A Decentralized Autonomous Publishing Organization

Abstract—The current publishing practice is not ideal as scientists notice various irregularities such as the absence of originality, inconsistency, methodology flaws, unrealistic conclusions, or partiality of the review process. This work proposes a new approach and technology for trustworthy scientific publishing that takes the form of a Decentralized Autonomous Publishing Organization (DAPO). All actors, such as readers, authors, reviewers, and editors benefit from transparent governance where the main workflow is run by a set of dedicated smart contracts. Key properties include the use of decentralized self-sovereign identities, reputation management, the use of tokens that underpin an innovative business model, and extensible integration principles so that the scientific community can engage and join the network. This paper investigates and outlines the long-term sustainability of the developed decentralized system.

Science may benefit from a novel technology that would support a transparent scientific publishing process, such as provable provenance, starting from article submission up to its publication. Today, each journal has an Editor-in-Chief and an Editorial Board, however, sometimes these are not fully engaged with their respective journals. Manuscripts are usually provided through a centralized system where different stakeholders play a role in the evaluation of a manuscript. The main function of the traditional scientific publishing system is sharing novel research findings, concepts, and methodologies, thus, establishing communication with a wider audience over time, using various Web-based repositories. Such repositories act as a research intermediate between the content authors and the content readers. There is a belief that researchers (readers, authors, editors) should follow all ethical criteria; however, this has been hard to achieve in real-world practice. A general observation is that even the most widely reputed scientific publishers rely on (partially) centralized systems where the stakeholder credentials are fully centralized. The peer-reviewer expertise in a given research area is not thoroughly verified before the review process begins. Moreover, the copyrights to the published content are usually transferred to the publisher, who stores it in a centralized way. Hence, the publisher usually maintains full control over the published content.

Our motivation is to design a novel democratic community-driven scientific publishing approach and technology. It would improve the publishing process through a Decentralized Autonomous Publishing Organization (DAPO). This DAPO is underpinned by a Distributed Ledger Technology (DLT) that provides a basis for the self-sovereign digital identities of all actors, improves the content verification processes, and transparently determines the reputation of the actors. Consequently, the integrity of the publishing process and content is maintained through a fully distributed system where the editorial policy of the DAPO is determined in democratic terms through the governance of the Editorial Board and voting for articles acceptance.

The goal of this study is to design an architecture of a novel DLT-based publishing system that provides several functional components. A novel protocol called a Proof of Trustworthy Publishing Consensus is a centerpiece of our work and the main contribution and innovation. This protocol aims at improving the overall content verification quality. We design a process of democratic selection of editorial board members, which aims at the graceful evolution of the journal publishing aims and scope over time. This means that a journal is no more attached to an Editor-in-Chief, but rather to a research community within a specific scientific domain.

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Other key functionality components are the DAPO's copyright claiming, publishing, and reputation management components. They complement the overall medium design and enable efficient communication among components and collaboration among the stakeholders of the media industry. The copyright claiming and publishing components aim to improve the process compared to the traditional approaches due to the decentralization approach, which is achieved through the use of DLT and the developed Smart Contracts.

Furthermore, compared to the technologies used in traditional media, our approach is novel as it is intended to improve stakeholders' engagement and collaboration. Hence, the DAPO can also be viewed as a new type of medium that relies on a trust-building technology that provides democracy, transparency, and traceability to the publishing research process.

Related decentralized journal solutions

Publication of scientific findings evolved in the 90s from the wide adoption of the Word Wide Web. The analog and commonly slow processes such as manuscript circulation among the involved entities went into a fully digital form. The scientific publishing process has become faster and more transparent but still raises concerns [1]. There is a possibility that a peer review may raise concerns about fairness, quality, performance, cost, or accuracy since the process is mainly centralized. See Fornes et al. [2] for the identified concerns where the authors, in particular, mention that the middlemen publishers may still impose partial policies to concentrate profits. Furthermore, scientific publishing processes may still be improved, for example, by using DLTs to implicitly improve transparency and smart contracts to enable process functionalities.

TimedChain is an editorial management system proposed by E. Daraghmi et al. [3] that relies on a custom blockchain, smart contracts, and a Proof-of-Authority mechanism to compensate the most prominent and active actors in the publishing process. Even though the solution is sustainable from the cost and system performance perspectives, it is too centralized and may become problematic in the context of scalability and maintenance.

Ongoing attempts in terms of scientific publishing solutions empowered with blockchain technology provided limited prototype solutions. EUREKA [4] utilizes blockchain tokens to cover the cost of reviewing papers. ARTiFACTS [5] is another blockchain-based scientific publishing solution that provides proof-of-existence of early scientific work and allows asset creation, tracking and sharing. Similarly, Pluto, Science Root, Eureka, and Ovium platforms [6] proposed a blockchain-based solution to exchange scientific data and know-how by using smart contracts and tokens to maintain copyright control but failed to reach a minimum viable product stage.

In contrast to these solutions, this paper describes a decentralized publishing system that facilitates the creation of distributed journals at a way higher decentralization level. In contrast to the investigated environments, our system is developed based on public and private EVM-enabling ledgers. It supports the pillar functionalities through smart contracts as a fully-fledged DAO. In addition, manuscripts are stored on an IPFS system.

Decentralized publishing medium design and implementation

Reviewing process methodology

The peer review process is the fundamental process during which journals scrutinize and regulate the quality of the content they publish. We distinguish four important stakeholders in the process: the authors, the editor, the reviewers and the readers. The peer review process (see Figure 1) can be summarized into three core stages: submission, review and editorial. The community of stakeholders engage with the journal by using their various roles. The DAPO in its initial setup has 12 members of the journal's Editorial Board, 120 reviewers with their verifiable credentials, and an unlimited number of authors and readers.

The submission stage begins with the authors submitting their manuscript to the decentralized journal. This triggers a blockchain transaction, notifying the editor and storing the manuscript in decentralized storage. The review stage is initiated when the editor receives the submission notification. After being notified, a handling editor interacts with the blockchain, which has records of all active reviewers and their reputations, to receive a set of reviewers for the given manuscript. The blockchain uses data from the DAPO and its reputation management mechanism to derive its proposal for reviewers from its reviewers base. This leads towards executing a new transaction, and as a result, the chosen reviewers are notified to initiate their work. Once the reviews are available, it is requested from the handling editor to make the final decision about the manuscript. The handling editor cross-checks and considers all the comments and suggestions before making the final decision. When the final decision is

made, it is first recorded on the blockchain, and then the authors are notified. At this point, the decentralized journal collects data from the authors and the editor related to the quality of service of the reviewing process. Essentially, the data is used by the DAPO to reevaluate the reputation of the reviewers, which by recording the results on the blockchain finalizes the final stage of the review process.

Architecture and detailed design of a decentralized publishing medium

Our system is described with different components that are categorized into three fundamental categories (see Figure 2): (i) end-user components, (ii) decentralized components and (iii) back-end components.

All involved stakeholders have their respective front-end solutions, that is, the created decentralized environment allows stakeholder interactions through Web applications or mobile applications. Such decentralized applications akka dApps do not need dedicated servers to be run. Their computation necessitates the triggering of specific smart contract functions and is performed entirely on decentralized nodes that form a decentralized ledger.

The DLT of these decentralized components supports Ethereum Solidity smart contracts, thus enabling us to build a network of Ethereum Virtual Machine (EVM) computational nodes. A network like this can be built as a stand-alone solution or attached to the Ethereum main net, for example, as a Layer 2 solution. Additionally, we integrated the following novel decentralized concepts:

- Decentralized Identifiers (DID) and Verifiable Credentials (VCs) are the 2022 World Wide Web Consortium's recommendations that may help develop self-sovereign digital identities within within decentralized systems.
- InterPlanetary File System (IPFS) is a protocol for file sharing using peer-to-peer network topology.
- Smart contracts represent the stakeholders' community policy, the review process and encapsulate democratic governance mechanisms, such as regular voting process for members of the journal's Editorial Board based on their existing verifiable credentials.
- Smart oracles allow smart contracts to interact with off-chain data through dedicated decentralized nodes of the network.

Back-end components consist of a database for storing system metadata and partial review process metadata, such as submitted manuscripts. Moreover, the services implement environmental processes that are not suitable for decentralized environments, such as notification services, webmail, Blockchain mechanisms such as Non-Fungible Token (NFT) minting services, and other supportive software solutions that are used in the review process.

Web-based Graphical User Interface

The Graphical User Interface (GUI), designed as a Web application, is the stakeholders' entry point into our decentralized publishing medium environment. It provides an intuitive interface to the scientific publishing business process. Besides the ordinary Web technologies, we enabled dApp operations for smart contract interaction through a well-known EVM-based bridge called MetaMask[1]. An example of the submission Web page is depicted in Figure 3.

Reputation management

Stakeholders involved in the publishing process vary by the level of activity, efficiency and even quality of their contributions, such as manuscripts, reviews, and decisions. Thus, it is important to enable a mechanism that encourages trustworthiness and discourages unwanted behavior. Gathering readers' feedback that is used to estimate reputation will level up the overall quality of the published manuscripts and distinguish the content by its quality. The integration of such a mechanism is integrated in a decentralized, transparent way using DLT through smart contracts. Moreover, to further motivate the stakeholders, we propose an NFT collection distribution to the most devoted stakeholders when certain milestones are reached. For example, after a reviewer provided a certain amount of reviews (e.g. 10 reviews), the system mints an NFT collection and leaves it in the reviewer's wallet. The main goal of such NFTs is the ability to unlock additional functionalities or provide other benefits such as candidacy to become member of the Editorial Board in the next 5 year journal round, to achieve better terms or discounted prices. We believe that the benefits should be community driven through DAPO voting as presented in the following subsection.

Democratic publishing process

Each organization, independent of the business process, ordinarily confronts important decisions that are often arranged among the leading stakeholders in the

[1] https://metamask.io/

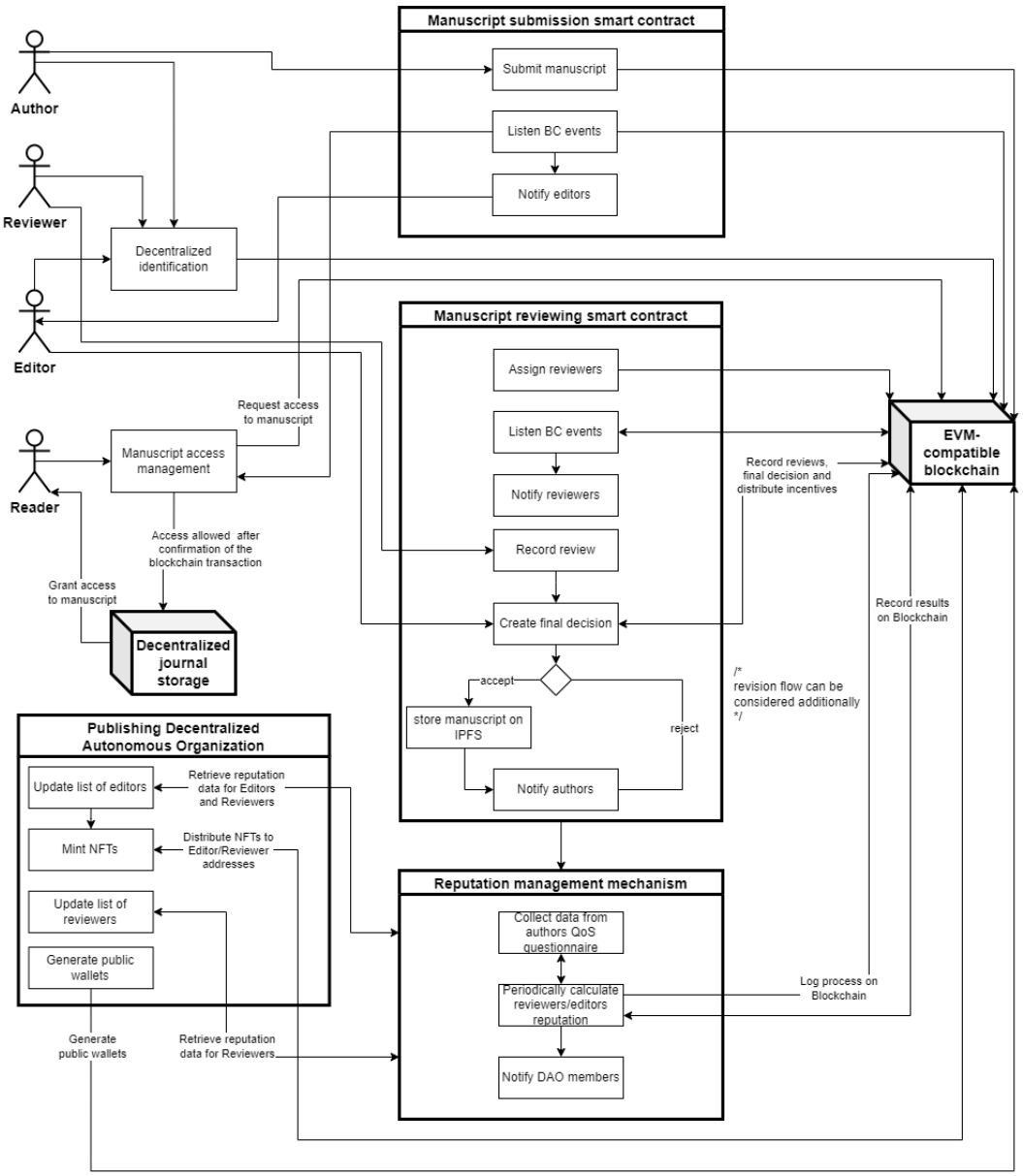

FIGURE 1. Review process diagram including pillar entities and components.

absence of the public or other non-leading stakeholders. To preserve a high level of democracy and transparency, we propose a DAO-based publishing organization that allows stakeholders such as editors and reviewers to propose changes in the business model or other key organizational decisions. For example, it is possible to submit a proposal in the form of a smart contract by a system stakeholder where the other stakeholders vote for or against the proposal. It is possible to define the period of the proposal, quorum and the voting token that is sent as a fraction represents a vote. A definition of voting smart contract suitable for our process, extended from public smart contract templates, is available in the public repository[2].

Decentralized storage for the journal

Journal articles are the final outcomes of the scientific publishing process. The size of such documents is not

[2]https://github.com/sandig/DAO-Sientific-Publishing-smart-contracts

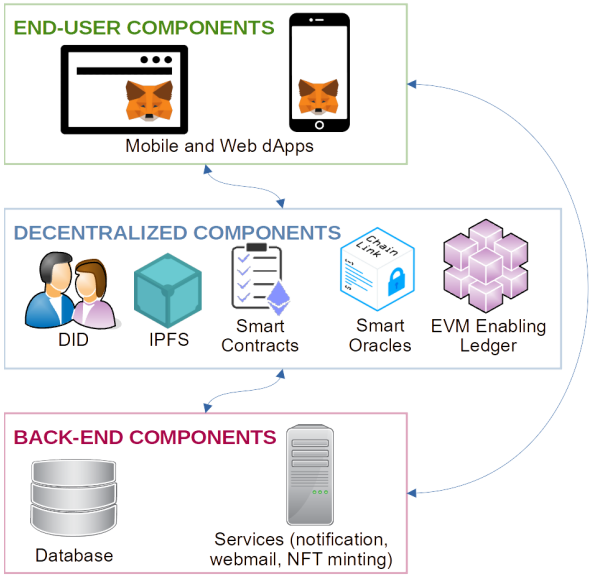

FIGURE 2. High-level architecture with the fundamental components of the developed decentralized publishing medium.

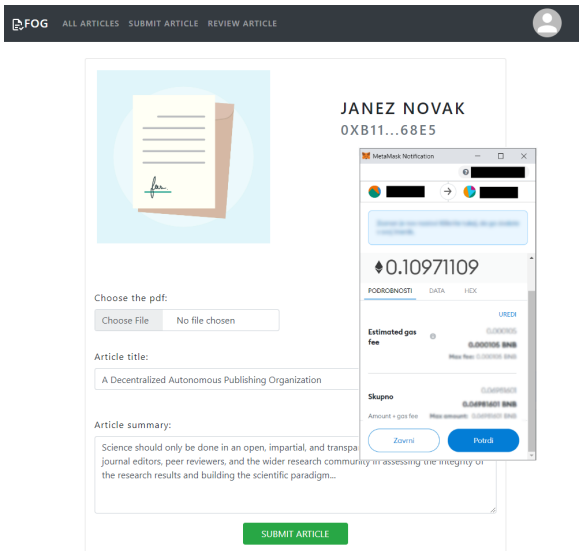

FIGURE 3. Example Web Graphical User Interface connected to the EVM-based DLT environment.

suitable to be stored on-chain therefore, we use more efficient approaches that are at the same time distributed, privacy-preserving and accessible. Our system integrates the InterPlanetary File System (IPFS) as a protocol for distributed (peer-to-peer) storage. The data stored in IPFS storage through node participants are affiliated with globally consistent identifiers called content addresses (CIDs). In our system, IPFS is used to store accepted manuscripts, that is, articles that are either publicly available in case of open-access journal policy or encrypted with content encryption mechanisms that are available to the readers on demand for a specific fee.

Identities involved in the publishing process

The business model of the scientific publishing system involves stakeholders around the globe that endeavor an effective, transparent identity management system that does not rely on centralized third-party entities. To overcome such limitations, we use decentralized identity management where a Decentralized Identifier (DID) is a globally unique identifier that enables an identity to be identified in a trustless manner, verifiable, and persistent and it does not depend on a centralized registry. An ordinary DID consists of a generic format <A>:<B> where A describes the DID method that describes the implementation of the formal syntax or schema and B the unique identifier. Moreover, DID method specifies the four pillar operations for DIDs manageable with a verifiable data registry: (i) generation, (ii) resolution, (iii) update and (iv) deactivation. Each DID is related to the DID subject, such as group, person, organization, digital object, logical object and so on, and controlled with DID controller enabling updates on the DID document. In our environment, DIDs and related DID document content is interpreted with a dedicated system called DID resolver. Our system benefits from DIDs to transparently manage the identifications of the system stakeholders.

Tokenomics

Cryptocurrency tokens are digital assets built on other blockchains, which trigger operations whose gas fees are paid in native coins. One of the most popular blockchains that support tokens is the Ethereum ledger and our solution is compatible with this popular blockchain. Although there are many token standards for tokenomics, the ERC-20 standard describing a fungible token is often considered as the most suitable. Apart from the tokens being designed to support the default token valuation and default ERC-20 operations, the token design is tightly dependent on the business

model of the token. Based on the latest findings in this field by P. Freni et al. [7], token behavior can be considered based on morphological token classification covering three pillar classifier domains: (i) technology, (ii) behavior and (iii) coordination. These have been carefully considered in the design of the DAPO's business model which is based on tokenomic principles.

The technological domain main focus is on the support of an existing EVM-based chain and fungible token representation (ERC-20), such as Ethereum[3], Polygon[4], Build and Build (BNB) Smart Chain[5] or others that consist of significantly reduced transaction cost compared to the Ethereum mainnet. To achieve better horizontal scalability in the decentralized publishing process, we strive to use a ledger technology that supports cross-chain interoperability, which EVM does.

Behavior domain describes the tokens based on the various properties that reflect token behavior. For instance, to force deflationary token behaviour, a certain amount of the tokens can be burned with carefully controlled actions, such as minting of NFTs or periodical burns. Another aspect is the token economic characteristics that should be defined before the token launch, such as spendability, expirability, fungibility, divisibility and tradability.

Coordination domain impacts the actual business model functionalities because it defines various incentives such as token supply strategy, which is an essential component of the business model and varies between use cases. In the case of a decentralized publishing process, the token supply should be several factors bigger than the research community in the world to prevent the shortage of tokens needed for the publishing process. To increase the impact of the token, its functionalities will focus on discounts, revenues, rewards, dividends or earnings, reputation, governance and other similar incentives or stakeholder rights. This will allow distinguish an ordinary reviewer from a reputable reviewer, which will allow the selection of reviewers based on their experience.

Based on the classification explained in the previous paragraphs, our fundamental functionalities are based on two token types:

- ERC-20 fungible tokens needed to perform the majority of functionalities through Smart Contracts as described in the next Section.
- ERC-721 NFT collections for stakeholders minted in reached important milestones, such as after 10 written reviews by a reviewer or 10 manuscript decisions done by a handling editor. The token specifics are described in the following Subsection.

Long-term sustainability analysis

Conventional publishers such as IEEE, Springer, Elsevier, Wiley and many others operate on established business processes. Thus, the overall system design consists of (semi) centralized, non-publicly available system components that is diametrically opposite to our system methodology relying on mostly public components based on DLT. The entire publishing process, from stakeholders registration, submission of the manuscripts, paper review and even the reputation, is transparently performed through the dedicated smart contracts available in a public repository[6]. Moreover, metadata not suitable to be stored on-chain (e.g. accepted manuscripts, experimental data) is persistently stored in distributed storage, that is, IPFS. There are also certain operational costs from front-end maintenance, domain registration and other infrastructure costs.

To prove the long-term feasibility of our environment, we perform a sustainability analysis of the decentralized publishing process that considers the cost of smart contract interactions deployed on a low-cost EVM-based ledger called Polygon[7]. All interactions of the smart contracts (e.g. deployment, function triggers) are performed on distributed EVM-enabling nodes that charge operational fees in EVM native cryptocurrency where the amount of the fee depends on the complexity of the computational operations that cannot be always rated deterministically [8]. Moreover, the decentralized storage cost is the one of web3.storage[8] where the pricing varies on the storage usage. Finally, system maintenance is considered to provide convenient services such as Graphical User Interface (mobile or Web), Webmail infrastructure, domain and other costs.

The main setup for our long-term sustainability simulation is the following:

- analysis of yearly cost on a 30 years period,

[3]https://ethereum.org
[4]https://polygon.technology/
[5]https://www.bnbchain.world/en/smartChain

[6]https://github.com/sandig/DAO-Sientific-Publishing-smart-contracts
[7]https://polygon.technology/
[8]https://web3.storage/

FIGURE 4. Sustainability simulation for two frequent types of journal policies (a) open access option and (b) non-open access option.

- 10000 accepted manuscripts with the annual growth or decline between −10% to 10%,
- inflation rate increasing overall system cost between 1% is 8% annual,
- acceptance rate is between 5% and 15%,
- manuscript submission fee of 200 USD for open access policy and
- each paper is accessed between 5 to 20 times for non-open access policy.

Since large publishers' business model focuses either on open access papers that require authors of the accepted manuscript to pay a publishing fee of 85 USD or a non-open access policy that is free of charge but the access to the accepted manuscript requires a fixed charge of 20 USD. The results of both policy variations considering all the cost, both deterministic and stochastic, is depicted in Figure 4.

Let alone, these results suggest that the manuscript submission fee of 200 USD in the case of an open access option may be enough to achieve operational sustainability of the journal, which is by an order of magnitude lower cost than the existing fees of scientific publishers.

Discussion and conclusion

In this paper, we present a comprehensive overview of the proposed decentralized scientific publishing system. IT is a decentralized publishing medium as it can be used to support democratic community member interactions. The system allows a transparent publish-

ing process sustained by dedicated smart contracts where the pillar metadata as accepted manuscripts are stored in a decentralized storage. The fundamental components describing the main business process use community-driven DLT that involves certain operational and/or usage costs. The purpose of our simulations is to consider both, business process costs and potential revenue. In the experimental setup, the on-chain review process is fee free since the system returns all the charges at the end of each review process to all involved stakeholders. The results indicate that such a community-driven system is feasible for both an open access and non-open access policies. The open access policy is more deterministic since the revenue is determined by a fixed price. In both cases, with a system like this, it would be possible to, for example, cover also the NFT minting operations, DAPO voting costs, and Smart Oracle service triggering costs.

This paper presents an approach and technology placed in the overall context of scientific publishing. When this technology is considered as a proof-generating tool, this article presents a novel consensus protocol, a Proof of a Trustworthy Publishing Process. This consensus protocol supports extensive verification (e.g. verification if the manuscript has been assigned to the required number of reviewers, verification of the required expertise of a reviewer to be assigned to the specific manuscript, published content verification, opinion polling, reputation management or handling editor decision verification). For an example, this novel protocol uses especially tailored Solidity smart contracts that anonymously select the editor and reviewers that will review the submitted manuscripts, thus contributing to the impartiality of the review process.

In our future research, we will design a reputation mechanism that will complement the selection of reviewers based on the quality of their prior reviewing work. Furthermore, additional evaluation of the proposed solution will be performed to additionally optimize the blockchain energy-efficiency, provide faster transaction rate, reduce transaction costs and allow inter-ledger transactions. Finally, we call-on the decentralized computing community to join our efforts in the creation of a Decentralized Autonomous Publishing Organization for Decentralized Computing.

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