Para-Autonomous Organizations (PAOs): Governance Agnostic, Dynamic & Interoperable Network States v0.1

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Abstract

This paper introduces a novel approach to onchain governance by translating fundamental characteristics of traditional governmental systems into virtual machine instructions executable on blockchain networks. While current onchain governance models predominantly revolve around Decentralized Autonomous Organizations (DAOs), which largely employ democratic principles, this paper argues that such systems, though potentially resilient, can also exhibit significant vulnerabilities. Democracy, in its various forms, has proven to be a powerful and enduring system of governance in the physical world. However, when translated to the digital realm of blockchain networks, it can face unique challenges and potential pitfalls. These include susceptibility to manipulation through token accumulation, voter apathy leading to low participation rates, and the potential for tyranny of the majority in decision-making processes. Our proposed primitive aims to address these issues by incorporating a more nuanced approach to onchain governance. By examining and adapting various governmental models - including but not limited to democracy, republicanism, and technocracy - we seek to create a more robust and adaptable governance system for blockchain networks. This system would include:

- Checks and balances to prevent concentration of power
- Mechanisms for protecting minority rights and interests
- Flexible decision-making processes that can adapt to different types of proposals
- Incentive structures to encourage active and informed participation
- Transparency measures to ensure accountability

By converting these governmental characteristics into smart contract logic and virtual machine instructions, we aim to create a governance primitive that is not only more resilient to potential attacks or manipulations but also more effective in serving the diverse needs of blockchain communities. This approach has the potential to significantly enhance the stability, fairness, and effectiveness of on-chain governance, paving the way for more sophisticated and sustainable blockchain-based systems and applications.

1.0 DAOs are Fragile

Decentralized Autonomous Organizations (DAOs) emerged as a revolutionary concept in blockchain governance, aiming to create transparent, democratic, and decentralized entities. At their core, DAOs are built on several key principles. Decentralization is paramount, with DAOs operating without a central authority and distributing decision-making power among members. This decentralization is

coupled with autonomy, as DAOs function based on pre-defined rules encoded in smart contracts, reducing the need for human intervention. Transparency is another crucial principle, with all transactions and decisions recorded on the blockchain, visible to all participants. Finally, participation is key, as members can propose and vote on decisions, often in proportion to their stake in the organization.

Since their inception on the Ethereum blockchain, DAOs have achieved several notable milestones. They have played a significant role in democratizing investment, with organizations like MolochDAO and MetaCartel pooling resources to fund projects within the Ethereum ecosystem. In the realm of decentralized governance, protocols such as Compound and Uniswap have implemented DAO structures for community-driven decision-making, allowing token holders to have a say in the future direction of these platforms. DAOs have also pioneered innovation in organizational structure, giving rise to new forms of collaboration such as Decentralized Autonomous Companies (DACs) and Decentralized Autonomous Societies (DASs). Most impressively, DAOs have enabled global collaboration on an unprecedented scale, allowing individuals worldwide to work together on shared goals without the constraints of traditional organizational boundaries.

Despite these achievements, the current state of DAOs reveals significant vulnerabilities. One of the most pressing issues is the tendency towards plutocracy in token-based voting systems. These systems often lead to wealth concentration and undue influence by large token holders, potentially undermining the democratic ideals upon which DAOs are built. Voter apathy presents another significant challenge. Many DAOs struggle with low participation rates, resulting in decisions being made by a small minority of stakeholders. This lack of engagement can lead to outcomes that don't truly represent the community's will. The potential for a tyranny of the majority is a further concern. Pure democratic models can lead to the suppression of minority interests, potentially harming the organization's long-term sustainability. This issue is compounded by the fact that stakeholders may make complex decisions without the necessary domain knowledge, leading to suboptimal outcomes. Governance attacks pose a serious threat to DAOs. Malicious actors can exploit voting mechanisms to pass self-serving proposals, potentially at the expense of the broader community. The democratic processes meant to ensure fairness can also hinder quick responses to rapidly changing environments, leaving DAOs at a disadvantage in fast-moving sectors. Regulatory uncertainty adds another layer of complexity. The legal status of DAOs remains unclear in many jurisdictions, creating potential risks for participants and hindering the wider adoption of decentralized governance.

Token-based governance is particularly susceptible to market manipulation. Wealthy entities can effectively buy influence, potentially skewing decisions in their favor and undermining the principle of decentralized governance. Coordination problems

present another significant challenge. Large, diverse groups of stakeholders often struggle to reach consensus on critical issues, leading to gridlock or hasty, ill-considered decisions. This issue is exacerbated by the inherent inflexibility of many DAO structures. Once deployed, changing the fundamental structure of a DAO can be extremely challenging, making it difficult to address emerging issues or adapt to changing circumstances. Perhaps most concerning is the potential for incentive misalignment. The interests of short-term token holders may not align with the long-term success of the project, leading to decisions that prioritize immediate gains over sustainable growth. These vulnerabilities highlight the urgent need for more robust, nuanced governance models in blockchain-based organizations. While DAOs represent a significant step towards decentralized governance, their current implementations fall short of the ideal. Future developments must address these fragilities to create truly resilient, fair, and effective decentralized organizations. The challenge lies in preserving the core principles of decentralization and community governance while implementing mechanisms to mitigate these inherent weaknesses.

2.0 Majoritarianism

2.1 Alternative Governance Models and Their Blockchain Potential

In the evolving landscape of decentralized governance, several models have emerged as alternatives to traditional majoritarianism. Holacracy, liquid democracy, sortition-based governance, polycentric governance, and conviction-based systems each offer unique approaches to collective decision-making. When considered in the context of blockchain technology, these models present intriguing possibilities for on-chain governance.

2.2 Holacracy and Blockchain

Holacracy is a decentralized management system that distributes authority across self-organizing teams rather than concentrating it at the top of a hierarchy. This model aligns well with the decentralized ethos of blockchain technology. In a blockchain context, holacracy could be implemented through smart contracts that define roles, responsibilities, and decision-making processes within an organization.

Onchain holacracy could utilize token-based systems to represent different roles and authorities. Smart contracts could automate the process of role assignment, task distribution, and decision ratification. This could create a more fluid and responsive organizational structure compared to traditional majoritarianism, allowing for rapid adaptation to changing circumstances.

However, implementing holacracy onchain presents challenges. The complexity of holacratic processes could lead to high gas costs for transactions. Moreover, the

nuanced interpersonal dynamics crucial to holacracy's success might be difficult to fully capture in code.

2.3 Liquid Democracy and Blockchain

Liquid democracy, also known as delegative democracy, allows participants to either vote directly on issues or delegate their voting power to trusted representatives. This model could be particularly powerful when implemented on a blockchain.

In an onchain liquid democracy, smart contracts could manage the delegation and voting processes. Tokens could represent voting power, which could be seamlessly transferred between accounts. This would allow for a dynamic and flexible system where expertise is leveraged efficiently.

Blockchain technology could enhance liquid democracy by providing transparency and immutability to the delegation process. Every delegation and vote would be recorded on the chain, allowing for full auditability. Smart contracts could also automate the process of vote counting and result implementation, reducing the potential for human error or manipulation.

However, liquid democracy isn't without its challenges. The potential for the emergence of "super-delegates" who accumulate significant voting power could lead to new forms of centralization. Blockchain implementations would need to consider mechanisms to prevent such concentration of power, perhaps through caps on delegated voting power or time limits on delegations.

2.4 Sortition-Based Governance and Blockchain

Sortition, the practice of selecting political officials or decision-makers through random selection, offers an intriguing alternative to elected representation. When applied to blockchain governance, sortition could provide a novel approach to decision-making that mitigates some of the pitfalls of token-based voting.

Onchain sortition could use verifiable random functions (VRFs) to select a representative group of token holders for each decision. This would ensure a fair and unpredictable selection process. Smart contracts could manage the selection process, the deliberation period, and the final decision implementation.

Sortition-based governance on blockchain could help address issues of voter apathy and plutocracy that often plague token-based voting systems. It randomly selects decision-makers, thus ensuring diverse participation and reducing the influence of large token holders.

However, implementing sortition onchain also presents challenges. Ensuring that selected participants engage in the decision-making process could be difficult.

Moreover, the random selection might sometimes result in a group lacking the necessary expertise for complex decisions.

2.5 Polycentric Governance and Blockchain

Polycentric governance involves multiple centers of decision-making that are formally independent of each other. This model, which acknowledges the complexity of governance in different domains, could find interesting applications in blockchain systems.

Onchain polycentric governance could involve multiple DAOs or governance contracts, each responsible for different aspects of a protocol or ecosystem. These could interact and coordinate through clearly defined interfaces and shared resources.

Smart contracts could define the boundaries and interactions between different governance centers. Cross-contract calls and token-based incentives could facilitate coordination between these centers, allowing for specialized governance in different areas while maintaining overall cohesion.

Polycentric governance on blockchain could allow for more nuanced and context-specific decision-making compared to monolithic governance systems. However, it also introduces complexity in terms of inter-DAO communication and conflict resolution.

2.6 Conviction-Based Governance and Blockchain

Conviction-based governance weighs participants' votes based on the strength and duration of their commitment to a position. This model is particularly well-suited to blockchain implementation.

In an on-chain conviction-based system, smart contracts could track the duration and amount of tokens staked on different proposals. The longer and larger the stake, the more weight the vote carries. This could be implemented through a continuous voting system where participants can change their votes at any time, but with increasing influence the longer they maintain their position.

Blockchain technology enhances conviction-based governance by providing a transparent and tamper-proof record of all votes and their durations. It also allows for automatic execution of decisions once certain conviction thresholds are met.

This model could help mitigate short-term thinking and reduce the impact of whale voters who might otherwise be able to sway decisions with large, brief token movements. However, it might also lead to slower decision-making and could potentially favor conservative positions that maintain support over long periods.

2.7 Coordinating Alternative Models On-Chain

Blockchain technology offers unique opportunities to not only implement these governance models individually but also to combine and coordinate them in novel ways. Smart contracts could define meta-governance systems that employ different models for different types of decisions.

For instance, a blockchain protocol could use sortition to select a group of token holders, who then engage in liquid democracy for a set period. The results of their deliberations could then be weighted by conviction over time before final implementation.

Interoperable blockchain systems could even allow for governance across multiple chains, with different models employed on different chains but coordinating for ecosystem-wide decisions.

The key to successful onchain coordination of these models lies in clear, well-designed smart contracts that define the rules of interaction. These contracts would need to handle the complexity of different governance mechanisms while remaining gas-efficient and user-friendly.

While blockchain technology offers powerful tools for implementing and coordinating these governance models, it's important to note that technology alone cannot solve all governance challenges. Human factors, such as community engagement, education, and shared values, remain crucial to the success of any governance system, whether onchain or off.

As we continue to experiment with these models in blockchain contexts, we have the opportunity to create governance systems that are more flexible, inclusive, and resistant to manipulation than traditional majoritarianism. However, careful consideration must be given to the specific needs and characteristics of each community or protocol when designing these systems. The future of blockchain governance lies not in a one-size-fits-all approach, but in thoughtful, context-specific implementations that leverage the strengths of various governance models.

3.0 PAOs: A New Primitive for Interoperable & Dynamic Governance

Para-Autonomous Organizations (PAOs) represent a groundbreaking concept in blockchain governance, offering a framework for autonomous yet interconnected onchain organizations. This new primitive allows different governance models to coexist and interact within a broader ecosystem, much like sovereign nations in the geopolitical landscape. By establishing a standard set of protocols for inter-

autonomous organization communication and coordination, PAOs open up a world of possibilities for complex, multi-layered governance structures on the blockchain.

3.1 The PAO Standard

Enabling trustless coordination at the heart of the PAO concept is the PAO Standard, a set of smart contract instructions that define how different PAOs can interact with each other in a trustless manner. This standard serves as a common language and protocol for inter-PAO communications, much like international laws and treaties govern interactions between nations. Key components of the PAO Standard might include:

Identity and Verification: Protocols for PAOs to verify the identity and status of members from other PAOs.

Resource Sharing: Mechanisms for PAOs to share or exchange resources, whether that's tokens, data, or computational power.

Dispute Resolution: Agreed-upon methods for resolving conflicts between PAOs.

Proposal Interoperability: Standards for how proposals from one PAO can be recognized or voted on by members of another PAO.

Cross-PAO Participation: Rules governing how members of one PAO can participate in the activities of another.

PAO Interactions: The VISA Analogy just as a citizen of one country can visit another with a visa, PAOs allow for structured interactions between members of different PAOs. This could manifest in various ways:

- *Visitation Rights*: Members of one PAO could be granted temporary participation rights in another PAO, subject to certain conditions or limitations.
- *Knowledge Exchange*: PAOs could establish protocols for sharing expertise or information, allowing for cross-pollination of ideas while protecting proprietary knowledge.
- *Collaborative Decision-Making*: On issues that affect multiple PAOs, the PAO Standard could define how cross-PAO voting or deliberation occurs.
- *Resource Lending*: PAOs could establish protocols for temporary resource allocation between PAOs, similar to how nations might provide aid or loans to one another.

3.2 Implementing Different Governance Models within PAOs

The beauty of the PAO system is that it allows for a diversity of governance models to coexist and interact. For example:
A holacratic PAO could interact with a liquid democracy PAO, with the PAO Standard defining how decisions from the holacratic structure are translated into the liquid democracy system. A sortition-based PAO could randomly select members to participate in a conviction-based voting process of another PAO, combining these two governance models in a novel way. A polycentric governance PAO could establish different centers of authority that interact with various other PAOs based on their specific domains of expertise.

3.3 Challenges and Considerations

While PAOs offer exciting possibilities, their implementation comes with challenges:

Complexity: The interactions between different governance models could become highly complex, potentially leading to confusion or unintended consequences.

Standardization vs. Flexibility: Striking the right balance between a standardized protocol and allowing for PAO-specific customization will be crucial.

Security: As PAOs interact more, ensuring the security of these interactions and preventing malicious exploitation becomes even more critical.

Scalability: The computational resources required to manage these complex interactions could be significant, posing scalability challenges.

3.4 The Future of PAOs and Blockchain-Based Governance Models

PAOs have the potential to create a rich, interconnected ecosystem of autonomous onchain organizations. This ecosystem could lead to the birth of the following:

Governance Marketplaces: Where Communities can "shop" for PAO governance modules or partners that complement their own structures.

Meta-Governance Structures: Emerging systems that govern the interactions between PAOs, similar to international bodies in geopolitics.

Adaptive Governance: Systems that can dynamically adjust their governance models based on interactions and outcomes with other PAOs.

PAOs represent a significant step forward in the evolution of blockchain governance. By allowing diverse governance models to coexist and interact in structured ways,

they open up new possibilities for complex, adaptable, and resilient decentralized systems. As this concept develops, it could fundamentally reshape how we think about organization and coordination in the digital age.

4.0 The ARK Protocol

In this section we will discuss our approaches towards establishing dynamic, flexible, governance-agnostic & standardized governance through PAOs. We will discuss the ARK Program, PAO Programs, the ARK Standard for PAOs, and use cases onchain.

The ARK Protocol is the network of PAOs onchain that facilitates their modularity, interoperability, flexibility, and governance agnosticism. It has three major components the ARK program, PAO programs, the Standard program which has its extensions.

PAOs are onchain organizations that have the ability to not only interact with each other but also change governance framework. Thus, they present a more dynamic governance option for blockchain communities and protocols, however their inherent flexibility and interoperability needs to be standardized and managed to ensure secure governance interactions. The ARK Program acts as a central record-keeper for PAO states across the ARK Protocol. This is unlike conventional onchain governance programs that typically manage a single DAO's structure within their own isolated environment. Hence, the ARK program is a Solana Virtual Machine (SVM) program that manages records of the creation, interaction, and transition of PAOs. For trustless inter-PAO relations and transitioning to occur there must be some sort of coordination at the global state and standard level.

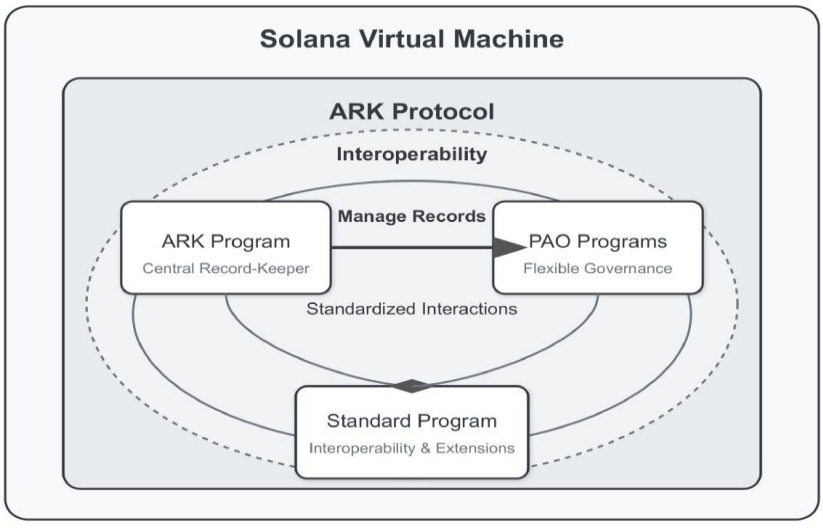

Fig. 1 The ARK Protocol Framework in Details.

4.1 Cross Program Invocation (CPI)

Cross program Invocation (CPI) allows Solana programs to be called by another program in terms of data request or assignment, this is analogous to an Application Programming Interface (API) call from one website to another, but in this case, it is between one SVM Program to another. It allows for programs to interact; system programs and custom programs engage in this interaction. CPI and Solana's ability to separate logic from state enables a native smart contract modularity system allowing several programs and accounts to work hand in hand.

On the ARK protocol every PAO program is independent at the governance level but are dependent on the ARK Program at the global state level to identify them, take note of their interactions and record their state. This allows the protocol to standardize their interactions, thus ensuring that each PAO interacts or transitions in a secure and organized manner.

The ARK program interacts with a library of PAOs and ARK Standard extensions, which allows it to track and store records of protocol members and their current global state on the protocol level.

Extensions are programs that are used for standard interaction between PAOs and these interactions cut across PAO transitioning, escrow & exchange, borrowing & lending, offchain data verifications, and more. The ARK program registers all PAO programs and extension operations upon their instantiation or initialization.

Every Cross-PAO program interaction is recorded at the protocol level by making a CPI call that updates the state of the governance accounts involved in the process. Concisely, the ARK Program's job is record-keeping and identification. This ensures that every PAO interaction is transparently logged, verifiable, and traceable within the ARK Protocol. It ensures accountability by maintaining a secure record of PAOs and their interactions, facilitating coordination while the autonomy of each organization is still preserved.

4.2 PAO Programs & Accounts

Solana's architecture is designed to separate logic from state, with a popular principle that everything is represented as an account. This allows programs to manage state independently, enabling parallel execution and scalability across the network. This understanding will serve as a background for how PAO programs and accounts work on the ARK Protocol. A PAO on ARK can be regarded as accounts interfacing with a PAO program. We define a couple of terms below to allow us thoroughly explain the entirety of PAO programs going forward.

PAO Program: A PAO program is a Solana program that provides the governance framework for interacting with governance accounts. These programs are integral to PAOs because they enable organizations to implement onchain governance in a cost-effective way. By leveraging an existing PAO program on the SVM, an organization can avoid the high costs associated with deploying and maintaining their isolated governance program.

Governance Accounts: These accounts interact with a PAO program and are created by organizations to manage the governance of a PAO. The PAO concept lives within the interaction between these governance accounts and the PAO program. Technically, a governance instance consists of Program Derived Addresses (PDAs) that are initialized via the System Program, as well as Associated Token Accounts, which rely on the Associated Token Program, along with Token Programs and Mint Accounts. These accounts enable a community, through the PAO Program, to store data and value onchain and also perform economic activities.

Centralized Autonomous Organization (CAO): A CAO is a governance instance that is interfacing with a PAO program whose logic holds the governance structure of a centralized organization. While this concept has little adoption, we believe for something to be truly governance agnostic then every pattern of governance must be included or are allowed to participate in that process. The ARK protocol was built to experiment how CAOs would operate and interact with DAOs, the aim therein is to prove our governance agnosticism thesis as well as show that CAOs are clear pathways to onboard real-world institutions and organizations onchain.

Sub-Autonomous Organization (SAO): An SAO is a governance instance that operates under the governance framework of another PAO following a transition process. It leverages the decision-making mechanisms of another PAO, borrowing its governance structure to make final choices regarding operations such as economic activities. While a Sub-Autonomous Organization (SAO) retains some level of operational independence, its autonomy is limited because it relies on another PAO instance for decision-making on critical governance matters. There are currently two types of SAOs available which are Full SAOs and Transient SAOs. Both of which represent complete and partial dependency of PAO on another. We will diver deeply into SAOs in the later section.

4.3 The Four Attributes of PAOs

PAOs have basically four attributes which are modularity, flexibility, interoperability, and governance agnosticism. We will use these attributes to explain in-depth how PAOs interact on the ARK protocol.

4.4 PAOs are Modular

For an average community or organization, writing and deploying their own programs can be technically and financially challenging. The goal is to provide them with a seamless way to establish PAOs on Solana. Drawing inspiration from SPL Governance and Realms UI, PAOs provide accessible, independent, yet interconnected governance instances.

PAO modularity means multiple autonomous governance units operating within a single program. When an organization initializes a PAO, it creates a set of Program Derived Addresses (PDAs) that store the PAO's unique state and information. These PDAs, generated deterministically with PAO-specific seeds, act as modular components within the program's ecosystem.

The program's architecture leverages Solana's account model, allowing seamless interaction through instruction parameters and account data. Users engage with specific PAOs by calling program instructions with the necessary identifiers, enabling the program to operate on the appropriate PDA-based accounts. This design facilitates the creation and management of new PAOs without deploying additional program instances, exemplifying modularity.

4.5 PAOs are Flexible

Traditional DAOs face a dilemma when their governance structures become inefficient or misaligned with community needs. It raises an important question: what happens next? Will the community lose its data and history in the process of change, or will they continue with an outdated or ineffective governance system?

Governance flexibility is essential, especially now considering that if all DAOs remain strictly flat or directly democratic, there may come a point when the community or its members wish to transition away from this governance model.

PAOs were not designed to introduce a novel governance system but rather to facilitate the integration of both existing and emerging governance frameworks.

One alternative approach could involve using a proxy contract that completely separates state from logic, enabling the logic to be altered and redeployed as needed. However, this method presents several challenges for average communities such as:

1. Maintaining a proxy system can be financially challenging.
2. Implementing a proxy contract requires a certain level of expertise.
3. Continuous redeployment may introduce unseen errors or bugs that could be exploited.
4. Such systems might be viewed as only partially decentralized, which could undermine trust.

Given these constraints associated with implementing a proxy DAO program, we chose not to pursue that route in our experiment. We also considered the approach of transferring data and funds when a DAO decides to change governance. However, we found that even if we could successfully extract all relevant data to another DAO, the initial DAO program would lose its historical context on-chain, as if prior proposals and decisions or the program itself had never existed. This realization led us to research another method of changing governance that preserves both history and data onchain -- The beginning of Para-Autonomous Organizations (PAOs).
How do you create flexible governance programs on-chain without tampering with the current state, we asked?

The solution we got was discovered in the standardization of DAO interactions, which involves creating a standard format for peer-to-peer communication among DAOs. This standardization means that if DAOs have a standard structure for their interactions, it is possible for two DAO programs to collaborate towards a shared objective. In this context, we are discussing the integration of two distinct governance systems into a single DAO, this thesis can be referred to as PAO transitioning.

4.5.1 What then is PAO Transitioning?

PAO Transitioning refers to the process through which a Para-Autonomous Organization (PAO) alters its governance structure while preserving its onchain history and data. In earlier sections, we explored how DAOs can collaborate to achieve specific governance objectives.

However, before the beginning of PAOs, there was no mechanism for these collaborations to occur seamlessly onchain, leading to a level of centralization due to the necessity of human intervention.

Transitioning represents a form of collaboration where one governance program partially or completely **adopts** or **colonizes** another, allowing for the flexibility needed in smart contract governance. While the term "colonization" may carry negative connotations in the real world, in this context, we use it to illustrate partnership.

We believe that flexibility is best achieved when one program is dependent on the functionality of another. In the Ethereum Virtual Machine (EVM) ecosystem, examples of this approach include Factory Contracts, the Diamond Standard, and Account Abstraction. On the Solana Virtual Machine (SVM), similar concepts are realized through Cross Program Invocations (CPIs) and delegated authority. It is through this interdependence that we build the peer-to-peer standard enabling PAO program adoption and collaboration.

Our theory of program colonization for on-chain governance transitions can be categorized into two types: Full Transition and Transient Transition. We cannot continue further without describing what becomes of a PAO when they are colonized partially or completely by another PAO.

4.5.2 Sub-Autonomous Organization (SAO)

In our experiment, we refer to colonized PAOs as Sub-Autonomous Organizations (SAOs). After a PAO transition, the SAO becomes dependent on a parent PAO for governance decisions, as the parent PAO holds the authority and instructions required for making decisions. This makes the SAO a subordinate entity under the parent PAO's governance. The behavior of SAOs differs between Full Transition and Transient Transition.

4.5.3 Full PAO Transition

In a Full Transition, only the accounts within the parent PAO are eligible to vote or make decisions for the SAO. However, in a Transient Transition, both the SAO's own accounts and the parent PAO's accounts can participate in voting and decision-making on proposals.

This type of transition signifies the process of transforming a PAO into a fully dependent SAO. In this case, the SAO loses its autonomy over treasury management and protocol governance, relying entirely on governance instructions from its parent PAO for transaction execution. This transition is permanent and irreversible, as the accounts within the SAO that were previously eligible to make decisions are disabled, with governance authority transferred solely to the parent PAO.

4.5.4 The Triangular Governance Interaction

For example, let's say an organization has been using a PAO called PAO A and has just initialized a new PAO, PAO B. PAO B is designed to function as an SAO, fully dependent on PAO A's governance decisions. In this setup, while proposals can still be created within PAO B (now referred to as SAO A), any final decision-making authority resides with PAO A. When a proposal is initiated in SAO A, it triggers an instruction in its own program that includes data like the parent PAO's authority.

This instruction uses Cross-Program Invocation (CPI) to interact with a transition extension in the Standard Program. The Standard Program, in turn, calls an instruction via CPI to the parent PAO's governance program (PAO A). PAO A then applies its governance rules to evaluate the proposal, deciding whether to approve or reject it. Once PAO A reaches a decision, it makes a CPI call to the Standard Program, passing the decision (either "Approved" or "Rejected") as part of the instruction data. This CPI triggers an instruction within the Standard Program, which processes the decision and initiates another CPI to the SAO, allowing it to execute the governance outcome based on the received result.

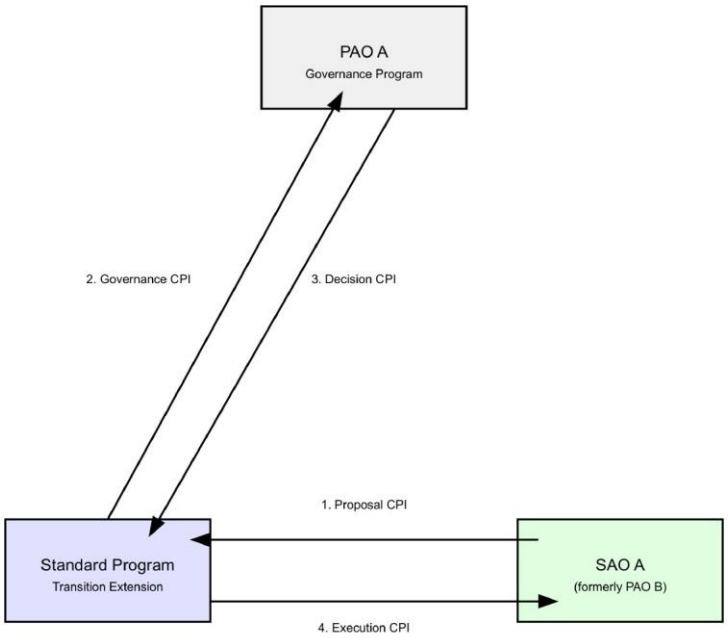

Fig. 2 Schematic Diagram of the Triangular Governance Process.

The Triangular Governance Interaction creates a structured, multi-phase process that enables secure and coordinated decision-making across PAO programs, ensuring governance integrity while preserving the modularity and autonomy of each participating PAO in transactions that doesn't affect their individual frameworks. Furthermore, our approach supports governance-agnostic interactions such that an SAO can have any PAO as an authority, allowing for transitions between governance systems without imposing a rigid governance structure. This flexibility ensures that SAOs can dynamically integrate with different PAOs while maintaining their unique operational logic, enabling diverse governance models to coexist and collaborate efficiently within the ARK Protocol.

4.5.5 Solana's Limits on CPI Calls

Solana enforces a limit of four Cross-Program Invocations (CPI) per transaction, which means in our experiment, both the SAO and the Authority PAO can assume the roles of either a colony or a colonizer program. Given this constraint, it implies that a PAO/SAO program can undergo a full transition up to four times in a single transaction.

4.5.6 Transient PAO Transition

Transient Transition represents the process of transforming a PAO into a partially dependent SAO. In this type of transition, the SAO retains its governance authority over the treasury and decision-making processes. However, it can delegate governance authority to another account in a PAO program on a temporary basis. This model is both reversible and flexible because community members can adjust the voting power based on token delegation or completely remove the PAO's authority. This enables a PAO to experiment with different governance structures while retaining ultimate control over its governance. This type of transition creates a "governance playground" for communities and protocols to test various models without permanently losing control.

To explain how this works, let's use the analogy of a "Delegator" and "Delegate." Consider PAO A as the Delegator, which holds a Program Derived Address (PDA) that governs the distribution of Solana's native token (SOL) for its governance. PAO B, the Delegate, also possesses a PDA containing SOL.

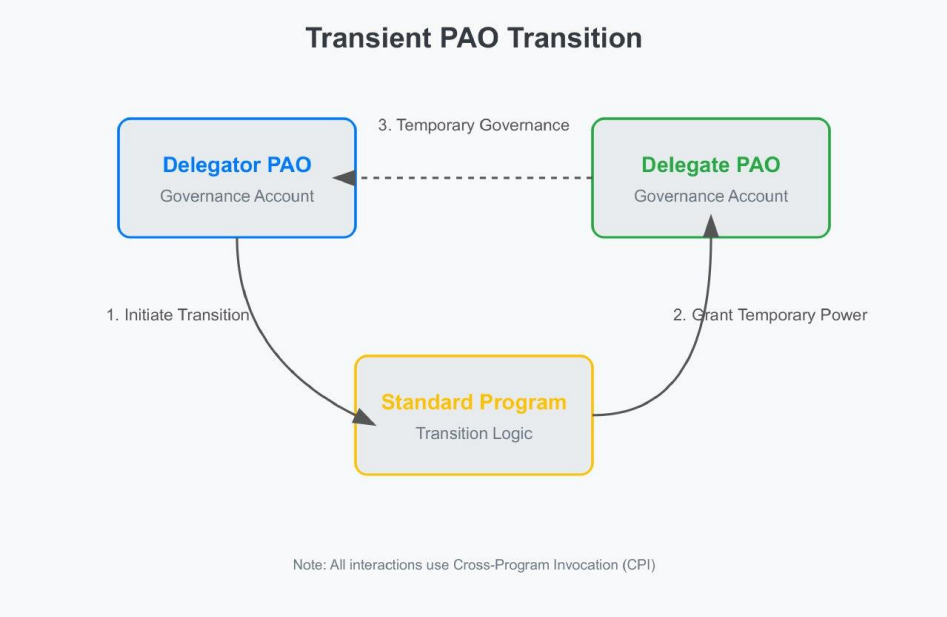

Fig. 3 Schematic diagram of the Transient Transitioning Process.

During the transition, the Delegate (PAO B) initiates a CPI call to the transition extension in the Standard Program. This CPI triggers another CPI directed at the Delegator (PAO A), invoking an instruction that grants PAO B (the Delegate) temporary governance power proportional to the amount of SOL it holds. This allows PAO B to vote on a proposal within PAO A's governance program, effectively acting on its behalf. The Delegate's vote is counted alongside the Delegator's votes. If the vote is approved, it is treated as a joint decision between both programs. If rejected, the execution fails.

During an active proposal or voting period, PAO A can delegate its voting power to PAO B, making PAO B's vote decisive depending on how much power it's granted. Notably, users of PAO B do not need to share the same Mint Account ID as PAO A to participate in governance. Whatever method PAO B uses to cast votes within its program will be transmitted as the decision for PAO A.

As long as PAO A has granted sufficient voting power to PAO B, PAO B's vote will act as the deciding factor on behalf of PAO A. The result of this fusion is that the SAO can grant or revoke delegated authority at will. When sufficient voting power is delegated, the Delegate can govern on behalf of the Delegator. Since these delegations are temporary, PAOs can leverage transient transitions repeatedly, as Delegate PAOs can be removed or replaced.

4.6 PAOs are Governance Agnostic

The concept of governance agnosticism emerged from our realization that true governance flexibility requires a diversity of structures that a PAO can adopt without being tied to a single model. This flexibility allows PAOs to migrate between different governance approaches, whether decentralized or centralized, without sacrificing operational efficiency.

This realization led us to create not only different types of PAOs but also build onchain governance structures for real-world organizations. For example, Centralized Autonomous Organizations (CAOs) serve as a mechanism for onboarding governments, institutions, and companies onchain. Through this model, we aim to bridge the gap between Network States and real-world governance structures, thus creating a novel economic system that is transparent, tamper-proof, and verifiable onchain.

4.6.1 Real-World Use Cases

Here are a few practical applications of this system:

1. Institutional Trade & Transactions between CAOs and DAOs
2. Decentralized Grants & Aid Distribution between CAOs and DAOs
3. Decentralized Borrowing & Lending
4. Information & Resource Sharing
5. Decentralized Agreements & Dispute Resolution

This new economic model offers limitless possibilities and is worth exploring as we build out the ARK protocol infrastructure.

4.7 PAOs are Interoperable

Interoperability is only possible among programs that are configured to interact through a standardized framework. The ARK protocol and its PAOs are designed to communicate and respond based on their distinct instruction sets, with interactions facilitated by the ARK Standard Program. Every PAO program contains a logic module that allows it to interact with the Standard Program, enabling asynchronous, dynamic communication through CPI calls. The Standard Program is responsible for orchestrating global interactions, such as value exchanges via escrows or PAO transitions. By acting as a central hub for communication, the Standard Program ensures that each PAO can operate in accordance with its own governance logic while still facilitating seamless cross-program collaboration. The ARK Standard Program serves as a global registry and facilitator for all extension programs on the ARK network. It manages interactions between PAOs and updates the global state of PAO relationships. This ensures that governance structures remain intact and that transitions between PAOs can be executed without compromising historical data or governance logic.

ARK Extension Programs are supplementary PAO programs that enable cross-PAO communication and interaction. These extension programs handle specific tasks, such as facilitating transient transitions, managing escrow accounts, or enabling cross-program value exchanges, all within the framework of the ARK protocol.

5.0 Model Use-cases of PAOs

In this section we will discuss possible use-cases of the ARK Protocol as proposed in the earlier sections. Use-cases cut across Offchain Verification, Governance, Trade, Payments, Borrowing & Lending, Decentralized Agreement and Dispute Resolution. More use-cases will arise but we are highlighting these ones as a result of our current discoveries.

5.1 Offchain Verification

One issue that most Onchain Protocols experience is the inability to fetch and verify offchain data. This was a very difficult problem until the Reclaim protocol and Zero Knowledge Transport Layer Security (zkTLS) was discovered. The Reclaim Protocol is a secure, tamperproof, and efficient way to fetch, attest, and verify offchain data and credentials onchain. We implemented connection to this Protocol as an Extension Program in the ARK Network, and this in turns makes ARK offchain data efficient. Below are potential areas of its use on the ARK Protocol:

Data Verification: The Reclaim Extension program will allow PAOs to verify information from sites offchain allowing them to make informed decisions based on the data received. This Extension enhances better conditional payments, governance, partnerships, and agreements that depend on offchain metrics or data.

Credential Verification: This Extension program allows members or intending members to verify their qualifications, credential or proof of membership stored offchain. This process allows PAOs to be very specifically identify its members and an example is a Flat PAO Golf Club that uses Soul-Bound Tokens (SBTs) for onchain membership & voting. Members would need to verify their membership on their site and send the proof to the PAO program for their SBT Membership Card issuance and reissuance. This method allows the PAO program to verify the authenticity of every member or intending member with the attested offchain data. Prior to Reclaim Protocol and ARK Network this was not possible.

5.2 PAO Governance

With PAOs governance can be collaborative, allowing different patterns of Governance process to exist which were priorly possible. We will highlight a few shortly:

Cross-PAO Participation: With ARK a PAO can be able to participate in another PAO's governance and this is facilitated through Transient PAO Transitioning. PAOs can now invite another existing PAO to use its governance to make decisions for it in the absence of consensus on a current proposal. This concept will birth the concept of onchain VISAs as the Inviter PAO members will now request from Invitee PAO a medium or Token that allows them to partake in the governance process of the proposal that affects their PAO. An interesting example is a model Dean's List PAO granting a futarchy PAO delegated Authority on a Proposal and all members that delegate Tokens to the futarchy PAO are issued a mock version DEAN Tokens to participate at the futarchy PAO according to the DEAN Tokens delegated.

Collaborative Decision Making: It is now possible for hundreds of PAOs to be controlled by a Singular Collaborative PAO either by fully or partially transitioning to its SAO. Where certain decisions at Collaborative PAO is transmitted as governance instructions to the proposing SAOs after other SAO members have voted upon the proposal at the collaborative PAO level. A perfect example would be Council or Multi-Signature PAO where Members have equal vote weight and Consensus is reached when 2/3 of the member Approve or Reject the Proposal. The Multi-Signature PAO gets configured to allow only PDAs which represent PAO Governance Accounts to be its members. The Multi-Signature PAO members will update the Council PAO as either their Full or Delegated Authority. Thus, allowing the governance at the Council Level to affect their PAO as they see fit.

PAO Colonies: Transitioning allows one PAO to be either the Full or Partial Authority PAO of any amount or types of PAOs, allowing for crucial decisions at those SAOs to be vetted and approved by the Authority PAO before there are executed. While this process also facilitates governance change, it has use-case in diversification of interests or business. An example would be a Corporation CAO that has four Protocols PAOs (DEX, NFT Marketplace, Borrowing & Lending, and Decentralized Name Service) and each of them have their own communities built around Flat PAO systems. The CAO Corporation is made a Delegated Authority in these SAOs and can now sends its decisions on every proposal as votes weighted on its holdings and/or on the Tokens delegated to them at those SAO levels. In the case where the CAO sells any of the protocols to another DAO or CAO on ARK, it is replaced with the new owners as that SAO's Delegated Authority.

5.3 Trade & Payments

With the ARK Standard Program financial transactions such as conditional payments, asset, and resource exchange can be facilitated with various extension programs.

Conditional Payments: The Escrow and Exchange extension allows for a variety of payments ranging from linear payments, time-based payments, conditional payment using offchain data, and/or a mixture of any of the three payments mentioned. These payments have use-cases in all types of structured and technical payments. This allows PAOs to both offer and receive strategic payment structures like grants, Aids, Acquisitions, Wage/Salary, etc.

Exchange: PAO Trade is facilitated by a Central Limit Order Book (CLOB), and it has support for both Tokens and NFTs on Solana. This allows PAOs to trade both onchain and offchain Assets, making information and resources tradable on the Order Book.

5.4 Borrowing & Lending

Borrow: Every PAO has the ability to issue NFTs and Tokens, as we implemented these features through Token Extensions and Metaplex protocol. PAO can now issue NFT Bonds and offer them up for sale after locking the intended collateral in an Associated Token Account owned by the Borrowing and Lending Extension. The Extension program allows PAOs to either redeem the funds in the Associated Token Account either with its associated NFT Bond after lending period elapse or with the required Redemption Payment (borrowed asset plus agreed interest).

Lend: PAOs can interact with the Borrowing and Lending Extensions to buy an NFT Bond when another PAO offers it for sale. This process involves purchasing the NFT with its tagged Stablecoin or hard Crypto asset value. The NFT Bond has a maturity date where the purchasing PAOs will have the ability to either exchange it for the collateralized asset or for their purchase amount plus interest.

5.5 Decentralized Agreement & Dispute Resolution

The Agreement & Dispute Resolution Extension allows PAOs to print Agreements Documents onchain as Non-Transferable NFTs and distribute to all parties involved. Ensuring that both parties that have proof of this agreement onchain. Building on the immutability of blockchain PAOs can lay claim that an agreement was made at a particular with the NFT as a proof.
PAOs can also resolve dispute by running a randomizer function where other PAOs are selected to listen, jury, and resolve the dispute. This Extension is still in works as there are other factors we need to consider before rolling out the extension.

7.0 Conclusion

Distributed Systems are revolutionizing the way we interact as humans around the world, one of those systems is blockchain. It has made record keeping and interactions more tamperproof, secure, and provable, it is only necessary we build the next internet of value and communication on it. The DAO Thesis started as a way to create completely onchain organization and it has since then grown to become one of the biggest and integral institutions in blockchain, and with Real-World governance becoming increasingly inefficient, communities have started to seek for viable and secure option. Blockchain sits at the center of these governance options as it ensures their security and tamper resistance, turning them into something ascribed as the Network States. The DAO structure is not sufficient enough to accommodate these Network States due to some vital factors (flexibility, interoperability, and governance agnosticism), a more efficient or scalable variant is required.

PAOs are our response to the current issue and possible future ones. They are autonomous onchain organizations that have the ability to interact and change governance. They were also created with modularity and governance agnosticism in mind, allowing them to support any governance structure and as well allow for multiple instances of that structure to exist. The PAO Thesis represents an efficient and scalable way for governance to operate, change, and interact. ARK Extensions aid peer-to-peer onchain organizational interactions, facilitating all cross-PAO interaction. They create social, governmental, financial, and resource partnerships and interactions for PAOs, handled atomically onchain.

PAO transitioning, particularly through the Triangular Governance Interaction is a feasible method for enabling governance flexibility and agnosticism, creating a robust and scalable model for decentralized onchain governance. With Solana's CPI functionality and adhering to a standardized protocol, PAOs can adopt, modify, or even merge governance structures without losing control or their onchain history.

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