MIT Computational Law Report

Governance in DAOs: Lessons in Composability from Primate Societies and Modular Software

Renita Murimi

Published on: Dec 05, 2022

URL: https://law.mit.edu/pub/governanceindaos

ABSTRACT

Governance, in its various forms, strives to solve the resource allocation problem in resource-constrained societies. Decentralized autonomous organizations (DAOs) have emerged as a new kind of institution, that seeks to leverage the decentralized nature of the underlying blockchain in its governance mechanisms. This paper offers a framework for composable governance, where key elements of consensus, cooperation, and conflict regulation are designed for reuse across domains. Our framework for composable governance draws inspiration from two sources: the governance mechanisms of primate societies, and modular structure of service-oriented architectures and object-oriented programming. The work in this paper raises important questions about the parallels between DAOs and conventional business and legal institutions, while emphasizing the role of the social relationships – consensus, cooperation, and conflict regulation – in creating frameworks that stand the test of emerging technologies.

1. Introduction

Every society, whether human or animal, faces problems of limited resources. In response, these societies have resorted to elaborate governance mechanisms for regulating the allocation of these sparse resources. Governance in such societies is an intricate interplay of forces of centralization and decentralization, with the goal of efficient resource allocation and establishment of social order. The different forms of governance differ in the amount of autonomy that an individual member of the group possesses in making decisions for the self and the group. For example, non-human primate societies such as harems in hamadryas baboons (Judge et al, 2006), grooming-centered neighborhoods in chimpanzees (Kanngiesser et al. 2011), grooming cliques in geladas (Dunbar, 2018), and bands in human societies (Hill et al, 2011) have intricate social systems in place that aim to reduce tensions from intragroup and inter-group competition for resources. Conflict, arising from competition for limited resources, is a hallmark of resource-constrained societies and has spurred varying forms of governance strategies. While governance strategies aim to reduce conflict, it should be noted that not all members of the social group work together or even agree with the established rules of governance. Thus, to address conflict, competition in resource-constrained societies has given rise to two other phenomena: consensus and cooperation.

Jane Goodall’s startling observations of social order among chimpanzees fascinated the world for several reasons, one of which was the elaborate structures of governance in the absence of written laws and legal frameworks that underpin the social fabric of human societies (Goodall et al. 1979). Social organization, social structure, and mating systems were explored for their role in primate social systems to provide clues about behavioral relationships between individuals (Kappeler and Schaik, 2001). Chimpanzee societies were found to exhibit a fission-fusion structure, where chimpanzees move around in groups and subgroups that vary in size, composition, and dispersion while merging and splitting over time (Mitani et al. 2002). Cooperation among individuals who frequently interacted with each other and sharing of the mutual benefits of cooperation was found to be a significant factor of social structure (Voelkl and Kasper, 2009). Members of early hunter-gatherer societies have been observed to display a similar fission-fusion structure (Grove et al. 2012). Fission-fusion social structures are an example of large groups that split to form smaller subgroups, where the smaller subgroups are linked together by weak ties between groups and strong ties within groups (Dunbar and Shulz, 2021). This inherent structure provides the foundation for composable governance, where the rules that apply to lower levels of the hierarchy are recursively applied to larger groups.

Governance depends on accompanying social contracts. A fundamental premise of governance in hierarchical societies is the differential power dynamic arising from varying resources available to the members of a group. Individual members, voluntarily or involuntarily, abide by the rules of social order and defer to the decisions of the group or the leader. Central to this deference is the assumption that the power to make rules and decisions is concentrated among a chosen few members of the group (Magee and Galinsky, 2008). Traditionally, these rules were codified in the form of contracts between members, which has evolved into the modern forms of contract law.

But what happens when the members are pseudo- anonymous and the contracts are written in software code for execution upon fulfilment of a series of if-then constructs? This scenario, exemplified by decentralized autonomous organizations (DAOs) running on smart contracts, has posed a unique challenge for governance. However, despite the differences between non-human primate societies and DAOs, this paper argues that the multilevel structure of non-human and human primate societies offers us insights for composable governance in DAOs. DAOs represent a new kind of society where the codification of the rules of exchange on blockchains also provides inbuilt structures for composability.

The contributions of this paper are as follows. First, we provide an overview of primate societies in terms of their structure, and the issues related to consensus, cooperation, and conflict regulation inherent to these societies. Second, we analyze three DAOs in different domains – grant making, decentralized finance (DeFi), and non-fungible tokens (NFTs) – to draw out the essential mechanisms by which these DAOs handle consensus, cooperation, and conflict regulation. Finally, we develop a framework for composable governance in DAOs based on consensus, cooperation, and conflict regulation. This framework borrows upon composability paradigms found in service-oriented architecture, object-oriented programming as well as primate governance.

2. Antecedents of composability

2.1 The structure of primate societies

What can non-human primates teach us about governance? Similar to human societies, decision-making among non-human primates is an expensive process - but so is conflict. Among the many mechanisms available to the members to prevent conflict, we will focus on consensus and consensus. Constraints from limited resource allocation have given rise to different social structures. The organization of human societies in multilevel hierarchical structures has been shown in a diverse range of settings (Peter, 2009). A biobehavioral perspective of political stratification was presented in Willhoite (1976), which argued that human societies have a propensity to organize themselves in hierarchies based on differential authority, power, and influence. Willhoite's argument draws from studies of four primate societies: rhesus macaques, savanna-dwelling baboons, gorillas, and chimpanzees. The core of Wilhoite's argument suggested that the goal of stratification in primate societies is to reduce disturbance and improve cohesion during crises. Leaders at every level of the hierarchy command the attention of their subordinates, and form the basis of traditional and legal authority. This is not unlike non-human primate societies. For example, Hans Kummer's studies of baboon behavior showed that each member of the baboon society "knew" its role in the hierarchy, such that younger and weaker members ranked lower than the stronger ones, and males ranked higher than the females (Kummer, 2017). Further, a summary of inequity studies in Brosnan (2013) showed that non-human primates both noticed and responded to inequity, which points to the role of cooperation in structured societies.

It might be helpful to point out why this essay focuses on primate governance. In contrast to large ungulate herds such as the wildebeest, primate societies feature distinct cohesive societies characterized by structured interactions stemming from status, influence, and authority distributions among members of its subgroups. But living in groups is not without its disadvantages. Small groups that bond over cohesive relationships have to constantly renegotiate the power dynamics within its members to reduce the stress caused by disagreements, squabbles, threats from both within and external to the group, as well as constraints on limited resources. Dunbar's work famously addresses the relationship between group bonding and group size, arguing that "a multi-level form of organization" provides the stability and cohesiveness that serves primate societies best in regulating the costs of living in groups (Dunbar, 2020). Work in Grueter et al (2012) addressed social structure in primate societies as a function of socio-ecological constraints posed by food and threats. These threats may originate in some societies from members at the margins of the group, or from within the group. In either case, the necessity to form groups to counter these constraints have led to the formation of "modular" societies, that possess distinct social structures. In human societies, the norms of social exchange theory suggest that resource exchange in social relationships are anchored on a combination of factors, among which include altruism, reciprocity, and status (Meeker, 1971).

2.2 Consensus, cooperation and conflict resolution in primate societies

Decision-making is an expensive process, but so is conflict. Given that ample evidence exists for multilevel hierarchical societies among primates, how do individual members within the group abide by social rules of governance? Some of the earliest research on consensus found that consensus about norms is required for the functioning of society and for achieving social equilibrium, and is derived from coercion. A refusal to adhere to these norms gives rise to conflict, and requires coercion to "control the non-cooperative" so that social control can be achieved for social integration (Adams, 1966). Horowitz (1962) identified three factors distinguishing consensus from cooperation. First, while consensus refers to agreement about a common set of "norms and values", cooperation is concerned with adhering to "procedural rules" so that problems can be settled in spite of disagreements and differences. Second, consensus refers to agreement on the "content of behavior", while consensus refers to agreement on the "form of behavior". As an example, Horowitz illustrated this point by noting that consensus is achieved by agreement about a certain position, while cooperation outlines the rules and formats for actualizing that agreeable position. The final distinguishing point is that of differences: while consensus calls for "abolition" of differences, cooperation calls for "toleration" of differences. In other work, consensus was shown to be a social mechanism to achieve the alignment of individual interests toward social norms using communication between members (Scheff, 1967), and was also not a prerequisite for cooperation (Star, 1993). An interdisciplinary perspective to the study of consensus formation is in Baronchelli (2018). Here, the author pointed to the role of network properties (structure, clustering, external forces, incentives) in consensus formation. Specifically, the findings emphasize the role of social connections and microscopic interactions, in addition to the network properties in information spread, and consensus formation. Central to these varying theories about consensus, cooperation, and conflict regulation is the need for functioning of society despite individual differences.

The mechanism of consensus formation is attractively simple. However, reaching consensus is not merely based upon individual perceptions of the costs and benefits associated with that decision. In groups, local interactions with other individuals and their choices also impact an individual's choice. For example, Sumpter and Pratt (2009) studied the role of quorum in consensus among animal societies. They found that several local interactions impacted consensus formation, ranging from simple copying of other's responses, group size, dominance hierarchies, and feedback from decision choices. The link between social network structure and consensus was explored in Seuer et al (2012), where the authors studied three different network topologies (star, centralized, equal), their network properties (centrality indices) and movement of group members using simulated models which were compared to empirical data from primate societies. They found that network structure was a significant predictor of the kind of consensus achieved, and consequently impacted leadership dynamics in the group. For example, they found that unshared consensus (found in centralized networks) where one individual or sub-group decides for the entire group led to faster decisions. The converse was found in the case of shared consensus, where every member contributed to the decision-making process.

Cooperation among members of a group is often challenging. Human societies have devised numerous mechanisms to decipher the mind of the group, such as bottom-up structures that leverage determinations of majority, including degrees of majority such as singular, simple, super, double, two-thirds, plurality and the rest. Work in Conradt and Roper (2005) has shown the prevalence of consensus in decision-making among animals, including mechanisms such as combined decisions where individual members decide without requiring consensus, but consensus is still dependent on the behavior of other members of the group. Their work showed that animals consider factors such as conflicts of interest and communication, that affect their groups locally and globally (using spatial communications with local neighbors). Work in Puga-Gonzalez (2009) and Hemelrijk (2012) analyzed grooming behaviors among primates as a social affiliation act, where the act of grooming was performed by members of lower rank for higher-ranking members as a mechanism to smooth tensions, reduce anxiety, and facilitate attraction. Thus, grooming served as a means of cohesion in primate societies, enforcing social structure through order and stability.

Conflict resolution is a key social interaction in bonded social groups. In the case of situations with high uncertainty where individuals in large groups are uninformed, the role of consensus and leadership are crucial. Work in Dyer et al (2009) found that the location (center and margins) of the network served as a facilitator of quicker consensus formation, and that a few informed individuals in these positions were adequate to guide the group toward consensus. Additionally, work in King (2008) showed that foraging decisions for the group were led by the dominant male, for whom the group foraging activity would prove more beneficial than for the members of his group. Further, consensus was shown to be costly for the subordinate members of the group, and that the strength of social ties was an indicator of social fissures and reduction in kinship effect among followers. Flack et al (2005) observed that third party policing of conflict resolution imposes greater costs on the policers than on the conflicting parties, and the benefits of their efforts affect the entire group. They found that when the policers were viewed as individuals with high power by the entire group and were few in number, it led to fewer conflicts, less intense conflicts, and imposed fewer costs on the policers too. Among primates, conflicts, aggressive behavior, and reconciliatory behavior were seen as an outcome of management of complex social relationships in multilevel societies (de Waal, 2000). While the preceding narrative examined the primate societies, the next section examines DAOs from the perspective of structure, consensus, cooperation, and conflict regulation.

3. DAOs

The core of a decentralized autonomous project (DAO) is the smart contract, which affords automatic execution of tasks upon completion of prerequisites (Buterin et al). These tasks could include transfer of funds, purchase of assets, transfer of ownership, and other similar activities. Requiring minimal human interaction or oversight, smart contracts work best when the activities underlying a task can be modularized and codified for storage, parsing, and processing on the blockchain (Wang et al, 2019). Work in Liu et al (2021) analyzed the impact of using DAOs for governance, commenting on the mechanisms for incorporating trust and security while also providing caution about the lack of adequate regulation in legal and accounting domains for DAO-based governance. Although DAOs hold promise for transparency of governance and immutability of record keeping, creating a DAO from scratch remains a daunting challenge that requires expertise in blockchain programming languages, interoperability with other DAOs, their tokens and currencies as well as compliance with tax and financial processes in several jurisdictions. An alternative to developing DAOs from scratch is using existing DAO templates that can be customized for a specific organization. As an example, work in El Faqir et al (2020) summarized the offerings of four different platforms that offer DAO templates in an infrastructure-as-a-service format.

Perhaps no essay about the challenges of DAOs can be complete without a reference to *The DAO*. Although Buterin's vision laid the foundation for DAOs, one of the first implementations of a DAO was a kind of crowdfunding project on the Ethereum blockchain (DuPont, 2017). Simply called "The DAO", this project aimed to offer shareholders a stake in governance by letting them vote for how the DAO should invest its funds. Raising close to $150 million in four weeks, The DAO emerged as the largest crowdfunding project at the time. However, this initial success was short-lived. A bug in the smart contract of *The DAO* was exploited, leading to a transfer of $50 million to the hacker's wallets forcing the Ethereum Foundation to reconsider the sovereignty of a smart contract's decision. An analogy of the attack is presented in Morrison et al (2020), where the attacker repeatedly withdrew funds while being logged in as the smart contract failed to update its balance. Once the attack was discovered, the Ethereum Foundation proceeded to issue a hard fork of the Ethereum blockchain, so that investors could be refunded. This decision to revisit the smart contract and reject its outcome to the point of forking the blockchain itself was a pivotal moment in the discourse of how much human intervention is required or expected in smart contract operations (Santos and Kostakis, 2018). This case also ushered in inquiry about codifying elements of contract negotiation that cannot be parameterized by software code, such as ethics, trust, and moral dilemmas (Meier and Schuppli, 2019). Work in Sulkowski (2019) noted that hardcoding business ethics on the blockchain presents unique challenges about encoding of changing social norms and accountability for errors or failing to meet the ethical standards that have been codified on the smart contracts.

Another DAO, called Swarm City, was analyzed in Beck et al (2018). Swarm City is a blockchain-based marketplace that eliminates the need for intermediaries and uses a reputation system to manage the listing, assignment, completion, and evaluation of tasks in peer to peer transactions. Their findings highlight three dimensions of governance in DAOs – decision rights, accountability, and incentives – which are challenging to codify while still adhering to the tenets of decentralized, immutable, record keeping and conforming to legal and social expectations for conflict resolutions and rewards. The lack of a "legal intervention point" that offers recourse to legal frameworks for conflict resolution in DAO-related arbitration was discussed in Rodrigues (2018), in which the author analyzed the intricacies of contract law from the perspective of DAOs that relegate the decision making, conflict resolution, and governance to smart contracts.

While DAOs seek to achieve consensus through governance frameworks and algorithmic intervention, at times, consensus fails. For DAOs, forks aren't the only answer. Forks can be expensive on several accounts. First, forks require investment of significant resources to create software features to meet the new requirements of the blockchain's stakeholders. Second, forks on cryptocurrency blockchains might require the development of entirely new currencies, which is challenging in the face of the evolving landscape of cryptocurrencies and the surrounding legal and tax frameworks. Third, forks disrupt the public perception of the stability of a blockchain creating uncertainty about the matter of adoption and support for the forked blockchains. Thus, although forks are a commonly proposed solution to resolve conflicts in governance on the blockchain, work in Reyes (2019) proposes a different solution – a business trust. The author's analysis of smart contracts, distributed ledger protocols, and DAOs suggests that structuring blockchain organizations as business trusts provides an efficient way to resolve the tensions between business and organizational law, especially where there are questions about whether computer code can act as a legal entity. Analysis of the SEC's response to *The DAO* incident created a blueprint for the structure and expectations of a decentralized partnership, drawing attention to the fundamental requirement of a partnership that partners share profits and losses (Oren, 2018).

Smart contracts by virtue of being developed in software are subject to biases. Observations of smart code biases showed that although smart contracts are objective, i.e. designed in code and yields outcomes that are dependent only on the inputs, they are still created by humans and are vulnerable to subjective bias and uncertainty caused by our bounded rationality (Werbach, 2018). The findings of Werbach (2018) pointed to the need to combine law with blockchain technology, since blockchain can't yield satisfactory outcomes for marketplace transactions without accompanying legal frameworks to adjudicate disputes arising from uncertainty, fraud, and system flaws. The need for DAOs to incorporate neutral third parties for dispute resolution is further highlighted in Minn (2019), where the author advocated for the need for legal frameworks and regulatory bodies in enforcing the fiduciary principles of loyalty and due care for DAOs. Similarly, Kolber (2018) cautioned against placing absolute trust in the code-as-contract philosophy that is ascribed to smart contracts, highlighting the pitfalls lurking in assuming that smart contract code exists independent of the context the contract or background law. Wright and De Filippi (2015) coined the term *lex cryptographia* to denote the role of cryptographical primitives in regulating the transfer of digital assets on the blockchain. In the absence of third-party intermediaries, these cryptographical primitives are leveraged to provide varying degrees of social relationships, such as trust, privacy, and anonymity on the blockchain. Further, Zwitter and Hazenburg (2020) noted new actors in technology, many of whom are anonymous, globally distributed, and possess superior technological skills are capable of altering the power dynamics between individual users, corporations, and governments resulting in the need for enhanced governance strategies.

3.1 A tale of three DAOs: Aave, Apecoin, and Maker

In this section, we analyze the terms and conditions of three DAOs from different blockchain domains (lending, NFTs, and grants) and draw some general lessons about how consensus, cooperation, and conflict regulation are addressed in current DAOs. These lessons will then be used to develop a connection between composability and DAO governance in the next section.

Aave DAO: The Aave DAO protocol is a "decentralized, community-governed" protocol for grants on the blockchain (Aave). Developed by Avara UI Labs, the DAO funds grant ideas that are reviewed by the Aave community or their governance forum, depending on the size of the grant being requested. Grant ideas are solicited in diverse categories such as intuitive Aave user interface development for analytics, governance and voting and integration with other applications potentially incorporating multiple blockchains. Aave works on top of underlying blockchains, and thus, the consensus algorithms that run on the underlying blockchains influence the operation of Aave. Changes resulting from changes in consensus rules of the underlying blockchains have the potential to cause damages, and Aave is not liable for these damages. Protocols such as Aave work in conjunction with several third-party applications such as wallet providers and user interface developers. Forks, described as “sudden changes in operating rules” of the underlying blockchain are explicitly mentioned, and users are urged about their responsibility in securing their wallets. Risk introduced due to factors such as forks, attacks on the blockchain, breaches, legal frameworks are acknowledged and passed on to the user, thus eliminating the potential for conflicts with the user. Users also bear responsibility for any taxes and Aave reserves the right to limit or exclude users who engage in fraudulent activities in accordance with the jurisdiction of the Cayman Islands. Thus, in dealing with the uncertainties imposed by changes to the underlying blockchain and third-party services that are fundamental to its operation, Aave has acknowledged the potential for conflicts and implemented a centralized version of governance that steps in to limit fraud and minimize liabilities.

Apecoin DAO: Spurred by the massive success of the Bored Ape Yacht Club (BAYC) collection of non-fungible tokens (NFTs), the developers of BAYC – Yuga labs – launched multiple companion collections such as the Mutant Ape Yacht Club and the Kennel Club. The founders of these collections started the Ape Foundation to oversee the development of this ecosystem and launched the Apecoin DAO in 2021 (Apecoin). Owners of NFTs from these collections are allocated tokens in proportion to the number of NFTs owned. These tokens called Apecoins can be used for community-led governance of a robust metaverse centered on games, events, entertainment and other activities involving the NFTs that combine both the physical and digital spaces.

Governance in the Apecoin DAO is centered on Ape Improvement Proposals (AIPs), which are voted upon by members in several rounds. Membership is limited to Apecoin holders, and voting is restricted to members whose wallets have been authenticated. One Apecoin confers one vote, and voting can be delegated. The governance of the Apecoin DAO is managed by a Board of five members, who are elected for annual terms. The terms and conditions specify the procedures for conflicting proposals, rejected proposals, and stalled proposals. Further, similar to Aave DAO, the terms and conditions prohibit Apecoin holders from participating in fraudulent or illegal activities, or activities that are not aligned with the mission of the Ape Foundation. The Apecoin token is designed to be a governance token, that can also be used as a payments token.

MakerDAO: MakerDAO governs the Maker protocol, which is a collateralized lending system that enabled users to create currency called Dai on the Ethereum blockchain (Maker). The Dai cryptocurrency token is pegged to the US dollar, reducing the risks of volatility that are inherent to many cryptocurrencies. Dai is generated when users deposit collateral in the market, and these Dai are entered into circulation as liquidity. The type of collateral accepted in the Maker ecosystem is chosen by voting, which includes information about the risk parameters associated with each collateral. Maker works by overcollateralizing, where the amount of collateral is in excess of the Dai debt. The governance token in the Maker protocol is called MKR, which confers upon holders voting privileges for some aspects of the software used in Maker protocol. As with the Aave DAO, the MakerDAO acknowledges that forks can disrupt the operation of the protocol and that the foundation reserves the right to decide whether it will support the forked chains. The governance adheres to the laws of the State of New York. MakerDAO affords token holders the ability to participate in on-chain voting, where voting records are stored in the blockchain and are processed according to rules that are encoded in the form of smart contracts on the blockchain. Similar to Apecoin DAO and Aave DAO, the terms and conditions of MakerDAO require that the user assumes the responsibilities and security risks inherent to online services, and draws particular attention to on-chain voting as a new experimental technology which might pose unique risks.

From the standpoint of decentralized governance, it is hardly clear how DAOs are governed any differently than regular corporations. Both have a centralized set of rules, or terms and conditions, and are managed by boards that seek to incorporate stakeholder input in governance. Governance of DAOs utilizes blockchains as tools for voting, storing and managing assets, and maintaining records. Each of the DAOs profiled here uses appropriate adjustments for dealing with sparse resources and uncertainties of economies spurred by new technologies. The terms and conditions are comprised of default rules, mostly governed by the three fundamental rules of contract law: rules that mimic the markets and follow the will of the parties, rules that are not meant to follow the will of the parties but to clearly specify their wishes, and rules that consider public policy or similar social context (Sunstein, 1999).

Some important themes emerge from this analysis. First, DAO governance is a mix of centralized and decentralized initiatives, manifesting itself in the form of structured terms and conditions incorporating contract law and hierarchies of boards and foundations that decide on the mission and vision for the DAO. In addition, DAOs insist on adherence to local, regional, national, and international laws for taxation, data sharing, and legal representation. Despite blockchain being a borderless technology that solely depends on nodes adding records based on the state of the distributed ledger, governance of the applications enabled by this technology is surprisingly similar to that of regular corporations. Further, DAOs are intricately embedded in a mesh of-third party services, which provide foundational infrastructure and collocated technological capabilities. Changes in the operations of any of these services has the potential to impact the operation of the DAO by means of intentional or accidental ripple effects. Thus, DAO governance is subject to the same inherent tensions of structure, scarcity, and resulting conflicts that occupy the governance of traditional institutions. The next section uses these insights to design a framework for composable governance, that considers consensus, cooperation, and conflict regulation as key elements in the governance.

4. Composable governance – consensus, cooperation, conflict regulation

Composability is a matter of degree. Frameworks for governance that are designed for composability can be chosen to incorporate modular, polymorphic governance at various levels. One of the major advantages of composability is its ability to be reused across different applications, and this inherent capability for potential reuse also lends itself to legal frameworks that mutate over time. The origins of governance are closely related to the processing of contracts, specifically the enforcement of payment for the object mentioned in the contract.

John Maynard Keynes, in his seminal work on the role of credit and state in his Treatise on Money (Keynes, 1930) put forth the conclusion that governance exists to enforce legal contracts of credits and debits.

> *The State, therefore, comes in first of all as the authority of law which enforces the payment of the thing which corresponds to the name or description in the contract. But it comes doubly when, in addition, it claims the right to determine and declare what thing corresponds to the name, and to vary its declaration for time to time – when that is to say it claims the right to re-edit the dictionary.*

Although Keynes' vision was of the state enforcing contracts, there was an implicit assumption that the elements of the contract were at par with the progress of the technologies of the time. However, over the decades, the gap between legal frameworks and emerging technologies has increased. While disruptive technology is nothing new, the pace at which such technology has been adapted for mainstream use on a large scale is a distinct hallmark of current technological trends (Fenwick et al, 2016). For example, the notion of "personal data" which dominates the privacy discourse is interpreted differently in different jurisdictions around the world ultimately influencing the decision of companies regarding their location (Rochelandet and Tai, 2016). New laws are enacted in response to pervasive societal challenges, such as Germany's Network Enforcement Act (aka the Facebook Act), which requires that social media companies take down offensive posts within 24 hours or risk paying a fine of 50 million Euros (Claussen, 2018). Older laws such as the Commerce Clause (Article 1, Section 8, Clause 3) of the US Constitution have been adjusted, as in the case of *Supreme Court v. Wayfair* (2018) where the Court decided that state governments can tax Internet commerce overturning its previous ruling in *Quill v. North Dakota* (1992). Another example of the gap between technology and the law concerns self-driving cars, which deems them to be illegal on the road in many jurisdictions. To accommodate the trend toward self-driving cars, the 1968 Vienna Convention has been amended to allow for the presence of self-driving cars on roads. This growing gap between legal frameworks and emerging technologies calls for a new kind of governance mechanism, one whose composable elements can be selectively chosen for use in several domains.

Composable governance borrows upon the notion of modularity inherent in a range of disciplines, including object-oriented software development, service-oriented architectures (Das and Patra, 2013), network structure (Newman, 2006). The fundamental tenets of object-oriented programming are centered on encapsulation, inheritance, and polymorphism. Encapsulation refers to the bundling of data and functions that operate on the data, such that these bundles can be reused in other programs or applications. However, not all of these functions may be required for another application. These bundles can be selectively used, by taking only the functions that are required and using them in their original format or by modifying them. Thus, the newer bundles "inherit" traits from the original bundles. Each of these bundles can be reused infinitely, creating objects with different data characteristics and different set of enabled functions exhibiting polymorphism. The question is: could we design a framework for composable governance that provides mechanisms for consensus, cooperation, and conflict regulation based on the modular structures of object-oriented programming and service-oriented architectures? While at first glance it might seem farfetched to extend composability to governance, a deeper look shows that the foundational principles of OOP and SOA bear a unique resemblance to the foundations of American constitutional law. Common law, which serves as the basis of American legal frameworks, addresses issues on a case by case basis, which is not unlike the principles of encapsulation, polymorphism, and inheritance that are found in OOP. Law and composability, and thereby governance and composability, share a common aspiration to be modular with a general preference for selective reusability.

Service oriented architectures (SOA) and object-oriented programming (OOP) offer some insights for such a governance. Distributed online services have steadily evolved in complexity, and are manifested in several applications such as the structure of the Internet, cloud computing, sensor networks, and even in malware. One of the models for distributed services was proposed in the form of service-oriented architectures (Perrey and Lycett, 2003; Laskey and Laskey, 2009; Valipour et al, 2009), whose fundamental tenets revolve around customized reusable software services for meet the needs of diverse applications. For example, work in Leusse and Brossard (2009) developed a SOA-based architecture for security governance, in which a variety of security infrastructure services, management processes, and resource constraints are managed to provide modular security governance.

The concept of modularity has been extended into governance of online communities. Work in Schneider et al (2021) argues that large online communities are run by a few corporations, leading to challenges about content moderation, surveillance, agency, privacy, profits from data, and interoperability. Their proposed conceptual framework for modular politics relies on polycentricity, which is enabled by the interplay of overlapping and interlinked online environments. Polycentric design for governance was explored by Elinor Ostrom in her Institutional Analysis and Development (IAD) framework (Ostrom, 2010) as a modular mechanism to facilitate collaborative decision-making mechanism among individuals and institutions. Ongoing work by Choi et al (2021) has addressed the issue of legal uncertainty for DAOs by creating a standard framework called the DAO Model Law for technical and governance requirements in DAOs. Consensus, cooperation, and conflict regulation in the context of the DAO Model Law refers to governance and legal decisions such as placing tokens on a secondary market, appointment of administrators for management, allowing the coexistence of forks, the choice of a particular fork for a given operation, legal representation and conditions for restructuring.

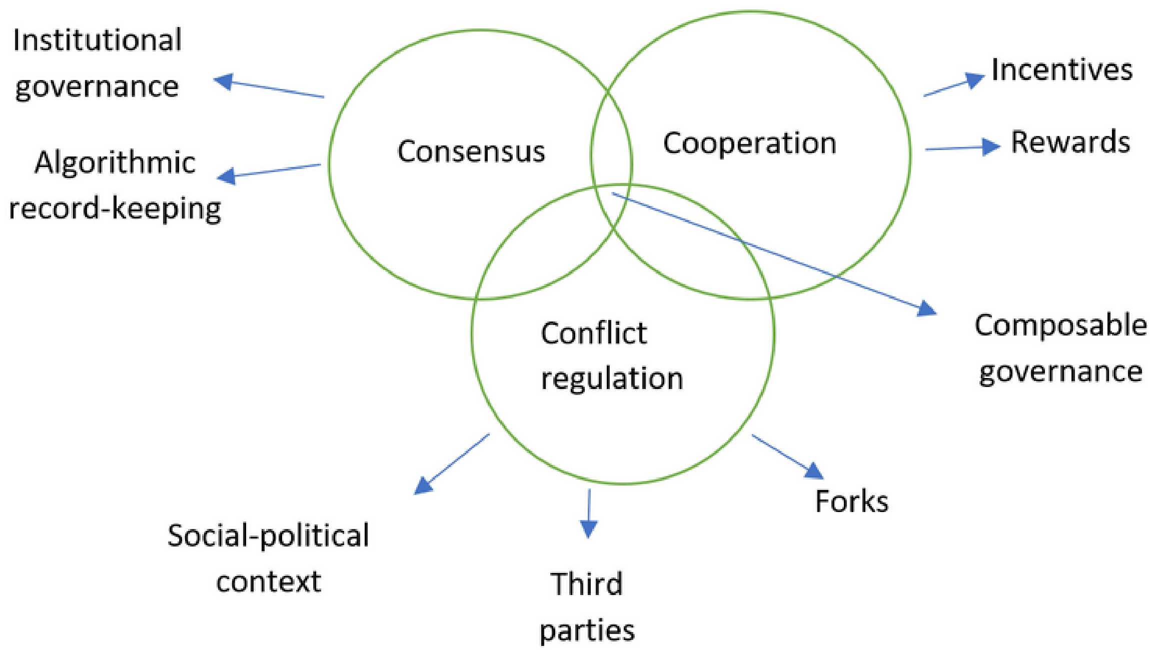

Figure 1. A composable governance for DAOs based on consensus, cooperation, and conflict regulation

Figure 1 shows a framework for composable governance for DAOs that lies at the intersection of consensus, cooperation, and conflict regulation. As we have already seen, consensus in embedded in the structure of DAOs at two levels. First, consensus is manifested in the algorithms in the underlying blockchain where nodes collectively decide upon which records are added to the blockchain. The second form of consensus is exhibited in the more conventional sense, where governance of the DAO institution itself is regulated by consensus rules that govern its stakeholders. Cooperation among DAO stakeholders is similarly facilitated with the help of incentives and rewards for their transactions on the blockchain, which encourage the development of the specific blockchain ecosystem. Conflict regulation in DAOs, as seen in conventional institutional governance, is managed by a system of socio-political pressures and third parties and may have to resort to a blockchain-specific mechanism of forks.

The model for composable governance in Figure 1 also highlights the inadequacy of governance when even one of the constructs is missing. For example, a framework that lean heavily on consensus and conflict regulation without affording mechanisms for cooperation will stall frequently on decisions, since consensus cannot be uniformly expected and the resulting conflict regulation mechanisms will depend on social pressures or expensive forks. Likewise, a framework that is sparse on conflict regulation but emphasizes consensus and cooperation has the potential for disenfranchised stakeholders in the event of conflicts. Similarly, a framework that emphasizes conflict regulation and cooperation without a consideration of the role of consensus creates confusion in decision making. The consequences are even more dire if a framework heavily emphasizes one of these principles while neglecting the other two. A carefully designed framework for DAO governance requires that all three of these principles be leveraged, especially since issues surrounding digital identity, degree of anonymity, and security of assets on the blockchain factor heavily into the adoption and success of the nascent DAO environment.

5. Discussion

Conflicts in societies are inevitable and expensive, and so societies have developed cooperation, consensus, and conflict regulation mechanisms. A governance framework built upon these principles reduces decision costs when disagreeing parties require broader socio-political interventions to decide cases. Below, we highlight a few directions for composable governance frameworks for DAOs, that could also find applicability in conventional legal applications.

1. Creating a sandbox for composable governance in DAOs: At the conjunction of governance for emerging technologies, lies the challenge for suitable legal frameworks. It is not possible to rewrite constitutions and overrule hundreds of years of jurisprudence scholarship and governance frameworks. Such an overhaul may be possible in some jurisdictions, such as in the case of Liechtenstein where the Liechtenstein Blockchain Act passed in January 2020 enabling the tokenization of any right or asset (Teichmann and Falker, 2020), or in Scotland where blockchain technology is being incorporated into the Scottish constitution and their legal frameworks (Digital Scotland, 2017). Instead of seeking to uniformly revise legal frameworks, it might be prudent to create a new legal framework for DAOs by treating it as a sandbox. DAOs cross jurisdictions, involve pseudonymous entities, and deal with new kind of assets that are not well-defined within existing legal and governance frameworks. Treating DAO law differently from conventional law also affords legal scholars and practitioners with room to innovate and test different solutions.
2. Structure of a crypto society: Should governance be based on social relationships? As blockchain technologies find their own niche in society, we need more careful examination to understand the structure of a crypto society. Consensus, cooperation, and conflict regulation are fundamental constructs in traditional human societies, but research is needed to determine the how they manifest in DAOs and other blockchain-enabled communities. For example, the 51% rule is commonly used to determine algorithmic consensus in blockchain. But, in human societies, different measures of plurality exist which are intricately linked to the socio-cultural norms prevalent in their environments. In such communities, wallet addresses and transaction records on the blockchain are usually the only available information about transacting entities, and so establishing digital identity and reconciling it with physical identity present an ongoing challenge.
3. Blockchain and social networks: The rapid spread of online social networks has led to the formation of online communities, where users might have hundreds of “friends”, thousands of “followers”, and other large numbers of online relationship metrics, all of which putatively suggest that humans are capable of forming and maintaining relationships with large groups of people. However, Dunbar’s view about these large online social communities is influenced by the notion that network structure, and thereby online friends and followers, are not indicative of the small structured groups that humans have inhabited. These small

groups depend heavily on social norms and relationships, that cannot be fully manifested in online environments. A comparative analysis of the sizes of various kinds of human social networks, ranging from egocentric networks such as email networks, to 18^{th} century English villages, academic networks, social media networks in Dunbar's work points to a fractal structure of highly structured human societies held together by social and psychological bonds. These bonds govern the layers of networks, starting with intimate relationships at the core, and then progressively increasing in scope to include family, friends (who are ordered in degree of closeness), acquaintances, and known names. It remains to be discovered how blockchain fits into online and offline social networks.

6. Conclusions

This paper presents a framework for composable governance for DAOs by borrowing upon constructs from primate governance, service-oriented architectures, and object-oriented programming. Composable governance has a few salient prerequisites: a multilevel structure, sparse resources, and a delicate balance of centralization and decentralization initiatives. What makes DAOs different from conventional societies is that there exist no established socio-political frameworks for facilitating consensus, cooperation, and conflict regulation. Too much or too little of any of these can steer a society toward chaos or rigid conformity at the two extremes, and crypto-societies have already shown signs of both. DAOs have collapsed, been breached, and struggle to establish their place alongside, within, or outside of existing legal and governance frameworks. While cryptocurrencies might be the most popular application of blockchain technology, there exist numerous other applications of blockchain that provide innovative solutions to record keeping, transparency, and data integrity. Frameworks for composable governance that are built upon the phenomena of consensus, cooperation, and conflict regulation can be reused across several such domains due to the prevalence of these phenomena in virtually every kind of multilevel society.

References

Aave DAO. Available online at: https://aave.com/

Adams, B. N. (1966). Coercion and consensus theories: Some unresolved issues. *American Journal of Sociology*, *71*(6), 714-717.

Apecoin DAO Governance. Available online at: https://apecoin.com/governance

Baronchelli, A. (2018). The emergence of consensus: a primer. *Royal Society open science*, *5*(2), 172189.

Beck, R., Müller-Bloch, C., & King, J. L. (2018). Governance in the blockchain economy: A framework and research agenda. *Journal of the Association for Information Systems*, *19*(10), 1.

Brosnan, S. F. (2013). Justice-and fairness-related behaviors in nonhuman primates. *Proceedings of the National Academy of Sciences*, *110*(Supplement 2), 10416-10423.

Buterin, V. et al. "Ethereum white paper: A next generation smart contract & decentralized application platform," First Version, vol. 53, 2014. [Online]. Available: https://cryptorating.eu/whitepapers/Ethereum/Ethereum_white_paper.pdf

Claussen, V. (2018). Fighting hate speech and fake news. The Network Enforcement Act (NetzDG) in Germany in the context of European legislation. *Media Laws, 3*(3), 110-136.

Choi, C., de Filippi, P., Dudley, R., Elrifai, S., Fannizadeh, F., Guillaume, F., Leiter, A., Mannan, M., McMullen, G., Riva, S., Shimony O. (2021). Model Law for Decentralized Autonomous Organizations. Available online at: https://coala.global/wp-content/uploads/2021/06/DAO-Model-Law.pdf

Conradt, L., & Roper, T. J. (2005). Consensus decision making in animals. *Trends in ecology & evolution*, *20*(8), 449-456.

Das, R. K., & Patra, M. R. (2013). A Service Oriented Design Approach for e-Governance Systems. *International Journal of Information Technology Convergence and Services, 3*(3), 1.

De Waal, F. B. (2000). Primates--a natural heritage of conflict resolution. *Science*, *289*(5479), 586-590.

Digital Scotland (2017). https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2017/03/realising-scotlands-full-potential-digital-world-digital-strategy-scotland/documents/00515583-pdf/00515583-pdf/govscot%3Adocument/00515583.pdf

Dunbar, R. I. (2012). Bridging the bonding gap: the transition from primates to humans. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1597), 1837-1846.

Dunbar, R. I. M. (2018). Social structure as a strategy to mitigate the costs of group living: a comparison of gelada and guereza monkeys. *Animal Behaviour*, *136*, 53-64.

Dunbar, R. I. M. (2020). Structure and function in human and primate social networks: implications for diffusion, network stability and health. *Proceedings of the Royal Society A*, *476*(2240), 20200446.

Dunbar, R. I., & Shultz, S. (2021). Social complexity and the fractal structure of group size in primate social evolution. *Biological Reviews*, *96*(5), 1889-1906.

DuPont, Q. (2017). Experiments in algorithmic governance: A history and ethnography of "The DAO," a failed decentralized autonomous organization. *Bitcoin and beyond*, 157-177.

Dyer, J. R., Johansson, A., Helbing, D., Couzin, I. D., & Krause, J. (2009). Leadership, consensus decision making and collective behaviour in humans. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1518), 781-789.

El Faqir, Y., Arroyo, J., & Hassan, S. (2020, August). An overview of decentralized autonomous organizations on the blockchain. In *Proceedings of the 16th international symposium on open collaboration* (pp. 1-8).

Fenwick, M., Kaal, W. A., & Vermeulen, E. P. (2016). Regulation tomorrow: what happens when technology is faster than the law. *Am. U. Bus. L. Rev.*, *6*, 561.

Flack, J. C., De Waal, F. B., & Krakauer, D. C. (2005). Social structure, robustness, and policing cost in a cognitively sophisticated species. *The American Naturalist*, *165*(5), E126-E139.

Goodall J, Bandora A, Bermann E, Busse C, Matama H, Mpongo E, Pierce A, Riss D. Intercommunity interactions in the chimpanzee population of gombe national park. In: Hamburg DA, McCown ER, editors. *The great apes.* Menlo Park, CA: Benjamin/Cummings; 1979.

Grove, M., Pearce, E., & Dunbar, R. I. (2012). Fission-fusion and the evolution of hominin social systems. *Journal of human evolution*, *62*(2), 191-200.

Grueter, C. C., Chapais, B., & Zinner, D. (2012). Evolution of multilevel social systems in nonhuman primates and humans. *International Journal of Primatology*, *33*(5), 1002-1037.

Hemelrijk, C. K., & Puga-Gonzalez, I. (2012). An individual-oriented model on the emergence of support in fights, its reciprocation and exchange. *PloS one*, *7*(5), e37271.

Hill, R. A., & Dunbar, R. I. (1998). An evaluation of the roles of predation rate and predation risk as selective pressures on primate grouping behaviour. *Behaviour*, *135*(4), 411-430.

Hill, K. R., Walker, R. S., Božičević, M., Eder, J., Headland, T., Hewlett, B., ... & Wood, B. (2011). Co-residence patterns in hunter-gatherer societies show unique human social structure. *science*, *331*(6022), 1286-1289.

Judge, P. G., Griffaton, N. S., & Fincke, A. M. (2006). Conflict management by hamadryas baboons (Papio hamadryas hamadryas) during crowding: A tension-reduction strategy. *American Journal of Primatology: Official Journal of the American Society of Primatologists*, *68*(10), 993-1006.

Kanngiesser, P., Sueur, C., Riedl, K., Grossmann, J., & Call, J. (2011). Grooming network cohesion and the role of individuals in a captive chimpanzee group. *American journal of primatology*, *73*(8), 758-767.

Kummer, H. (2017). *Primate societies: Group techniques of ecological adaptation*. Routledge. Hassan, S., & De Filippi, P. (2021). Decentralized Autonomous Organization. *Internet Policy Review*, *10*(2), 1-10.

Horowitz, I. L. (1962). Consensus, conflict and cooperation: a sociological inventory. *Social Forces*, *41*(2), 177-188.

Kappeler, P. M., & van Schaik, C. P. (2002). Evolution of primate social systems. *International journal of primatology*, *23*(4), 707-740.

Keynes, J. M. (1930). Treatise on money: Pure theory of money Vol. I.

King, A. J., Douglas, C. M., Huchard, E., Isaac, N. J., & Cowlishaw, G. (2008). Dominance and affiliation mediate despotism in a social primate. *Current Biology*, *18*(23), 1833-1838.

Kolber, A. J. (2018). Not-so-smart blockchain contracts and artificial responsibility. *Stan. Tech. L. Rev.*, *21*, 198.

Laskey, K. B., & Laskey, K. (2009). Service oriented architecture. *Wiley Interdisciplinary Reviews: Computational Statistics*, *1*(1), 101-105.

Leusse, P. D., & Brossard, D. (2009, June). Distributed systems security governance, a SOA based approach. In *IFIP International Conference on Trust Management* (pp. 302-305). Springer, Berlin, Heidelberg.

Liu, L., Zhou, S., Huang, H., & Zheng, Z. (2021). From technology to society: An overview of blockchain-based dao. *IEEE Open Journal of the Computer Society*.

Magee, J. C., & Galinsky, A. D. (2008). 8 social hierarchy: The self-reinforcing nature of power and status. *Academy of Management Annals*, *2*(1), 351-398. MakerDAO. Available online at: https://vote.makerdao.com/terms

Meeker, B. F. (1971). Decisions and exchange. *American Sociological Review*, 485-495.

Meier, J., & Schuppli, B. (2019). The DAO Hack and the Living Law of Blockchain. *Digitalisierung–Gesellschaft–Recht: Analysen und Perspektiven von Assistierenden des Rechtswissenschaftlichen Instituts der Universität Zürich*, 27-43.

Minn, K. T. (2019). Towards Enhanced Oversight of" Self-Governing" Decentralized Autonomous Organizations: Case Study of the DAO and Its Shortcomings. *NYU J. Intell. Prop. & Ent. L.*, *9*, 139.

Mitani, J. C., Watts, D. P., & Muller, M. N. (2002). Recent developments in the study of wild chimpanzee behavior. *Evolutionary Anthropology: Issues, News, and Reviews: Issues, News, and Reviews*, *11*(1), 9-25.

Morrison, R., Mazey, N. C., & Wingreen, S. C. (2020). The DAO controversy: the case for a new species of corporate governance? *Frontiers in Blockchain*, *3*, 25.

Mouzelis, N. P. (2016). *Back to sociological theory: The construction of social orders*. Springer.

Newman, M. E. (2006). Modularity and community structure in networks. *Proceedings of the national academy of sciences*, *103*(23), 8577-8582.

Ostrom, E. 2010. Beyond Markets and States: Polycentric Governance of Complex Economic Systems. American Economic Review 100:641–672.

Oren, O. (2018). ICO's, DAO's, and the SEC: A Partnership Solution. *Colum. Bus. L. Rev.*, 617.

Perrey, R., & Lycett, M. (2003, January). Service-oriented architecture. In *2003 Symposium on Applications and the Internet Workshops, 2003. Proceedings.* (pp. 116-119). IEEE.

Peter, T. (2009). Evolution of complex hierarchical societies. *Social Evolution & History*, *8*(2), 167-198.

Puga-Gonzalez, I., Hildenbrandt, H., & Hemelrijk, C. K. (2009). Emergent patterns of social affiliation in primates, a model. *PLoS Computational Biology*, *5*(12), e1000630.

Quill Corp. v. North Dakota, 504 U.S. 298 (1992).

Rochelandet, F., & Tai, S. H. (2016). Do privacy laws affect the location decisions of internet firms? Evidence for privacy havens. *European Journal of law and Economics*, *42*(2), 339-368.

Reyes, C. L. (2019). If Rockefeller were a coder. *Geo. Wash. L. Rev.*, *87*, 373.

Rodrigues, U. R. (2018). Law and the Blockchain. *Iowa L. Rev.*, *104*, 679.

Santos, F., & Kostakis, V. (2018). The DAO: a million dollar lesson in blockchain governance. *School of Business and Governance, Ragnar Nurkse Department of Innovation and Governance*.

Scheff, T. J. (1967). Toward a sociological model of consensus. *American Sociological Review*, 32-46.

Schneider, N., De Filippi, P., Frey, S., Tan, J. Z., & Zhang, A. X. (2021). Modular politics: Toward a governance layer for online communities. *Proceedings of the ACM on Human-Computer Interaction*, *5*(CSCW1), 1-26.

South Dakota v. Wayfair, Inc., 585 U.S. ___ (2018).

Star, S. L. (1993). Cooperation without consensus in scientific problem solving: Dynamics of closure in open systems. In *CSCW: Cooperation or conflict?* (pp. 93-106). Springer, London.

Sueur, C., Deneubourg, J. L., & Petit, O. (2012). From social network (centralized vs. decentralized) to collective decision-making (unshared vs. shared consensus). *PLoS one*, *7*(2), e32566.

Sulkowski, A. J. (2019). The tao of DAO: Hardcoding business ethics on blockchain. *Bus. & Fin. L. Rev.*, *3*, 146.

Sumpter, D. J., & Pratt, S. C. (2009). Quorum responses and consensus decision making. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1518), 743-753.

Sunstein, C. (1999). One rule at a time: Judicial Minimalism on the Supreme Court. Harvard University Press.

Teichmann, F. M. J., & Falker, M. C. (2020). Cryptocurrencies and financial crime: solutions from Liechtenstein. *Journal of Money Laundering Control*.

Valipour, M. H., AmirZafari, B., Maleki, K. N., & Daneshpour, N. (2009, August). A brief survey of software architecture concepts and service oriented architecture. In *2009 2nd IEEE International Conference on Computer Science and Information Technology* (pp. 34-38). IEEE.

Voelkl, B., & Kasper, C. (2009). Social structure of primate interaction networks facilitates the emergence of cooperation. *Biology letters*, *5*(4), 462-464.

Willhoite, F. H. (1976). Primates and political authority: A biobehavioral perspective. *American Political Science Review*, *70*(4), 1110-1126.

Wang, S., Ouyang, L., Yuan, Y., Ni, X., Han, X., & Wang, F. Y. (2019). Blockchain-enabled smart contracts: architecture, applications, and future trends. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, *49*(11), 2266-2277.

Washburn, S., and Moore, R. (1974). Ape into Man: A Study of Human Evolution. Boston: Little, Brown.

Werbach, K. 82018). Trust, but verify: Why the blockchain needs the law. *Berkeley Technology Law Journal*, *33*(2), 487-550.

Wright, A., & De Filippi, P. (2015). Decentralized blockchain technology and the rise of lex cryptographia. *Available at SSRN 2580664*.

Zwitter, A., & Hazenberg, J. (2020). Decentralized network governance: blockchain technology and the future of regulation. *Frontiers in Blockchain*, *3*, 12.