Governance of Decentralized Autonomous Organizations that Produce Open Source Software

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Abstract

Decentralized Autonomous Organizations have found a use in the governance of open source software projects. However, none of the existing decentralized governance frameworks encompasses all aspects of open source software projects. Therefore, this study presents a governance framework for decentralized autonomous organizations that produce open source software. The framework is built upon a total of 34 articles of DAO and OSS governance. The framework was evaluated in three leading decentralized autonomous organizations that produce open source software. The evaluation highlighted the relevance of the framework and the categorization of governance mechanisms. Finally, we list emerging governance practices in various governance domains in this developing field.

Index Terms

Decentralized Autonomous Organizations, Open Source Software, Governance Framework, Blockchain, Commons

I. INTRODUCTION

NAKAMOTO started the widespread blockchain emergence in 2008 with his Bitcoin whitepaper [1]. Bitcoin allowed two parties to confirm an event or transaction without a middleman for the first time. Six years later, Buterin presented Ethereum, which added Turing-completeness and state awareness to blockchain networks [2]. Ethereum allowed for code to be written, deployed, and executed on the decentralized network. This enabled the creation of a range of decentralized applications, including decentralized autonomous organizations (DAOs). A DAO, as defined by Hassan et al, is "a blockchain-based system. It that enables people to coordinate and govern themselves mediated by a set of self-executing rules deployed on a public distributed ledger, and whose governance is decentralized" [3].

Various types of DAOs have since been instantiated, including investment DAOs [4], protocol DAOs [5], Common DAOs [6], and others. Another variant, open source software (OSS) producing DAOs allow OSS project governance in a decentralized and transparent manner. OSS projects that are maintained by its community could be well supported by a DAO [7]. These OSS producing DAOs are the scope of this research.

We define an OSS producing DAO as *an organization that runs on a public distributed ledger without a strong centralized actor that autonomously manages the production of Open Source Software*. Since DAOs run on public infrastructure, their reliance on algorithmic governance is bigger than traditional forms of governance [8]. Algorithms provide flexibility regarding the level of decentralization (decentralization of governance or infrastructure) and level of autonomy (autonomous or automated). A DAO could therefore provide flexibility and decentralization at a much higher level than traditional projects can. Within DAOs, it led to the creation of liquid democracy [9], where voters have a flexible voting share depending on their participation. This flexibility has a downside. In algorithmic governance, When *Code is law* [10], bugs in code become faults in governance. This has already happened in the failed TheDAO, where a bug in the smart contracts led to drainage of project funds [4].

The failed project highlights both the wide use and importance of quality smart contracts. A smart contract is *A set of promises, specified in digital form, including protocols within which the parties perform on these promises* [11]. The smart contracts of an OSS producing DAO define the roles, relationships and interactions of actors with each other and the organization. An OSS project scales to many types of stakeholders, such as software engineers, maintainers, translators, and designers. An OSS producing DAO

governs the development of the project, including the onboarding and participation of all the stakeholders. It defines their interactions with the project as well as their cooperation with each other.

The field of decentralized governance is continuously evolving. Valiente et al describe how scholars and practitioners have tried to simplify and clarify the process of building DAOs to ultimately make them an accessible organization form [12]. However, due to its complexity, the extreme flexibility and low fault tolerance, it remains a daunting task to build a DAO that fully incorporates all aspects of governance.

Some scholars have described blockchain governance frameworks, such as van Pelt et al. [13] and Beck et al. [14]. However, given the focus on blockchain governance, these frameworks do not encompass the complexity of the particular community, autonomous decision making and organizational governance that DAOs face.

We observe the necessity of a framework that complements the OSS governance practices with the complex social challenges that DAOs face. The research question is: *How are OSS producing DAOs governed?* The goal of this research is to build an OSS producing DAO governance framework to answer this research question. To build a framework that covers the governance aspects of OSS producing DAOs, we gather OSS governance elements from literature and complement this with DAO governance elements from academic and grey literature.

The objective of this research is to a) build a framework that integrates OSS governance practices with DAO governance practices, b) evaluate this framework through three case studies at leading DAOs and c) assess how leading DAOs are solving blockchain governance challenges.

We first investigate what other authors have written on the intersection of OSS and DAOs in Section II. Afterwards, we explain how the framework is created through literature study and evaluative case studies. This happens in Section III. Section IV describes the OSS producing DAO governance framework, which is evaluated in the case studies in Section V. We reflect on these findings in Section VI. Finally, we conclude this research in Section VII, where we reflect on the growth of the number of DAOs and reiterate on the challenges of this novel field.

II. THEORY: HOW OSS LITERATURE CAN CONTRIBUTE TO SOLVING DAO GOVERNANCE CHALLENGES

In this section, we describe the contributions of other authors to the fields of OSS governance and of DAO governance. We first list the leading governance frameworks for open source software and the types of governance present in OSS communities.

Afterwards, we turn to DAO governance literature. We list the current DAO governance challenges, and review current frameworks that address them. After concluding that no framework fully encompasses the governance that DAOs need, we describe how the envisioned OSS producing DAO framework will fulfill this.

A. Open Source Software governance frameworks

Markus defines OSS governance as *"The means of achieving the direction, control, and coordination of wholly or partially autonomous individuals and organizations on behalf of an OSS development project to which they jointly contribute* [15]. OSS governance is a multi-faceted challenge. Two authoritative scholars have created unified frameworks that describe OSS governance: De Laat [16] and Markus [15]. Here, we briefly compare them, as this will be an input for OSS governance for DAOs. Both authors divide the concept into multiple dimensions. De Laat recognizes six dimensions of governance: I, modularization, II, division of roles, III, delegation of decision making, IV, training and indoctrination, V, formalization and VI, autocracy/democracy.

Markus uses a different multidimensional model. She divides OSS governance in seven dimensions: I, ownership of assets, II, project chartering, III, community management, IV, software development processes, V, conflict resolution, VI, rule changing and VII, use of information and tools.

Some of these dimensions overlap and some are distinctive. For example, the 'use of information and tools' of Markus' framework matches the 'formalization' of de Laat's framework. Both describe how

and which tools are utilized to communicate information and manage repositories. But there are also discrepancies between the frameworks. One of the pillars of de Laat's framework is project chartering. This is the establishment of a mission and vision for the project and also includes roadmap development [16]. This is not present in Markus' framework. Similarly, training is one of the main dimensions of Markus' framework, which is only implicitly present in the work of de Laat. In this work, we integrate both frameworks following the method described in Section III.

Aside from unified frameworks, other researchers focus on specific aspects of OSS governance. For answering the research question, we need to know the OSS solution to two of the most complex problems within DAO communities: motivation and role structure.

OSS projects have to motivate their contributors. Motivation is particularly interesting because OSS projects have many diverse incentives. A project can provide contributors with a feeling of accomplishment, status in the developer community or financial motivations [17], [18]. Other incentives are intellectual stimulation and improvement of skills, a sense of moral obligation to the open source community and the belief that software should be free [19]. However, matching incentives with the community is challenging. Nevertheless, it is essential for DAOs and other OSS projects to ensure alignment between community desires and the used incentives [20].

Role structure is another aspect of OSS governance that both differs from traditional organizations and is of particular relevance in DAO governance. Within open source software projects, Crowston and Howison observe that members gravitate towards central roles [21]. At the project core there are leading developers or project leaders, with less involved participants around them. The authors refer to this structure as an onion model. Over time, the active users in the outer layers become more important and gradually transition inwards. These movements are referred to as role migration. Role migration in OSS is more fluid than in traditional organizations and can be highly based on meritocracy and reputation [17], [22].

The standards of OSS role structure and migration are of particular relevance to DAO governance because it guides the management of DAO participants. The smart contracts allow extremely flexible roles which at the same time require rigid and correct coding. By mimicking the open source role characteristics, DAOs can design effective roles and bring clarity to its members.

B. Categorizing OSS governance types to find a niche for DAOs

Finding a framework and selecting mechanisms is insufficient for successful OSS governance. It requires adaptation to the circumstances at hand, and therefore needs a *style* of governance [23].

Multiple authors have presented the case of the bazaar vs cathedral types of software development, that was originally presented by Raymond [24]. In a cathedral, a few master builders define a central plan which is executed by a large group of developers. A different development type is a bazaar. In a bazaar, there is no central control or basic building plan. Instead, many small shops execute whatever works. Translated beyond the metaphor, programmers can autonomously offer different approaches to different problems.

Recent scholars provide less appealing and more sophisticated types of governance. Di Tullio and Staples adapt the framework of Markus [15] to find three types of governance configuration [25]. First, *open communities* are bottom-up software projects with little overhead, little defined processes but clear tooling. Second, *defined communities* are also bottom-up projects but they do have clear processes for decision making, conflict resolution and software development. The rules of the project are clear and the community enforces use of specific tooling. Finally, *authoritarian communities* are guided top-down. A few central actors make the decisions, and there are few processes to manage conflicts. Tooling is unenforced and the rules remain unclear.

Other authors created other community classifications. Germonprez, Kendall and Kendall divide the open source project group in four types, according to their goal [26]. The groups are divided in a quadrant of adhocracy versus bureaucracy and family versus meritocracy. Adhocracy and family provide freedom and flexibility, while bureaucracy and meritocracy maintain control and reward structures. Combining

bureaucracy and family focuses on inward reflection, while adhocracy combined with meritocracy generates outward achievements.

De Noni, Ganzaroli and Orsi provide a final classification [27]. they discovered four clusters with their own characterizing configurations: *open source-based*, *sponsor-based*, *tolerant dictator-based* and *collective*.

As described, the literature shows different governance categories. Authors have named these governance structures, governance configurations or community types. These classifications show similarities. The models differentiate on the same governance properties. Generally, we observe that the authors classify projects on (I) the level of formalized governance, which ranges from undefined/open to defined governance; and on (II) the type of rule, which ranges from democratic to authoritarian governance.

An OSS producing DAO framework should accommodate all possible types of OSS governance. Based on the previous work, we observe three requirements for the framework. First, It should allow for formal and loose governance. Second, it has to be flexible in incorporating actors, actor groups and the various modes of rule. Third, it should be relevant for projects with democratic governance and with authoritarian rule.

C. The challenges of DAO governance

A Decentralized Autonomous Organization is an organization form which is jointly owned by its members, with each having direct influence in its decision making. It is facilitated by the transparent, immutable and auditable nature of blockchain [3]. Jentsch describes the first high profile DAO, which started in 2016 [28]. It failed spectacularly because of an exploit of its smart contracts. That exploit allowed a malignant to steal parts of the treasury. The event had severe consequences for its Ethereum blockchain community [4].

In the aftermath, the advancements and adoption of DAOs were tempered and their technology remained nascent [28]. It is only recently that DAOs are maturing and new tools are developed to support DAOs. At the moment, DAOs face many unsolved governance challenges. Rikken, Janssen and Kwee investigate these challenges [29]. These authors recognize that DAOs among other challenges lack control over infrastructure, experience voter fatigue, fail to act in crises, and cannot handle immutability breaches.

Both practitioners and scholars work to solve these challenges that prevent DAOs from becoming a popular governance form. We shortly describe how three governance challenges are being solved by the introduction of new technology: on-chain versus off-chain governance, voting, and tokenomics.

- Within DAOs, governance can be executed in two ways: on-chain and off-chain decision making. Reijers defines on-chain governance as the rules and decision making processes that have been encoded directly into the underlying infrastructure of a blockchain-based system [30]. Off-chain governance comprises all other rules and decision making processes that are not encoded on the blockchain.
  The current governance of DAOs consists of a small part on-chain governance at the project core, while most governance happens off-chain. This is because of the limitations of the current early state of DAO technology. On-chain decision making was affected by gas costs, although the newer consensus algorithms minimized this [31]. The high gas cost did limit user activity, as Faqir et al remark [32]. As the technology matures, Wang et al suspect an increase in on-chain governance [33]. Despite the increasing availability in on-chain governance tooling, it remains a challenge to find the adequate synergy between on- and off-chain governance.
- Practitioners built voting systems for DAOs, which have been described by Liu et al[34]. In traditional organizations, decision making is concentrated at the top. This is different in DAOs. in a DAO cooperative, all shareholders can directly participate in the decision making through decentralized voting [35]. The current approach for most DAOs is governance by proposals. Some or all members can submit proposals after which all DAO members vote [33], [36]. The proposal and votes are recorded on the underlying blockchain[37]. The proposal outcome may be an action that is automatically executed by the DAO, such as promoting a member, accepting a new member, allocating funds, or

performing a payment. Members can vote on these proposals by using tokens. To further complicate the decision making, DAOs use vote counting methods, including plutarchy [30], reputation scores [14], [38], quadratic voting, liquid democracy and conviction voting [8]. So far, it remains unclear which form leads to the most effective governance.

- Governance of decentralized systems is further complicated by a wide variety of tokenomics. The tokens in DAOs have different properties and roles. In Bitcoin and most classic application, it is a digital currency indicating value. But today crypto-tokens fulfil a wide variety of roles. Some tokens are similar to currencies, others are like securities, and others have properties that are entirely new [39]. Wang et al., 2019 describe three utilities that are generally embedded in crypto-tokens: equity, property and currency [33]. First, Equity implies that the token is value adding and provides long term income. Secondly, Property means that tokens represent goods, services or a right to use. finally, currency properties facilitate circulation within a certain range. At the moment, practitioners are experimenting with these three token properties and we are witness to a rapid development and diversification.

A fourth technical development that aids decentralized governance is the rise of platforms for developing DAOs. Several platforms integrate governance mechanisms into services. Aragon, DAOstack and Colony are the most popular DAO platforms [34]. These platforms simplify building a DAO, while services aid in the operations and governance of the DAO. They offer tools for registering a DAO on-chain and for creating tokens, registering proposals, vote on proposals and manage funds. Aragon appears to offer the most complete platform for building DAOs [40], [41]. To aid practitioners in selecting the right DAO platform for their DAO, Baninemeh, Farshidi & Jansen created a decision making model [42]. Although these platforms hand us tools to govern DAOs, they do not provide guidance on effective leadership.

D. Existing frameworks that guide decentralized governance

Researchers have described the governance areas that come with managing a blockchain. Beck, Müller-Bloch & King divide governance in decision rights, accountability and incentives [14]. Decision rights range from centralized to decentralized, while incentives range from aligned to unaligned. Accountability can be institutionally enacted or technically enacted.

van Pelt et al's blockchain governance framework has a different division. It contains three layers, off-chain community, off-chain processes and on-chain protocol [13]. The framework has six dimensions that stretch across the three layers. It complements the framework of Beck et al with social elements including membership, roles and communication.

Liu et al create a framework that includes the ecosystem around it, and thereby offer a wider perspective than blockchain governance itself[34]. These authors suggest six principles that together foster the blockchain and the surrounding ecosystem. This view adds the layer of ecosystem-level governance. Furthermore, Liu et al. emphasize a consideration of the level of decentralization, thereby following Beck et al. Finally, the authors add legal and ethical considerations.

A final framework concerning decentralized governance comes from the field of economics. The work of Ostrom describes eight principles of successful commons governance [43]. The work of the Nobel prize winner helps communities to create collective action without relying on a central authority. In other words, it is decentralized governance. Commons governance has several similar characteristics with DAO governance, and the comparison is made in Rozas et al, 2021 and Cila et al, 2020 [44], [45]. Both commons and DAOs require decentralized enforcement of rules, participatory decision making and collective action. This work can be used to provide conceptual guidance for the field of DAO research. We hope to work out the connection between DAOs and commons in later research.

E. The envisioned role of the OSS producing DAO Framework

OSS governance is complex and diverse in its demands of hierarchy, governance types and formality. the governance structures should be advanced to handle both decentralized and centralized projects. At the same time, the current stage of DAOs is nascent, and faces numerous governance challenges.

Still, several brave groups are trying to build an OSS producing DAO. To guide them in establishing the right form of governance, we are writing this paper.

We suspect that they would be helped by a framework that integrates the acquired practices of open source software into the DAO research field. The fields are similar, and the frameworks too. for example both fields face questions of decentralization, accountability and institutionalization [14], [15], [16].

Although, several blockchain governance frameworks exist, none incorporate all essential elements of open source software production. For example, the work of Markus mentions project chartering and the resolution of conflicts as essential elements of governance, but none of the blockchain governance frameworks has these dimensions. Therefore, an integration of OSS elements into DAO governance would be a novel contribution to this field. In the words of Rikken et al, for developing DAO governance models, "we recommend learning from the lessons from the open source community" [29].

III. RESEARCH METHODS: DESIGNING THE DAO GOVERNANCE FRAMEWORK

The OSS Producing DAO Governance Framework was constructed in three steps. In this method, we first describe the literature collection process for OSS governance and DAO governance. Secondly, we describe the framework production steps. Finally, we list the procedure for the evaluative case studies that were conducted at well known DAO projects.

A. Literature Study for capturing OSS governance and DAO governance

We conducted a literature study to identify relevant literature and extract the governance practices from it. These practices were used in the creation of the OSS Producing DAO Governance Framework.

Two search engines have been selected for identifying relevant OSS governance and DAO governance mechanisms. These are Scholar and Scopus. Scholar has been selected as it possesses the biggest academic collection, and Scopus because it has the most advanced tooling [46]. For both OSS and DAO framework types, we used both search engines. The result is shown in Table I in the four rows. We derived the queries from the research question. They are also listed in the table.

Sufficient academic literature was available to build the OSS governance side of the framework. However, the queries provided too little results for the DAO governance side. To overcome this lack of articles, we added gray literature to the scientific results. We followed the guidelines of Garousi et al. [47] for a multivocal literature review.

After defining search queries and running the engines, we selected relevant papers from the results. We first excluded all papers that were not publicly available or not in English. Afterwards, we conducted two exclusion rounds. The first round was conducted after reading title and abstract, and the second round after reading the full paper. Papers were excluded based on two criteria. Either they did not concern OSS or DAO governance or they did not report concrete governance activities. This selection resulted in a total of 16 relevant articles for OSS governance and 18 papers for DAO governance, as shown in the second to last column of table I. The list of articles used for framework creation is in Table II.

In combining these results in a single overview we used a systematic approach, based on guidelines of Kitchenham & Charters [48]. The documents were first uploaded in Nvivo. Codes of OSS producing DAO governance were created in an exploratory manner: whenever a governance concept was encountered, it was created as a new code. To adhere to the standards of Kitchenham & Charters, the data extraction was conducted by the lead researcher, and reviewed by the supervising researcher.

As a result of this process, 165 Codes were created for OSS governance and 136 for DAO governance.[1] These codes were governance concepts, challenges, legal designs and ideas related to governance.

After creating the codes, we synthesised the results. We conducted two qualitative syntheses in adherence to the guidelines of Kitchenham & Charters. One investigation was for OSS governance and the other for DAO governance:

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[1]The full list of codes is available upon request

Literature search method	Queries	Search engine hits	Excluded on title and abstract	Excluded on full read	**Total relevant articles**	relevant articles / total hits	**Articles after duplication removal**	Number of codes
Scopus OSS governance	TITLE(((open source software) OR OSS OR OSSD) AND governance)	28	13	2	**13**	46%		
Scholar OSS governance	allintitle: open source software governance OR allintitle: OSS governance OR allintitle: OSSD governance	83	53	14	**26**	31%	**16**	165
Scopus DAO governance	TITLE((decentralized AND autonomous AND organization) OR (decentralized AND autonomous AND organizations) AND governance)	5	3	1	**1**	20%		
Scholar DAO governance	allintitle: decentralized autonomous organization OR allintitle: decentralized autonomous organizations	116	85	12	**18**	16%	**19**	136

TABLE I: Selecting literature from OSS and DAO literature. Scopus and Scholar together create enough relevant work for the creation of the framework.

1) OSS Governance overview: The OSS governance mechanism overview in Appendix I is the result of clustering and classifying the 165 codes. During this process, the governance dimensions of Markus [15] provided a framework for classifying governance mechanisms. These governance mechanisms are (I) ownership of assets, (II) chartering the project, (III) community management, (IV) software development processes, (V) conflict resolution and (VI) use of information and tools. These were combined with the similar categorizations of governance of de Noni et al and di Tullio & Staples [49], [25]. Appendix I provides a summarizing description of what each mechanism entails and references to literature that describe these governance mechanisms.

2) DAO governance overview: The 136 created codes were combined into 21 governance mechanisms. For each of the identified mechanisms, we added a description from the literature set. The DAO overview divides the governance mechanisms into 1) decision making, 2) incentives and 3) community. Additional governance mechanisms beyond this categorization can be imagined, but have not been found in the literature set. This process resulted in the DAO governance overview in Appendix II.

B. Creating the OSS producing DAO governance framework

The second part of creating the OSS producing DAO governance framework was integrating the OSS governance overview of Appendix I and DAO governance overview of Appendix II in a single framework. Every identified governance aspect was analyzed and integrated, adapted or excluded for the OSS producing DAO governance framework. ²

The dimensions were formed by considering its relative importance to the entirety of DAO governance. Mechanisms such as *use of information and tools* or *conflict resolution* were were fit into the other dimensions. Some of the OSS dimensions were reworded to suit DAO specifics.

In Table II, we map the analyzed studies across the seven governance mechanisms. As visible in the table, DAO governance literature is primarily concerned with the decision making systems and incentive design. Those columns are more filled than the others. We suspect that it stems from the novelty of DAO technology. In contrast, OSS governance has been well-researched and embedded in academic literature. This is visible in the table too.

Table II shows that OSS governance literature covers observably more of the framework than DAO governance. This has two explanations. First, the framework was created using a governance classification

²The overview of governance mechanisms, inclusion and explanation is available at https://data.mendeley.com/datasets/ptkygymvyj.

that stems from OSS literature. Other work from that field can cover the same subjects and therefore have a better match to the framework. Second, OSS governance literature is more mature than DAO governance literature. The table indeed highlights that DAO research can learn from open source research. The most apparent knowledge gap in DAO research is chartering and in software development processes.

ref	Article	Data set	Lead & Role Structure	Decision Making	Legal Foundation	Chartering	Incentives	Community Mgmt	Software Dev proc
[16]	De Laat, P. B. (2007). Governance of open source software: state of the art.	OSS	◉	●	●	●	●	◉	●
[50]	Capra, E., Francalanci, C., & Merlo, F. (2008). An empirical study on the relationship between software design quality, development effort and governance in open source projects.	OSS	○	●	○	●	○	○	●
[51]	Jensen, C., & Scacchi, W. (2010, May). Governance in open source software development projects: A comparative multi-level analysis.	OSS	●	●	○	●	○	●	●
[27]	De Noni, I., Ganzaroli, A., & Orsi, L. (2013). The evolution of OSS: a dimensional comparative analysis.	OSS	●	●	●	●	◉	●	●
[52]	O'Mahony, S. (2007). O'mahony, S., & Ferraro, F. (2007). The emergence of governance in an open source community.	OSS	●	●	○	○	◉	◉	◉
[53]	Sadowski, B. M., Sadowski-Rasters, G., & Duysters, G. (2008). Transition of governance in a mature open software source community: Evidence from the Debian case.	OSS	●	●	○	○	◉	◉	◉
[49]	De Noni, I., Ganzaroli, A., & Orsi, L. (2013). De Noni, I., Ganzaroli, A., & Orsi, L. (2011). The governance of open source software communities.	OSS	◉	◉	●	○	●	◉	○
[25]	Di Tullio, D., & Staples, D. S. (2013). The governance and control of open source software projects.	OSS	●	◉	●	○	○	◉	○
[26]	Germonprez, M., Kendall, J. E., Kendall, K. E., & Young, B. (2014). Collectivism, creativity, competition, and control in open source software development: reflections on the emergent governance of the SPDX® working group.	OSS	◉	●	○	○	○	◉	○
[15]	Markus, M. L. (2007). The governance of free/open source software projects: monolithic, multidimensional, or configurational?.	OSS	◉	◉	●	○	◉	●	●
[54]	Nyman, L., & Lindman, J. (2013). Code forking, governance, and sustainability in open source software.	OSS	○	◉	●	○	○	◉	○
[17]	Midha, V., & Palvia, P. (2012). Factors affecting the success of Open Source Software.	OSS	●	○	○	○	○	◉	◉
[55]	Jensen, C., & Scacchi, W. (2007, May). Role migration and advancement processes in OSSD projects: A comparative case study.	OSS	●	○	○	○	○	◉	○
[56]	Shah, S. K. (2006). Motivation, governance, and the viability of hybrid forms in open source software development.	OSS	◉	○	●	○	●	◉	○
[57]	Sagers, G. (2004). The influence of network governance factors on success in open source software development projects.	OSS	○	○	○	◉	◉	●	●
[58]	Lee, S., Baek, H., & Jahng, J. (2017). Governance strategies for open collaboration: Focusing on resource allocation in open source software development organizations.	OSS	◉	◉	○	○	◉	●	◉
[4]	DuPont, Q. (2017). Experiments in algorithmic governance: A history and ethnography of "The DAO," a failed decentralized autonomous organization.	DAO	○	●	○	○	○	○	○
[59]	Hsieh, Y. Y., Vergne, J. P., Anderson, P., Lakhani, K., & Reitzig, M. (2018). Bitcoin and the rise of decentralized autonomous organizations.	DAO	○	●	○	○	○	◉	○
[60]	Kondova, G., & Barba, R. (2019). Governance of decentralized autonomous organizations.	DAO	◉	●	○	○	○	○	○
[8]	Kaal, W. A. (2020). Decentralized corporate governance via blockchain technology.	DAO	○	●	○	○	●	●	○
[33]	Wang, S., Ding, W., Li, J., Yuan, Y., Ouyang, L., & Wang, F. Y. (2019). Decentralized autonomous organizations: Concept, model, and applications.	DAO	○	◉	○	○	●	○	○
[30]	Reijers, W., Wuisman, I., Mannan, M., De Filippi, P., Wray, C., Rae-Looi, V., ... & Orgad, L. (2021). Now the code runs itself: On-chain and off-chain governance of blockchain technologies.	DAO	○	●	○	○	○	○	○
[61]	Virovets, D., & Obushnyi, S. (2021). Decentralized Autonomous Organizations as the New Form of Economic Cooperation in Digital World.	DAO	○	◉	○	○	◉	◉	○
[62]	Riva, S. (2019). Decentralized Autonomous Organizations (DAOs) as Subjects of Law–the Recognition of DAOs in the Swiss Legal Order.	DAO	◉	○	●	○	○	○	○
[32]	Faqir-Rhazoui, Y., Ariza-Garzón, M. J., Arroyo, J., & Hassan, S. (2021, May). Effect of the gas price surges on user activity in the daos of the ethereum blockchain.	DAO	○	○	◉	○	○	◉	○
[2]	Buterin, V. (2014). A next-generation smart contract and decentralized application platform.	DAO	○	◉	●	○	◉	○	○
[35]	Wright, A., & De Filippi, P. (2015). Decentralized blockchain technology and the rise of lex cryptographia.	DAO	○	◉	○	○	○	○	○
[63]	Swan, M. (2015). Blockchain: Blueprint for a new economy.	DAO	○	◉	○	○	○	○	○
[9]	Fan, X., Li, P., Zeng, Y., & Zhou, X. (2019). Implement liquid democracy on ethereum: A fast algorithm for realtime self-tally voting system.	DAO	○	◉	○	○	○	○	○
[64]	Lalley, S. P., & Weyl, E. G. (2018, May). Quadratic voting: How mechanism design can radicalize democracy.	DAO	○	◉	○	○	○	○	○
[38]	De Filippi, P. (2021). Reputation.	DAO	○	◉	○	○	◉	○	○
[14]	Beck, R., Müller-Bloch, C., & King, J. L. (2018). Governance in the blockchain economy: A framework and research agenda.	DAO	○	◉	○	○	●	◉	○
[65]	Braun, A., Häusle, N., & Karpischek, S. (2021). Incentivization in Decentralized Autonomous Organizations.	DAO	○	○	○	○	●	○	○
[66]	Diallo, N., Shi, W., Xu, L., Gao, Z., Chen, L., Lu, Y., & Turner, G. (2018, April). eGov-DAO: A better government using blockchain based decentralized autonomous organization.	DAO	○	○	○	○	○	○	◉

TABLE II: Two data sets of in total 34 articles fill the framework. The columns indicate governance coverage of the article: ○ indicates no coverage, ◉ indicates partial coverage of the mechanisms, ● indicates coverage of all mechanisms.

C. Selecting case studies and framework evaluation

The created framework has to be evaluated by case studies. A case study is an observational evaluation method which is used to study the designed artifact in depth in its intended business environment (Hevner & Chatterjee, 2010). The objective of the case studies is to evaluate the framework on its completeness and its usefulness. This study follows the holistic multiple case study approach of Yin. It entails a design with multiple cases but one unit of analysis [67]. We chose for this design because it creates a better understanding of the differences and similarities between the cases [68]. It allows us to understand the similarities and differences of DAO governance between case studies.

Cases were selected based on the researchers' perceived ranking of most mature OSS producing DAOs. Maturity criteria were the project age, governance maturity and availability of information. This is a form of purposive sampling, based on the case study classification of Campbell et al [69]. Six DAOs were contacted and three replied positively for an interview. These are dOrg, Aragon and TEC. dOrg is the first legally registered blockchain based LLC [3]. Aragon is perceived as one of the oldest, largest and most well-known organizations working on DAOs and is the largest DAO platform [5]. The final case study, Token Engineering Commons (TEC), is relevant because of its remarkably mature governance system, founded upon the work of Ostrom.

We started the data collection for every case with an in-depth investigation of the DAO's communication channels, forums, handbooks and other publications. This information was used to create an initial overview of the DAO's governance framework. The overview followed the governance mechanisms of Figure 1. The data collection took around two months, and ended with the interview. In the interview, the findings were validated and extended.

The interviews were conducted between December 2021 and February 2022. For Aragon and TEC, we conducted the interview with two DAO participants. dOrg could only provide a single interviewee for the interview. Descriptive information about the interviews is available in Table III.

A case-study protocol allowed the researchers to evaluate the framework through semi-structured interviews.[4] It contained the questions that guided the interviewee through the governance overview in a semi-structured manner. The case study protocol also informed the participants of the context and purpose of the case study and contained an informed consent form.

The completeness of the framework was assessed by modeling the complete governance of the DAOs in scope. After going through the framework dimension by dimension, we asked the interviewees if any governance aspects of their DAO was not covered by the framework. Finally, we evaluated the usefulness of the framework. We asked the interviewees how the case study gave them new insights, was useful to them and may be of use to others.

In the next section, we discuss the case study results.

	dOrg	Aragon	TEC
Interviewee Role(s)	dOrg member	Executive sub-DAO members	Stewards working group members
Interview duration (minutes)	120	56	116
Interview date	02-02-2022	20-12-2021	10-01-2022
Number of interviewees	1	2	2
Information collection period	01/2022-02/2022	10/2021-12/2021	11/2021-01/2022

TABLE III: The three case studies that we analysed using the framework. dOrg, Aragon and TEC are leading DAOs.

Fig. 1: The OSS producing DAO governance framework classifies governance mechanisms in seven areas. It combines the governance mechanisms of the 34 articles on OSS and DAO governance research.

IV. RESULTS: THE OSS PRODUCING DAO GOVERNANCE FRAMEWORK

The OSS producing DAO governance framework is a governance blueprint for OSS producing DAOs. DAO builders and researchers can use it to design, improve or evaluate DAO governance. The general overview is in Figure 1. DAO creators may use the governance framework to assess the maturity of their DAO and its governance. Researchers may use the OSS producing DAO framework to identify DAO governance challenges and form new theories about OSS creation. For both practitioners and scholars, the framework aids in DAO governance by providing structure in understanding this complex phenomenon. In the following paragraphs we outline the concepts that form the framework.

[3]As discussed in https://www.coindesk.com/markets/2019/06/11/dorg-founders-have-created-the-first-limited-liability-dao/

[4]The interview protocol and the transcripts are available upon request

A. *The seven dimensions of the framework*

The dimensions of the framework are based on the identified dimensions of OSS governance in Appendix I and the categorization of DAO governance concepts in Appendix II. We created the framework according to the aforementioned method.

Some of the governance mechanisms are rather abstract. We therefore added references throughout this section to the case study chapter. The cases add real world examples that aid in understanding the governance mechanisms.

The seven dimensions of the DAO for OSS Governance framework are:

I. **Leadership and role structure** (see subsection V-B and table V) represents the decentralized and initially flat hierarchical structure of DAOs. It combines the leadership aspect of the *leadership and decision making* dimension, while incorporating the role structure aspects that are included in the OSS *community management* dimension.

DAOs emerged as a response to an overly structured centralized power. Therefore, the initial DAOs were fully decentralized, had no power hierarchy, and were fully democratically governed. However, democratic decision making does not need to remain essential in the development of this new organizational form. Neither does it mean that all members in existing DAOs are equal. Roles appear in DAOs that characterize how individuals participate in the community. For example, in an OSS organization, developers or contributors are a role that naturally emerges.

Within this governance area, we list how leadership establishes within a DAO and how the other roles are acquired. Leadership and role structure has four concepts:

a) **Roles and Responsibilities**

Within a DAO, there is a division of work into roles. Roles types include traditional roles such as observer, developer, core-developer and project owner but a DAO can come with new roles such as decentralized infrastructure developer or community manager. There should be a role that distributes and manages responsibilities [10]. The number of roles differs per project and maturity level [53].

b) **Role structure**

The role structure describes the DAO's organizational structure. It ranges from fully democratic to single, absolute dictatorship, and everything in between. Commonly, OSS projects have a form of elected leadership, but this is not necessary. The flexibility of DAOs can create wildly varying types of organizations [66].

c) **Role advancement**

In formalized communities, members may be obliged to go through a process of vetting and quality control to advance through roles. Role migration ranges from fluid and informal to very formal [25]. Roles can be acquired by volunteering, earning appointment or election [51].

d) **Establishment of leadership**

Leadership structure must be designed and established. It can be self-appointed or elected. Leadership may also rest with an organization outside of the community [49], [16].

II. **Decision making** includes the essential community governance mechanisms of proposals and votes, divided over the on-chain and off-chain channels. (see subsection V-C and table VI). It incorporates the decision making aspect of the OSS *leadership and decision making* dimension.

a) **On-chain decision making**

On-chain decision making covers all DAO decisions that have been formally written to the blockchain. Despite the growth of on-chain governance solutions, not all governance decisions are currently possible on-chain [30], [33]. It varies per DAO what decisions are made on-chain.

b) **Off-chain decision making**

Any governance decisions that are made through other channels than the blockchain are off-chain decisions. Reaching agreement is more practical off-chain [8]. Most decisions of a DAO are made off-chain, and various DAOs have various preferred methods of reaching agreement.

c) **Proposal management**

Proposal management is the process of organizing and coordinating the creation of proposals. Proposals are one of the two ways in which DAO members democratically interact with the DAO. Depending on the underlying smart contracts, proposals can be made for only operational decisions, or for fundamental and constitutional decisions. Proposals pass through several gates before execution. For most DAOs, these are submission, approval, voting and execution. A proposal usually requires collateral to be submitted [59].

d) **Voting management**

Voting is the other method by which members govern a DAO. They vote on the proposals of their own or other members. Votes can be distributed in several different manners, such as based on token possession, or by or a classic one token one vote design [8]. Proposals can be voted for in several different manners, including quadratic voting [64], Futarchy [8] and reputation based voting [32].

III. The **legal foundation** dimension (see subsection V-D and table VII) includes OSS *ownership of assets* and the legal aspects of DAOs. The legal foundation of a DAO is not well-defined, as the concept of a DAO is relatively new and the legal implications are still being explored. The legal foundation of a DAO may be based on the same principles that govern other forms of organization. Hence, a DAO has to consider its legal representation, and ownership of both the software and the DAO itself. Legal foundation therefore consists of three aspects for an OSS producing DAO:

a) **Legal representation**

the legal entity that represents the DAO, which enables interaction with the rest of the world. Currently only a few countries have a suitable legal representation for DAOs [70]. In general, a DAO may be represented in legal matters by its members, or by a specific individual or group of individuals who have been appointed to act on behalf of the organization. One of the main concerns is that current legal frameworks leave a gray area regarding liabilities, putting DAO members at risk.

b) **Software ownership**

DAOs in principle have to be radically open for participants to trust and join it. For this reason, most, if not all, DAOs use open source licenses for their software. the software produced by the DAO may be released under various OSS licences. The license is the fundamental legal mechanism that ensures that the software will be open source. Various licenses that generally range from permissive to restrictive designs on the use and redistribution of the software are available. Their main distinction is whether they incorporate the concept of copyleft.

c) **DAO ownership**

The specific ownership structure of a DAO will depend on its governance model and the rules and regulations that govern it. A DAO may be owned by a specific individual or group of individuals who have been appointed to manage its operations, while in other cases it may be owned by its members collectively. Ownership concerns the DAO itself with The DAO itself with all its funding, intellectual property and assets. It may be arranged on-chain by linking ownership to the number of tokens held. The ownership can also be given handed to a traditional organization or foundation.

IV. **Project chartering** (see subsection V-E and table VIII) is a renaming of the OSS *chartering the project* dimension, for naming consistency. It consists of overarching decision making and project steering mechanisms.

DAO charters describe the purpose of a DAO and the underlying structure. Currently, charters vary wildly in length and contents, but most contain a mission and vision statement, values and norms, and roadmaps. As the field of DAOs matures, we may observe how DAO charters adopt elements of traditional governance. Given that governance is as old as mankind, the charters may inherit elements from traditional foundations of communities, polities or organizations, such as national constitutions.

a) **Mission and vision**

Mission and vision statements are the core instructions for the way individuals and organizations interact with the community as a whole [51]. Mission statements are used to guide the day-to-day activities of the organization and to help employees understand their roles and responsibilities. Vision statements are used to guide long-term planning and decision-making. These documents may be created by the founders of a project, or by community democracy.

b) **Values and norms**

Values are the beliefs and principles that guide the actions and decisions of the DAO. They are the fundamental ideas and principles that the community considers important and worth pursuing. Norms are the unwritten rules and expectations that are shared by members of a group or society. They are the social standards that govern the behavior of individuals within a group. Values and norms can be either explicitly encoded in smart contracts [53] or laws or be present implicitly, such as in social customs and traditions. Values and norms can be used as a tool of social pressure that discourages opportunistic behavior and self-interest [25].

c) **Roadmaps and Release plans**

Roadmaps and release plans steer project development and provide a timeline. A roadmap is a high-level view of the organization's plans and priorities. It typically includes a timeline that outlines the major milestones and achievements that the organization hopes to achieve over a given period of time. A release plan, is a more detailed view of the organization's development efforts. It typically includes a schedule of when specific features or capabilities will be delivered, and who will be responsible for their development and deployment [50]. They gain importance in formally controlled OSS projects and commercial OSS DAOs [55].

V. **Incentives** (see subsection V-F and table IX) are essential to DAO governance, as there are many alternative ways to incentivize members. the lack of a central authority and the anonymity of participants can make it difficult to provide traditional incentives.

Additionally, the decentralized nature of a DAO can make it challenging to coordinate and align the efforts of the organization's members and stakeholders. In a traditional organization, this is often achieved through a hierarchy of leaders and managers who can provide direction and guidance. In a DAO, however, there is no central authority to provide this guidance, and participants may not have a shared understanding of the organization's goals and objectives.

In OSS producing DAOs, incentives are divided into development incentives and DAO participation incentives. Development incentives are remunerations for building software. DAO participation incentives refers to non-development activities that are rewarded.

Incentives are frequently aligned with the tokens in the DAOs. These tokens can have many utilities, but generally have a twofold purpose. First, they have monetary value and therefore enable economic activity in the DAO. Second, they provide governance rights, for example by representing reputation.

a) **Development incentives**

A DAO has to consider the incentives for development. Developers of OSS project are either paid for their efforts or work voluntarily. The DAO could be employing developers or offering rewards for specific work, allowing anyone to take on the work [61]. This can be done in cryptocurrency or standard fiat currency [33]

b) **DAO participation incentives**

Rewarding social participation is an important way for a DAO to recognize and acknowledge the contributions of its members, and to encourage them to remain active and engaged within the organization. By offering rewards and incentives for social participation, a DAO can help to foster a sense of community and collaboration among its members, and to support the growth and development of the organization.

A DAO can reward social participation by offering reputation-based rewards, such as badges or rankings, that are tied to the contributions and achievements of individual members. This can be

based on the reputation tokens that a participant possesses [8].

c) **Token model**

A token model is a system for using tokens or digital assets to incentivize and coordinate the activities of the organization's members and stakeholders.

In a DAO token model, tokens are used to represent ownership, value, or voting power within the organization. They can be earned or acquired by members who contribute their time, effort, and resources to the organization, and they can be exchanged for goods, services, or other forms of value within the organization.

The specific details of a DAO token model will depend on the goals and objectives of the organization, as well as the preferences of its members and stakeholders.

a DAO needs to consider which tokens to use and what utility they provide. The utility gives the token its value and can therefore be used as an incentive for the DAO [8]. DAOs can consider using the token for governance [65]. Designing the token model involves setting the issuance, circulation, distribution, and utility [33].

d) **Reputation model**

Participants may be incentivized by earning reputation that is non-transferable, unlike tokens. The reputation can provide a certain utility, adding additional incentive to earning reputation. Without additional utility, the system can simply represent reputation that can be used to indicate the standing of a DAO member or signal their trustworthiness [8]. A DAO has to consider how reputation can be earned, whether reputation can be lost or depreciates and the additional utilities for reputation[33].

VI. **Community management** (see subsection V-G and table X) inherits all remaining mechanisms of the OSS *community management* dimension.

An OSS project is traditionally surrounded by a community. As a project grows, it attracts and fosters a community that in return further expands the project. This joint growth of OSS projects is enhanced in a DAO. DAOs present new opportunities to directly involve the community in the development and governance of the project. It consists of four concepts:

a) **Joining process**

A DAO grows by the joining of new members. DAOs structure this process in various ways to formalize joining. The formalization may consist in assigning a community role, or by an explicit application process [8].

b) **Vetting of new members**

candidate vetting refers to the process of reviewing and evaluating potential candidates for membership in the DAO. Potential DAO members may need to prove their knowledge, technical competences or alignment with the values of the project [8].

c) **Identity verification**

The anonymity of decentralized applications is at odds with the creation of communities. Therefore, DAOs consider adding formal identifications of DAO member [8]. Both on-chain and off-chain solutions can help in registering members [66]. Common methods of identity verification in a DAO include using digital signatures, blockchain-based identity systems, and other forms of secure and verifiable online identification.

d) **Conflict resolution and sanctions**

Given the absence of a central punishing authority, a DAO has to design a protocol to manage conflicts. Conflict resolution typically involves procedures and processes for addressing and resolving disputes between members of the DAO, while sanctions are penalties or other forms of punishment that can be imposed on members who violate the rules of the organization. Resolutions can be a formally defined process or a very loose process[16]. Formal guidelines and rules can help to prevent conflict and thereby ensure the quality of the project [57].

VII. The **Software development processes** dimension (see subsection V-H and table XI) was included from the OSS *Software development processes*. The DAO governance literature did not mention

additional governance mechanisms that belong to this dimension.

As OSS projects centers around the development of a project, governance directly affects the software development processes. It consists of three concepts:

a) **Task responsibility distribution**

The allocation of responsibilities should be formally allocated within the DAO. the management of responsibility for tasks range from open (unmanaged) to delegated (managed) responsibility [17]. Tasks may be divided by the centralized institution or in a decentral way per working group.

b) **Code acceptance procedures**

Code acceptance procedures for are the processes and criteria that are used to evaluate and approve new or updated code for the DAO. This process should be defined for the acceptance of new code [57]. Additionally, a role or member should be given responsibility to make decisions about this acceptance [49].

c) **Releases procedures**

Release procedures refer to the processes and procedures to deploy and release updated versions of the DAO software. These procedures involve several steps, including testing the code, soliciting feedback and input from other DAO members; and deploying the code to the blockchain or underlying technology. Release procedures increase software quality [16].

A DAO should consider which steps need additional DAO involvement and the scale of involvement. A certain stap can be approved by a single DAO member, a selected committee or by a full community vote. Additionally the DAO should consider which steps are registered on-chain.

V. RESULTS: CASE STUDIES

In our search to understand how OSS producings DAOs should be governed, we must add practitioner's insights. In this section we write the results of the framework application to the three case studies. We first provide a description of the three DAOs and add descriptive statistics in Table IV. Afterwards, we describe governance of the three DAOs by following the framework areas. Finally, we add summarizing remarks on the case studies.

A. Three leading DAOs in scope: dOrg, Aragon and TEC

dOrg is a collective of web3 engineers, designers and project managers organized in a DAO. They collaborate on projects to advance the web3 stack. Their mission is to become the best service provider, workplace and example of what is possible to achieve with web3 technology.[5] The members conduct DAO development, operations and governance themselves. The DAO was formed in 2019 and is registered as a Blockchain-Based LLC (BBLLC) in Vermont. When the interview took place, the DAO had 55 active members.

The Aragon Network DAO was launched on 20 October 2021 and came out of the related Aragon Association. The association was founded in 2016 [71]. Aragon builds a platform for the standardized creation of DAOs. The Aragon Network DAO determines the spending of funding on software development. The DAO consists of the main DAO, the executive sub-DAO, the compliance sub-DAO and the tech committee sub-DAO. Through an initial coin offering in 2017, they raised, an equivalent of $25 million in crypto currencies[72]. There are 12000 addresses that held Aragon tokens (ANT tokens) at the time of the interview [73]. The DAO Charter is the founding document of this community. [6]

Token Engineering Commons (TEC) funds and builds open source software projects, research, and education that relates to token engineering. TEC's purpose is "to become a Schelling Point for the token engineering community." TEC started in July 2020 with a cultural build. The cultural build is the social

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[5]as stated in the dOrg handbook, available at https://docs.dorg.tech

[6]The Aragon Network DAO charter is available at https://ipfs.io/ipfs/bafybeifbytiwuf6gvexfqice7dbwkdmrwahg6vv5ohb64elvyqfnwhnchm/blob

Descriptives	dOrg	Aragon	TEC
Purpose	Become the best service provider, workplace and example of what is possible to achieve with web3 technology	Use technology as a liberating tool	To become a Schelling Point for the token engineering community
Legal Entity start	2018	2016	2020
DAO launch	2018	2021	2021
Number of token holders	55	12000	271
Used blockchain	Ethereum	Ethereum	xDAi

TABLE IV: DAO descriptives. The three DAOs are of vastly different size and have a very different governance structure, as is shown in the upcoming pages.

foundation of the DAO. TEC envisioned a community formed around the 8 design principles of Elinor Ostrom's Governing the Commons [74]. The DAO commenced with a phase in which the DAO was formed and built, called the Hatch. A temporary Hatch DAO was instantiated to support the community as they were building the final DAO. In January 2022, after the hatch, the DAO launched their TEC token. [7]

In the upcoming sections, we compare these DAOs on the seven governance areas. We add italicized quotes from the interviews. For every governance area, we follow the order of dOrg, Aragon and TEC. After these areas, we add general summarizing remarks.

B. Leadership and Role Structure

The three DAOs have a different way of establishing leadership and assigning roles. *dOrg* has no formal leadership. Instead, the DAO possesses the signer role. These are *"the top 7 reputation holders in dOrg"*. They hold the keys to the treasury and therefore *"are owners of the treasury. [...] They sign and propose or execute transactions from [the] treasury that result from governance decisions on Snapshot"*.

To acquire the signer role, a member has to to become one of the top seven reputation holders, which would lead to a change of the signer roles and a transfer of ownership of the treasury. A hostile takeover would require four of the seven signers to conspire against the DAO.

All members are given the builder role, even the seven signers. They may also have other roles such as marketing, accounting, legal talent, acquisition, builder experience and client experience. For project management, there are the tech lead(TL) and project manager(PM) roles. *"The tech lead is ultimately responsible for the technical delivery, whereas the project manager is ultimately responsible for keeping the non-technical aspects on track."* Acquiring an internal role is a *"governance decision"* that is voted on.

Although there are multiple defined roles in the DAO, according to the interviewee, these are only loosely defined. They aim to adhere to the model of a collective. Although they do have *"some specialists"*, they do not have *"constricting roles for people"*. The overview of DAO leadership is in Table V.

Within the *Aragon* DAO, three sub-DAOs have been created. They are the Executive sub-DAO, Compliance sub-DAO and Tech committee. The members of the sub-DAOs are elected. However, the interviewee noted that only *"0.1% voted on the members of the executive subdao"*. Any person that has the backing of a person with many tokens, could take control over such a decision and have themselves elected.

The Aragon DAO delegates various workstreams to different teams. According to the interviewee, this is *"a direction the whole [DAO] space is going. [...] Various competent and experienced groups [are] taking up workstreams and have relative autonomy within"*. Work and power will be pushed towards teams that take ownership of the workstreams.

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[7]The TEC Handbook is available at https://token-engineering-commons.gitbook.io/tec-handbook/

	dOrg	Aragon	TEC
Role Structure	Leaderboard of seven. Other members may have internal or external roles.	Organized in participants in various DAOs. There are a Main-DAO, Executive Sub-DAO, Compliance Sub-DAO, Tech committee Sub-DAO and Work groups/guilds.	Members are divided across eleven working groups. The stewards working group coordinates the other working groups.
Roles & Responsibilities	Leaderboard executes the vote outcomes. Sourcing team is responsible for sales. Project manager and tech lead decide on project members. Project manager guides project and project funds. Tech lead is responsible for code quality.	Executive sub-DAO members manage the treasury. Compliance Sub-DAO has permission to veto proposals that breach the charter or are harmful. Tech committee approves releases. Work groups execute a work stream.	The working groups (WG) are: Stewards WG for overall governance, Softgov WG for governance of the commons, Legal WG for legal strategy, Transparency WG for mutual monitoring within the DAO, Omega WG for the ethos and ethics in the group, Gravity WG for maintaining equilibrium and conflict management, Communications WG for external communications, Labs WG for innovation, Communitas for community building, Rewards WG for the reward system, and Sampo WG for tokenomics.
Establishment of Leadership	Top 7 builders in reputation form the leadership	Positions in Sub-DAOs are established through voting/elections.	Working group leads are established by the stewards.
Role advancement	Positions are voted on through Snapshot	Funding proposals ensure that certain work is funded. Members move with proposals.	Candidates can be nominated to become a steward by an existing steward.

TABLE V: Governance Area 1, leadership and role structure. dOrg is governed by a meritocratic leadership, TEC by a democratic leadership. Aragon divides leadership across sub-DAOs and the association.

Workstreams solve voting fatigue, a problem that emerges when voters are confronted with voting for various irrelevant proposals. Instead, the DAO delegates operational decisions to autonomous teams. This delegation brings focus to important decision in the main DAO.

Besides the Aragon Network DAO, there's a committee in the Aragon Association that currently stewards the tangible assets treasury of the Aragon Network. The Aragon Association is *"the operational unit, which does most of the productive work on the network"*. According to the interviewee, they are planning to transfer the treasury to the DAO over the course of the next three years. *"Currently the DAO only has a small portion of that budget"*.

The *TEC* DAO is organized in 11 working groups (WG). The primary representatives and facilitators of the DAO are the Stewards. The Stewards are the informal leaders of the TEC. In addition to this role, there are Working Group Coordination Leads who support coordination of the working groups. There are several working groups that facilitate internal DAO cooperation, while others advance projects of the DAO.

TEC leadership encourages autonomy of DAO participants. One of the interviewee explains: *"We actually do not want the Stewards to be seen as the leaders that tell people what to do and what to work on"*. This quote shows the informality of the steward's leadership.

C. Decision Making

The three DAOs execute similar decisions on-chain, as shown in Table VI. For example, all three make on-chain decisions for funding and the creation of proposals. However, proposal management and voting management differ wildly across the DAOs. The differences will be discussed below.

Regarding the off-chain decision processes, *dOrg's* builder covenant defines the expectations of off-chain behaviour. There even is an escalation protocol to resolve conflicts in urgent situations. Many project level

	dOrg	Aragon	TEC
On-chain decision making	Changes to the DAO, proposal funding, new projects, new members, member removal, final stages of escalation protocol.	Charter changes, proposal funding, electing sub DAO members.	Changes to the DAO, Proposal funding, community signals, large cultural change.
Off-chain decision making	Escalation protocol, project discussions, all other decisions.	New members, community advice, new projects, all other decisions.	New members, community advice, all other decisions.
Proposal management	Members make proposals at no cost on Snapshot. Proposals are not automatically executed. Proposals cannot be challenged, are legally binding.	Token holders make proposals at 50ANT on Aragon Voice. Any member can execute proposals. Compliance committee has veto power over proposals.	Covenant signers make proposals at 200TEC on Garden. Funding proposals are automatically executed, others not. Members judge proposals and can be challenged.
Voting management	REP. One REP is earned for every USD that a member earns. Additional REP is earned by donating time to dORg.	ANT. Tokens can be bought or received for participation in the DAO.	TEC Token. TEC is bought at the augmented bonding curve, secondary markets, or earned by community participation.
Voting specifications	Voting is free, no delegation, no quorum.	Voting is free, no delegation, 0.5% quorum.	Voting comes with minor xDai costs, delegation for TAO voting, 10% quorum for governance of the DAO and 4% for DAO governance

TABLE VI: Governance Area 2, decision making. dOrg's proposal management integration with its legal structure creates the unique legally binding proposals. Aragon's governance suffers from the value of its token. TEC is leading in voting tooling.

decisions do not occur on-chain. As the interviewee states: *"Those do not need to go on chain. The team can work it out themselves. Usually decisions go on-chain when we need more visibility through the DAO. Like meta governance especially..."* If there are important decisions these are taken on-chain; *"That's how we maintain our identity, right? If we have major decisions happening off-chain, then we might as well be a traditional corporation, right?"*

In *Aragon*, According to the interviewee, the *"main DAO has free reign over the budget"*. The main DAO holds control over the treasury, and *the other assets have not been transferred away from the association"*.

Any token holder can create a proposal for funding from the treasury. For making a proposal, the token holder has to stake 50 ANT. The proposal is first posted to the forum, to give members the opportunity for deliberation and feedback. According to the interviewee, the forum is the stage for "off-chain negotiation and politics". Everyone on the forum can disagree, but "*if you have someone in your back pocket that has a lot of tokens, they can overrule that disagreement"*. After the forum discussion, the proposal is uploaded to Aragon Voice. In that tool, members can vote on the proposal.

Before an approved proposal executes, the compliance committee assesses it for alignment with the charter. If it conflicts, the committee has the power to cancel the proposal.

Voting power is represented by the ANT tokens. A DAO member can buy ANT tokens or receive them as compensation for doing "productive work for the network". Currently, Aragon DAO uses the one token one vote system, although the interviewee expressed Aragon's interest in other voting systems such as conviction voting.

TEC makes a distinction between DAO governance and governance of the DAO, and has distinct decision making processes. DAO governance entails the governance of all activities that fall under the DAO, such as approving proposals or whether or not someone should become a member. Governance of the DAO is the design of the DAO itself. It includes decisions such as proposal design and setting admittance criteria.

For both types of decision making, TEC uses self-designed tools within the 1Hive gardens platform. We now explain how both tools work.

For Governance of the DAO, TEC uses a tool called TAO voting. The tool is used for proposals that alter any fundamental parts of the on-chain DAO. It concerns any decisions impacting the meta-governance, smart-contracts, the token contracts or other economic parameters. As these decisions have a major impact on the DAO's performance, it has four measures that should lead to better proposal outcomes. First, TAO voting has high voting requirements. It requires a 10% quorum and 85% support to pass. Second, it has lengthy decision periods as members can vote for five days on a given proposal. Third, The voting system allows for delegation. Members can delegate their voting power to other members. Fourth, delegated votes can change after the results. After the voting period passed, members that delegated their votes can change them. If this changes the proposal outcome, the voting period is extended by two days.

DAO governance in TEC mainly consists of funding proposals. the DAO uses an unusual method of voting. Votes are "counted" in a method called conviction voting, which follows the design of Zargham [75]. Conviction voting measures the conviction of its electorate towards a certain outcome. Instead of dichotomal yes-or-no voting, members support proposals by allocating tokens for a certain period. The weight of a vote increases over time, up to a limit. Currently, tokens gain half of their potential weight in seven days, and reach 75% in fourteen days. Funding proposals require 4% of the total potential weight to pass. The maximum funding for a single proposal is set to 11% of the total common pool.

D. Legal Foundation

dOrg is the first DAO to be legally registered as a Blockchain Based limited liability company (BBLLC) in the state of Vermont [76]. Regarding the liability of the DAO and its members, the interviewee stated; *"being a LLC, everyone is a co-owner and contractor and so we use the limited liability of US corporate law"*. Later during the interview, the interviewee elaborated that the members are independent: *"since they're contractors, they have their own business. ... Maybe it's specific to U.S. law, but every contractor has their own LLC, their own business and so they contract with dOrg"*. This legal construction is the current best conceivable for the DAO and its members. The BBLLC guarantees the DAO's legal existence and legal compliance. At the same time, the members' LLC protects them from liabilities while they interact with dOrg.

dOrg strives for producing software under an open source license: *"For the stuff we build, we prefer to use open source. Usually MIT because if we build something we want anyone to be able to use it for any reason, or change it, or contribute to it. The things we build for our clients on our behalf, are open source or closed source, depending on our clients' preferences"*.

dOrg ownership is formalized in it's statutes. The dOrg DAO is owned by its members proportionate to the on-chain reputation of each member.

The legal status of Aragon remained unclear in this case study. The charter of the *Aragon Network DAO* contains a section that explicitly states "the Aragon Network is not intended to have legal personality" [77, Section 2.2e]. The interviewee, brought some nuance to that statement. *"[We are not] ideologically opposed to it. [...] When it makes sense, there could be a legal wrapper, [since] the space around legal wrappers is rapidly evolving"*.

To overcome Aragon's legal indistinctness, the Aragon DAO has chosen to transfer the liabilities to a committee. The charter states; "the Compliance Committee members assume full legal responsibility for the approval of any illegal, unlawful, criminal or fraudulent proposal" [77, Section 6.4b]. However, the liability for individual voting members remains unclear.

According to the interviewee, the software is open source. However, the Aragon Association holds brand ownership, treasury access and has the repository keys. According to the interviewee the association *"will [in the future] transition those assets into the DAO"*. For now, the Aragon DAO appears to be owned fully by the association.

The *TEC DAO* is not represented by a legal entity or legal wrapper. The Commons Stack, the organization that initiated the TEC, is represented by a Swiss foundation. Common Stack also created the codebase

🏛	dOrg	Aragon	TEC
Legal Structure	Registered as a BBLLC in Vermont	No legal entity. Aragon Association takes on certain responsibilities	No legal entity. Commons Stack association provided funds for legal defense
OSS License	MIT for public projects, various licenses for client projects	GPL or AGPL	GPLv3 and MIT
Ownership and control	DAO ownership is proportional to tokes held	The Aragon Association holds trademarks, repository keys and funds	The DAO owns itself. TEC token holders have full decision power.

TABLE VII: Governance Area 3, legal foundation. dOrg is the first BBLLC in the world. Aragon's charter prevents it's registration as a legal entity. TEC created a unique ownership in which the DAO owns itself.

and cultural guidelines, but it is not involved in the creation of the DAO. Members of the Commons Stack Association that participate in the TEC hatch DAO do so as individuals.[8] TEC releases its software under GPLv3.

TEC created a remarkable ownership structure for itself. The purpose is to become as independent as possible. The TEC DAO is deployed and owned by the DAO itself, including all of its contents, functionalities and elements. Tokenholders also govern the protocol that provides infrastructure and services. Since they govern both the DAO and the underlying infrastructure, the electorate can change all elements that constitute the DAO. As a result, there is no ultimate owner beside the DAO and the community that governs it.

E. Project Chartering

dOrg's charter is called the builder covenant and consists of a list of standards and a list of expectations of professionalism. The covenant did not exist until they encountered *"internal challenges and disputes"* and discovered that they had not laid out the expectations of behaviour for their members. Therefore, the DAO drafted a builder covenant. It was approved through an on-chain vote. The covenant exists of a list of examples of expected behavior, a list of examples of unacceptable behavior, and a description of the situations when the covenant is in effect.

The *Aragon* Network DAO charter contains a manifesto titled: The Aragon Manifesto: A pledge to fight for freedom. The interviewee stated that specifying a structured mission and vision has been overlooked, which leaves Aragon without a formal DAO purpose. Adding a mission or vision to the charter would need on-chain proposal acceptance, which requires a 0.5% quorum [77, Section 2.2f]. However, according to the interviewee, the current charter was enacted while only receiving 0.2%. The interviewee states that *"most people don't care enough to show up to vote"*.

In addition to the manifesto, the charter contains guidelines, provisions, agreements and a description of the structure and responsibilities of the DAO. Finally, Aragon's roadmap and release plans are managed by the Aragon association.

For *TEC*, the mission, vision and values document was designed and approved by the community.

The community held that it should be a collaboration of all members to form the mission, vision and value statements, but it did not find a suitable design process. Therefore they created a process in collaboration with Tokenlog.

The procedure was as follows. First, community members could submit proposals for TEC's mission, vision and values in Tokenlog. They could also fork submissions and submit a modified version. Afterwards, a community vote on the top submissions determined the final statements. Snapshot was used for this

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[8]As stated in the hatch terms, https://token-engineering-commons.gitbook.io/tec-handbook/voting-templates-and-the-bonding-curve/hatch-proposal-tl-dr/full-hatch-terms

	dOrg	Aragon	TEC
Mission and Vision	dOrg's covenant includes a mission and vision statement and was approved by on-chain community vote	Aragon's charter contains a broad manifesto: A pledge for freedom. A concrete mission or vision has currently not been established.	TEC has a mission and vision, built by its community
Values and Norms	Covenant describes standards for behavior. Additionally, dOrg has a list of core values	The Charter describes a code of conduct with examples of behaviour.	A code of conduct describes behavior practices for members Organizational norms describe DAO practices
Roadmaps	Decisions made at the project level	Determined by the Aragon Association.	No over arching roadmap as DAO is no longer in build mode, but evolved to operational mode. Working groups may have their own roadmaps
Release plans	Decisions made at the project level	Determined by the Aragon Association.	Working groups have autonomy to organize release plans.

TABLE VIII: Governance Area 4, chartering. dOrg has a concise covenant to guide its small community. Aragon has a manifesto which appears weakly aligned with its community. TEC covenant is created by its community in a collaborative process.

final selection. This process had three advantages for the community. One, it allowed curation of the ideas of all community members. Second, it encouraged active community involvement. Third, community participation in the design process should lead to more support and adoption of these statements.

The created covenant contains three sections: 1) the pledge which all members commit to, 2) a set of standards of acceptable and unacceptable behavior, and 3) decision making process descriptions.[9] The covenant is a living document, and currently is in its second iteration.

During the hatch phase the TEC had a clearly defined and community accepted roadmap to launch the DAO. However, since the hatch phase ended and the DAO is built, the TEC lacks an overarching roadmap. Luckily, not all steering is lost, as the working groups autonomously determine their roadmaps. Nevertheless, the interviewee remarked that creating a new roadmap would give more support to their vision.

F. Incentives

Within *dOrg*, the primary incentive for software development, is a compensation based on an hourly rate. Members are paid in stable coins. For governance, dOrg uses a nontransferable token that indicates reputation. dOrg rewards reputation for internal work and for every dollar that the member earns at dOrg. Reputation tokens grant voting rights, and possession can lead to election as a signer. The overview of incentives and token models is in Table IX.

Within *Aragon*, development is mostly handled by the Aragon Association which has employees and contractors. Some components are outsourced to teams outside of the association. These people are *"incentivized through funding proposals"*.

Aragon has other incentives to participate. It tries to foster a culture of appreciation and recognition. According to the interviewee, people are also attracted to the Aragon brand. *"Aragon has been one of the first projects in the DAO space"*. This attracts individuals that *"want to make the world a better place"*.

Aragon's ANT token is a transferable token that can be freely bought and sold.

It has two uses. First, it is a currency, as ANT is used to fund project and reward community members. Second, it is a governance token, as possession of ANT gives voting rights.

Etherscan shows a 43,029,810 tokens in circulation. The tokens are controlled by a meter contract. New tokens could be minted by the committee that controls the pool of assets. The interviewee remarked that

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[9]This community covenant can be found at https://forum.tecommons.org/t/tec-community-covenant/572

this put immense power in the hands of some individuals. The only limit that prevents the committee from freely minting additional tokens would be the community and the market response.

Token holders have one more benefit of possessing ANT: they can become juror on the forum of the arbitration system. *"you have to stake ANT to be able to be part of that pool of jurors that gets elected to vote on things within the arbitration system"*. The interviewee stated that tokens are not burned or taken out of circulation, and there is no reputation system in place.

For *TEC*, the development incentives are funding to the working groups. The Commons Swarm is the main working group that develops the DAO. But some of the other WGs also develop software.

TEC has a comprehensive set of participation incentives. It consists of two rewards systems, POAPs and education. We briefly discuss these four methods that encourage community building.

The two rewards systems of TEC are Sourcecred and Praise. These systems collect community member contributions. SourceCred captures measurable contributions, such as number of likes, forum posts, and time spent in meetings. Every contribution has a value based on previously defined parameters. The Praise system rewards hidden or invisible work. Members praise hard to measure work that is deemed eligible for remuneration. [10] The system stores all praises in a list. Randomly selected DAO members discuss the entire praise list in a periodic quantification process. In this process, every praise receives a monetary value. Sourcecred and Praise thereby create an overview of eligible rewards for all members. This is paid out periodically in TEC tokens.

TEC also has two non-monetary rewards: POAPs and education. TEC utilizes the Proof of Attendance Protocol (POAP) for community recognition. POAPs are NFTs that members receive as badges of accomplishments. These POAPs can be displayed in the community. In our research we came across different achievements, including 2021 TEC Steward and a Hatcher title.

Education is the final DAO participation incentive. The interviewees stated that education motivates people to contribute to the DAO. Working in the DAO prepares for cryptocurrency jobs. The TEC even offers internal training to its members.

Finally, people participate in TEC because of the open culture of the DAO. The culture is described as *"welcoming, radically open, inclusive, transparent"*, which makes people eager to participate. Members feel part of a community that is revolutionary and at the forefront.

The final interesting remark of TEC's incentives is it's currency design. Where other crypto currencies suffer from high value fluctuation, the TEC DAO has a unique way of ensuring crypto stability. The price of TEC tokens is kept stable by an Augmented Bonding Curve (ABC). The ABC is a set of smart contracts that create a local economic ecosystem. It will buy and sell tokens at a self-determined rate. When the ABC has distributed many tokens, the exchange rate goes up, and vice versa. This leads to an economic system with three advantages: 1) Since the token can always be bought and sold, there is infinite liquidity. 2) The ABC will always buy and sell tokens, and therefore creates a stable exchange rate. 3) The ABC takes a tribute when buying or selling TEC tokens. The tribute is added to the common pool treasury. Use of the ABC therefore generates additional community funding.

G. Community management

Unlike most OSS projects, where a community may form around the OSS product itself, *dOrg* is a closed organization. One cannot freely participate in dOrg. In fact, currently it is *"incredibly selective, in terms of who can join"*. To join, dOrg, a person can fill in the *builder interest form* to show his interest. The potential member is interviewed, and feedback of the interview is posted on the forum. The existing members deliberate over the potential new member. If the candidate passes the subsequent Snapshot proposal, they are on-boarded. The identity of every member is verified, as members are a contractor from their own companies. dOrg verifies their information to be compliant with the law.

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[10]For example, the interviewees praised the researcher with a discord message: "!praise [researcher] for the long 2-hour discussion with [name of interviewee]."

🎁	dOrg	Aragon	TEC
Development Incentives	Builders are paid in stablecoins, and have occasionally a reputation weighted bonus	Aragon Association develops the software	Working groups receive funding from funding pool
DAO participation incentives	None	Monetary rewarding of tech support guild	Token engineering education, SourceCred and Praise systems give rewards for social building, event participation POAPs
Token model	No fungible token model	ANT token grants governance rights and has monetary value	TEC token grants governance rights and has monetary value
Reputation model	Reputation as a token	No reputation model	Praise, SourceCred and NFTs

TABLE IX: Governance Area 5, incentives. dOrg's reputation token creates a meritocratic leadership. Aragon's token is controlled by its committee. TEC has an elaborate model to reward all DAO participation

Regarding the management of conflicts, in dOrg *"ultimately things come down to the escalation protocol"*. For instance, if members fundamentally do disagree with project managers, the matter would be handled according to the escalation protocol. In the most severe cases, an on-chain vote determines the conflict outcome.

Within *Aragon*, individuals do not become DAO participants by following a joining process, as there is none. Instead, buying tokens is the method for DAO affiliation. Token holders are not vetted or required to show alignment with the project. When a token holder applies for funding, the funding proposal should provide a justification for the strategic alignment of their proposal. In the words of the interviewee: *"We don't want the association to be the single chokehold of power. You can do something different, but you need to explain why you are doing it"*. Currently there are no protocols other than the arbitration system to handle conflicts.

TEC has the most elaborate community management. There is an extensive onboarding process and conflict resolution. At the same time, there is no formal definition of the community and stakeholders. One interviewee suggests that the DAO and the active community are two different things. A person can be a token holder, without participating in the DAO, while others may be active without holding any tokens. There is no formal process for a new member to join the DAO. The DAO is open to anyone and all *"meetings are open to anyone"*. Anyone can buy tokens. The other interviewee suggested that anyone that received Praise, can be considered a member. So far, TEC has not formalized the definition of community.

Despite the absence of a formal joining process, the DAO has the Communitas Working group, tasked with facilitating the community and onboarding new members. As one interviewee explained: *"their main objective is to create social cohesion in the existing community"*. Communitas consists of guides who welcome new members. Every week there's an orientation call and a community call. People who join the discord server are invited to the orientation call and have a *"one on one sync with one of the guides"*. Additionally, new members are actively included when join a call. The meeting host will acknowledge the presence of a new member, ask them to introduce themselves and give them space to participate in the call.

For participation in TEC voting, a formal affiliation is required. Token holders that want to vote have to sign the covenant through an on-chain transaction. In this way, members show their awareness, understanding and agreement with the values of the DAO. The identity of the members is, according to the interviewees, intentionally not verified.

The DAO has a specific working group assigned for conflict resolution. The Gravity working group offers conflict mediation and provides mediation training. The training courses are 8 to 10 weeks each, and cover topics such as nonviolent communication, mediation, role playing and leadership. After completing a training, participants receive a POAP for training completion.

While many DAOs experience conflicts, TEC has had little fights in its community. Therefore, the interviewee holds that Gravity's approach is successful in managing conflicts.

	dOrg	Aragon	TEC
Joining Process	Joining by referral or suitable builders are selected from the list of applicants, when needed.Candidate builders are then interviewed by existing builder.Interviewer creates a proposal to accept new builder. After acceptance the new builder is onboarded	No formal joining process. There's a growing list of ways to participate. Work streams are proactively being pushed towards the community and offloaded from the Aragon Association. This is done by providing funding and actively including community members	Communitas WG facilitates onboarding experience by proactive engagements and personal guidance
Vetting of new members	Candidates are evaluated on the forum and through a proposal	Contributors are not vetted. When applying for funding, arguments for (strategic) alignment with the project must be given	Participating in TAO voting and conviction voting requires on-chain signing of the covenant
Identify verification method	The identity of builders is verified by their legal agreement	Commercial solution	No identity verification
Conflict resolution	Escalation protocol manages conflicts	Funding contracts can be ceased. Members in a formalized position of power can be removed. Arbitration system: Aragon Court	Gravity WG educates mediators and creates processes for conflict mediation, conflict resolution and graduated sanctions

TABLE X: Governance Area 6, community management. dOrg is a selective collective which eases its community management. Aragon uses token acquisition as a joining process. TEC's gravity working group is a solution to community conflicts.

H. Software development processes

The essence of an OSS producing DAO is the production of software. Even though all three DAOs have software production as their goal, they defined only a few software development guidelines on DAO level.

dOrg is not working on a single open source software project but it is involved in many (client) projects. Therefore, it did not create overarching software development processes. Instead, the tech lead defines the code acceptance procedures at project level. As the interviewee said, the *"tech lead is responsible for the technical delivery of a project, and so ultimately the technical side."*

Regarding the release procedures, the interviewee states: "*the release process is appropriated to a project. It depends on the needs of the team, [and] the needs of the client.*" Since the needs, requirements, team members and stakeholders differ per project, these governance aspects will also differ per project. Even though dOrg and the interviewee insist on tailor making processes for projects, it also created a quality assurance worksheet. The worksheet sets a software development baseline for project managers and tech leads. The interviewee explains: *"We started with this QA worksheet guide. These are our best practices. We want our project managers and tech leads to make sure these are getting covered ."* We observe that this is an initial DAO-level formalization of the software development processes within dOrg.

Currently, within *Aragon*, software development is mainly handled by the association. The association oversees task responsibility distribution and code acceptance procedures. The tech committee sub-DAO approves releases and deploys accepted proposals that contain new code [77, Section 5.1c]. The tech committee also has the authority to remove proposals that do not meet technical quality standards.

TEC does not define DAO-wide software development processes. Instead, software producing working groups have a high level of autonomy. The working groups use GitHub projects to allocate work to people.

According to one interviewee, the working groups follow standard procedures in software development, such as having a code reviewer and a merge process. As the interviewee explained: *"I've seen a few different groups who use what you would expect"*.

	dOrg	Aragon	TEC
Task responsibility distribution	Depends on project and expertise	Handled by the association	Tasks are divided over working groups. Working groups further partition these tasks themselves
Code Acceptance procedures	QA worksheet defines development and code acceptance procedures	Handled by the association	Working groups have highly autonomous procedures but follow industry practices
Release procedures	Procedures differ per project and depend on the needs and requirements	Releases are approved by the Technical committee	No overall defined processes for release procedures

TABLE XI: Governance Area 7, software development processes. All three DAOs have little overall processes defined.

I. The effectiveness of governance in the three DAOs

DAO governance is divided in seven governance areas, but it is an entangled phenomenon. We therefore use this section to reflect on overall governance in the three case studies.

The *dOrg* interviewee concluded with *"I feel like we're covering [dOrg] pretty well. This is an insight, because sometimes being in a collective, things are a little messy. But we are hitting our base pretty well"*.

dOrg is registered as a BBLLC in Vermont, and therefore is a legally compliant entity. Their incentive designs compensates their builders in stable coins and separates the governance utility from the monetary incentive. This ensures that governance power can not be gained in a simple manner by simply buying tokens. Instead, it encourages long-term commitment to the DAO.

dOrg moved away from the DAOstack, its original on-chain DAO framework infrastructure. Instead, it votes on Snapshot and its treasury is on Gnosis Safe. This reduces its gas fees. Every project has its own treasury. Project level finances and decisions have thereby been separated from DAO-wide decisions.

dOrg has created an effective governance design and solved their problem of high gas fees. Its governance turns around highly skilled individuals. The most committed of these are selected for leadership. This creates a DAO that is competitive and more structured than the other two. It remains relevant to question whether the dOrg model can be copied for other collectives and to which degree it can be scaled.

The *Aragon* interviewee acknowledges that *"there are a lot of things [governance mechanisms] that we are not currently doing, but that we are thinking of. You [the interviewer] are touching upon those things"*. The Aragon token holds significant value and is divided across 12000 token holders. At the same time, Aragon faces difficulty in attracting voters with turnouts of 0.2% or lower. The development of the DAO is actually hindered by the high value of ANT. The value of the token may attract investors who are less or not at all interested in governance.

Even though Aragon is built around a DAO, the decoupled proposal execution, influence of large token holders, and the fact that most work is performed by the association does indicate centralization. The DAO appears very dependent on the association. At the same time, the push of workstreams and transfer of treasury funds to the DAO indicates a move towards a further decentralized governance structure.

The *TEC DAO* built its governance and the tools needed to support it. Instead of investigating the technological possibilities that a DAO offers, they started from a social foundation through their cultural build.

TEC's culture, grounded in Ostroms 8 principles, is at the foundation of many aspects of the DAO. The principles were encountered in many of the governance dimensions that were discussed in the interview.

Noticeably, the DAO possesses an arbitration mechanism to overrule proposals that are not in line with the charter of the DAO. This is a human control mechanism that limits the autonomy of the DAO.

The development of the DAO can be characterized as ad-hoc. Often they were building the tools that they needed as the tools did not exist. One of the interviewees remarked, that he felt they were *"building the airplane as you jump off a cliff"*.

VI. DISCUSSION

Now that the framework is finished and we have displayed how dOrg, Aragon and TEC govern themselves, we turn to the discussion of our research. In this research we addressed the research question: *How are OSS producing DAOs governed?* We have provided a twofold answer to this question. The first answer is an academic framework that categorizes governance mechanisms for OSS producing DAOs. Afterwards, we used this framework to analyze the governance of three leading DAOs. The second answer is the governance practice of those DAOs. In this section, we first address viability and reliability concerns of this research. Afterwards, we discuss the relevance of the framework and link it to existing literature. As a concluding part of this discussion, we list opportunities for further research.

A. Addressing validity and reliability concerns

The method that created results has to be assessed on validity and reliability concerns. Here, we note the threats to framework validity, external validity, framework reliability and case study reliability.

We assessed the **Framework validity** together with the interviewees. It was the final part of the interview. In general, the interviewees had three positive remarks. First, the framework was well able to map the DAO's governance structures. Second, the framework provided clarity and structure to the various DAO governance aspects. Finally, the framework reminded them of the importance of some of the governance aspects. Sometimes, a lively discussion in the interviews arose how the framework could help to structure the existing governance processes.

We asked the interviewees whether they noticed irrelevant mechanisms or if any were missing. Fortunately, there were no mechanisms that were irrelevant for the practitioners. We observed ourselves that the DAOs had few software development practices in place. But, the interviewees remarked that it is important for the DAOs to create these practices. Therefore, we did not remove any governance mechanism from the framework.

The case studies did reveal missing elements from the framework. We found two elements in the case studies that were absent. There were the arbitration mechanisms and a financial layer. Aragon and TEC have an arbitration mechanism that allows members to challenge proposals against the DAO charter. The TEC case study also revealed the absence of financial governance in the framework. The interviewee remarked that the framework could be extended with funds governance or compensation decision making. Even though financial decisions are an aspect of governance, we did not observe it in the DAO governance literature. Therefore, for this current work, we considered it out of scope. In a future work, we would like to extend the framework with these two mechanisms.

The **external validity** of the framework was tested in the case studies. To evaluate whether the framework is valid for many OSS producing DAOs requires diverse case studies. Luckily, the DAOs that agreed for an interview had a significant variation in purpose and governance maturity. Our framework was valid for these three varied DAOs. Therefore, we expect that our findings can be applied to other OSS producing DAOs.

This study mitigates threats to **framework reliability** by utilizing a structured approach and by employing standardized research methods. Sourcing the literature was done through a predefined search string with strict inclusion and exclusion criteria. This mitigated inclusion and exclusion biases. We tried to mitigate research bias by using tools in the framework creation. Nvivo was used to extract, codify and group OSS and DAO governance concepts. To further increase the transparency of our framework creation, we published our data sets online as well.

Two aspects of the method contributed to this research's **case study reliability**: the availability of information and the use of an interview protocol. First, the DAOs published many internal documents online for open access. Therefore, we could create rather complete overviews of their governance before the interview started. This complete overview of the DAO governance led to an effective interview, as it was a mere validation of the earlier observations. Because of the large availability of information, the initial description was often correct.

Second, the strict interview protocol helped to create a reliable case study. Since we structured the interview along the governance areas, the findings followed the framework. In the transcription, we could easily map the findings across the governance mechanisms. Making the protocol out of the framework had another advantage. The protocol ensured that every governance mechanism would be discussed. We ended the interview by asking open ended questions for governance mechanisms outside of the framework. This was another measure to ensure that we publish a complete overview of the governance of the DAOs. Summarizing, we tried to create a truthful overview of the DAOs' governance By collecting the available information, adhering to a structured interview protocol and asking for missing mechanisms.

B. Framework positioning within the research field

This research created the first governance framework that intends to create a complete overview of governance mechanisms that OSS producing DAOs use. We intended to provide a foundation for establishing shared understanding and discussion surrounding the topic of DAO governance. The framework can be this foundation. It offers the concepts and words that can categorize and divide up the often entangled governance aspects that come with a DAO.

This research complements blockchain governance research by adding more sophisticated community mechanisms. Liu et al, 2022 is our example. These authors simplified blockchain governance by breaking down its governance into concrete principles [78]. Their emphasis on community governance gives a deeper understanding on why some DAOs fail to govern their funding and community, and others succeed.

This research touched upon two other DAO governance aspects that we address here: intertwinement between social and technical governance and the combination of on-chain and off-chain decision making.

The OSS producing DAO governance framework combines social and technical governance aspects. However, the practice of DAO governance shows that these aspects are inseparable. This is also seen in the final version of the framework, as every governance area contains both technical and social mechanisms. This intertwinement is also visible in other authors. Markus [15], insists on understanding the social requirements of producing open source software. Another research, Van Pelt et al, 2021, calls the community one of the three pillars of blockchain governance [13]. A correct alignment of community governance with the on-chain protocol is crucial.

This research integrated these findings, and makes two contributions for combining social and technical governance. First, the framework provides concrete governance mechanisms that a DAO community can consider for bridging the socio-technical gap. These mechanisms aid in creating the socio-technical integration on leadership and decision making. Second, the case studies, analyzed through the lens of the framework, reveal three attempts in aligning the social and technical aspects of DAOs. These results give guidance on successful and unsuccessful governance strategies.

The other remarkable governance aspect is the combination of off-chain and on-chain decision making. The framework contains both processes, and we observe healthy complementarity between off-chain and on-chain governance. It can be good, necessary and effective to conduct many decisions off-chain, especially for decisions that do not affect the majority of a DAO. In our vision, this does not affect the decentralization of a DAO. We therefore disagree with the view of Rikken, Jansen & Kwee [79] that the lack of automatic execution of decisions always affects decentralization. Sometimes it might be necessary to put decision making power in the hands of an individual. Emergencies might require this. But this decision to trust in an individual should not be taken lightly. It would create a kill-switch or emergency dictator. Only with specific rules can it be used well. These rules should be grounded in the DAO charter.

This is in line with Rijers et al[30]. These authors propose a similar role for the Ethereum foundation in the Ethereum blockchain.

C. Future work

This research drew from OSS governance research and observed how DAOs present new opportunities for OSS project organization, incentive models and further decentralization of OSS development. The field looks promising. DAOs as a form of advanced decentralized governance could create approaches to solving societal challenges that were previously not possible. However, the novelty of DAOs makes it a challenge to understand the full extent of this new technology. Because of this, the field has many opportunities for research.

Here, we propose future work in OSS producing DAO governance and mention bigger opportunities in the field.

There are two research opportunities in governance frameworks for OSS producing DAOs. First, research can enhance the completeness of DAO governance frameworks by adding the two governance aspects that were not present in the literature set. The aforementioned financial dimension and the arbitration mechanism can be included in a new framework. To make that possible, we recommend further exploration and research of financial governance and fail-safe mechanisms in DAOs. Second, further research can deepen the governance aspects of this framework. It can define health metrics, maturity levels and stages for the existing governance mechanisms.

A second area for future work is the investigation of financial governance in the DAOs. None of the DAO governance articles in the literature set investigated financial governance. At the same time, understanding financial stability in DAOs is becoming increasingly important. There are two reasons that add a certain urgency to this research. First, DAOs have more financial resources than most traditional open source software projects. And second, we have already witnessed several financially mismanaged DAOs. This indicates an increasing need for effective financial governance.

A final area for further research is extending the DAO governance field to other domains. DAO governance is a multidisciplinary field consisting of technology, law, sociology, economics and more. These other disciplines can help us create a better understanding of DAO governance.When rightly configured, a DAO may even be able to contribute to local economies, grassroot democracy and community building, But making a DAO socially relevant would require a synergy between the technical configuration and these other research fields. Building this bridge helps our field to understand the societal change that DAOs could bring. We consider several academic giants from other fields relevant for extending DAO research. These are: Ostrom for commons management [43], Schumacher [80] for distributive economies, and Hayek [81] for understanding liberty, decentralization and society.

VII. CONCLUSION

In the aftermath of the 2008 financial crisis, an anonymous researcher created Bitcoin. In a period dominated by the systematic failure of large centralized institutions, blockchains gave hope to an alternative financial system. Since then, researchers and practitioners have created blockchains, smart contracts and financial investment DAOs. Alternative forms of finance sparked so much interest that other fields are also investigating similar community collaborations. In this paper, we investigated the governance of one type of new community, open source software producing DAOs.

We contribute the governance framework for OSS producing DAOs. It describes the seven required mechanisms for successful governance. First, a community that desires to build open source software in a DAO should design a role structure and establish leadership. Second, it has to establish decision making processes. Third, it organizes the legal representation, DAO ownership and software ownership. Fourth, the community requires management and steering of members. Fifth, its incentives need to be worked out. Sixth, the DAO sets up effective community management. Finally, the overall direction in which

the project should move has to be anchored in software development processes. For these governance mechanisms, the case studies show three practical translations.

In the near future, we do not expect large communities to transfer to the DAO model. Nevertheless, the number of DAOs is rapidly growing and DAOs may well become an adopted organization form in our society, financial systems, and regulations. One determining factor for this adoption is the establishment of successful DAO governance. It remains paramount for DAO developers and researchers to understand the governance of DAOs, to improve the governance designs of DAOs, and anticipate attack vectors.[11] To the rapidly developing DAO governance field, this research contributes a foundational high-level overview of the various governance aspects of an OSS producing DAO.

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[11]Recently, the Build Finance DAO has been taken over and had its funds drained because of failed governance. An attacker exploited the governance mechanisms of the DAO by creating a proposal that remained unnoticed https://decrypt.co/92970/build-finance-dao-falls-to-governance-takeover.

Governance mechanism	Description	Author
Leadership and decision making		
Leadership	Leadership structure must be designed and established. This ranges from autocratic to democratic designs, where leadership is self-appointed or elected. Leadership may also rest with an organization (company, institution or committee). Institutionalization of leadership is attractive to those who prefer a more standardized and stable workplace, and less attractive to those who prefer the (creative) freedom in OSS development. Leadership may change over time into more autocratic or democratic forms.	De Laat [16], Capra [50], Jensen [51], de Noni et al., [27], O'Mahony [52], Sadowski [53].
Elections	Elections allow for the community or a subcommittee to elect the leaders. Some OSS projects employ yearly elections. In elected leadership, the technical contributions of the candidates may be less important than their organization building skills.	Sadowski [53], De Laat [16], O'Mahony [52] , de Noni et al., [49]
Delegation of decision making	In OSS projects decisions have to be made about community matters, the project, architecture and design and code acceptance. Different levels of roles are entitled to make these decisions. The arrangements may vary from centralized to decentralized designs.	De Laat [16], de Noni et al., [27]
Voting	Voting systems can be used for decision making processes, electing leaders, representatives or board members or conflict resolution. Some communities only require a subset of the community to participate in the decision making process.	Di Tullio & Staples [25], Germonprez [26], O'Mahony [52]
Ownership of assets		
OSS License	The licensing agreement underpins OSS and dictates the degree of freedom to which the software may be used, incorporated and distributed. Licensing schemes can dictate that all derivative work needs to be open sourced under the same open source license or that the software is only freely available for non-commercial purposes. OSS Licenses can be characterized as: a) viral/recursive/copyleft: All derivative work must be released under the same OSS license, b) partially recursive: A recursive license with exceptions or less strict terms (e.g., LGPL), c) permissive/open license: Use of the software is allowed in commercial closed source derivative work, or d) dual licensing: commercial users are required to pay a fee to get access to the source code, but is freely available for non-commercial purposes.	de Noni et al., [27], Di Tullio & Staples [25], De Laat [16], Markus [15]
Foundation	Foundations safeguard public accessibility and control of project management, project development and source code. It protects the project from liabilities and manages interactions with external parties. Governance elements of foundations in OSS are typically a board of directors, foundation bylaws, membership agreements and intellectual property rights. It handles donations and upholds copyright licenses, trademarks and brand names.	de Noni et al., [49], Di Tullio & Staples [25], Markus [15], De Laat [16]
Code forking/sub-projects	Code forking refers to implementing the existing code bases and implementing it in a separate project. Its meaning is not limited to a split in the community where both parties continue working on their own code base and are incompatible with each other. It also includes sub-projects that are started. The right and possibility of code forking protects against planned obsolesce, vendor lock-in, unfavorable actions by project leaders by giving developers the option to continue their own version of the program. Finally it increases innovative potential by freely allowing modifications.	Nyman & Lindman [54], de Noni et al., [27]
Chartering the project		
Mission and vision statement	Mission/vision statements are the core instructions for the way individuals and organizations interact with the community as a whole.	Jensen [51]
Release plans and roadmaps	Release plans and roadmaps steer the development of a project and provide a timeline. They gain importance in formally controlled OSS projects and commercial OSS.	Jensen [51], Capra [50]
Community management		
Membership	Formal or informal processes may be in place to oversee and vet who can be involved and in what capacity. As communities grow, coordination and control increase in complexity. Having multiple ways for users and observers to get involved with the project helps to grow the community.	de Noni et al., [49], Midha [17], Di Tullio & Staples [25], Sadowski [53], Jensen [55]
Role advancement	In formalized communities members may need to go through a process of vetting and quality control to advance through roles. In others members may take on multiple roles while migrating through different role sets. Role migration may be much more fluid and informal. Roles may be acquired by a) volunteering, b) earning or granting it, c) appointment/assignment and through d) election.	Di Tullio & Staples [25], Jensen [51], Jensen [55]
Division of roles/role structure	A range of roles (e.g., observer, developer, core-developer, project owner) distributes and manages responsibilities. By defining roles and assigning responsibilities, it enhances coordination within a project. The number of roles may very from a small number up to a much larger number.	De Laat [16], Sadowski [53]
Incentives and motivations	In an OSS project motivations of participants vary. Some are paid by companies to contribute, while others are contributing out of their own interest. The project and project governance may impact the interest of contributors and their willingness to contribute. An OSS project with the right incentives can attract developers much easier. Motivations are often characterized as altruistic or egoistic and external or intrinsic. Generally the motivations of contributors are need driven, economical, because of enjoyment or because of a sense of moral obligation.	de Noni et al., [27], Shah [56], de Noni et al., [49], De Laat [16]
Training and indoctrination	Contributors need to prove their knowledge, technical competences and alignment with the values of the project.	De Laat [16]
Reputation	Reputation is important in network governance, because it relays information about prior behaviors and serves to deter opportunism. When members of the project perceive reputation as an important part of their identity, they are more likely to cooperate in conflicts. Additionally it may be relevant in role advancement or leadership elections.	Sagers [57]
Norms	Norms can be a tool of strong social pressure that discourages opportunistic behavior and self-interest. In the Debian project, norms were even institutionalized into the Debian social contract(DSC). Norms are often informal and not explicitly stated, but could be represented by explicit values.	Di Tullio & Staples [25], Sagers [57], Sadowski [53], de Noni et al., [27]
Collective sanctions	Collective sanctions are punishments enforced on individual entities who violate the norms, values or goals of the project. Sanctions include flaming, shunning, expulsion and more.	Sagers [57], Markus [15], Di Tullio & Staples [25]
Software development processes		
Release management	The procedures and rules surrounding releases, managing what code and features are included in the releases.	de Noni et al., [27], De Laat [16]
Modularization	Splitting the project in different modules reduces governance complexity, increases decoupling, decreases interdependency and allows for community members to focus on specific modules of the project without affecting development of other modules, and decreases the coordination burden. Most developers should focus on a small number of projects/modules, while a small number should participate in more projects/modules.	De Laat [16], Capra [50], Jensen [51], Lee, Baek & Jahng [58]
Responsibility management	The allocation of responsibilities for various tasks should be given to a community member or community role. The level of management ranges from open(unmanaged) to delegated(managed) responsibility. Bug fixing tasks benefit from delegated responsibility, while developmental tasks(new features/improvements) benefit from open responsibility.	Midha [17]
Code control	A role or member should be given responsibility to make decisions about inclusion of submitted code. This includes assigning code contributors.	De Laat [16], de Noni et al., [27], Sagers [57]
Conflict resolution		
Rules and procedures/policies and guidelines	Rules, policies and guidelines prevent conflict, facilitate coordination and ensure the quality of the project. Procedures may streamline testing, bug reporting or code acceptance.	Jensen [51], Sagers 2004, De Laat [16]
Use of information and tools		
Formal tools and procedures	Formal procedures and tools standardize and accelerate development. Examples are version control systems, issue trackers or release management procedures.	De Laat [16]
Communication channels	Communication channels such as mailing lists or chats facilitate discussions, decision making and community involvement. Communication tools may range from free form discussions(e.g., chats) to structured discussions(e.g., scrum boards, bug tracking systems, wiki's)	Midha [17], Jensen [51] De Laat [16], Sagers [57], Capra [50], Sadowski [53]
Issue tracker	An issue tracker that tracks feature requests, bug reports and other work, allows developers coordinate work and users to report feedback.	Jensen [51]

Appendix I: OSS governance mechanisms overview

DAO Governance mechanism	Description	Author
Proposals		
Proposal submission	A DAO may decide to limit the submission of proposals to certain members. A member may need a certain standing (e.g., number of tokens or reputation) before being allowed to submit proposals, or they need to have a certain role.	Hsieh et al., [59], Dupont [4]
Proposal approval	Proposals may require approval (by a subcommittee) or a certain support threshold before it is voted on.	Hsieh et al., [59]
Proposal costs	A proposal may require collateral or involve a cost to prevent an overload of proposals. This increases quality of proposals.	Kondova & Barba [60]
Proposal domains and on-chain vs off-chain	On-chain governance refers to all governance activities that are orchestrated through the DAO. Any governance that occurs through other channels, formal and informal, are off-chain. Despite the growth of on-chain governance solutions, not all theoretical governance models are currently possible on-chain. Reaching agreement can be more practical off-chain. Therefore a DAO can consider offloading governance activities and decision making (i.e., membership approval, allocation of funds, code changes etc.) off-chain and only register its outcomes on-chain, or completely conduct activities off-chain.	Kaal [8], Wang et al., [33], Reijers et al., [30]
Improvement protocol format	Proposals follow a well-defined format and are reviewed in a standardized process, similar to academic journal review processes. Ideas and proposals are discussed in the community or in focus groups. Editors can then reject or approve them. After approval by the editors, the community votes for the proposal. An example is the Bitcoin improvement protocol.	Hsieh et al., [59], Virovets & Obushnyi [61]
Voting		
One token one vote	In a one-token-one-vote design, fungible, exchangeable tokens are used to vote. Token holders are somewhat similar to shareholders as each token represents a vote and their power. As tokens can be bought and as larger token holders hold more power, this governance model is susceptible to plutocratism.	Kaal [8] Riva [62]
Conviction voting	Through dedication, votes are cast with tokens. Members can support multiple proposals with different numbers of tokens. A member cannot vote with more tokens than they own. Additionally, conviction voting employs a dynamic threshold before a proposal passes.	El Faqir El Rhazoui [82], Kaal [8]
Futarchy	The idea of a futarchy governance system was orginally proposed by economist Robin Hanson. It utilizes prediction markets as a governance tool. It works similar to a stock market, where traders buy and sell stocks, based on the perceived value and future value of the stock. Participants may bet on the outcomes of a proposal, compelling them to research the proposal and make an educated decision.	Kaal [8], Buterin [83], Wright & Da Filippi [35], Swan [63]
Liquid democracy	Liquid democracy is a combination of direct and representative democracy. Voters have the right to directly vote on a proposal, but also have the option to delegate their vote to someone to vote on their behalf. This allows voters to exercise their votes to the fullest, without the need to actively participate in every vote and research every proposal.	Kaal [8], Fan et al., [9]
Quadratic voting	Participants are allocated a voting budget to spend on voting. Votes can be cast on different outcomes depending on how strong the voter feels about it. However, the cost for each vote increases quadratically.	Lalley & Weyl [64], Kaal [8]
Reputation based voting	The weight of a vote is proportionate to the reputation score of the voter. The score may be awarded through a non-fungible token that is assigned to the blockchain address of the community member or the votes may be directly tallied to and associated with the address. A voter may earn reputation through performing activities for the DAO. As reputation can only be earned, reputation based voting is a form of meritocracy.	Kaal [8], Da Filippi, Shimony & Tenorio-Fornés [38], El Faqir El Rhazoui [82], Beck, Müller-Bloch & King [14]
Staking	Tokens or reputation is staked on the outcome of a proposal. Staking it on a losing outcome may lead to a direct loss of tokens or reputation or just a loss of opportunity.	Kaal [8], Riva [62], Braun, Häusle & Karpischek. [65]
Incentives		
Fungible tokens/Economic rewards	Fungible tokens can be exchanged and therefore represent a monetary value. With tokens, many aspects require consideration, including their creation, circulation, utility and value management. In a DAO their utility may be a reward for performing actions such as voting and making proposals. Or in a token based voting system they represent equity and are used to vote and represent voting power. A DAO could also reward workers with tokens or other currencies for completing tasks.	Wang et al., [33], Virovets & Obushnyi, [61], Kaal [8], Braun, Häusle & Karpischek. [65]
Indirect economic incentive	DAO members can be rewarded with monetary value, based on other activities or standing in the DAO community. I.e., members are paid a regular salary in traditional currencies or fungible stable tokens, based on their non-fungible reputation tokens.	Kaal [8]
Reputation	Members may be incentivized by gaining reputation. Reputation may represent reliability or contribution level. reputation may give monetary value or voting power. The DAO needs to determine how reputation is awarded or deducted. Reputation should be non-fungible/non-transferrable.	Kaal [8], Beck, Müller-Bloch & King [14], El Faqir El Rhazoui [82], Wang et al., [33]
Admission fee	Admission fees are a discouragement to betrayal and defection as there is a sunk cost associated with joining the DAO. It also discourages leaving and rejoining. In a pseudonymous environment it adds to the cost of joining under different pseudonyms and to the cost of a possible sybil attack.	Kaal [8]
Community		
Member identification	In some applications formal identification of a DAO member may be necessary. Both on-chain and off-chain solutions can help in registering members.	Diallo et al., [66], Kaal [8]
Shareholders	Token holders may represent the DAO's shareholders when a token represents one share or one vote. Tokens, like shares can be bought and sold and tokenholders are rewarded with the appreciation of the value of the token. This model makes DAO members comparable to shareholders, granting them all a stake and voting power in the DAO.	Hsieh et al., [59]
Community monitoring and compliance	In centralized organizational designs, governance is hierarchically monitored and validated. In DAOs, audits and monitoring of governance can be conducted by the community or individual DAO members.	Kaal [8]
Forking	Forking refers to performing software changes which lead to a hard or soft divide in a community (hard forks are not backwards compatible). It may also serve to settle disputes. Each party of the community can adopting the DAO version which they believe is right. However, this results in a social and economic loss for the DAO as a whole.	Hsieh et al., [59], Kaal [8], Beck, Müller-Bloch & King [14]

Appendix II: DAO governance mechanisms overview

ACKNOWLEDGMENT

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