for DAOs that is easy to understand and analyze. This contributes to identify potential problems or issues with the design and to determine how it can be improved [33] already at an early stage. Conceptual modeling can represents the governance structure and the design decisions of a DAO as a set of artifacts and their inter-relationships. These artifacts can include elements such as decision-making mechanisms, regulations and incentives. In this way, it is possible to understand how the different artifacts interact and how it contribute to the overall functioning of the organization. A novel and innovative approach to design decentralized governance has been recently introduced by taking a conceptual modeling approach. This method to design decentralized governance is coined as DECENT [33] which we will discuss hereafter.

Introduction of DECENT. Kaya et al. states that finding an appropriate sound governance solution for a decentralized ecosystem is a design problem [34]. Due to the different application fields and environments of ecosystems, from the perspective of model development, they face different contexts, and the required components/system components will also be different. In order to avoid serious problems such as centralization of the system, low efficiency or loss of fairness the governance structure can be conceptualized in a clear approach that is understood by every actor in the decentralized ecosystem. In order to explore the topic of DGD, authors have co-founded "DECENT" [31, 33] and presented in Fig. 2. DECENT[18] is developed with the vision that it is a societal and economical responsibility to create ecosystems that promote equity in how we set the rules of participation. DECENT is a conceptual modeling method that will allow an actor or a group who is not proficient in programming languages or technology to conveniently and easily design an ecosystem collaboratively.

DECENT employs a conceptual modeling approach, and this type of an approach (machine-processable formalization) will enable the idea of a decentralized ecosystem to be more widely disseminated and applied. For different decentralized projects, the resulting proprietary decentralized governance model will be considered the product of a rigorous design process [34]. DECENT is positioned within the generic modeling method framework as proposed by [30]. DECENT can be used to describe specific DECENT governance models, i.e. conceptual models. All governance models are based on real-life research subjects, which can be seen here as abstracted and aggregated from requirements analysis

[18] https://dise-lab.nl/

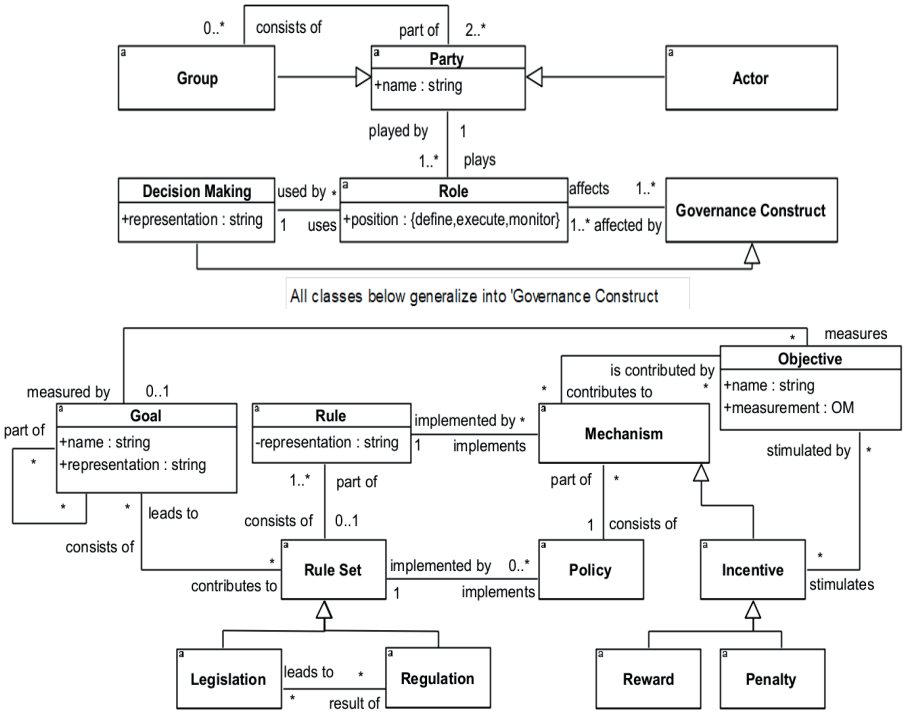

Fig. 2. DECENT meta model [33]

in specific domains such as DeFi, P2P Energy, and Decentralized Social Media.
DECENT meta model. Kaya et al, positions and presents the relevant design artifacts for decentralized governance as the DECENT meta model [31,33]. DECENT is lightweight and easy-to-handle with a well-defined set of decentralized governance concepts. It responds to the design needs of developing governance structures and aims to provide an easy-to-understand modeling environment and tools for users having the desire to design and built a decentralized ecosystem. Figure2 shows its meta model as a UML class diagram, consisting of attributes, associations, generalizations(is-a) and constraints. The DECENT meta model provides a clear and structured approach to defining governance structures and relationships. A very special aspect of the DECENT meta model is the multi-participant approach, which differs from a single participant involved in coordinating system decisions and operations. Each participant has a specific role to define, implement and monitor, and these roles constrain each other, influence each other and complete the whole process of governance design decisions under the influence of other institutional rules etc.
DECENT governance models. The DECENT governance model belongs to the domain of conceptual models and can be seen as a bridge between the real

world and the DECENT meta model in the overall meta modeling approach [30]. Governance consultants are expected to use the DECENT modeling language as a descriptive tool to conceptually decompose and abstract real-world study subjects(banking, social software, etc.) according to the context and characteristics of the desired decentralized ecosystem in order to present a concrete, specific DECENT governance model.

Contribution of DECENT. Decentralized governance as a new field of research has not yet emerged as an unified, authoritative definition. In DECENT's field of research, the process of multiple participants working together to understand rules and create rules is called decentralized governance, and it is positioned as a design product. The study of DGD by adopting a conceptual modeling approach contributes to the understanding and design of structured governance and unification across industry and as a research domain.

4 Discussion

In this section, we discuss the findings of our systematic literature review on decentralized governance and answer our research questions. The development of Internet technologies, especially the introduction of blockchain and Web 3.0, have both driven the field of decentralized governance from theory to practice, with the emergence of many blockchain-based DAO organizations and decentralized governance frameworks. Finding the most adapted governance solution for decentralized ecosystems in different application domains and environments is a design problem, and DECENT employs a conceptual modeling approach to provide a useful solution for analyzing, discussing and developing a reference framework and structured foundation for decentralized ecosystem governance.

RQ1: Evaluate existing methods for decentralized governance and what are the drawbacks of the existing methods?

Emergence of blockchain technology and the problems with centralized governance models, decentralized governance (DG) has developed as an emerging research topic in anticipation of responding to the need for more efficient, democratic and transparent governance structures. The continued emergence of DAOs has been a key driver in the development of DG, which is essential to the operation of DAOs as it allows for a decentralized decision-making process and ensures that no single entity has complete control over the organization. We identified the following decentralized governance characteristics are: fairness, transparency, accountability, flexibility, effectiveness and resilience. The evolution of DAOs and provide a brief introduction to some notable current DAO approaches (Compound, Uniswap, ENS) and evaluates several representative existing decentralized governance frameworks: Aragon, MakerDAO, Moloch DAO and DAO stack. We also identified the drawbacks in existing decentralized ecosystems that follow a DAO philosophy: (1) difficulty in finding a balance between decentralization and decision-making efficiency, (2) the issue of scalability, (3) Application scenarios and functions of DAO ecosystems is limited, and (4) the potential legal risks.

RQ2: Why is a conceptual modeling relevant for decentralized governance design? Conceptual modeling is useful in the context of DGD. It can be used as a method for designing and representing complex systems in a simplified, abstract approach, allowing the design and representation of complex decentralized systems for DAOs in a way that is easy to understand and analyze. DECENT is a new and novel approach that conceptualized decentralized governance design and DECENT has already been applied in the domains of peer-to-peer energy trading and digital currency development [31–33]. A conceptual modeling method helps to identify potential problems in decentralized ecosystem design and determine how to improve them already at an early stage. Also it can be understood and applied by every actor with no reliance on the technology provider to prevent powerful concentrations in developing the governance decision structure.

5 Conclusion

This systematic literature study on decentralized governance design has the following main contributions. First, this work presents the characteristics of decentralized governance and the current drawbacks by providing a comprehensive introduction and summary of DG, DAOs, DGD and other related concepts and technologies, which provides a direction for thinking about the development direction and quantitative criteria of future governance frameworks. In particular, this paper shows the historical research development of DGD, which can be used as a reference for further research. Additionally, researchers can use the DECENT modeling approach as a reference framework for decentralized ecosystem governance design, such as empirical and comparative case studies.

Limitations. The academic sources we have selected are mostly related to computer science. We excluded sources from a business or political perspective and this can potentially affect the generalizability of our results.

Future research. Decentralized governance design requires further exploration from a theoretical foundation and technical development perspective. We also recognize that DECENT can be further deepened by extending it towards a domain specific language (DSL) and testing DECENT in other emerging decentralized ecosystem domains such as the decentralization of intellectual property rights and decentralized social media.

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