

DAOstack

An Operating System for Collective Intelligence

White Paper V1.1

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Work in progress, comments are welcome.

Abstract

DAOstack is an operating system for collective intelligence and a new form of human association: the DAO. Decentralized Autonomous Organizations have captured the imagination of the best minds in the blockchain space, but despite their promise have yet remained unachievable. A central missing element is a solid framework for decentralized blockchain governance, and in particular scalable and resilient governance protocols that can support the processing of large number of crowd decisions effectively. At the base of the DAO stack, Arc[1] is a modular and adaptive framework for governance and collective value management over the blockchain. Just as HTTP allows the creation and interoperability of web sites and web applications, Arc allows the creation and interoperability of web *companies*, collaborative apps and DAOs, as well as the crypto-economic alignment of their interests. Implemented with novel Holographic Consensus protocols that allow a scalable consensus, the result is a new web of open collaboration, in which global networks can self-organize around shared goals and joint action. We believe that DAOs will impact every territory of life and will jumpstart the evolution of society toward a more cooperative and sustainable future.

[1] Derived from the Greek word Arche, meaning "method of government".

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1. Introduction

Since first appearing on the planet, humankind has been constantly inventing new ways to organize and increase the scale of cooperation with more and more effective structures, from the nuclear family and tribes to states, corporations, and the global economy. The most advanced organization thus far, the Internet, opened the door for real-time information exchange at a worldwide scale, but it lacks the economic means for general-purpose coordination and global peer-production. The Blockchain made this possible by providing a reliable, open and programmable accounting system, consequently leading to the invention of the Decentralized Autonomous Organization (DAO).

DAOs are open, self-organized networks coordinated by crypto-economic incentives and self-executing code, cooperating around shared goals. Powered by the network effect, DAOs provide a revenue model and incentive for the production of open, shareable resources (such as open-source code and a music file). With the creation of more open resources, the DAO will be able to scale indefinitely while keeping its agility and coherence, and in many cases outcompete existing corporate structures. DAOs have attracted top talents in the blockchain space, holding promise for more efficient and resilient organizations. Despite this, they have lacked critical elements to be successfully deployed so far, and in particular an adequate decentralized governance system.

DAOstack is an operating system for DAOs. With DAOstack, thousands of open-source creators can jointly produce decentralized applications (DApps), while distributing individual ownership in the product to contributors of value. Crowd curators can cooperatively own and manage multi-valued ranking systems to compete with Yelp, TripAdvisor, or YouTube. And autonomous networks can run their collective investment or insurance fund. We believe DAOs will radically change the way people organize, from startups to corporations, to nonprofits and even nation-states. DAOstack develops the foundational elements needed to enable this transition to the future of work.

In the next chapter we describe the future of the DAO: an *acentric*[2], *anti-rival*, scalable cooperation (to be defined below). In the third chapter we explore the topic of blockchain and in particular DAO governance. In the fourth chapter we present our technology: the DAO stack that enables this new form of organization, and give multiple examples for its usage. In the fifth and last chapter we elaborate on the DAOstack economy, the GEN token and its engine of growth.

[2] The common term is '*decentralized',* but we find '*acentric*' (= has no center) more elegant and accurate.

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2. DAO: The Future of Organization

The ability to well-organize and coordinate a large number of individuals is one of the greatest forces and drivers of society, which has gone through constant evolution over thousands of years. In this chapter we describe the challenges of the legacy organization today, and a new possible form of web organization: the DAO.

Legacy Organizations

Cooperation of agents increases their efficiency with respect to external competing market forces. This is the basic origin of the company[3] and the reason organizations want to grow. However, coordination of agents entails increasing coordination cost as the organization grows, and that is why organizations cannot grow indefinitely.

When growing, organizations need more rigid structure in place, and thus face a growing challenge to: a) maintain agility with respect to rapidly changing conditions, and b) preserve alignment of interests, trust and engagement among their members. In short, the larger an organization is, the more internal friction it needs to cope with; the smaller it is, the more external competition is predominant. The actual size of a company is generally the sweet spot balancing between these two forces.

Once in a while, the introduction of a new technology or paradigm shift enables the reduction of coordinational cost, pushing up the scale and efficiency of organizations to new levels. It triggers a transition in the landscape of work and business, and thereafter a social change too, as was exactly the case with the invention of crowdsourcing and the Internet itself.

The Internet allowed for an open, real-time and peer-to-peer information exchange on a global scale. As such, the Internet media has become more effectively scalable than traditional media outlets, and has quickly assimilated the latter. However, the Internet by itself does not support open, peer-to-peer exchange of value and general-purpose coordination, and is thus limited in its potential to power global cooperation.

The Blockchain

Blockchain is the second internet revolution, doing for value and business what the Internet has done for information and media. It allows unprecedented levels of crowd coordination by eliminating altogether the

[3] As formalized by Coase in his famous paper “The Nature of the Firm”.

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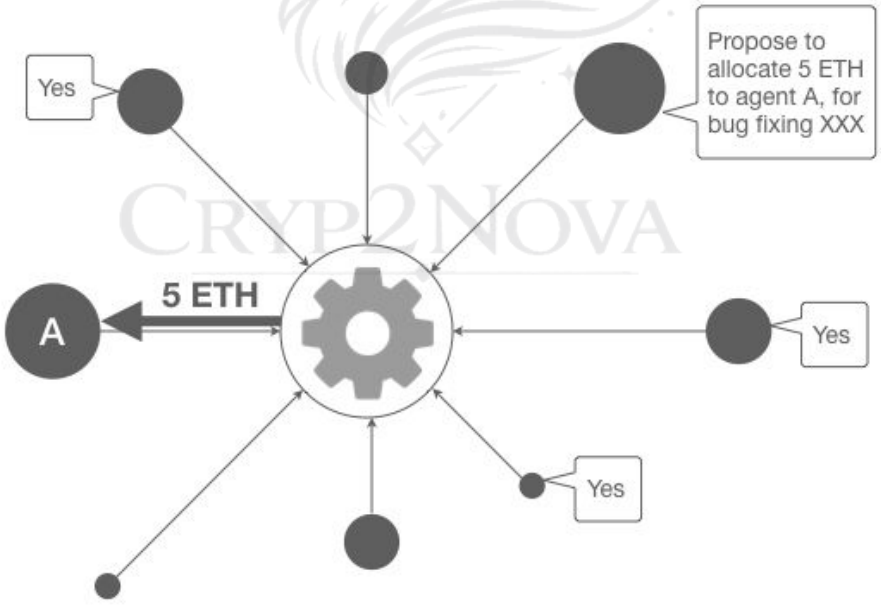


issues of fault and trust, and consequently forms the technological basis for Decentralized Autonomous Organizations (DAOs). A DAO is a new form of scalable, self-organizing cooperation, that is operated by smart contracts on the blockchain. Many believe that DAOs hold the promise for the future of business and work, but despite a lot of traction in the blockchain community around this subject, a successful governance system and operational basis for DAOs is still missing.

Agencies

The building blocks of DAOs are *smart companies*, or *agencies* (we will use those terms interchangeably). A smart agency is an atomic governance unit that is managed and operated with smart contracts on the blockchain. It has its own *token* (related to benefits of the company's resources), its own *reputation systems* (related to credibility and influence in company matters), and its own governance system (its "bylaws" encoded in smart contracts).

The governance protocol embedded in the smart contract of an agency can be anything one can come up with. A simple example is a proposal-based governance system, with a yes/no majority vote on proposals needed for approval and execution (which become a single action in smart companies). Proposals might be about token distribution, for example, and votes can be weighted by the voter reputation. We will give a handful of other examples in the next chapter. In a heuristic visualization it could look like this:



A *schematic illustration of a blockchain agency.*

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The solid balls represent agents in the company; their distance from the center reflects their influence power, or reputation (the closer they are the more influence they have); and their size reflects their native token possession (the larger the ball the more of the company's tokens they hold). One agent is proposing to allocate 5 ETH to agent A for her valuable contribution of fixing bug XXX. The agents of the company vote, with their vote weighted by their reputation, and as soon as a majority of reputation holders agree with the proposal the contract automatically executes the suggested token allocation.

DAOs

Agencies operate with smart contracts on the blockchain. They follow verifiable rules that cannot be broken and are changeable only in accordance with the rules themselves. They may or may not be autonomous depending on their chosen governance system; for example, an agency can reserve a veto option on its own decision making process for another agency.

A DAO is a centerless mesh network of agencies, which is also an agency in itself. There is no single point of control, or failure, in the organization. Instead of central management there is indirect coordination between agents, also known in biology as stigmergy, triggered by incentives and code. A DAO is a self-organizing entity, and at large better resembles an organism rather than an organization.

Scalability

The one common factor of all legacy organizations is that they are "sub-scalable". Which means that they become less and less effective as they grow in the number of agents and number of decisions they need to make. Free markets, the Internet and network-effect based applications (such as Facebook and Airbnb) are all "super-scalable" structures — that become more effective as they grow in members and interactions. With this terminology, the DAO is a "super-scalable organization", that assimilates the efficiency, agility and scalability of free markets, while maintaining the coherence of a startup and the ability to pursue scalable missions.

DAO Topology

There are various modes of decentralization, and accordingly various modes to think about DAOs with respect to an agency. The commonly known way to think about DAOs is the large assembly mode:

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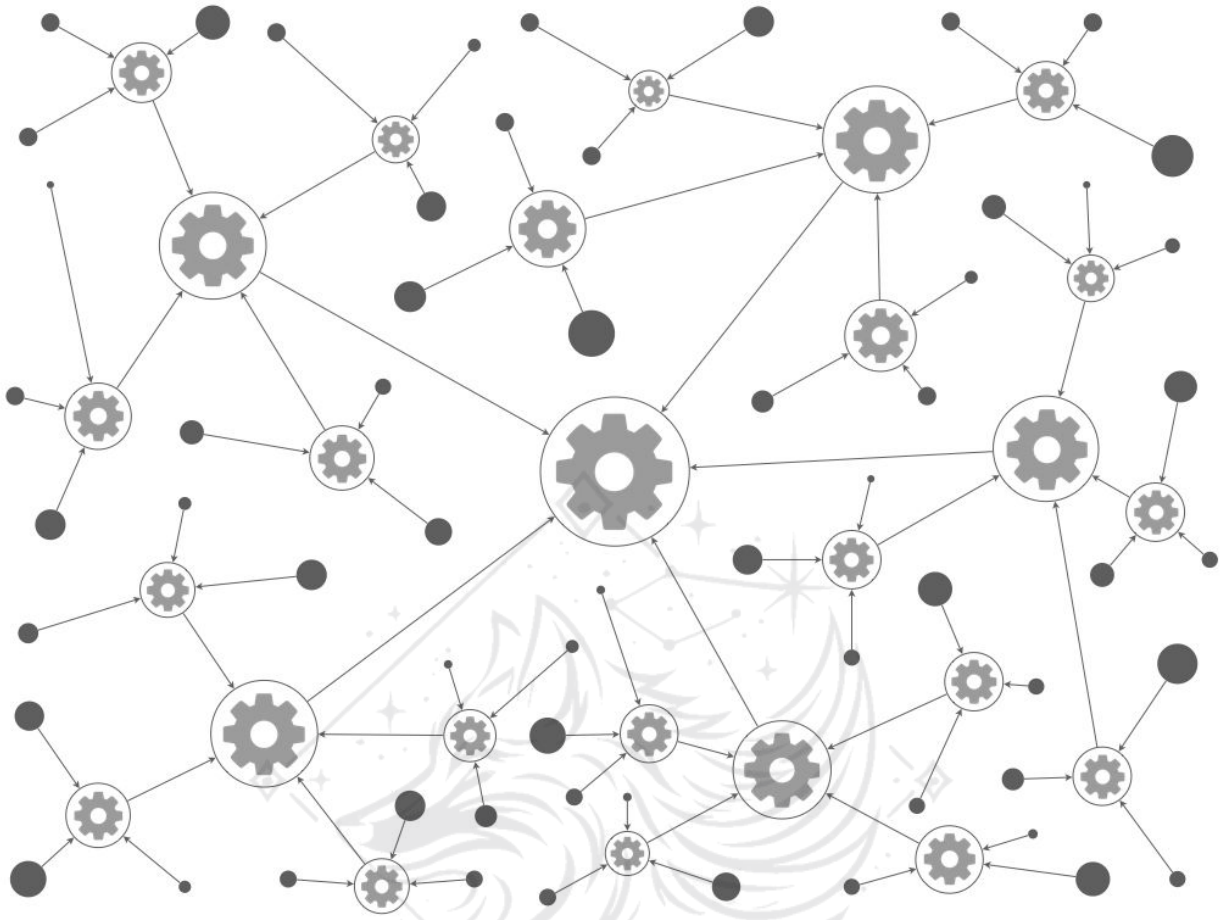


The assembly mode of a DAO.

In an *assembly* mode of a DAO, a large number of agents are interacting in decision making within a single agency via its smart contract, assuming that reputation, and thus decision-making power, is fairly distributed. Despite being the simplest, this mode is inherently in tension with scalability and has a limit on its processing capacity, while maintaining resilience. We will introduce tricks to extend the process capability of this DAO mode as well, but by itself it cannot be the entire answer.

The second mode of decentralization is the *fractal federal governance*:

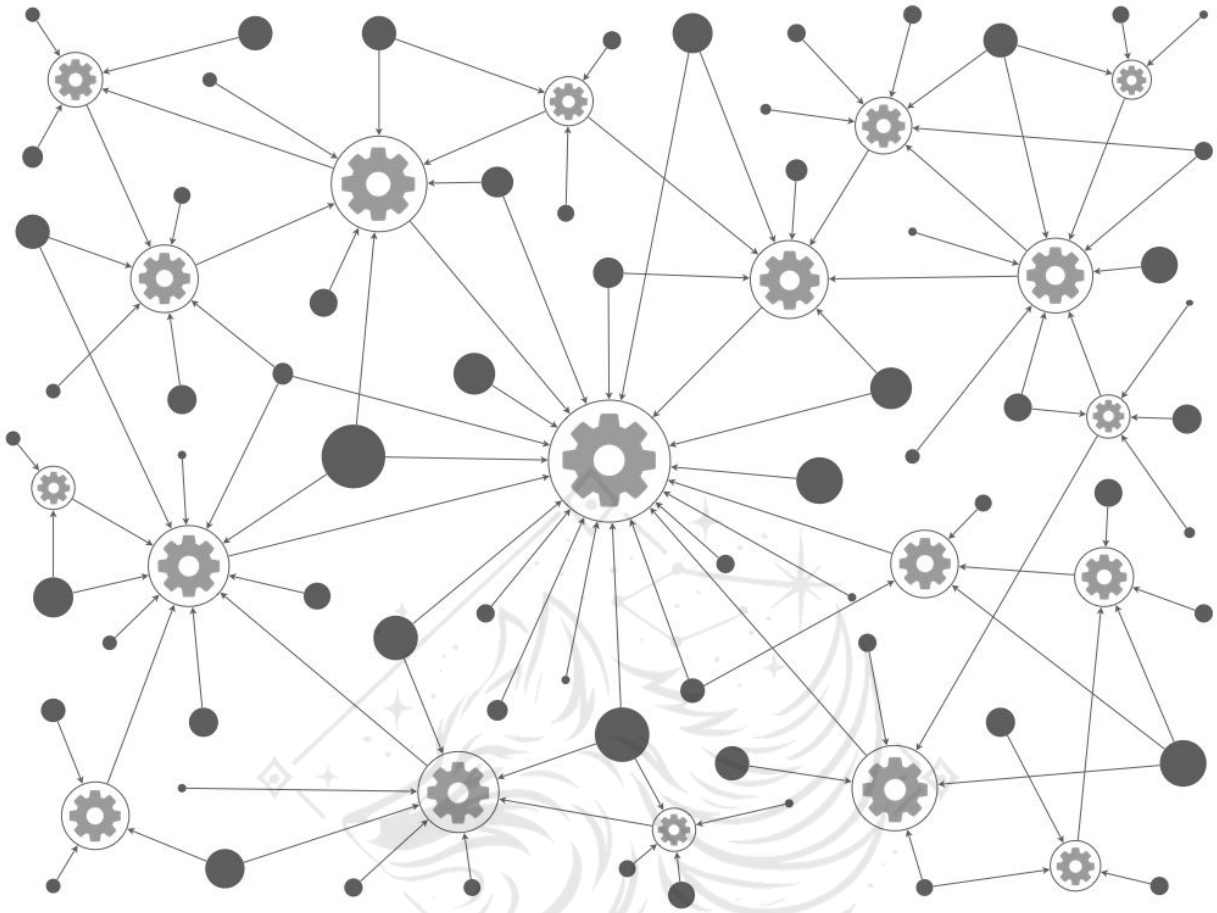
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The fractal federal-governance mode of a DAO.

In the extreme fractal federal-governance mode of a DAO, the DAO is an agency with a a few agents, each of which is itself an agency with a few agents, each of which is itself an agency, and so on and so forth. In reality, the DAO would probably be somewhere in between those two modes, and well beyond, as a nested mesh network of agencies, interwoven with other DAOs through shared agencies:

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The complex mesh-network mode of a DAO.

The complex DAO mesh network will naturally arise from its building blocks (agencies) with the infrastructure provided by the DAO stack. Power can be well distributed in a *meritocratic* way across the DAO in order to effectively utilize its collective wisdom and benefit the organization as a whole.

Known Decentralized Structures

Decentralized structures are abundant in nature. The human body is a decentralized structure made of organs, sub-organs and sub-sub-organs, all the way to the atomic cells, which themselves have their internal structure. The functionality of the body is pretty decentralized and no cell instruct other cells what to do. Rather, each cell is autonomously operating according to inputs it receives from its environment. The sense of an organism —an autonomous and sential human being, is an emergent phenomena apparent only at the collective level.

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An ant colony is a decentralized structure. It functions without central management or control (the queen doesn't decide about the colony, it lays eggs), and individual ant behaves in reaction to the conditions of its nearest environment. The sensible colony is an emergent phenomena at the collective level, derived from an indirect coordination of ants which need not even communicate directly with one another.

The Internet is a human-based decentralized structure. It is an acentric system which has gracefully scaled to more than 2bn users over fifty years of existence. Its dynamic self-governance helped it evolve and upgrade itself over time just like a living system. The Internet does not support internal value distribution, though, so it lacks an inherent economic incentive model for engagement. Its functionality is thus limited to the distribution of information.

In fact, the blockchain itself is the closest existing thing to a DAO (more accurately, it is DApp). It is a centerless, living organism operated by a wide crowd of engaged members (AKA *miners*). With a new form of internal economic incentive model, it opens the door for growth and adoption levels never seen before. At the time of writing, the Bitcoin blockchain network has grown from zero to over $100bn in value without any central management or coordination. The Ethereum blockchain has similarly grown to $50bn in four years! (Which means the lucky investors of the Ethereum crowdsale have seen their investment going up about 2000 times in that time window.) But the functionality of these value-based DApps is limited, and an additional element is needed to enable general-purpose DAOs that could organize around general purposes. The DAO stack is that missing element.

Open Organizations

Our current economic system is based on an approximately zero-sum, or win-lose game. The force of competition triggers evolution toward peak performance, but which is maximized with respect to local rather than a global win. (I.e. a company optimizes with respect to its own survival, and not with respect to the benefit of a larger whole.[4]) This is the problem of non-cooperative Nash equilibrium. The meaning of Nash equilibrium is that, while another cooperative equilibrium may exist and is better for everyone, no single agent has the incentive to change her strategy alone. It is a problem of large-scale coordination that prevents the transition from competition to cooperation.

This non-cooperative Nash equilibrium prevails almost everywhere, but in the domain of production and development it shows up clearly in the form of closure or obscurity (if not deceit) of knowledge and information, and more generally anti-rival resources. Anti-rival resources are unlimited in usage, and rather

[4] The same holds true for any sovereign entity, down to the individual level.

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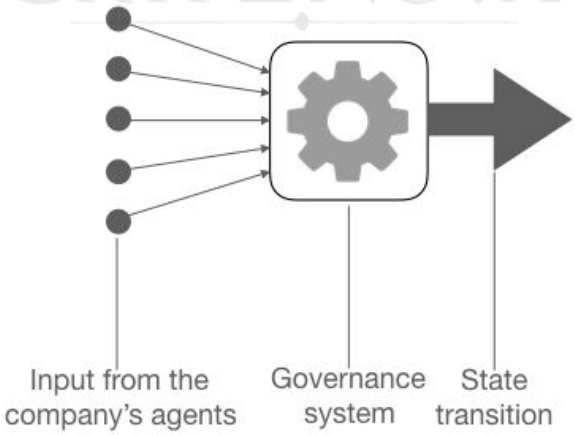
become more valuable the more they are being in use. A common example is code; it is never consumed, and rather the more eyes are on it the better (and safer) the code is. At the same time, companies have no incentive to open-source their code, as otherwise they would asymmetrically give advantage to their competitors. On the other hand, clearly, if ten competing companies produce a similar product, they could have all benefited from co-producing the shared elements of their products rather than all independently producing them on their own. This conundrum is probably most notable in the pharmaceutical industry.

Intellectual Property (IP) is the traditional means to turn anti-rival resources into scarce elements, thus make them sellable, but it has become less and less sensible, as well as practical, in today's accelerated pace of invention.

Opening up shared resources is inconsistent with the current economy. But on the other hand, it is the very basis for large-scale, open collaboration, or DAOs. To be effective, the DAO needs to incentivize and reward the sharing of reusable components. In result, more existing shareable components will support the growth and effectivity of the DAO. Open organizations is the means to shift from the current non-cooperative Nash equilibrium to a future cooperative state. However, DAOs will replace the existing corporate structures not because they are nicer or more moral, but rather simply since they will be far more effective.

3. Blockchain Governance

Agency is the basic unit of governance over the blockchain. A blockchain governance system is a state-transition function, that collects inputs from blockchain addresses and under certain rules spells out an output in terms of the blockchain global state transition.



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Blockchain governance system.

Instead of unwrapping this statement in formal language, let us explain it via an example.

Example

The simplest possible agency manages an ETH fund, and internally only has its native FND token. We will call it Fundis. There are only three rules in the Fundis governance system:

1. The only collective decision that Fundis makes is sending ETH from its main wallet to a certain blockchain address (i.e. make an investment). This action is initiated by a proposal that is put up by some agent: say, agent X proposes to send 1000 ETH to address A. Then agents vote yes or no on that proposal, weighted by the number of FND that the voter has in her address:

Address	FND
0x00eFBC5D0A96e…	6
0x67248B65b6E0f7…	7.5
0x5F42801ac21677…	0.21
0x70f67cD70A50DA…	120
0xEA3C6A6b31dAD…	1.4
⋮	⋮

FND balances of blockchain addresses.

Once a majority of FND holders approve a proposal, it is automatically executed.

2. The second rule of Fundis is that upon its establishment, FND tokens are issued and sended to buyers, one FND per ETH, for a period of one week.

3. The third and final rule is that at any time, any FND holder can send his FND to the main Fundis wallet, and get back his share of the ETH existing in that wallet at that moment, pro rata. His FND is destroyed.

There are a few immediate issues with this governance system, such as:

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1. It might be very hard to recruit a majority of FND holders to vote on one proposal. This issue is related to governance scalability, which we will discuss in length below.
2. It can be corrupted by a 51% attack. Say, there is $100m worth of ETH in the Fundis wallet. And, say, that it costs $60m to buy half of all FND tokens in the market. Then, an agent with enough liquid capital can purchase just above half of the FNDs in the market, and immediately thereafter make a proposal to send all ETH to his own address. That's an easy $40m hit. This problem is related to resilience, which is the second topic we will cover below.
3. It is not clear (and probably not true) that those who hold more tokens would make the best investment decisions. It is not a deal-breaker, but might be leading to a pretty ineffective investment fund. This is in tension with meritocracy, which is another important criteria.
4. For further illustration, an additional attack is made by making the proposal to distribute all of Fundis ETH into addresses that will vote yes on this proposal, pro rata. Perhaps in the beginning decent agents will refrain from approving this cunning proposal; but once the first approvals will come, there will be a growing pressure for approving it (and not losing all of your money), until an avalanche effect will take place and the cunning proposal will be approved. This to demonstrate that resilience is a tricky issue.
5. Finally, even after the Fundis creators have realized that its governance system is heavily flawed, they cannot do much about it since Fundis governance system is not upgradable, which is another criteria we would like to impose.

This simple governance system highlights almost all of the issues with blockchain governance, which we will discuss below. It also demonstrates the initial statement above: "A blockchain governance system is a state-transition function, that collects inputs from blockchain addresses and under certain rules spells out a global-state transition."

Indeed, there are four types of inputs that agents can inject into the company:

1. Submitting a proposal;
2. Voting yes or no on an existing proposal;
3. Sending ETH to Fundis in order to buy FND in the first week of its establishment;
4. And sending FND to Fundis in order to claim back one's ETH share.

There are three possible actions (resulting with a global-state transitions) Fundis can make, and three rules of its governance system to trigger them correspondingly:

1. Issuing and sending FND to senders of ETH in the first week (1 FND per ETH);

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2. Sending ETH from Fundis wallet to senders of FND, pro rata (and burning the FND);
3. Sending ETH to an address following a successful proposal (as described above).

Reputation Systems

Instead of weighing votes of agents with their native token stake, a company can have different balance sheets to denote the influence of agents inside votes. Generally, reputation scores are non-transferable assets — an agent cannot transfer its reputation to another agent. The simplest case is when a company has a single reputation system — meaning, the same influence score for all types of decisions. More generally, a company can maintain multiple reputation scores that are used for different cases. Reputation is used here interchangeably with influence power, and can form the basis for a meritocratic governance system, where those who are most appreciated — due to their past contributions — have the most influence. One way to allocate reputation to agents would be via proposals. For example, one can propose to allocate 100 FNDr (Fundis reputation score units) to agent A for her recent valuable contribution C. Reputation can also be algorithmically tied with economic remuneration of the company to a contributor of value; as well as with one's votes and evaluations in relative to the collective. This topic is called reputation flow, and will be covered somewhere else.

Reputation systems alone solves most of the problems of the previous token-based governance system, but it still remains unscalable.

Blockchain Governance structure

The governance of an agency can be divided into two types of actions, the *do's* and the *don'ts*:

1. The *do's* are the logical and operational rules under which ***agency functionalities*** can be triggered. For example: if a majority of reputation holders in a DAO approve the issuance of new tokens, token issuance will be automatically triggered by the DAO's smart contract. We call these operational logics: ***governance schemes***.

2. The *don'ts* are the restrictions and limitations that must absolutely be respected by an agency, and that cannot be violated even by an approved scheme. For example, if a DAO approves an upper cap of one million tokens, token-issuance schemes will operate only as long as the total number of tokens issued is less than a million. We call these limitations: ***global constraints***. Constraints can be absolute, or they can be designed to be upgradable under specific conditions.

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We collectively denote governance schemes and global constraints by ***elements***. Given the elements of an agency, its entire governance protocol (including the protocol to change the protocol) is unambiguously defined.

Agency functionalities

An agency deployed on the Ethereum blockchain via the DAO stack can, in principle, do anything that can be done on the blockchain. In particular:

- **Token distribution**. Each agency or DAO can issue and distribute its own native tokens to contributors of value, as valued by the organization. The issuance of native tokens enables the organization the creation of its own separate economy. The utility or benefit of the tokens can be anything that the agency decides about, such as entitling access to the DAO's product (we will call these *utility tokens*), or entitling a share of the agency's revenue (we will call those *share tokens*).

- **Funds allocation**. An organization can earn, or collect via its own-token sale, external tokens such as ETH, GEN or other DAO's tokens. It can keep them in reserve, and distribute to third parties in exchange of a particular effort or contribution. This is somewhat analogous to an agency using its funds to compensate contributors, employees or other service providers.

- **Reputation assignment**. Each agency can assign *reputation scores* to its members. Reputation is a representation of one's professional credibility, and thus influence, within the organization. As opposed to traditional blockchain-based tokens, reputation is not transferable. It is awarded to or earned by specific members, according to their merits and contributions made to the organization. Since reputation is tied with decision-making power in the organization, more reputation should be allocated to those who the organization believes make the best decisions. However, in order not to lock up decision-making power over time, the organization might decide that reputation dissipates over time.

- **Collective data curation**. An organization can manage its own collective databases of objects, and maintain their curation. It can be the curation of articles, website, organizations or anything else. The power of a shared database lies in its network effect; if everyone are looking at the same spot (because it's well-curated), then that spot is valuable (and monetizable too). We will see below a few examples with the collective DAOstack registries, the ArcHives.

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- **External activity**. An agency can act within another agency as a single entity. For example, an agency can submit a proposal inside another agency (or DAO), and vote on others' proposals.[5]

- **Governance upgrade**. Each organization can configure and update its own governance system. By approving or removing certain elements, the agency defines how it functions, what it can or cannot do, and what are the mechanisms for changing these governance schemes.[6]

Schemes

Schemes are logical functions made of a series of instructions that take a particular set of inputs, and process them to generate a particular set of outputs. Schemes can be designed to do virtually anything, although most of them will trigger one of the basic functionalities of an agency, such as token and fund allocation, reputation assignment and protocol upgrade. Common schemes are based on *proposals* — the proposition to trigger some of the basic actions of an agency in a particular way. These will then be voted on with *yes* or *no* and be possibly approved, resulting in the automatic execution of the proposal.

A simple rewarding scheme

For example, a simple rewarding scheme in a DAO can be as follows:

- An agent submits a proposal to the DAO to reward 150 tokens and 200 reputation bits to another agent for contribution made to the DAO.
- Anyone can vote *yes* or *no* on this proposal, to be weighted by their DAO reputation score.
- Once a majority of the DAO reputation holders vote *yes,* the DAO's operating system executes the proposal and allocates 150 tokens and 200 reps to the contributing agent. Note that this agent can also be yet another agency.

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Similarly, when looking back at the Fundis example above, it had three rules, which could be written as three distinct schemes. Thus, the entire governance system of Fundis is describable via those three elements. We will use this modularized formalism in the next chapter, when describing the DAO stack and in particular the *Arc* governance framework.

A more complicated example

For the sake of illustration, a fairly more complicated reward scheme could be described as follows:

[5] More generally, a DAOstack agency can act anywhere within the blockchain domain, thus preserving full interoperability with other systems. E.g. an agency in DAOstack can open a user in a company in Aragon :)

[6] The agency can also upgrade the technology stack itself, either to an upgraded version of DAOstack, or a whole new architecture.

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- An agent submits a proposition requesting to be rewarded for a particular contribution.
- The scheme triggers an alternative voting system, enabling anyone holding reputation in the DAO to propose a specific number of tokens to award the agent with.
- Votes are weighted by the reputation score of each voter, and the total amount of tokens to be awarded equals the weighted *median* of all voters.[7]
- As soon as 20% or more of reputation holders have expressed a vote, and not more than 2% of reputation was engaged in the vote during the last day, the DAO will allocate the amount of tokens and a proportionate amount of reputation to the contributing agent, following the median at that moment.

More generally, the spectrum of possible scheme's design is nearly endless. Schemes can activate different actions (including the functionalities mentioned above), incorporate a variety of different logics, and rely on a variety of different voting systems which might associate voting power with reputation, tokens, or a combination of both. Another common typology of schemes is the one allowing DAOs to offer their native tokens for sale under some conditions (the so-called token sales).

Global Constraints

Global constraints are specific conditions that can be attached to a particular agency or DAO and that will limit its functionalities. As a general rule, for any operation to go through within a particular agency, it must comply with the list of constraints configured by the organization. Regardless of the list of approved schemes in the agency, none of these schemes will be able to trigger a particular functionality in the organization if doing so would not conform with even a single one of the global constraints.

For instance, global constraints that might be adopted by DAOs and agencies include:

- An upper cap imposed on the total amount of tokens that can be issued by the organization.
- A rate of token inflation (i.e. dynamic cap) over a time period (e.g. 2% per month).
- A burn rate on the usage of the an agency's funds.
- A maximum amount of reputation that can be issued within a particular time period.
- A list of agents that can request the issuance of more tokens or reputation (i.e. whitelisting).
- The registries from which the DAO can approve new schemes.

[7] This is the largest number that 50% or more of voting reputation has assigned a larger or equal number of it.

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An organization can define certain global constraints to be permanent and others to be modifiable. In the latter case, the organization will also define under what conditions these constraints can be updated (e.g. by a 75% decision of token holders, or only via this or that specific scheme).

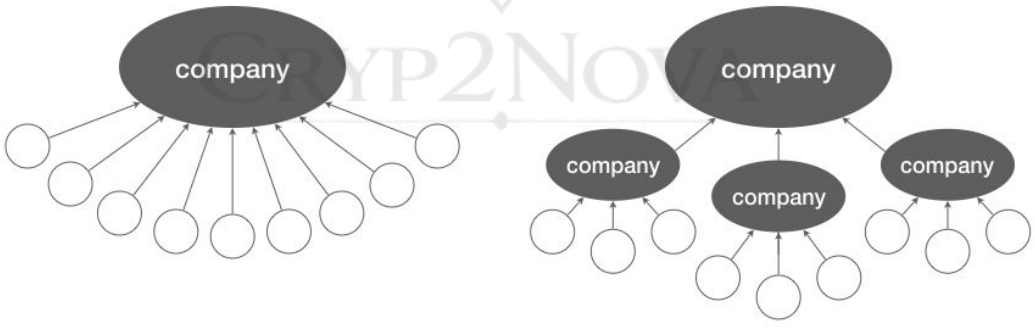
Scalability

The scalability of a decentralized governance system is in inherent tension with its resilience. Decentralization requires the system to be open for random participants under certain rules (i.e. it uses an *open protocol*). By resilience we mean that we need enough participants to review every decision. But this is clearly in tension with the scarce resource of participants' attention, whether it is computing power — in the case of blockchain, or human attention — in case of DAO governance.

We argue that there are generally three ways to resolve (to some degree) the tension of scalability and resilience in a decentralized governance system, which are: *compositionality*, *attention monetization,* and *relative majority*. The blockchain itself is a form of decentralized governance system, in which these mechanisms are analogous to: *sharding*, *gas*, and *off-chain* computations.

Compositionality

Consider the following two cases. In the first, nine agents of a company with equal votes. In the second, three agents of a company with equal votes, each of which is by itself a company, composed of three agents with equal votes. A sub-company casts its votes in the mother company as soon as it develops its decision via an internal majority.



The assembly vs. federated governance.

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It is easy to see that in the first case, it requires the attention and consensus of five human agents in order to cast a decision in the mother company; whereas it is sufficient to have the consensus of four human agents in the second scenario to form a decision in the mother company.

This very simple example illustrates the fact that *compositionality*, or *fractalization*, of governance systems makes them more scalable. One can argue that by this we have compromised resilience (as less human agents can take over the system); but we can also observe that not any configuration of four human agents in the second scenario can form a decision in the mother company. With a deeper scrutiny it can be shown that under different assumptions the resilience in the second case can be weaker or stronger.

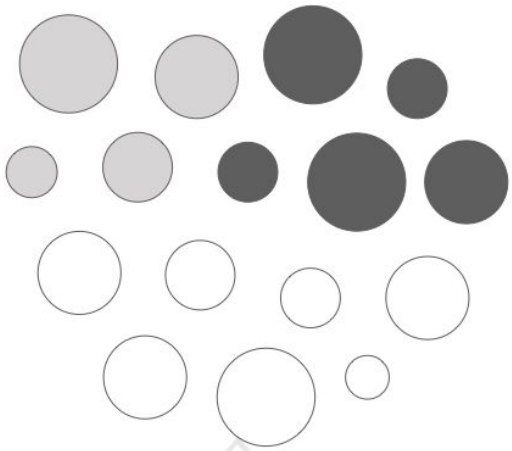
Monetization of Attention

Forming a decision requires the attention of voters. The more decisions are there to evaluate, the more attention is needed. However, attention is a scarce resource. In one way or another, to form a resilient decentralized decision-making system, attention should be monetized to reflect its inherent scarcity. In the Bitcoin blockchain it is formed in terms of *transaction fees*, and in the Ethereum blockchain as *gas*. For DAO governance, attention needs to be monetized with the token that reflects the community of agents whose attention is being called for. For internal DAO decisions that would likely be the DAO token, whereas for inter-DAO activities we would use GENs (GEN), the DAOstack ecosystem token. Note that monetization of attention does not buy decisions, but only buys the attention over proposals; we will elaborate on this point further below.

Relative Majority

Naively, a straight-forward way to form scalable decision-making process is by demanding only a relative majority to approve a decision. By relative majority we mean that the majority of approvals is only with respect to those who cast their vote and not all potential voters in the system.

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The size of the balls reflect the voting power of agents. The empty balls are those who have not cast their vote on a specific proposal; the darker balls voted yes, and the lighter balls voted no. Clearly, there is no absolute majority of approvals, but there is a relative majority of approvals out of all voting agents.

Note that relative majority votes requires a finite time window for the proposal to be considered.

To solve this problem, previous systems of governance introduced a *quorum* — the minimal amount of voting power that needs to be engaged into a decision to make it legitimate for approval. The problem with a quorum is that it is impossible to fix the right amount of it, and will either damage resilience — if set too low, or scalability — if set too high, and possibly both. If at all, quorum needs to be dynamic.

We describe next a resilient governance protocol, without a quorum, that is based on relative majority and attention monetization.

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Attention funnel

Another trick to improve on scalability is to programmatically focus the entire collective attention at any given time on a few decisions, and thus enhance attention per decision and guarantee resilience. We describe it through an example, the simplest decision-making protocol that is potentially decentralized, resilient and partially scalable — in the number of agents the organization can have, but not in the number of decisions the organization can make. The protocol is described with the following steps:

1. **Proposals**. Decisions are initiated by proposals; proposals are submitted by agents and are then voted on with a *yes* or *no*.

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2. **Reputation**. Agents' votes are weighted with their reputation. We confine to a single reputation system per company for now. Sub-companies and sub-sub-companies in a DAO will focus on specific branches of production or decision making. In this fractal framework, the notion of a single reputation score per company is not inconceivable.

3. **Boosted proposals**. Once a proposal is *boosted* — by means defined below — it is opened for voting for a finite time (say, 2 weeks), by the end of which a decision — yes or no — is made according to the relative majority of voters reputation (i.e. majority out of all those who placed a vote during that time).

4. **Quiet ending**. To avoid finalization attacks, the effective decision (majority of yes or no) cannot be changed in the ending interval (of, say, 1 day). Meaning, if on the last day of opening the majority changed from yes to no (or vice versa), the opening interval is extended by another day. The vote is closed only once there is no change of decision during the last day of voting.

5. **Boosting stack**. At any point in time there can only be a finite number of boosted proposals, say, 10. All other proposals stand in a queue, and are ordered by a ranking system. Every time a proposal in the boosting stack is finalized, the proposal with the highest rank in the queue enters the boosting stack and is opened for finite-time voting.

6. **Promotion**. Anyone can propagate a proposal up in the queue by placing GEN tokens on stake. If the proposal is successful the promoter gets back her tokens plus some possible profit; and otherwise they are destroyed, going to the DAO, or distributed to voters according to the specifics of the protocol.

7. **Ranking system**. The ranking system of proposals in the queue can be a function of R_+, R_- and B, where R_+ (R_-) is the amount of reputation already voting yes (no) on this proposal and B is the total amount of tokens staked to promote that proposal. A simple sensible choice could be, for example, $(R_+ - R_-)^2 \cdot B$. Note that anyone can promote an existing proposal, not only the proposer.

Finally, rather than limiting the number of boosted proposals, we can have a boosting threshold for the scoring function of proposals in queue, above of which proposals are being boosted. This alternative way solves for scalability, but again potentially compromises resilience. An additional element is needed.

Holographic Consensus

We have discussed above a variety of solutions to resolve the scalability problem of governance systems, the core tension between scalability and resilience; but at least so far did so partially. This is an issue for any consensus

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system: too much of the collective attention spent on each decision makes the system unscalable; while too little potentially makes it not resilient to faulty decisions, or not representative of the consensus. Naive consensus is simply not scalable.

To fully overcome this problem a decentralized and scalable governance system has to allow for “edge decisions” that are made by non-majority groups, as long as they are ensured to be in line with the consensus. We coin this situation “holographic consensus”, reminiscent of a hologram in which each little piece of the three-dimensional image contains the information of the entire picture. While we fully elaborate on this in a separate article, we would like to draw here the basic principles behind holographic consensus.

In holographic consensus we want to eliminate possible mismatches between decisions made by small groups on behalf of the greater majority and the decision that would have been made by the greater majority itself, if enough attention was available. To eliminate possible mismatches, we introduce a novel prediction game, in which anyone — not necessarily a DAO reputation holder — can place predictions, backed by stake, on the fate of proposals. You can identify an under-appreciated proposal and place a 100 GEN stake on the prediction that this proposal will pass once attaining the collective attention. Or vice versa, you can stake 200 GEN predicting that a certain proposal is over-hyped and will not pass as soon as being boosted and tightly considered. Correct predictors make profits, and incorrect ones lose their stake. By playing the prediction game predictors contribute to the governance process by signaling to, filtering and maintaining the governance process.

Finding out these social mismatches, or inefficiencies, is the most important part of making a collective attention more efficient and a governance system more scalable. By providing stake-backed predictions, the predictors provide valuable signals to the governing network about proposals that are under or over evaluated. An open market is much more efficient in signaling than a static governing body. At the same time, proposals are only boosted once enough stake has been predicting that they will pass in this DAO, and thus this predicting game is also used as a filtering layer. And finally, once a proposal is being boosted, there is enough predictors’ skin in the game to make sure the process is effective and that whoever needs to be participating indeed participated. We use
crypto-economics incentives to “outsource” the navigation of the collective attention of DAOs to a professional network of predictors.

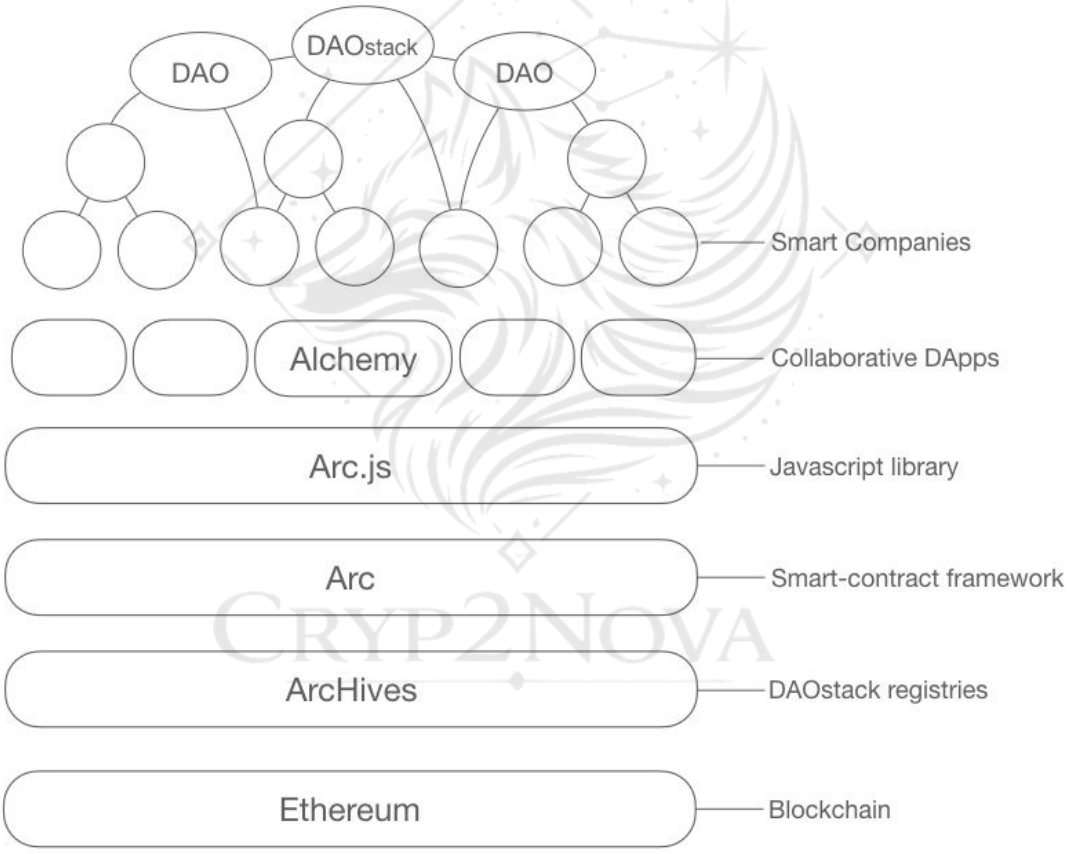
There’s much more to write about this topic, and we will. But in the meanwhile, we’d like to note that the suggested solution of holographic consensus comes in close analogy to the way scalability is being solved for blockchains with off-chain computations. The legacy consensus paradigm that “everyone need to look at everything” is replaced with the idea that “everyone can look at everything; there is nice profit for right behavior;

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a descent penalty for wrong behavior; and a reward to fish and signal right and wrong behaviors". A similar logic has also appeared in Polkadot's Fishermen protocol.

4. The DAO stack

DAOstack provides the foundational tools for the creation, operation and governance of DAOs, internally and externally within a broader ecosystem. In a nutshell, it can be regarded as an analogue of *Wordpress* for DAOs — it does for blockchains what *WordPress* has done for the web. This vision is made possible with the following stack of components in place:



A sketch of the DAO stack.

The DAOstack ecosystem is made of a multitude of distinct but interoperable DAOs, interacting with one another in order to maximize the potential benefit of open and distributed collaboration. At the technical level, all DAOs are made of a series of smart contracts, deployed through ***Arc***: a Solidity framework of governance

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allowing to create, configure, deploy and operate DAOs onto the Ethereum blockchain,[8] possibly relying on IPFS as an overlay network for data storage and retrieval.

People can interact with these DAOs either directly, through the execution of blockchain transactions, or indirectly, by relying on a particular front-end to the underlying blockchain ecosystem. ***Alchemy*** is the collaborative DApp developed internally by DAOstack, enabling anyone to create a new agency or DAO and start collaborating with others in the DAOstack ecosystem. It relies on ***Arc.js***, a JavaScript library that operates the Arc Solidity framework via Web3.js. It is designed to make it easy for front-end JavaScript developers to create collaborative applications on top of Arc without the need to interact directly with the Solidity code or the Ethereum blockchain. The ***ArcHives*** is a public set of registries, curated by the DAOstack community and serving its global ecosystem. It is where the ecosystem and network effect builds up.

Arc

Arc is a general governance framework for an interacting internet of blockchain agencies, the basic operating system for DAOs. It is an open-source, modular and general-purpose framework by design, and it comes with an open library of template governance modules, or *elements*, that will evolve by the needs of its users. It also allows an easy upgrade and modification of a governance system to better fit the organization's needs over time.

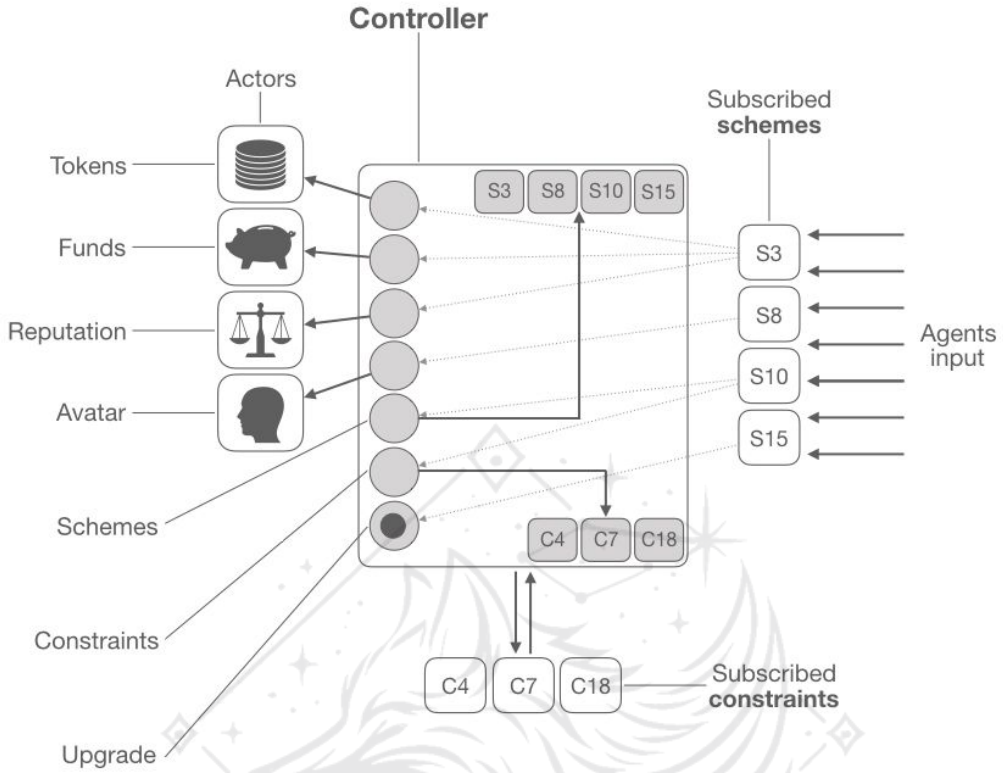
Arc is not limited to a specific set of governance systems, and it makes it easy for third parties to create their own *elements* per their needs. By combining available *elements* each agency can implement its own governance system that specifies the rules for the issuance, management and assignment of scarce resources, including transferable assets (e.g. tokens) and non-transferable assets (e.g. reputation).

Architecture

Arc elegantly implements in smart contracts the basic decomposition of governance systems discussed in the previous chapter, with: *actions, schemes* and *global constraints* that every agency can be built of. Below is a visual representation of the logic and smart contract architecture of the Arc framework:

[8] While Arc is currently based on Ethereum, the framework aims to be blockchain agnostic once other technologies mature and become interoperable with one another.

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A sketch of the Arc contract bundle per agency.

The Controller

The controller contract is the main engine of the agency. It is "owned" by and gets commands from the *subscribed schemes* alone, which operate its functions. Via its functions its sends commands to the *actors* contracts: the *token* and *reputation* printers, the funds *wallet* and the *avatar*, as well as the upgrading functions of the governance system and the technical architecture itself.

Subscribed elements

Subscribed schemes and constraints are elements that have been registered by a previous scheme which is allowed to register schemes. An agency usually begins its life with one such scheme, the *Genesis Scheme*, but can add new ones that can register or unregister certain elements under certain conditions.

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Agent's input

The only interface for agents to interact with the agency is via its subscribed schemes. Each scheme comes with its specific "knobs" (functions) which can be operated by external agents (blockchain addresses) via transactions that call and operate these functions.

Token printer

The token printer issues and allocates the native tokens of the agency to agents. It is "owned" by and gets commands from the controller alone.

Reputation printer

The reputation printer assigns the agency reputation to agents. It is "owned" by and gets commands from the controller alone.

Wallet

The *wallet* will be implemented in a next version (at the moment the *avatar* is also the wallet). It holds external funds owned by the agency and distributes them to agents. It is "owned" by and gets commands from the controller alone.

Avatar

The *avatar* is the "face" of the agency (and its address), which acts externally and is capable of doing — via the help of particular schemes — anything that can be done on the blockchain. In particular, it can participate as an agent in other agencies — e.g. submit and vote on proposals — on behalf of its agency. It is also the identity to which reputation in other agencies is assigned.

Protocol upgrade

The controller can — when receiving commands from the *subscribed schemes* — register new *schemes* and *constraints*, or unregister old ones. Since the governance protocol of an agency is fully specified via its *elements*, every agency can easily upgrade and modify its governance system (if this ability is rooted in its existing protocol). The conditions to perform a protocol upgrade are defined in subscribed schemes that can operate the elements-(un)registration. The agency can have different conditions to register or unregister different elements. (E.g. it might require a 60% majority of reputation holders to modify the schemes and most of the constraints, but a 75% majority of token holders to increase the token supply.)

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Technical upgrade

The controller has one special function that transfers its ownership over all of the *actor* contracts to a new address. Whatever would be this new address, it will have a complete control over the assets (transferable and non-transferable, such as reputation in other agencies) of the agency. It can be an upgrade to an improved architecture of Arc, or to a whole new architecture, if desired so by the agency.

Example

We present below an illustration of the interaction between the above elements:

- An agent wants to activate a certain "reward scheme" of a particular DAO.
- The agent will submit a transaction to the smart contract of that scheme (possibly via one of the DApps integrated with Arc), along with the relevant input required for that scheme (e.g. agency, number and type of tokens, recipient address, etc.).
- Other agents may approve this request with their vote.
- Once enough votes approve the request — as defined by that specific reward scheme — the reward scheme will command the controller to execute the proposal (with the specific parameters), and the controller will command the relevant acting contract to execute the reward allocation.
- All functions governed by the controller are subject to the global constraints registered by the DAO. Global constraints act as both an ex-ante and ex-post modifier. Before executing any function, the controller is required to run all global constraints stored in the array to ensure that they all return false at this particular point in time. Given that the state of the DAO might change after a function has been executed, once execution is completed, the controller is required to go — once again — through all global constraints, and will revert everything to the previous state if any of them returns false.

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Universal elements

Elements — schemes and constraints — are universal by design. Meaning, all DAOs can rely on the same universal element contracts rather than deploying their own contract each time. The only contracts that are deployed independently for each agency are the controller and the actors. Such a design contributes to the scalability, functionality and security of the framework.

Design Principles

Arc was designed with the following design principles in mind:

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- ***Generality***. Arc is a general framework that supports an indefinite number of governance elements. Arc's library of schemes and global constraints will grow with the addition of new templates and modules, possibly developed by third parties and the open-source DAOstack development community. When combined, it will allow for people to experiment with an increasingly large number of governance protocols, and consequently for the successful ones to float up by evolution and natural selection.

- ***Modularity***: The Arc framework is highly modular by design. Every DAO's governance structure is made of small building blocks (the governance modules, or *elements*) that can easily be added, combined, edited or removed. This modularity becomes a point of efficiency in that these building blocks do not need to be redeployed onto the blockchain, rather only referred to, saving both storage and operation cost. Moreover, it makes development of sophisticated governance protocols easier and easier the more building blocks exist. Last but not least, it makes contract security management much more sane, whereas writing entire protocols each time from scratch is inconceivable security wise.

- ***Simplicity***: Arc has been designed with a strong emphasis on simplicity — in terms of both technical design and usability. The modularity of the framework makes it possible to focus on individual building blocks, whose complexity can be kept to the minimum. As the building blocks are modular and reused, each will receive a lot of individual scrutiny, affording a higher level of vetting and the corresponding greater level of security. To facilitate ease of use, in Arc, bundles of smart contracts can be deployed with a single transaction.

- ***Upgradability***: The governance structure of each DAO can be easily upgraded to use new schemes and constraints or different parameters of existing ones. More granularly, each DAO created through the Arc framework comes with a particular set of rules, which by default include rules to change the rules. In addition, the DAO also comes with the ability to upgrade its technical architecture and evolve to a better and better one over time.

- ***Interoperability***: Arc is designed to facilitate interactions and promote interoperability between different agencies and DAOs. In practice, it means that agencies can interface with other agencies in a seamless manner, exchange tokens, form agreements, act as individual agents within other agencies and acquire their tokens and reputation. Arc makes it possible for a mesh network of interconnected agencies to emerge and spontaneously create the DAO ecosystem.
- ***Openness***: Open frameworks such as Wordpress, Google add-ons and Android invite independent developers to create their own apps, templates and integrations — thereby instantiating and supporting a vibrant development community and which in turn benefits the framework with a wide set of

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applications. Similarly, we expect DAOstack to attract developers from the Ethereum community to develop their own governance modules or frontend DApps — thus creating a thriving plethora of templates, modules, and applications for this emergent ecosystem. The DAOstack code is fully open source, backend and frontend. Another aspect of Arc as an open protocol is that all integrated collaborative DApps are potentially interoperable with one another. Just as users of two web applications can interact with each other since both apps ride on the same open protocol (HTTP), then users of two collaborative DApps riding on Arc will potentially be able to interact with one another (if enabled by the collaborative DApps).

Arc.js

Arc is a pretty extended Solidity framework, the integration with which requires a sufficient acquaintance with the Solidity smart-contract programming language and the Ethereum blockchain. To make the integration of third-party apps simple for enthusiastic front-end (JavaScript) developers, we have designed Arc.js as an easy JavaScript gate.

Arc.js is a JavaScript library built on top of Web3.js (Ethereum's JavaScript API), with which any functionality of the Arc framework can be called directly from within the JavaScript environment, without knowledge of the Solidity programming language.

We expect this additional layer to make the Arc framework (and the rest of the DAO stack) extensively more accessible for the open-source development community, and third parties, and thus greatly promote the early adoption of the DAO stack and the growth of its ecosystem.

The ArcHives

Arc is the basis operating layer for the DAOstack ecosystem, and the ArcHives are its shared, curated records. Shared, curated registries can be very powerful, providing a central locus for data integrity and data quality; but more so, they are the locus for the ecosystem network effect, which is also a source for another open-ecosystem monetization (i.e. business model). We will describe below the basic ArcHives of DAOstack: Compendium, Mosaic and the Hive Registries, and will explain the monetization model behind them. Beyond these, each agency or DAO can have their own independent registries, and in particular DAOstack can also have many other registries in the future.

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Compendium

Arc's open framework makes it possible for anyone to deploy new governance *elements* — schemes and constraints. For the purpose of security, DAOs will likely decide to limit themselves to schemes that have gone through exhaustive and professional audit, and more so, have been heavily battle tested. For that purpose, DAOstack has implemented its own "app store" for elements, the Compendium, which records all governance modules that have been approved by the DAOstack expert community.

Compendium provides an additional utility to the GENs. One one hand, it would cost GENs to deploy a governance module onto the registry. On the other hand, independent developers who develop and register their own elements on Compendium can have a universal business model, collecting a particular amount of GENs (voted on by the DAOstack community) upon every subscription of new agency to that module. It is an app store for governance modules. All of the elements developed by the DAOstack founding team will remain free of charge for the community.

Once there is a network effect of users using the Compendium for the elements they subscribe to, the value proposition of this registry will appreciate and accordingly its monetization capability. It will be more profitable for developers to publish their elements on this registry, and thus to pay the registration fee. The registration fee is also useful to filter spam publications, as it will only be profitable if the element will be approved and sufficiently used by the DAOstack ecosystem.

Mosaic

DAOstack also implements an organization registry that records a list and metadata of all agencies and DAOs deployed through the Arc framework. This database is critical for the interoperability of all collaborative DApps and organizations in the DAOstack ecosystem. Mosaic will be curated by the DAOstack community, which also implements a search engine to facilitate discovery. Just like in the case of the Compendium, it will cost GENs to register or promote an organization on the Mosaic registry.

The Hive

The Hive is where innovators, professionals and stakeholders can meet each other within multiple organizations. It is an open billboard that everyone can use to post requests or offers, which are registered and can be promoted by spending GENs. The Hive registry is curated by the DAOstack community, which, again, also implements a search engine to facilitate discovery. While each collaborative DApp may have its own (non-blockchain) database, the Hive is where all collaborative DApps can maintain data interoperability and enhance the network effect.

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Alchemy

The DAO stack is designed to make it easy for independent developers and third parties to develop their own collaborative application on top of Arc and to be integrated with the DAO stack and its community. At the same time, DAOstack itself develops its native collaborative DApp which makes it easy to interface with Arc: open agencies and DAOs, configure their governance protocol, make proposals and vote on existing ones, collaborate with others on projects and much more. It is intended as a first interface to this new world of work and organization.

In its Alpha stage, Alchemy is an app for crowd management of resources, enabling organization to significantly increase their decision-making capacity and deploy large capital to large communities, effectively. Alchemy is ready to launch for pilot on the Ethereum mainnet.

5. The GEN Economy

Circular Token Economy

Agencies, DAOs and DApps (Decentralized Applications) are all based on circular token economies. The general idea is that tokens are being distributed to contributors of value — for value that is contributed to the network. On the other hand, the same tokens gain benefit from the value created by the network. The more value is being created the higher the value of the tokens, the more the organization can incentivize the contribution of more value, and so on and so forth.

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The DApp Model

In the *DApp model*, the utility — and thus value — of the tokens is directly related to the usage of a network application. Tokens are being distributed to contributors of value to the network: builders, early adopters and maintainers of the DApp. On the other side, the usage of the DApp requires the spend of those same tokens. For example, Ether was distributed to founders and builders of the Ethereum blockchain, and is now being distributed to miners that maintain the network. On the other hand, Ether needs to be spent by users in order to process autonomous computations on the Ethereum blockchain or use its storage.

Success of the DApp drives up the demand for its usage, thus the demand for its token and thus the token's value. The more people run computations on the Ethereum blockchain the more Ether they would need to spend, and the higher would be its value in the open market (given its limited supply).

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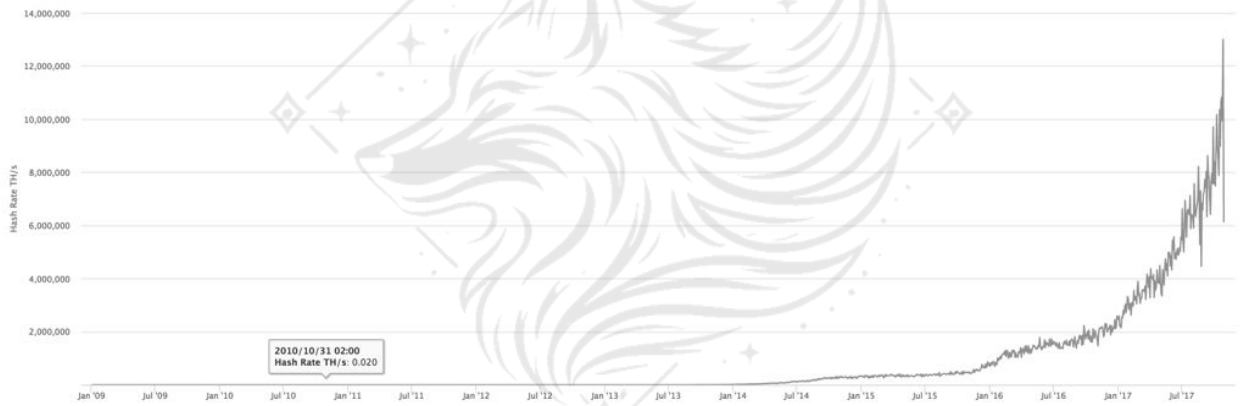
DAO Economy

The added feature of a DAO with respect to a DApp is its ability to process and execute general-purpose collective decision making. There are various domains of decisions a DAO can engage with, and accordingly a various categories of DAOs (and the possible hybrid of those).

Decentralized Collaboration

When the governance system of the DAO is used for decisions about the incentivization and reward of contributions to the DAO itself, we would call it a *decentralized collaboration*.

As already seen from the blockchain DApps, the token-distribution incentive model works very well in driving engagement and adoption. In the Bitcoin network, miners adoption rate looks like this:



Total hashing power in the Bitcoin network has grown exponentially and multiplied about 650 millions times over the past 7 years, due to the built-in economic incentive in mining.

However, in the blockchain case, miners are only the maintainers of the network, and no direct reward is awarded for the developers of the network or its early adopters. In newer projects tokens are commonly distributed to founders of the project, and by the founders as bounties to other contributors of value. But this incentivization model cannot be systematized and scaled up without the governance system of the DAO.

With DAO stack and, for example, the relative-majority decision-making protocol described above, tokens can be easily distributed to contributors of value, including developers, promoters and early adopters of a network. There is no limit (unless chosen so by the DAO itself) on the purpose and rate of reward to contributions, and it

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allows for crowd engagement and coordination at unprecedented levels.

The token of a decentralized collaboration is tied to the result of that collaboration. For example, if the result is a DApp, then the tokens distributed in the decentralized collaboration are the DApp tokens.

Decentralized Cooperative

In the DApp model the purpose of the network is to create and support an application, and the value of the token is tied to the usage of that application. A *share model* fits the situation where the purpose of the agency, or network, is simply to gain external revenue. It can be an agency that is developing inside a bigger agency, or a DAO, and receives its tokens in return; or it can be an investment DAO that invests in other projects and is intended to make a return on investment. In either case, the value of the token is tied with the external revenue of the organization, and this relationship can be implemented in various ways. One way is to implement a redemption scheme whereby the agency (or DAO) tokens are made redeemable against the funds existing in the agency wallet, pro rata, and thus the value of the token is derived from the revenue made by the agency. Other implementations can involve dividend or other mechanisms. In this model the DAO is a *decentralized cooperative*, and its token resembles its share.

Decentralized Curation Network

DAOs can also organize around the curation of content. The value of the network is then manifested in having a shared locus of information, thus shared locus of attention, on the DAO registries. Once there is a network effect of attention looking at the same point, that point can be monetized by the network itself. The network curates the objects posted on the its registries, and promoters of content would pay with the network's token to post and promote content. Posting low-quality content would result in negative curation, and thus reduction of the poster's reputation. Promotion of content is tied both with boosting fees and the endorsing reputation; thus, the better the content of a promoter is, as curated by the network, the cheaper it would be for him to post again in the same network, and vice versa.

The GEN Model

DAOstack is a DAO that involves the three above categories. It incentivizes contributors to participate and develop the DAO stack and its ecosystem. In that sense it is a *decentralized collaboration*. It intends to use part of its raised funds (collected via its token sale) for investments in projects that would come on top of the DAO stack (as well as in projects which will build and enhance the DAO stack), and accelerate the ecosystem, while also expecting return on investments. In that sense it is a *decentralized cooperative*. Finally, it will also be a *decentralized curation network*, in particularly for governance elements and DAOs, but possibly for many other

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things. In all contexts, the GEN is the token that drives the effective navigation of the collective attention of DAOs on top of the DAOstack ecosystem, and in particular the token that engines the prediction games described above that are critical for holographic consensus and effective governance of large organizations.

The DAOstack code is fully open source, backend and frontend, and is found here on Github.

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