THE STATE OF BLOCKCHAIN GOVERNANCE

Governance by and of blockchains

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1 Introduction: What is governance?

Organizational governance refers to the means that organizations deploy to influence organization members and other stakeholders to contribute to organizational goals and purposes and the means by which the goals and purposes are determined.[1]

Aguilera and Jackson[2] view corporate governance as encompassing the rights and responsibilities of stakeholders towards a firm, which compete for resources in an institutional actor-centered view of the firm. Turnbull[3] provides a broad definition in order to account for the plurality of institutional settings for organizing productive endeavors in society, beyond the notion of the traditional firm. He points towards all influencing factors of institutional processes, which includes nominating the controlling or regulating parties engaged in the process of organizing production and distribution of goods and services.

Organizational governance is heavily influenced by national governance, providing the constitutional and legal framework in which firms and markets operate to resolve certain market imperfections.

Overall, governance is concerned with considerations for total welfare maximization as well as balancing the interests of a wide set of stakeholders with various needs, values and political viewpoints. Stakeholders are identified through the actual or potential harms and benefits that they experience or anticipate experiencing as a result of the organization's actions or inactions (as opposed to "strategic" stakeholders as defined by Freeman – "without which a firm would cease to exist"). Most probably, there cannot be one optimal form of governance, as stakeholders have diverse interests and values and there exists a large trade-off space in policy decisions.[4] Thus, different communities need to maintain distinct visions, objective functions as well as governance systems that attract certain members, enable them to provide input as well as exit if there is no longer a fit between the collective and the individual.

In order to build governance systems with and for blockchains it is crucial to ask what they are. Are blockchains institutional technology to serve the private interests of their initiators and community? Are blockchains a public good? Digital commodities? If the "community" owns the platform/blockchain, are there stakeholders who are affected but not properly represented? Thus, in the next sections, blockchains are compared with existing institutions as well as organizational forms, while it will be argued that they extend the trend that open-source communities started in creating distributed innovation systems, that push the firm out of the center of prominence in coordinating value creation.

2 Public Blockchains are institutional & governance technology

Institutions are representing rules and norms guiding and constraining interaction of individuals, organizations, and markets.[5] Institutions take the form of both informal constraints (culture, customs, and traditions) and formal rules (constitutions, laws and articles of association for companies). Until the invention of Bitcoin, the economic institutions of capitalism were comprised of firms, markets, commons, clubs, relational contracts and governments (see e.g. Hayek, Williamson[6], De Davidson et. al[7] and Ostrom[8]). De Filippi, Davidson and Potts[9] posit for the first time that blockchains are institutional technology for groups of people to coordinate their economic activity.

Blockchains as distributed ledgers are basically recording the state of an economy, and alterations in the ledger record changes in the economy in consequence of economic actions and transactions. A highly-trusted ledger creates the basis for a low transaction cost economy, for economic efficiency as well as prosperity.[10] Klein[11] shows how trust is necessary to facilitate trade, however establishing that trust can be expensive, often involving large, visible and irreversible investments.

In case of third-party enforcement through platforms or nation states, a monopoly on coercive powers is required[12], implying not to abuse that power (a social contract). As a result, vast rents are captured by centralized monopolies of trust (see evaluative infrastructures, platforms such as Uber, etc.). Firms have been able to scale larger using technology to become central planners within markets or creating markets on their centralized infrastructure. The detrimental impact of monopolies on societal wealth has been widely recognized by both theory and practice (see deadweight losses; antitrust laws).

The term trustless, which is frequently mentioned in relation to blockchains, refers to not needing to trust any individual person or firm, but the system as a whole (similar to trusting that a legal contract is enforceable at court). Trust is created to a large extent by the system being open-source (anyone can verify it), decentralized (many actors are keeping each other in check), using cryptographic proofs (mathematical assurances) as well as economic/game-theoretic assurances (e.g. the cost to acquire 51% of bitcoins hashrate that allows to validate transactions unilaterally). Crypto-economic incentives are special insofar, that the actions that are incentivized (e.g. mining/ performing some computation) can be cryptographically verified at minimal to no cost (versus having to hire an audit firm or in a technical sense re-doing the whole computation in order to check it's correctness).

New institutional economics is concerned with why certain transactions occur in firms/hierarchies as opposed to markets. It has been argued that transaction costs in dealing with uncertainty, asset specificity (sunk costs due to assets that are only relevant in a specific business relationship), and frequency of deals, certain transactions can be conducted more efficiently in hierarchies.[13]
The boundaries of firms are limited by decreasing returns to scale by employing more managers, (inefficiencies of centralized control), and end where monitoring costs exceed market transaction costs.[14]

From an institutional perspective, blockchains can be viewed as a new coordination technology competing with firms, markets and national economies as institutional alternatives organizing the economic actions of groups of people.

Catalini and Gans[15] argue that blockchains are lowering transaction costs through costless verification and without the need for costly intermediation, which they suggest will improve the efficiency and scope of markets, moving them closer to a direct peer-to-peer ideal. What is more, building networks is more efficient, based on token issuance to early adopters, which in turn have the potential for value appreciation, incentivizing them to bootstrap network effects.

Williamson (1979) pointed towards hierarchical organization (in firms) to control opportunism (principal agent dilemma, moral hazard) in the presence of bounded rationality and asset specificity, by internalizing the (transaction) costs of opportunism (e.g. a contractor providing low quality service in a not ex-ante specified or unobservable dimension). Blockchains can minimize opportunism by combining public transparency with cryptographic enforcement and execution through smart contracts and their agents.

A smart contract is "a mechanism involving digital assets and two or more parties, where some or all of the parties put assets in and assets are automatically redistributed among those parties according to a formula based on certain data that is not known at the time the contract is initiated."
(Vitalik Buterin)[16]

In cases where blockchains can mitigate opportunism through crypto-economic incentives at lower transaction cost they will be more efficient (transaction-cost minimizing) institutions for coordinating economic action compared to organizational hierarchies and relational contracts. However, by far not all activities are reliably traceable and automatically verifiable on public blockchains (especially human labor, where some subjectivity in quality is involved).

A counterargument is that while firms are made of incomplete contracts blockchain-based smart contracts and DAOs represent complete contracts.[17] Blockchains and smart-contracts will however hardly enable complete contracts in

all circumstances, which leads to a need for active stakeholder governance (residual control) and dispute resolution - see Kleros or Aragon for "crypto-native" solutions & Mattereum for an attempted solution to integrate with traditional jurisdictions and international arbitration.

As will be laid out later in this paper through a couple of cases, there are various blockchain-based decentralized organizations (DOs) that depend on their stakeholders active input and judgement and show similarities to firms constituted by incomplete contracts, while the transparency, global scale and secure, open access of public blockchains is utilized.

This highlights the distinction between blockchains, firms, relational contracts and markets. A firm can be viewed as a nexus of (incomplete) contracts. If there were no transaction costs, all contracts could be complete, and all economic activity would efficiently be conducted through market transactions. Incomplete contracts typically exhibit transaction costs due to: 1) uncertainty/unforeseen contingencies, as information problems; 2) the costs of writing contracts; 3) the costs of enforcing contracts.[18] [19] Blockchains could enable more complete contracts lowering transaction costs on one or more of the three factors.

For example, smart contract-based transactions could experience lower inefficiencies due to information asymmetries (due to increased transparency, publicly visible to anyone or through privacy preserving zero-knowledge proofs that only show relevant metrics or statements), adverse selection (better information on the quality of a potential partner, based on reputation systems or transaction history prior to a transaction) as well as moral hazard (following a transaction, due to problems observing the agent, mitigated by blockchain on-chain records or game-theoretic mechanisms) can be mitigated.

Smart contracts could also be effective to easily write agreements with large numbers of low-probability state contingencies in order to cover as many edge-cases as possible to bring contracts close to a complete ideal (available in modular and composable fashion in open-source libraries, lowering the costs of writing contracts). Machine readable contracts can be then automatically enforced based on verifiable and decentralized/redundant data feeds (oracles), thus reducing the costs of enforcing contracts. Monitoring could be automated (or dispersed to a community/market of peers) by recording an organization's activities on a shared ledger and decentralizing control to the network. Social scalability of cryptonetworks, due to a trusted shared protocol and ledger (Szabo, 2017)[20] enables large-scale online coordination.

Public, permissionless blockchains can be seen as decentralized self-governing organizations (decentralized autonomous organizations – DAOs). They have been framed as entities with an automated center, based on a standardized protocol and human edges[21] with coordination properties of markets, the governance properties of commons and the constitutional, legal and monetary properties of a

nation state. They have the coordination properties of a market through token systems that orchestrate collective action, but as opposed to a market, production (of a shared database/state), not exchange is organized (markets and exchanges are built typically on layers above). The constitutional properties of a rule-of-law governed nation state are implied by community members opting-in the social contract and the automatic execution of the rules of the DO/DAO, by executing the protocol code.

There is no commonly accepted definition of blockchain-based decentralized organizations and DAOs, and the terms are being used loosely in practice. De Filippi[22] mentions that DAOs do not depend on human intervention in decision-making ("autonomous" –e.g. the Bitcoin protocol coordinating its shared state through hard-coded incentives), and Decentralized Collaborative Organizations (DCO) which involves humans coordinating themselves with a blockchain-based platform. Such organizations fit the notion of distributed innovation systems (such as open-source communities; see next section), which want to avoid asymmetric power dependencies, inherent in centralized platforms (see also hold-up problem, discussed later).

Reijers et al.[23] argue that blockchain governance is a special type of social contract, and that the general will (of the community) is ultimately unrepresentable (in unchangeable code) because it entails a continuous act of willing which leaves its identity forever incomplete and thus available to new demands and reformulations. Thus, code needs to follow changing social consensus over time, however slowly enough, so the status quo is reliable enough to build a stable basis for commitments.

If blockchains are institutional and governance technology, they can govern collective action but also need to be governed (ultimately by humans) in order to represent the governed. Thus, one can separate governance by (blockchain) infrastructure and governance of the infrastructure.

2.1 Governance by the infrastructure – (decentralized) organization design

While in general, any organizational structure is thought to be implementable using blockchain based smart contracts, decentralized (autonomous) organizations are particularly interesting, demonstrating both the institutional infrastructure (layer 1 blockchains), as well as entities on top of it (layers above). The related entities fit into the notion of actor-oriented forms of organizing,

while a decentralized software protocol coordinates collective action, reduces the need for trust between parties, as well as allows for monetization and, thus, value appropriation by distributed communities. Connected to this, the underlying token-systems allow for financing open-source software as well as foundational protocols and value appropriation thereof, in a novel way. Decentralized business models ought to bootstrap ecosystems in community ownership, featuring strong network effects, by incentivizing early buy-in by token issuance.[24]

In the following section, organization design in the era of peer production and distributed forms of organizing that go beyond the boundaries of firms (incl. platforms as a dominant model) are discussed. Building on this, the merits of using blockchain-based organizations to solve incentive problems are laid out.

2.1.1 Organization design in the age of platforms, peer production & blockchains - distributed innovation systems

Innovation is what drives progress and productivity growth, which is thus arguably the core activity to focus on in order to drive marginal value creation (while exploitative, as opposed to explorative, business processes are increasingly automated). Knowledge and informational goods (i.e. data) can be transmitted and leveraged at near zero marginal cost in today's digitized economy, while its creation and transformation remain challenging.

Kornberger[25] asks how does organization design, defined as the structuring of communication, coordination, and control[26], enable as well as constrain the activities within distributed innovation networks?

Traditionally scholars have been focused on the firm as the unit of analysis in organizational design, which has become less and less congruent with the emerging patterns of organizing in peer-to-peer networks and on platforms.

However, also platforms that coordinate delivery of physical goods & services fit into the model, and the platform business model has increasingly been becoming dominant in terms of economic success (see figure below). They considerably minimize information-based search and transaction costs, by regulating quality standards[27], influencing market price structures, as well as aggregating suppliers.

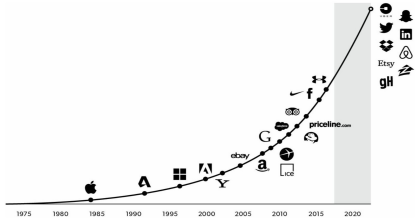


Figure 3.1. Platform businesses in the S&P 500 over the last forty years.

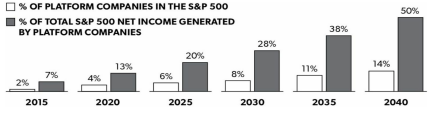


Figure 3.2. In twenty-five years, 50 percent of the S&P 500's net income

Source:
Modern Monopolies (2016) – forecast from 2016 incl. platforms that might enter the S&P – in fact in 2020 platform companies will generate 20% of the S&P 500 returns and count 4% in numbers[28]

Distributed innovation has been viewed from various organizational vantage points, including user driven innovation[29], commons-based peer production[30], platform innovation[31], co-creation[32], crowdsourcing[33], and other means to collaborate with actors outside of the boundaries of the firm.

Santos & Eisenhardt[34] distinguish between boundaries of competence (e.g. open-/user-innovation, co-creation, crowd-sourcing) and boundaries of power (e.g. free-revealing & non-restrictive licenses). Meta-organizational designs are incorporating knowledge through closed to open boundaries and facilitate decision-making in heterarchical or hierarchical processes.

It is assumed that the "locus of innovation" is shifting from hierarchical firms to actors in distributed networks[35], conceptualizing innovation as a distributed process to which users, rivals, and other non-firm members contribute[36]. Distributed innovation is viewed as "decentralized problem-solving, self selected participation, self-organizing coordination and collaboration, 'free' revealing of knowledge, and hybrid organizational models that blend community with commercial success".[37]

Collaborative communities are organizational forms enabling and enhancing networking among autonomous and interdependent participants, entailing membership, commitment to shared purposes and rules for participation.

They enable large groups of collaborators to self-organize, implying that they accomplish control and coordination primarily via direct interaction among themselves rather than by hierarchical subordination.[38]

Commons are crucial in producing, sharing, and accumulating resources.[39] Infrastructures provide spaces for collaboration and sharing.[40] Shared values create trust which is essential for collaboration.[41] Diversity of participant knowledge, skills, and views is favorable for complex problem solving and discovering new opportunities. The relating organizational design processes show strong emergent properties.[42] Actors are usually motivated by contributing to a common good as well as generating private benefits.[43]

Kornberger highlights three distinct components in this new era of organizational design: 1) interface design (mediating interaction within distributed innovation systems); 2) participatory architectures (enabling peers to articulate ideas and contribute meaningfully); 3) evaluative infrastructures (accounting mechanisms judging quality and value).

Interfaces

An interface is a medium that organizes the exchange between two or more heterarchically distributed elements.[44] Interfaces can be online (events such as conferences or meetups serve as interfaces between firms and communities).

Generally, interfaces act as filters structuring access to and the exchange of information between two or more subsystems (formatting devices governing exchange across boundaries).

Interface design often influences and constrains the action space for actors or subsystems (e.g. like button encouraging to show support, while making dissensus less likely). Nudging and decision architecture as well as the general discipline of behavioral economics can inform aspects of design.[45]

In contrast to traditional organizational design, interfaces do not promote integration. Particularly there are diminishing returns of integrating external actors due to three effects: 1) socially, growing distant from their network, which has been their original source of innovation[46]; 2) cognitively, integrated actors adapt to dominant frames, which reduces diversity of thought[47]; 3) motivationally, contractual obligations and economic incentives might lead to crowding-out effects.[48]

Thus, interfaces should create communication between heterogeneous modules while maintaining their differences. Galloway and Thacker[49] highlight the notion of interoperability for interfaces mediating between distinct data forms.

Viewing organizations as networks of humans as well as machines, it is crucial to

highlight the role of interfaces to integrate diverse forms of input through APIs, different programming languages or human languages. Open access and composability to and of open-source code and blockchains (and their state) are crucial to allow effective interfaces to emerge.

By connecting various parts of ecosystems through interfaces (and allowing them to be added in a permissionless fashion) actors with a particular geographical, cultural or technical background and knowledge can build bridges as well as front-ends in order to cater to users that are local to them. As mentioned above, it would be detrimental to the potential for innovation as well as local adaptation if all production would be integrated in a single firm, as it is especially important to maintain the diverse backgrounds of actors.

Interfaces in the blockchain space range from mailing lists, meetups as well as video calls to front ends that connect a certain class of users (e.g. Multis[50] catering to businesses for financial use-cases) or technologies that connect distinct blockchains (e.g. Cosmos inter-blockchain-communication protocol[51]; see section Discussion for more examples).

Architectures of participation

Architectures of participation demonstrate a design mechanism for integrating external production.[52] They structure collaboration by designing open production processes showing 3 characteristics: 1) modularity (products can be deconstructed into modular units and developed independently, allowing diverse actors to work asynchronously on distinct parts, leading to higher stability in the face of environmental uncertainty through loose coupling of elements). 2) granularity (modules should be small to attract people with various levels of motivation and resources. 3) low integration costs (integration can occur in various forms: second-order peer production mechanisms, like in review based quality control systems;[53] normative control, such as in the case of Wikipedia (see Duguid[54] on the limits of self-organization); technology & specified conditions of integration; or managerial hierarchy as in the Linux community for important decisions about system evolution).

As a result, distributed innovation is not limited by the overall complexity of a problem, but by its modular, granular, and integrative characteristics. Collaborative community forms are well-suited to address ill-structured problems. The ability to dynamically self-organize provides collaborative communities with sensing and adaptive capabilities, improving the potential to thrive in complex and dynamic environments.[55]

In a blockchain context, both governance by the infrastructure (e.g. users utilizing composability in decentralized finance) as well as of the infrastructure (e.g. development in layers; splitting issues in distinct improvement proposals) can

be designed in a modular, granular fashion.

On the one hand a blockchain community that tries to solve the technical complexities of building a scalable layer 1 blockchain benefits from self-organizing actors working on modular units (e.g. the Ethereum Improvement Proposal process, Ethresearch forum discussions; see case studies). On the other hand, the sum of all individual blockchain communities, including application developers, represents a distributed innovation system that attempts to solve problems much too complex for individual actors or firms: Building a more open, decentralized and robust internet, data and financial infrastructure.

What is more, specialized actors participate in providing computing power for validating transactions in Bitcoin or providing storage capacity in Arweave[56], while they each can tweak their hardware and optimize on input costs such as electricity in order to contribute in a distributed fashion, benefitting from local knowledge and circumstances.

Evaluative infrastructures

Evaluative infrastructures can be defined as methodologies (epistemological assumptions about what is valuable as well as calculative practices through which things can be evaluated) and technologies (measure, quantify, index, compare, fix, and calculate values) of valuation that are distributed across innovation networks.

Examples of evaluative infrastructures include rankings, ratings, reviews, tagging, bestseller lists, and awards.[57] They can be produced by users/peers (like buttons, star ratings, curation markets, token curated registries) or automatically through algorithms (Google Search, Bitcoin Proof-of-Work).

Trust plays an important role in knowledge intensive production processes.[58] Evaluative infrastructures make trust visible (e.g. reputation scores/average ratings, market price of a token).

In general, reputation gains are important motivators for contributors to distributed innovation.[59] Evaluative infrastructures enable a reputation economy for people to build their career in the open. However, they do not only make values visible but also catalyze developing new values (e.g. followers in a social network as a new form of social currency).

Evaluative infrastructures are especially valuable when the scarce resource is the cognitive capacity to select alternatives.

Relevant for example is using curation markets, where participants curate content while being rewarded, when users with reputation upvote it afterwards. Ocean Protocol[60] utilizes curation markets for data curation, evaluating data quality as well as predicting relevance. Algorithmic tokens are then being rewarded to

curators according to the value of economic stake they put on a particular dataset as well as the percentage of usage of said dataset.

All ex-ante (predictions, curation) as well as ex-post (actual usage, likes) evaluations are recorded on-chain, while in many cases such as with Ocean Protocol the token value should be driven by the economic activity facilitated or the value created by the protocol (due to demand). As a result, the market of tokens represents a form of meta-evaluative infrastructure (potentially built on on-chain decentralized exchanges), where investors curate high-potential protocols (driving token value), while in the end usage drives fundamental token value.

Competitive advantage in decentralized organizations / distributed innovation systems

Organization design in distributed innovation systems is not primarily aimed at actually organizing production or innovation, but to create the circumstances in which distributed peers can do so.

The question of search as an experiential and cognitive task is shifted toward search as a distributed process facilitated by organizational design. Actors are distributed heterarchically and perform searches for new ideas according to their own evaluation criteria (driven by their own bounded rationalities).

Resource-based view

Prahalad and Hamel[61] suggested that products and services represent only the leaves of a tree, but the true "roots of competitiveness" lie in the core competencies, its roots storing an organization's main resource (knowledge).
If knowledge is distributed across networks and outside the boundaries of firms, not ownership or direct control of resources represents a competitive advantage, but rather access to them.[62]

Considering a distributed resource base, competencies reside in an organization's ability to design interfaces between externally situated knowledge, to provide architectures for meaningful conversation and collaboration, and to develop evaluative infrastructures to make contributions visible and valuable.

A decentralized organization's competitive advantage lies in its data and knowledge – in its community, as well as its accessible and interoperable state, as well as in its ability to coordinate for maximum value creation, such as providing actionable intelligence on resource allocation.

Knowledge lives in the knowledge commons (wiki's, databases, ledgers) and in knowledgeable members. The openness and transparency of critical resources in commons stand in opposition to the focus on non-imitability of firm-controlled resources through e.g. property rights protection in centralized resource-based

firms.[63] Commons increase in value by wide availability as they then attract more contributors. Thus, defensibility is achieved by superior resource gravity and network effects as opposed to secrecy.

Avoiding firm-centricity, also the authorship of interfaces, participatory architectures, and evaluative infrastructures can be organized as a distributed phenomenon (see governance of the infrastructure). Modularity in building blocks based on open-source software allows governance systems to emerge in an experimental, evolutionary process. Permissionless blockchains as well as a culture of cooperation are important attributes to allow distributed innovation in action. Both the infrastructure and tooling that enables subsequent innovation at higher layers, as well as applications are being developed in an archetypical distributed fashion, leveraging a diverse pool of talent, that self-select to the problems that fit their skillset best. Attracting a large, driven as well as knowledgeable community becomes the most important aspect of managing a distributed innovation system like a blockchain ecosystem.

From Management to diplomacy

Distributed innovation challenges the traditional role of the manager (no formal authority over the production process). Rather, producer-consumers as well as other external agents whom the manager can neither hire nor fire are valuable yet also uncontrollable organizational resources. Thus, the challenge is shifting from the efficient allocation of internal resources to organizing "the open," (designing structures and systems for coordination outside the boundaries of the firm).[64]

Management could be reimagined as the diplomacy, as the "attempt to govern the ungovernable—the anarchical society—through discursive and cultural practices" Der Derian.[65] Especially as historically, the power of diplomacy evolved in opposition to the demise of the power of the sovereign. Foreign nations had to be coped with diplomatically as they could not be oppressed or ignored anymore. In open networks of peers with distributed leadership and agency a manager-diplomat needs to be creating the conditions for collective action to occur.

Community management in blockchain ecosystems is therefore of utmost importance, not only to attract the best possible community (with a fit regarding values and skills), but also to moderate and translate in discussions in order to crystallize common or opposing viewpoints and unite the community to a coherent whole.

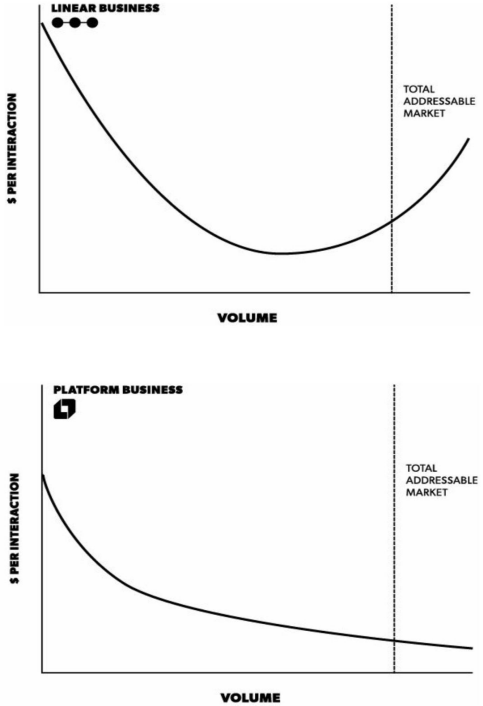
Blockchains solving incentive and trust problems in distributed innovation / peer production systems

The Internet is a technology that networks society and, thus, reduces communication, information, and search costs[66]

Monopolies and contestable markets

Digital platforms emerged that provide the interfaces, architectures for participation and evaluative infrastructures for building trust between strangers online and creating networked markets on centralized infrastructure. They dramatically minimize information-based search and transaction costs, by regulating quality standards, creating market mechanisms (e.g. auctions), as well as aggregating suppliers. There are strong network effects and thus economies of scale involved in those platforms, often representing the conditions for natural monopolies (decreasing average costs for the whole relevant range of demand/total-addressable-market, thus a single large entity is naturally the most competitive). These positive externalities arise from expanded opportunities for collaboration, sharing, and exchange from increased participation (i.e. direct network effects) and a self-reinforcing gravitational effect from common resources becoming more attractive to use and contribute to as they grow (i.e. resource gravity).

Those digital monopolies have amassed massive amounts of data creating information asymmetries used to the detriment of platform users,[67] while users lose trust in those platforms, that increasingly lock them in.



Source:
Modern Monopolies: The average cost curves for linear and platform business.

While it is highly beneficial to maintain logical centralization and interoperability of state of architectures of participation and evaluative infrastructures, it is highly desirable to build those crucial pieces of infrastructure in a politically as well as architecturally decentralized way to prevent monopolization and the related lack of trust due to potential excessive rent-seeking and exploitation.
Such behavior by platform operators has not remained theoretical, when viewing cases such as Facebook's user-data exploits or Amazon's practice of attracting participants on their marketplace to then later use their information advantage to outcompete them by own offerings in the most profitable areas, as well as the potential for differential pricing - the practice of using data to determine each user's maximum willingness to pay and to earn the highest rents possible.

Blockchains could represent platforms allowing to utilize the benefits of network effects (due to logical centralization/common standards), while avoiding the pitfalls of excessive market power by being contestable markets, as low barriers to entry due to the open-source nature of protocols keep a logically monopolistic network in check (see Bailey & Baumol[68] on contestable markets).

„Blockchains are politically decentralized (no one controls them) and architecturally decentralized (no infrastructural central point of failure) but they are logically centralized (there is one commonly agreed state and the system behaves like a single computer)" Vitalik Buterin[69]

As permission-less public blockchain protocols are usually open-source, the community (or parts thereof) can fork the codebase together with the history of state/transactions and start a separate, backwards compatible blockchain. Users incur low switching costs as data such as their token balance or reputation is equally valid on a fork.

Abadi and Brunnermeier[70] argue that when network effects are weak, the entrant (the forked Blockchain) can manage to capture positive market share, whereas when network effects are strong, the entrant does not capture any share of the market. However, the market remains contestable in the sense that the incumbent sets its fee low enough to keep the entrant out of the market, which can also correspond to policies or conditions other than transaction fees such as founder's rewards or token issuance.

Hold-up

Connected to the issue of becoming reliant on a monopolist, or an actor with excessive market/negotiating power is the hold-up problem, for which Barrera & Hurder[71] suggest blockchains serve as a solution in the context of shared databases. This has wide-ranging implications as shared databases arguably also form the basis for shared architectures of participation & evaluation.

The hold-up problem is demonstrated by an entity that is making relationship

specific investments, which is later being put in an unfavorable negotiating position, as the costs are already sunk. One can imagine for example a developer, that is building on a platform with lock-in. At first, while in heavy growth mode, the platform offers very promising conditions, based on an incomplete contract. Over time, as the platform becomes more and more dominant, the contract is either renegotiated/dictated (e.g. fee increase) or some not previously considered aspect comes into play, that has not been covered in the contract such as the platform provider using information advantages to launch competing products in the most profitable segments.

What is more, firms that could create much more value if they collaborate in a data-sharing agreement face similar incentive problems, such as automotive companies that do research in battery technology for electric vehicles. This is due to the fact that data property rights are complex, especially when a relationship spans multiple jurisdictions and a platform that potentially intermediates such an endeavor could read all relevant data, which opens the door for exploits by internal or external actors.

In addition, there are considerable relationship-specific investments necessary (hardware and/or software) in order to support a given shared format, which is potentially only useful in this particular setting or on the platform that facilitates the consortium.

As a result, rational entities may not invest in potentially profitable relationships in the first place, as they might be held up.

In reality there are, however, many cases where developers have been building on platforms with lock-in such as iOS or companies have invested large sums in order to use CRM software such as Salesforce, while the data they collect over time is not easily portable (if at all). On the one hand this can be related to bounded rationality, while on the other hand it might just be the best alternative at the time to build on a platform with strong market power, giving such platforms an even more powerful position

Generally, inefficiencies in trade arise when parties reach not the best possible collective outcome, either through frictions such as search costs, or due to incentive problems such as the hold-up problem. The internet has largely tackled frictions through search costs, while blockchains are interesting when frictions arise because of a lack of trust.

Blockchains in combination with complementary technologies such as encryption schemes and zero knowledge proofs can reduce inefficiencies (transaction costs) in particularly three margins:

1) Coordination – the blockchain provides an easily verifiable common source of truth (see also evaluative infrastructures and architectures for participation). Every participant can and ideally does operate a full node, which allows full access, as well as validation of relevant data. Especially, often substantial efforts and costs in reconciliation of disparate systems can be eliminated.

2) Commitment – increasing contractual completeness and reducing re-negotiation can be reached by credible commitments on an immutable, independent blockchain (potentially augmented by large open-source libraries of contract templates that cover more edge-cases). The blockchain serves as an independent enforcer of algorithmically defined agreements, as programs will be executed as previously defined in a fault-tolerant manner (e.g. tolerant to ⅓ of participants being malicious or offline).

3) Control – the user or the participating firm in an ecosystem consortium can retain local and/or cryptographic control over data as well as assets, while access control is reliably managed by an independent blockchain (see e.g. Ocean Protocol).

2.1.2 DAOs as platform cooperatives

Another lense through which DAOs can be viewed is platform cooperatives. Whereas platforms have been characterized as networked markets, studying Colony, Laing[72] argues that DAOs should be characterized as networked firms, programming for the division of labor rather than exchange, enabling flexible production rather than consumption, and optimizing for coordination effectiveness rather than matchmaking efficiency. As opposed to markets, firms have the unique ability to organize groups of people around shared purpose and learning.

DAOs also show a close resemblance to worker cooperatives:
1) The economic activities are carried out primarily for the benefits of participants.
2) Most, if not all, of the capital of the organization is held by the participants (in colony or other DAOs investors are incentivized to participate in staking, governance as well as other productive activities – otherwise they risk dilution).
3) Often participants need to buy into the cooperative, resembling staking in DAOs

In many of such firms, delegated management still exists, but the board is elected by workers and they retain extensive informational rights.[73] Worker cooperatives provide an appealing governance structure due to their positive effects on employee alignment.[74] This is congruent with the view of that employees in

knowledge-intensive work tend to be more skeptical of hierarchical employment relations and believe that "the locus of decisions has to coincide with the locus of knowledge".[75]

This is in line with agency theory, that suggests that investment in specific assets for a given project/firm/organization requires governance rights as well as rights to residual profits. This has been the argument for capital, as specific assets were long needed for production. As knowledge intensity increases, specific assets shift towards knowledgeable people as well as their data.

The key difference to open source communities is that DAOs may not be limited to the private provision of public goods but may be used for the production of private goods as well. The dynamic meritocratic governance of certain DAOs, shows similarities with cooperatives that also weigh voting power by e.g. production.[76] The relative transferability of a token can be compared to a partnership interest, a standard cooperative membership, or an employee share held in a trust that allow workers to diversify their risk. On the flipside, external investors can participate in the project.

In terms of collective action problems, a frequent issue of worker cooperatives is time spent in meetings to reconcile differing interests. Thus, taking actions on the basis of tacit consent (freedom at the edges, humming), rather than majority voting or unanimity, may in fact be preferable.[77] (see rough consensus & running code)

2.2 Governance of the infrastructure

So far, we have argued that governing collective action on blockchains can be superior to other institutions.

However, who is governing the governors? Are blockchains autonomous as implied in the term decentralized autonomous organizations or are still people pulling the strings? As Vitalik Buterin[78] argues regarding the first DAO, Bitcoin, it is autonomous with certain imperfections in implementation.

Autonomous or not, there will inevitably be unanticipated events that need to be adapted to.

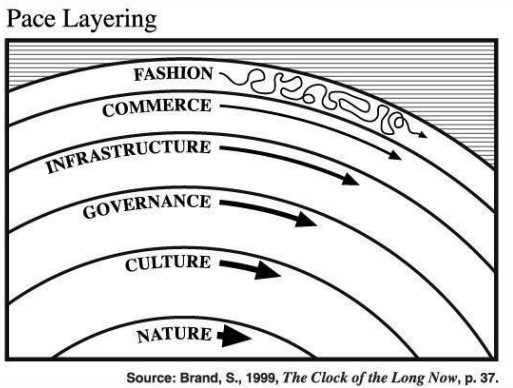
2.2.1 National, corporate, platform, internet – governance in layers

In order to argue how to govern blockchains it is crucial to view them as part of larger systems and institutions. One of the most important questions is what is the highest institution a blockchain or blockchain-based organization is embedded in?

If there should be an immutable base-layer as a stand-alone jurisdiction akin to a nation state on the internet the following quote should highlight the century old struggle for optimal governance:

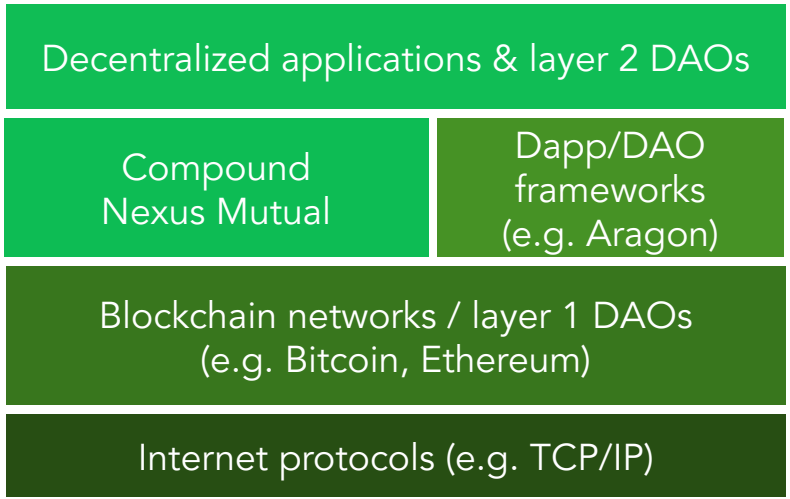
"Democracy is the worst form of government, except for all the others"
(Winston Churchill)

However, even when assuming a blockchain being a sovereign entity like a nation state, one has to bear in mind that it does and cannot exist in isolation.



Productive activities in societies are based on many layers of systems that change at different velocities. Nature sets the general boundaries of what is possible, human culture and ethics serves as general assumptions of what ought to be done and emerges over generations. Governance of nation states and communities is informed by and embedded in the lower layers, which in turn demonstrates the system to decide upon building infrastructure and commerce (and their boundaries). Governance of commerce conducted within firms is the space of corporate governance. It is crucial to highlight that one cannot view any of the layers in isolation, but mutually intertwined and that people's behavior is informed by this complex system.

If traditional nation states or some form of (self-)governance (representing all stakeholders) remains in control and are involved in dispute resolution, corporate governance/token-holder based on-chain governance might be an apt lens to view the issue. This is, because stakeholders without sufficient influence would be protected from negative externalities (such as excessive pollution) that a pure profit motive might bring about, by a higher-level institution.



Source:
Adapted and updated from Coala global – Governance of blockchains

On a technical level, blockchains depend crucially on established internet protocols, their governance as well as certain network operators (ISPs), who are in turn influenced by the nation states they operate in. One guiding principle of the web has been net neutrality, that ISPs do not differentiate data packets they transmit depending on their content. However, net neutrality was abolished in 2018 in the US and while discussed to be reintroduced in 2019 (approved by the house of representatives), it is unclear and controversial in US institutions.[79] Also China's great firewall had considerable influence on bitcoin miners.[80] Thus, when building and governing blockchains and applications on top, it is crucial to account for broader internet governance, and potentially participate in order to represent an agenda.

Decentralized applications or layer 2 DAOs in turn depend on base-layer blockchain governance and dapp-frameworks they are built with.

2.2.2 Corporate governance

In order to holistically view the issue of blockchain governance, especially given similarities around the discussion of token-holder/shareholder-value maximization and stakeholder-value maximization, an overview of corporate governance is provided. Corporate governance may be defined broadly as the study of power

and influence over decision making within the corporation. Aguilera & Jackson[81] see comparative corporate governance as the study of relationships between stakeholders in a firm and their influence on strategic decision making in relation to different nation's wider institutional environment (labor market, capital market, legal system, political system etc.). As the firm is itself a legal institution, where rights and responsibilities of different stakeholders are anchored in law (created and changed through politics). Regarding blockchains it is important to point out that layer 1 protocols could be viewed as defining differing institutional settings akin to nations, while actors themselves are still operating in and from various nation states, affecting their action space and decision making. For example, when comparing the Polkadot and Cosmos ecosystems and their envisioned/actual governance systems, in the former token-holders have larger influence over projects building on the infrastructure (e.g. grant special access or blacklist), while the latter envisions an alliance of sovereign entities (see case studies later for details)

What is more, there are various disciplines and perspectives from which to view corporate governance:

Economic Perspectives

Nexus of contracts among: "The set of constraints that shape the ex post bargaining over the quasi rents generated in the course of a relationship".[82]

The key aspect is that contracts are incomplete, leading to lots of room for bargaining about how to divide the firm surpluses (as argued before smart contracts could contribute to enabling more complete contracts – the Bitcoin Proof-of-Work function can be seen as a complete contract, as it is fully algorithmic; however, some ambiguity will arguably always remain in many cases).

Team production model: The corporation embodies a number of stakeholders who invest firm-specific resources, but jointly relinquish control over those resources to a board of directors for their own benefit in order to solve the problem of coordinating efforts within the team.[83]

In the case of DAOs, a set of algorithmic rules (architectures for participation & evaluation) can partly or fully replace the board of directors in order to solve coordination problems for teams that invest DAO/goal-specific resources. In some cases, there are still boards employed by DAOs/DOs, not least to cover edge-cases (when contracts are incomplete), while in others there are attempts to have directly democratic forms of governance (to alter the set of algorithmic rules; see case studies for detailed examples).

The stakeholder perspective: The corporation is a set of relationships between stakeholders with an interest in the firm and thus a broader set of goals to be maximized or satisfied.[84]

When there are firm-specific investments by employees (such as specific skills), the board should not be seen solely as agents of the shareholders but as trustees of stakeholders.[85]

Similarly, Rajan and Zingales[86] argue that the growing importance of human capital relative to physical assets in modern organizations decreases the relevance of the agency theory view of the firm based on property rights over physical capital.

Clarkson states: "The firm" is a system of stakeholders operating within the larger system of the host society that provides the necessary legal and market infrastructure for the firm's activities. The purpose of the firm is to create wealth or value for its stakeholders by converting their stakes into goods and services.[87]
Blair[88] supports this view: The goal should be maximizing total wealth creation by the firm.

A crucial element in this line of arguments is the firm that operates within a set of higher-order institutions (host society providing the necessary legal and market infrastructure). While a layer 1 DAO provides features to program algorithmic agreements (potentially replacing legal agreements) as well as market infrastructure (e.g. exchanges on blockchain infrastructure), there is a lack of democratic legitimacy as regards to the general society of such systems.

The key to achieving this is to enhance the voice of and provide ownership-like incentives to those participants in the firm who contribute or control critical, specialized inputs (firm specific human capital) and to align the interests of these critical stakeholders with the interests of outside, passive shareholders.

This also relates to the previously covered aspect of certain DAOs resembling digital worker cooperatives. In the blockchain space and the software industry more generally, human capital (knowledge) is the most crucial input factor for production. Thus, as previously argued, access to an aligned knowledgeable community is of utmost important (besides the core founding team). Such alignment is partly represented economically, by distributing ownership to strategic stakeholders, such as traditionally key employees (with stock options). In the blockchain space, token issuance should represent a similar instrument, with the difference that the transaction cost of distributing them is much lower as well as can happen in a permissionless fashion (e.g. for miners or other participants contributing work to a network). As a result, a network of economically aligned actors can come into existence by self-selecting into a given crypto network based on goals, values and

economic prospects on an international scale with much greater social scalability and lower transaction costs as in a firm (by speaking the same language of code/following the same protocol, facilitated by locally adapted interfaces).

Also, Porter[89] recommended to US policy makers that they should encourage long-term employee ownership and encourage board representation by significant customers, suppliers, financial advisers, employees, and community representatives. He also recommended that corporations seek long-term owners and give them a direct voice in governance (i.e. relationship investors) and to nominate significant owners, customers, suppliers, employees, and community representatives to the board of directors. Control of the firm is likewise shared between investors and stakeholders through multiple boards to remove conflicts of interest.

As this relates to blockchains, it is crucial to highlight the importance of a founding team or operating DAO selecting or targeting long-term, mission aligned investors (especially, but not only, in the tokenholder voting based on-chain governance systems that are comparable to shareholder votes). More difficult, but very important nonetheless, is to give a voice to community members that do not have a significant economic stake (while the design of a blockchain should distribute tokens to the stakeholders that are most strategic, delivering the most value to its continued success).

Agency theorists in turn criticize stakeholder theory:

1) Too many stakeholders exist,
2) their inputs may not be critical,
3) stakeholder participation can lead to deadlocks in decision making,
4) lacking a single objective function undermines managerial accountability.[90]

Agency costs exist due to problems in monitoring management by shareholders: Imperfect information; limits to management discretion may be difficult to enforce contractually; shareholders exhibit free rider problems when portfolios are diversified, thus reducing individual incentives to exercise control rights and creating preferences for exit.[91] In this view comparative corporate governance usually caters to the mechanisms available to minimize agency problems[92]; e.g. the structure of ownership, board structure, executive compensation, the market for corporate control, accounting rules, the audit process and role of gatekeepers).

The value of a firm cannot be maximized because managers possess discretions which allow them to expropriate value to themselves. In an ideal world, managers would sign a complete contract that specifies exactly what they could do under all states of the world and how profits would be allocated. However, most future contingencies are too hard to describe and foresee, and as a result, complete contracts are technologically unfeasible.

Agency problems reflect a trade-off between liquidity and control. Problems may be solved through blockholder control, where one or few blockholders retain tight control over the firm.

In countries with dispersed patterns of ownership, a model of shareholder control has emerged that relies on a number of different market-oriented mechanisms. Rules on accounting and disclosure support the role of independent members of the board who act on behalf of shareholders. Here, the market for corporate control plays a critical role through hostile takeovers aimed to disciplining the management of inefficient firms.

In some countries, monitoring is performed by large shareholders having strong incentives for control but less liquidity. Elsewhere, fragmented shareholders have greater liquidity and risk diversification but little individual incentive to monitor.

As an important element of decentralized blockchains, especially those that are governed by tokenholders, is deemed the decentralization of token holdings, the above mentioned free-rider problem of diversified investors comes into play. Every individual might not care enough or might not have sufficient mental capacity to thoughtfully consider issues relating to governance, if token-holdings are insignificant in their overall portfolio (see also later rational ignorance in voting and liquid democracy).

The issue of deadlocks in decision making, when too many stakeholders are participating and in consideration, is being exemplified in off-chain governance systems which are laid out later in detail (Bitcoin and Ethereum).

Enlightened approach to shareholder-value

Investors would have to be encouraged to act more like owners than traders. Independent directors would have to feel stronger obligations to stakeholder constituents. And the high-power incentives in the name of shareholder interests will need to be fundamentally addressed. In the long run, such a market-oriented and shareholder-centered system could develop many more commonalities with stakeholder-oriented systems by democratizing financial markets and making finance itself accountable to the public interest.

Lock-ups for investors in private funding rounds, as well as when participating in staking (to validate transactions in Proof-of-Stake blockchains) or governance (voting) demonstrate a healthy step towards promoting long-term value alignment. What is there is a great opportunity for investors to act like responsible constituents and build a sought-after brand for values-driven communities as a result.

Cultural and Sociological Perspectives

Corporate governance has a cognitive/cultural dimension related to the interpretative frameworks for actors to understand reality.

Hofstede[93] developed four cultural dimension indices based on 1966 data—power distance, individualism, uncertainty avoidance, masculinity and later on added long-term orientation. Culture has a strong influence on people's behavior and for example a country's dispersed ownership is significantly correlated with the Individualism Index.[94]

Strong informal norms may provide functional substitutes in promoting trust where strong legal norms are absent. Beyond geographical/demographic cultures, company or organizational culture is a crucial aspect to build in order to steer groups towards reaching a shared goal (e.g. through hiring, training & leadership by example).

Blockchain communities are much more than the tangible code they work on and run (e.g. Bitcoin nodes). There is a deep and complex cultural element that can catch-on like fire in order to create a movement (e.g. memes such as sound money, freedom, self-sovereignty). In the end it is social consensus that defines what a blockchain is (which client/node software is the adopted version), especially due to the option to fork (even if token holders decide one thing, a part of the community could fork away and create an altered version).

It is culture that represents the deep values driving participants (i.e. the social protocol that runs on people's minds). Thus, culture shapes all governance layers above (see figure "pace layering" by Brand).

The Legal Origins Perspective and Comparative Approaches to Law

Corporate law and investor rights constitute complex legal and economic constructions established through corporate law, bankruptcy law, and contractual articles of incorporation.[95] Property rights define mechanisms through which shareholders (capital) exert control, such as information exchange and voting rights, and how control is balanced with managerial discretion.

Given the agency costs of ownership, the protections afforded by law, particularly to minority shareholders, have a large impact on ownership structures. Their main hypothesis links poor investor protection to high ownership concentration.[96]

Blockchains provide strong assurances regarding property rights both regarding assets as well as data. A user/investor can always remain in full control over assets and data while engaging in contractual relationships, governed by code (governance by the infrastructure). While there is no regulation regarding minority token-holder protection (which is ideally the majority in a decentralized token distribution), liquidity as well as the possibility to fork while porting relevant data to another ecosystem provides minorities exit routes, if a majority decision is not compatible with their viewpoints or value system.

Reporting standards have a large influence on governance, especially for more distant and small stakeholders: International Financial Reporting Standards (IFRS) have been developed by the International Accounting Standards Board (IASB), which is a London-based independent, privately funded accounting standard setter, not connected to a government, which is in charge of developing and promoting the effective use of these accounting standards.

As in blockchains the standard is that transactions are public, anyone can query performance metrics in real-time, which has never been possible with firms. What is more, there is a tradition of working out in the open with code public on Github, communications in public chat rooms/open calls, through blog posts or podcasts. As a result, the barrier to gaining access to relevant information regarding the status of a given blockchain project has been considerably reduced compared to previous iterations of tech companies. Still there is misinformation as well as manipulation of metrics such as exchange volume (wash trading), for which there have been projects formed in order to bring more transparency and higher standards in terms of reporting (e.g. Messari[97] disclosure database for project information that can be freely accessed industry-wide).

Usually in public financial markets (such as the equities markets), there are regulatory requirements regarding disclosures in order to reduce information asymmetries towards investors (especially minority investors). Blockstack[98] selling tokens to the wider public, including non-accredited investors, under US Regulation S demonstrates an interesting example of a project to comply with traditional regulatory standards (9-month approval process by the US Securities and Exchange Commission, extensive documentation). Other projects are often voluntarily as transparent as possible in order to gain trust but do not sell utility tokens to the wider public before there is a functioning network (and thus a live use-case for the token as a product, as opposed to the token as a security).

2.2.3 Governance in open-source communities

OSS communities have specific characteristics as they are developing pure information goods with high degrees of modularity and open as well as free access common resources (the source code) and products (applications).[99]

3 phases in OSS governance

"Spontaneous" governance

OSS communities are found to be self-directing without any kind of explicit and formal coordination or control. Apart from the licensing framework, communities are spontaneously creating a stream of innovations. Studies persistently show that

a minority (about 20%) actually produces most of the code contributions (about 80%). This enables the high-performers to constitute themselves as informal leaders.

Internal governance through six main categories of tools

Modularization: As the number of participants grows projects are split into modules.

Division of roles: Bundles of tasks are associated with differentiated access to project files (e.g. developer vs. committer who can vs. cannot commit code to the main branch).

Delegation of decision-making: Centralized (e.g. Linus Torvald, founder of the famous Linux operating system, personally deciding upon all changes to experimental version) vs. decentralized (committers or developers in a given module to take these decisions).

Training and indoctrination / values-based selection: At e.g. Debian (operating system, based on the Linux Kernel - "fork of Linux"), to become a developer (with commit privileges) one had to succeed a three-step application process with an existing developer (prove identity by having cryptographic key signed face-to-face, prove their knowledge of and adherence to OSS philosophy, and demonstrate technical competences).

Formalization: Mailing lists and newsgroup archives for discussions. Tools like Bugzilla standardized bug reporting and raising issues for discussion. Versioning systems and platforms work together simultaneously on the code-tree and keep track of all changes (Git and Github).

Autocracy/democracy: Autocracy in Linux; Linus Torvalds started the project and has remained leader ever since. On the other hand, democratic processes for electing leadership have been introduced in Debian (Project Leader elected annually by developers).

De Laat[100] notices that in all OSS designs, some form of hierarchy is present. Even if tasks are chosen voluntarily, access to files has to be granted, new code approved as well as tools and procedures accepted.

Table 1 Two ideal type OSS configurations and their design parameters

Design parameters	Autocratic-mechanistic structure	Democratic-organic structure
Autocracy/Democracy	Autocracy	Democracy
Horizontal differentiation (modularization)	High	**High**
Vertical differentiation (division of roles)	High	Low
Vertical centralization (delegation of decision-making; in reversed order)	High	Low
Formalization	High	**High**
Training and indoctrination	Low	High

Remarkable scores in bold type (see text)

Source:
De Laat (2007)

Both ideal-typical settings of OSS governance by De Laat rely on high levels of modularization and formalization. For democratic-organic structures, entry to the community is scrutinized more heavily as individuals have more influence on core code, while autocratic structures rely on hierarchical control.

This highlights the core requirement for open-source development / effective organisation in distributed innovation systems: Modularity. The overall complexity of a task is considerably less relevant, if problems can be split into modular chunks, to which the best equipped person on the internet can self-select.

Even though it is true that the blockchain ecosystem is driven by values including permission-less access and innovation, individual teams developing client software (that form the basis for nodes and miners, that in the end constitute the network in aggregate; see case studies later), selectively add members based on technical skillset as well as alignment in values. Thus, one could say anyone can start a new client and try to find adoption and gain reputation, already existing teams have strict selection criteria.

Governance towards outside parties

Usually, a non-profit foundation is established to typically handle donations, upholding copyright licenses, trademarks and brands as well as defending against charges of patent infringements. Generally, foundations are distinct from the actual project, in order to guarantee independence with proceedings. Still, they may begin to dominate a project due to external pressures (and a democratic organic regime might transform towards a less democratic and less organic form – see Iron Law of Oligarchy[101])

O'Mahony and Ferraro[102] find that members or the Debian community developed a shared basis of formal authority but limited it with democratic mechanisms to limit that basis of authority (ensuring the governance system represents the community's interests, but also provide an adaptive mechanism). Debian was meritocratic in the sense that technical as well as organization-building contributions to the project influenced the likelihood of being elected as a leader. This led them to posit that any examination of meritocracy must develop a context-specific understanding of how merit is conceptualized. What is more, they predict that the more information and knowledge are distributed, the more likely it is that democratic approaches will be appropriate.

They also note that organizations with directly democratic forms of participation do not manage to scale well and are noted for having difficulty managing complexity and decision making.[103] It remains to be seen if innovative mechanisms can enable democratic governance to scale better (see e.g. holographic governance by DAOstack).

Collaborative community governance through an agency lens

Agency relationships in collaborative communities entail three distinct multiple agency structures: commons, team production, and brokering. These are governed by four main categories of mechanisms:

1) Mutual monitoring, enabling self-regulation and peer-based control (e.g. community members checking each other's code contributions or nodes in Bitcoin mutually monitoring network state)
2) member selection, regulating admission to the community (see earlier, technical fitness as well as value alignment)
3) values and rules, guiding member action and collaboration (see culture earlier)
4) property rights and incentives, regulating rights to community resources and distribution of rewards (see software licensing in general OSS and property rights of network resources through token distribution discussed earlier). The governance mechanisms mitigate the sources of agency problems (information asymmetry and differing interests) in different ways. The extent of mutual monitoring is decreased depending on the strictness of member selection (alternative modes of quality control). Community performance is contingent upon values, rules, incentives, and their enforcement. In case of lacking these, agency problems and the risk of failure are exacerbated.

Agency relationships in collaborative communities are complex and dynamic, as participants are principals as well as agents. As agents they contribute to fulfill community needs and requirements according to shared values and rules. As principals they request contributions from other participants, peer-review contributions, and influence the direction, protocols, and rules of the community. Often, there are organizers acting as principals in shaping rules and roles, specifying tasks, as well as performing monitoring and quality assurance tasks, but

act as agents in brokering roles between other community participants and in steering commons and infrastructures on representation of the community.

This again resembles worker cooperatives. Management (the principal of the agent/worker) is shaped collectively and not by a separate class of actors, which is a desired setting also in DAOs. Reputation systems that formalize expertise in certain domains are a further development of this fluid, task-specific and gradual set of principal-agent relationships (see case-studies later, e.g. Colony formalizes reputation based on different domains of expertise that grants weighted decision power).

Institutions

Formalized rules and protocols guiding collaboration and sharing together with transparency lead to less dependencies on social cohesion as the basis for trust in communities. This provides the basis for scalable designs enhancing self-organization as well as adaptiveness. Thus, governance of collaborative communities is practiced primarily through institutional mechanisms, in contrast to authority-based mechanisms in hierarchical organizational forms.[104]

Institutional architectures need to be adapted to context.[105] Rules have to be understood and considered legitimate by actors to be effective.[106]

This reflects the previously mentioned "social scalability" that is reached through using the same blockchain protocol. While a protocol can be of technical nature, implemented in software, there are also social protocols, embodied in cultural artefacts.

Adaptation to context can potentially be implemented through different kinds of interfaces (e.g. local community meetups that translate the general rules of a community to the local culture in the case of a social protocol or decentralized finance interfaces, such as Multis, that adapts general protocols to the needs of business users).

Licensing

Beyond the organizational mode of collaborative peer production as well as the ideology of code-reuse and sharing, innovative licensing is a defining factor of open-source software development. Choice of a fitting license is crucial to govern the future usage as well as possibilities for commercialization.

There are permissive ones (e.g. Apache, MIT), which allow closed-source and commercialized off springs (as well as open core projects that provide closed-source and paid premium features and services). It is possible to link certain contingencies around when someone has to pay for a license and when not.

Copyleft licenses (e.g. GPL, AGPL) are located on the other end of the spectrum, which require every fork and alteration of a project to be open sourced as well.

Bitcoin for example is MIT licensed, which allows closed-source and commercialized derivatives. One could argue that it was chosen due the advantages towards adoption, which a permissive license brings about. If network effects and first-mover advantages are strong, Bitcoin benefits more from being adopted, experimented with and altered in various settings than pushing everyone towards a specific license of the offspring.

Most of the Ethereum stack is copyleft licensed on the other hand, while it is still being discussed which license to be used, especially for core software such as the consensus engine.

3 Specifics of governance of blockchain infrastructure

3.1 Blockchains as digital commons

The blockchain protocol's own underlying software is a form of digital commons, for which few individual users have sufficient incentive to unilaterally finance improvement.

Collective action problems, such as the tragedy of the commons is prevalent in blockchain communities. Thus, there is a challenge to fund public infrastructure, which has been tackled by experiments in token sales and token engineering (e.g. bonding curves, work tokens). A couple of further mechanisms to tackle fund allocation are described further below. Following this, the central question in governance of the infrastructure is how to affect change in the protocol rules and thus the governance by the infrastructure.

3.2 Typical stakeholder groups

Miners

In proof-of-work based blockchains there are miners who contribute to the common infrastructure through providing hashpower-based security guarantees (the higher the security budget, the higher the value of a transaction that can be safely sent). The architecture for participation is the mining game included in the protocol, implemented in client software.

The incentive designs that drive miners to participate are an example of governance by the infrastructure, that in turn enable higher layers of governance structures.

Validators

In proof-of-stake blockchains (and also other forms such as proof-of-authority) the class of actors that provides security are called validators, as they validate transactions, while economic security guarantees are provided by native tokens, they need to stake as a security guarantee. Often, validators are divided in sub-classes, dependent on the protocol.

Users

Users of a blockchain protocol can range from the novice, who stores a small amount of value on a centralized exchange, to the power user that operates a business on the blockchain (e.g. merchants, wallets, lending products). In off-chain governance systems (see further below) users often have no formal control, while on-chain governance systems try to formalize control over the protocol by e.g. token-based voting.

Full-nodes

Power users that do not trust external parties with full validation of the blockchain run full nodes. Such users can exert influence in blockchains as they forward valid blocks in the gossip (peer to peer communication) networks of the related protocols. The ruleset that the majority of full nodes runs, decides over the kind of blocks that will be propagated throughout the network. Thus, the user activated- soft-fork has delivered a strong case for user influence in bitcoin (see further below).

Core developers

Core developers work on the specifications of protocols and implementations of such in client software. Thus, they have a heavy influence over the ruleset of a blockchain and its upgrade path.
Developers can be part of the founding team, employed by the founding foundation or company. In addition, in the spirit of open-source, strong

communities feature many voluntary contributors that are driven by intrinsic (interest derived from the task itself) & identified (furthering the shared goal) motivation. Last but not least, also extrinsic factors such as monetary rewards and status play a role.

Exchanges

Exchanges are influential in that the token value of blockchains (which they depend on for security & utility) is manifested on such. Large players can be decisive in the case of forks (see further below), because the ticker symbol that they attach to a specific chain in case of a split can drastically alter public perception and price.

Foundations / companies

Funding rounds have often been structured so that a foundation receives a proportion of the proceeds and is responsible for fund allocation. What is more, e.g. in the case of Ethereum, the trademark of the Ethereum brand is owned by the foundation, which can thus decide, which is the "original" Ethereum chain.

For-profit companies could also be part of the driving stakeholder groups in some projects. They also usually hold tokens on their balance sheets to benefit from appreciating value to then sell to raise further funding for the project or turn a profit for the founders.

3.3 Forking

Traditionally, the way to implement blockchain protocol changes has been forks (which have to be differentiated from forks of differing blockchain state/ledger content). Any portion of the community can choose to fork at any time without anyone's permission. Generally, it is distinguished between soft-forks, which are backward compatible, and hard-forks, which are not.

In a soft-fork rules are tightened or added – thus now valid transactions would also have been valid under the old ruleset. Following from that, the client software is backwards-compatible. Multiple different versions of client software can co-exist on the same chain (e.g. reducing rewards, reducing maximum base block size). As long as a majority of hashpower (in Proof-of-Work) enforces the new rules, all nodes will continue to converge on a single chain.

In a hard-fork existing rules are loosened or eliminated and thus allow previously invalid transactions and blocks to become valid. Nodes must upgrade their clients in order to stay on the hard-forked chain. Multiple alternative chains can co-exist if they gain/retain miner & user traction (e.g. increasing the block reward, increasing the maximum base block size). This leads to a default of a chain split, unless all

the nodes on the network update their software by the time the rules change. It can then be controversial which version constitutes the original chain. Exchanges have a strong influence over which ticker symbol refers to which chain. In the case of Ethereum, the Ethereum foundation controls the trademark for Ethereum and can thus define what constitutes "original" Ethereum (as opposed to Ethereum Classic).

The consensus layer is by far the most difficult to change since it defines the rules determining whether a particular block (and thus, a particular blockchain) is valid. This includes checks for proper block data formatting, size limits, ensuring the block reward is not excessive, making sure all coins being spent actually exist, checking transaction signatures, and so on. Any change to these rules could create a chain split (not all changes/upgrades demonstrate changes in consensus rules but could be simple optimization).

Highly controversial forks are particularly forks where miner/validator preferences and user preferences conflict.[107]

Bilateral hard-forks: Rulesets are incompatible forward & backwards. Users, investors & exchanges drive value of competing forks – miners usually follow the most valuable/ profitable opportunity. (e.g. Ethereum & Ethereum Classic split after the DAO hack - Ethereum altered the contract in order to return the lost funds, while EthClassic did not - they are incompatible forward & backwards. Both chains have been continued, while Ethereum sustained a considerably higher market capitalization, which attracted more hashpower by miners.)

Strictly expanding hard-forks: Strictly expand the set of transactions that is valid. Arguably the non forked chain will be accepted as the longest chain by both original-client and forked-client rules - and thus the forked chain "will be annihilated", as the original chain will likely have the higher hash-rate. In order to eliminate that risk, it is advisable to make the fork bilateral (e.g. a Bitcoin fork increasing its rule for block size to 2MB so that blocks (max 1MB) of the original chain would still be accepted by the new chain to comply with the ruleset).

"User-activated soft-forks" (UASF): Users (non-mining full-nodes) switch the soft-fork rules without consensus from miners - miners are expected to follow along due to their profit motive. However: miners can fight back by creating their alternative "miner activated soft-fork" (see later in Bitcoin case study).

3.4 Off-chain

On-chain vs. off-chain governance refers to whether the means of decision-making are on the blockchain or off the blockchain. Actors that coordinate through meetings and online chats is an example of off-chain governance, while actual

changes still need to be implemented in client software and cause a fork to come into effect (see case studies later). In almost all cases, there is some combination of on- and off-chain mechanisms employed.

The possibility to fork is also one of the most crucial properties of public blockchains as it always provides a group of stakeholders for the ability to exit, if they were unsuccessful in voicing their values and viewpoints. Thus, social consensus is in the end the deciding factor in blockchain governance.

Most protocols have chosen rather centralized governance processes where only entities with credible threats of forking have clear influence. Ultimately, contentious forks represent the greatest threat to the stability of blockchains, and they are especially problematic for protocols encouraging experimentation on layer 2.

Proposal systems

In multiple cases there are (semi-)formalized proposal systems such as BIPs (Bitcoin Improvement Proposals) in order to suggest changes to the protocol that are conducted off-chain. However, the discussion around formal and informal proposals is shaped in various channels ranging from dedicated forums to social media platforms and exclusive conferences and meetings.

Resource/fund allocation

The overarching theme of governance that is also touched by changes in rulesets/protocols/company bylaws is the allocation of scarce resources. Crypto networks often instantiate a foundation or other legal entity, which is responsible for allocating a budget that has been raised for furthering the network and its goals. Besides non-profit foundations there can also be for-profit companies that can generate revenue by acting as service providers to the network, hold a share of the token supply and work to make its value increase or provide auxiliary services.

Decision making is regulated by the legal set-up and leadership in the respective organizations, which is more or less centralized. Often grant programs fund initiatives that should improve the protocol and solve R&D or implementation challenges.

3.5 On-chain

On-chain governance refers to stakeholders influencing a protocol's parameters through signaling that is recorded on the blockchain. Usually, a tightly coupled mechanism is assumed so that agreed upon decisions are automatically enforced through the blockchain.

Both the protocol itself as well as entities built on top can be governed by an on-chain mechanism – the rules are enforced by the blockchain.

3.5.1 Building blocks beyond forking

On-chain proposal system

Besides off-chain proposal systems, proposals could be formally made on-chain, and then voted upon (or created and stored off-chain with hashing proposals on-chain, in order to have an immutable audit chain but save on-chain resources).

Voting

Various kinds of voting systems could be implemented on-chain, while there are challenges in the details.

Token holder voting (1 token 1 vote) / Plutocracy / Shareholder Value Maximization

Token holder voting (1t1v) is relatively simple to implement in a decentralized setting and thus currently the dominant approach among on-chain governance systems. The main criticism is the inherent plutocracy – the rule of the wealthy (and thus also the threat of being captured by potentially hostile, external, wealthy entities). It is akin to shareholder-value maximizing corporate governance, which one could argue leads to stakeholders which have skin-in-the-game being incentivized to act in proper diligence to represent their stake. Probably, this is only viable if there is a more democratically governed meta-system in which the system in question operates and through which it is being constrained, that takes into account market failures such as external effects (such as regulation by a well-functioning state).

1 person 1 vote

A widely known principle in democracies – 1 person 1 vote – can be implemented in various settings, the simplest of which is direct democracy. The biggest challenge for implementation is that it requires an identity system (confirming someone is a unique person). So far there has not been a fully sybil resistant and decentralized identity system. Potentially, one has to accept trade-offs to some extent. Related to this, Glen Weijl has argued that as long as blockchains formalize ownership but not identity, it will always be anti-democratic, but plutocratic.

Liquid democracy

Liquid democracy describes a system in which voters can delegate their votes to experts, potentially only in certain domains and vote if a certain case or domain is of particular interest. It is particularly well suited for a blockchain-based system, as delegations can be programmed in a fine-grained fashion. One can imagine various settings including previously mentioned 1 token 1 vote delegation, but also 1 person

1 vote. All in all, the approach is an attempt to merge the best of direct and representative democracy.

Quadratic voting

Quadratic voting also requires identity, as it assigns a certain vote budget to a voter, which can be allocated to different domains or elections depending on subjective importance. Crucially, the more someone allocates to one domain, the more expensive a vote becomes (quadratically). This is especially interesting in alleviating some drawbacks in traditional voting systems, such as a certain disregard for minorities. A minority that particularly values a specific policy can assign a higher weight to it and make it count more against a majority that might not put the same emphasis on the same policy.

Reputation based voting

Votes could also be counted according to some quantified measure of reputation that a voter can build up according to some ruleset (see evaluative infrastructures). This has the dual effect of governing actors towards a shared goal, as they are incentivized to build up reputation (as on average actors value influence over projects they value), while granting them governance power over the properties of the shared goal, protocol or other aspects of a project. Such reputation systems could be multidimensional, taking into account expertise in different domains. While a great potential is to assign knowledgeable and motivated community members more weight and thus improve the quality of governance outcomes, the system is prone to concentration of power in a technocratic elite with the time, knowledge and reputation to vote and decide on policy change. An interesting spin on reputation systems in a wider sense are the pagerank inspired evaluative mechanisms for open-source software by Oscoin[108] as well as SourceCred[109] (value creation is measured by how much software depends on a contributor or a piece of software and assigns reputation scores - see evaluative infrastructure; as a next step there is a vision for a token that is distributed to projects and individuals depending on the score). A controversial aspect is how and if it is feasible and necessary to include open-source work in a wider sense beyond pure code commits, which are however harder to measure objectively through dependencies.

Voting issues

Caplan[110] observes that voters' democracies rarely have incentives to consider their thoughts thoroughly. This stems from rational ignorance, as most policy decisions don't have immediate impact on the welfare of most voters. Thus, voters are often apathetic. However, if voters have explicit economic value at stake, it has been shown that votes are carried out even against certain biases.[111] It is generally accepted that voting in secret is important in order to maintain individual sovereignty and resistance to bribery. However, in electronic voting it is easier for bribery to be observed and smart contracts can easily automate and enforce bribery attacks. Attackers can simply post an open offer to anyone who votes in his favor.[112] Later, Daian[113] suggested permission-less, bribery resistant mechanisms:

Users can be provided with a secret channel that lets users defect from a briber without anyone being able to tell, using "complete knowledge" proofs to make sure there is no trusted execution environment (such as Intel SGX) or secure multi-party-computation (MPC) preventing channel use. Thus, bribery is not effective, as one can always take a bribe and then still vote otherwise.

Voter information & manipulation

Even if voters are fully honest and willing to exert the necessary effort (cognitive cost) to consider alternatives, their behavior is highly influenced by the information they are presented. Independent media has been historically a crucial public good for functioning democracies. In recent years, however, voter manipulation on social media has reached increasing scale.[114] (see Cambridge Analytica) Possible solutions are novel approaches to news curation, also potentially on decentralized platforms (such as Relevant[115]) as well as traditional approaches of funding independent quality journalism.

Specifically in the context of crypto-economic systems, there have been tools[116] suggested that simulate the consequences of certain policy decisions in order to provide automated decision support systems for voters. It is especially important that the code and data powering those tools is open source, to enable anyone to critically assess the underlying assumptions of the simulation in question.

On-chain budget allocation

Various mechanisms for budget allocation can be implemented on-chain as smart contracts that enforce compliance. The previously mentioned voting mechanisms can be integral parts of such.

Grant DAOs

A phenomenon that has gained traction is DAOs forming around certain goals that are related to furthering the mission of cryptonetworks.

The term DAO will be used as it is the acronym that has gained more widespread momentum in practice, even though the level to which projects are autonomous is blurry (and decentralized organizations DOs or decentralized collaborative organizations DCOs could fit better). One could argue autonomy is meant in the sense that an automated objective function such as the Bitcoin PoW mechanism coordinates the organization. On the other hand, autonomy could reflect the extent to which a set of humans that vote on issues, are autonomous from actors that are outside of the group or the extent to which code used by a group to coordinate themselves runs autonomously from third parties.

A couple of them or the frameworks they depend on will be elaborated on in the case study section below. In general, donators that can include private individuals, companies or foundations pool funds that are then allocated according to the DAO member's votes.

Quadratic funding mechanism

Rooted in quadratic voting, quadratic funding is a proposal[117] to allow (near) optimal provision of a decentralized, self-organizing ecosystem of public goods (such as open-source software that makes up blockchain protocols).

An entity/entities put up a budget to be allocated towards public good initiatives (e.g. projects that enhance Ethereum). The budget could be funded through sources such as donations, token sales or continuous token issuance towards that specified purpose. The common budget will be allocated according to the square of the sum of the square roots of contributions per person (additional donations towards a specific project) received. Again, like in quadratic voting, the mechanism relies on reliable identity as the idea is that many small contributions are matched to a larger extent than few large contributions. In the extreme case of 1 large contribution, one can assume that only this one entity derives utility from the project (private good), while many individual contributions show that many individuals derive utility (tending more towards a public good). While similar issues like elaborated on in voting such as manipulation or collusion could be problematic, first experiments (Gitcoin grants) have been quite positive, with changes in the formula implemented though (attempting to reduce the impact of collusion).[118]

4 Projects & approaches

After having established the theoretical groundings of different perspectives on governance that are related to Blockchains and their ecosystem, a couple of case studies of projects and approaches in the space will be laid out. While governance of various blockchains has many aspects that cannot feasibly be described in their entirety in this paper and their approaches build on each other, the most distinct features of the projects as regards to governance are discussed. First a selection of layer 1 cryptonetworks/DAOs are presented, followed by a selection of layer 2 DAOs as well as DAO/dApp frameworks that allow easier composition of such.

4.1 Bitcoin – Layer 1 DAO

Bitcoin: A Peer-to-Peer Electronic Cash System – has been coined the first DAO (Decentralized Autonomous Organization) in which a distributed network of peers, with roughly aligned incentives is providing a censorship resistant form of digital cash/digital gold, without central control or intermediation.

Community norms entail a strong libertarian value-system valuing decentralization above all else that is heavily influenced by Austrian Economics. Social consensus favors a disinflationary monetary policy, which is deemed sound money.
A separation of powers between developers, miners and users allows no stakeholder to force decisions unilaterally on the others. As a result, Bitcoin is a very slow moving but stable network. Trustlessness is a crucial factor:

"Use bitcoin without trusting anything but the open-source software that you run".
However software can and needs to change, which brings about the need for (humanled) governance of the infrastructure.

Bitcoin governance is the process for maintaining transaction and block verification rules and forming an intersubjective consensus of what Bitcoin is.

As a DAO, the tricky question arises of how a leader-less, autonomous organization is governed and can evolve with a changing environment. Bitcoin governance works, albeit not perfectly (surfacing various controversies), and is archetypical for further DAOs and inspired various novel designs, which will be further outlined in an exemplary fashion.

The Bitcoin Core Github repository (the dominant client software, which almost all nodes & miners run), is owned by a single entity identified by an email address as well as login data: https://bitcoin.org/. Bitcoin.org in turn is co-owned by pseudonymous Github accounts Cøbra aka Cobra-Bitcoin as well as theymos, while it was originally registered by the Bitcoin whitepaper author Satoshi Nakamoto (according to theymos through anonymousspeech.com).

The independent Bitcoin Foundation (instantiated by a group of early developers and believers, headquartered in Washington DC) as well as bitcoin exchange Paxful sponsor the site.

However, the following statement on the website:

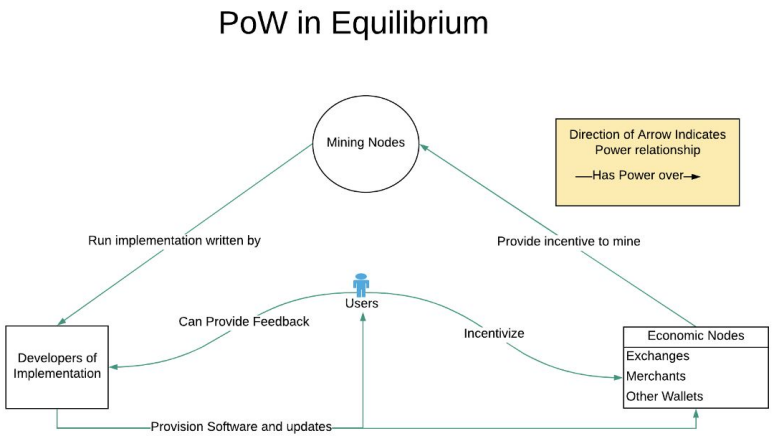
Bitcoin.org is not Bitcoin's official website. Just like nobody owns the email technology, nobody owns the Bitcoin network. As such, nobody can speak with authority in the name of Bitcoin.

Further, the site states that: *"Bitcoin is controlled by all Bitcoin users around the world. Developers are improving the software, but they can't force a change in the rules of the Bitcoin protocol because all users are free to choose what software they use. In order to stay compatible with each other, all users need to use software complying with the same rules. Bitcoin can only work decently with a complete consensus between all users. Therefore, all users and developers have strong incentives to adopt and protect this consensus."*

Technically however, the maintainers of the bitcoin Github repository are responsible for merging any new code commits with the main repository, only if it has been sufficiently reviewed and tested (currently 5 developers[119], the most recent one was nominated at an invite-only core dev meeting of the most active contributors and added to the maintainer list by existing maintainers).

This has a couple of crucial implications:
There is little user influence over decision-making on core development beyond politicizing on social media. However, the user-activated-soft-fork (by users running full-nodes) is argued to demonstrate the case, how finally users are in control over what bitcoin is.

Andreas Antonopolous[120]: *"Bitcoin holds an election every 10 minutes – to decide the greatest difficulty, valid chain, but also it is nodes choosing the validation rules they want to support – it is 5 constituents of consensus: miners, developers, wallets, exchanges & merchants (think of it as a ⅘ multisig – if you try to carve away from the other constituents, you get burned – by losing rewards)"*



Source:
Decred Community[121]

The figure above showcases the Bitcoin network in equilibrium. A main argument highlighted is that users are ultimately in control, as they choose how to use it, by selecting relevant economic nodes (full-nodes as well as interfaces to the fiat financial system - exchanges - or goods and services - merchants), where the economic value of Bitcoin is manifested. Mining nodes are predominantly profit-driven actors that follow economic value (see also later, the case of the UASF and the role of full-nodes in shaping consensus).

The (unformalized) Bitcoin governance process[122]

Proposals

Anyone, who discovers a solution to a problem or an improvement such as a protocol researcher, is free to share their proposal with other protocol developers. This could be through the bitcoin-dev mailing list, a white paper or a Bitcoin Improvement Proposal (BIP). Almost all soft-forks have gone through the BIP process.[123]

Implementation

Proposals that gained traction in the community (e.g. by favorable peer review) are implemented through writing tangible code changes by the proposing researcher and peers. Further, the maintainers of the reference implementation (previously mentioned: bitcoin core, ca. 99%[124] of nodes) need to merge the changes into the main codebase, which they won't do if it is seen as controversial/contentious (thus oftentimes stuck in indecisiveness). Changes can be however made to a fork (copy) by anyone, which might gain traction as an alternative project such as Bitcoin Cash (hard-fork) or through a user-activated-soft-fork (see below for UASF case study). Some changes can, however, only be implemented as a hard-fork (such as SegWit).

Bitcoin had only planned soft-forks (hard-forks are alternative coins such as bitcoin cash; soft-fork vs. hard-fork: forward compatible – vs. forward incompatible)

Deployment

Once the client software is changed, users need to be convinced to update it – nodes such as block explorers are more important than other users, as many use light-clients and delegate validation to such full-nodes. If there are contentious hard-forks, exchanges have power as they control what version of bitcoin corresponds to the ticker symbol BTC. They are however kept in check by other exchanges.

MASF (Miner Activated Soft-fork): Miners can signal on-chain by hash-rate (BIP-9 Version bits with timeout and delay).[125] Miner support for soft-forks is measured on a continuous basis, which is seen as a proxy metric for the wider community (activate if 95% of hash-rate signals). 95% was chosen to be on the safe side to not

cause chain splits but was never intended to be a vote. Soft-forks are supposed to be vetted and discussed in the community and the threshold should merely solve the coordination problem of transition. Even though soft-forks do not require all nodes to update at once, miners should update to enforce the new rules to ensure they don't end up mining blocks that will be rejected by nodes that enforce the new rules. However, miner signaling allows a minority of hash rate to veto node activation of an upgrade for the whole network. Today, soft-forks have taken advantage of the rather centralized mining space where a couple of mining pools build valid blocks. As we move towards more decentralization of hash rate, it is likely that we will exhibit even more inertia as most upgrades will be vetoed. Thus, it has become apparent that miner activation cannot be relied upon if there are diverging interests (see SegWit later).

Before the norm of miner activation, Bitcoin relied on flag date and block height activation which depend on economically important nodes (such as wallet providers) updating their software as the incentive for miners to follow suit (newly installed client software will shift to the new ruleset automatically on a specific date/block number). This mechanism has been termed a UASF (User Activated Soft-fork). In fact non-mining full-nodes have a strong influence on transaction validation and governance, as they propagate valid blocks in a random fashion throughout the network (detailed explanation[126]).

User activated soft-fork (UASF)

The case of a user activated soft-fork (UASF) around the contentious SegWit & SegWit2x proposal in order to solve the long-lasting scaling debate illustrates the dynamic: Segregated Witness (SegWit) has been suggested already in 2015, implying that signature data is stored in a segregated side chain in order to save space and allow for more transactions within the 1MB block-size limit, besides solving transaction malleability (technical details[127] go beyond this paper).

In order to activate SegWit (BIP-141[128]) in the usual manner, 95% of miners signaling would have been necessary; no majority was however formed by the miners, partly it has been argued, the increased capacity from SegWit would lead to lower fee revenues for miners. What is more it also reduces certain advantages for ASICs, application specific integrated circuits - specialized mining hardware (especially Bitmain was against the soft-fork, who is the leading manufacturer of such).

A developer introduced BIP-148[129] in March 2017 on Github as a User-Activated Soft-fork in an effort to force miners to signal for SegWit.

If BIP-148 was left unchecked, blocks that miners mine would be rejected by nodes if those miners did not signal support for SegWit (which would activate automatically on August 1st). Miners not signaling for SegWit would waste electricity costs and would not earn rewards by mining non-SegWit blocks.

"The New York agreement": At Consensus 2017, over fifty businesses in the space came to their own compromise of lowering the SegWit activation threshold from 95% to 80% in exchange for agreeing on working on a hard-fork to double the block size within 6 months (SegWit2x). The settlement was agreed upon two months after BIP-148 was introduced as a user initiative.

On June 14, 2017, Bitmain published a blog post made available in eight different languages titled "UAHF: A contingency plan against UASF (BIP148)"

UAHF is Bitmain's User-Activated Hard-fork (which didn't make much sense since they were miners with a minority user following) that eventually became Bitcoin Cash. If BIP-148 were activated, to protect the miners mining non-SegWit blocks, Bitmain and company would simply hard-fork into their own chain.

James Hilliard introduced BIP-91 early-June to make BIP-148 and S2X compatible and allow NYA signatories to save face. It was not until mid-July that his proposal started gaining community attention and above all, acquired enough mining support to finally enable the original BIP-141, or Segregated Witness, with +95% consensus.

Enforcement

The decentralized p2p network of fully validation nodes use the verification rules to independently verify that transactions are included in valid blocks. Nodes will not propagate blocks which do not follow the rules.

Miners exercise a proof of publication function ("timestamping") with proof-of-work for transaction ordering, deciding which as valid propagated transactions get included in the blockchain. Most individual miners of a mining pool do not run full-nodes (as it is not necessary to participate in a pool, while causing costs) and thus rely on the pool operator for validation, which has become quite centralized.[130]

Theoretically, the benefits of user-side validation are optimized if every user runs an independent "ideal full-node" - a node that accepts all blocks that follow the protocol rules that everyone agreed to when creating the system and rejects all blocks that do not. However, as long as there is a relatively large number of them, and they come from diverse backgrounds, the coordination problem of getting these users to collude will still be very hard.

"This is the essence of engineering decentralized institutions: it is about strategically using coordination problems to ensure that systems continue to satisfy certain desired properties." Vitalik Buterin[131]

The coordination problems mentioned refer to cartel-like behavior that becomes easier as there are less and larger entities participating in the network. This

highlights the importance of a highly decentralized network in aspects such as the number as well as demographic/geographic diversity of full nodes, miners and client implementations.

Asymmetries in incentives and slow progress

Incentives in Bitcoin governance are not perfectly aligned. Miners push for changes (or resist change, such as SegWit) which increase future cumulative transaction fees, while developers do not care as long as the value of Bitcoin keeps going up.

Developer's direct economic incentives are weak - new developers have little incentive to work on Bitcoin as there is no direct way to earn money by doing it - as a result they work on new projects / creating their own tokens. As a result, hardly any new core developers are entering and a self reinforcing cycle of more power becoming concentrated in a small group of early core developers, slow technological advancement and conservatism has been established. However, exactly this conservatism and resistance to change, in combination with a less complexity in comparison with smart contract platforms is often praised to maintain a high standard of security in Bitcoin.

Other Blockchain projects, especially those that incorporate on-chain governance, attempt to create systems that are more adaptive and eager to change.

4.2 Ethereum – Layer 1 DAO

Ethereum is a decentralized platform for applications that aims to resist fraud, censorship or third party interference.

It expands Bitcoin with its Turing complete scripting language, while retaining the general concept of proof-of-work mining (though with a tangible roadmap to transition to proof-of-stake).

Ethereum governance has many similarities with Bitcoin governance, as the whole system is very much inspired by its predecessor's design.

Governing Ethereum in a narrow sense is about changes to the core protocol (the specification), which affect client implementations (repositories, as well as miners and users executing those implementations) and as a result of adhering to the protocol, the blockchain (data layer) is governed, which then affects applications built on the layers above.

However, the community (people) represent Ethereum in a wider sense and the Ethereum Foundation is its core, if not the most influential stakeholder of the

community. The values of the community affect how people behave and how the wider world perceives Ethereum.

Vitalik Buterin, Ethereum's inventor is still the most influential figure in governance, as he is well respected by the community. However, himself and the foundation (which he mostly steers) have and want to give away power, in order to have more diffuse influence and avoid single point of failures. His high-level viewpoint is that L1 (layer 1) does not have to be innovative and agile, but rather slow and stable (once it is feature complete).

Increasingly, Ethereum development resembles the often quoted bazaar[132] model of open-source development. Radical openness is an important value that has attracted a great level of engagement from the community and talents self-select to pressing issues in research and development (frequent communication from the foundation[133], 62 contributors to the Eth2 specification[134], 9 independent client implementations, R&D discussion on ethresear.ch[135], open and livestreamed all dev calls).

The community does increasingly appear to follow norms and precedents (creating Schelling points[5]) established at critical junctures (e.g., the DAO hack) – however still lively debated different viewpoints.[136]

Much legitimacy is now tied to the technical road map and existing governance processes that it would be hard to change course.

What is more, Ethereum governance is influenced by various stakeholder groups, discussion platforms as well as processes.

4.2.1 Stakeholder groups

Formal

- Ethereum Foundation (managing token sale proceeds – providing grants, managing core go-ethereum Github repository)
- ConsenSys (dapp development studio founded by Ethereum co-founder Joe Lubin)
- Parity (prev. Eth-core – founded by technical yellow paper author Gavin Wood)
- Infrastructure (Infura, Metamask, MyCrypto, etc. – querying services & front-ends through which many users interact with the chain, which demonstrate thus important full-nodes)

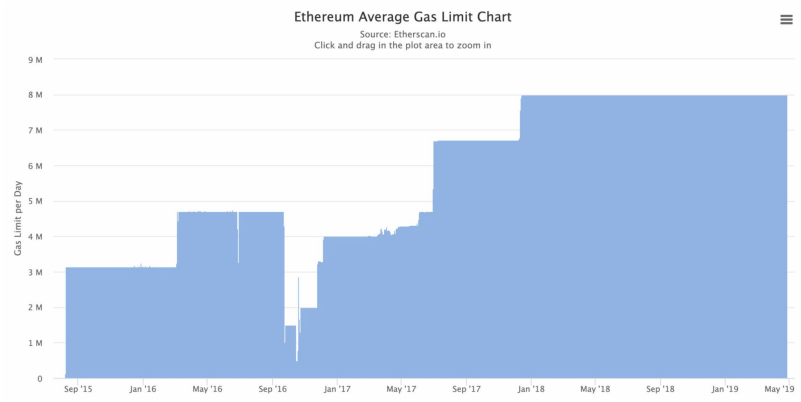
Informal

- Core developers (core client developers – mainly geth by the foundation & parity)
- Fellowship of Ethereum Magicians (technical council, everyone is welcome to participate)
- Cat Herders (project management team instantiated in 2019 to support in administrative an coordination matters)
- EIP editors (currently 5, decide upon formal correctness of EIPs – see below, no judgement regarding subject of the EIP)
- App developers: Teams of ETH-incentivized developers (ERC20s are usually funded with ETH) have a greater role in protocol governance than miners and VC-backed startups do in Bitcoin governance
- Miners/validators
- Investors
- Ethhub & Ethresearch (go to informational websites & forums)
- “The wider community”

4.2.2 Processes/mechanisms

Many members of the community dislike formalized processes as they see the threat of them being captured by providing a well-defined surface area for corruption (e.g. hostile take-over; incomplete contracts – never all circumstances can be foreseen – if formalized, decision makers can maneuver around).

All off-chain governance – except small gas-limit adjustments



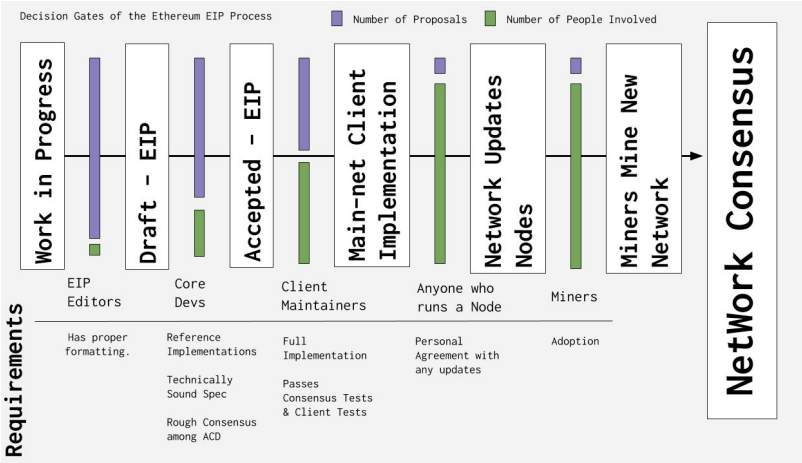
The most part of Ethereum governance is carried out off-chain, while there is one exception: The per block gas limit. Miners are able to move the per-block gas limit up or down by 1/1024 per block produced. For example in December 2017, due to rapid increase in network usage, miners moved the gas limit from 6.7M gas per block to 8M gas per block (in order to support more and/or more complex transactions).

One of the few formalized processes is the EIP processes, defined in EIP1.[137] Connected to a discussion[138] around sources of legitimacy of Ethereum governance, community members have argued that core devs inherit legitimacy from participating in the EIP process, which is open for everyone to participate and has well-followed rules. While not being a settled debate, another interesting argument for legitimacy of the EIP process is that it is being used and there are precedents of projects that came before with similar processes.

Ethereum Improvement Proposal - EIP process

Similar to BIPs (Bitcoin improvement proposals) that in turn have been inspired by Python Improvement Proposals, EIPs are Ethereum Improvement Proposals. An EIP should provide a concise technical specification and a rationale of the feature. The author is responsible for building consensus within the community and documenting dissenting opinions.

Parties involved in the process are the champion or EIP author, the EIP editors, and the Ethereum Core Developers. It is recommended to gain feedback for an idea first through opening a discussion thread on the Ethereum Magicians forum, one of the Ethereum Gitter chat rooms, the Ethereum subreddit or the Issues section of the Ethereum Github repository.



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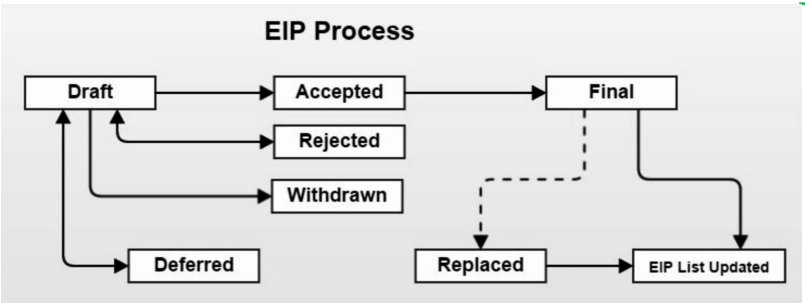
https://twitter.com/JHancock/status/1153870305154281472?s=20



Source:
Mastering Ethereum, 2018

In the following the statuses of EIPs are explained to highlight the process.

Work in progress (WIP): Once the champion has gathered feedback, he will write a draft EIP as a pull request.

- Accept: The EIP editor will assign the EIP a number and merge the pull request. The EIP editor will not unreasonably deny an EIP.
- Reject: Reasons for denying draft status include being too unfocused, too broad, duplication of effort, being technically unsound, not providing proper motivation or addressing backwards compatibility, or not complying with the Ethereum philosophy. Draft: Follow-up pull requests with further changes to the draft should be posted until it is deemed mature enough.

- If agreeable, the EIP editor will assign Last Call status and set a review end date, normally 14 days later.
- A request for Last Call status will be denied if material changes are still expected to be made to the draft.

Last Call: EIP will be listed prominently on the https://eips.ethereum.org/ website

- A Last Call which results in material changes or substantial unaddressed technical complaints will cause the EIP to revert to Draft. Accepted - Core EIPs only – a successful Last Call leads to a core EIP being considered accepted (e.g. non-core EIPs are meta EIPs such as processes and guidelines as well as ERC standards as they don't modify any functionality that requires new network consensus, they are only application logic implemented where there is a decentralized consensus network): Further changes to the EIP are unlikely and client developers should consider it for implementation. Only changes to the core protocol that need to be implemented in Ethereum represent core EIPs. The all core devs meeting is a good platform to discuss and convince the leading client developer teams to implement the EIP.

Final - This EIP represents the current state-of-the-art.

- Non-core EIPs are considered final if they pass the Last Call stage
- Core EIPs are considered final if at least three viable Ethereum clients implement the change

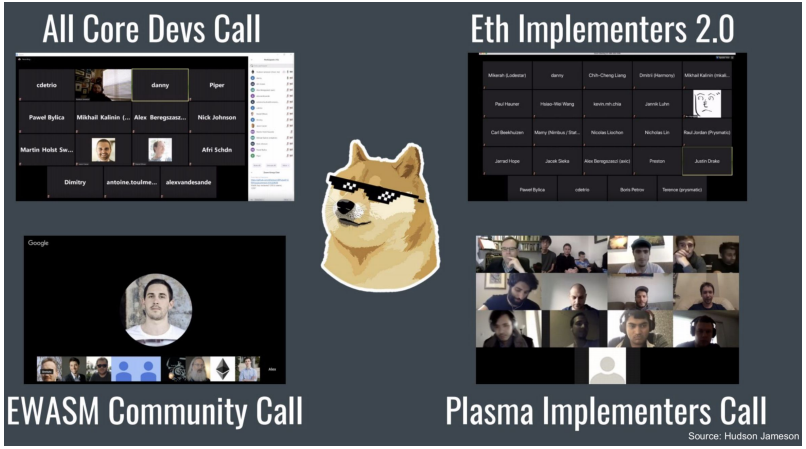
Discussion & decision-making bodies

All core devs meeting

The all core devs[139] meeting call is happening bi-weekly to discuss current proposals on a regular basis. Anyone is free to join and make proposals, while calls are recorded and uploaded on youtube.com for anyone to view (in 2019 on average 20-30 people participants). The calls are facilitated by Hudson Jameson, the only community Manager employed by the Ethereum Foundation, while anyone can suggest points to the agenda on Github. The practice can be interpreted as a developer technocracy, while developers are highlighting the fact that only technical issues are being discussed and no political decisions are taken in order to avoid legal liability (while in practice it is hard to separate and technical variables often have political implications, which makes it challenging).

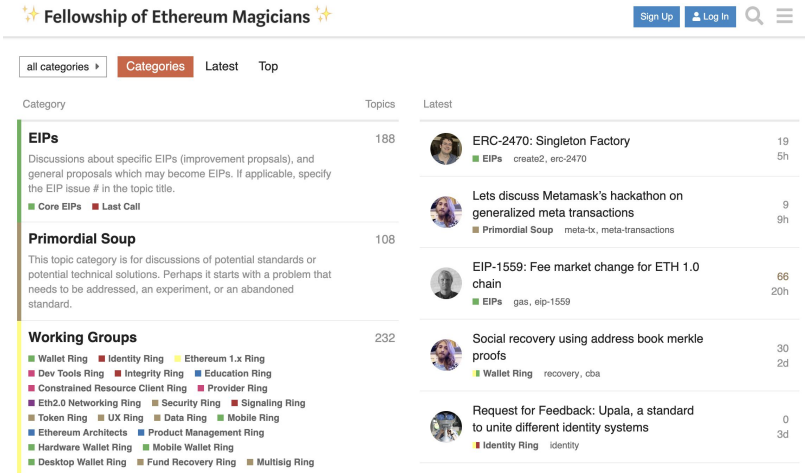
There is the mantra of "rough consensus and running code" modeled after IETF[140] (Internet Engineering Task Force) decision making. Humming is used to gage the level of consensus in the room, while formal voting is neglected. While boiling down rough consensus to a certain quantitative level of agreement is opposed, one can say that 51% is not rough consensus and 99% overachieves it. Mainly, it is aimed at addressing any objections that might arise thoughtfully in order to protect minority interests. Also, the IETF tries to avoid policy and business decisions as far as possible focusing on engineering questions.

Protocol changes are usually decided on in all core devs meetings, while individual client teams (consisting of core developers) then go on to implement them. In order to become a core developer, one either needs to be accepted by an existing team (see training and indoctrination in open-source) or start a new client implementation (which will start out with no adoption).



Source:
Hudson Jameson – facilitator of All Core dev meetings and contractor of the Ethereum foundation (all core devs call as one of regular calls happening as community interfaces for coordination)

Traditionally there have been specific Meta-EIPs that would combine various individual EIPs in order to integrate them for a combined hard-fork. Often, the attempt to batch everything planned, from multiple teams, into one specific combined upgrade led to delays. More recently an improved process has been suggested[141] that would mainly define bi-yearly upgrade dates, which include every update that has been deemed ready by then.



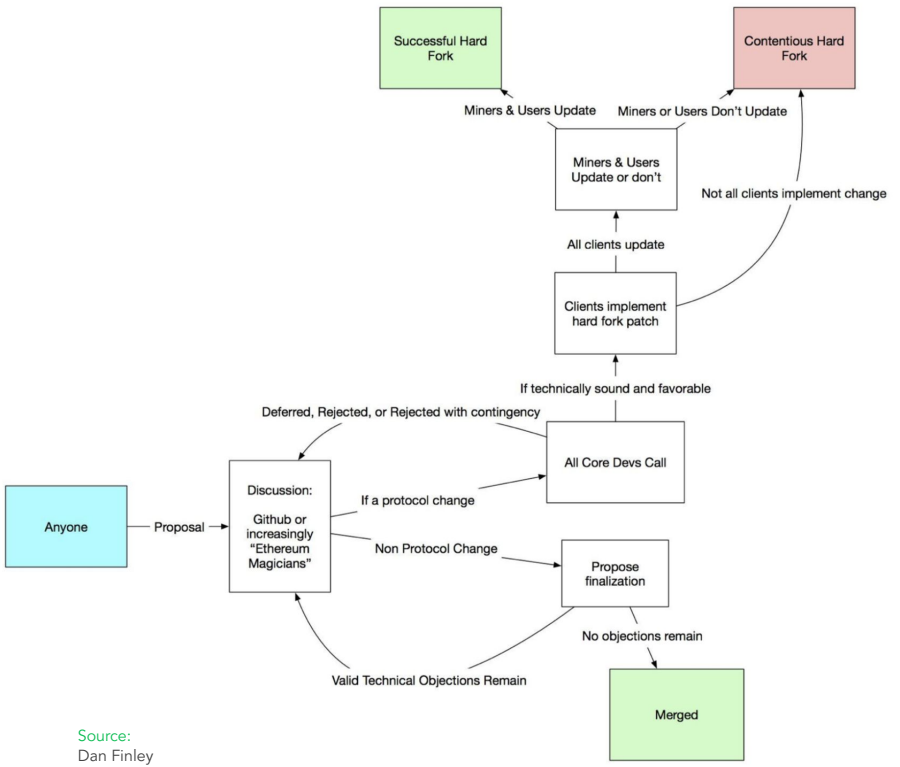
Source:
https://ethereum-magicians.org/

The Fellowship of Ethereum Magicians

The Fellowship of Ethereum Magicians (FEM) is an open technical committee, also modeled after technical governance committees such as the Internet Engineering Task Force (IETF). The FEM is intended as a forum for developers to discuss the merits of various technical proposals, the topics are however more wide ranging than those discussed in all core devs (such as wallets, signaling and dapp business models). They have been holding in-person gatherings in various countries, while an online interface provides for continuous and asynchronous discussion. Different working groups are formed as “rings” and decision making also follows the “rough consensus and running code” mantra (successful outcomes of working groups are further developed into EIPs). Certain individuals are facilitating the discussion as ring leaders.

Source:
Lane Rettig

Proposal implementation & rollout



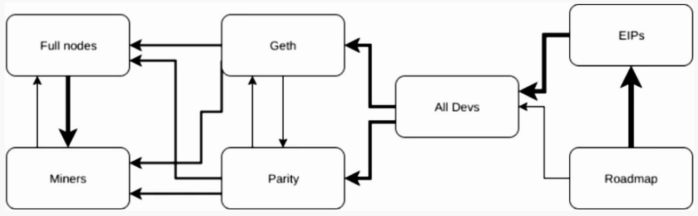
Source:
Dan Finley

The figure above illustrates the process again. If an EIP is non-core, it does not need to be implemented by client developers, while core EIPs do. If there is consensus around a given hard-fork all miners & users update and the network remains one logical entity.

Implementation by different client teams requires coordination and in order to enable a smooth transition, updates are first rolled out on test-networks.

Once clients implement a change, the updated software needs to be adopted by full nodes as well as miners in order to actually change the running network implementation. Protocol changes come into effect at a specific block number/ height (and thus specific point in time in terms of the blockchain). Nodes running the old client software after this date will be incompatible with the new version in case of a hard-fork (which has been the common upgrade path for Ethereum).

Contentious hard-forks could lead to a network split such as experienced when Ethereum split into Ethereum and Ethereum Classic after the discussion around TheDAO exploit. The community was discussing whether immutability and strict interpretation of code (Ethereum Classic viewpoint) or the widely assumed intent of the code (Ethereum viewpoint) should be honored, and whether a hard-fork should be utilized in order to reimburse investors in TheDAO by affecting ex-post state changes.



Source:
Vlad Zamfir – Core protocol changes

The figure above is an illustration highlighting the fact that in general the discussion around EIPs is informed by the roadmap, which forms a reference point for the community in making proposals and deciding on changes. As mentioned earlier, the all core devs meeting is the usual interface to convince client developers (Geth & parity are the dominant clients) to implement core protocol changes.

As discussed in Bitcoin governance, full node adoption has a strong influence over miner adoption and miners are widely assumed to be simply profit driven, rational actors that will adopt the software that maximizes their chances for finding valid blocks in the most widely used and thus most valuable network.

Informal processes & interfaces

As mentioned above the Ethereum community dislikes the idea to have a fully formalized governance process, such as tightly coupled on-chain governance (to avoid capture of said process). Even if there would be a formalized process, there would arguably be many informal avenues influencing the process (and potentially capturing it and thus implementing some hidden agenda by a select stakeholder group). Following, an exemplary set of informal processes and interfaces are provided:

- Devcon, conference sidebars
- Chat groups such as Telegram and Gitter
- Open forums such as Twitter and Reddit
- Regular calls (see e.g. Plasma implementers call)
- EIP0
- “The roadmap” – established vision
- Tyranny of structurelessness (a concept that has been discussed within the community, surrounding the forming of implicit hierarchies due to asymmetries in information, charisma, social capital, financial capital in a non-formalized or supposedly “free” system)

Signaling

The goal of successful network governance is to drive changes that are aligned with as many stakeholders as possible in order to remain a cohesive network. Alternatively, minority factions might fork off and create a competing network (hard-forks - as described above), which is a crucial power dynamic as it forces all participants to take into account the other stakeholders. When splitting, it can often be argued that the individual networks are less valuable as a whole and to individual participants, than one cohesive whole, due to network effects.

Core developers are usually trying to gauge the opinions of the wider community in order to consider stakeholder interests.

Over the time there have been a couple of approaches to gather community input in a quantifiably way, by allowing stakeholders to signal their view.

One mechanism has been signaling based on token holdings (such as carbonvote initiated after the DAO hack). Recently, there have been other examples of coinvotes, all with relatively low participation rates (well under 3% of ETH participating).

Another mechanism utilized has been signaling by proof-of-work miners, whose signals are weighted based on the hash-rate they contribute to the network.

Ethsignals (previously Tennagraph)

Ethsignals is a community initiative aiming at aggregating and displaying different signaling approaches. Besides coin voting, they currently display gas voting and the verified stances of influencers in the ecosystem.

Gas voting is supposed to take into account the intensity as well as duration an account has been using Ethereum, as opposed to simply owning tokens currently (the weight of an account is determined by the cumulative gas that has been spent for processing transactions). The concept has so far not been widely used (2 EIPs informally voted on so far).

Further community input

EIP0 survey 2018

The EIP0 survey[142] aimed at discovering the values of the Ethereum community, their perceived strengths as well as weaknesses, with around 200 respondents. Governance was one of the most highlighted problem areas, while I would argue the survey itself is part of Ethereum governance and an attempt to improve it. As opposed to the survey from 2019 covered below, the EIP0 survey was conducted using open ended questions, of which a couple of interesting examples are provided.

"What does Ethereum stand for? What do we want Ethereum to become? While some people are immutability maximalists, some are not."

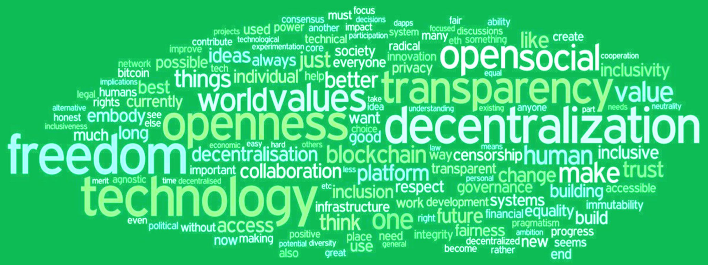
"…the post-parity hack discussions were kind of a mess. Everyone seemed to be talking over each other, rather than at each other. No one seemed to understand each other's perspectives"

"While not "failing," I feel that the Ethereum Foundation needs to become increasingly decentralized and transparent.
This could take the form of adding more contributors, more articles about what is being worked on, and so on. We want to avoid the perception that decisions and meaningful work is happening in the proverbial smoke-filled room"

Ethereum governance survey 2019

In 2019, another survey[143] has been conducted in order to gain a better picture on the demographics, values and viewpoints of the community. Two examples of the results are provided.

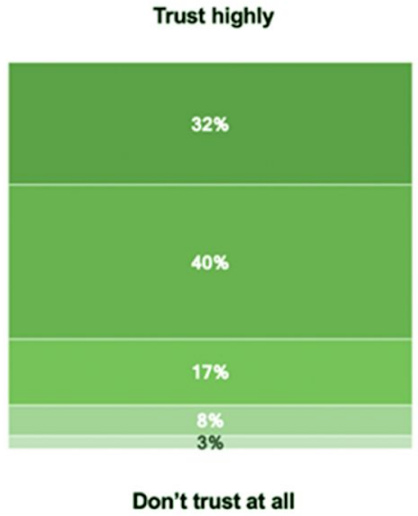
Ethereum's values:



The community largely trusts core devs to make decisions in the best interest of the protocol, which to some extent legitimizes a developer technocracy:

Q: Do you trust the Ethereum Core Devs to make technical decisions in the best interest of the protocol?

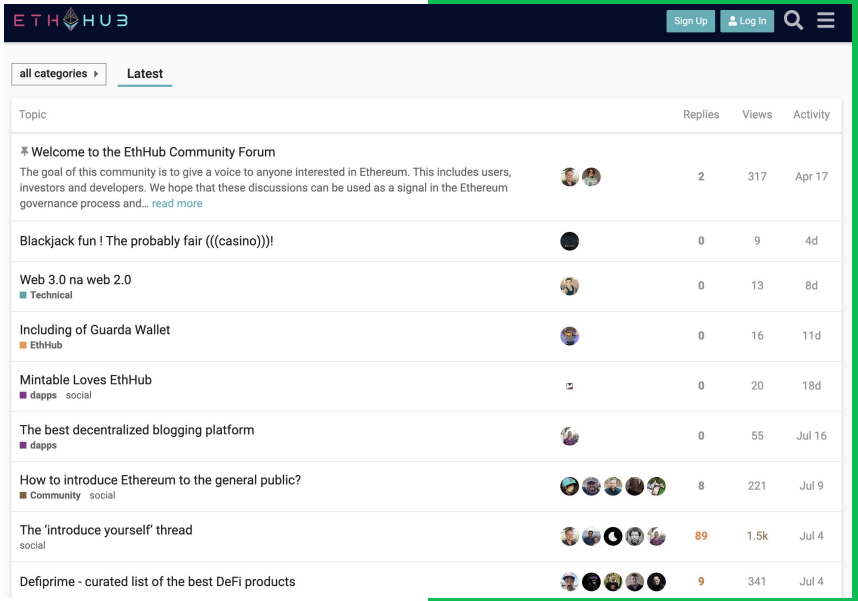
282 responses



GREEN FIELD ONE

Ethhub

Ethhub is another community initiative to provide an interface for participants to discuss broader issues around Ethereum, while also trying to be the go-to resource for the latest information about Ethereum.



4.2.3 The Ethereum Foundation & Consensys

Neither the Ethereum foundation (managing the proceeds of the initial fundraise), nor Consensys (dev studio founded by Ethereum co-founder Joe Lubin) has a formal role in governance, however as they employ (or fund through grants) a lot of important people to Ethereum, their influence is significant. What is more, the Ethereum foundation controls the geth client repository, which is one of the two most widely used clients. However, in developing Ethereum 2.0, there are considerably more teams working on independent client implementations (in different programming languages) in order to further decentralize Ethereum, which are partly supported by grants by the foundation.

Additionally, it holds the rights to the Ethereum trademark which gives it the power to define which chain is associated to it (e.g. opposed to Ethereum classic).

EF mission:
"The Ethereum Foundation's mission is to promote and support Ethereum platform and base layer research, development and education to bring decentralized protocols and tools to the world that empower developers to produce next generation decentralized applications (dapps), and together build a more globally accessible, more free and more trustworthy Internet."

Crucial to that mission is to fund projects that contribute to the public good of Ethereum and do not have an immediate business model (akin to basic research). Aya Miyaguchi, the executive director of the foundation, believes that there is more value to be created by subtraction than addition. The significance of the foundation should decrease over time; thus, they want to decentralize their influence by giving away grants.

No longer there would be "official" in-house teams versus external contributors, the foundation would be a financier of everyone inside and outside, and the internal teams had to compete for these resources like everyone else.[144]

4.3 Decred – Layer 1 DAO

Decred is an autonomous digital currency with a hybrid consensus system. It is built to be self-ruling in that everyone can vote on the rules and project-level decision making proportionately to their stake.

On-chain voting is comprised of validating blocks and consensus rule changes, while off-chain voting is centered on Politeia proposals (see below).

Proof-of-stake (PoS) validation is carried out in tandem with Proof-of-Work (PoW) miners, which makes attacks particularly expensive, in relation to the project's market capitalization and hinders PoW miner collusion. PoS voters further protect the network against unwanted forks, majority attacks, and other misbehavior such as mining empty blocks. 30% of token issuance is released towards stakers, 60% towards miners, 10% towards community fund. Due to the reward distribution, stakers will slowly be diluted if they do not contribute otherwise (PoW, off-chain work), thus countering the capital accumulation issue that is often being criticized of pure PoS systems ("the rich are getting richer", increasingly concentrated ownership).

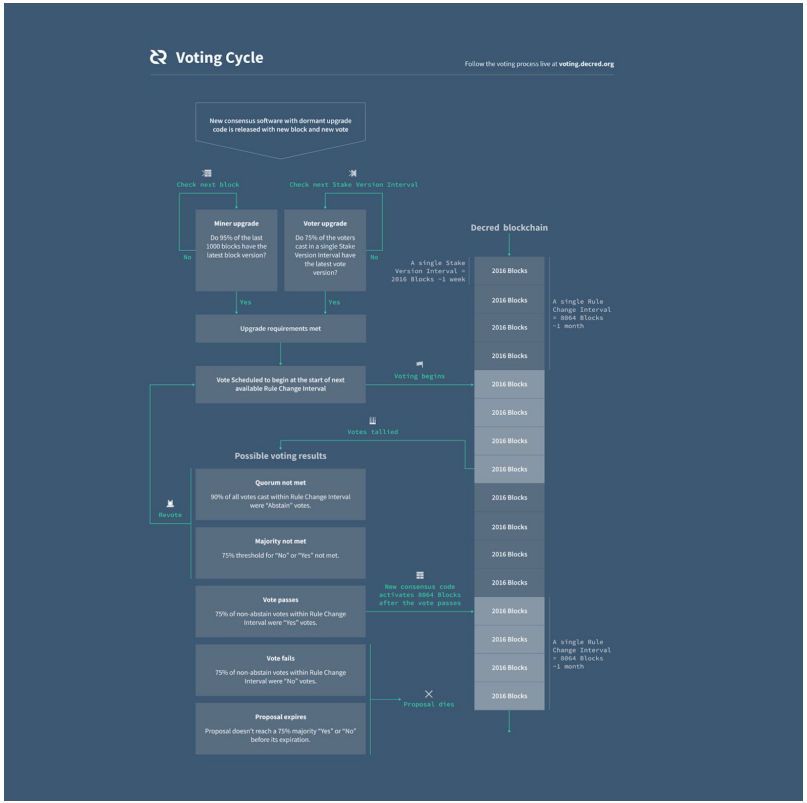
Ticket-holder voting

One ticket allows for one vote (yes/no for every proposed consensus rule change and Politeia proposal). To acquire tickets, DCR holders have to time-lock their funds for an average of 28 days, which ensures skin in the game, and due to the randomness of the lockup makes planning attacks considerably more difficult (lock-up up to 128 days). What is more buying up tickets to skew decisions drives up the ticket price as well as the Decred price, in combination to a larger extent than if voting would happen directly with Decred tokens, which provides better protection against hostile takeovers.

On-chain protocol upgrade process

A developer or group of developers creates a Decred Change Proposal (DCP), similar to Bitcoin's BIPs. Next, developers have to release new software that incorporates their protocol changes.

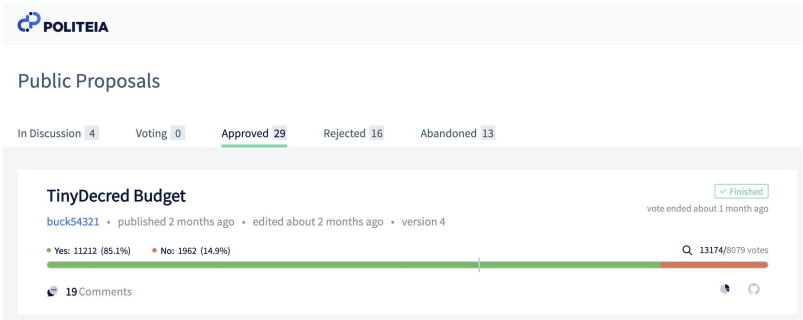
Further, PoW miners and PoS participants need to upgrade their software, and once specific upgrade thresholds are met, voting begins. In order for an upgrade to be locked in, 75% of all non-abstaining votes must be in support of the proposal. Once the upgrade has been locked in, the remaining network participants have approximately 4 weeks to update their node software before the upgrade goes into effect.



Source:
https://docs.decred.org/governance/consensus-rule-voting/overview/

Politeia – off-chain proposal system with on-chain anchoring

Politeia[145] is Decred's off-chain component that is anchored on-chain, in order to prevent intransparent censorship and allow any proposer to prove that they suggested a proposal at a particular time (moderators will still remove spam proposals, which can be cryptographically proven afterwards). It allows ticket holders to vote on work proposals made by ecosystem participants who want to grow the network. Anyone can create a funding proposal, and have it voted on by stakeholders (on-chain). 10% of block rewards are funding a treasury that should soon be controlled by a DAO. Currently, the treasury is centrally controlled by Decred Holdings Group LLC, a corporate entity which owns the keys to the multi-sig treasury address.



Implementation of proposals

Once a prospective contractor is approved through the Decred Contractor Clearance Process[146], they are able to submit monthly invoices of their work which are reviewed by the treasury auditors. It has been decided through the politeia process, to transition control of the keys to Decred's stakeholders through the DAE[147] — a decentralized autonomous entity that has complete autonomy over what gets funded (which should be renamed to DAO in order to align terminology with the broader crypto space; originally a connection with the Ethereum TheDAO hack was supposed to be avoided).

Is Decred governance considered plutocratic by their community?

A token weighted governance approach is often referred to as being plutocratic as wealthy stakeholders have an over-proportional influence on the system.

Luke Powell, Decred developer states that Decred is not meant to govern society[148], but instead is meant to be a global store-of-value.

"If you call a cryptocurrency network a plutocracy, what you're saying is that you think cryptocurrency networks are platforms for governing society. They're not. They're platforms for coordinating digital commodities."

As also exemplified by Tezos governance below ("corporate governance is a better analogy than national governance"), the framing of what is governed, and its boundaries are crucial to arguing of the appropriateness of a particular system. If then, however, a system is being framed as autonomous (and thus not influenced by external parties), but influences external parties in potentially negative ways (negative externalities such as carbon emissions through PoW), it might be difficult to defend autonomous corporate governance in a vacuum, without honoring a higher-level governance system that is for example democratically legitimized.

4.4 Tezos – Layer 1 DAO

Tezos is a self-amending blockchain that features formally verified smart contracts and a proof-of stake consensus algorithm which enables all token holders to participate in the network.

The network incorporates a formal, on-chain mechanism for proposing, selecting, testing, and activating protocol upgrades without the need to hard-fork. Members of the team have been elaborating that they see Tezos governance as being more similar to the dynamics of corporate governance than the dynamics of a democracy.

4.4.1 Tezos proposal process

Nodes decide upon protocol upgrades through a delegative (liquid[149]) token-holder democracy model, directly implementing the chosen protocol amendments. To incentivize innovation, Tezos uses inflation funding to reward upgrade proposals within the protocol explicitly. Validators in the Tezos ecosystem are called "bakers" who get a "roll" (vote) per 8,000 tezos tokens (changed in Athens upgrade from originally 10,000). Bakers, whose interest is to maximize delegations and thus rewards, actively engage in governance and position themselves politically (e.g. committing to a policy[150]).

Every of the following periods runs for 8 baking cycles, thus leading to a regular interval of potential upgrades, which provides for an institutionalization of consistent change.

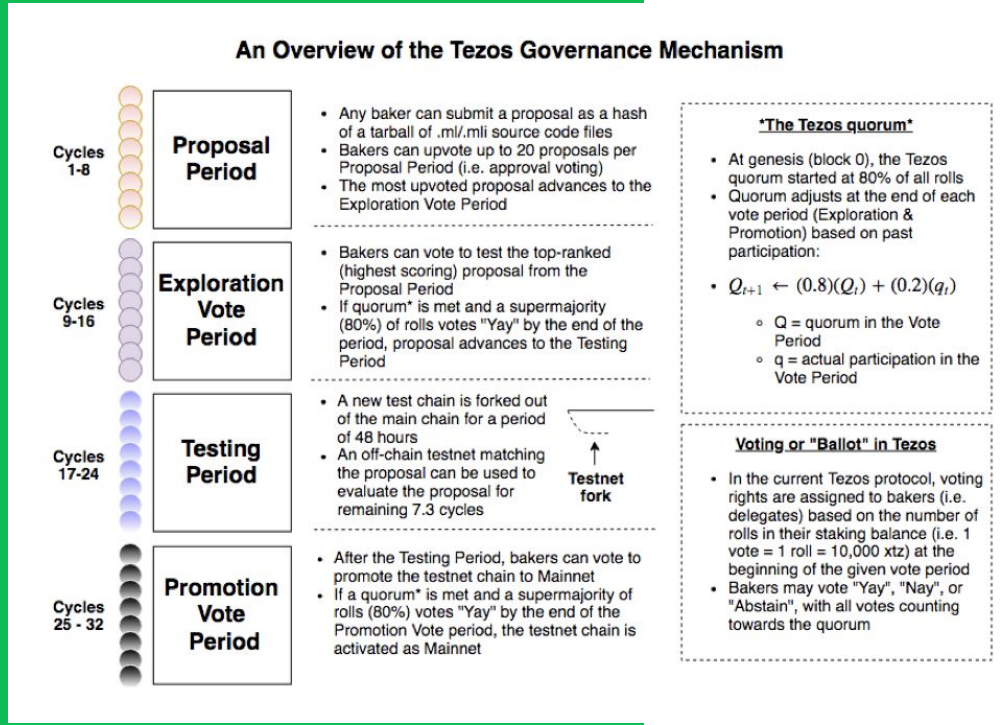
Proposal period: Bakers may submit up to 20 proposals in each Proposal Period (which limits spam, while other community members could convince an elected baker to make a proposal). Other bakers vote by approval votes for up to 20 proposals. Voting is conducted on tangible code updates (full update is hashed in the blockchain). At the end of the Proposal Period, the network counts the proposal votes and the most-upvoted proposal proceeds to the Exploration Vote Period.

Exploration Vote Period: Bakers votes are counted based on the number of rolls in their staking balance at the beginning of the Exploration Vote Period. If the proposal meets the quorum (dynamic, to match an exponential moving average of the past participation rate, formula explained in figure below) and a supermajority of 80% the proposal reaches the testing period. The Babylon update set the quorum floor at 20% and the cap at 70%.

Testing period: A proposal that received a supermajority in the exploration vote period enters a 48h testing period, which is automatically terminated in order to prevent any confusion with the main chain. However, this period is likely too short to evaluate the new chain in-depth. Thus, an off-chain testnet will usually be evaluated for the remainder of the testnet period.

Promotion vote period: After evaluation in previous periods, bakers vote weighted by their active rolls at the beginning of the period. If the minimum quorum and again the 80% supermajority is met, the new chain activates as the now canonical main-chain. If the new chain does note reach its quorum or supermajority, the quorum adjust based on the previously mentioned formula, when entering the proposal period again.

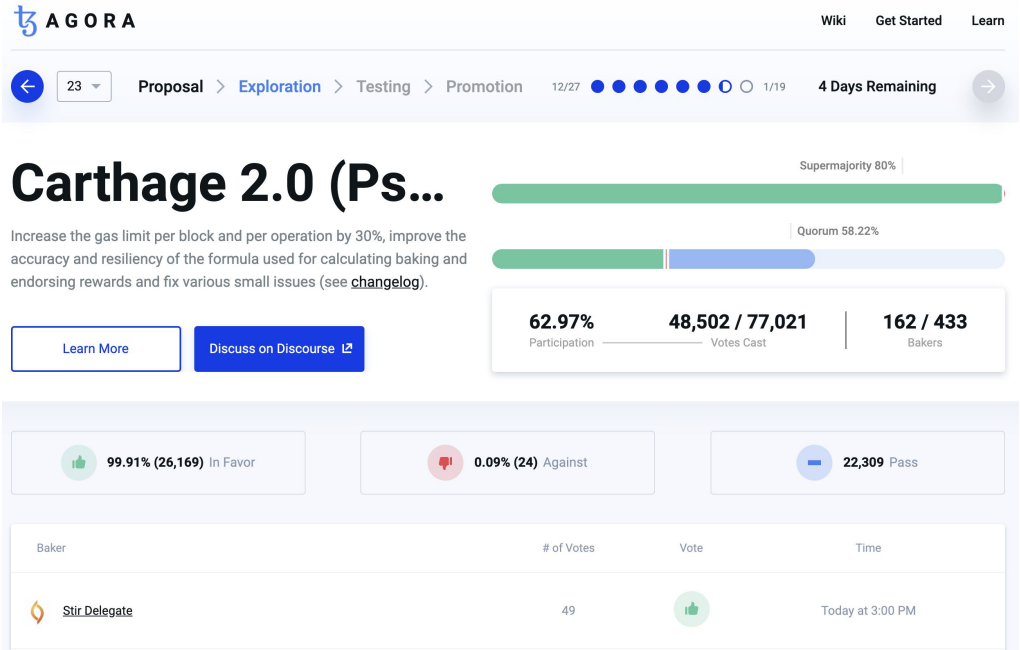
An Overview of the Tezos Governance Mechanism



Source:
https://medium.com/tezos/amending-tezos-b77949d97e1e

4.4.2 Tezos Agora – exemplary off-chain governance component

Tezos Agora[151] is a discussion forum and governance explorer designed to complement the on-chain amendment process. In line with forums in the Ethereum space, Agora is built on Discourse and should represent the go-to interface for discussing Tezos governance. Naturally, there are many platforms on which discussion takes place, which on the one hand improves resilience through decentralization but makes it harder to understand and follow for the individual.



Source:
Tezos Agora Governance Explorer - https://www.tezosagora.org/period/23

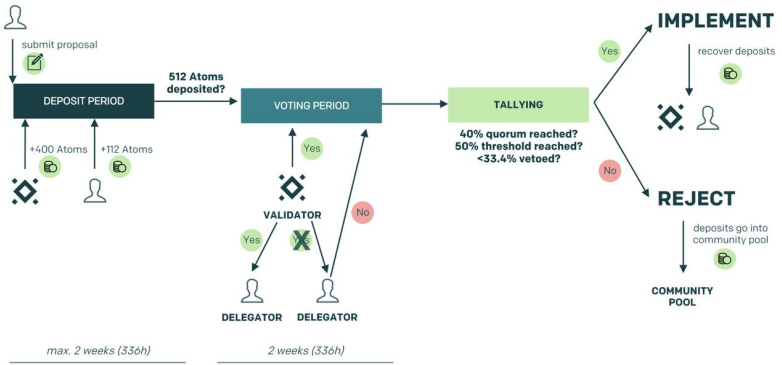
4.5 Cosmos – Layer 1 DAO

The Cosmos Network is a decentralized network of independent, scalable, and interoperable blockchains.

Every blockchain needs to bootstrap their own validator network and enjoys the freedom of sovereign governance. The Cosmos hub, itself a decentralized network based on the Cosmos SDK (Software Development Kit), should intermediate token transfers and in future also arbitrary message passing between “zones” which are the mentioned independent chains, all to enable a balance between interoperability, complexity reduction and collaboration amongst sovereign communities.

4.5.1 Cosmos hub governance

Anyone can submit a proposal, while a minimum deposit is required for it to enter the voting period in which Atom holders (Cosmos hub native token) are entitled to vote.



Source:
Chorus One – a cosmos validator

Deposit period

For a proposal to be considered a minimum number of tokens (512 Atoms) need to be deposited within 2 weeks for spam protection. Anyone can contribute during the period and the deposit is returned once the proposal turns out successful or does not enter the voting period (it is transferred to a community fund though if it enters the voting period and fails).

Voting period

During the 2-week voting period Atom holders can vote “Yes”, “No”, “No with Veto” or “Abstain”. Only bonded (staked) tokens can participate and votes are weighed by stake. Validators that have tokens delegated to them can vote for them, while delegators can choose to vote for themselves (some form of liquid democracy).

Tallying results

In order for a proposal to pass the following requirements need to be fulfilled:

- Quorum: More than 40% of the total staked tokens need to participate
- Simple majority: More than 50% “Yes” votes (in relation to “Yes”, “No”, “No + veto”, excluding “Abstain”)
- Veto: Less than 33.4% “No with Veto” votes in relation to “Yes”, “No”, “No + veto”, excluding “Abstain”)

Implementing the proposal

After a proposal passed a vote, it needs to be implemented by validators.

4.6 Polkadot – Layer 1 DAO

Polkadot empowers blockchain networks to work together under the protection of shared security.

Polkadot employs on-chain governance, for upgrading protocol rules and allows such without hard forks, through changing runtime modules, that define the state transition rules of the network. This mechanism can be leveraged both for relay chains and parachains. The relaychain allow for interoperability of the parachains, which are blockchains that run in parallel and can access arbitrary function calls of other parachains in the network (based on specific run-time modules that define their specialized state-transition logic).

As opposed to Cosmos (often compared to Polkadot for their distinct approach to interoperability), governance of the Polkadot relay chain can affect parachains, by removing them in case of them being found malicious. Parachain governance itself can however be completely independently defined.

In general, parachains can have their own economy and governance, so relaychain governance will probably be more focused on keeping the main protocol running with little regard for details in parachains.

However, in the case a parachain is perceived to be malicious, it could be removed by relaychain governance. And on the flip side, if a parachain is useful but cannot afford a parachain slot (tokens need to be bonded by a parachain to enter the relay chain ecosystem), governance could grant it one.

In 2019/ early 2020, a couple of upgrades of the Kusama network (Polkadot testnet) have been successfully implemented[152], while a technical incident has occurred and has been resolved[153].

4.6.1 Referendum process

A **Referendum** is a specific proposal, which takes the form of a privileged function call in the runtime (which is able to alter the entire code of the protocol implementation, usually requiring a hard-fork in other systems).

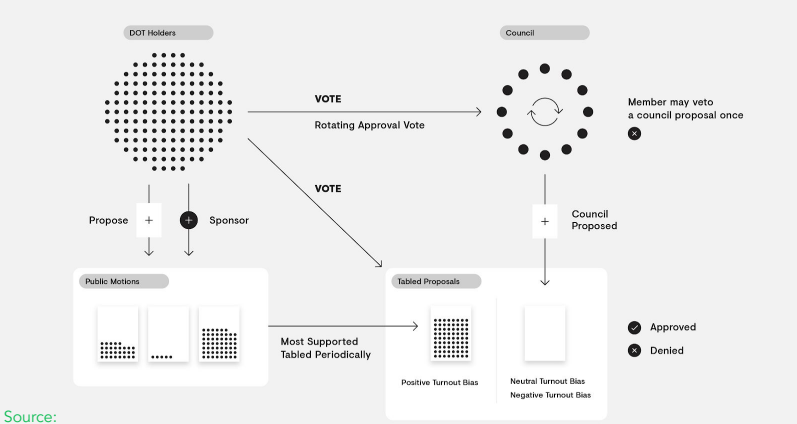
All changes to the protocol must be agreed upon by **stake-weighted referendum**; the majority of stake can always command the network (usually 2/3 majority). Stake is weighted according to the number of tokens, multiplied by the time they are locked. Thus, a smaller stakeholder, who is however very committed can increase influence over a larger stakeholder who is not willing to commit as long term.

An enactment delay is supposed to allow strongly disagreeing stakeholders to leave (and sell their stake) in time before a particular change is implemented. The stake of voters that were in favor, will be locked at least for the enactment delay period (specified in a particular proposal).

There are 4 ways proposals can be submitted:

1. **Publicly submitted proposal:** Any token holder can publicly propose and stake tokens, others can stake and proposals with most stake get voted upon in regular intervals.
2. **Proposals submitted by the council:** The council is akin to a board of directors, which are delegates of stakeholders. Each of the members is elected through an approval vote on a continuous basis (12 months term, 23 members). They can make proposals either through a no-veto majority or unanimously (1veto/ member/proposal, a proposal can be re-submitted after a cool-down period). What is more, the council can cancel a referendum (unanimously, for uncontroversial last-resort cases such as a bug that is found late in the upgrade cycle).

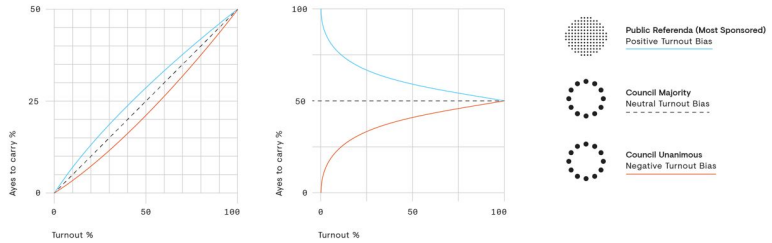
3. Proposals submitted as part of the enactment of a prior referendum.
4. Emergency proposals submitted by the Technical Committee and approved by the Council: They deal with urgent problems and thus feature a shorter enactment delay. The Technical Committee is composed of the teams that have successfully implemented or specified either Polkadot (incl. Kusama testnet) runtime or the runtime environment (added or removed through a simple majority vote of the council).



Source:
Polkadot documentation

Adaptive Quorum Biasing intends to automatically alter the necessary supermajority required depending on the way a proposal was brought to a vote, as well as the participation rate of voters (turn-out by stake):

1. Public referendum: Positive turn-out bias – there is a supermajority necessary to accept a proposal. As turn-out increases towards 100%, the majority required approaches a simple majority.
2. Council (unanimous support): Negative turnout bias – there is a supermajority necessary to reject a proposal. As turn-out increases towards 100%, the majority required to reject approaches a simple majority.
3. Council (majority support): A simple majority is necessary to accept a proposal.



Source:
Polkadot documentation

Spontaneous subject committees

In order to capture stakeholder sentiment in a more agile way, spontaneous subject committees might be utilized through statistically significant random sampling of the stake-weighted voting population. Voters are compensated, and turnout is taken into account. If an approval or rejection is determined with sufficient confidence, a proposal may be fast-tracked or dropped, freeing up the pipeline for other more contentious legislation.

4.7 DAO frameworks

DAO frameworks represent toolkits to more easily spin-up organizations on public blockchains, that partly provide opinionated decision making and market mechanisms, partly leave everything open for the developer. Community and team members have been discussing that combining the frameworks could be promising as well, while some mechanisms that were pioneered by one framework team might be implemented also by another or a developer building a module on top.

4.7.1 Aragon – Layer 2 (transitioning to L1) DAO

Unstoppable organizations

Aragon primarily focuses on enabling uncensorable digital organizations in independent cyberspace, based on a highly modular system. Their permissioning[154] and transaction[155] forwarding systems are built to enable a wide variety of modules to be securely connected together. What is more they are launching a game-theory based digital court system in order to resolve disputes that arise due to the difficulty in building complete contracts.

The team puts an emphasis on developing general infrastructure for building organizations, as opposed to designing specific decision-making mechanisms. While DAOs have mostly been connected with decentralized, non-hierarchical decision-making Aragon highlights, that any organizational structure can be implemented on their platform. Their focus on modularity should attract a wide developer community building new kinds of decision-making mechanisms. Three distinct teams were building such components, funded through the now dismantled Aragon grants program, which uses token holder voting for decision making (Autark Labs, Aragon Black, Aragon One). Reasons cited for discontinuing the program include a checklist-based disbursement process instead of iterative user driven design, no-strings attached upfront funding prevented lean setups as well as lead to a lack of accountability and high coordination costs in disparate teams.[156]

While any decision-making structure can be implemented, the following standard templates are provided:

- Company: one-token-one-vote, tokens are transferable, no limit on how many tokens each token-holder can have
- Membership: one-token-one-vote, tokens are not transferable, each token-holder can hold only one token
- Reputation: one-token-one-vote, tokens are not transferable, no limit on how many tokens each token-holder can have

The Aragon Network Token

The Aragon Network Token entitles its holders to vote in their governance system to a large extent to allocate treasury funds through grants (1 token 1 vote). Besides that, holders can use it to receive stake for Aragon Court and it will demonstrate the native token in their own chain. At the time of writing, an adapted governance model is being developed, that will entail an Aragon Agreement acting somewhat like a constitution, to be interpreted by Aragon Court (in order to protect minorities).[157]

Aragon Chain

While starting as a layer 2 project on top of Ethereum, Aragon has decided to shift towards building their own blockchain optimized for their organizations with the Cosmos SDK in order to fulfil scaling needs.

Pocket Network (incentivizing full-nodes for other layer 1 chains)

Pocket network is an example of a layer 1 DAO, planning to base its governance on a constitution, an off-chain "protocol" that defines the "social contract" for governance of the infrastructure. Its consensus mechanism, defines governance by the infrastructure (complete contracts). They introduce the concept of Lean Trias Politica (inspired by Trias Politica[158], which is a modular design that establishes legitimacy through on-chain validation of decision-making inputs (Stakes), cross/off-chain conservation of throughputs - interpreting the constitution (Aragon/Cayman courts), and enforcement of decision outputs (parameterized governance transactions, controlled by the Pocket Network Foundation).

4.7.2 DAOstack – Layer 2 DAO

An operating system for collective intelligence

DAOstack explicitly values decentralized decision-making, while focusing on solving the problems that come with decentralized decision-making at scale[159]. They highlight that organizations with decentralized and crowd-based decision-making processes are more resilient. However, large amounts of accept/reject decisions that are likely to emerge with increasing sets of participants are too cognitively straining. Large numbers of proposals are fighting for limited attention. In addition, especially with large numbers of voters, voter apathy is a looming problem (particularly for personally not relevant proposals – participants might be rationally ignorant).

Holographic consensus: A crypto-economic mechanism for efficiently as well as reliably taking decisions in large groups, while minimizing the cognitive load individuals need to exert. Analogous to a hologram, in which every part of the picture contains the information for the whole, holographic consensus should lead to sub-group decisions that approximate the will of the whole group, without requiring attention of everyone on overwhelming numbers of proposals. A network of predictors is betting (“boosting”) on proposals likelihood of acceptance, which influences the prominence it receives in consideration as well as quorum

requirements necessary for the proposal to pass (fewer total votes to approve a heavily "boosted" proposal). Holders of non-transferable reputation finally decide on the acceptance of proposals, which have been pre-filtered by predictors.
For every proposal, there is a pot to be received by the winning side of predictors (pass/fail), which creates a market for decision making. In order to make the game non-zero-sum, the organization automatically puts a down-stake (bet) on every proposal, which is paid out, when it is accepted (thus putting an initial reward in the pot).

An organization using holographic consensus should be able to scale to arbitrary numbers of proposals as well as arbitrary numbers of participants without sacrificing speed or quality of decision-making. The mechanism will however need to be proven resilient in practice. An important assumption is the independence of predictors and voters. Predictors attempting to corrupt voters are assumed to be counter-balanced by profit motivated participants that bet against them and uncover their attempt. Predictors might however try to lobby and present themselves as subject matter experts.

Genesis Alpha

DAOstacks "Genesis Alpha" was the first DAO built with the toolkit that decides on budget allocation as well as other governance decisions regarding the stack.

4.7.3 Colony – Layer 2-DAO

Open organizations

Colony, seeks to create the infrastructure for decentralized, self-organizing entities in which influence on decisions is derived from high-quality work. They aim for lowering the costs of a diverse group of people coordinating their efforts and resources to realize shared goals, even if they do not know or trust each other.
The team puts a strong emphasis on mechanisms which avoid the friction of voting as far as possible to enable an efficient, digital, future of work.

While in DAOstack's case, holographic consensus should allow organizations to scale the synchronous process of accept/reject decisions, Colony wants to achieve scale by an asynchronous process by using a domain tree and breaking down work into tasks which resembles more traditional divisional or departmental organizations.

Colony leverages time for allocating resources in a permission-less fashion in their mechanisms. Reputation decays over time and funds are distributed continuously as a function of time. The more reputation backing a proposal, the faster funds are released, while a participant with little reputation can still slowly receive funding.

Reputation is awarded through work, based on peer evaluation. Evaluators risk to receive diminished payouts as well as reduced reputation scores for inadequate evaluations, while challenging a decision through the dispute resolution mechanism requires staking tokens and reputation.

As a result, Colony hopes to combine the best of hierarchical organizations (experienced peers have outsized influence) and independent decision-making at the edges in order to leverage local knowledge.

Colony budgetbox – a user-friendly decentralized budgeting tool

Budget box should allow to use simple inputs on complex objects of stakeholders (to reduce cognitive complexity) transformed into complex inputs on simple objects (to leverage computational complexity). For example, a national budget is a complex object, but a relative choice between "infrastructure" and "education" is simple. Using said inputs, algorithms can optimize a budget based on relative preferences and an objective criterion such as utility maximization.

Governance of the infrastructure

Governance of the Colony Network will be gradually transferred to the Meta Colony (1st, parent colony). Decision-making will be based on reputation and work in the Meta Colony entitles members to a revenue-share in fees.

4.7.4 Moloch – Layer 2 DAO

Moloch DAO, a coordination mechanism, has been described as a "minimum viable process" to allocate shared resources towards a common goal, while minimizing social as well as technical attack vectors for abuse. The project came to live, as the initiators recognized that there was no efficient and coordinated way to respond to grants and proposals in the Ethereum ecosystem. The term "Moloch" was inspired by the essay, Meditations on Moloch[160] – "the god of coordination failures", that argues humankind faces many collective action problems (e.g. negative externalities such as excessive pollution/emissions) which seem logical to avoid from a god´s-eye view, but in practice individual incentives lead towards sub-optimal collective outcomes.

Members pool funds on a donation basis, which are then spent based on collective voting. In order to ensure alignment in values (furthering Ethereum development), access to DAO membership is permissioned and vote based. In addition, the team wanted to limit the attack surface through simplicity by only putting the absolutely necessary features on-chain and leave the rest to social off-chain coordination.

Moloch shares

Moloch shares represent the participants' pro-rata interest in the DAO and are not transferable. They are directly proportionate to the tribute (grant) they pay into Moloch.

Grant proposal process

Members can submit proposals that can be hashed to Ethereum and stored on IPFS (Interplanetary File System). As a next step, members vote on a proposal and if it passes, new shares reflecting the size of the grant are transferred to the grantee. Through those she can access the pro-rata of the locked collective tribute (members are diluted). Proposals are rate-limited (5 per day), they are voted on for 7 days and 35 can be outstanding at the same time (staggered by 4.8h). Passing requires a simple majority and there is no quorum, as rage-quitting, described below, allows dissenting members to leave before being exposed to the consequences of a proposal.

Rage-quit

The team recognizes that there are a large number of edge cases and/or downsides in voting-based systems (e.g. collusion, unavailability, tyranny of the majority). Thus, they introduced the feature of "rage-quitting" which allows any participant to exit the DAO within a grace period after a proposal was passed and withdraw their current pro-rata ownership, before the proposal is enacted.

On the flipside, the remaining participants need to cover the full cost of the proposal, thus increasing their pro-rata amount due to a now lower total asset base. Thus, only "no" voting participants are allowed to rage-quit after a proposal. Another disincentive for rage-quitting and especially abusing the mechanism is social stigma, related to the public identity that needs to be known for a participant. It is likely that a previous rage-quitter will have a harder time reapplying for the DAO. What is more, there is a dilution bound (e.g. max. 5x / 80% of members rage-quitting at once) – if its threshold is reached, the proposal fails.

As a result, incentives for mutual cooperation should be increased as individuals supposedly do not want to pass proposals, which cause a large proportion to rage-quit. Another effect of the system is arguably that it lowers the barriers to participation in the first place based on de-risking it (usually people are risk averse).

Fork evolution without being explicitly a framework

As in all DAOs considered, Moloch's code is open-source and can thus be easily forked. Anyone can start a re-branded and/or altered copy and add an early participants bonus in terms of membership tokens to bootstrap early interest. Already a couple of projects have been started as Moloch forks within its first year of existence, including projects like MetaCartel Ventures (focused on UX) and Marketing DAO (focusing on Ethereum Marketing).

Legal wrappers to blend digital organizations with traditional law

OpenLaw, a free, legal agreement repository, created by a collaborative legal community, allows Moloch DAO forks (at first, and continuously other DAOs) to mirror a digital organization on Ethereum with a US limited liability company (LLC). As contract templates are being built and maintained by the OpenLaw community, more and more functions such as voting are represented in the traditional legal way. This is another example of how parts that make up governance by the infrastructure are being built in a distributed fashion themselves, thus leveraging knowledge at the edges, in this case the interfaces to traditional law.

4.8 MakerDAO – Layer 2 DAO

Maker is comprised of a decentralized stablecoin, collateralized loans, and community governance.

Currently, the main goal of MakerDAO is keeping the value of DAI, a collateral-backed cryptocurrency, stable relative to the US Dollar (pegged). In the future, further stable tokens that could be pegged to anything with a reliable price feed are imaginable. What is more, the DAO serves as a decentralized credit facility in a symbiotic relationship to the stable tokens it issues.

Creditors can lock-up assets according to the programmatically set parameters and generate DAI in order to take out a loan (governance by the infrastructure).

MakerDAO governance (of the infrastructure) is primarily focused on determining the risk parameters to manage the portfolio of assets backing DAI (previously only Ether, in Multi-collateral DAI also other tokens).

4.8.1 MKR governance token

The Maker governance token (MKR) is supposed to align incentives for proper decision making. One MKR token entitles one to vote in on-chain decision making.

MKR as a lender of last resort / insurance fund

If the internal system of liquidations fails to liquidate a collateralized debt position early enough (due to falling collateral value) and thus there is too little collateral backing DAI, new MKR is minted and sold to cover the difference. Thus, the total value of MKR tokens can be viewed as an insurance fund that covers the residual risk of collateralized debt positions, which gets diluted if it needs to be utilized.

Value capture of MKR

In order for MKR to be valuable and serve its function as an insurance fund, it needs to capture value. Stability fees (interest) from debt are used to purchase-back and burn MKR, comparable to share buybacks. Thus, expected future interest payments are attributable to MKR, which allows traditional valuation approaches such as dividend discount/net present value to be applied. This in turn, provides a solid foundation for the value of MKR to secure the stability of the Maker system.

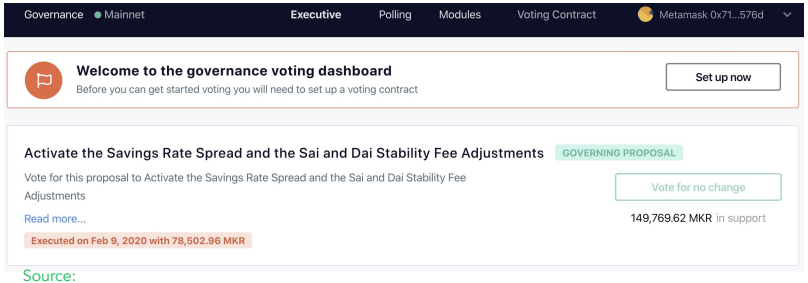
Incentive alignment towards goal of stability

As MKR holders' risk being diluted if they do not appropriately govern risk parameters, they are incentivized to limit such risks. Token holders' decisions influence the stability as well as growth prospects of the system. Specifically, factors such as assets to be allowed as collateral, collateralization ratios and the level of stability fees (borrower interest) and savings rate (depositors interest). If parameters are set very attractive to borrowers (many asset types as collateral, low collateralization ratios, low interest) growth prospects are higher, while compromising security.

4.8.2 Governance process

Governance polls (on-chain) are used to gauge community sentiment regarding topics such as the structure of governance processes, adding new Oracles (e.g. price feeds), adding/changing a risk team (create and apply risk models), or changing stability fees. They are time-limited and a simple majority (>50%) determines the outcome. Often a couple of options are tested in order to decide upon the executive vote to hold.

Executive votes (on-chain) are used to implement proposals and change parameters of the smart contracts constituting the Maker infrastructure. If passed, they are automatically executed on-chain after a 24h delay (as a security measure). Proposals are fully permission-less, so anyone can add a proposal and trigger a vote. However, currently, only executive votes created by the core team currently have reasonable chances of passing. Both governance votes, as well as executive votes are accessible through the voting contracts and dashboard.[161]



Source:
vote.makerdao.com

Continuous approval voting is utilized for executive votes to emphasize the need to continuously monitor and govern the system over time (voting is always, continuously happening through staking on the preferred contract). The amount of staked votes challenges and reinforces the current state of the system through movements of the majority of votes between desired new proposals and the most recent successful proposal.

Proposals for executive votes created by the Maker Foundation are following their formal Risk Governance Framework. While also now feedback from MKR holders and the general community is taken into account at various stages, there is a stated goal to perform gradual decentralization over time.

The risk governance framework formalizes how qualitative and quantitative risks associated with various collateral types are continuously evaluated. Risk teams are employed by the Maker Foundation to assess e.g. the volatility risk, liquidity risk, and stability of assets. Then, risk parameters such as the debt ceiling, liquidation ratio, stability fees are derived, feedback gathered by the wider community to then being put up for an executive vote. Going forward also risk teams are supposed to be voted for in a decentralized fashion, while employing several competitive teams that keep each other in check.

Risk team members regularly answer questions on interfaces such as Maker's chat and subreddits. Major decisions are typically discussed in weekly Governance and Risk meetings, open to community participation via livestream and later uploaded on YouTube and transcribed to github.

Emergency shutdown

While changes to existing risk parameters (variables in existing smart contracts) can be implemented automatically, major upgrades involving changes to smart contract logic must be performed through the emergency shutdown process (rebooting the entire system).

The emergency shutdown, as its name implies, also represents a way to interfere if there should be a major security breach or attack. It allows the system to shut down and make underlying collateral available for redemption by Dai holders and Vault (previously CDP – collateralized debt obligation) owners.

There are two primary ways to trigger an emergency shutdown. 1) A minimum number of MKR called the emergency shutdown threshold can trigger the Emergency Shutdown Module (ESM - 50,000 MKR, which are permanently lost, and can only be retrieved after redeployment as a decision of MKR governors); 2) a regular executive vote, with the regular 24h delay.

Transitioning towards a self-sustaining, truly decentralized DAO

Over time, the foundation is planned to be dissolved, while Maker should transition towards a self sustaining, fully community-operated DAO. The team highlights the need for the community being well-informed and equipped with clearly defined governance processes. A Maker Improvement Proposal (MIP) process, should be set up that is comparable to other Blockchain Improvement Proposals (BIPs, EIPs..). It is emphasized, however that there is a need for the process to be rigidly structured and formalized to avoid any ambiguity (as criticized with other processes that have historically grown in other communities).

Paid contributors are supposed to be elected by token-holders, that will perform critical human tasks, as the foundation team slowly fades away.

What is more, it is planned to implement a form of liquid democracy, as Maker holders will be able to select delegates, if they do not vote themselves on individual issues. Any community member will be able to be selected as a delegate.

Finally, a new foundation, the DAI Foundation is being set up, with the sole purpose of managing the trademark portfolio of the project in an independent fashion, while the operating foundation will be dissolved in a 1-2-year timeframe.

4.9 Nexus mutual – legally linked Layer 2 DAO

A people-powered alternative to insurance

Nexus Mutual is a digital cooperative that provides risk cover through a decentralized capital pool and governance mechanism. It is an interesting case as it is one of the first projects to put smart-contracts on sound legal footing, by founding a traditional UK mutual, requiring every member to join with a nominal value of 1 GBP and limiting each member's liability to said amount.

The mutual started by offering a solution to a pressing problem in the blockchain space: Risk cover for bugs in smart contracts. An algorithm (open-source) that takes into account various factors quotes an insurance premium programmatically, while there are a couple of human actors involved in the process.

Source:
Nexus Mutual

Risk assessment

Members of the DAO can provide value by assessing the security of a specific smart-contract (potentially a smart-contract auditor or the owner) and staking tokens on it in order to signal that it is secure. As a result, the staker co-insures the contract, as in case of a damage the tokens will be used to partly cover it. On the flipside, a staker receives a commission, if cover is sold for the relating contract. The more value is staked on a given contract, signaling for its security, the lower the premium.

Claims assessment

In case a damage is claimed, members of the DAO can participate in assessing whether the claim is legitimate. This happens in a Schelling Game, in which any member can vote for their assessment and if they vote with the consensus (which is assumed to be the objective outcome – the Schelling Point), they can receive a share of reward tokens (20% of the cover price). If they vote against the consensus, they do not receive a reward and their stake is locked for a longer period (representing an opportunity cost).

4.9.1 Governance of the DAO

Nexus Mutual members can decide to change any aspect of how the mutual operates by upgrading parameters in the code, or even the entire code base itself.

There is a board of 5 members that whitelist proposals (with some exceptions). The board further provides a recommended outcome for each proposal.

Votes are put to the entire member base for a token weighted vote (capped at 5% maximum weight). The majority outcome prevails if the quorum of 15% is reached. If the quorum isn't reached the board recommendation proceeds. Most decisions require a simple majority of 50%, while special resolutions such as winding down the mutual or changing the board power require a 75% super-majority.

Tokens are locked for a period of time after participating in voting, to ensure those voting have a vested interest in the outcome of the votes.

In order to encourage wider participation, there are token rewards for participating in the vote (to compensate for cognitive load). Rewards are split between the number of members voting, rather than number of tokens voting, to make it worthwhile for all members to participate. A member can delegate a proxy to vote on their behalf

and still receive all their rewards in the vote. A proxy can be any other member and may be revoked at any time (a component resembling liquid democracy).

To reduce the influence of centralized power with the board any member can raise a proposal to replace a board member with themselves, bypassing the white list. If accepted by the members they automatically join the board.

Thus, the DAO wants to reach a trade-off between relying on experts to both move faster and respond to emergencies and full decentralization.

Technically, governance builds on GovBlocks (another DAO framework) that allows a modular approach so parts can be easily changed if necessary. Voting weights, rewards, quorum levels and virtually all components of the governance process can be tweaked.

4.10 Compound – Layer 2 DAO

Compound is an algorithmic, autonomous interest rate protocol built for developers, to unlock a universe of open financial applications. Users can deposit whitelisted tokens into the protocol in order to receive interest payments on the lender side or draw credit against deposited collateral on the borrower side.

Further, every token lent in Compound is represented with a c-token, that tracks its ownership while remaining transferable. As a result, developers can use interest bearing tokens in other applications, which is one example of the composability unlocked by such open finance protocols.

At its launch, the Compound team had complete control over the operation of the protocol. However, they started to decentralize power by implementing the COMP governance token, first issued to the team and shareholders that backed Compound Labs, which is developing the protocol, which should decide over all upgrades.

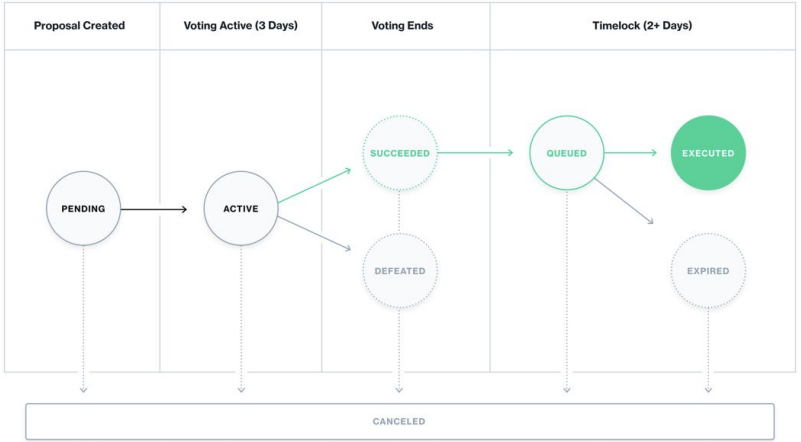
The first proposal that was passed with this new governance process, was approving to distribute COMP tokens to users, in order to give them a say in protocol evolution. As the token distributed to users was transferable from the start, though with limited liquidity, its relatively high price started to tremendously accelerate the amount of assets in the protocol by more than 5x within a week. While currently having now explicit value capture mechanism, COMP holders could potentially introduce payouts from reserves that are built up from a fee on interest paid.

4.10.1 Governance process

The COMP governance token gives users voting and proposal rights for referendums on how Compound should operate.

The community uses a variant of liquid democracy, so that any COMP holder can delegate voting power to any other address. Anyone with 1% of COMP holdings or delegations to his address can propose a governance action. Such proposals must be executable code, which means that the Compound team does not maintain control over the implementation of the changes. While the threshold is applicable for ready to be implemented code proposals, anyone is invited to discuss in the relevant discord channel, forum and other interfaces.

Every proposal is subject to a 3-day voting period, in which any address with voting power is eligible to vote for or against. If a majority (>50%) with a 4% quorum (400k of 10M total tokens/votes) votes are cast for the proposal in question, it is queued in the Timelock stage and can be implemented after 2 days (which can be triggered by any Ethereum address).



Source:
Compound

Pause Guardian

For emergency situations in the event of an unforeseen vulnerability, there is a designated Pause Guardian address capable of disabling protocol functionality. The Pause Guardian can only disable a select set of functions: Mint (depositing e.g. ETH to mint interest bearing c-ETH), Borrow, Transfer (c-tokens), and Liquidate (positions below the collateralization threshold). The Pause Guardian can neither unpause an action, nor can it prevent users from redeeming (c-tokens for their underlying deposit) or repaying borrowings to close positions and exit the protocol. The Pause Guardian address is designated by COMP token holders (currently held by Compound Labs).

4.10.2 Leadership through setting principles & cultures

Besides the formalized on-chain components of Compound governance. Leadership, which is first and foremost CEO Robert Leshner laid out their view of good governance practices, as well as principles that would guide his own voting.[162]

This includes that proposals should start with community discussion, questions, and analysis (a forum post is emerging as a good way to organize conversation on a topic). At this stage, there should be as much knowledge & information added as possible about the effect of a potential proposal.

What is more, any proposal that introduces new code should be thoroughly audited by the community. Development should be carried out in the open. Significant changes should be audited by professional third parties (paid for by the Compound Governance system by removing reserves). Further, proposals should implement a single idea, so that token holders can vote on an isolated set of changes, without having to weigh multiple scenarios or changes simultaneously.

4.10.3 Token distribution process

In total, 4,229,949 COMP are distributed over 4 years (0.50 COMP per Ethereum block, approximately 2,880 per day) in a liquidity mining program. To begin with, the distribution has been allocated to each market, proportional to the interest accrued in the market (50% to suppliers, 50% to borrowers). However, quickly after launch of liquidity mining, large divergences of interest rates emerged between the different markets on compound, as stakeholders were able to exploit the mechanism by skewing interest distribution through large leveraged positions as well as due to initial differences in interest models between assets. As a result, a proposal passed that distributes COMP solely based on the amount of assets borrowed and lent, irrespective of the interest rate. This shows the difficulties in distributing a token according to a given set of metrics, which can be manipulated in ways not foreseen in advance. The dynamic was taken to the extreme, as the token traded at a relatively high value from the start and liquidity mining distribution was liquid right away, leading to a situation where it was profitable to take out large leverage positions in the compound markets, potentially introducing systemic risk for all other stakeholders (e.g. large scale liquidations of positions, that fall below a given threshold of over-collateralization).

At the end of the liquidity mining program, approximately 42% of COMP will have been distributed to users of the platform, while 24% will have been distributed to shareholders and 25% will be distributed to individuals on the Compound team.

4.11 Voter participation (turnout)

	Average participation	N (no. of proposals)
Decred on-chain proposals (stake)	65,1%	4
Decred politeia proposals (stake)	31,3%	45
Tezos (stake - exploration & promotion votes)	74,7%	6
Cosmos (stake)	61,3%	14
Aragon (stake)	4,5%	54
Aragon (unique addresses per vote batch)	0,2%	5
DAOstack (reputation)	4,6%	136
Moloch	6,7%	72
MakerDAO (polls)	2,7%	71
MakerDAO (executive votes -continuous, voting MKR/total supply)	17,3%	8
Nexus Mutual (stake)	19,0%	10
Compound (stake)	16,3%	10

Source:
Greenfield One analysis from publicly available data, January & June (for Compound) 2020

Participation rates in DAO votes vary widely, partly due to differences in community size and composition but arguably to the largest extent due to the differences in voting systems as well as quorum requirements.

Polkadot has at the time of writing launched an initial mainnet, but has not had any referanda being processed on it and Colony is in private beta, so there has not been any data obtained.

The layer 1 Proof-of-Stake blockchains Decred, Tezos and Cosmos (hub) have achieved considerably higher voter turnout compared to the layer 2 projects analyzed. This is largely due to fact that only tokens that are participating in staking are counted as the total voting population (which are financially rewarded to do so), as well as their high quorum requirements. In addition, this partly reflects the liquid democracy elements in Tezos and Cosmos which are blending the best of representative and direct democracy. This is achieved through allowing anyone to directly vote on an issue, if she feels to be well informed or there is a strong opinion, as well as allowing for delegating one's voice to a representative (validators in this case). Thus, voters who are rationally ignorant might have enough incentive to at least delegate, while the cognitive load of deciding on a matter is outsourced to the delegate (which increases turnout). Voters who are motivated to decide for themselves can still do so, which increases decentralized input.

In the case of Decred, stakers/delegators need to continuously purchase tickets (on average every month, though with some randomness) in order to generate rewards, thus arguably nudging towards more engagement.

Of the layer 2 projects analyzed, Nexus Mutual, the only DAO with token rewards for voting, has the highest participation rates. The comparatively high executive voter turnout in MakerDAO reflects the nature of the continuous vote (as continuous approval voting is "always on" and not happening for a limited period of time).

Compound's comparatively high turnout (largely due to delegations) further increased after the introduction of COMP liquidity mining, which is arguably due to an increase in general public attention the project received due to large scale excitement about the high rates of return to be earned.

The case of Aragon has been selected to analyze both voter turnout based on stake (which is the relevant metric in decision-making) and turnout based on unique addresses, due to the fact that voting on 54 decisions happened in 5 batches (simplifying data retrieval and cleaning). Only on average 43 unique addresses (out of around 20,000 addresses holding Aragon tokens) have been participating in a batch (probably due to the previously mentioned issue of rational ignorance). A couple of decisions have been able to be turned around by a single voter with large token-holdings, which has been criticized in terms of reflecting a degree of centralization.

Also, other DAOs such as Maker, Moloch, Compound and Nexus currently show quite concentrated ownership structures, thus enabling a couple of large stakeholders influencing outcomes. Only Nexus Mutual puts a limit on the maximum weight an individual member can have in a vote (5%). This makes sense, considering that it is the only DAO in the sample that is legally linked to a traditional legal entity, requiring KYC (know-your-customer, identity verification). Thus, one could argue it does not represent a true DAO as it has elements of centralization

and lacks true autonomy. However, as mentioned above, also other projects show centralized aspects, highlighting the fact that decentralization is multi-faceted as well as a spectrum and not absolute.

In the other cases, it would be relatively easy for a stakeholder to distribute holdings over a couple of addresses in order to vote with maximum stake. This again exemplifies the fact that decentralized identity is still an unsolved problem, which is one reason why stake-weighted voting is often chosen over 1 person, 1 vote in order to remain sybil resistant as well as permission-less DAOs.

5 Discussion

5.1 DAOs as distributed innovation systems

The following table summarizes the case studies, following the classifications of distributed innovation systems. As argued before, they demonstrate the decentralized infrastructure (L1 DAOs), as well as can be based upon decentralized infrastructure (L2 DAOs) in order to avoid the problems inherent with platform monopolies.

	Interfaces	Participatory architectures	Evaluative infrastructures
Bitcoin	Bitcoin dev mailing list, forums, conferences, meetups, wallets/clients	Proof-of-work, BIP process, Github repo	Token rewards (mining)/decentralized ledger state
Ethereum	All-core devs calls, Ethereum magicians, forums, conferences, meetups, wallets/clients	Proof-of-work, EIP process, Github repo, community DAOs	Token rewards (mining, quadratic funding)/decentralized ledger state
Decred	Politeia voting interface, forums, conferences, meetups, wallets/clients	Proof-of-work, Proof-of-stake, Politeia governance & funding, Github repo, Decred Change Proposals (DCPs)	Token rewards & penalties (PoW mining, PoS validating, Politeia funding)/decentralized ledger state
Tezos	Tezos Agora forum & voting interface, conferences, meetups, wallets/clients	Proof-of-stake, formal on-chain governance process, Github repo	Token rewards & penalties (PoS validation)/decentralized ledger state
Cosmos	Cross-chain communication, forums, conferences, meetups, wallets/clients	Proof-of-stake, formal on-chain, Github repo	Token rewards & penalties (PoS validation)/decentralized ledger state
Polkadot	Cross-chain communication, forums, conferences, meetups, wallets/clients	Proof-of-stake, formal on-chain governance process, Github repo	Token rewards & penalties (PoS validation) /decentralized ledger state
Aragon	Governance interface, forums, wallets/clients	Proof-of-stake, jurors in game theoretical court system (staking), on-chain governance	Token rewards (PoS, jurors)/decentralized ledger state, grants

	Interfaces	Participatory architectures	Evaluative infrastructures
DAOstack	Governance interface, forums, wallets/clients	Prediction market (proposal filtering), reputation voting (decision-making)	Token rewards - monetary (prediction market) & reputational (community voting)
Colony	Governance interface, forums, wallets/clients	Reputation mining (layer 2 - PoS), Metacolony system governance, domain-task based reputation hierarchy	Token rewards - monetary (PoS, metacolony profit) & reputational (peer feedback/voting, decaying reputation)
Moloch	Voting interface/wallet, calls, chat groups, meetups/conferences, linked Delaware LLC structure in e.g. MetaCartel interact with off-chain assets	On-chain proposal & voting system, rage-quit to exit, replicate & adapt through forks	Value of stake, off-chain reputation
MakerDAO	Risk Governance Calls, voting interface, forums, price oracles/feeds, wallets	Formal on-chain governance, keeper incentives	Token rewards & penalties on decentralized ledger (e.g. liquidations)
Nexus Mutual	Web app for using, participating & governing, governance calls, legally linked UK mutual for limited liability	Formal on-chain governance, risk & claims assessment through staking	Stake for risk & claims assessment; token rewards & penalties on decentralized ledger
Compound	Web app for using, participating & governing, forums	Formal on-chain governance, ability to program c tokens, lending/borrowing, norms around community discussion	Token rewards (liquidity mining), interest rate & liquidation models

5.2 Governance in layers

As elaborated on in previous chapters, governance is multi-faceted as well as made up by several layers, of which the three most important ones, that are in the direct realm of DAOs, are summarized in the following table.

	Governance by the infrastructure / objective function	Governance of the infrastructure	Soft governance: culture / values / memes
Bitcoin	Proof-of-work rewards to create p2p ledger/money	Relatively unformalized off-chain - core devs make code proposals - semi formalized BIP process (Blockstream devs are quite dominant), full-nodes & miners need to adopt, UASF set precedent for fullnodes in strong position - miners follow full-nodes); history of upgrades through soft-forks, hard-forked Bitcoin chains such as Bitcoin cash and derivatives started new, distinct chains/DAOs	Strong libertarian value-system valuing decentralization above all else that is heavily influenced by Austrian Economics; disinflationary monetary policy - which is deemed sound money, token holder value maximization (more and more shifted from p2p cash objective function)

	Governance by the infrastructure / objective function	Governance of the infrastructure	Soft governance: culture / values / memes
Ethereum	Proof-of-work rewards to create p2p smart contract platform	Relatively unformalized off-chain (exc. small on-chain gas-limit adj.) - semi formalized EIP process, all core-devs calls, miners & fullnodes need to adopt/opt-in to changes; history of upgrades through hard-forks, remaining Ethereum - trade-mark owned by Eth foundation; forked-off distinct chain -> Ethereum classic, remaining unaltered after DAO hack	Freedom, openness, decentralization, transparency, stakeholder value maximization, developer technocracy, avoid capture (hostile takeover - deemed more likely with formalized & on-chain systems), immutability - internet jurisdiction (less emphasis than EthClassic after DAOhack), beauty in subtraction, "Eth is money" faction (leaning towards token-value maximization), no contentious hard-forks, Don't Break the Protocol, Keep Crypto Law Legal, innovative in the short-term, stable in the long-term
Decred	Proof-of-work & Proof-of-stake rewards to create p2p ledger/money	On-chain (ticket holder voting, tight coupling of protocol updates) & off-chain (meetings, conferences, politeia for natural language proposals - anchored on-chain)	Autonomous currency, token-holder value maximization - while avoiding stake centralization through PoW component, more corporate governance than national governance ("governing a digital commodity, notsociety")
Tezos	Proof-of-work rewards to create p2p smart contract platform	On-chain (liquid token-democracy) & off-chain (forums, conferences, etc.)	Conservative evolution (continuous, scheduled update process with 80% supermajority), security (formal verification, emphasis on testing), more corporate governance than national governance, liquid democracy
Cosmos	Proof-of-stake rewards to create hub enabling the internet of independent blockchains/ interoperability	On-chain (liquid token-democracy) & off-chain (forums, conferences, etc.)	Ecosystem of independent - sovereign but collaborating zones/chains/entities, internet of blockchains

	Governance by the infrastructure / objective function	Governance of the infrastructure	Soft governance: culture / values / memes
Polkadot	Proof-of-stake rewards to create hub enabling the internet of independent blockchains/ interoperability	On-chain (direct token-democracy) & off-chain (forums, conferences, etc.)	Ecosystem of purpose-built - interoperable chains that share security, more progressive bias towards change (dynamic quorum biasing), ultimate control with token holders, representative elements
Aragon	DAO/dappframework; PoS based Aragon chain based on Cosmos SDK; fee- & staking-based internetnative court system	Aragon network L1 DAO: On-chain (direct token democracy/transitioning to new governance model with constitution interpreted by Aragon court to protect minority stakeholders in token-votings) & off-chain (forums, conferences etc,.)	Freedom & sovereignty, censorship-resistant digital organizations, collaboration, modularity Individual communities using the framework have their own distinct values & culture.
DAOstack	DAO/dappframework; OS for collective intelligence/scaling decentralized decision making - prediction market-based proposal filtering, reputation based decision-making	Genesis DAO (first DAO created using DAOstack, with a mission to advance the DAOstack project and ecosystem): On-chain (direct reputation democracy) & offchain (forums, conferences etc,.)	Collaboration, collective intelligence, scaling decentralized decision-making, resilience Individual communities using the framework have their own distinct values & culture.
Colony	DAO/dappframework; layer 2 scaling for reputation systems	On-chain (direct reputation-democracy) & off-chain (forums, conferences etc,.)	Collaboration, hive mind - bio-mimicry, meritocracy - influence through high-quality work (focus on recency - decaying reputation), avoid friction of voting - independent decision-making at the edges Individual communities using the framework have their own distinct values & culture.
Moloch	DAO for fund allocation such as grants	On-chain (direct token-democracy) & off-chain (forums, conferences etc,.)	Moloch: god of coordination failures - urge for internalizing external effects to maximize societal

	Governance by the infrastructure / objective function	Governance of the infrastructure	Soft governance: culture / values / memes
			wealth, simplicity to constrain attack vectors, permissioned access based on value - furthering Ethereum, voice or exit through rage-quit
MakerDAO	Risk parameter-based credit facility & stable-coin	On-chain (liquid token-democracy & representative) & offchain (forums, conferences, etc.)	Most decentralized stable-coin, stability, scientific risk management, token holder value maximization, incentive alignment
Nexus Mutual	Risk parameter & staking-based risk sharing pool (insurance fund)	On-chain (liquid token-democracy & representative) & off-chain (forums, conferences, etc.)	Risk pooling as well as risk reduction through incentives, transparency, pragmatic decentralization - representation by board but ultimate control with tokenholders, digital cooperative (scaling a UK mutual internationally)
Compound	Risk parameter-based lending & borrowing facility incl. native token issuance to users (liquidity mining)	On-chain (liquid token-democracy) & off-chain (forums, conferences, etc.)	Thorough community discussion, questions, analysis & auditing of proposals

These DAO projects all feature examples of governance by blockchain infrastructure: A protocol or smart contract sets incentives by which it defines an objective function and programmatic rules according to which stakeholders need to operate, quite similar to the "nexus of contracts" that represents a firm. One stark difference is, however that DAOs either represent public, permissionless blockchains (L1 DAOs) or are built on them (L2 and above). This allows for increased scalability (low friction to join or set-up, rules are automatically enforced), resilience (if some nodes drop out, others can easily come in to gain the reward, automatic rule enforcement) and innovation (functionalities can be easily integrated and stacked upon each other). Layer 2 DAOs are often-times permissioned to join (Moloch requires members to be voted in – on-chain; in Nexus Mutual, one needs to become member of the UK mutual). As their code is open source, it is though permissionless to copy the code and start a similar offspring.

Governance of the infrastructure is crucial, as the world is moving, stakeholders change, and new insights necessitate evolution in the code that represents the basis of the DAOs. Some DAOs have core decision making facilitated through tightly coupled on-chain voting, while others use a variety of signals to then have off-chain coordination follow-through on actual code updates. All in all, however, it is always social consensus that is the deciding factor and the ability to fork allows any fraction to split, which is usually tried to be prevented by only implementing changes that have broad support as well as would not incentivize a crucial minority to split.

As in the end the driving force and actors in organizations are people, culture and memes ("ideas, behaviors, or styles that spread by means of imitation from person to person within a culture") are a crucial aspect of any DAO community. Besides pure profit motives, which appeal to extrinsic motivation, intrinsic (the pleasure of executing a task) as well as identified (to achieve a shared goal) motivation are strong drivers of human behavior (which are especially important in the open-source space). The essence of a DAO goes beyond the pure code that defines its rules, and members are often attracted by ideology and stories, which they then in turn shape as well.

All in all, a DAO is the attempt to collectively organize towards a shared common goal (with potentially untrusted peers) in a novel way. A crucial question is whether such organizational forms can align stakeholder interests in order to be sustainably successful, which will be elaborated on in the next section.

5.3 Digital commons & aligning incentives towards stakeholder value

Many of the blockchain communities are creating digital commons that demonstrate commonly shared resources such as source code and data. Public/permissionless blockchains, which are the focus of this paper, explicitly allow anyone to participate creating these commons and accessing them. To some extent services are non-rivalrous, as data once stored on a blockchain can be accessed nearly freely by anyone (within limitations), while write access (e.g. to send a Bitcoin transaction) is rivalrous as there are certain capacity limits, which are addressed by mechanisms such as fee markets, thus featuring aspects of private goods (rivalrous/excludable). The more abstract utility of having resilient, independent, always available infrastructure, however, represents a public good (non-rivalrous, nonexcludable). Communities are experimenting with solutions to the well-known incentive problems to create public goods (free rider problems). These represent governance by the infrastructure through token-engineering (e.g. bonding curves, quadratic funding).

Bootstrapping digital commons could be summarized to establishing a vision, purpose and culture (creating memes), setting objective functions (incentive systems) and communicating those to enthusiastic initial members (potentially incentivized

by early token issuance) until resource gravity/network effects kick in to self-sustain growth.

Already at start, the course for governance of the infrastructure / the commons needs to be set, as community members and their expectations as well as values will be attracted and formed by the initial vision set out. In order to create sustainable ecosystems as well as attract a broad member/user base in the first place, it is desirable to have well-balanced interest alignment of various stakeholder groups. However, in order to iterate quickly at early stages, decentralized governance can be introduced gradually over the lifetime of a project.

In communities with off-chain governance such as Bitcoin and Ethereum no stakeholder group is officially in charge and they each have certain veto rights in practice, making them rather slow moving. What is more, strong personalities tend to dominate discourse and decision-making processes, especially if there is no formal hierarchy. The user-activated-soft-fork, however, is argued to have proven that users are ultimately the most powerful stakeholders in Bitcoin and thus in similar (offchain governance) systems such as Ethereum by analogy as well.

Communities with tightly coupled on-chain governance on the other hand, put token-holders in charge, resembling aspects of shareholder value maximizing corporate governance (see agency theory), which makes them more prone to capture/hostile takeovers, as argued by off-chain governance proponents. To some extent stakeholder groups overlap and token-holders are users (using a store-of-value/medium-of-exchange currency). One could also argue that ultimately market forces are crowding out projects that do not cater to users' needs, thus also putting users in control ultimately. However, as laid out below, network effects and market power have opposing effects.

5.3.1 Tyranny of structure-lessness & the free market

Arguably, a completely free market with perfect competition is a form of decentralized governance. However, it traditionally at least requires property rights, usually enforced by a central government, while most free market advocates would also support various other rules and regulations. What starts as perfect competition, however, might evolve into more and more monopolistic competition. Thus, there is a need to actively design and govern institutions in a way that counters forces towards monopolization, which would lead to an imbalance in stakeholder representation.

Without any structured form of governance (and regulation), the raw survival of the fittest prevails and economies of scale as well as information asymmetries lead to monopolies of power as well as wealth accumulation in ever fewer hands.
This results in not only inequality in outcomes, but also in inequality in opportunity (see e.g. education in emerging markets and even the US – private elite schools vs. public schools).

Despite the fact that permission-less distributed blockchains are intended to enable disintermediation and egalitarianism, its ecosystems are characterized by various third parties, some very profitable, as well as asymmetric information, a lack of transparency in decision making and power disparities amongst core developers and users. Thus, there is still considerable room for improvement in increasing transparency through measures such as better interfaces, education and industry best practices in disclosures.

Wright[163] argues that all PoW (and PoS) systems, will ultimately lead to corporate consolidation or to plutocracy, as influence over the system depends on token or hash-power ownership. A plutocracy implies government or rule by the wealthy, and consequently favors private interests over the common good. Economies of scale for example in mining, as well as in accumulating tokens can lead to asymmetric accumulation of power. There are however projects such as Spacemesh[164] tackling exactly those issues in order to create mechanisms that are resistant to centralization based on economies of scale and capital accumulation.

5.3.2 Platforms create markets – cryptonetworks create contestable markets

Similar to other network industries, such as platforms, blockchains feature positive externalities (the more users, the more possible connections/interactions/value creation). As laid out earlier, platforms therefore represent natural monopolies, as it is most efficient to converge on one ("winner takes all").

Thus, as mentioned earlier, there is a problematic trend towards monopolization in digital platforms. Cryptonetworks could demonstrate a solution to still leverage the network effects of common infrastructure, however making the monopolistic network contestable, due to the possibility as well as credible threat of forks.

In the words of Vitalik Buterin on intermediaries such as platform operators (as a common theme in blockchains communities is to eliminate middlemen):
"I recommend crypto discourse changes emphasis from ***eliminating the middlemen*** *to some combination of* ***shackling the middlemen*** *and* ***making the market for middlemen more competitive."***[165]

What differentiates blockchain-based systems from platforms as well as nation states is their permission-less, voluntary participation and exit (with full control over one's data, assets and open source code). As mentioned earlier, participants can fork or threaten to fork, in order to exit one ruleset (as long as there is a critical mass that makes an altered or split community feasible). Being able to exit, radically reduces the need to voice opinions of members. Still, it makes sense to use mechanisms to discourage excessive reliance on exit, and to express and converge on the community's diverse voices.

Maximizing value by reaching social consensus

If network effects exist, there are strong benefits to remain unified instead of splitting communities. As a result, if values and objectives amongst communities are similar enough to agree on common protocol parameters, there is considerable value to be created by preventing factions to split.

Thus, value can be maximized if decision-making processes enable finding common ground. Various interfaces, participatory as well as evaluative infrastructures have been covered, while there is being experimented with more. It is worth highlighting that even if a governance system is generally off-chain, projects such as EthSignals that try to aggregate community signals in a structured way are especially valuable.

Barrera and Hurder[166] model blockchain upgrades as a coordination game comparing majority rule and quadratic voting and find that neither voting scheme eliminates the occurrence of suboptimal hard forks in the sense of maximizing total welfare (depending on community composition and the upgrade in question).

Closely related to this is the concept of input legitimacy (or procedural fairness) as opposed to output legitimacy. Even if a system does not give people what they want, the fact that processes are democratically legitimated or at least take community input into account as good as possible, members tend to consider it fair and worthwhile to be part of. This goes beyond voting and a well-designed proposal process (incl. filtering) is crucial to engage the broad community.
As mentioned earlier, in distributed innovation systems the role of management shifts more towards diplomacy as the locus of control lies in self-sovereign actors. Thus, there is a crucial role in community diplomats to translate between different stakeholder groups, aggregate various viewpoints and negotiate towards social consensus.

If individual communities are too distinct to find social consensus on values and protocols, federations of interoperable blockchains such as envisioned by Cosmos are an interesting avenue.

Network effect lock-in

A crucial question remains: Will network effects in certain DAOs become strong enough to make exit for individuals infeasible? We see in the case of Ethereum and the decentralized finance (DeFi) ecosystem, that is blossoming that in order to start building DeFi on alternative layer 1 DAOs/blockchains, there is at least a bridge to Ethereum necessary, as most token liquidity is currently there. If network effects are strong, it is especially dangerous if there is a stakeholder group that has outsized influence, such that they can exploit other stakeholder groups (e.g. plutocracy). Arguably, there exists a minimum viable faction of stakeholders such as users to collectively exit and bootstrap a new community, so coordination mechanisms to allow an orchestrated switch are important in order to make the threat of exit credible.

5.3.3 Challenges regarding stakeholder value maximization based on agency theory

DAO communities speak of aligning incentives for all stakeholders, which is a challenging goal. Agency theory criticizes the maxim of stakeholder value maximization particularly due to four factors, which need to be overcome.

Too many stakeholders exist

As elaborated earlier, multiple stakeholder groups are participating in a DAO (miners, users, exchanges, etc.). However, if one imagines DAOs become so wildly successful that they orchestrate a large share of human value creation, external effects touch much wider parts of the population (already today Bitcoin causes negative environmental externalities in the form of energy consumption). It becomes more and more complex to cover all of them.

Stakeholders' inputs may not be critical

Not all stakeholders are strategic (input critical), thus in the case of upgrade decisions, some will not have much leverage by threatening to fork.

Stakeholder participation can lead to deadlocks in decision making

As seen in Bitcoin's and also to some extent Ethereum's off-chain governance process in which different stakeholder groups need to form social consensus in order to collectively affect change, there have been deadlocks in decision making (e.g. see block size debate).

Lacking a single objective function undermines managerial accountability

In the traditional sense, a firm's single objective function would be profit (in a shareholder value maximizing model). Taking into account stakeholder interests is much blurrier and requires a political process in order to balance interests.
In addition, qualitative success criteria are much more difficult to measure than profit, which means tightly coupled incentives are difficult to apply. One can argue, however that optimizing towards balancing stakeholder interests can very well serve long-term profit maximization, as a healthy ecosystem will sustainably be successful, while an ecosystem that is sucked out by a few stakeholders cannot bloom.

In the case of DAOs, there are hard-coded incentive models that aim at optimizing an objective function (e.g. maximize security through hashrate in PoW). Individual actors or participating firms (miners) are assumed to be profit-maximizing actors.

A purpose driven DAO can start off by setting a vision, objectives and a constitution in order to allow members to self-select to a given project and then optimize towards the set goals. This, however, potentially does not take into account non-strategic stakeholders that might suffer from external effects. In order to implement effective governance that takes into account broad stakeholder interests, the above-mentioned challenges need to be addressed. This is especially crucial and challenging if such an entity operates autonomously across borders.

6 Conclusion

In this paper we have been looking at blockchain/DAO governance from various viewpoints, first elaborating what governance is, what blockchains are, reviewing extant literature (blockchain focused, as well as selected works on classic economics/organization science), laying out distinct features regarding governance of major blockchain projects to then synthesize common elements and conclusions from both theory and practice.

Blockchains are institutional and governance technology, they can govern collective action but also need to be governed (ultimately by humans) in order to represent the governed. Thus, one can separate governance by blockchain infrastructure (akin to organizational and mechanism design - the structuring of communication, coordination, and control) and governance of the infrastructure.

Governance by the infrastructure – distributed innovation systems on blockchains

Three distinct components define a new era of organizational design – distributed innovation systems, that span open-source communities, platforms and open organizations that have been inspired by them: 1) interface design (mediating interaction within and across systems, as well as their different sub-systems and

actors); 2) participatory architectures (enabling peers to articulate ideas and contribute meaningfully or provide other resources such as computing power or data); 3) evaluative infrastructures (accounting mechanisms judging quality and value).

Distributed innovation systems that are based on governance by blockchain infrastructure can potentially solve the problem of further platform monopolies emerging, by making the logically monopolistic network contestable based on the threat of forks (of the single protocol/ruleset, as well as data that is owned by users) which makes the market for middlemen more competitive, while benefiting from decentralized infrastructure and control. Thus, networking of distributed peers is facilitated, without the market power costs that usually go alongside centralized operators.

From reducing transaction costs due to distant search to alleviating monopolized trust

Generally, inefficiencies in trade arise when parties do not reach the best possible collective outcome through transaction costs such as search costs, complexities in contract drafting and enforcement or incentive problems like the hold-up problem.

The internet has largely tackled frictions through search costs, while blockchains are interesting when frictions arise because of a lack of trust. The hold-up problem, one premier reason why firms exist (as contracts are usually incomplete), could be solved in a novel way, by using blockchains as neutral, shared databases, on which crucial components of distributed innovation systems depend, namely architectures for collaboration as well as evaluation.

Rules are clearly and transparently defined and to the largest extent immutable (viewing the case of The DAO hack in Ethereum and the resulting hard-fork to manually reimburse victims as an exception and symptom of an early ecosystem). Thus, business relationships ought to be more predictable and leverage to renegotiate of a stronger partner/platform operator can be mitigated (which allows rational actors to enter into such a relationship in the first place, as no re-negotiation is expected).

Contracts can potentially be designed in a more complete way, leveraging commons libraries of contingencies that cover more edge cases and automated enforcement. However, many organizations will still depend on incomplete contracts and human judgement. Aragon Agreements is an example of natural language contracts, that are interpreted by Aragon court, a game-theory based, distributed arbitration court. DAOs like Pocket network are exploring to organize around a constitution which lays out the social contract of the community as an “off-chain protocol”, while its consensus mechanism defines the explicit contracts (complete contracts) of using the on-chain protocol.

Permissionless public infrastructure creates resilience

A protocol or smart contract can set incentives by which it defines an objective function and programmatic rules according to which stakeholders need to operate, quite similar to the "nexus of contracts" that represents a firm. One stark difference is, however that DAOs either represent permissionless layer 1 infrastructure or are built upon such, which allows for increased scalability (low friction to join, automated rules enforcement), resilience (while some peers can drop out, others can easily come in to gain the reward) and innovation (functionalities can be easily integrated and stacked upon each other).

Besides pure profit motives, which appeal to extrinsic motivation, intrinsic (the pleasure of executing a task) as well as identified (to achieve a shared goal) motivation are strong drivers of human behavior (which are especially important in the open-source space). The essence of a DAO goes beyond the pure code that defines its rules, and members are often attracted by ideology and stories, which they then in turn shape as well.

Balancing immutability/stability with change

One can debate the extent to which blockchains are and should be immutable, which has a large effect on governance by the infrastructure. If one of the most crucial aspects of a layer 1 DAOs/blockchain is to securely store and transfer digital property rights (which promotes access to capital and economic development), as well as represent reliable and legitimate institutions for layer 2+ DAOs, it should favor stability over change (as stable systems/institutions have historically been more economically successful and less change opens fewer avenues for questioning legitimacy of an institution). However, systems will always need to evolve, as circumstances and the people they serve change, which necessitates governance of the infrastructure.

Governance of the infrastructure

Communities have been experimenting with various systems to govern the infrastructure, from informal to formal processes, from loosely coupled off-chain to tightly coupled on-chain systems. There is no doubt that voting plays an important role in gauging community sentiment and to condense individual preferences into a picture that reflects the aggregate. The main questions are, 1) which stakeholders are entitled to vote (to the largest extent token-holders in permissionless systems, as "1-person-1-vote" has so far been either reliant on centralized KYC or not sybil resistant) and 2) how tightly coupled is the result of the vote with a protocol change. As for the 2nd dimension, there is a strong argument regarding the importance of the default behavior of client software that powers full-nodes (which have shown a dominant position in enforcing consensus rules as in the case of the UASF) and whether those stakeholders should be required to opt-in to a new set of rules or required to opt-out actively in order to avoid a change (given the former will be biased towards the change, as there is a strong Schelling point/coordination flag

towards the tightly coupled result). Non-mining full-nodes or users running full-nodes, that do not hold a significant number of tokens do not have a sybil resistant mechanism to signal their stance towards an upgrade such as token-holders. Thus, the requirement for full-nodes to actively opt-in to a protocol change represents an important counterbalance of power that leads towards a more holistic stakeholder representation (though with a bias towards the status-quo, that can lead to stasis in the worst case). Tightly coupled on-chain voting, however, forces nodes to implement change if decided so by token-holders (if they do not opt-out and fork off, which might be more difficult to coordinate).

Stakeholder lock-in as a measure of interest alignment & legitimacy of governance rights

Agency theory commands that the providers of specialized inputs should be in charge of governance, which has traditionally been providers of physical capital/ investors, as they are locked-in with their investments (sunk costs – inputs are not useful otherwise or it is costly to make them so). In the knowledge age and digital sphere it is increasingly specialized knowledge, data and the use of standards, but also capital that is being invested, staked or locked-up for extended amounts of time to contribute to network security and value creation that represents those specialized inputs or sunk costs.

While user and app developer lock-in through user-controlled data, open code and the ability to fork is considerably decreased compared to centralized platforms, it still exists due to network effects and coordination problems that make it harder to fork together with large stakeholder groups. Thus, the requirement to opt-in to protocol changes by full-nodes that are run by and represent power users (strategic stakeholders - sophisticated end-users, exchanges, app developers) such as in non-tightly coupled voting as in off-chain governance, might be necessary as long as there is no sybil resistant way to include them in tightly-coupled on-chain governance. Core developers that provide their specialized input arguably have strong influence in both tightly coupled on-chain as well as loosely coupled off-chain voting, due to information advantages, as well as them actually implementing upgrades. It is true that tightly coupled on-chain governance can also lean towards conservatism and stability by requiring higher quorums and/or supermajorities, however it is still only token-holders that vote, as opposed to a broader strategic stakeholder base.

As the level of lock-in depends on the strength of network effects, a network can arguably be governed in a more centralized way early in its evolution (which allows a faster pace of change and iteration), however it is important to engage a broader stakeholder base as the network scales in order to set up a sustainably successful ecosystem (which can be established through the vision & roadmap that is communicated early on, through which stakeholders self-select to adopt the protocol – this can then create a Schelling point for stakeholders to converge on).

Stakeholder representation vs. scalability of decision making

There are large differences in participation rates in voting, due to differences in community size and composition and differences in voting systems as well as quorum requirements. Direct democratic approaches suffer from low participation as decision-making involves cognitive costs, so some amount of representation by councils, boards and/or through liquid democracy might be necessary in many cases in order to enable effective decision making (e.g. voting power delegation in Compound). Liquid democracy structures are blending the best of representative and direct democracy, allowing anyone to directly vote on an issue, if she feels to be well informed or there is a strong opinion, as well as allowing for delegating one's voice to a representative. Thus, voters who are rationally ignorant might have enough incentive to at least delegate, while the cognitive load of deciding on a matter is outsourced to the delegate (which increases turnout). Voters who are motivated to decide for themselves can still do so, which increases decentralized input. There have been votes that were able to be influenced by large individual voters, which becomes easier as there is low participation. Adaptive quorum biasing, introduced by Polkadot is an interesting approach to autonomously protect against low turn-out votes having a result that does not reflect the whole. Making an elected board decide and let them be overridden by a sufficient threshold of voters is also a pragmatic way of leaving uncontroversial and day-to-day decisions to agents that focus on the matter, while keeping the option of decentralized direct decision-making. One could argue Nexus Mutual does not represent a true DAO as it has elements of centralization and lacks true autonomy and permissionless-ness (limiting influence of individual voters to 5% by KYC). However, also other projects show centralized and permissioned aspects, highlighting the fact that decentralization is multi-faceted as well as a spectrum and not absolute. Finally, token/vote distribution (incl. the level of participation and decentralization of full-nodes) is the most crucial factor in determining the extent to which power is decentralized and communities ought to target and select long-term, mission aligned and knowledgeable investors (timelocking for voting can be a feasible proxy for long-term alignment).

Multi-layer Governance

One of the most important questions is what is the highest institution a blockchain or blockchain-based organization is embedded in? One cannot view any of the layers in isolation, but mutually intertwined and people's behavior is informed by the sum of this complex system. If a DAO aspires to be autonomous in the sense that it understands its purpose as representing a completely self-sovereign entity, a governance approach that balances all stakeholder interests (not only strategic) with democratic (1p1v) legitimacy might be required in order to limit negative external effects such as carbon emissions of PoW (while it is questionable how far ranging the voting population is defined and decentralized identity has not been solved yet).

This stands in contrast to the view of Vitalik Buterin that if Ethereum becomes something political, which rules you can debate, its utility gets reduced considerably

(as a neutral, immutable state machine). In fact, cryptocurrencies have been started due to the frustrations with the current imperfections in governance, such as collusion and bribery. However, in practice, already TheDAO hack and subsequent split into Eth/EthClassic has shown the political aspect. Vitalik makes the distinction that an entity that changes/evolves due to the collusion of 51% of actors is a DO while DAOs are resistant to collusion (which he argues to be especially important, given plutocracy favoring effects such as wealth concentration and bribery). This hints towards him wanting Ethereum to be more of a DAO than a DO that can explicitly be influenced by a majority of e.g. token holders through on-chain governance. He highlights that a base-layer chain should be innovative in the short term and stable in the long-term, while satisfying hard crypto-economic guarantees in order to be reliable. Other community members, however, frequently highlight the fact that autonomous software is to be avoided, due to ex-ante unknown external effects. Rough consensus and running code with core developers balancing stakeholder interests is resistant to be captured by hostile takeover of token-based voting rights, but excessive power of developers on the other hand can also be a risk, while still being kept in check by users/nodes needing to adopt a given update.

In contrast to the viewpoint that blockchain networks could be platforms for governing society, members of the Decred and Tezos communities, argue that cryptocurrency networks are rather platforms for coordinating digital commodities and thus better compared with corporate governance than national governance.

A DAO that subordinates itself to a higher-order governance system that is democratically legitimated (akin to a nation state), can operate based on token-holder based on-chain governance, while being held in check. However, bribery and manipulation of news channels is a real phenomenon that must be solved for crowd participation to be effective in any case. The approach that a cryptonetwork is regulated (by states) at the edges (node/exchange) level basically translates to a setting in which actors are governed by various layers, with state level regulation as a meta-layer finally trumping blockchain incentives for an individual. Still, a decentralized network as a whole can remain resilient to changes in legislation in any particular jurisdiction. It is however crucial, for a cryptonetwork to maintain effective interfaces with jurisdictions (e.g. legal wrappers, compliance tools, stakeholders negotiating/taking into account rules and protocols) in which it is supposed to be adopted, as interoperability drives network effects and thus value.

Ultimately, governance is about social consensus

In the end, social consensus is what defines a cryptonetwork. The option to fork is the most crucial instrument of last resort to force decision-makers to take stakeholders into account, while effective governance gathers maximum stakeholder voice in order to avoid exit. Coordination mechanisms that allow for coordinated switching to a new fork are important to make the threat of a fork realistic. A default setting of not to update, as in loosely coupled off-chain governance creates a coordination flag towards stability, important for base-layer institutions.

As network effects exist, there are strong benefits to remain unified instead of splitting communities. As a result, if values and objectives amongst communities are similar enough to agree on common protocol parameters, there is considerable value to be created by preventing factions to split. Thus, value can be maximized if decision-making processes enable finding common ground. Designing good interfaces and participatory infrastructures that enable the aggregation of viewpoints of diverse stakeholder bases are of utmost importance. Also, effectively filtering through proposals and gauging community sentiment before resources are spent to develop an upgrade that might not be adopted are crucial.

What is more, management changes from hierarchical relationships to community management through diplomacy "to govern the ungovernable—the anarchical society—through discursive and cultural practices", as open network-organizations made up of self-sovereign actors (to whom the locus of control shifts, due to them being allowed to exit and self-select to a new protocol, for which exist lower barriers to entry). In open networks of peers with distributed leadership and agency a manager-diplomat needs to be creating the conditions for collective action to occur. Community management in blockchain ecosystems is therefore of utmost importance, not only to attract the best possible community (with a fit regarding values and skills), but also to moderate and translate amongst different stakeholders in order to crystallize common or opposing viewpoints and unite the community to a coherent whole.

It is culture that represents the deep values driving participants (i.e. the social protocol that runs on people's minds). Thus, culture shapes all governance layers above and especially also which protocols participants self-select towards. A community's culture (like a company culture) gets built over a longer time horizon, is mostly implicit/tacit (exists in the participants' minds, potentially only subconsciously) and is thus hard to codify and as a result, hard to imitate (as opposed to open-source code).

Bootstrapping DAOs could be summarized to be establishing a vision, purpose and culture (creating memes), setting objective functions (incentive systems) and communicating those to enthusiastic initial members (potentially incentivized by early token issuance) until resource gravity/network effects kick in to self-sustain growth.

The discussion around governance is to some extent highly ideological, as no optimal form of governance exists – considerations for efficiency, as well as trade-offs among stakeholders have to be taken into account, which makes the process inherently political. Thus, there is room for a diversified set of DAOs, covering broad ranges of objective functions and value systems, that will be also reflected in their governance systems. In a space where code and data are open (and/or user-owned), governance driven by values, norms as well as community composition and thus access to knowledge, offers sustainable competitive advantage.

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