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Abstract

The concept of "Decentralized Autonomous Organization" has been popularized as part of the "Web 3.0" movement. This movement is characterized by digital infrastructures that are 'decentralized' in network architecture and permissionless to use. Decentralized autonomous organizations, referred to as DAOs, are a digital expression of the political will to self-organize. The granular entanglement of social and technical concepts makes it challenging to identify a historical precedent for DAOs. Yet, literature review and analysis reveals that this particular entanglement of information systems and self-organization is consistent with longstanding conceptual development and practice in the field of cybernetics. Drawing on Stafford Beer's Viable Systems Model, this piece bridges DAOs and cybernetics via two main principles of organization: viability and purpose. Viability is a property of a system such that it has sufficient adaptive capacity to thrive in the face of change; adaptive capacity is characterized according to Ross Ashby's concept of 'variety'. Purpose is the ability to define and collectively pursue a goal in the sense of feedback control systems. Building on the control theoretic concepts of observability, controllability, and reachability, we examine the 'governance surface' of an organization and the associated trade-offs between resilience and robustness that emerge in governance surface design. We propose that this trade-off can be addressed with a constitutional archetype whereby an organization's ability to update its code is constrained but not eliminated. A case study from a DAO known as '1Hive' is explored to demonstrate this archetype in action. We consider the limitations of the cybernetics perspective by emphasizing the subjectivity of the governance designer. Finally, we conclude with future research directions.

1 Introduction

The concept of 'decentralized autonomous organization' (DAO) has been popularized as part of the Web 3.0 movement, characterized by permissionless peerto-peer digital infrastructures, including public blockchains, cryptocurrencies, and smart contracts. The tools for the design, development, and use of these digital infrastructures are widely distributed via open source software. The popular appeal of decentralized autonomous organizations is political in nature: the desire of individuals to have influence over the structure and behavior of the organizations of which they are members, or 'self-organization'. These participatory organizations operate on digital infrastructure and are made up of members who are geographically distributed. While political power within the organization may be more or less distributed depending on the mechanisms in place, these organizations exhibit group-level (or 'collective') autonomy. Cybernetics is also concerned with interactions between group-level and individual level processes, as characterized by purpose-driven systems manifest through self-organization. It is, therefore, extremely relevant to align DAOs to precedents in cybernetics.

In Section 2, relevant literature on DAOs and cybernetics is explored. In Section 3, the cybernetic principle of viability is discussed in terms of adaptive capacity, as manifest in the governance surface and its relationship

to resilience. In Section 4, purpose and capacity to achieve that purpose are framed using core concepts from feedback control and then applied to expose the trade-offs inherent in governance surface design; the constitutional archetype is offered to address the trade-off. In Section 5, a case study of the 1Hive DAO is used to demonstrate the archetype in action. In Section 6, we review the limitations of the cybernetic perspective by exploring historical criticisms. Concluding remarks and further research directions are then offered in Section 7.

2 Literature Review

Open-source, peer-to-peer blockchains are digital systems that are technically and ideologically designed to facilitate self-determination through participatory ownership of coordination infrastructure [1]. Blockchains enable novel forms of social organization, including "decentralized autonomous organizations" (DAOs), that offer experimentation into distributed, digital self-governance. Blockchain networks are comprised of geographically distributed computers (or "nodes") [2]. The aim is to "decentralize" power structures to reduce the reliance on central points of trust. People can participate as operators of the organization and by placing their trust the software encoded rules of the system.

Decentralized autonomous organizations (or DAOs) are a manner of selforganising among multiple stakeholders towards a stated objective, via digital tools. The phrase "decentralized autonomous organization" was originally used in the field of cybernetics to describe a complex, multi-agent "intelligent" home system that could self-organize [3]. The term "DAO" first appeared in relation to blockchain technology in an article by Ethereum's co-founder Vitalik Buterin in Bitcoin Magazine in 2013 [4]. "What is a corporation?" asks Buterin, "it's nothing more than people and contracts all the way down." [4]. This conception of DAOs perpetuates the "cypherpunk" ideology of anarchic self-organization. Here, DAOs are conceptualized as political organizational vehicles, within the context of decentralized technologies as scalable coordination infrastructures for self-governance and political autonomy [5]. Scholars of blockchain networks define a DAO as "a blockchain-based system that enables people to coordinate and govern themselves mediated by a set of self-executing rules deployed on a public blockchain, and whose governance is decentralized (i.e. independent from central control)". DAOs have proliferated as a method of community organization in number, goals, and scale [6]. There is a need for conceptual frameworks and tools as to how to go about decentralized governance design and analysis that consider both the social and technical aspects of these organizations.

Buterin was far from the first to pose the question "what is a corporation?" or to observe the recursive nature of such organizations. A deep and comparatively novel investigation occurs in the field of Organizational (or Management) Cybernetics pioneered by Stafford Beer, with the development of the Viable Systems Model, [7–9]. Taking cues from biology, a viable system is one which has sufficient adaptive capacity to survive in a changing, potentially adversarial, environment.

Cybernetics is not a scientific field so much as it is a research aesthetic for complex systems drawing on biology, engineering and mathematics [10]. In the 1940s and 1950s, computer and information systems were just emerging and the pioneers of these fields necessarily worked outside of disciplinary boundaries. Many research areas grew out of cybernetics and became disciplines of their own, such as artificial intelligence and control theory [11]. Management Cybernetics fits into the modern field of Operations Research [12]. In this work, cybernetics is defined as transdisciplinary research focused on self-organizing systems within an aesthetic blending mathematically rigorous engineering methods and biomimicry.

The term cybernetics stems from the Ancient Greek word "kubernetes" meaning "steersmen" or "governor" [13]. The cybernetics literature addresses purpose-driven regulatory processes, canonically associated with Norbert Wiener's 1948 book Cybernetics: Communication and Control in the Animal and the Machine [14]. Beer's work on viable systems builds on Weiner's work, as well as von Bertalanffy and Ashby's work on General Systems Theory [15, 16]. A focus is placed on self-organization through codified rules enabling coordination amongst otherwise independent actors, by building on the question "what is organization?" posed by Ashby in 1947 [17].

Gabriel Shapiro, a prominent legal engineer in the DAO space takes a narrow definition of DAOs, emphasizing that autonomy and decentralization are spectra, and the term DAO should be reserved for those organizations pushing the boundaries in both dimensions [18]. Stafford Beer speaks to both decentralization and autonomy in his work on the Viable Systems Model. According to Swann, Beer's thinking on decentralization is nuanced.

> *Even as early as in the 1967 second edition of Cybernetics and Management, he [Beer] wrote of the hard distinction between autonomy and centralised control that 'the [cybernetic] model shows how na¨ıve that dichotomy is as an organizational description. No viable organism is either centralised or decentralized. It is both things at once, in different dimensions.'(Beer, 1967: 75–6)[sic]*

The principles of self-organization conveyed by Beer in the Viable System Model are complimentary to the prefigurative politics of crypto anarchism from which blockchain systems stem [19]. Prefigurative politics is a radical political philosophy where activism includes embodying the social relations, decision-making, and culture to create in opposition to existing power structures [20]. The vernacular of 'viable systems' as a mode of organization provides a way to express the elements of non-hierarchical organization, creating space for criticism of existing power relations while still pursuing a clear purpose. Beer viewed the autonomy of the organization and the relative autonomy of its members to be "computable functions of viability" [21]. It is a stretch to consider these relationships "computable" but relevant that the concepts of autonomy and decentralization are matters of concern in the cybernetics literature. The observation that autonomy, decentralization and viability are deeply related concepts motivates us to exposit the Viable System Model in the section that follows.

3 Viable Organizations

Without realizing it, decentralized technology communities are already practicing cybernetics [22]. By becoming aware of the cybernetics literature, it is possible to benefit from the existing conceptual frameworks to develop and act within viable organizations capable of self-organization.

3.1 Brief Review of the Viable System Model

The Viable System Model (VSM) is a representation of the organizing structure of an autonomous system which is capable of adapting to changes in its environment, in line with its purpose. Autonomy in this context means that the system is self-governing. The VSM is comprised of five systems which co-regulate the organization at different scales in time, and different spatial scales encompassing the various critical functions of the organization.

• System 1: Primary Functions, or day-to-day activities conducted by constituent parts of the organization interacting with its environment.

• System 2: Co-ordinating Functions, which align the day-to-day activities of System 1 with each other, its collective purpose.

• System 3: Rules and other structures (such as software), which support the activities in System 1 and System 2.

• System 4: Strategic Functions that look both outward and inward, to consider how internal systems might adapt to external changes.

• System 5: Governance Functions that align the overall organization, defining or refining the goal(s), and resolve resource conflicts between the other systems.

Each System of the VSM from 1 to 5 operates on a progressively slower natural timescale. Systems 1 and 2 rely on consistency from System 3, but Systems 4 and 5 must have the capacity to adjust System 3. Beer compares this model to human decision-making by suggesting that Systems 1-3 are like the autonomic nervous system, System 4 is like cognition and conversation, and System 5 can be related to conscious reasoning and decision-making [9].

For the purposes of analyzing DAOs, it is important to move past the anthropomorphism to focus on the viability of an organization, across the different systems and as a whole. When self-organization is advanced through technological infrastructure, the intent is to produce the bio-mimetic attribute of "autopoiesis." An autopoietic system is self-reproducing, and it is able to maintain and renew itself by regulating composition and conserving its boundaries [23] [24].

3.2 A VSM perspective for DAOs

Systems 1 and 2, Primary Functions and Co-ordinating Functions, tend to be embodied in a mixture of human activities and software processes. System 3 is entirely software-based; strict rules are codified in smart contracts–software whose correct execution is enforced by a blockchain network. Implementation details rule enforcement for non-blockchain software components vary by organization.

Let us consider the Bitcoin network to be a DAO as it satisfies the strict definition put forth by Shapiro [18]. The Bitcoin network ascribes to the doctrine of immutability, ostensibly meaning that the rules embodied in the software making up System 3 cannot be changed. This is true of the Bitcoin network's defining properties such as its fixed supply but this property is actually an emergent property derived from locally enforced rules [25]. The Bitcoin software can and has changed over the network's lifetime but those code changes were to preserve, rather than change the defining properties of the Bitcoin network. Adaptations in its code come through the Bitcoin Improvement Proposal (BIP) process which can be interpreted as a decentralized manifestation of System 4 [26].

While System 4 is capable of identifying changes required in Systems 3 to remain viable, those changes must be aligned with the whole organization via the governance function provided by System 5. For DAOs, the most common form that System 5 takes is organization-wide voting mechanism [27]. For the Bitcoin network the protocol determines whether changes are canonical based on the decisions of individual node operators. In both cases there are social processes involved but they are not binding. Individual actors make their own choices and the resulting 'distributed trust' provides a stable economic substrate without an extrinsic source of legitimacy. This argument amounts to an appeal to code as a social contract, as a substitute for government [28].

The potential for amendment of the software by humans via collective decision making processes can be seen as an emerging regulatory process for cyberspace, dubbed 'Code as Law' [29]. The processes governing the code bases of peer-to-peer networks can be interpreted as constitution-like; human oversight of code legitimizes the practice of allowing algorithms to govern human activities. The VSM supports this perspective if we place the algorithms in the role of Systems 2 and 3, and distributed (but not necessarily decentralized) political processes in the role of Systems 4 and 5.

3.3 Adaptive Capacity and Resilience

Focusing on Systems 4 and 5, strategic functions and governance functions respectively, we ask "how does a DAO identify threats and adapt?" In order to proceed we must also address "what is governance?" According to Foucault, the "art of governing" can be described as the "techniques and procedures for directing human behaviour" in a liberal democratic society, which is predicated on individual and collective participation; Foucault defines governance as the process of "structuring the possible field of action" for others, to determine what actions are possible within a system [30].

In the language of the Viable System Model, governance is structuring the organization by applying the strategic and governance functions of Systems 4 and 5 to modify the rules embodied in System 3, which in turn regulates the primary and co-ordinating functions of Systems 1 and 2. In decentralized systems, actors are subject to the field of action, as well as responsible for shaping and iterating on that field [31].

An organization is viable in so far as it is able to survive a wide range of potential unknown changes to its environment (including emergence of adversaries). In the cybernetics literature, the range of behaviors a system is capable of exhibiting is called "variety" [32]. The concept of "requisite variety" means that governance in a system has a wide enough range of behaviors to respond to a changing environment to survive and continue to fulfill its purpose.

An organization which has "requisite variety" has sufficient adaptive capacity to adapt to new threats. This adaptive capacity provides resilience in the sense that an organization which has been adversely affected by conditions outside its control can 'bounce back' by adapting itself to changes in environment and continue to fulfill its purpose [33]. The set of actions available to an organization which allow it to adapt itself is called the governance surface.

3.4 The Governance Surface

Since the protocols (or shared rules) underpinning DAOs are embodied in software it makes sense to examine the means by, and extent to which, that software can be changed by the humans subject to those rules. The governance surface is defined as the set of parameters through which an organization's code may be be modified [34]. To provide intuition for the governance surface, Figure 1 shows the various feedback loops within a DAO, and has been edited to denote the actions which exercise the governance surface.

****[Image needing pulled - pg. 7 in PDF]**

Figure 1: Figure 5 from [31] with the Governance Surface Identified

In a DAO, it is common for the mechanisms for modifying the organizations code to be tightly access controlled. The process for determining what if any changes should be made can be ascribed to Systems 4 and 5, while the rules for amending the rules belong to System 3. Use of the governance surface may be interpreted as legislative process where any changes to the algorithms is tantamount to policy-making [35].

Therefore, the use of the governance surface cannot be evaluated on purely objective terms. When there is a well defined goal for the organization, it is only possible to evaluate in hindsight whether the decision furthered that objective. The formal study of iterative decision-making based on observed outcomes is called feedback control [36]. The term 'governance surface' is a variation of 'control surface', which refers to the variables that can be directly affected by decision making software in a feedback control system. In Section 4, core concepts

from feedback control are explored as a means of understanding the manner in which organizations exercise their governance surfaces to pursue their purposes.

4 Purpose Driven Organizations

Framing the governance surface as a control surface to be exercised pursuant to an organization's purpose invites the question: "who fills the role of controller of an organization?" For DAOs, the answer to this question must be those that are considered members of the organization [37]. A canonical control system is defined in terms of a logically centralized decision making agent, 'the controller,' which when considered in political terms evokes the feeling that this control is backed by coercion. However, the cybernetic imagining of control is more organic, connoting regulation or balancing [38].

> *The cybernetic concept of control (or regulation) [...] maintains that regulation is a universal and ubiquitous phenomenon. While there are no systems (and no societies) without regulation, regulation rarely takes the form of coercion or linear causality. This is because complex systems are 'highly differentiated', which prevents them from being easily steered from a control centre. [39]*

The notion of 'highly differentiated' rings true for systems which are politically decentralized and is thus more in keeping with values of DAOs. Furthermore, there are mathematical rigorous treatments of multi-agent control systems informed by observations of self-organizing systems in nature [40].

4.1 Brief Review of Feedback Control

Feedback control systems are mathematical representations of the processes through which systems (such as organizations) pursue their goals. A controller is a process, which conditioned on some beliefs, makes a decision pursuant to a goal. Decisions are limited to making changes to variables which are part of the control surface. Since the decision is executed through a mechanism called an actuator, the variables the actuator can manipulate make up the control surface. The actuator is also an interface which transforms the decision into a concrete action, and eventually an outcome. Outcomes are observed by sensors which are interfaces which transform outcomes into measurements. Those measurements are used to update beliefs on which decisions can be conditions. The recursive (or circular) nature of this process is of critical importance, hence the term 'feedback control'. In section 3, we defined the governance surface as the control surface of an organization with specific attention to the code that defines the rules of a decentralized organization. Following with this analogy, it is prudent to explore the attributes of feedback control systems which are successful in pursuing their goals.

4.2 Observability and Controllability

In the field of control systems engineering the concepts used to determine whether it is possible to create a control system capable of achieving a certain goal are controllability and observability. Observability relates to

the extent

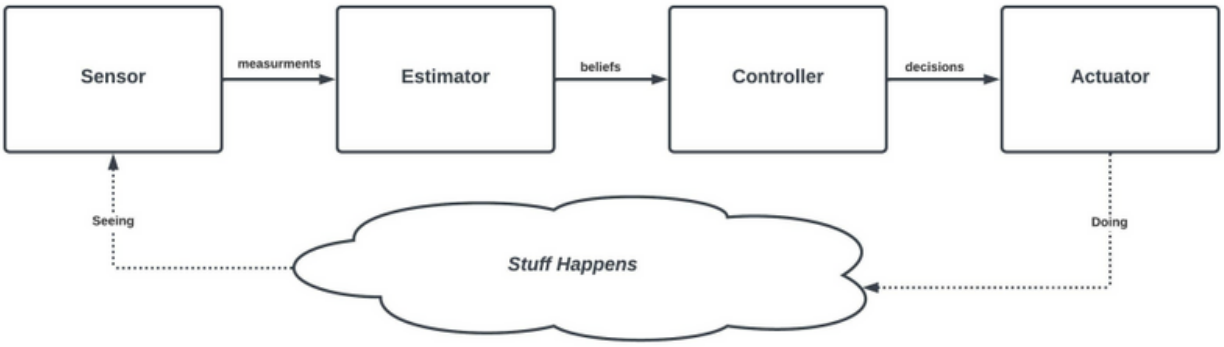


Figure 2: An Elementary Feedback Control System

to which the sensors are sufficient to measure current status of the system, whilst controllability relates to the extent to which the actuators are sufficient to change the system to align its behavior with its goal. While these concepts are introduced in simple terms they have mathematically rigorous formalisms used by control systems engineers to determine what sensors and actuators are sufficient to enable their systems to reliably achieve their goals [41, 42]. Since these are abstract mathematical concepts pertaining to whether it is possible to drive a system towards its goal through a feedback process, they apply as much of decentralized decision-making systems, such as DAOs, as they do for control systems engineering.

4.3 Reachability and Robustness

Observability and controllability not only determine whether it is possible for a control system to achieve its goal but also all other states that system can achieve. The term reachability is used for the condition that a certain state is achievable. Reachability is closely related to concept of variety (introduced in Section 3) which referred to all the behaviors a system can exhibit. Another way of framing 'requisite variety' is that our system's control surface (or an organization's governance surface) is large enough to ensure that the goal is reachable.

However, increasing the control surface (or governance surface) comes at a cost. The reachable set may grow to include undesirable or even extremely problematic states. It is prudent to limit risk by constraining the reachable space by intentionally limiting the governance surface. This practice is used in safety-critical control systems such as medical robotics to limit the risks of harm [43].

A system with a small set of reachable states can be described is robust to controller errors. In this work, robustness refers to the ability of a system to remain unchained in the face of threats or disturbances [33]. Robustness is different from resilience but also contributes to viability, as viability only requires that the system persists in the face of uncertainty. For Bitcoin, the doctrine of immutability as discussed in Section 3 is an appeal to viability through robustness. However, it was also noted that Bitcoin as some limited adaptive

capacity through its BIP process and miner's individual upgrade decisions. In Bitcoin's case those individual upgrades are an example of a decentralized governance surface.

4.4 A Fundamental Trade-off in Governance Design

No matter how we approach the design of a governance surface, there is an inescapable trade-off: a larger governance surface provides the organization with greater resilience but a smaller governance surface provides the organization with greater robustness. Fortunately, there is a middle ground. The governance surface should be large enough to ensure the organization's goals remain reachable, even in the presence of unexpected changes in its environment. Increasing the governance beyond this minimum level required to preserve purpose and viability is inadvisable. This approach is in line with doctrine of governance minimization [44], subject to the constraint that "requisite variety" be preserved.

Over the course of Section 3 and Section 4 a wide range of concepts from cybernetics and control theory were reviewed to arrive at the conclusion that there is a fundamental trade-off in deciding the extent to which a DAO should be able to adapt its code. As shown in Table 1, approaches to code governance have been organized into three archetypes: Immutable, Constitutional, and Mutable. For contrast, immutable code cannot be changed and mutable code can be changed at will. DAOs remain viable by adopting the constitutional archetype, which allows their code to be modified but imposes significant constraints on the nature and means of those modifications. In Section 5 that follows, we explore how 1Hive embodies the constitutional archetype for a viable system.

5 Case Study: 1Hive

The organization 1Hive originated in 2017 and spent its early years as an independent smart contract design and development team [45]. 1Hive was funded primarily by grants, and its smart contract design and development work was focused on DAO infrastructure [46]. 1Hive has evolved significantly over a number of years, including the formalization of its evolutionary mechanism and publishing an explicit statement of purpose in a community covenant.

> *1Hive is a community of activists seeking to build a future that is more free, fair, open, and humane.*
> *1Hive is also an economic proto*-col, similar to Bitcoin or Ethereum, where a digital currency, Honey, is issued and distributed programmatically. [47]

Table 1: Archetypes for Governance of Organizational Code

Archetype	**Immutable**	**Constitutional**	**Mutable**
Governance Surface	None	Small	Large

Variety	Low	Medium	High
Adaptive Capacity	None	Constrained	Unconstrained
Resilience	Low	High	High
Robustness	High	High	Low

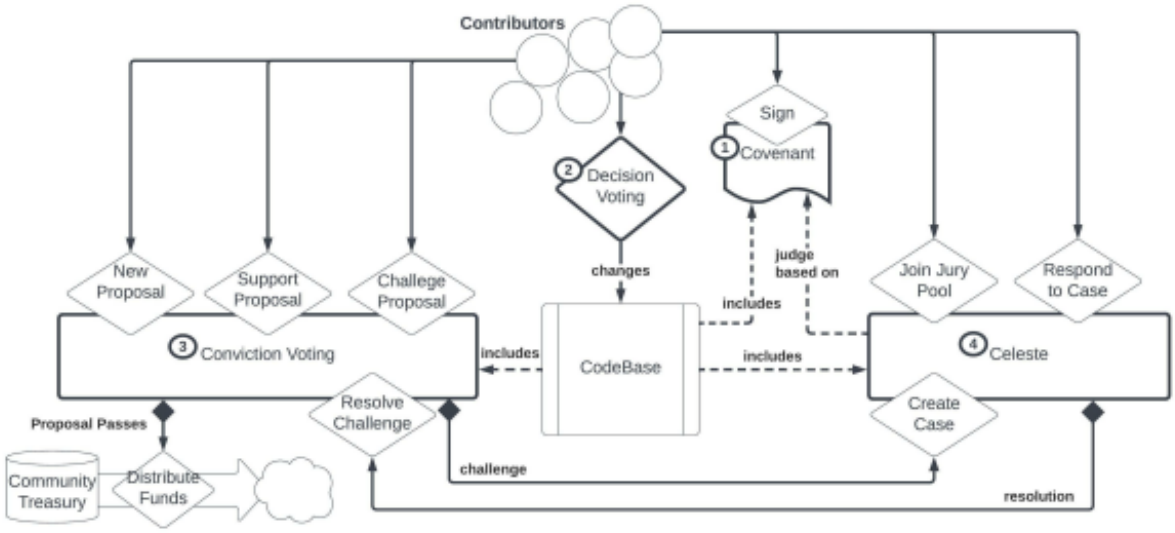


Figure 3: 1Hive is governed through the four pillars.

Over its lifetime, 1Hive has taken a wide range of actions pursuant to this goal including but not limited to the design, development, and use of decentralized applications for finance (such as HoneySwap and Agave) and governance (such Conviction Voting and Celeste) [48]. This case study explores the governance surface of 1Hive by outlining the process through which 1Hive designed, developed and deployed a new monetary policy for their currency, 'Honey'.

5.1 Organizational Architecture

In Section 4 archetypes were presented for software-based organizations. 1Hive fits the constitutional archetype because its software can be used to upgrade its software but that capacity is constrained within the code. This is embodied by the Gardens framework which 1Hive designed, developed, and uses for its own governance. The Gardens framework is based on four pillars: (1) Community Covenant, (2) Decision Voting, (3) Conviction Voting, and (4) a decentralized dispute resolution mechanism or "court" known as Celeste.

The Covenant is the prose portion of 1Hive's constitution which defines the identity of 1Hive in terms of its purpose and values. The Covenant has been referred to as a social contract [49] which echos the argument from

Beltramini paraphrased in Section 3. In order to interact with 1Hive's code, prospective participants must sign the Covenant. While the covenant is prose, it is also explicitly part of 1Hive's codebase.

The governance surface of 1Hive is the set of parameters that can be changed by Decision Voting, "a special form of voting (requiring community consensus around discrete, binary choice decisions). It is used to update governance parameters (metagovernance), as well as anything that fundamentally changes or transforms the DAO's DNA" [50].

Conviction Voting is the portion of 1Hive's code responsible for allocating community funds to project-based proposals. Proposal are requests for funds from the community treasury, which are discussed on public forums. Proposals pass when they have sufficient support over sufficient time. Majority consensus is not required to pass a proposal, but any member may challenge a proposal via a dispute mechanism called Celeste if they feel it is in violation of the Covenant.

Celeste is a smart contract based court system. "Celeste serves as the interface for a DAO's shared values, beliefs, and hopes. It provides a way to resolve subjective disputes, and to peacefully enforce the covenant." [48]. Anyone can join the jury pool, and jury members are selected at random when disputes, such as proposal challenges, arise.

Collectively the four pillars make up the VSM System 3. The covenant and Celeste are noteworthy because they make space for System 4 and 5 activities by 1Hive members in interpreting and potentially refining the organizations purpose and values through decision voting. Conviction Voting creates support for Systems 1 and 2 through continuous participatory budgeting. In the following section we outline how 1Hive leverages this infrastructure to adapt itself pursuant to its goal.

5.2 1Hive's Algorithmic Monetary Policy

It was observed by community members that its monetary policy was failing to achieve the community's goals. In order to enact a change, all five systems in VSM were exercised. The observation of the issue and the public discussion constitutes a decentralized System 4 activity.

> *Finding the right balance is critically important. Currently honey holders can use governance to adjust the issuance policy (status quo), but discretionary governance over such a critical and central policy is not ideal and doesn't really align with the governance minimization philosophy that makes 1hive unique. [51].*

This discussion thread had over 90 distinct posts and gave rise to multiple funded work proposals for research, design, development and testing of an issuance policy based on feedback control. Within 1Hive, working groups are called swarms. Rather than having every individual member of 1Hive making small funding requests to cover their own work, most proposals submitted to conviction voting are at the swarm level. For

example, in response for the need to do control theoretic modeling and analysis of the proposed issuance policy a new working group formed and worked alongside the smart contract developers [52].

In order to complete the work on the issuance policy multiple working groups were engaged. The main feedback loop of 1Hive's operations (the inner loop in Figure 4) mimics the elementary feedback control system from Section 4: contributors serve as sensors, swarms as estimators, passing proposals with conviction voting is the controller and the labor which creates the artifacts are the actuators. In the process of developing the new issuance policy this inner feedback loop was traversed multiple times in parallel (multiple working groups) and in series (development follows design).

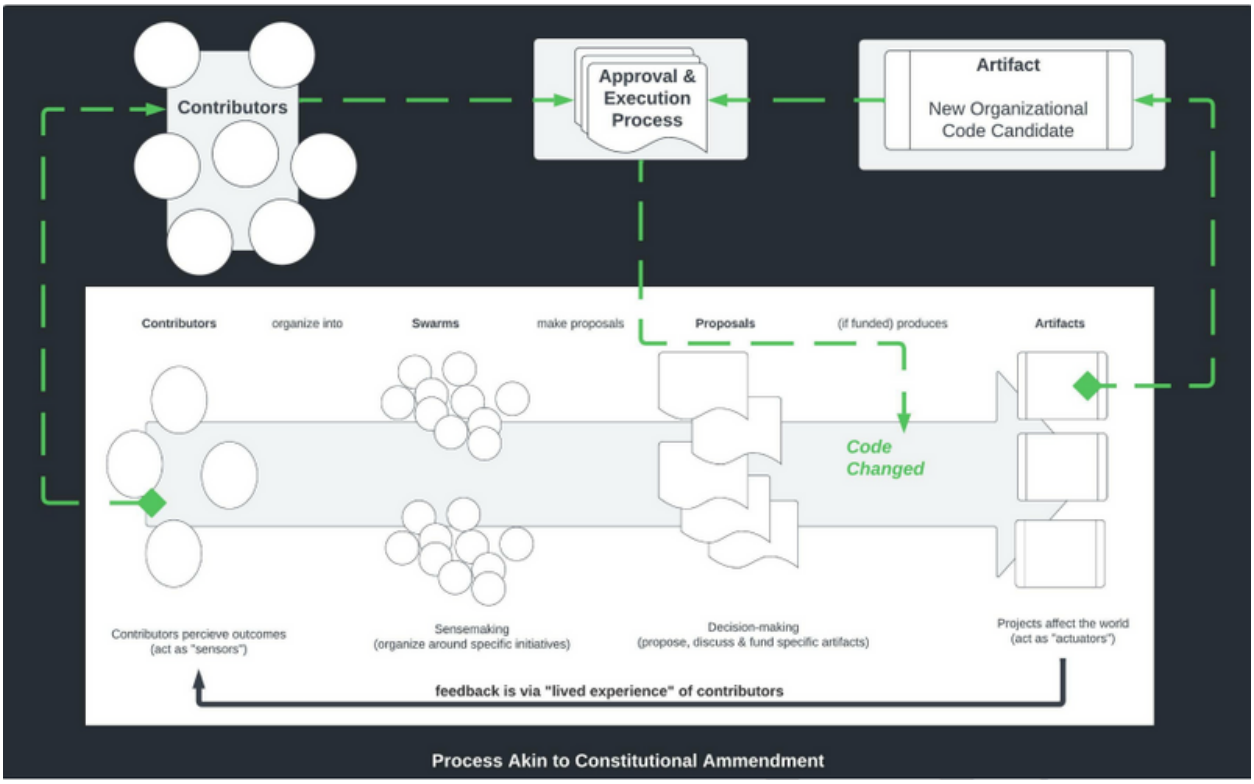


Figure 4: Double Feedback Loop Through Which 1Hive adapts itself

After nearly six months of iterative work, the issuance policy was designed, tested and implemented but not yet deployed. To be deployed it needed to pass through decision voting. The code was developed in public git repositories and meetings were held in 'Discord' chat app. The final design was posted in the forums with a discussion of the parameters chosen, including a battery of stochastic simulations showing key performance metrics for Honey's monetary policy under a range of scenarios [53]. Although the work was technical, data visualizations helped the community understand the potential impacts of their parameter choices.

When the 1Hive community was satisfied, the code change was passed via decision voting. This approval and execution process is required for amending 1Hive's constitution and as such it is quite burdensome. For

practical reasons the approval and deployment of the new issuance policy was bundled with the approval and deployment of Celeste. While such changes are rare, 1Hive does not consider any code change final. As a stategic function (VSM System 4), contributors monitor these smart contracts and discuss whether possible future changes will be required to stay in alignment with 1Hive's purpose.

6 The Limitations of a Cybernetic Approach

The cybernetics lens is an engineering heavy perspective for exploring decentralized governance. It needs to be contrasted with social science perspectives such as law, economics, and sociology [54] [55]. In this section, we explore the limitations of cybernetics as articulated by social scientists and then examine how these criticisms apply in the context of DAOs.

6.1 Second Order Cybernetics

First order cybernetics is the application of control theory to steer social systems, but "Control is not an idea that should be used everywhere, and we need to know when we should not use it" [56]. Second-order cybernetics applies the principles of cybernetics to cybernetics itself to include evaluating the role of the designer as a part of the designed system [24].

Anthropologist Margaret Mead expressed concern with the consequences of organizing society according to cybernetic means, insofar as designers do not assume responsibility for how these systems affect society [57]. Mead calls on cyberneticians to attend to their contributions to ongoing transformations of society and to be accountable for those effects by incorporating self-reflection as a "second-order" feedback loop [58].

> *"The systems-approach "of the first generation" is inadequate for dealing with wicked problems. Approaches of the "second generation" should be based on a model of planning as an argumentative process in the course of which an image of the problem and of the solution emerges gradually among the participants, as a product of incessant judgement, subjected to critical argument" [59].*

At the core of the criticism of cybernetics is that it imagines that the controller is objective in relation to the system being governed. The breakthrough of second-order cybernetics is to acknowledge and make explicit the subjectivity in creating and maintaining these models [60].

6.2 DAOs and the Pitfalls of Cybernetics

Emerging narratives in the design of decentralized governance systems such as "governance minimization" and "governance automation" risk recreating the pitfalls of cybernetics. The extreme of governance minimization perpetuates the doctrine of immutability, that code should be impossible to change. This ultimately places the social system in service of the technical system, as there is no means through which humans can steer the system [61]. The doctrine of immutability is appealing from a crypto anarchic perspective for exactly the

reason it is problematic, it eliminates the second order feedback loop as it hard codes decisions made by the system designer, making the subjectivity of design choices opaque.

Automation is the design and implementation of algorithms serving as estimators and controllers as defined in Section 4. Automation should not be conflated with autonomy, as automation of a governance process may reduce the actions available to DAO members, especially if it is paired with the doctrine of immutability. In practice, governance through code enshrines subjective assumptions and goals into a system. Asserting as objective, the assumptions which form the basis for algorithms has been called "ground truthing" [62]. When these assumptions and goals are treated as objective or optimal then community members lose the opportunity to steer. Second order thinking requires that subjective goals and assumptions should be subject to revision by DAO members.

6.3 Applying Second Order Cybernetics to DAOs

At the heart of second order thinking is acknowledgment of one's own biases. Within the social sciences, reflexivity is the process of explicit, self-aware reflection and analysis of one's own role and biases [63]. Second order cybernetics requires that a DAO exhibit reflexivity not just at the individual level but also at the organizational level. In VSM this occurs when Systems 4 and 5 are leveraged to manifest changes to System 3, as demonstrated in the 1Hive case study.

Second order feedback has been referred to as "the control of control" and "the cybernetics of observing systems" [60]. It is a common research practice in ethnography, which Mead may have ported from anthropology to engineering. Similarly, Waddington, Ackoff, Beer and others "insist that the biggest gains in practical situations are likely to arise from seriously questioning the most obvious and certain of the 'facts'" [64].

Revisiting the concept of observability introduced in Section 4, governance includes observation and measurement in which "the role of the observer is appreciated and acknowledged rather than disguised", as has become common in digital infrastructure western science [56]. A shift to decentralized governance requires self-awareness by the designers, governors and participants of DAOs. Making assumptions and goals of these organizations explicit creates awareness of the trade-offs occurring in governance decisions and accountability for the outcomes those decisions produce.

7 Conclusion

This piece has explored how fundamental principles from cybernetics and control theory apply to decentralized governance. The Viable System Model was used to highlight the importance of viability to DAOs and to define the governance surface. We then leveraged this understanding of the governance surface to explore how DAOs pursue their purposes. By examining the trade-off between resilience and robustness, we found that constraining but not eliminating governance is key to viability. We labeled this approach to decentralized

governance of organizational code the constitutional archetype. We proceeded to demonstrate these concepts with the 1Hive DAO case study by delineating what is automated from what is governed through participatory protocols. We then reviewed the core criticisms of cybernetics and applied those criticisms to emerging DAO narratives in order to argue that reflexivity is required for viable DAOs.

This research contributes to the rapidly evolving and influential field of governance design, practice, and analysis in communities utilizing decentralized technologies. There is further research scope to compare and contrast other disciplinary paradigms for the design, development, operations, and governance of participatory institutions, as well as to explore how well these paradigms align with the observed behaviors. DAOs produce a wealth of public event data and in many cases public code and documentation. The cybernetics perspective may be further explored using a combination quantitative and qualitative methods.

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